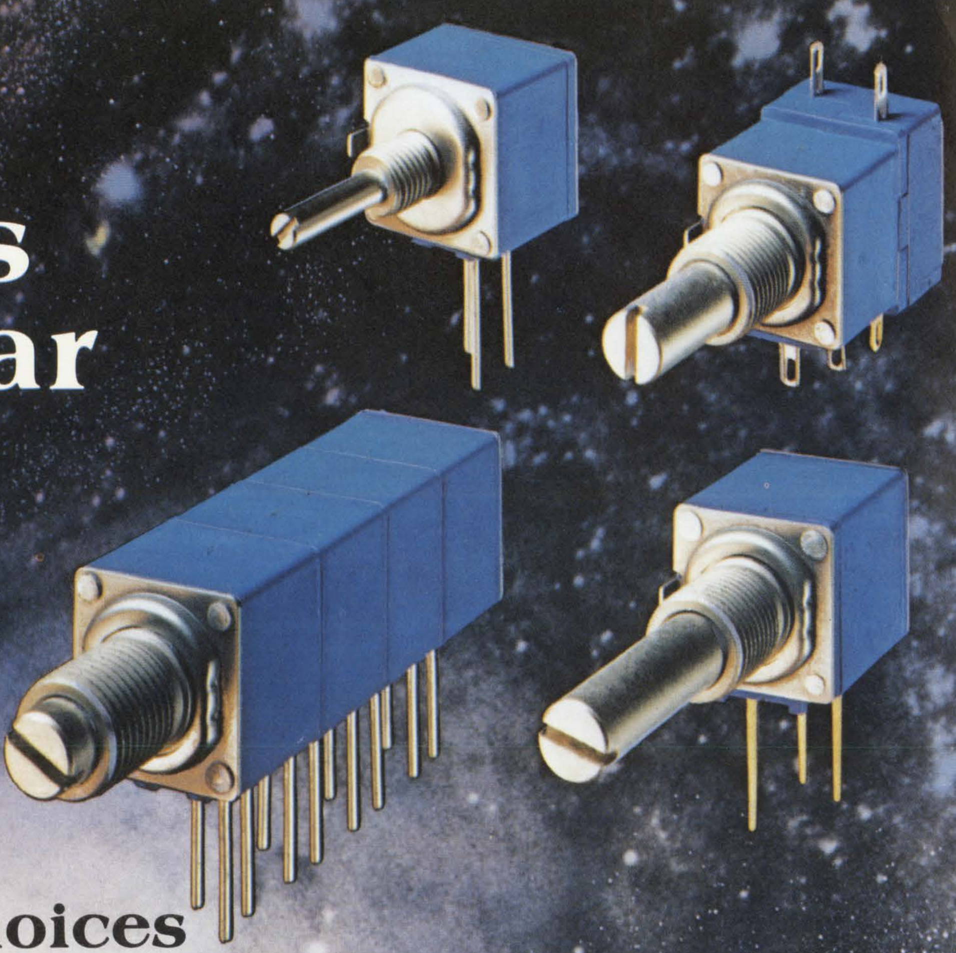
Electronic Design® VOL. 26 NO. 10
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE
MAY 10, 1978

The DPM picture is changing. In an 'old-time' meter, the norm was an out-and-out failure. Now the problems are more subtle. All the digits show, but are the readings accurate? Do the latest meters tell the truth? Find out where their faults are hidden. Focus on digital panel meters. The story begins on page 90.

*** A CHANGE IN SUBSCRIPTION POLICY BEGINS WITH THIS ISSUE**

TURN TO PAGE 45 FOR COMPLETE INSTRUCTIONS

Bourns Modular Pots...



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A BILLION DESIGN CHOICES:
(1) Precision potentiometers, semi-precisions, panel controls or switch modules, (2) Cermet, conductive plastic or wirewound elements, (3) Linear tapers, CW or CCW audio tapers at various tolerances, (4) A wide selection of bushings and single or dual concentric machined shaft options, (5) Gangable up to four cups, (6) PC pins or solder lugs, and (7) A wide range of resistance values. We offer the broadest line of modular pots and switches available anywhere.

PRECISIONS — Model 83/84 10-turn wirewounds with modular construction and PC pins. A Bourns exclusive.

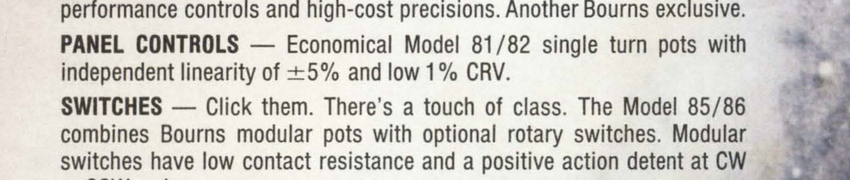
SEMI-PRECISIONS — ±1% to ±2.5% zero-based linearity range achieved by laser tailoring. The Model 87/88 fills the gap between low-performance controls and high-cost precisions. Another Bourns exclusive.

PANEL CONTROLS — Economical Model 81/82 single turn pots with independent linearity of ±5% and low 1% CRV.

SWITCHES — Click them. There's a touch of class. The Model 85/86 combines Bourns modular pots with optional rotary switches. Modular switches have low contact resistance and a positive action detent at CW or CCW end.

And, there's more: Consistently smooth, quality feel, regardless of model or modular configuration (torque range of only .3 to 2.0 oz.-in.); Bourns quality; competitive pricing; and universal flexibility. Send today for your new catalogs on the Model 80 family of modular pots and switches . . . Reach for a star from the Bourns Galaxy.

TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, CA 92507. Phone: 714 781-5122 — TWX 910 332-1252.



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For Immediate Application — Circle 130 • For Future Application — Circle 230

VOL. 26 NO.
Electronic Design® 10
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE
MAY 10, 1978

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Cover design by Art Director, Bill Kelly. Prints courtesy of: Analog Devices, Analogic, Ballantine Laboratories, Datel Systems, Fairchild Instrumentation, Newport Laboratories and Weston Instruments.

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DON'T FORGET TO SEND IN YOUR SUBSCRIPTION RENEWAL FORM — SEE PAGE 45

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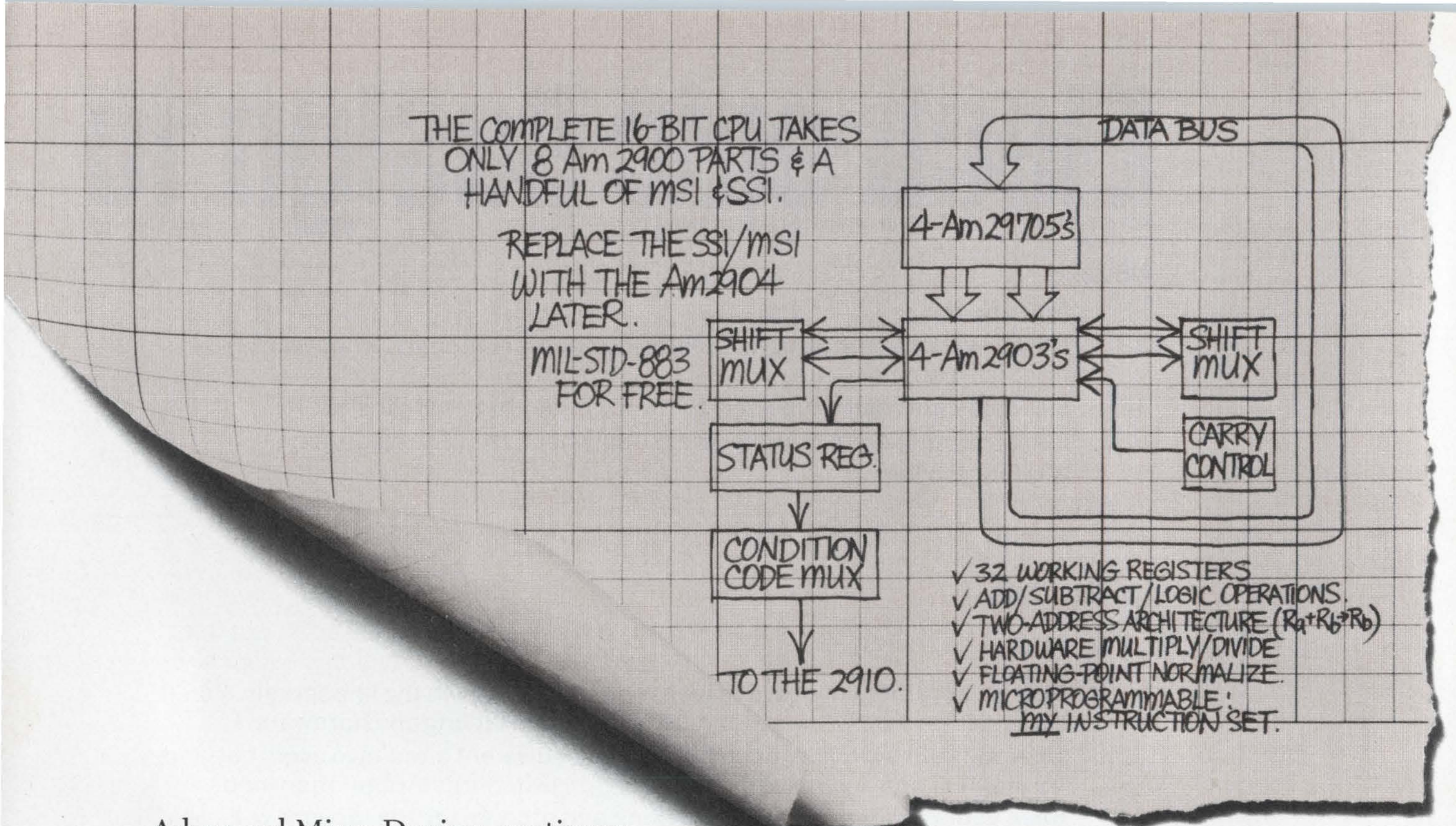

Advanced Micro Devices continues its advanced course in microprogrammable microprocessing.

Step by step, function by function, month by month, we'll show you how to build a fast, powerful microprogrammed machine.

And on December 31, 1978, you'll know what we know. As it turns out, that's quite a lot.

CHAPTER THREE: THE CPU, PART ONE.

The Central Processing Unit is where all arithmetic functions take place.

The CPU consists of an Arithmetic Logic Unit, working registers, circuits to control the

BUILDING A MICROCOMPUTER, CONTINUED.

shifting of registers and storage for the results.

Two parts in the Am2900 family are designed to combine all those functions on one chip, or slice. (Each chip is a 4-bit wide vertical slice of the CPU.)

THE SLICE.

Advanced Micro Devices' Am2901A and new Am2903 are 4-bit CPU slices with sixteen internal working registers, two-address architecture, multi-function arithmetic logic unit and shifting logic.

THE SUPERSLICE.™

And if that's not enough, hang on. The Am2903's register file is expandable. If sixteen registers aren't enough, add as many working registers as you want and still retain the two-address architecture.

If two-address architecture isn't enough, we made three-address operation possible in the Am2903.

For those of you who hate using SSI and MSI, we put all the extra hardware to do 2's complement multiply and divide right inside the chip.

BUILD YOUR LIBRARY. FREE.

Each of these monthly messages is backed by a ton of theory and applications information.

Chapter Three shows all the details–complete designs, timing diagrams and tradeoffs. Send in this coupon and we'll send you Chapter Three and tell you how to get the whole book.

5/10/78/ED

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Across the desk

Nothing to the inventor

It was never proposed to assign title to patents to the inventors in government-sponsored R&D, but to assign the title to their employers (Washington Report, ED No. 3, Feb. 1, 1978, p. 47). American engineers' inventions come generally under the "master-servent" doctrine of English common law. Japan, Germany, and Sweden do recognize inventions as something beyond the call of duty, and their laws require royalty payments to the individuals. Russia rewards inventors with "Certificates of Authorship."

A sample of \$4.3-billion worth of Defense R&D contracts was found to have produced 537 patents, or one patent per \$8-million spent—about one invention per 400 man-years. The Government policy of zero recognition for inventions—either to the inventor or to the company—has, it seems, been interpreted to mean "Uncle Sam doesn't want inventions."

L. T. Fleming

Innes Instruments
Box 5216
Pasadena, CA 91107

Get exact 50% duty cycle

I would like to point out that in Fred Chitayat's Idea for Design, "Dc-to-Ac Power Inverter Drives Ac Cooling Fans"(ED No. 1, Jan. 4, 1978, p. 158), a simple change to the circuit allows the duty cycle to be trimmed to exactly 50%.

Though the idea has been around for awhile, it has yet to find its way into the manufacturer's literature. In the circuit, capacitor C_1 charges through R_1 and R_2, and discharges through R_2. The original values result in a duty cycle of about 51%, admittedly insignificant for many applications.

However, if a diode is added across R_2, and R_1 is made equal to R_2, then C_1 will charge through R_1 and the diode, and discharge through R_2. If R_1 is made variable, it can be adjusted to about 300 kΩ so that the switching times of not only the 555 timer but also the transistors in the circuit can be compensated for. And that's how you get a duty cycle of exactly 50%.

Raymond K. Ferris
Supervisor

Actron
700 Royal Oaks Dr.
Monrovia, CA 91016

Stop fooling around. It's time to renew your free subscription to ELECTRONIC DESIGN. Turn to page 45.

(continued on page 26)

*

DON'T FORGET TO SEND IN YOUR SUBSCRIPTION RENEWAL FORM — SEE PAGE 45

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

What engineering about using micro

Microcomputers are changing the competitive picture in hundreds of industries, in thousands of applications.

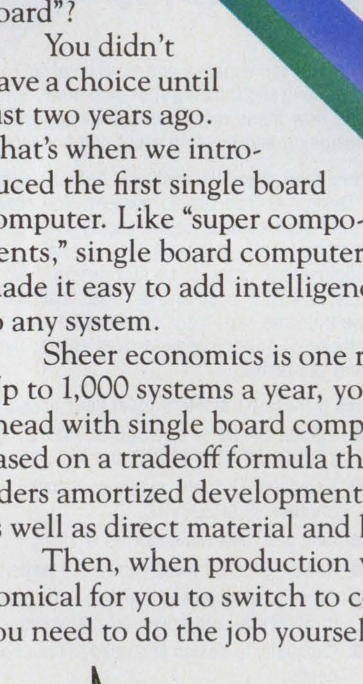
Designers are using microcomputers to create new products, even new markets. Microcomputers are breathing new life into existing products and providing competitive advantages in both price and performance.

For management, there's an added challenge. What's the most *profitable* way to take advantage of the microcomputer revolution? Should you start from scratch, dedicating time and resources to component-level design? Or should you take advantage of fully assembled and tested "computers-on-a-board"?

You didn't have a choice until just two years ago. That's when we introduced the first single board computer. Like "super components," single board computers have made it easy to add intelligence to any system.

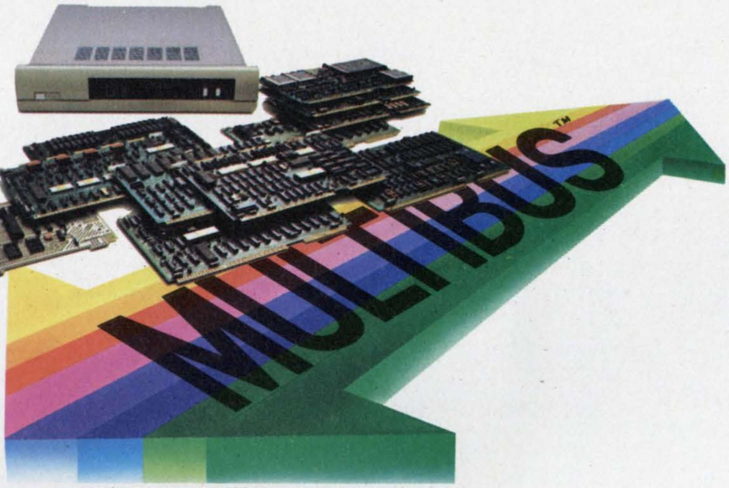
Sheer economics is one reason why. Up to 1,000 systems a year, you're money ahead with single board computers. That's based on a tradeoff formula that carefully considers amortized development and testing expenses, as well as direct material and labor costs.

Then, when production volume makes it more economical for you to switch to components, we'll provide all you need to do the job yourself—manufacturing drawings, pc artwork and a volume source for all the essential LSI components.



Time saved is another important reason single board computers make sense. You're into production sooner, without time spent developing the computer sub-system. Your engineers can go directly to the design of application-dependent hardware.

managers should know computers profitably.



RMX-80™ Real-time Multitasking Executive gives you a head start in software development, without the need to reinvent system software for every application. Intellec,® our microcomputer development system, speeds application software development. It puts PL/M and FORTRAN-80 (ANS FORTRAN 77) high-level programming languages and a macro-assembler at your command. And supports full text editing, relocation and linkage capability. In-Circuit Emulation, with symbolic debugging, provides a diagnostic window into your prototype to speed and simplify system development.

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You're assured of the highest reliability when you build your system around an Intel single board computer. For example, MTBF for our iSBC 80/10 is 91,739 hours at 25°C. Ask for your copy of our iSBC Reliability Report.

There's also the security of Multibus,™ the multi-processing bus architecture we developed for single board computers. Multibus has become such a widely accepted industry standard that today there are over a hundred Multibus-compatible products available from 42 independent companies. And Multibus is your guarantee of compatibility with future Intel iSBC products.

Get started with our comprehensive iSBC System Configuration Kit. It's a catalog of Intel single board computer products, with detailed configuration instructions and worksheets to help you define the optimum iSBC solution for your needs.

For your kit, or for on-site assistance in configuring and pricing your iSBC system, contact your Intel representative or distributor. Or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone: (408) 987-8080. In Europe contact: Intel International, Rue du Moulin a Pàpier, 51-Boite 1, B-1160, Brussels, Belgium. Telex 24814. In Japan contact: Intel Japan, K.K., Flower Hill-Shinmachi East Bldg. 1-23-9, Shinmachi, Setagaya-ku, Tokyo 154. Telex 781-28426.

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Motorola introduces more RF technical knockouts in modules, mobile & microwave.

Get Au for the price of Al

Our new generation gold linear CATV hybrid lineup is priced equally and, in some cases, less than aluminum. The new MHW1171/1172 units are just $27.50 and $30.50, 100-up!

The family of 10 represents one of the most diversified and complete collections of hybrids available. Spec'd for MATV and CATV applications, they're available with gains from 12–34 dB. The Motorola case 714-01 is the CATV industry standard.

And they've got state-of-the-art linearity, and a wider temperature range (-60° to 100°C) than comparables. All use ultra-low distortion, push-pull cascode circuitry to achieve 40–300 MHz bandwidth, flat response and super-low distortion products.

Aluminum's out, gold is in! **G**

Get your mobile in overdrive

. . . with new 30 and 40 W MRF844/846 UHF transistors 100%-tested to withstand highline supply, RF overdrive and 10:1 VSWR.

A standard Motorola spec!

Characterized for C amplifiers in FM mobile two-way, these 900-MHz units are common-base, internally-matched CS-12 packages with input matching optimized for 100-MHz instantaneous bandwidth. They offer 6 and 5.2 GPB (dB) and complement an existing 1–20 W family.

Ruggedness combined with high gain and 806—947 MHz bandwidth make the devices industry performance leaders for public safety, mobile telephone, industrial and transportation services as well as the upcoming cellular systems for handheld and mobile radio in the 1980s.

. . . OR with the only industry 470-MHz units guaranteeing ruggedness at both highline *and* overdrive . . . MRF641/648.

The '648 offers state-of-the-art 60-W output. Both offer load mismatch capability at 20:1 VSWR, all phase angles, at 16 V and 50% overdrive. That's unbeatable.

The industry-standard 0.5″ CQ package is characterized with large signal impedance parameters; minimum gains are 4.4 and 7 dB with efficiency rated at 55%. Design them into FM, UHF mobile and fixed station equipment for just $13 and $25. **H**

Cascadable amplifiers take price drop

If you've been paying $40–$50 apiece for hybrid amplifiers in TO-12 packages—STOP! We've got the new MWA110/120 devices here for just $6.50 and $7 (1–99).

These 400-MHz hybrids are complete units ready to go in 50-ohm microstrip circuits. They're cascadable, ready for series connection without bandwidth shrinkage.

Providing flat response over 6 octaves of bandwidth, they offer 13 dB min gain, 4.5 and 6 dB noise figure, 1-dB min compression of -3 and +6.7 dB, ±1 max flatness over -20° to 125°C and VSWR (input/output) of 2:1. **J**

4.5 GHz @ 50 mA from Motorola

Here's a lineup of microwave transistors ideally suited for low-to-medium power amplifiers requiring high gain, low noise figure and low IMD.

The BFR96/MRF961 are three- and four-lead plastic devices designed for use in broadband MATV/CATV amplifiers. MRF962 uses a hermetic, stripline ceramic package and is intended for hi-rel, high-gain use.

The hermetic MRF965 in TO-46 makes an excellent VHF/UHF Class C driver amplifier for several hundred milliwatts power out.

All use the same state-of-the-art microwave chip (BFRC96) featuring fine-line geometry, ion-implanted arsenic emitter and gold top metallization. **K**

New Selector Guide

Motorola now offers its newest *RF Selector & Cross-Reference Guide* . . . 20 pages of data including power transistors with outputs to 150 W for 1.5 MHz to 1 GHz; small-signal transistors with f_t to 6 GHz; linear hybrids for CATV/MATV; power amps for VHF/UHF up to 30-W output; package dimensions, cross-referencing and latest pricing. A short-form complement to the new *RF Data Manual*, it offers an at-a-glance look at a wide gamut of advanced-technology, high-quality RF devices. Yours on your company letterhead.

Motorola presents an economical 10-bit DAC

Nobody makes higher value 10-bit DACs than the MC3410/3410C/3510 series.

These are low-cost, high-accuracy, laser-trimmed, monolithic D/A converters that, like their MC1408 series predecessors, provide the logic-controlled switches, the R-2R resistor ladder network and output termination networks.

Output buffer amp and ref voltage have been omitted to allow greatest system speed (settling time is 250 ns typical, multiplying input slew rate is 20 μ A/μs typical), flexibility and lowest cost.

Relative accuracy is, of course ±0.05% maximum. Noninverting digital inputs are TTL- and CMOS-compatible (from 5 to 15 V CMOS), output voltage swing is +0.2 to -2.5 V and all categories are guaranteed monotonic across temperature. The ref amp is internally compensated and output current ranges from 0 to 5 mA.

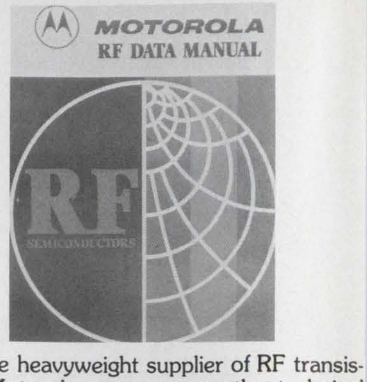
No one makes a direct replacement and most SC majors don't make a 10-bit DAC at all. The ones that do are almost always overpriced so Motorola can really offer you the best deal all around in 10-bits.

The MC3410C, incidentally, is a 9-bit unit which can be a rock-solid replacement for those 8-bit devices you've just been getting by with. And its only a few cents more.

Use it in industrial control and MPU-based systems and save a bundle.

100–ups are $4.95, $7.95 and $13.95. **L**

Two pounds of RF data from Motorola



The heavyweight supplier of RF transistors, Motorola, announces another technical knockout—the new RF Data Manual complete with data sheets, application notes and cross-references.

The two-pound, 736-page volume describes RF devices with outputs to 150 W for commercial, military, aircraft, marine and ham bands from 1.5 MHz to 1 GHz, as well as linear hybrid amplifier modules for CATV/MATV and GP use, power hybrids up to 30 W in VHF/UHF and small-signal transistors with f_t values to 6 GHz.

Detailed application information includes impedance matching networks, mechanical RF construction techniques, biasing, reliability, noise figure and gain optimization procedures, mounting, heat sinking and discussions of SSB linearity, broadbanding and power combining. Specific amplifier configuration articles include actual printed board layouts.

It's available from your franchised Motorola distributor for just $1.75 a pound.

New character generators need only single +5 V power supplies

As the leader in character generators, Motorola introduces a new solution for character display, this time with the MCM66700 and MCM6670 mask-programmable horizontal-scan families.

Both feature fully static operation, complete TTL compatibility, three-state outputs, fast access time (350 ns max), and each uses only a single +5 V power supply.

The MCM66700 series is a pin-for-pin replacement for all eleven patterns of the earlier MCM6570, and many have on-board shifted characters. MCM66700s contain 128 characters in a 7 x 9 matrix, with programmed versions for ASCII shifted and unshifted, math symbols, alphanumeric control, Japanese, and British, French, German, and European, shifted. They are also CMOS and microprocessor compatible.

The MCM6670 displays 128 characters in a 5 x 7 matrix. It's available in both plastic and ceramic 18-pin packages. Corner pins are used for the ±10% +5 V supply. The MCM6674 is a version preprogrammed with alphabet and math symbols.

Mask charges, and minimum order quantities of 250 pieces, apply to the custom program MCM66700 and MCM6670 types. Preprogrammed versions are available from Motorola and authorized Motorola distributors. No minimums apply. **M**

LSI to Glue ... and Memories, too

All you need for TTL microprogrammable processors

Motorola is unique when it comes to providing what it takes to design and build your high-speed TTL microprogrammable processor. We're the only ones who has it all*, and it's all off the same Schottky process for uniformity, reliability, and lower over-all component cost.

*The MC2901A 4-bit slice and our other M2900 Family industry-standard LSI functions, for sequencing, number crunching, and interface.

*Memories, for microprogram storage, with your option of 2K, 4K, or 8K PROMs, or even RAMs.

*LSTTL "glue," a whole family of over 100 SSI and MSI functions for logic and interface, to bind your system together for your specific application.

The MC2901A is the familiar plug-in replacement that shows greatly improved performance over the 2901 4-bit slice in higher speed, reduced power supply current, increased noise immunity, and increased low-level output current. A new M2900 Family 4-bit slice, the MC2903, with easy register file expansion and no loss of speed or flexibility is scheduled for third quarter availability.

Additional M2900 Family LSI for your processor system includes the MC2909 and MC2911 microprogram sequencers, I/O sequencer functions MC2905-7, MC2915A-17A, and the MC2918 register file. The MC2910, planned for mid-year, is a new 12-bit wide microprogram controller that can address up to 4096 words of microcode.

Among the memories, the MCM93415 and MCM93425 1K RAMs, and the 4K MCM7641 and MCM7643 three-state PROMs are available now, and due to be joined by a large group of additional industry-standard PROMs: 2K MCM7620, 21—MCM7640 and 42 4K (open-collector output)—and 8K MCM7680, 81. All are planned for availability by July.

These Motorola PROMs are pin-compatible replacements for industry-standard PROMs and ROMs. All have common dc performance and programming.

As for LS, let it suffice to suggest that among the more than 106 SSI and MSI parts available now, and the more than 150 parts to be available by year's end, we have what your processor system requires. The 74LS240 series, bus-oriented octal line drivers and quad receivers, and the 74LS365A hex buffers are typical examples.

We can save you money when you buy it all here, by packaging your orders to get lower, large-quantity prices in play. Come to Motorola, where we've got it all. **N**

Plastic Triac saves 30% over old metal TO-5

Here's a low-cost, drop-in replacement for those old, TO-5 2.5 A (RMS), 3 mA sensitive-gate RCA T2300 Series Triacs that have been around since year 1.

It's tested and spec'd for the same electricals and available in TO-5 pin circle.

There's an actual 30% price saving over RCA, too—the Motorola T2300PB is just 70¢ and the T2300PD is only 87¢, both 100-up.

Time-tested design and materials add up to reliability documentation that's really impressive for plastic units like these. Power cycling at extreme ΔT operation shows over 43 *million* cycles resulting in an estimated MTTF of over 3 million cycles. Blocking life tests are equally impressive and a variety of other tortures proves glass-passivated thyristor die and greatly improved molding compound afford a reliability level that easily meets industrial and consumer requirements.

Other series, the T2301P and the T2302P, are available with I_{GT} spec'd at 4 mA and 10 mA, respectively. **P**

Diode guide reflects 20 years of knowhow

The right device for nearly every application is listed and cross-referenced in the new Motorola *Rectifier/Zener Diode Selection Guide & Cross-Reference.*

Included are rectifiers, bridges, Schottky and fast recovery units, high voltage diodes/stacks and high current devices. Also zener, TC and precision reference diodes, amplifying and current regulator diodes, low-voltage regulators, transient suppressors and optional variations. Without a doubt the most complete publication of its kind and it's yours on company letterhead request.

Motorola opens op amp/comparator game with 2 pair

The MC3405/3505 offer an economical quad function with a twist. Two of the four devices are op amps and the other two voltage comparators. An industry first.

The op amps are internally compensated, have true differential inputs and are equivalent in performance to MC3403/3503. The comparators provide low offset voltages with low power consumption and are similar to LM339/139. The circuit offers 3–36 V single supply and +1.5–+18 V split supply operation plus low current drain. Both are capable of common-mode inputs down to the negative supply.

It's a useful, versatile building block in automotive, consumer and industrial designs including PWM, window comparator, squelch circuit for AM or FM, LS to CMOS interface with hysteresis, high/low limit alarm and zero crossing detector with temperature sensor.

The MC3405/3505 is available in two temperature ranges in plastic (P) or ceramic (L) 14-pin packages. The '3405 has a specified operating ambient range of 0° to 70°C and the '3505 is spec'd from −55° to +125°C.

Input offset voltage is typically 2 mV and power supply current is typically 2.5 mA.

100-up pricing is MC3405P, $1.15; MC3405L, $1.50; and MC3505L, $7.50. **Q**

MOTOROLA OMNIBUS Looking ahead in all technologies.

(Coupon Missing?) Send inquiries to: Department LDC, Motorola Semiconductor Products Inc., P.O. Box 20912 Phoenix, AZ 85036

(Please Check Only The Items You're Interested In:)

A ☐ MDA2500	**F ☐ MC3448AL/AP**	**L ☐ MC3410C/3510**
B ☐ MC14469	**G ☐ MHW1171/1172**	**M ☐ MCM66700/6670**
C ☐ MC14443/47	**H ☐ MRF844/846, 641/648**	**N ☐ TTL, LSI to Glue**
D ☐ MC14495	**J ☐ MWA110/120**	**P ☐ T2300PB**
E ☐ LM148/248/348	**K ☐ Microwave**	**Q ☐ MC3405/3505**

For complete product itineraries, fill in and send to:
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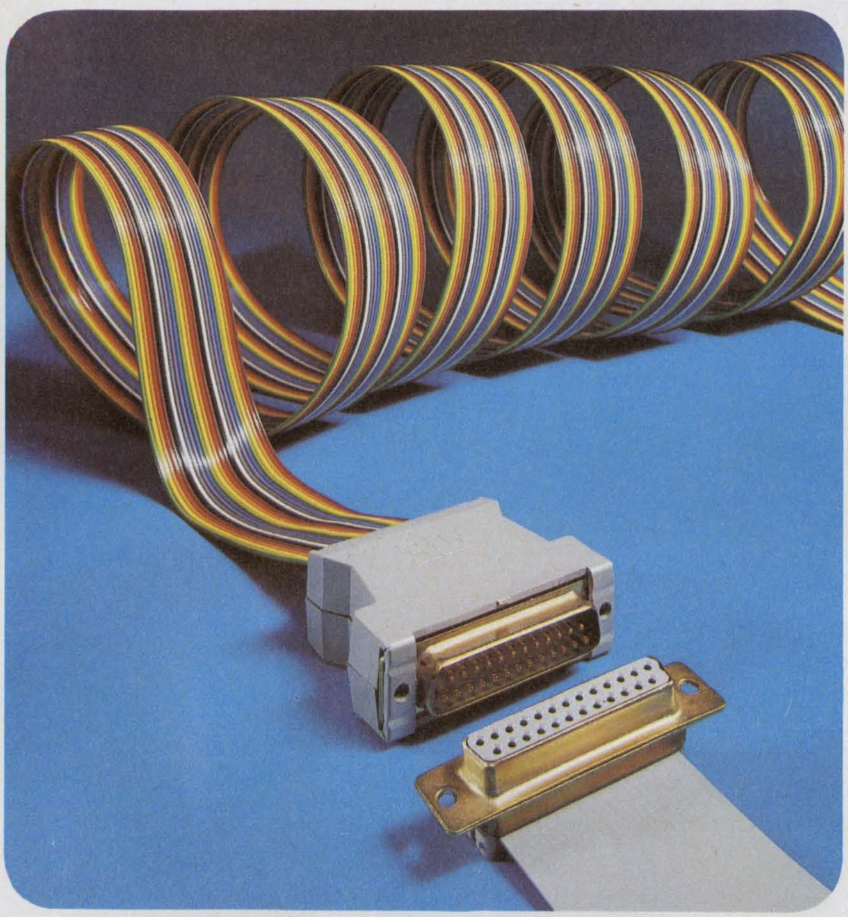
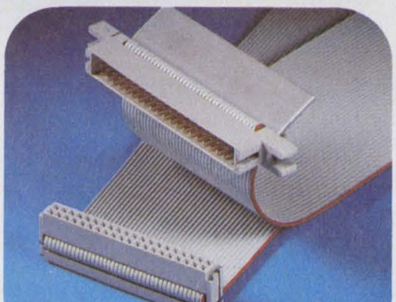
Want mass terminations for I/O interconnecting?

We have the widest choice.



Our broad line of Scotchflex socket connectors includes a variety of 12 different sizes and center spacings to fit standard wrap panels and custom configurations. Also offered are Scotchflex card-edge connectors in sizes for 20 to 50 conductors.

Now Scotchflex brand DELTA Connectors bring the proved labor-savings of 3M's mass termination system to subminiature connections. DELTA series components include pin and socket connectors, junction shells, 25-conductor flat cable and strain relief clips. These system assemblies interface directly with all other industry standard "D" series subminiature connectors. They're also compatible with all connectors in our complete Scotchflex line.



A family of Scotchflex male plug connectors is now available in sizes from 10 to 50 contacts to mate with Scotchflex socket connectors for T-tap or mid-span connections or rack and panel applications.

Only 3M offers you so wide a choice of mass terminating flat cable and system components for fast, economical assembly of I/O interconnections between modules or sub-assemblies in your equipment designs. Plus off-the-shelf availability from experienced distributors, and the unmatched experience of the people who pioneered electronic mass terminations.

For more information on Scotchflex products call 612-733-3350.

Scotchflex® systems from 3M.

The source.

3M COMPANY

See our catalog in EEM, page 2256

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CIRCLE NUMBER 11

"Simplicity is the key to advanced fiber optic terminations. That's why OPTIMATE connectors light the way."

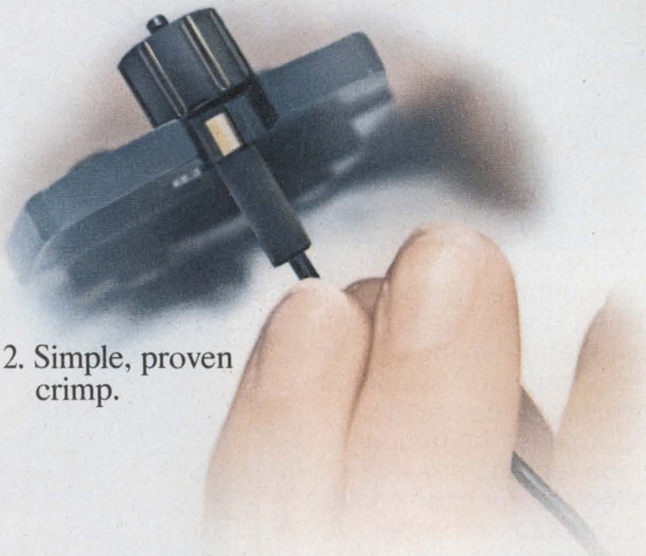
Meaningful progress in fiber optics technology is no longer hampered by impractical termination techniques. Today, AMP innovation is opening the way for an expanding array of applications.

We are especially proud of the unique contributions of our OPTIMATE line. These connectors have made universal termination possible for a wide variety of fiber optic cable. And they do it simply, quickly and with highly repeatable accuracy. Single optic fibers, as small as .004", can be terminated and OPTIMATE connectors incorporate a resilient material which ensures optical centering. Precise, accurate polishing is easy and fast, thanks to a simple adaptor.

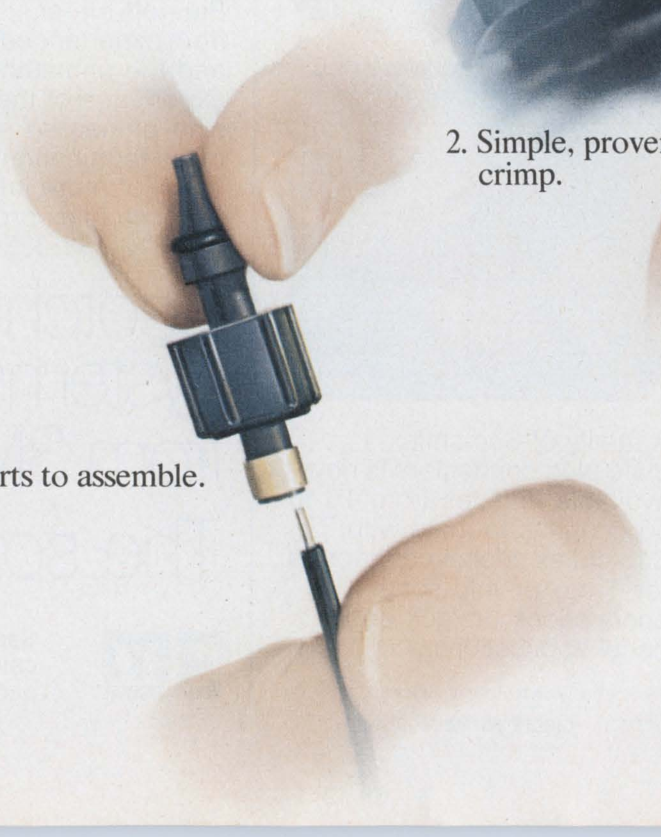
There are more OPTIMATE contributions...such as providing for the intermixing of fiber optics with conventional power or signal cable in a wide range of standard housings. And more are on the way. Because we at AMP have over 2,000 people involved in research, development and engineering activities alone. And because we are committed to the same kind of leadership in fiber optics that we have achieved in other termination areas.

For more information on our OPTIMATE line, just call Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.

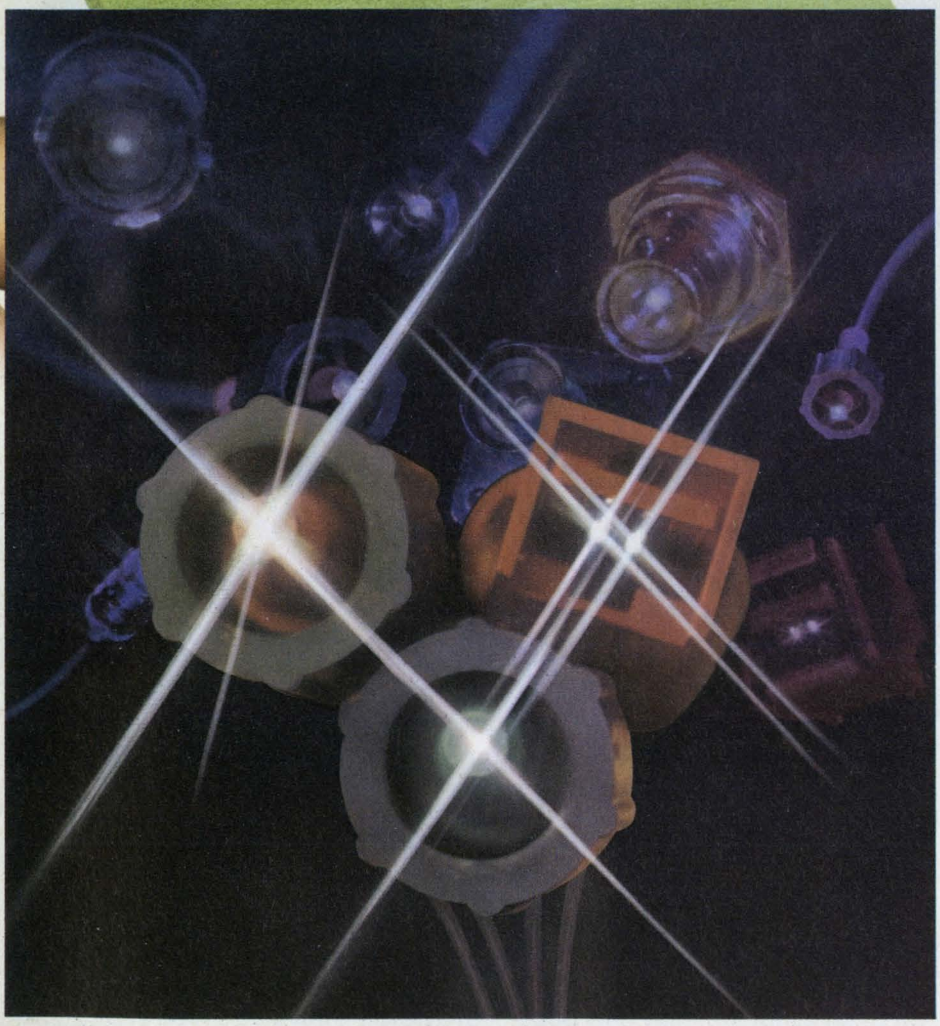
3. Accurate polishing.



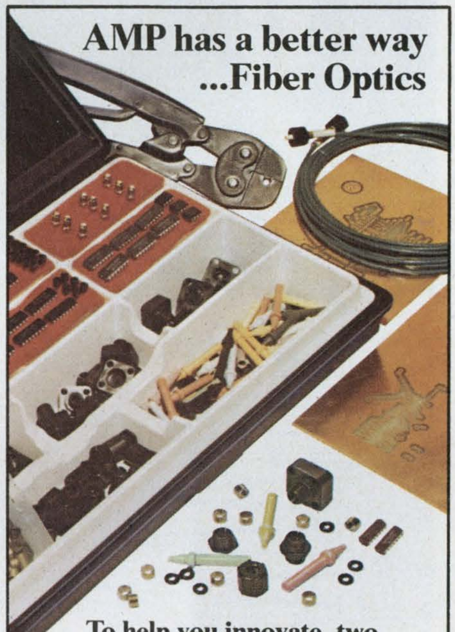
2. Simple, proven crimp.



1. Few parts to assemble.



AMP has a better way ...Fiber Optics



To help you innovate, two OPTIMATE Kits are available: just connectors, cable and tooling, or complete with active devices and predrilled circuit boards for construction of optical links with TTL or CMOS input/output.

For information on other fiber optic contacts for intermixing in standard connectors, please call Customer Service at (717) 564-0100.

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Precision quad op amps. *Precision.*

PMI's new OP-09 and OP-11 are pin-compatible with the un-precision quads now on the market.

The quad op amp has finally come of age. With the introduction of the OP-09 and OP-11, PMI has made it a truly workable reality. Consider:

Low V_{OS} and other goodies.

Since quads can't be nulled—there aren't enough pins available—the user is at the mercy of whatever input offset voltage (V_{OS}) he happens to get. PMI refined the manufacturing process to get V_{OS} under control. We came up with the lowest V_{OS} of any quad op amp made today.

At the same time, we gave the OP-09 and OP-11 the highest gain and the lowest drift of any quad op amp. We expanded bandwidth, reduced offset and supply current, and increased the slew rate. Here it is in black and white:

OP-09/OP-11 Features

	TYP.	MIN./MAX.
• **Low V_{OS}**	0.30 mV	0.5 mV MAX.
• **Low offset current**	8.0 nA	20 nA MAX.
• **Low supply current (Total for all 4)**	3.5 mA	6 mA MAX.
• **Voltage gain**	250K	100K MIN.
• **Slew rate**	1.0 V/μS	0.7 V/μS MIN.
• **Matched positive and negative slew rate for low distortion.**		
• **Bandwidth**		2.0 MHz MIN.

We make them match.

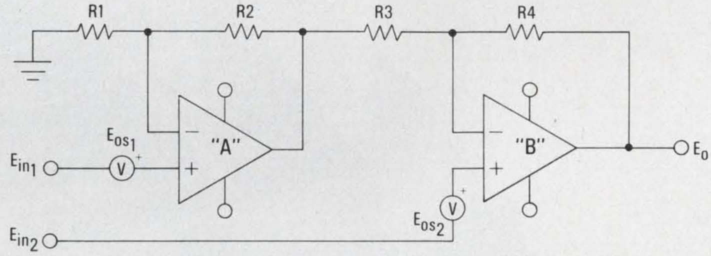
Another important advantage: we guarantee that all four op amps will match in terms of V_{OS} and CMRR. Here's how we specify them:

Matching Characteristics

		OP-09A/E OP-11A/E			OP-09B/F OP-11B/F			
Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Units**
Input Offset Voltage Match	ΔV_{OS}	–	0.5	0.75	–	0.8	2.0	mV
Common Mode Rejection	ΔCMRR	–	1.0	20	–	1.0	20	μV/V
Ratio Match		94	120	–	94	120	–	dB

(Match exists between all four amplifiers)

DUAL INSTRUMENTATION AMPLIFIER 2 OP AMP DESIGN (1/2 CIRCUIT SHOWN)



These matching dc characteristics should interest you. They reduce distortion, improve system performance, and simplify your design. But that's not all.

We've given all four op amps symmetrical positive and negative slew rates—an important thing to keep in mind for audio system design.

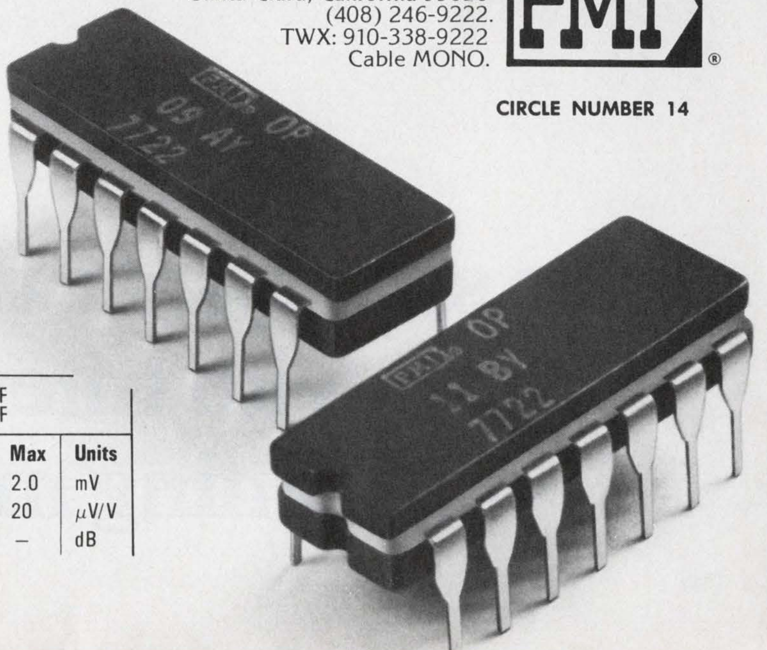
It's fair to say that the OP-09 and OP-11 are the most accurate, most advanced and the only **precision** quad op amps on the market. And they **are** on the market—available now, today.

Like to check one out? Be our guest. Just drop us a line on your company's stationery, telling us if you'd prefer an OP-09 (4136 pinout) or an OP-11 (148/4741 pinout). We'll be glad to send literature and a sample.

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

PMI®

CIRCLE NUMBER 14



CIRCUITS FOR THAT

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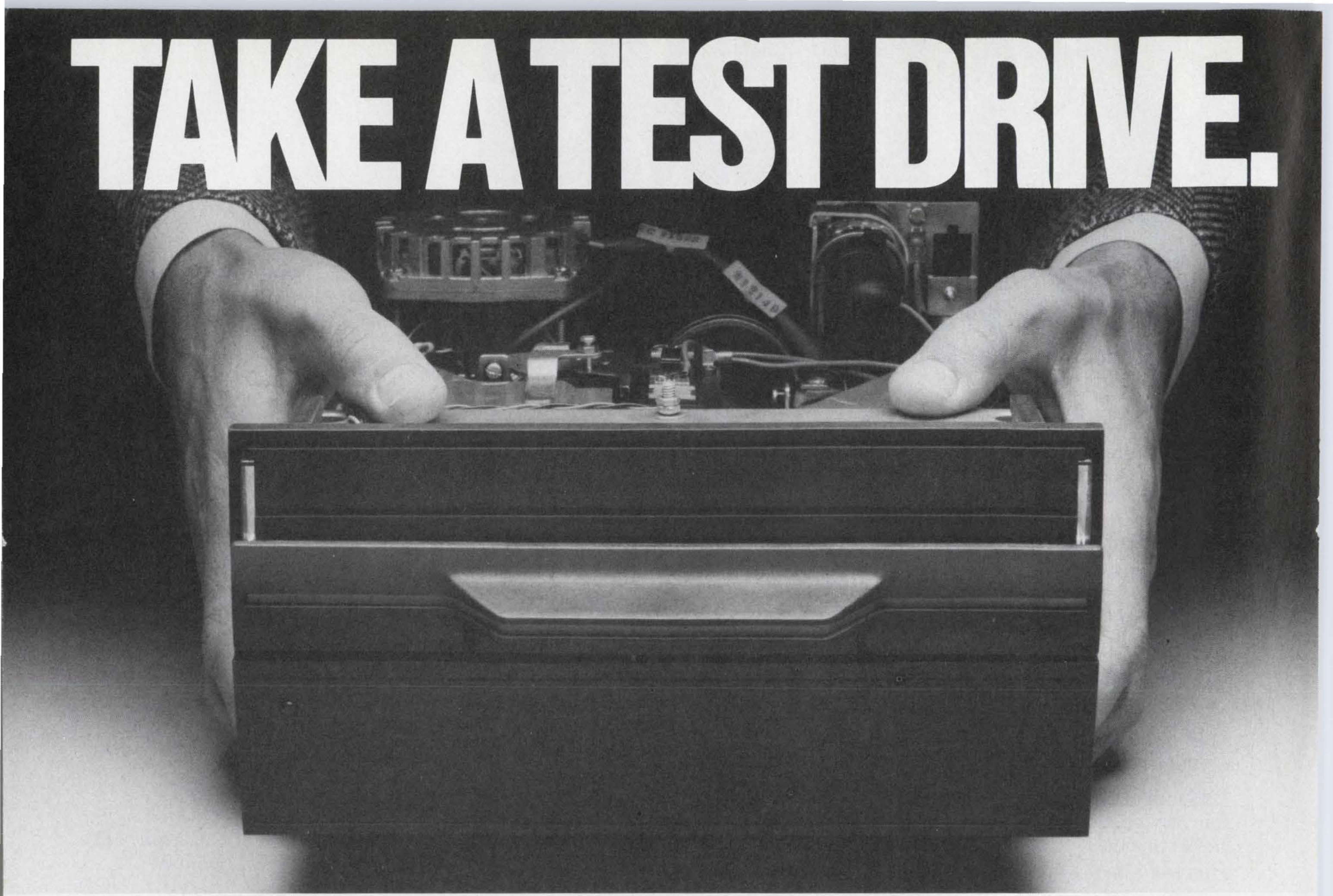

Introducing the Memorex® 552 Dual-Head Flexible Disc Drive—and a great way to find out just how great it is:

Just give us a call and we'll loan you one of our new 552's. So you can test it in your systems, under the conditions important to you. So you can confirm for yourself the 552's 1600 kilobyte capacity, 3 msec access time, and high reliability. So you can see for yourself the benefits of all the features Memorex builds in for better performance, greater versatility, operating ease, and reduced cost of lifetime ownership.

If a dual-head drive is more than you need; our 550 single-head, double density drive may be just the one you need. All the features you've come to expect as industry standard, plus some others that are setting new standards. Like the fastest access time of any single-head drive. And fast conversion of our 550 to dual-head, because of the near total parts commonality with our 552. Unique features that make the 550 a uniquely-effective performer. Take one of our test units and you'll see just how well the 550 performs.

To get your evaluation unit, just call the Memorex office nearest you, or write us at General Systems Group (OEM Division), San Tomas at Central Expressway, Santa Clara, CA 95052.

We'd be pleased to have you test our drives, because we're confident you'll be pleased with the results.

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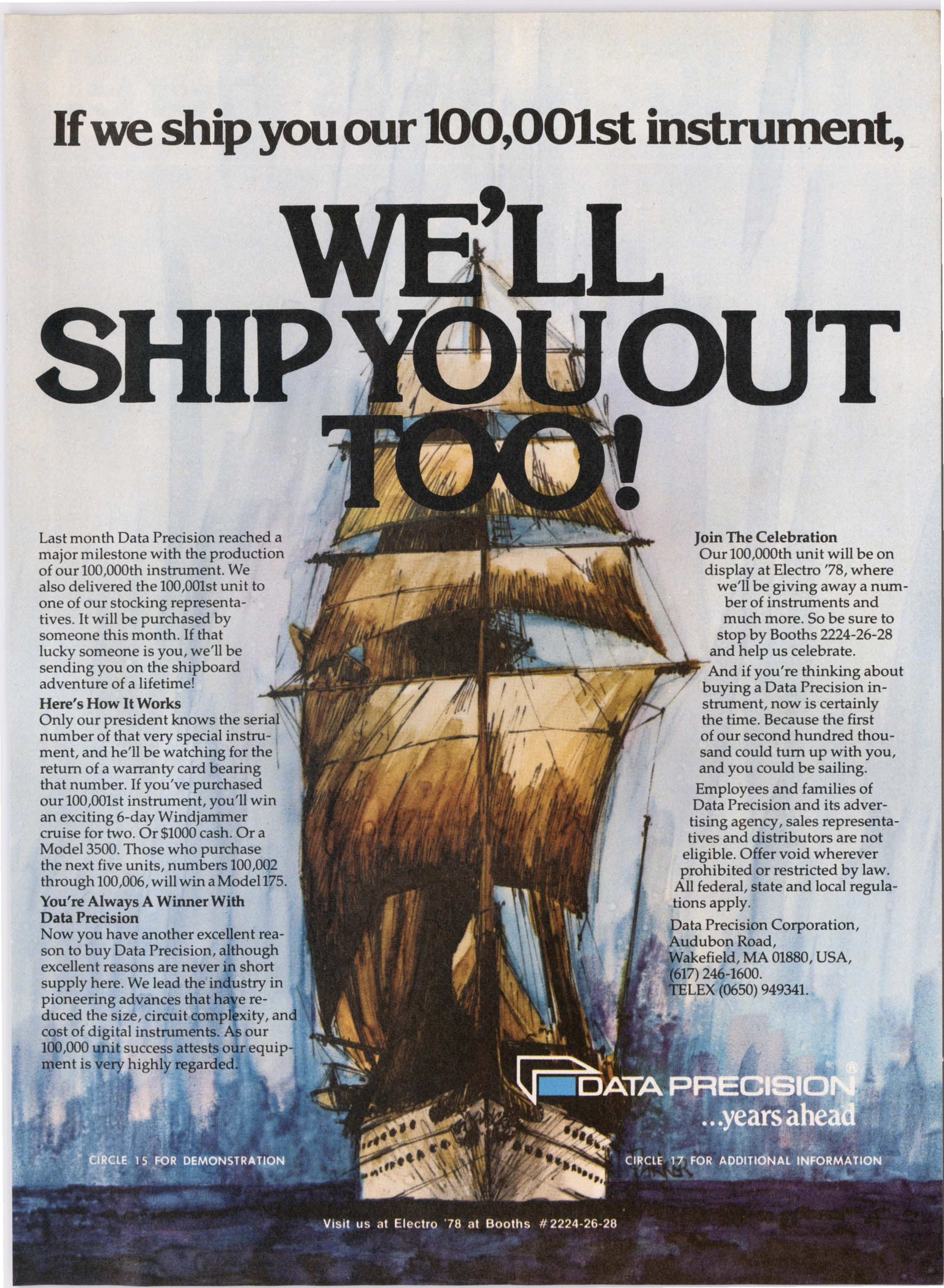
CIRCLE NUMBER 16



If we ship you our 100,001st instrument,
WE'LL SHIP YOU OUT TOO!
Last month Data Precision reached a major milestone with the production of our 100,000th instrument. We also delivered the 100,001st unit to one of our stocking representatives. It will be purchased by someone this month. If that lucky someone is you, we'll be sending you on the shipboard adventure of a lifetime!
Here's How It Works
Only our president knows the serial number of that very special instrument, and he'll be watching for the return of a warranty card bearing that number. If you've purchased our 100,001st instrument, you'll win an exciting 6-day Windjammer cruise for two. Or $1000 cash. Or a Model 3500. Those who purchase the next five units, numbers 100,002 through 100,006, will win a Model 175.
You're Always A Winner With Data Precision
Now you have another excellent reason to buy Data Precision, although excellent reasons are never in short supply here. We lead the industry in pioneering advances that have reduced the size, circuit complexity, and cost of digital instruments. As our 100,000 unit success attests our equipment is very highly regarded.
Join The Celebration
Our 100,000th unit will be on display at Electro '78, where we'll be giving away a number of instruments and much more. So be sure to stop by Booths 2224-26-28 and help us celebrate.
And if you're thinking about buying a Data Precision instrument, now is certainly the time. Because the first of our second hundred thousand could turn up with you, and you could be sailing.
Employees and families of Data Precision and its advertising agency, sales representatives and distributors are not eligible. Offer void wherever prohibited or restricted by law. All federal, state and local regulations apply.
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Visit us at Electro '78 at Booths #2224-26-28

The ICEMAN is Here!

Across the desk

(continued from page 7)

Remember this

By sheer accident, while working on more conventional microcomputer applications, I developed a revolutionary single-chip UV EPROM microprocessor. It's made on an exceptionally low-yield mirror substrate, while the chip has an intense ultraviolet source for erasing the mirror image of the UV EPROM software.

Probably the most unstable processor available, this exceptional circuit executes three to 3-million double complements per hour, depending on how it feels. This inherent nonpredictability makes the chip ideal for random synchronization of real-time microcomputers in applications like the control of plane, train and bus arrivals in major cities.

The 317-bit UV EPROM can be used interchangeably with the dangling 316-bit unalterable RAM. For added convenience, an on-chip power source can be recharged by rubbing one's feet on a dry carpet and touching pin 41.

The address and antidata bus of the 40-pin package use a tridirectional scheme in which any combination of the 20 pins on the north side of the package can be used for data while the remaining pins become the address bus.

Jim Lewis
President

Micro Logic Corp.
100 Second St.
P.O. Box 213
Hackensack, NJ 07601

*

Have you noticed all the asterisks in this issue? We hope you'll notice that they are supposed to remind you to renew your free subscription by filling out the card on page 49.

Count us in

Digital Scientific Corporation is pleased to advise ELECTRONIC DESIGN of our advanced microprogrammable minicomputers, which are capable of data-base management. Your mini/micro article in ED No. 2, Jan. 18, 1978, p. 24, included a table of minicomputer and microcomputer companies. Not only will our advanced systems allow you to sort among the 95 companies listed, they will also allow you to insert the following additional entries:

Digital Scientific Corp:
Microcomputer systems—yes
Microcomputer development systems—yes
Minicomputer systems—yes
Other products—yes

Digital Scientific
11425 Sorrento Valley Rd.
San Diego, CA 92121

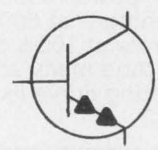
J.J. Gormley
Vice President
Technology

Digital Scientific Corp.

CIRCLE NO. 317

Private symbol goes public

About a year ago I invented the following symbol for monolithic Darlingtons as a private convenience:



In that time I have found it to be an extremely concise means for differentiating between monolithic devices and discretes, where the differences are important. (These are more common than you might think, given manufacturers' propensity for including goodies like nichrome ballast resistors and fast turn-on flyback diodes.)

In fact, I have found my symbol convenient enough to warrant bringing it to the attention of a wider audience. I would very much like to know what your readers think of it.

Richard W. Bowser

R.W.B. Research Co.
5648 Pierce
Omaha, NE 68106

New Books

Digital Continuous-System Simulation—G.A. Korn and J.V. Wait, Prentice-Hall, Englewood Cliffs, NJ 07632, 212 p. $15.95.

CIRCLE NO. 318

Computer Storage Systems & Technology—R. Matiek, John Wiley & Sons, One Wiley Drive, Somerset, NJ 08873, 667 p. $29.95.

CIRCLE NO. 319

There's a Simpson DPM

that's right for your application

All Simpson DPM's feature:

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- 3-1/2 digit readout
- Automatic zero and polarity
- Dependable LSI circuitry
- Choice of 120/240 V AC or 5 V DC operation
- Panel cutout 1.682" x 3.622". Adaptors available for IEC/DIN and other domestic cutouts
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- Full 200 hour burn-in
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Model 2860

The Dedicated DPM

New Series 2860—high performance at a low price from 49^{40}*

- 9 stock ranges available
- Bright 0.43" LED readout

The Systems DPM

Deluxe Series 2850—printer/computer interfacing capability and options for custom applications $92*

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- Specials available including AC ranges
- Choice of 0.43" LED or 0.55" planar gas discharge display
- BCD output standard

*100-lot OEM prices

Model 2850

Model 2852

Available From Electronic Distributors Everywhere

Write for Bulletin P612 containing complete technical specifications.

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CIRCLE NUMBER 19

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You can program every commercially available PROM on a Data I/O Programmer. What does that mean to you? First of all, it means design freedom. You can incorporate state of the art microprocessor and PROM technology in your designs with the assurance that the Data I/O PROM Programmer will meet your needs.

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THEM ALL.

Third, it means money. You won't have to purchase, or build, a new programmer every time you use a new PROM. You'll also be able to shop for best supplier prices.

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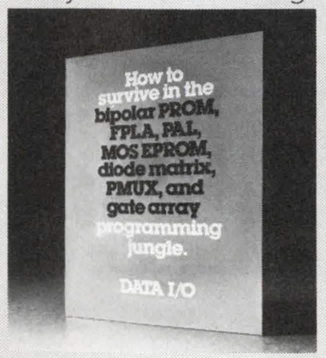
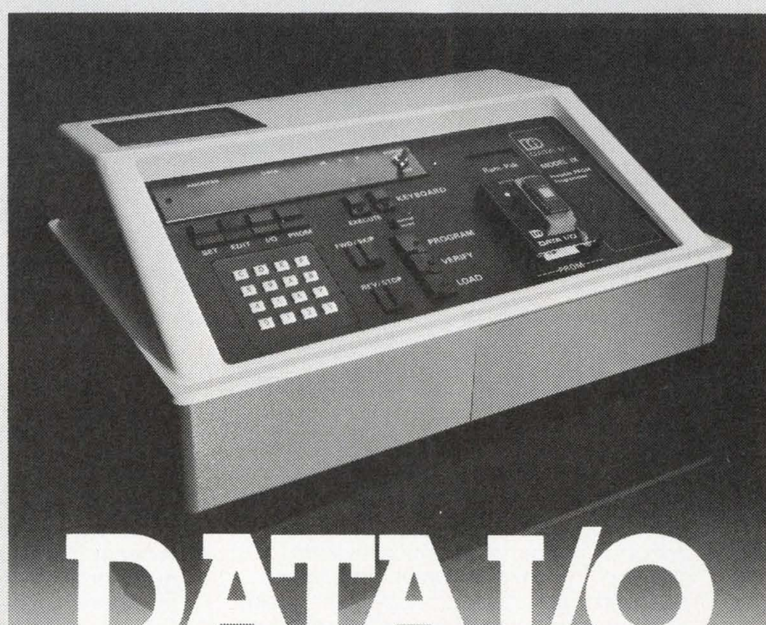




DATA I/O

CIRCLE NUMBER 20

When you hop a plane to troubleshoot 8080, 6800, 6502 or Z-80 software, grab our new

Micro Bus Analyzer™

. . . because all μP-based systems need help.

E-H's new MBA-1, designed and priced (at $1000) for field service software debug, has a giant memory that can trap 128 32-bit words at clock rates to 5MHz.

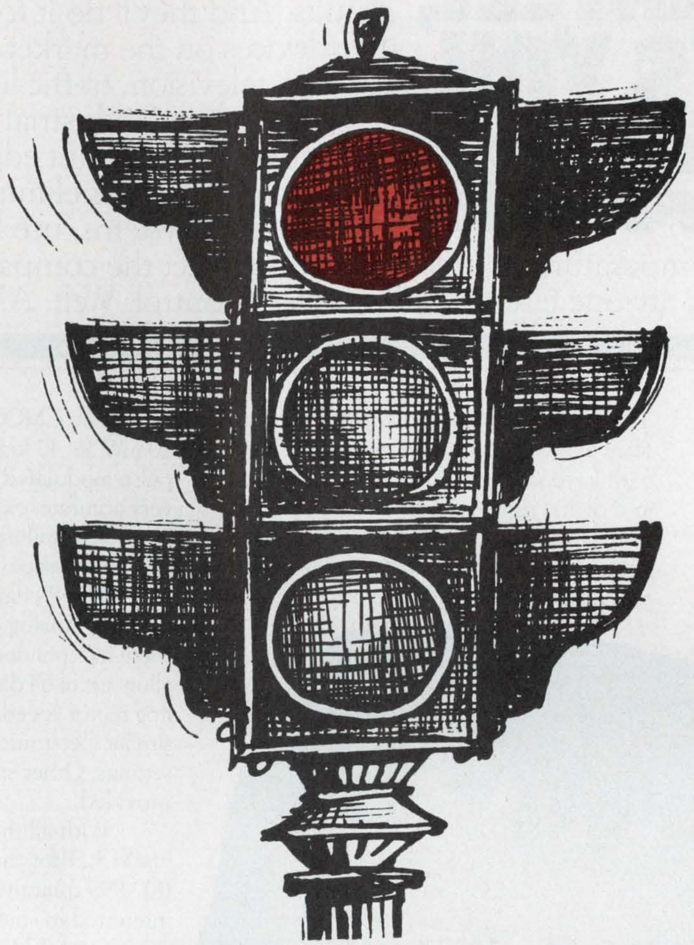
But your field service guys had better hide it from your engineering and QC people, because the MBA-1 is flexible and versatile enough for their purposes, too.

It's a simple diagnostic tool. Takes an accurate snapshot of critical system software information while the microprocessor is running in its regular socket. You can step ahead 96 words or back up 32 from your *trap* condition. In RUN mode, it will generate a scope trigger every time it passes the *trap* condition to let you study it more thoroughly.

Unless people stop making programming mistakes, software will always need fixing. Our MBA-1 is a 12-lb under-your-seat solution to finding what needs fixing. Probes are available at about $200 for 8080, 6800, 6502 and Z-80 systems. Ask us about the probe you need. We're working on a bunch more. Write or call, or use the reader service number for the data sheet. If you want to order one, hell, call us *collect*.

E-H International, Inc., 515 Eleventh Street, Oakland, CA 94607.
Phone: (415) 834-3030
TWX: (910) 366-7258

CIRCLE NUMBER 21



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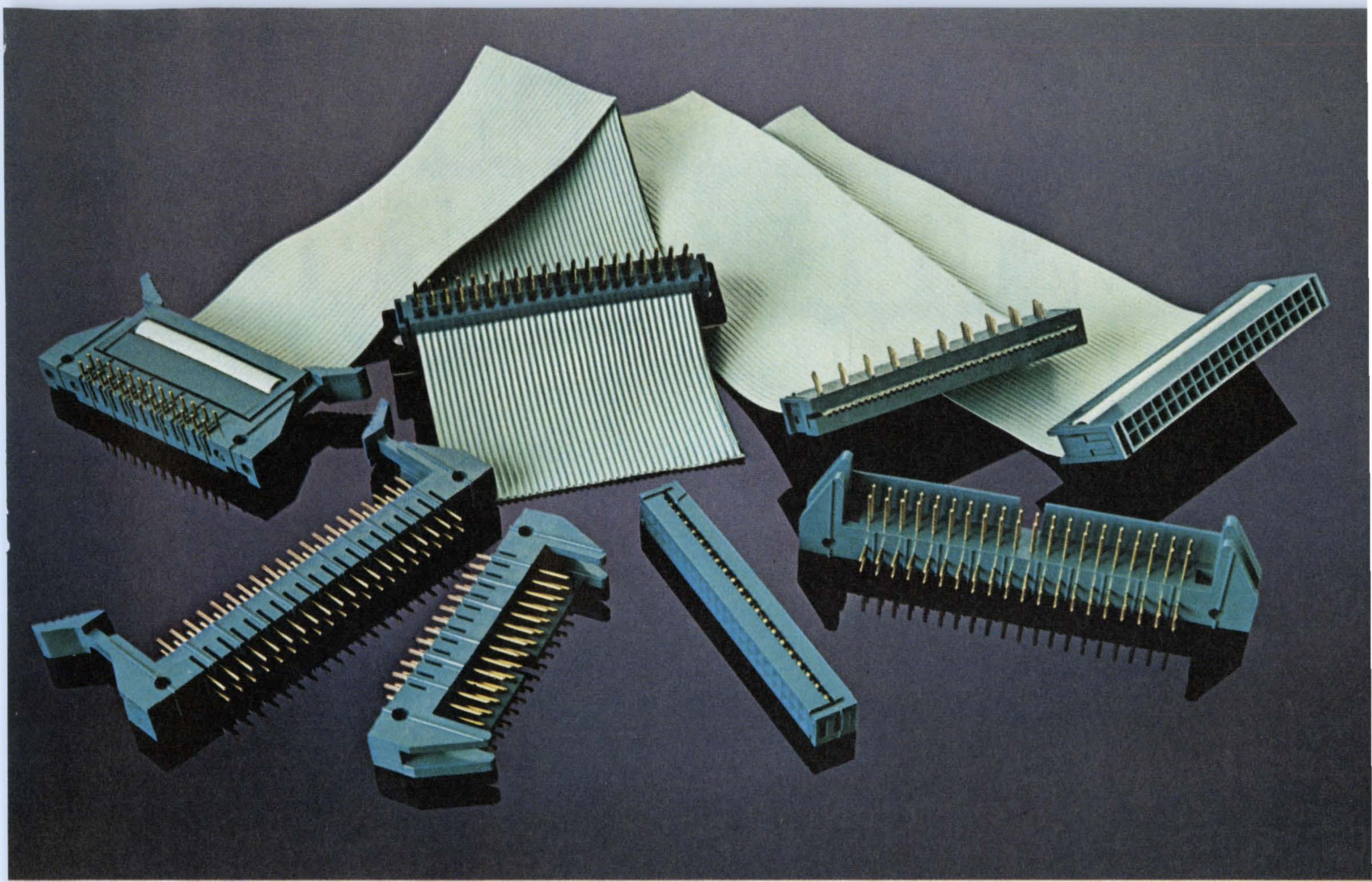
SEE PAGES 45-50.



Minifloppy-disc drive does more on less power

How do you halve the power consumption and improve the performance of a standard minifloppy disc drive? You transfer most of the functions of the drive electronics to the computer's processor.

Apple Computer Inc. does this by modifying a standard SA 400 drive from Shugart Associates (Sunnyvale, CA). The drive is used with the Cupertino-based company's mainframe processor, the Apple II.

The number of integrated circuits in the drive electronics has been cut from 19 to 4 by transferring a majority of the functions to the computer's processor. This modified drive was shown at the Mini/Micro Computer Convention in Philadelphia last month.

In the system, data are transferred between the computer and the disc slowly enough for the computer's microprocessor to handle most control and formatting tasks, says Steve Wozniak, Apple's research and development vice-president.

Much of the electronics in the Shugart unit is there to make the drive compatible with a variety of CPUs, says Wozniak. Apple's circuitry can be simpler because it has to interface only with the Apple computer. One design objective was to power the drive from the computer's power supply, instead of incorporating a power supply in the drive.

Among the pieces left out in Apple's drive are the infrared emitter and detector, which tell the drive the disc's rotational position. This is needed for hard-sectored operation, where the drive finds data stored on the disc by its physical location. In the Apple soft-sectored format, the controller locates data from what it is reading, which allows more data to be stored on each disc.

In addition, power to the disc drive board is cut whenever the drive motor stops, which reduces standby power demand by 4 W.

At the same time, access time is improved by changing the way the magnetic read head is moved. In the Shugart drive, a sequence of pulses moves the head to the selected track at a fixed 40 ms/track. In the Apple drive, the head accelerates from one position until it is halfway to the next, then decelerates to the proper track. This is possible, Wozniak explains, because the Apple drive's controller always knows which track it is looking for.

The disc drive with a controller board is priced at $595. Additional drives are $495. The controller board, which plugs into the Apple mainframe, can handle two drives. Deliveries are scheduled to begin in June.

Laying out ICs, PC boards may be computer-aided

Soon, even the initial layout of integrated circuits and printed-circuit boards may be done directly on computer-aided-design terminals. And the first CAD system to do it could very well come from Calma (Sunnyvale, CA).

Today, virtually all ICs and PC boards begin as art drawn by hand, using various drafting aids. Only after these originals are digitized do the labor-saving benefits of CAD come into play. A computer produces the variety of IC photomasks, PC-board artworks and drilling tapes which are optimized for performance, size, placement, routing and spacing. It also provides parts lists, connect lists, wire lists and N/C tapes to drive insertion machines and backplane wiring equipment, as well as schematics and other documentation.

Calma's GDS-II CAD system does all this, too, but also makes it easy to originate the artwork on the CRT screen.

"A true design system should not require you to type or look away from the screen," says John Claiborne, Calma's product manager for IC applications. "It should be easy to learn, and should prompt you and help you if you forget. The graphics screen should show you what you're doing, displaying all moves and changes instantly."

First GDS-II and VMD shipments are planned for September, 1978, and final versions will go in January, 1979.

Multivalued logic boosts chip density

Chip designers are taking advantage of every advance in processing and fine-line lithography to pack more circuitry on a chip. But getting pattern geometries below two and three micrometers requires expensive projection aligners and E-beam and X-ray lithographic equipment to do the job. Moreover, as the chips get more complex, the real estate taken by the metal interconnections expands from 30 to 50% or more of the chip area.

One way to overcome these limitations is to use multivalued logic, which employs levels of 0, 1, 2 and 3 or more, instead of binary levels of 0 and 1. For a given set of fabricating rules, this technique promises to either double the number of functions per LSI chip or halve chip size for the same number of functions.

How to implement 4 × 8 multilevel threshold gates that will reduce the number of devices required by a full binary adder by half will be revealed by Professor K.W. Current of the University of California, Davis, at the forthcoming Eighth International Symposium on Multiple-Value Logic (Rosemont, IL, May 24-26).

"We decided to get around the LSI density problem by leaving the technology alone and changing the way the signal is processed," he notes.

In Current's system, the logical voltages are converted to logical currents that produce voltage levels of 0.4 V across load resistors for a logical increment. These can easily be converted to binary ECL outputs.

For medium-speed, high-density logic, Dr. T.T. Dao, head of logic and systems research at Signetics, Sunnyvale, CA, will describe an I^2L version of multilevel arithmetic logic in an advanced development stage. Signetics is using I^2L for a four-level full adder that nevertheless will be compatible with binary inputs and outputs. Density savings are in on-chip circuits.

The multivariable logic is a hybrid of digital and analog, but closer to digital, says Dao. Whereas analog logic has an infinite number of levels, the multivariable approach limits the number to a few discretes.

Signetics will offer this multivalued logic first in a chip that has binary inputs and outputs, so that the logic can be used with current binary technology.

Minicomputer can run IBM 370 software

A new minicomputer may enable OEMs building small data-processing systems to cash in on the large amount of existing IBM 370 software as well as on the large pool of programmers familiar with the 370 system. The Two Pi/V32, a 32-bit computer built around the 2900 series bit-slice microprocessors, is the first mini with microcode to run the standard 370 instruction set, according to its maker, Two Pi Company Inc. (Sunnyvale, CA).

Now entering production in the company's Santa Clara facility, the V32 also has about 40 kbytes of control store available for microprogramming additional features. A microcode assembler helps with writing such microprograms.

The V32 is also the first OEM mini with a built-in refrigerated air cooling system, says the company, a subsidiary of U.S. Philips Corp. This not only improves its reliability significantly, but also eliminates the need to operate in an air-conditioned room.

The basic system has 256 kbytes of main memory, which can be expanded to 4 Mbytes—about four times the capacity of the nearest IBM equivalent, the 370/138.

CIRCLE NO. 315

Computer-power use cut by balancing delay times

The power consumed by a computer system can be cut to a minimum by making the delay time of its integrated circuits one-third that of the system, says a researcher at Hitachi Ltd.'s Central Research Laboratory in Tokyo.

Hitachi's Tsuneyo Chiba made his discovery by drawing a series of curves for power density as a function of circuit delay time at a number of system delay times. The minimum power density falls along the straight line corresponding to allotting one-third of the system delay time to circuit delays.

The curves, published in April's *IEEE Transactions on Computers*, are based on three assumptions: The system delay time is the circuit delay time plus the packaging delay time; packaging delay per gate is inversely proportional to the square root of the effective packaging density of gates on a card; and the power-delay product is constant for a given semiconductor technology.

The curves and other factors are balanced to obtain the highest possible logic speed in Hitachi's HITAC M-170 and M-180 computer systems. The speed relationship can be used, says Chiba, while considering thermal and packaging density restrictions.

Chiba also notes that the most obvious way to increase packaging density, larger-scale integrated circuits, faces two hurdles: the part-number problem and gate-pin restrictions. A great many part types, each with unique circuitry, are required in a computer system. "About 60 to 80% of the total gates can be covered by a comparatively small number of types," says Chiba, "However, the remaining 20 to 40% aren't suitable for LSI packaging."

System performance rises as memory costs fall

With memory capacity getting higher and dynamic RAM chips getting faster, the cost of main memories in data-processing systems will continue to go down 30% a year—as system performance goes up.

Over the last five years, the price per byte of main memory systems has dropped fourfold to 3.1 cents per byte, according to Hewlett-Packard's Data System Div. (see table). As a result, designers can use their memory budgets for main-memory storage of more powerful operating systems as well as for implementing higher-capacity application systems. And with the additional memory, they no longer need expensive software preparation in assembly language to save memory.

Increased memory density and speed mean a smaller price tag. Like many memory suppliers, HP is incorporating the highest-density 16-k dynamic RAMs on its newest boards. Because of this, an HP 650-ns RAM board containing 128 kbytes costs under \$1000. And a 350-ns 128-kbyte board costs \$1350—a far cry from the \$4300 price tag of a 1974-vintage 650-ns, 16-kbyte board of the same size.

Dynamic RAM system cost—Performance trends

Year	Chip		Board		Cost		Number of boards per 128-kbyte system
	capacity (bits)	speed (ns)	capacity (bytes)	speed (ns)	per byte (cents)	per 32 kbytes ($)	
1974	4-k 22-pins	350	16-k	650	13.4	4300	8
1975	4-k 22-pins	350	16-k	650	9.3	3000	8
1976	4-k 16,18 pins	250	32-k	650	6.5	2100	4
1977	4-k 16-pins	250	32-k	350	5.0	1600	4
	4-k 16-pins	150	32-k	350	6.5	2100	4
	16-k 16-pins	250	128-k	650	5.0	1600	1
1978	16-k 16-pins	250	128-k	650	3.1	1000	1
	16-k	150	128-k	350	3.9	1250	1

Source: Hewlett-Packard

It takes a lot more than bright to be best.

Brite-Lite LED lamps have a way of dimming people's enthusiasm for other brands. It starts with the fact that Brite-Lites are 25x (50 mcd vs. 2 mcd) brighter. But there really is more than meets the eye to Brite-Lites.

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CIRCLE NUMBER 25

News

Chips, systems, and design: An early look at NCC

Design and applications information abound in the technical sessions at the upcoming National Computer Conference to be held June 5 to 8 at the Anaheim (CA) Convention Center. Key topics at NCC: semiconductor memories and microprocessors, dedicated LSI and VLSI chips, computer-aided design, computer peripherals and computer architecture.

In semi memories, look for the latest crop of static and dynamic RAM, CCD, and bubble memories. In computer-aided design, look for the newest techniques for handling the most complex ICs, while peripheral system designers can see the latest in continuous media mass storage devices, printers, displays and voice processing equipment.

Semis have come a long way

"Semiconductor RAMs began to challenge magnetic core memories when RAMs stored only 1 kbit on a chip," says Lewis M. Terman of IBM's T.J. Watson Research Center (Yorktown Heights, NY) who will chair NCC memory Session 57. "And we're talking about 64-k RAMs." Moreover, according to Terman, charge-coupled devices and magnetic bubble memories "have reached a stage where the prospect of solid-state mass storage is at hand." Indeed, the whole future of semiconductor RAMs will be projected at the session by Andy Varadi of National Semiconductor (Santa Clara, CA) and J. Egil Juliussen of Texas Instruments Inc. (Dallas, TX) will do the same for bubbles and CCDs.

The incompatibility of RAMs from different manufacturers will be the topic at Session 47 of J. Reese Brown of Burroughs Corp. (Piscataway, NJ). Brown will look into establishing standards to lower the cost of building and testing computer-memory systems. Moreover, CCDs and bubbles should help lower memory costs because their small cell structures allow high densities on a chip.

Ever increasing device densities resulting from new VLSI techniques will be the highlight of a paper in Session 48 by Ron Whittier of Intel Corp. (Santa Clara, CA). Another aim is to add more functions to microprocessor CPUs, says Federico Faggin of Zilog Corp. (Cupertino, CA), chairman of Session 48.

Increased density made it possible to build not only semiconductor memories but also hand-held calculators, Faggin goes on. "Since then, memories have continuously increased in complexity, resulting in dramatic reductions in cost per bit," he says. Calculator chips having evolved into microprocessors are now combined with memory to make microcomputers. Prices have dropped so far already that the major cost in microcomputers will soon be the packaging and distribution. So the only way to improve the price/performance ratio is to increase the intelligence in the μC. "This increase," says Faggin, "can take the form of higher memory capacity, greater CPU power and increased input/output capability."

Automating IC designs

One problem to overcome in designing larger-scale chips is the time it takes to design, debug, and correct new chip layouts. One promising solution, to be described at Session 6, is computer-aided layouts.

"The design of integrated circuit masks using manual techniques is very tedious, time-consuming, and often subject to errors because of the precise design rules that must be followed

Andy Santoni
Associate Editor

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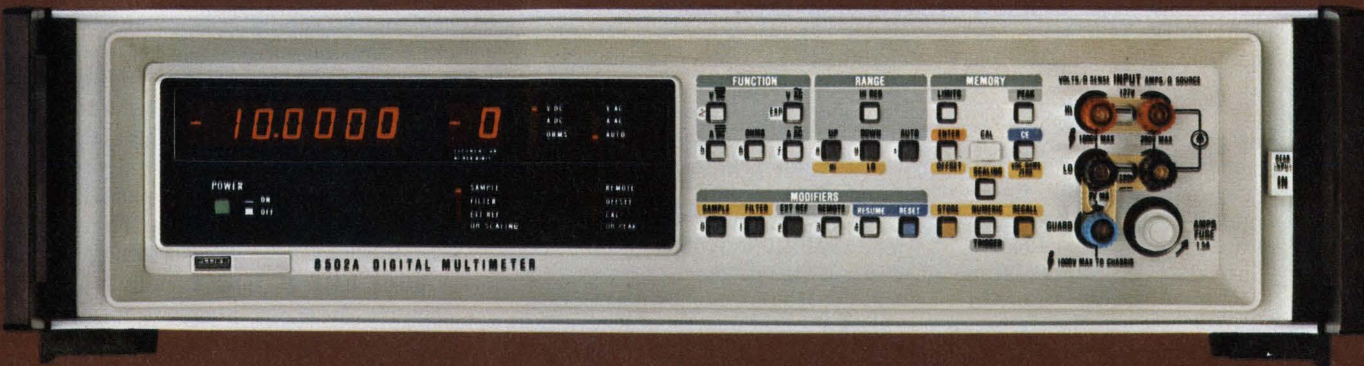

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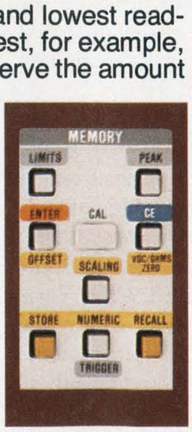

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CIRCLE NUMBER 26 FOR LITERATURE

CIRCLE NUMBER 27 FOR DEMONSTRATION

Plenty of products, too

Technical sessions aren't all that's happening at NCC. Over 300 firms at more than 1300 booths will exhibit a wide variety of products to bring engineers up to the minute on computer-related hardware.

A 1-k-by-8 static RAM is the second static RAM from EMM/SEMI (Phoenix, AZ) structured with a byte output compatible with 8 and 16-bit microprocessors. The Model 16 PROM programmer from Data I/O (Issaquah, WA) simultaneously programs up to 16 MOS PROMs in parallel, with data from a master PROM. The M-910 PROM programmer from Pro-Log (Monterey, CA) is for production-line duplication, listing, and verification of programs.

The Vector 1++ microcomputer from Vector Graphic (Westlake Village, CA) is an 18-slot mainframe aimed at small business systems, as is a new system from Perkin-Elmer's Interdata Division (Tinton Falls, NJ). Rair Microcomputers of London will introduce 8085-based microcomputers with priority interrupts and DMA, integral single or dual minifloppy-disc drives, up to 64 kbytes of RAM, dual serial I/O ports operating up to 19,200 baud, and software.

CRT display modules for OEM terminal makers include the M4408 from Motorola Data Products (Carol Stream, IL), which can display more than 6300 characters—a full typewritten page worth. Among the CRT terminals are the Chromatics (Atlanta, GA) CG, an eight-color, 512 × 512 machine built around a Z-80 CPU, and including memory and I/O structures. Datamedia (Pennsauken, NJ) will show a buffered APL terminal compatible with major communications protocols. The Delta 7000 from Delta Data Systems (Cornwells Heights, PA) is a programmable video-display terminal built around the TI TMS9900. Intelligent Systems (Norcross, GA) will display its Intecolor 8001G, a 48-line by 80-character graphics terminal for process control applications. Princeton Electronic Products (North Brunswick, NJ) will unveil its Model 8500M graphic display terminal, which uses a microprocessor to generate conics, rotation and grey scale. And Tektronix' Information Display Group will bring to NCC its 4025 terminal, which allows scrolling of both alphanumerics and graphics.

Among the newest printers at NCC will be the LP400 heavy-duty 300 LPM line printer with graphics option from Compagnie Internationale Pour L'Informatique Cii Honeywell-Bull (Waltham, MA). A 300-LPM "band" line printer will be in the booth of Data Printer (Cambridge, MA). And General Electric's Data Communications Division (Waynesboro, VA) will introduce a new line of printers.

Vadic (Sunnyvale, CA) will present its 50 Series of small, low-cost modems for applications from 0 to 1200 bps. And ComData (Skokie, IL) will have modems starting at $150.

Computer Power Systems (Long Beach, CA) will show its PowerMite MK II power center, a distribution system for small computer systems. Elgar (San Diego, CA) has a new uninterruptible power system to keep computer systems from crashing when utility companies cut power. And Nova Electric (Nutley, NJ) will show a line of voltage-regulating transformers.

during mask layout," says Charles Gwyn of Sandia Laboratories (Albuquerque, NM), chairman of Session 6. "In recent years, many computer aids have been developed to generate custom IC mask layouts automatically for a range of fabrication technologies and design philosophies."

Gwyn lists four techniques for computer-aided IC layouts: the master slice approach with fixed cell locations, standard cells, various-sized rectangular cells and connecting arbitrarily-shaped components that have been described in shorthand in a manually generated layout. A technique for automatic-wiring LSI chips will be described by Ning Nan and Michael Feuer of IBM Corp. (Hopewell Junction, NY), and an automatic layout program for even higher-density VLSI devices by Al Feller of RCA's Advanced Technology Laboratories (Camden, NJ).

Computer-aided design and analysis of digital hardware or software is the theme of Session 14. A method called Sara supports multilevel design of concurrent hardware or software systems, says William M. van Cleemput of Stanford University (Stanford, CA). Verifying that a real system will work requires accurate models that the computer can process, since "the design of real concurrent systems depends upon the validity of system models."

Automated-design systems are useful for more than circuits and software, says Thomas J. Reno of General Motors Corp. (Warren, MI). At Session 18, Reno will describe a low-cost graphics system for body tooling that helps GM engineers prepare programs for numerically controlled machines. And the role of interactive graphics in design automation will be covered by Carl Machover of Machover Associates Corp. (White Plains, NY).

Putting it on-screen

But the biggest interactive problem confronting computer-systems designers is the one between users and computers. In CAD systems, intelligent graphics terminals make it easier to see the design as the computer sees it, and to make changes with convenient controls like joysticks and light pens. Lower terminal prices resulting from incorporating microprocessors and other large-scale ICs into terminals are bringing these advantages to terminal users such as small-business and other commercial users.

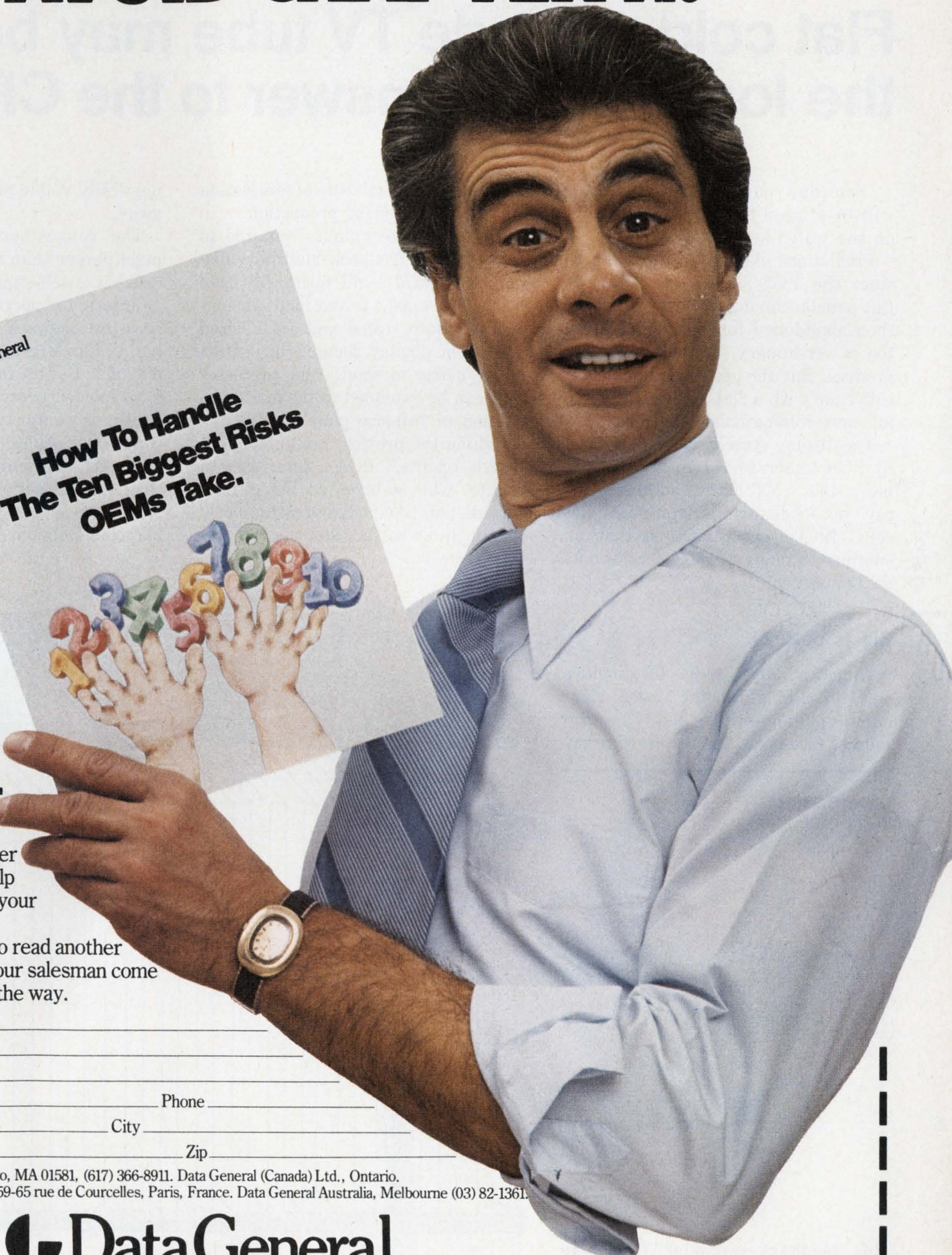
But the ultimate user interface with computers—by voice—will be covered at Session 80. Several universities and equipment vendors are pressing for reliable voice-input computer terminals to meet the needs of industrial and government users, particularly for speaker identification and verification.

Besides terminals, major peripheral devices to be highlighted include printers and mass-storage systems. At Session 65, Donald Swatik of Computer Peripherals Inc. (Rochester, MI) will track trends in printer technology, both impact and nonimpact, with special emphasis on electro-photographic and ink-jet nonimpact printers. The evolution of magnetic-disc memory technology to meet the growing need for mass storage will be traced by David Conway and Thomas Muran of Magnetic Peripherals Inc. (Bloomington, MN) at the same session.

Another magnetic-storage evolution will grace the agenda at Session 57 where Steven Puthuff of Memorex Corp. (Santa Clara, CA) will describe the growth of large magnetic-storage technology. "The fixed and moving-disc memory technology continues to improve with significant reduction in the cost per byte," says session chairman Terman, "and thus provides an elusive and moving target to the solid-state mass-storage technologies."■■

Have You Mailed Your Requalification Card? See Page 45

READ THESE TEN CHAPTERS. AVOID CHAPTER 11.



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CIRCLE NUMBER 28

Flat cold-cathode TV tube may be the long-sought answer to the CRT

"Someday your color TV picture tube will be a large thin panel that hangs on the wall like a picture."

Predictions like that have circulated since the 1950s. Since then, various flat-panel technologies have been tried, then abandoned for being too costly, too power-hungry, or too complex to produce. But the goal may be in sight this time with a flat-panel system using new cold-cathode technology.

The display system, being developed by RCA Laboratories (Princeton, NJ), has a 480 × 500 matrix-addressed array of feedback electron-multiplier cells—240,000 current sources that can energize as many as 960,000 color dots on the screen.

Big is better

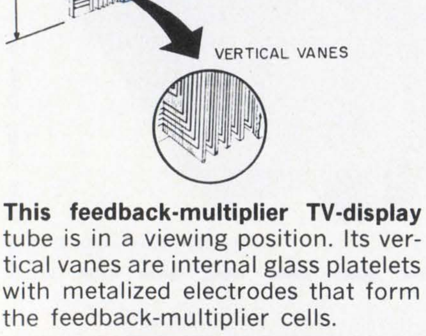
Aimed at 30 × 40-in. TV displays only 1 1/2 in. thick, the system combines photomultiplier-like electron sources (see box), a multiplexed array structure, and a mixture of fabrication techniques for mass production.

The special techniques required to fabricate the feedback multiplier display to typical 1-mil tolerances have been developed, tested and demonstrated. Both scaled and actual-sized models of display sections have been built, using methods and processes that can be extended to the mass production of full-size panels.

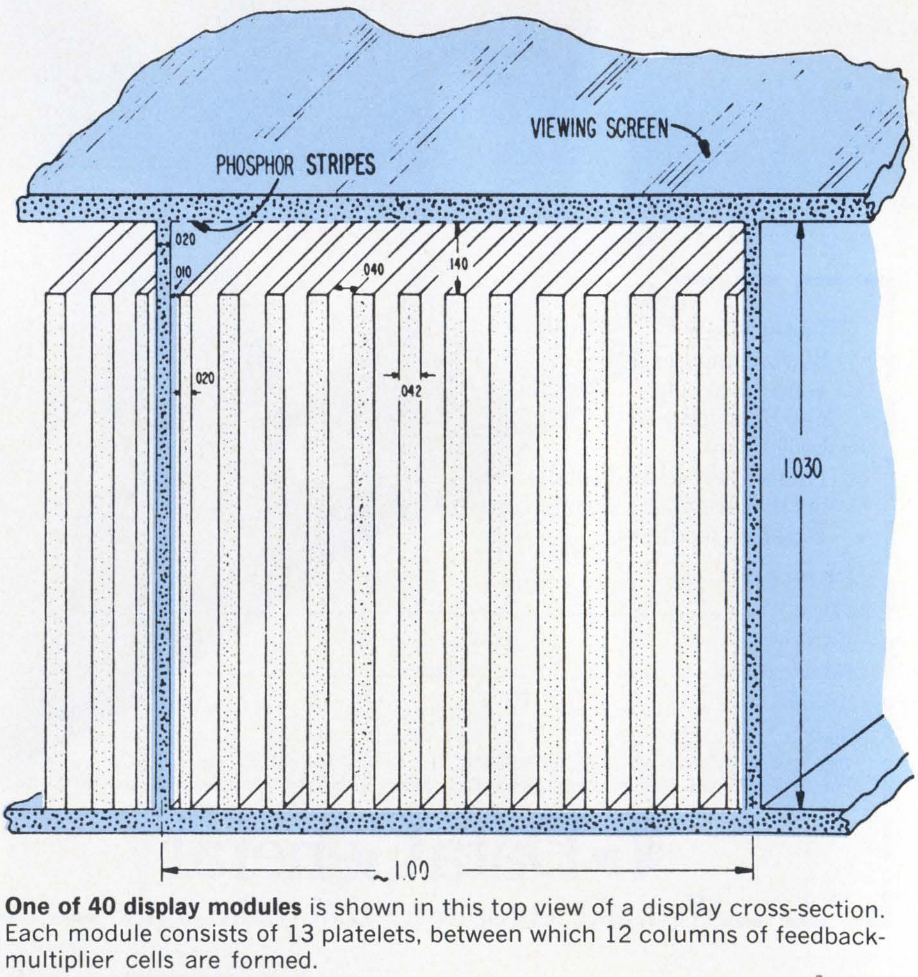
Calling the project "preliminary research results," RCA's John A. van Raalte, who co-invented the display system, points out that many problems remain to be solved, and that an economically viable product is still years away.

The cold-cathode display can be much larger than a standard CRT because it is self-supporting. A CRT has no internal supports, and external air-pressure loading makes it unfeasible to build CRTs larger than about 30 inches diagonal. But the flat-panel's face plate is supported every inch by thin glass vanes inserted between modules, each consisting of 12 vertical multiplier vanes. In addition, the matrix structure eliminates the standard CRT problems of overscan and pincushion or barrel distortion.

Dave Barnes
Western Editor



This feedback-multiplier TV-display tube is in a viewing position. Its vertical vanes are internal glass platelets with metalized electrodes that form the feedback-multiplier cells.



One of 40 display modules is shown in this top view of a display cross-section. Each module consists of 13 platelets, between which 12 columns of feedback-multiplier cells are formed.

Have You Mailed Your Requalification Card? See Page 45

The CRT—tough to bring down

Many flat-panel display technologies are struggling to capture some of the marketplace now dominated by the conventional cathode-ray tube. But, CRTs still offer desirable features like very low cost, simple addressing, high speed, high resolution, good contrast and color, high luminous efficiency, and long life.

Some new technologies have attempted to attack the CRT where it is strongest: in the fast-analog TV domain and in the 10-to-27-in. size range. But Society for Information Display experts agree that to do that, a display would need both better performance and lower cost —a tall order.

Instead of a head-on attack, RCA and others are targeting display needs to sizes greater than 30-in. diagonal or smaller than 12-in., where the CRT is really vulnerable.

At the 1976 SID conference, Zenith described a flat-panel design somewhat like the RCA approach, but with thermionic cathodes.

Northrup's Digisplay—remember when?—used a planar-area cathode, and switched the electron beams on and off with digitally addressed aperture plates. Although it offered most of the features of both CRTs and flat panels, it cost more than a conventional CRT and couldn't be adapted readily to large sizes.

But Texas Instruments describes a small display similar to the Digisplay at SID this year. (It should be similar. It's based on technology 11 purchased from Northrup.) The full-color flat CRT device, still in research, delivers 100-ft-L white, 76,800 pixels, and 10 shades of gray for only 25-W—and it needs only 205 addressing connections.

Despite technical and mechanical difficulties, attempts to reshape the CRT itself into a flat scanning-beam display continue. A scanning electron-beam unit using a linear electron gun along one edge of the screen was recently patented by RCA.

Two alternatives

Two electron-source cell designs have been built and tested for flat-panel display use at RCA. Both designs have the cell structure shown, but one uses ion feedback and the other uses photon feedback.

The ion-feedback multiplier (IFM) contains low-pressure gas, while the optical-feedback multiplier (OFM) is a hard-vacuum tube in which ultraviolet photons leave the target phosphor on the anode and return to the photocathode, which closes the feedback loop.

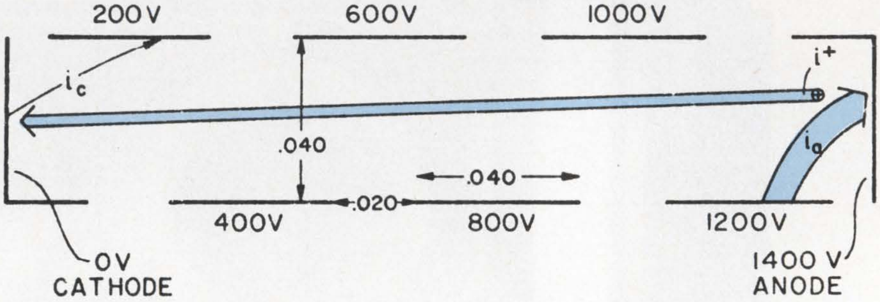
Electron multiplication in both versions is similar to that in conventional vacuum-tube photomultipliers: An electron leaving the cathode (left) accelerates to the first dynode (an electrode held at 200 V) and, since the dynode material has a secondary emission ratio greater than one, causes several electrons to be emitted.

The beam current is multiplied by the secondary-emission ratio at each successive dynode, as the growing beam zig-zags toward the phosphor-covered anode. Current builds up until space-charge saturation occurs, which reduces the loop gain to one and stabilizes the anode current.

Exponential current buildup in the IFM, using 10^{-4} torr of helium and a loop gain of 20, has a typical time constant of 26 ns. This is fast enough to provide the square 1-μs 3-mA current pulses needed for the flat-panel system.

At the same loop gain, the OFM version has an even faster time constant for current buildup—1.5 ns.

To ensure both fast current buildups, very small background or "start-up" currents are provided by mixing long-time-constant and short-time-constant materials. In the IFM, slow-decay xenon is mixed with the helium; in the OFM, slow-decay phosphor is mixed with the display's basic cerium-doped lanthanum phosphate phosphor.



The flat-panel picture is inherently stable, registered, rectangular, and perfectly interlaced, according to van Raalte. The new design concept will ultimately produce TV pictures of outstanding quality, he goes on, and the quality will suit home viewers of movies and slides. But van Raalte also points out some problems in converting today's research to what could be tomorrow's product.

Uniformity—a problem?

For one thing, the brightness over this matrix display's screen area will have to be more uniform than that over a standard CRT screen, or else its images won't look as good. Keeping brightness equal all the way across a CRT isn't necessary, since the eye is insensitive to gradual—less than 1%—changes in brightness. Being gradual, the CRT's typical center-to-edge brightness variations can approach two-to-one and remain acceptable (see "Designing a Large-screen Display," ED No. 5, March 1, 1978, p. 24).

In the flat-panel display, the chance for abrupt changes in brightness in adjacent areas is built-in, since there are many separate sources of beam current. These will have to be balanced to within 1% and kept in balance.

RCA has a solution, not yet borne out in full-scale operation, but described in one of three papers on the system at the Society for Information Display Symposium in April in San Francisco.

Uniformity of brightness can be obtained by anode sensing, a technique in which an external amplifier provides negative feedback from the screen electrode (anode) to the modulator electrode inside each cell.

Computer simulation of anode sens-

(continued on p. 51)

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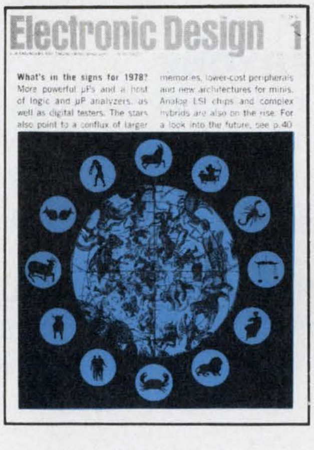

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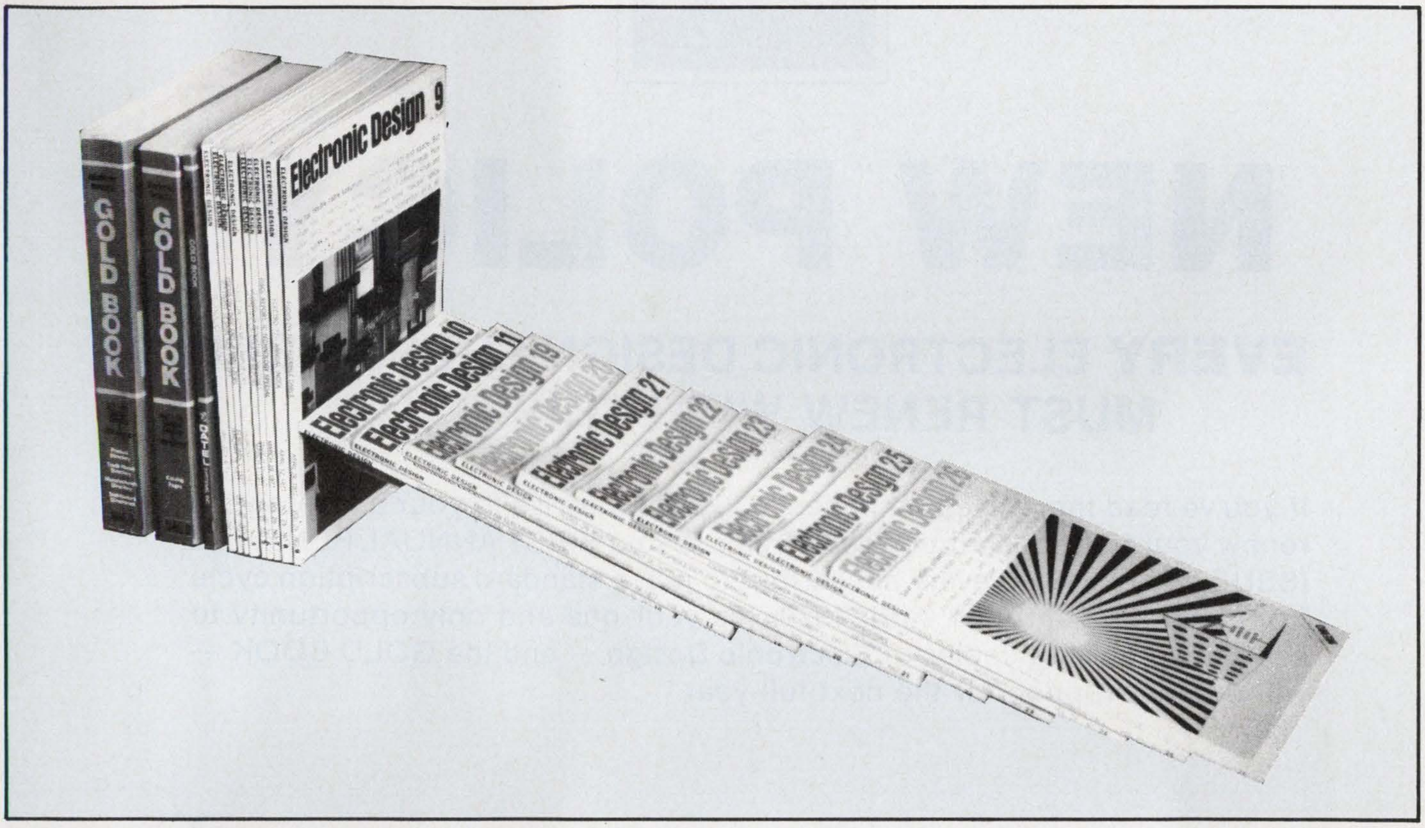

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ing indicates that the method will meet the target specifications: 1% spread in brightness at 100 foot-lamberts, and 10% spread at 1 ft-L—both in spite of a 20% spread in multiplier output before correction. But there is a price to pay for this solution.

The feedback amplifier must have some fine capabilities: 106-dB open-loop gain flat to 49 kHz, with a roll-off of 6 dB per octave to 40 MHz. Such performance from a dc amplifier tends to be expensive. Fortunately, with the multiplexing method used in the flat display system, only 40 such circuits —one per module—are required to control the whole tube.

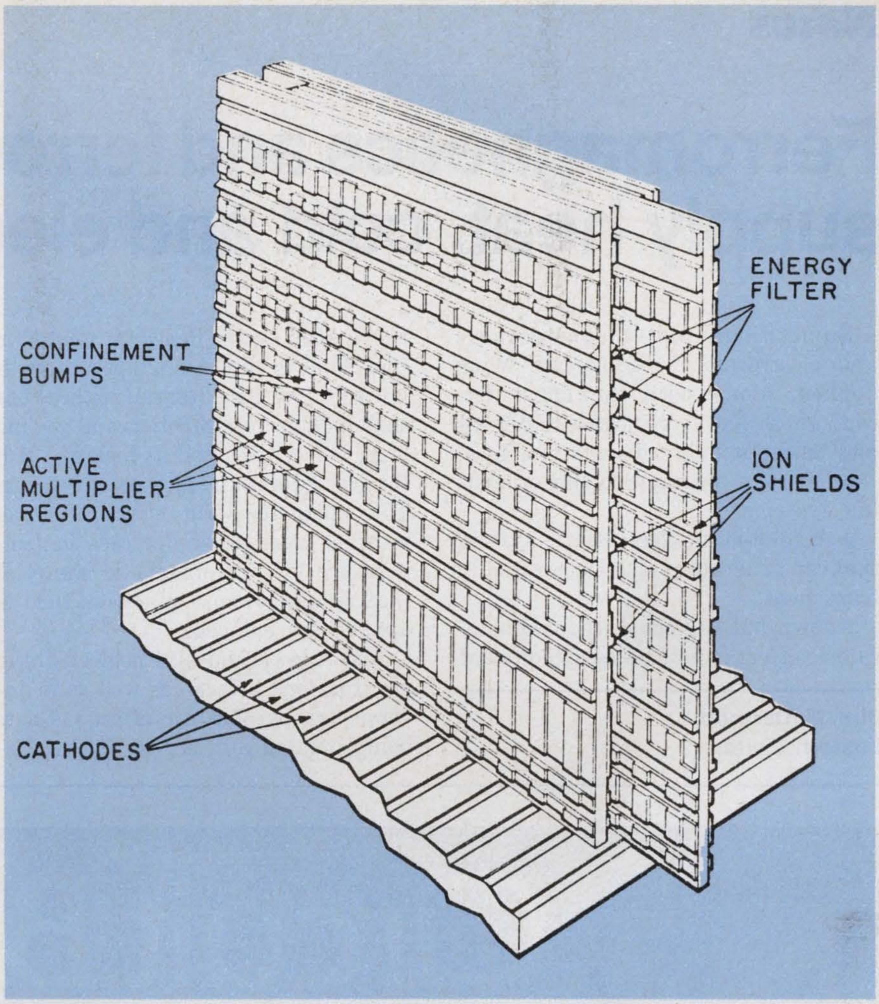
Each anode-sensing modulator circuit delivers processed and sampled video to one of the 40 modules across the line, and successively modulates each of the module's 12 elements four times. Since the National Television System Committee time standard is about 66 μs, more than 1-μs dwell time is available for each element.

During line time, all 40 modules work at once, each painting its own inch of the line. The input video signal comes from a line buffer that stores an entire line of video information and makes it available to the modulators as needed.

Five hundred cathode stripes define the 500 lines of the TV picture. They are addressed sequentially as each new line is ready to be displayed.

Along each horizontal line, there are 1920 vertical color phosphor stripes, successively red, green, blue, etc. The current from each of the 480 elements is deflected to strike one of the stripes.

Inside the display, four stripes of phosphor can be excited by each element so each electron multiplier drives not one pixel, but 1-1/3. This overlap is why the horizontal resolution is essentially as good as the vertical resolution, as required by NTSC standards, and with about as many elements to handle the 40-in. width as to handle the 30-in. height.

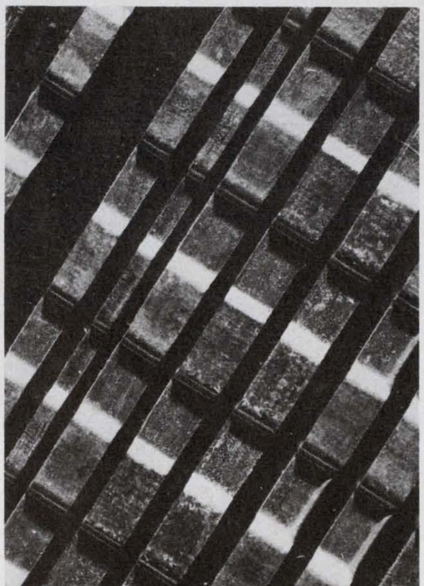


These platelets, or vanes, have confinement bumps to isolate separate picture lines. All electrodes in a column are bused together.

The big picture

In operation, a horizontal line is addressed by switching its cathode electrode to an appropriate voltage, so that ion feedback discharges occur at only those points along the vertical vanes crossed by that cathode. Additional electrodes between the lines on the vertical vanes ensure that only one multiplier element—for the right line —is "on" at a time.

Display performance depends largely on ion-shield bumps, energy filters, and electroding structures that permit only particles of the desired types to pass through the feedback multiplier cell (see sketch). Ion-shield bumps prevent spurious discharges that otherwise would result from ion feedback onto dynodes.



Formed strips of aluminum-magnesium foil, bonded to the platelets and activated after assembly by oxidation, form a layer of magnesium oxide, which is a good secondary emitter.

Extraction and low-voltage modulation of the space-charge-limited beam occurs in the three-bumped energy-filter-and-modulation region of the cell. The beam then passes through deflection and focusing electrodes while being accelerated to the phosphor screen.

RCA's modulator and focus-electrode designs reportedly provide 100:1 modulation of the beam with a 40-V video signal. Over the full range of modulation, beam size remains 0.004 in. at the half-maximum points, considerably smaller than the beam spot of conventional CRTs. The flat-panel design requires the smaller spot because there is no shadow mask to prevent spill-over onto other-color-phosphors.■■

Have You Mailed Your Requalification Card? See Page 45

Ferromagnetics and ferroelectrics supply heat, cold and electricity

Somethings old—magnetocaloric and electrocaloric effects—are being applied, along with the latest ferromagnetic and ferroelectric materials and concepts, to breed something new:

- Efficient magnetic cooling or heating systems.
- A solid-state electrostatic system that can generate ac electricity directly from heat.

Known but neglected, the magnetocaloric effect is now being exploited at the NASA Lewis Research Center in Cleveland to produce temperatures as low as −13 F for potential applications that include refrigeration and cooling large computers, and as high as 131 F for heat pumps aimed at space heating. The magnetocaloric effect is a reversible increase or decrease in temperature of ferromagnetic material that results when a magnetic field is applied or removed.

Jim McDermott
Eastern Editor

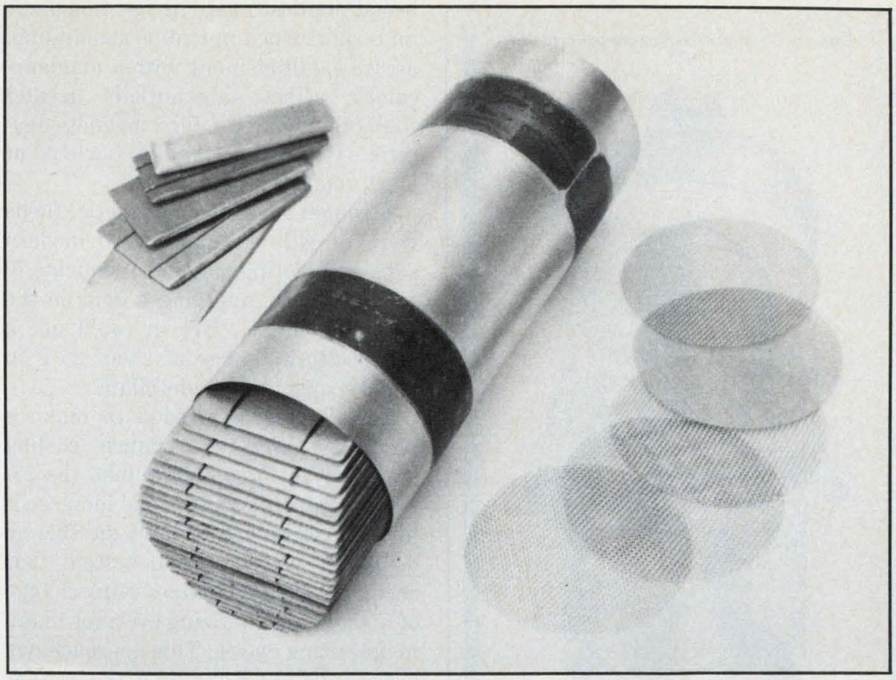
Also known and also neglected, the electrocaloric effect—as well as its inverse, the pyroelectric effect—is now being pressed into service by the Department of Energy to convert such heat as solar radiation into 60-Hz electrical energy. The former effect is the temperature change that results in a polarized ferroelectric material when a change occurs in its electrical field. The latter is the change in negative and positive polarized charges that occurs when temperature changes.

The idea isn't new

It's been known for 30 years that weak paramagnetic salts and magnetic field strengths on the order of 20 kilogauss (kG) could be combined for cooling—but only within a few degrees of absolute zero. So until now, a practical room-temperature magnetocaloric system has been awaiting the advance of technology and the right material. First, the ferromagnetic material to be used must have a strong, interatomic interaction with a magnetic field to increase its apparent strength many times. Second, the material's Curie point must be close to room temperature to get the greatest magnetocaloric effect.

A third requirement is that the magnetic fields be quite a bit stronger than can be attained with conventional electromagnetics.

The discovery of all the required ingredients was a stroke of luck. Seeking a system to provide cryogenic cooling for space propulsion and power at NASA Lewis, Gerald V. Brown, chief of the Magnetics and Cryophysics Branch found, instead, the ingredients for a room-temperature system having



This working element of the magnetic cooling system is a 2-in. stainless-steel cannister containing stacks of 40-mil gadolinium plates. The plates have spaces between them for fluid flow. The wire screens smooth out the flow pattern.

broad applications. His ferromagnetic material turned out to be gadolinium, a rare-earth element with a magnetocaloric effect substantially greater than other common ferromagnetic materials (see Fig. 1). And its Curie point is at room temperature.

Stronger external magnetic fields were already at hand, with modern superconducting magnets producing 70 or 100 kG. By applying a field on the order of 70 kG, Brown could get a temperature change of about 25 F in a 2-lb capsule of gadolinium.

The final step needed to make a practical room-temperature cooling system was to somehow take the 25-F temperature increase and increase it to 100 F or greater. Brown did this by devising a regeneration system that accumulated the temperature change of a single magnetizing cycle for many magnetizing cycles. This approach has produced a 144-F spread in the present system.

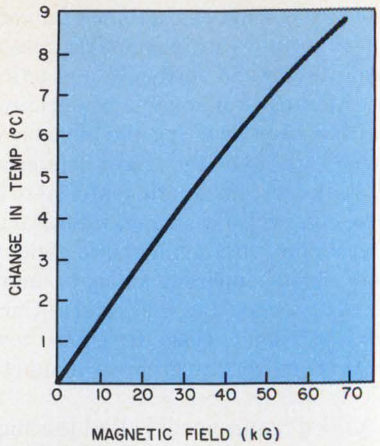
Regenerator uses gadolinium

Brown's regenerator is a vertical column of fluid in which a temperature gradient is built up and stored. The working magnetocaloric material is an assembly of stacked, separated gadolinium plates with gaps for the fluid to flow through and improve the heat transfer between the gadolinium and the fluid (see photo). At the top, or hot end, of the column, a heat-transfer coil removes the heat of magnetization (see Fig. 2). At the bottom, or cold, end, a transfer coil is attached to the thermal load to be cooled.

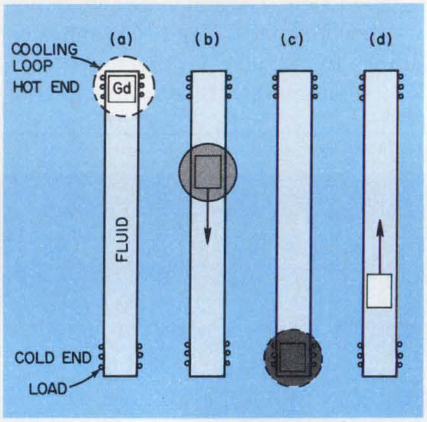
The refrigeration cycle begins by applying a superconducting magnetic field of 70 kG and maintaining the temperature of the gadolinium element. The temperature is held constant by removing the heat due to magnetic temperature rise by means of the heat-transfer coil. Then the gadolinium—a constant 70 kG around it—moves to the bottom of the regenerator.

There, the field is removed and cooling occurs. As the gadolinium element passes upwards through the column, but without magnetization, a temperature gradient occurs within the regenerator. As each cycle is repeated, the gadolinium arrives at the bottom colder than in the previous one. The demagnetization at the bottom further lowers the temperature. As the rare-earth element is again lifted to the top, the regenerator is cooled even more.

As the cycles continue, and the lower end gets colder and the higher end gets hotter, the temperature gradient in the liquid goes up. The cold-end temperatures will decrease until a thermal load is connected to the bottom heat-transfer coil.



1. **Applying a strong magnetic field** changes the temperature of gadolinium. The variation of temperature with field shown above was obtained in NASA experiments.



2. **A magnetic heating-cooling cycle** is obtained with a gadolinium working element that exchanges heat with a working fluid. The dotted circle (a) represents an increasing field while that in (c) is a decreasing field. For operation, see text.

The latest version of the thermomagnetic refrigerator produces a 144-F temperature span ranging from 248 K (−13 F) to 328 K (131 F).

Brown foresees practical reversible machines being developed with efficiencies on the order of 45% of Carnot—the maximum theoretical efficiency any refrigerator system could have.

With the experimental setup, about 60 W of refrigeration is obtained in about 12 in.^{3}, or 5 W/in.^{3} of a 2-lb gadolinium working element. But losses with the prototype are high. With optimum heat transfer from the gadolinium, the same-size element could produce upwards of 10 kW of cooling, or about 1 kW/in.^{3}, says Brown.

One way to improve the heat transfer will be to form the working element as a screen of fine wires or very thin plates. The plates currently used are 40 mils thick, which severely limits the machine's running speed.

Electricity from heat

Meanwhile, something that is more than a possibility is electricity directly from heat. An electrostatic heat engine being developed for the Dept. of Energy promises to convert thermal energy directly into ac without going through the intermediate mechanical systems required with present generators. The key is a combination of electrocaloric and pryoelectric effects.

The "solid-state heat engine," being developed by Power Conversion Technology in San Diego, can be powered from relatively low-temperature sources like solar energy, geothermal wells and waste heat from power plants. It is designed to convert heat to electricity by rapidly exposing wafer-thin ferroelectric capacitors to 120-Hz cycles of heating and cooling.

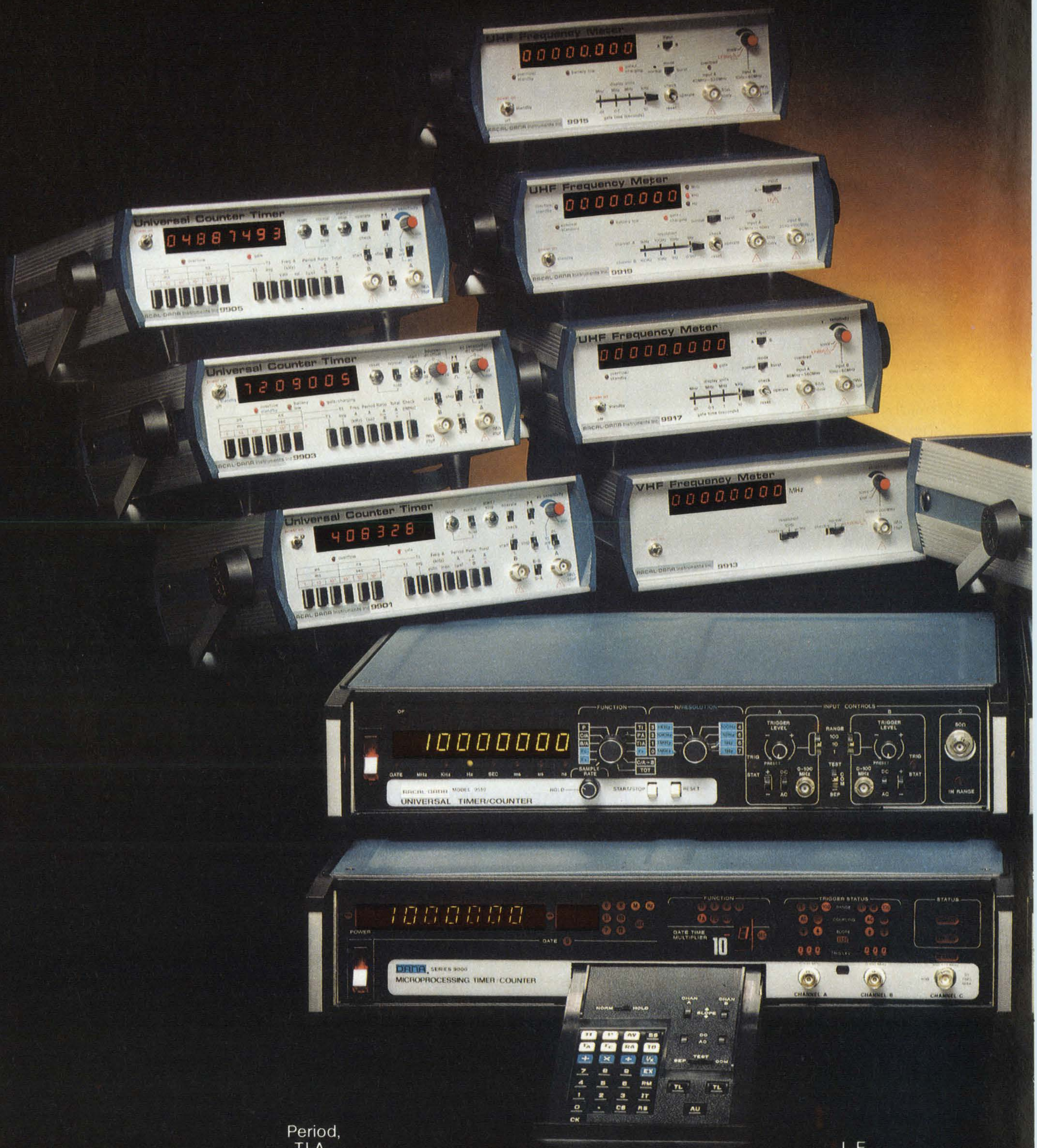
The thin capacitors have a low-enough thermal time constant to follow the heating and cooling and reverse the polarization and state of charge on them in the same time sequence.

While Power Conversion Technology concentrates on the mechanical and thermodynamic structure of the heat engine, ferroelectric capacitor materials are being evaluated, under a DOE contract, by Dr. David Payne, associate professor of ceramic engineering at the University of Illinois (Urbana).

"The best candidates for the Power Conversion Project are single or polycrystalline ferroelectric ceramics," says Payne. "Because it's difficult to get large single-crystal slices, it may be necessary to make thin-layers of polycrystalline material."

Temperature ranges for the materials are limited to about 350 C, maximum, so the frontrunners are the PLZT compounds and the lanthanum-modified lead zirconia titanates, which have highest spontaneous polarizations and electrocaloric coefficients.

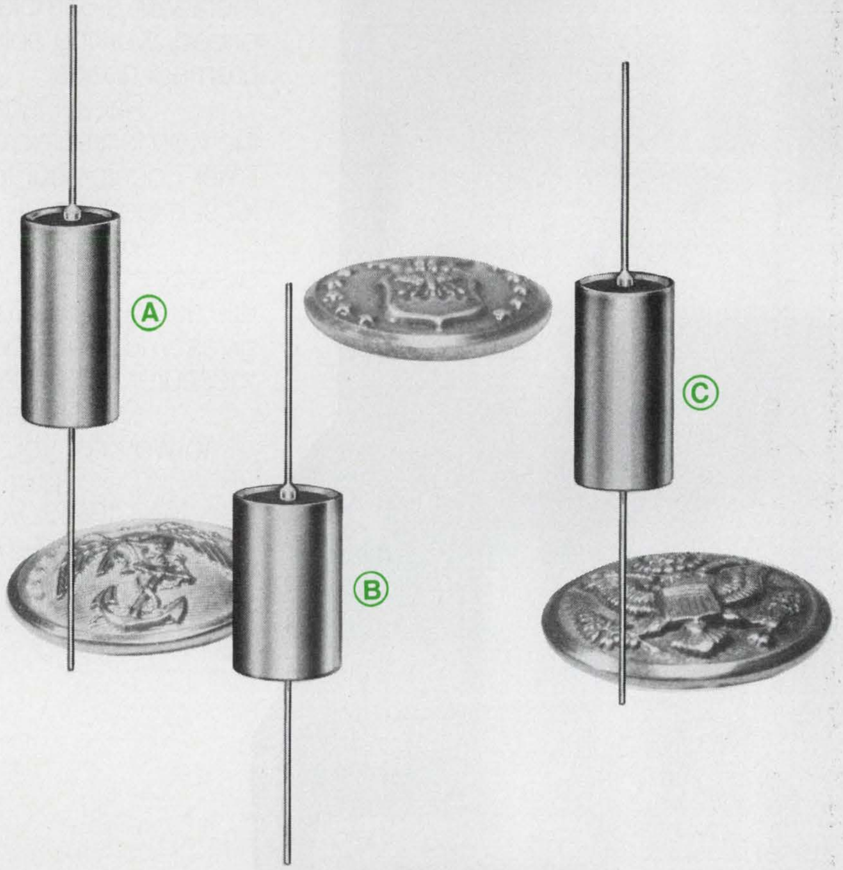
For heat stages around 100 C barium titanate compositions may prove satisfactory. These are currently being evaluated for polarization intensity, random polarization and fast switching time for polarization reversal.■■



Model	Frequency (MHz) Direct	Prescaled	No. of Digits	Sensitivity	Period, T.I.A., Ratio & Totalize	Trigger Level Auto	Adjust	Fixed	Programmability	RF Shielding	Battery Option	L.F. Multiplier Option	Base Price (U.S. List)
9015	100		9	25mV	*	*	*		*			Standard	$2,995.00
9035	100	512	9	15mV	*	*	*		*			Standard	$3,495.00
9510	500	1250	8	25mV	*		*						$1,295.00
9514	500	1250	8	25mV	*	*	*		*				$1,995.00
9901	50		6	10mV	*			*					$ 675.00
9903	50		7	10mV	*		*				*		$ 850.00
9905	50	200	8	10mV	*			*					$ 795.00
9913		200	8	10mV				*		*		*	$ 395.00
9915	60	520	8	10mV				*		*	*	*	$ 650.00
9917	560		9	10mV				*		*		Standard	$ 895.00
9919		1100	8	10mV				*	*	*	*	*	$1,095.00
9921	560	3000	9	10mV				*	*	*		*	$1,995.00

Dearborn

now has 'R' level approval on these MIL metallized polycarbonate capacitors



Ⓐ MIL Style CHR01 (per MIL-C-39022/9). Capacitance values from .001 to 22.0 μF. Voltage ratings from 30 to 400 WVDC.

Ⓑ MIL Style CHR10 (per MIL-C-39022/10). Capacitance values from 0.010 to 22 μF. Voltage ratings from 50 to 600 WVDC.

Ⓒ MIL Style CRH (per MIL-C-83421). Capacitance values from .001 to 22.0 μF. Voltage ratings from 30 to 400 WVDC.

Based on more than 23,000,000 unit hours of testing, these MIL style hermetically-sealed capacitors have performed with less than .01% failure to gain 'R' Level Approval.

Like other metallized polycarbonate capacitors in the Dearborn family, these capacitors feature excellent capacitance stability, low temperature coefficient and high insulation resistance.

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CIRCLE NUMBER 38

Washington report

John Rhea, Washington Bureau

Two new navigation systems may dominate future civil needs

Two navigation systems currently in development will become the dominant aids for ships, aircraft and pleasure boats over the next 15 to 20 years. They will supplement and, in some cases, replace the hodge podge of present systems —according to a new study by the Department of Transportation.

One is a microwave landing system (MLS) being developed for the international civil-aviation community, and the other is the Defense Department's Navstar global-positioning satellite system, according to DOT's third National plan for Navigation. The first of the series was issued in 1970, and the second in 1972.

The MLS is expected to replace the instrument landing system (ILS) in operation at commercial airports since the 1940s. Unlike the ILS, the microwave landing system will allow aircraft to approach airports from many directions at the same time, notes the DOT report. And its signals will be less susceptible to the effects of terrain.

The heated competition between the American time-reference scanning beam system and the British Doppler-based system is now over. The International Civil Aviation Organization has selected the American system, developed by Texas Instruments and Bendix.

Navstar is envisioned as a navigation aid for civilian planes and ships en route but, according to the report, it's not accurate enough for aircraft landings.

Other navigation systems are discussed in the DOT Plan:

- Loran-C, a long-range marine navigation aid, should cover all U.S. coastal areas as well as the Great Lakes by early 1980. It will replace Loran-A, developed during World War II.
- Omega, which will end up being an eight-station worldwide navigational system, is used by ships and some airlines during overseas flights to provide accuracies within two to four miles. Seven stations are operating, and the eighth is scheduled to open in Australia in late 1980.
- VOR-DME, the basic inflight navigation system for aircraft traveling within the continental United States, should continue to be used until an alternate system is developed and deployed, possibly in the 1990s.
- Radio beacons, used primarily by private aircraft and recreational boaters, will go on indefinitely because of their high use and low cost.

Carter okays $1-billion flying command

A $1-billion plan to outfit six modified Boeing 747 jumbo jets to serve as flying military command posts has the go-ahead from President Carter.

The jets, known as Advanced Airborne Command Posts (AABNCPs), are intended to replace smaller EC-135 flying command posts—essentially, modified Boeing 707s—which go by the code name Looking Glass. Four of the advanced aircraft were approved by previous presidents, but the Pentagon had been holding up funding for the last two AABNCPs, which threatened to delay the program and push up costs (see ED No. 7, March 29, 1978, p. 59).

President Carter flew in the first AABNCP, the E-4A, shortly after he took office and declared that the aircraft was too expensive. He recently changed his mind, however, after Defense Secretary Harold Brown argued that the AABNCPs would not only provide greater capability than the Looking Glass aircraft, but would permit the Air Force to retire 17 of them.

Under the plan approved by the President, an additional $15-million will be made available to prime contractor Boeing (Seattle) to continue the program without interruption. All six aircraft will be built to the E-4B configuration with advanced, nuclear-resistant avionics and will join a reduced fleet of 25 EC-135s. Secretary Brown considers this aircraft mix the strongest to have in the event of nuclear war.

The aircraft will permit the commander-in-chief of the Air Force's Strategic Air Command to direct nuclear retaliatory strikes and, serving as the National Emergency Airborne Command Post, will enable the President and other high government officials to exercise command from the air in case of a nuclear war.

Europeans opt for European comsats, launchers

The European Space Agency has approved a system of four of its own operational communications satellites, which should be placed into geostationary orbit by European launch vehicles beginning in late 1981. The first of the four is expected to go up using the Ariane launch vehicle.

These European Communications Satellites (ECSs) will replace the Operational Test Satellite (OTS) comsats being launched for the European agency by the National Aeronautics and Space Administration (NASA). The first of those satellites, OTS-1, failed to achieve orbit last Sept. 14 after its Delta launch vehicle malfunctioned: The second, OTS-2, was due to go up in late April.

Initially, the ECS series will provide a capacity of 5000 telephone circuits, but will work up to 20,000 by 1990. The European comsats will use the ground stations built for the American comsats, and will operate on an uplink frequency of 11 GHz and a downlink frequency of 14 GHz rather than on the typical American frequencies of 4 and 6 GHz. The higher frequencies are less susceptible to radio interference in the congested European environment.

Capital capsules: The Air Force and Navy have decided to outfit their Sparrow air-to-air and ship-to-air missiles with **an advanced monopulse seeker that is not only less susceptible to electronic jamming than the present pulsed Doppler seeker, but is also the first air-to-air missile to employ an on-board digital processor.** Although the monopulse concept originates with Marconi, Ltd., a British firm, an American firm was sought to develop the new system. Raytheon beat General Dynamics in a competition in which each firm submitted five prototype seekers for evaluation. . . .The Department of Energy's Argonne National Laboratory has awarded Eagle-Picher Industries (Joplin, MO) $1.1-million to develop **an advanced lithium-metal sulfide battery to power an electric vehicle.** The goal is to produce a 40 kilowatt-hour battery capable of running an instrumented van at up to 45 mph. The new battery is expected to provide greater power density than conventional lead-acid batteries. Delivery is scheduled for some time next year.

Four new Motorola system development tools

for MPU, bit-slice, and single-chip microcomputers.

A quartet of recently introduced system development tools from Motorola Microsystems keeps Motorola's product line in harmony with the unmatched versatility of the processors they support.

The EXORciser II* Development System improves on the original EXORciser* without making it obsolete. MACE 29/800* extends the EXORciser's capability to systems using bit-slice architecture. The 3870 Emulator and 141000 Simulator are EXORciser-based development tools for single-chip microcomputers.

EXORciser II develops high-speed systems.

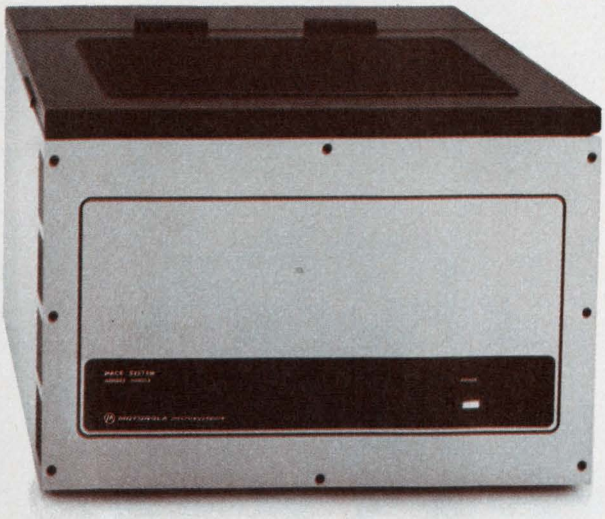
EXORciser II does everything the EXORciser does, adds a couple of neat new wrinkles, and operates at twice the speed. The key to the high speed is the new MPU II module, which includes both the system clock and the 2.0 MHz MC68B00 MPU. The clock circuit generates your choice of 1.0, 1.5, or 2.0 MHz signals, so the EXORciser II supports the full range of M6800 Family microprocessors.

DEbug II provides EXORciser II with a dual memory map. This capability dedicates a full 64K memory map to EXORciser II, and creates a second 64K map in which you may implement your system. EXORciser II I/O can be accessed from either memory map.

The EXORciser II includes 32K of RAM, power supply, RS-232 port, selectable Baud rates from 110 to 9600, and a Macro Assembler/Editor. Optional modules also are available.

As for software, EXORciser II operates with all Motorola standard resident software packages; FORTRAN, COBOL, MPL, BASIC and Macro Assembler/Linking Loader.

*Trademark of Motorola Inc.

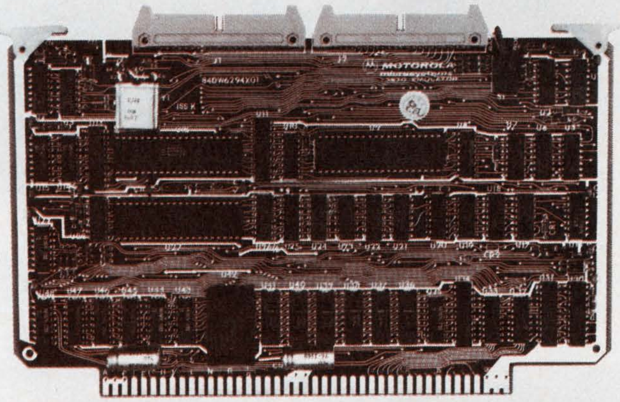


MACE develops ultra-high-speed systems.

MACE 29/800 minimizes the time and trouble of producing microprograms for systems based on bit-slice families like Motorola's high-speed M2900 and ultra high-speed M10800. The MACE 29/800 includes an EXORciser bus-compatible interface module and an EXORciser-resident software package that translate all microprogramming tasks into M6800-oriented operations.

The Write Control Store (WCS) in which your micro-program will reside is expandable in both depth and width. Ratios range between 8K words by 16 bits and 2K words by 112 bits, with intermediate configurations selectable in increments of 2K words or 16 bits. A maximum of seven WCS modules can be used.

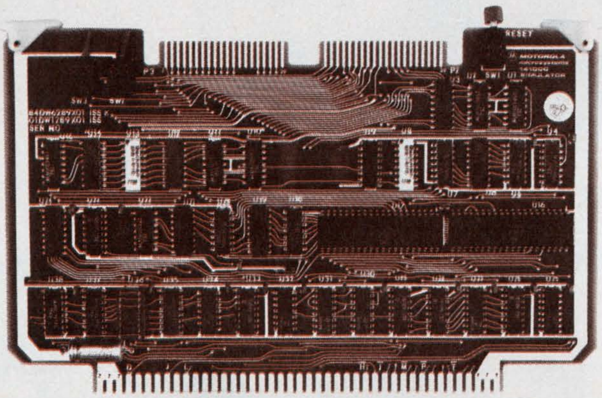
MACE 29/800 is available as a separate unit for those who already have an EXORciser, terminal, and printer, or as a complete development station.



MC3870 Development System provides real-time emulation.

The 3870 Emulator is another plug-in extension of the EXORciser. It provides real-time emulation of the MC3870 single-chip microcomputer.

The EXORciser-resident Cross Assembler converts your 3870 source statements into an executable program. After this program is debugged, it's stored in a 2K EPROM for final evaluation. With the EPROM inserted in the socket provided, the emulator module can operate independently of the EXORciser.



MC14 1000 Development System provides microcomputer simulation.

The 14 1000/1200 Simulator is an EXORciser-based system development tool for debugging designs using the new MC14 1000 series CMOS single-chip micro-computers. Complete software requirements are met, including cross assembler, loader, and debug package.

This module provides complete simulation of the proposed MC14 1000/1200 system hardware characteristics, for correction of problems prior to initiation of final production masks.

For additional information on any of Motorola's EXORciser or EXORciser-based system development tools, complete the coupon or write your request for specific information to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036.

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CIRCLE NUMBER 41

Editorial

Goodbye, Charlie and Jack

For seven great years I've had the opportunity to write to the most influential people in the most important industry in the world. Through my buddies, Charlie and Jack, I've been able to get things off my chest about practices I hated in our industry—and practices I loved. Let me tell you—it was fun. I loved talking to you and hearing from you.

I'm going to miss that as I move on to broader responsibilities as Associate Publisher of ELECTRONIC DESIGN.

Larry Altman is the new Editor of ELECTRONIC DESIGN, and we're delighted to have him with us. Larry comes from the Far East—across the Hudson River—where, as Senior Editor of ELECTRONICS magazine, he earned the respect of the entire electronics community. He holds impressive editorial and engineering credentials.

George Rostky

Associate Publisher

Rostky, Scrupski and Altman......a new lineup

Those who read mastheads will notice several significant changes on ours. Editor George Rostky moves up to the new position of Associate Publisher of ELECTRONIC DESIGN. George is the most experienced and one of the most respected editors in the electronics press. We will now be able to apply his 25 years of technical and market savvy to planning and developing all aspects of our publication.

Our new Editor is Larry Altman, who was Senior and then Managing Editor of ELECTRONICS magazine. As an award-winning journalist and as a senior electronic design engineer, Larry has been directly involved in the dramatic growth of electronic technology as it spread from an aerospace and communications-oriented group of companies to the broad assembly of electronics-based enterprises that today dominate the industrial world. His reporting on developments in electronic technology—ranging from industrial and communications equipment to semiconductors, microprocessors and mini/micro computer systems—has earned him an outstanding reputation among both his fellow design engineers and fellow journalists. I believe he is uniquely qualified to lead our editorial staff.

Also joining the staff is Senior Editor Steve Scrupski. We are particularly pleased to have Steve come home. Having started his 16-year editorial career with us, Steve has gone on to develop a breadth of technical knowledge unequaled in electronics journalism.

These moves are part of our continuing commitment to make ELECTRONIC DESIGN the most helpful information source for electronic design engineers and engineering managers.

William Maass

Publisher

The Analog Devices' AD534 Analog Multiplier. A new, monolithic, laser-trimmed, four-quadrant analog multiplier destined to smash the myth that analog multipliers are more complex than the computing function they solve.

The AD534 has a guaranteed maximum multiplication error of ±0.25% without external trims of any kind. This level of accuracy you'd normally expect to find only in expensive hybrids or bulky discrete modules. Excellent supply rejection, low temperature coefficients and long-term stability of the on-chip thin film resistors and buried zener reference preserve the AD534's accuracy even under the most adverse conditions.

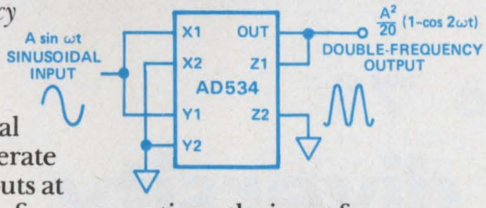
The AD534 is the first general purpose, high performance analog multiplier to offer fully differential high impedance operation on all inputs. And that's what gives the AD534 its amazing flexibility and ease of use.

The AD534 is a completely self-contained, self-sufficient multiplier which can generate complex transfer functions very close to theoretical. Our active laser trimming of thin film resistors on the chip to adjust scale factor, feedthrough and offset allow you to plug in the AD534 and run it virtually without adjustment.

In addition to straightforward implementation of standard MDSSR functions (multiplication, division, squaring and square rooting), the AD534 simplifies analog computation (ratio determination, vector addition, RMS conversion); signal processing (amplitude modulation, frequency multiplication, voltage controlled filters); complex measurements (wattmeters, phasemeters, flowmeters) and function linearization (transducers, bridge outputs, etc.) You can set up the AD534 to perform complex calculations by using various feedback arrangements to manipulate the AD534 transfer function of $(X_1 - X_2)(Y_1 - Y_2) = 10(Z_1 - Z_2)$.

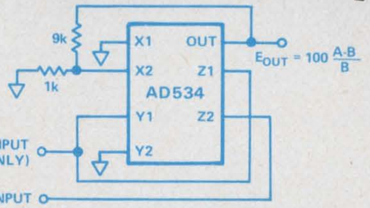
and use,

In Frequency Multiplication. Nonlinear circuits which accept sinusoidal inputs and generate sinusoidal outputs at two, three, four, five or more times the input frequency make use of trigonometric identities which can be implemented quite easily with the AD534 as shown. For this frequency doubling circuit the output should be AC-coupled to remove the DC offset resulting from the trigonometric manipulation.



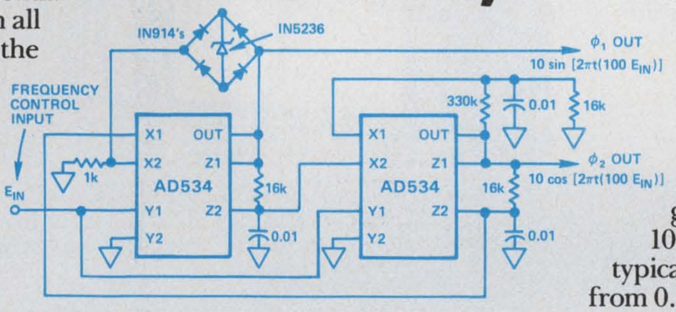
and use,

In Ratio Computing. The percentage deviation function is of practical value for many applications in measurement, testing and control. The AD534 is shown in a circuit that computes the percentage deviation between its two inputs. The scale factor in this arrangement is 1% per volt although other scale factors are obtainable by altering the resistor ratios.



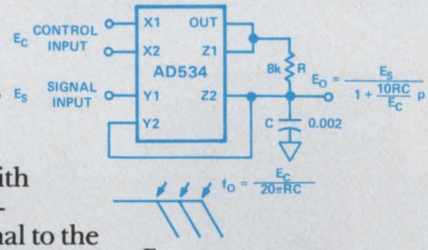
and use,

In Sine Wave Function Generation. The voltage controlled 2-phase oscillator uses two AD534's for integration with controllable time constants in a feedback loop. The frequency control input, E_{IN}, varies the integrator gains, with a sensitivity of 100Hz/V and frequency error typically less than 0.1% of full scale from 0.1V to 10V.



and use.

In a Voltage Controlled Filter. The output voltage, which should be unloaded by a follower, responds as though E_s were applied directly to the RC filter but with the filter break frequency proportional to the input control voltage $\left(\text{i.e. } f_0 = \frac{E_c}{20\pi RC}\right)$. The frequency response has a break at f_0 and a 6dB/octave rolloff.



These uses of our new Single Chip Analog Computer, the AD534, are only the beginning. For the big picture call Doug Grant at (617) 935-5565. Or write for a copy of our new Multiplier Application Guide and the data sheet on the AD534.

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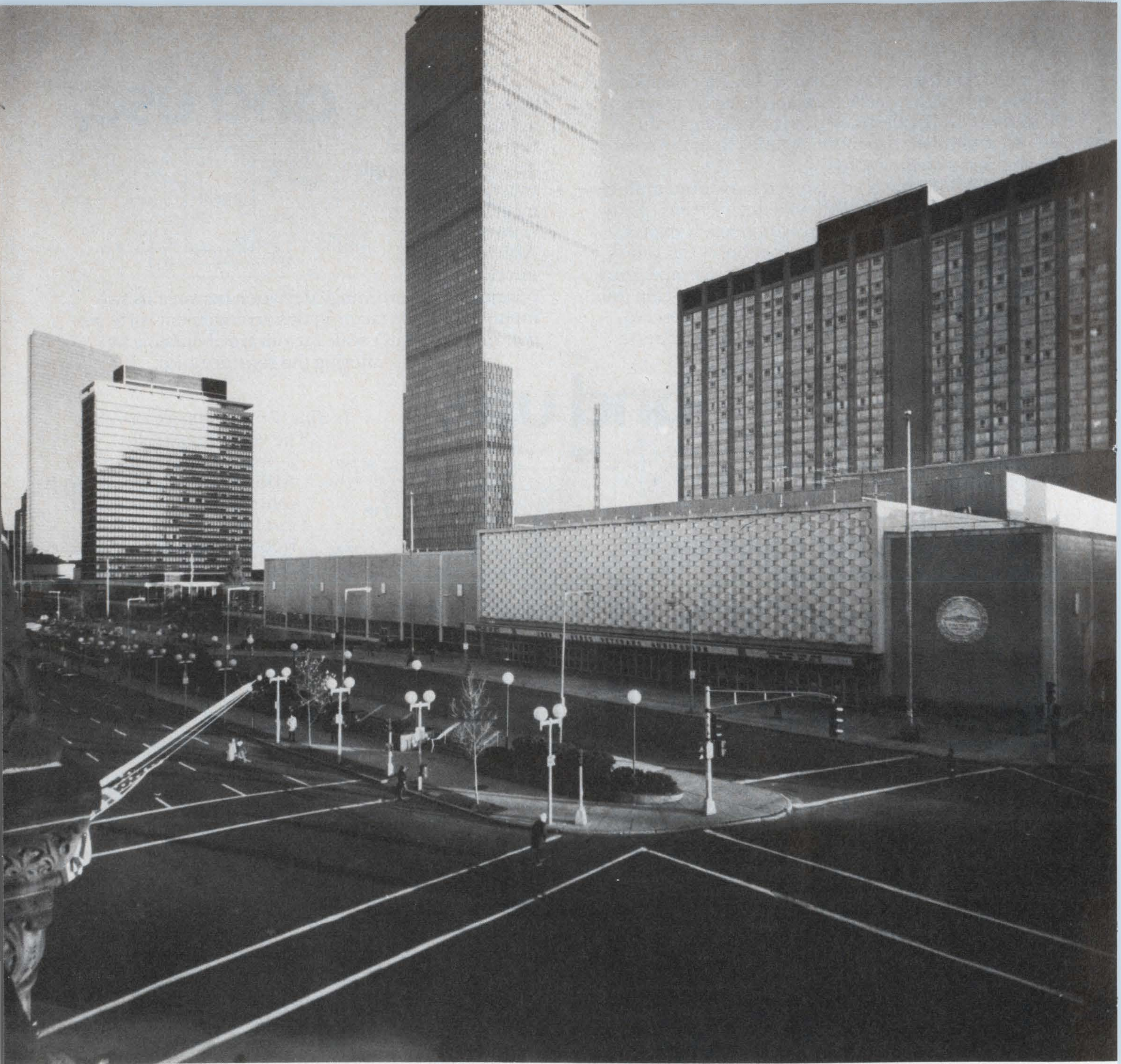
CIRCLE NUMBER 43



Electro '78

Direction, diversity mark this year's show

"Look ahead," proclaims this year's Electro—the IEEE international convention and product exposition—and the exhibitions and diverse technological program will echo and re-echo the theme.

Electro '78 will be held May 23-25 in Hynes Veteran's Auditorium as well as in the Sheraton Boston next door. The three-day convention is expected to attract 25,000 visitors who will view the products of 349 companies in over 658 booths.

Many will flock to hear the latest technical presentations on subjects ranging through automatic test equipment to microprocessors, data-base memory development, home computing and fiber-optic data links.

The technical program consists of 35 half-day sessions and a special Wednesday evening session with the intriguing title, "New Electronic Methods for Medical Diagnosis and Treatment Using the Human Energy Field: A new Beach-head for Scientific Discovery."

Some of the more down-to-earth technical papers are offered in Session 4, "Bridging the Analog-to-Digital Gap," and Session 14, "Microprocessor Applications in NASA." Both sessions point to a host of new intelligent peripheral μC components and systems that are affecting the architecture of small μC-instrumentation systems and large-scale mini-computer test systems.

How to test microprocessor and μP-based products continues to plague designers and users alike. Sessions 3, 9, 11, 17 and 22 will attempt to supply effective answers.

In communications, the action these days is in fiber-optic systems, with reliability and performance improving almost weekly. Nevertheless, some problems do remain, notably losses incurred in splicing individual fibers, and differences in fiber parameters. The ups as well as the downs of optical communications will be discussed in Session 29.

The new generation of semi memories is coming out with more options and capabilities than ever before. Session 27 will help designers choose the right one for their specific application.

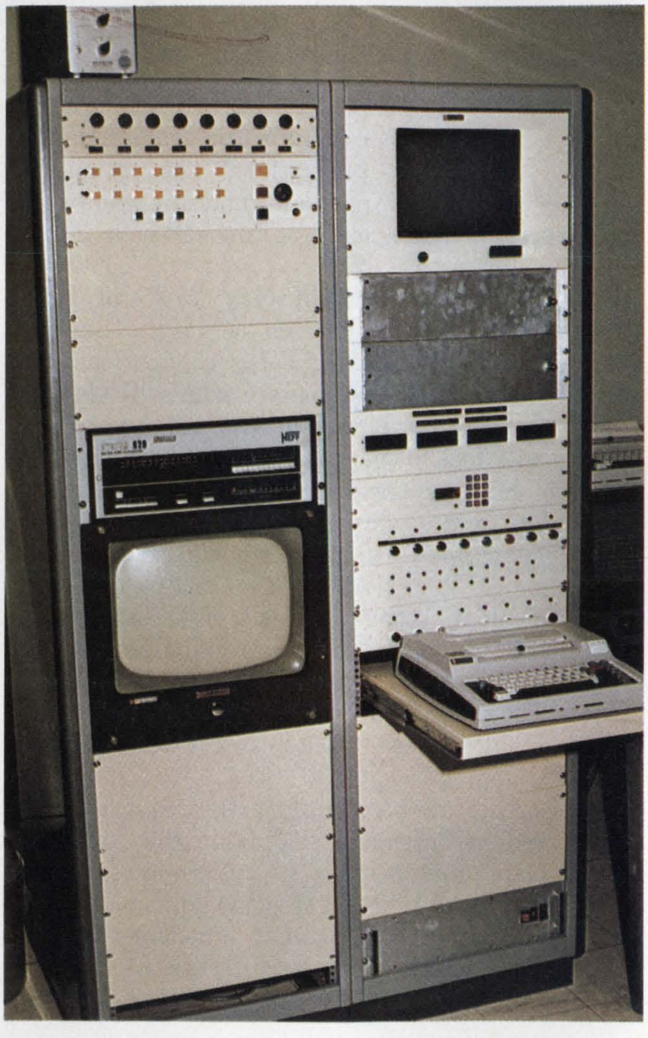
Sessions 16 and 23 will focus on computer peripherals rather than on the computer itself. This is particularly true at the consumer end, where designers are trying to develop hard-copy devices, mass-storage media, communications interfaces, and sense and control components for the new wave of home computers.

These Electro articles were written by Associate Editors Andy Santoni and Jim McDermott.

Smart peripherals simplify a/d and improve both μC and mini setups

Intelligent peripheral μC components and systems are bringing new, simpler ways to acquire and convert analog data into digital form. Not only that, but these low-cost hybrid and monolithic components, which talk directly to μPs and μCs, are producing an evolution in the architecture not only of small μC instrumentation systems, but also of large-scale minicomputer test systems like the ones applied in space-vehicle dynamic structural analysis.

Just what these new analog peripheral components are, how they're changing architectures, and what the newer instrumentation architectures will look like are highlighted in two sessions at Electro 78: Session 4 on "Bridging the Analog-to-Digital Gap," and Session 14 on "Microprocessor Applications in NASA."



These 8080 microcomputers incorporated at NASA test sites change system architecture by centralizing, not distributing, the minicomputers the 8080s feed.

New interfaces change architectures

The hardware to perform accurate analog data acquisition and conversion was, until not too long ago, physically large and demanded a great deal of power. Cost, size and power requirements for most systems kept data-acquisition and conversion hardware, as well as its interface to minicomputers, in the central-processing area, Stephen Harward, product line manager for Burr-Brown Research Corp. (Tucson, AZ), points out at Session 4 in "A New View of Architecture and Partitioning in Data Acquisition and Control Systems."

But now, microcircuit hybrid and monolithic peripherals have been produced that are tiny and intelligent enough to move the analog conversion and computation circuitry out to the sensor locations. Preprocessing done at the sensor site cuts down on the volume of data to be transmitted to the central location, Harward notes. More important, digital transmission of data from the sensor to the central location markedly improves noise immunity.

Indeed, with components now available, a complete data-acquisition and control system, including preprocessing and storage of data, can be put on a small PC card. Examples are single-chip computers like the 8048 family, the 3870, and others that operate from a single power supply voltage and are self-contained. Not only do these components have on-chip program and data storage, but their architectures very often eliminate the need for support chips. What's more, the price, in volume, can be less than $10 each.

Sweeping advances have also taken place in hybrid and monolithic circuitry, which can now convert analog signals to digital equivalents with as much as 16-bit accuracy. For bus interfacing, many of these are available with three-state output buffers. Virtually all the 16-bit, and some of the 8 and 10-bit resolution devices, are integrating types, with conversion times up to several hundred milliseconds.

Successive-approximation a/d converters, with 10 to 50-μs conversion times, are available with three-state output control that enables codes longer than eight bits to be sent out in two bytes of data on an 8-bit bus.

Because they're small and don't take much power, these new components make signal conditioning at the sensor feasible, Harward says. For example, an intelligent remote-sensor processing station can be provided by a complete minisystem consisting of a Burr-Brown MP-22 chip, an 8048 single-chip μC, and a 4-bit latch—and all on half a 4 × 6-in. PC card. The MP-22 is a complete hybrid data-acquisition system already interfaced to a μC bus and a control bus. This kind of system also permits local control at the sensor, in addition to remote operation.

The MP-22 is one of the most advanced hybrid microperipheral data processing devices, says Harward, with its 16-channel analog multiplexer; adjustable gain instrumentation amplifier; complete 12-bit successive-approximation a/d converter; and interface, timing and control logic. These features make the MP-22 directly compatible with some microprocessors without additional interfacing, and with virtually all other μPs after one or two simple logic chips have been added.

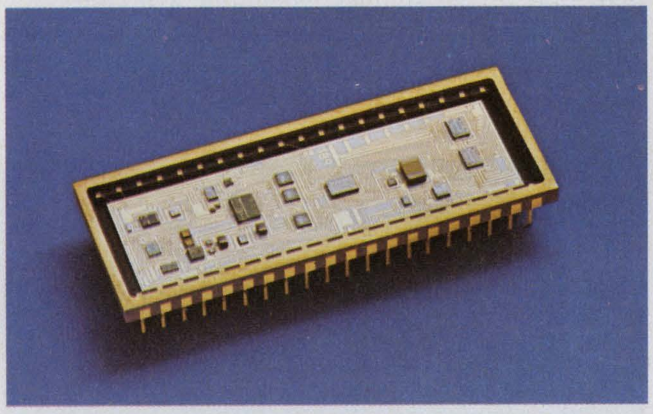
The MP-22 can be accessed not only by conventional I/O techniques, but also by a new feature—memory mapping. In memory-mapped operation, the computer accesses the Burr-Brown chip just as it would a memory. Each channel in the MP-22 has its own address, which the computer addresses as if it were part of the system's RAM.

Hybrid d/a and a/d's add interfacing

Up to now, monolithic and hybrid d/a and a/d converters have been available without interfacing circuitry on the chip. Adding interfacing chips would produce a full-sized computer board array. However, two new intelligent microperipherals bring this problem down to single-package size: they are self-contained hybrid data converters by Micro Networks Corp., Worcester, MA. Described at Session 4 by Robert Calkins, manager of circuit development, in "Simplify Analog I/O Design—Design It with Low Cost Microcomputer-Compatible Components," the MN3500 is a 12-bit, 32-pin voltage-output d/a converter and the MN5500 is a 12-bit, 40-pin multirange a/d converter. These devices, which are μP-compatible, contain the interface circuitry including address decoding, timing and control logic as well as the a/d and d/a elements.

Both the MN3500 and MN5500 can mate directly with the 6800, 8085 and Z80 and just about any 8-bit μC, says Calkins, because they can be addressed like a standard I/O device, or as with Burr-Brown's MP-22 —like a memory address, by means of memory mapping. A chip-select type of architecture permits both Micro Networks converters to be used as building blocks in large, distributed multichannel systems. The data transfer, using a bit-parallel, word-serial format, is consistent with 8-bit processors. To simplify mating with advanced microcomputers, handshaking signals are also generated.

One significant feature of the MN5500 a/d converter is a 12-bit latch for holding the a/d data. The 12-bit data are transferred in two 8-bit bytes by means of



Local control of data acquisition at the sensors is provided by new hybrid components like this d/a microperipheral interface package, the MN5500 by Micro Networks.

a three-state conversion signal. A conversion is initiated by writing a dummy word at the base address of the a/d. After conversion, the "end-of-conversion" signal line latches the output data into the 12-bit latch. This information can now be read by addressing the two memory locations used by the a/d.

This 12-bit latch allows a software interrupt to initiate the data transfer. And with this type of output interface, another conversion may begin before the a/d data are read out.

Monolithic a/d makes its bow

Indeed, these hybrid microperipheral devices have monolithic competition—the first single-chip monolithic data-acquisition system, the 15-mW ADC0816 from National Semiconductor, Santa Clara, CA. Following the microperipheral data-acquisition device trend, this 5-V, single-supply device can replace as much as \$100 to \$200 worth of hybrid and discrete component analog boards for \$20 (in 100 quantities). Fabricated with an ion-implanted high-density, metal-gate CMOS process and housed in a 40-pin package, the ADC0816 has a single 28,000 square-mil chip that includes a true 8-bit a/d converter with Tri-State latched outputs. According to John Jorgensen, National's CMOS design manager, who gives an in-depth look at the device and its use in "A Monolithic

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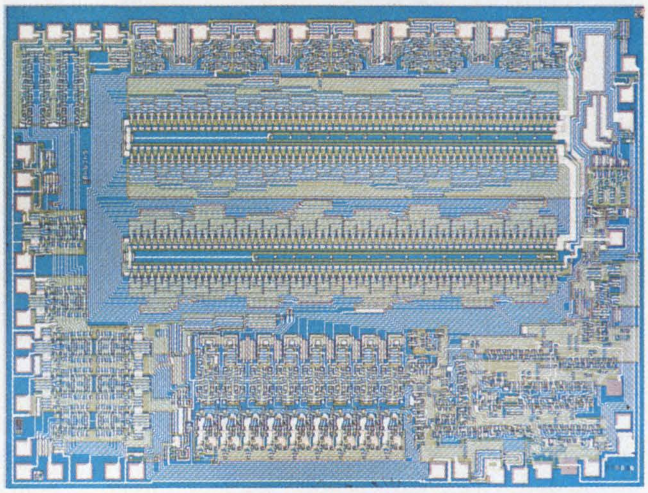
Data Acquisition System—Its Design and Application," the chip also contains a 16-channel expandable multiplexer with address input latches, provisions for handling external signal conditioning and all the logic control needed for interfacing the ADC0816 to all standard microcomputers.

The ADC0816 duplicates the classic structure of a data-acquisition system on a single chip, and performs a conversion in 50 μs. Radiometric design makes the chip essentially adjustment-free, says Jorgensen. Moreover, the linearity and accuracy are equal to that of most hybrid and discrete equivalents and better than that of the simpler monolithic a/d chips.

At 25 C, the linearity, zero error and full-scale errors are each no more than $\pm 1/2$ the least significant bit (LSB). While the total unadjusted error is typically



The first single-chip monolithic data-acquisition system, the ADC0816 by National Semiconductor, has an 8-bit a/d, a 16-channel multiplexer and microprocessor-interface logic. It performs a conversion in 50 μs.

$\pm 1/4$ LSB, the absolute accuracy—the sum of total unadjusted error and quantization error—is guaranteed to be less than ± 1 LSB.

The heart of the single-chip system, its 8-bit a/d converter, is divided into three sections: a 256-step resistor-ladder network, a chopper-stabilized comparator, and a successive-approximation register. High and drift-free accuracy in the comparator is achieved with chopper-stabilization, even though this is difficult to implement.

The chopper-stabilized comparator converts a dc input signal into an ac signal, which is then fed through high-gain ac amplifiers, where its dc level is restored. This technique limits the amplifier drift, since drift is a dc component not passed by the ac filter. As a result, the entire a/d converter is insensitive to errors due to temperature change, long-term drift and input offset.

To prevent oscillations that might occur in a closed-loop feedback control system using the ADC0816, a 256-step (256R) ladder network, rather than a conventional R/2R ladder, is incorporated on the chip. The reason is the 256R network's inherent monotonicity. A nonmonotonic relationship can introduce phase shifts and produce oscillations that may be catastrophic. In addition, the chip's 256R network does not cause variations in the reference voltage.

The chips can perform without the use of external components when applied in ratiometric sensing applications, such as with potentiometer strain gauges, thermistor bridges and pressure transducers. In these systems, only the change in parameter is measured rather than the absolute value. Consequently, the 0816 can operate without an external voltage reference, and the transducers are connected directly into the multiplexer inputs. For absolute measurements, a standard voltage reference must be added to the system.

Architectural changes are also affecting minicomputer systems. While microcomputers go one way, minicomputers are going quite another.

Minicomputers centralized

Minis used in large test and instrumentation systems have traditionally been decentralized so that each mini is close to its assigned task. The primary reasons have been system simplicity and low cost. But microprocessors and intelligent microperipherals have produced an about-face in that architecture at NASA Lewis Research Center in Cleveland, where research test facilities are scattered over a 340-acre area. Here, minicomputers have been gathered in a central location, and microprocessors and microcomputers successfully process and feed test information that is gathered in different areas back to minicomputer central.

The reason for the change in minicomputer-system architecture, says Robert L. Miller, chief of data system development, is increasing software costs, even as minicomputer hardware prices continue to decline.

"We found that programmer costs were rising because of the time required to service the various locations at which the minis were distributed. We found we could save programmer time by concentrating the minis in one spot," says Miller, who discusses the new architecture at Session 14 in "Escort: 1A Data Acquisition and Display System to Support Research Testing."

Minimum down time was also a goal. "Our task here at Lewis is research testing on power and flight systems for aeronautics and space. Some of those systems tests are very costly. Wind tunnels, for example, cost thousands of dollars an hour to operate. And we don't want to shut a test down because some computer component fails," Miller explains.

With the minis centralized and manned during test,

a system that goes down can be quickly pulled off the line and another mini or a plug board quickly substituted. Where discs are being used during a test, they can be readily transferred to the substitute system.

Another important concern is to be able to install a system for testing and have it running quickly. With custom-designed systems incorporating minicomputers at the test facility it was not unusual for one, even two, years to pass from initial requirement review until the test system was procured and the minicomputer was installed, debugged and running.

This prohibitive delay has been cut down to a brief two weeks by incorporating a microcomputer at each test site along with standardized μC packages with programmed, predesigned and pretested options.

The 8080 is used for standardization, Miller points out, because it is a stable design and looks like it will be around for the next 10 years or so, which is the expected useful life of the test systems using them.

As it now stands, the architectural configuration at Lewis Research consists of 8080 microcomputers located at the various test sites, and a pool of centrally located minicomputers, PDP-11s.

Three levels of PDP-11 are being used to satisfy different computing power requirements. One advantage of assigning a particular PDP-11 model to a job according to processing requirements is that the software is upward-compatible. So if the computing power must be increased in the middle of a test run, it's only a matter of plugging into the next higher-level PDP-11.

PPS-8s run 100-Mbit bubble memories

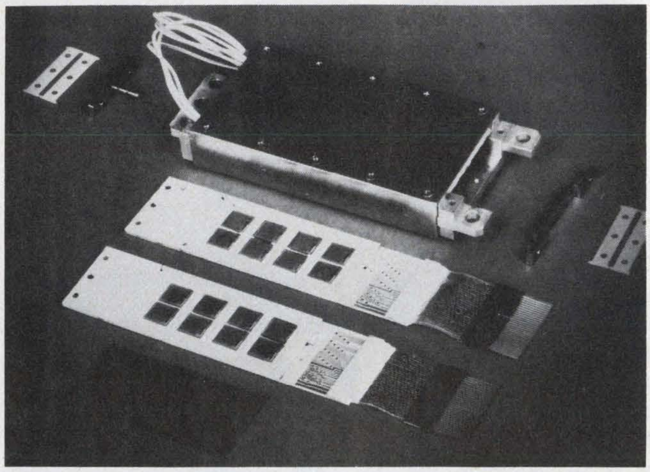
Microprocessors are also being used in a variety of esoteric developments at other NASA Research Centers. At Langley in Hampton, VA, for example, problems with "the most failure-prone component in U.S. spacecraft"—magnetic tape recorders—is being solved by the development of a microprocessor-controlled solid-state data recorder using magnetic bubble domain memories as the storage medium. In addition to overcoming reliability problems the μP-controlled approach has given increased flexibility and improved the over-all system, according to William A. Howle, Jr., assistant project manager at Langley.

"For instance," says Howle, who will detail the recorder development at a Session 14 paper: "A Microprocessor Controlled Solid-State Data Recorder," "the new device can look like a quasirandom access memory. That is, you can look at the data in blocks, rather than go through an entire tape sequence. Also, you can store portions of the data in an area and protect that data. Then you can use the rest of the storage as a conventional recorder, somewhat like permanent RAM storage.

"This same philosophy can be used to eliminate bad storage areas. Suppose, for instance, you have a failure in one of your bubble cells. The μP can instruct the controller to make those cells look transparent to the user. The system can be programmed to skip that defective cell address and not recognize it."

The data recorder is a multichannel system, so four separate record and playback functions can go on simultaneously as long as the address limitations are remembered.

The solid-state recorder, as Howle described it, has four serial-data channels, each controlled by a Rockwell PPS-8 μP. Total storage capacity is 100 Mbits. The bubble memories are Rockwell 100-kbit domain chips. The system can be configured as either one channel providing 102.4 Mbits, two serial channels providing 51.2 Mbits each, or four channels providing 25.5 Mbits each.



Four PPS-8 μPs control four independent bubble-memory channels in this NASA 102.4-Mbit solid-state recorder, which replaces tape machines. One of the channels is shown here. Total rate for all channels is 2.4 MHz.

Input/output buffers enable the external system connected to a channel to clock data in and out at any data rate from 0 to 12 MHz for any single channel. In the four-channel configuration, the total rate for all channels is 2.4 MHz.

The firmware for controlling the PPS-8 is located in two 2k × 8 RAMs. Three programmable I/O data controllers interface the PPS-8 to the rest of the system. A core-storage memory array is used to maintain the status of the recorder when it is in an unpowered state. Variables stored here include read and write pointers, command status, and cell status. A ROM sequencer stores all the control sequences required to read, write, erase and address-align the bubble memory storage subsystem.

A ROM sequencer produces timing and control pulses required to access the data storage subsystem. Read, write and erase sequences are stored in the ROM.■■

How to test μPs and μP products—a good question looking for answers

It's getting tough to tell which sessions at Electro cover instrumentation and which cover computers. Just look at the test and measurement session topics at this year's conference: Testing microprocessor-based products, microprocessors in instrumentation, computer-automated testing, and digital logic testing.

Microprocessors have been supplying more and more answers to design questions. But a big question remains unanswered: How do you test microprocessors and the end products that use them? Unfortunately, that question is a lot easier to ask than it is to answer. You won't find simple, direct answers at Electro.

What you *will* find are some approaches to microprocessor testing that should lead to definitive answers sometime soon.

One response, to be disclosed at Session 3, is a test plan developed by Peter Hansen of Teradyne Inc. (Boston, MA) to test a microprocessor-based board. The board, an Intel SBC80/20 single-board computer, is enough like other μP boards for the plan to apply to more than this single product.

"What we have is a very wide range of component types which can be assembled to form a wide range of functions, and all of it can end up in a most perplexing way on the printed-circuit card that we're trying to test," says Hansen, adding: "I wish that I could stand up here and tell you that there is a simple answer to this problem."

Hansen doesn't guarantee that bad boards won't get by or that some good boards won't fail his test. But it is a straightforward approach to a rather complex problem, and it does promise to minimize the number of bad boards that get out.

The central-processor chip is removed either physically or by setting all its lines to the high-impedance state. The test system is inserted in its place to control the board under test. The non-CPU section is tested by traditional means, including automatic pattern generation for devices that have been modeled.

The CPU is then activated and tested for gross faults using a manually-generated program that executes a few basic μP instructions. The entire board is then run at full speed to approximate actual system operation. The resulting test is reasonably complete.

It takes more than one μP to digitize a transient. In Tektronix' 7912, there's a processor in each plug-in and two more in the mainframe.

This last step, functional testing, is important, says Nick Wells of Digital Equipment Corp. (Acton, MA). "The key is to functionally test the module as closely as possible to its functional end use and not to test every possible combination of states that each module element can take." At Session 3, Wells describes testing a product that is 65% bus-oriented and more than 80% medium and large-scale integrated circuitry.

"This module has enough functionality contained on it that it can be viewed and tested almost as if it were a complete computer peripheral, less only a very few I/O pieces," says Wells. The module can be checked by a dedicated tester that consists of hardware and software building blocks.

The same test concept is used with other μP-based products so that only a few building blocks have to be changed for each product. This reduces development cost and time for module testers.

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The tester, Wells explains, is basically a microprocessor and memory whose bus attaches to the bus of the module under test, takes control of the bus, and electrically replaces the μP of the unit under test. Interface is via a bed-of-nails fixture that contains probes pneumatically operated to contact the non-component side of the board.

First, the board's clock is checked, then the bus is examined for stuck-at-one and stuck-at-zero faults. The memory is checked by reading ROM and writing and reading RAM. Then communications circuits are checked. A dedicated test section of the tester then looks at specific portions of the module. Finally, the system releases control to the unit under test, and self-contained ROM confidence tests are run. Total average module test, diagnosis and repair time, says Wells, is 10 to 15 minutes.

Testing μP boards is a challenge, and the answer comes from automatic test systems like this Teradyne L135. Price starts at a mere $150,000.

Testers tell more than pass/fail

But test and repair aren't all an automatic test system is good for, says Michael Salter, product marketing manager at GenRad Inc. (Concord, MA), at Session 9. "An ATE system can provide numerous process feedback mechanisms," he says. At the same session, Boris DeBussy, manager of software marketing at Faultfinders Inc. (Latham, NY), agrees that "reporting and analysis of failure trends can be used for correcting consistent manufacturing discrepancies and for isolating above-normal component failure rates."

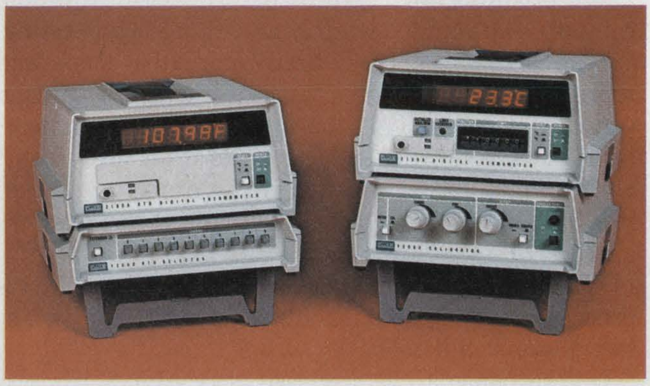
Session 9 chairman Dick Stein, new product manager at Computer Automation's Industrial Products division (Irvine, CA), says, "By capturing failure data and mapping successful repair action to recurring process or component faults, the full measure of payback can be realized from ATE."

Computer-automated testing isn't limited to digital circuits, either. Two sessions at Electro attest to that.

Session 11 focuses on computer-aided testing of analog circuits. "Computerized modeling of analog circuits and networks continues to be the neglected area," says session chairman Fred Liguori of the Naval Air Engineering Center, Lakehurst, NJ. "Fortunately, there are still a few stouthearted people who have not given up on analog circuit modeling or succumbed to the lure of the much simpler problem of digital circuit modeling."

One researcher, Heinz Schreiber of Grumman Aerospace Corp. (Bethpage, NY) and the State University of New York at Stony Brook, uses a piecewise constant waveform first to drive an analog network to an initial state, then to step it through a control sequence that returns the network state to zero. The driving signal, called the complementary signal, has step amplitudes that not only are functions of the poles of the network but also constitute a fault signature that can be related to drift failure element values.

Automated microwave measurements are the subject of Session 17. Here, Thomas Dowling and Richard Conti describe the operation of an automated antenna test facility at Raytheon Co.'s Missile Systems Division (Bedford, MA). And J.O. Taylor of MIT's Lincoln Laboratory (Lexington, MA) describes a technique for making measurements at frequencies from 26.5 to 37.0 GHz using a modified Hewlett-Packard automatic network analyzer.



You can tell just how hot μPs are with digital thermometers like Fluke's processor-controlled units. Microprocessors here control, and are part of, the a/d converter. They also handle I/O and massage data.

Microprocessors in instruments

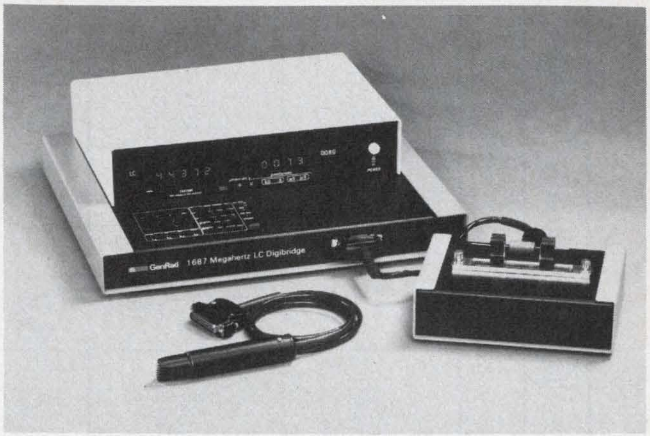
Where minicomputers form the heart of many large automatic test systems, microprocessors are becoming more and more common in smaller, bench-top and rack-mount instruments. The latest in microprocessor-controlled instrumentation is the topic of Session 22 at Electro this year.

A Mostek single-chip MK3870 microcomputer handles the analog circuit control and the digital portion of the a/d converter in a pair of digital thermometers from John Fluke Manufacturing Co. Inc., Mountlake Terrace, WA. The μP also makes it possible for the thermometers to store maximum and minimum readings, display the difference between the reading and a set point, compare a reading to a limit value and activate alarms, and communicate data to peripherals.

One microprocessor isn't enough in another instrument to be described at Session 22. In a transient digitizer from Tektronix Inc. (Beaverton, OR), "the nature of the tasks to be performed dictated a multiprocessor approach," says Robert Bretl. In the digitizer's mainframe, data processing and output routines require high throughput, yet have to run in parallel with several other functions such as monitoring the sweep speed and duty factor to protect the digitizer's display screen from burn-out.

"This would have been more than a full-time, full-speed task for any single MOS monolithic processor that would be on the market for the foreseeable future," says Bretl. So a 6800-type microprocessor was used in each plug-in for the digitizer to handle front-panel operations and an IEEE-488 interface. A second 6800 is in the mainframe itself to control internal operation and monitor sweep speed and duty factor. A 2900-based microprogrammable processor is a memory controller that provides the bulk of the data-processing capabilities for the instrument.

Another instrument that uses a microprocessor for data processing and IEEE-488 interfacing is the Model 1687 1-MHz impedance meter from GenRad. Here, the availability of the low-cost memory and processors permit the use of a technique that had been too expensive: One voltmeter measures the drop across the unknown resistor and a precision resistor in series.



Sort out Ls and Cs with a microprocessor-controlled bridge like this GenRad 1687. There's a five-digit readout and 10 limit-comparison bins for sorting.

The value of the known resistor is stored in ROM and applied by the microprocessor to calculating the unknown from the voltmeter measurements, which are stored in RAM. For ac measurements, complex voltage ratios must be resolved; they require a phase-sensitive detector and at least two voltage measurements for each impedance—with precise 90° relative phase shifts.■■

Memories

Now there are many good memories, but choosing is getting confusing

With memory circuits offering more and more options and capabilities, designers are finding themselves hard-pressed to choose the right ones for their applications. The fast-growing selection is fast growing confusing. Help is offered at Electro's Session 27.

Semiconductor RAMs, ROMs, UV EPROMs and other circuits all promise to be faster and less expensive. The reason? A technology called VMOS. "In all these devices, VMOS offers the highest density and considerable performance improvements," says Chris Peterson of American Microsystems Inc. (Santa Clara, CA). In static RAMs, for example, VMOS can reduce die sizes from 25,000 square mils to 14,000 or 15,000 square mils for a 4-kbit device. "In addition, VMOS memory circuits are fast, having speeds equivalent to memories using bipolar and short-channel NMOS technologies," says Peterson.

V grooves can be used to make ROMs, too. A cell is formed by the intersection of bit and word lines and the location is programmed by the presence or absence of a V groove. If a groove is present the bit line is connected to ground through a VMOS transistor. So when the word line is raised high, the transistor turns on and pulls the bit line low. If no groove is present, the bit line remains high.

The density of this layout is limited only by the widths of the bit and word lines, says Peterson. Using this technique, a 64-k VMOS ROM has been built in a 29,000-square-mil space. Cell area is only 0.21 square mils, considerably smaller than most NMOS ROM cells.

A polysilicon floating gate added to the basic ROM structure turns it into an ultraviolet erasable programmable ROM cell. Programming is accomplished by injecting electrons onto the floating gate, which raises the threshold voltage. Once this is above 5 V, the transistor will not turn on when the word line is raised to 5 V. So the bit line stays high.

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Timetable to the technical sessions at Electro/78

MAY 23, 1978 TUESDAY		MAY 24, 1978 WEDNESDAY		MAY 25, 1978 THURSDAY	
10 am	2 pm	10 am	2 pm	10 am	2 pm
1 Looking Ahead at High Density Packaging	**7** Engineering Management Tools for Improved Effectiveness	**13** ABC's of Financing a Growing High Technology Business	**19** Professional Concerns for Today's Engineer	**25** Upward Mobility & Career Development for Women Engineers	**31** Latest Techniques and Design for Solid-State Communications
2 Software: The Key to Using Microprocessors	**8** Small Package/Large Performance: 16-Bit Microcomputer	**14** Microprocessor Applications in NASA	**20** Examining Single-Chip μP Products	**26** Microprocessors as Manufacturing Support Tools	**32** Minis & Micros: Convergence on the Same Market
3 Testing μP-Based Products	**9** Using ATE More Effectively	**15** A Corporate Commitment to Service: Before You Build It, Service It	**21** Computer Applications in Public Utility Control Centers	**27** New Generation Memories: Greater Speed or Higher Density	**33** Energy Saving Through Infrared Technology
4 Bridging the Analog-to-Digital Gap	**10** μP Interfacing: Today & Tomorrow	**16** The Home Computer & Its Peripherals: A Look into the Future	**22** μP Applications in Instrumentation. How Smart is Smart?	**28** Advances in Radar Technology	**34** Civilian Applications of Radar
5 Recent Advances in Computer Aids to Circuit Design	**11** Computer-Aided Test Design for Analog Circuits	**17** Automated Microwave Measurements	**23** Computer Graphics: From False Start to Boom	**29** Optically Guided Wave Transmission Systems	**35** Industrial Applications of Optical Communications
6 Searching for Future Electronics Applications	**12** Memories for a Low-Cost Computer System	**18** Logic Measurement & Development Products	**24** Energy: Crises & Challenges	**30** Technology for Non-Invasive Monitoring of Physiological Phenomena	

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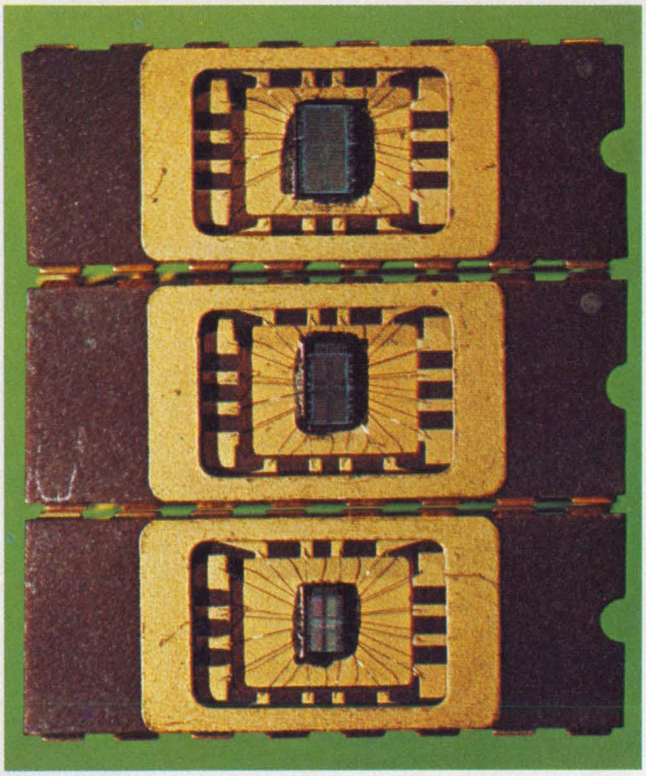


VMOS shrinks static RAMs. These three AMI 1-k static devices went from 100 to 83 to 66 mils on a side, while access times dropped from 45 ns to 35 to 25.

Erasure is accomplished by exposure to UV light. This raises the energy level of the electrons trapped on the floating gate, and they can escape.

A VMOS EPROM cell occupies half the area of its NMOS equivalent, says Peterson. Thus, a 16-k VMOS EPROM occupies 18,600 square mils, compared to about 30,000 square mils for the NMOS version.

VMOS shrinks dynamic RAMs

VMOS can also help save a great deal of space in dynamic RAMs, Peterson goes on. Here, the VMOS transistor accesses a buried capacitor that sits directly under it. When the word line is raised to 5 V, the transistor turns on and dumps stored charge onto the bit line so that the memory reads out a "1."

VMOS dynamic RAM cells enjoy a 2:1 advantage in density over double-poly dynamic RAM cells, says Peterson, adding that the storage area of the VMOS dynamic RAM cell is actually greater than its surface area, and has the largest charge capacity per unit surface area. "The efficiency of the cell (storage area/surface area) is 160%, where the double-poly cell is 30%—60% at most if an extra implant is used."

But RAMs, VMOS or otherwise, are not the ticket when low-cost storage is a necessity.

CCDs cost less

Charge-coupled-device memories are being used in applications ranging from large computer hierarchical memories to point-of-sale terminal look-up files, where they offer lower cost than RAMs and higher performance than discs, says Kirk MacKenzie of Intel Corp. (Santa Clara, CA).

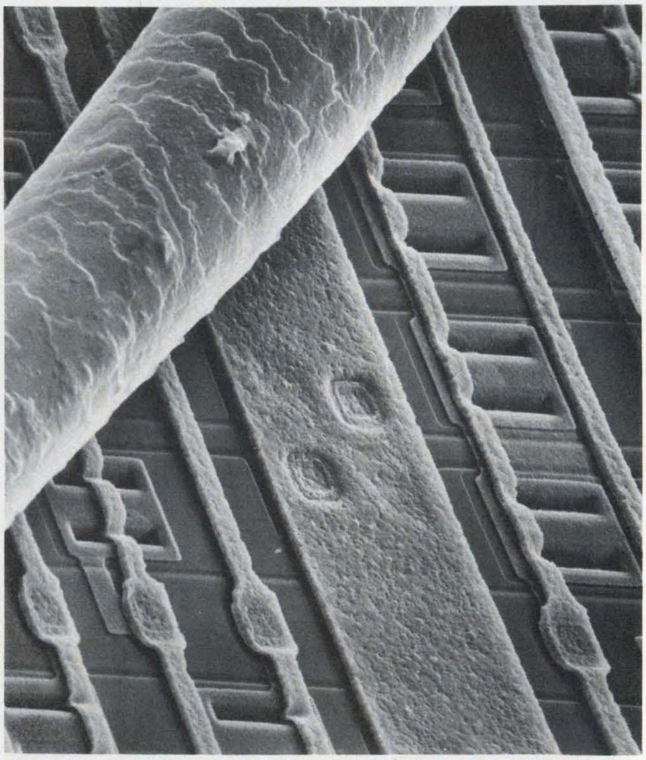
"All these applications have in common the need for very low-cost memory storage," says MacKenzie. Knowing that the ball is in their court, CCD manufacturers are pursuing several approaches to come up with the *lowest*-cost CCD that will be most compatible with market needs.

The most fundamental variation so far, the length of the memory loop, affects over-all device performance and system architecture. A device can be made with a few long loops, or several shorter loops, and each approach has its advantages and disadvantages, says MacKenzie.

Long-loop CCDs are generally implemented with a serial-parallel-serial organization, in which a single loop consists of a high-frequency input register, a high-frequency output register and a low-frequency parallel array. The parallel section, where most of the bits are located, operates at a significantly lower frequency than the I/O registers which substantially cuts power consumption.

In a typical short-loop CCD, a single loop consists of a short, straight path for moving charge. Power is reduced by using an internal multiplexing scheme to reduce the actual shift frequency of the array. In Intel's 2464 CCD, four 64-bit registers are multiplexed to create one 256-bit loop, and the array shifts at only 250 kHz for an effective shift rate of 1 MHz.

Another difference between available short and long-loop devices—and a big one—is clocking. The



Using three dimensions, VMOS shrinks memory cells until eight fit in the cross-section of a human hair. This photo is a 10,000-time enlargement from AMI.

2464 requires only two low-frequency nonoverlapping, TTL-level shift clocks, where long-loop CCDs require either two or four high-capacitance, cross-coupled MOS-level shift clocks. The latter also demand bipolar drivers to achieve 5-MHz rates, and that means higher cost and power consumption.

Long-loop devices do have the edge in data rates, MacKenzie admits: typically, 5 MHz compared to 2.5 MHz. This can be important in small, high-performance applications where tying devices in parallel to improve data rates may not do it.

But short-loop devices have a wider dynamic operating range—65 kHz to 2.5 MHz vs. 1 MHz to 5 MHz. And latency time, how long it takes to get to the first desired bit, is 128 μs—a far cry from the long-loop's typical 410 μs.

Bipolars are easy to use

But suppose the important consideration isn't low cost, but speed combined with easy use.

One group of memories is not only getting faster, but offers ease of use as one of its most attractive features: bipolar RAMs, says Tom Goodman, manager of applications engineers at Fairchild Semiconductor (Mountain View, CA). "Timing is simple, speed is very fast, and a single power supply is required," he explains. "Power-supply decoupling practices for bipolar RAMs are similar to those for MSI logic."

But as easy as bipolar RAMs are to use, says Goodman, some basic system-design errors are still committed, and frequently. Using a high-speed Schottky part to drive long lines and assuming the output of the device is stable until the next state change is completed are two big ones.

"The Schottky negative-going edge is so fast that, with a long line, a significant undershoot can occur, says Goodman. "Memory input glitch diodes may see peak currents greater than 100 mA—considerably in excess of the typical 8 to 12-mA specification."

As for timing, "Sometimes designers assume that data from the preceding cycle remain valid, then switch instantaneously to the new state," Goodman observes. "The outputs of most memories, however, go through several intermediate phases before settling into the new state."■■

Communications

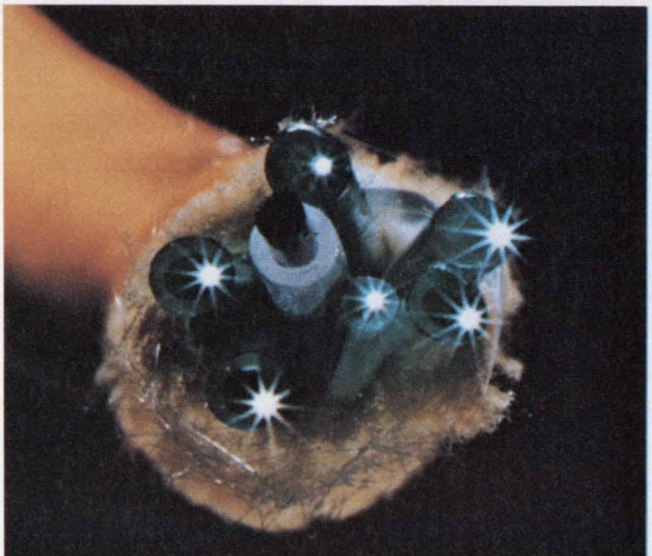
Fiber-optic systems reach for GHz but losses are still a big problem

Field-trial optical-communications systems throughout the world are demonstrating a reliability and performance exceeding even the highest hopes of their designers. The ceiling on system performance —it's now in the 100-MHz region and promises to reach into the GHz region—is being pushed upwards by continuing improvements in the performances of individual system elements: optical fibers, optical-fiber cables, emitters and detectors.

Nevertheless, problems continue to slow development. Both the ups and downs of optical-communications components will be examined at Electro '78 Session 29, "Optical Guided Wave Transmission: Components."

Fiber splicing and losses

Present limitations on system performance stem from one thing, from losses incurred in splicing the individual fibers as well as losses due to differences in fiber parameters, says C.M. Miller, supervisor of



The key to long-range optical communication systems lies in continuing improvements in optical fibers and cables, such as this new Siecor six-fiber structure.

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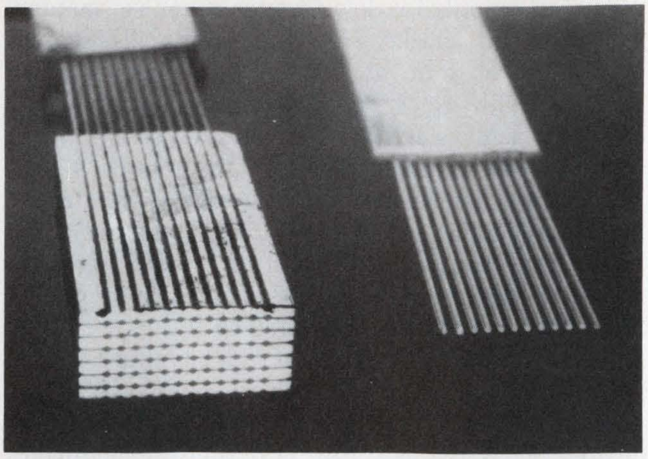

Single and multiple optical fibers can be spliced several ways. Multiple fibers in Bell Telephone ribbon cable are spliced with the fixture shown here.

the Exploratory Optical Fiber Splicing Group at Bell Telephone Laboratories (Norcross, GA) in "Optical Fiber Connecting."

Basic system design is going to be greatly affected, because, generally speaking, the losses in splicing optical systems can compound to a sizable portion of the end-to-end loss. Miller believes that connecting losses are probably going to be as much as 50% of the total losses. In a non-fiber-optic communication system, on the other hand, the connection losses are negligible compared to the media loss.

Both single-fiber and fiber-bundle connectors are being produced by a number of U.S. companies. But multiple-single-fiber connection technology is still a hand-crafted art. An example of this "art" is Bell's special array-splicing technique (see photo). Fiber-optic cable is designed around a multielement fiber ribbon, and a Bell-invented system that makes splicing relatively easy.

A number of techniques for splicing fibers have been developed, with most of them using a butt-joint configuration. A simple, end-to-end butt joint not only is the easiest-to-fabricate method of joining optical fibers, but also gives the lowest loss. The fibers are aligned by precision grooves, pins or tubes. Once aligned, the fibers are held together or welded to form permanent splices.

Welding is a recent hardware advance that works well and contributes to lowering losses, according to Miller. Fiber ends are aligned and heat is applied either by an electric arc, a plasma torch or a laser. A Japanese electric-arc welder is the first commercial system available.

With welding, it doesn't matter if the fiber has a step index or graded index. The fuse' ends, if properly made, have no added bulk at the splice, which is almost undetectable.

But even as optical-fiber connection losses are reduced to a few tenths of a dB by sophisticated splicing techniques, other losses will remain difficult to minimize. Such losses come from intrinsic fiber mismatches resulting from fiber-manufacturing vari-

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CIRCLE NUMBER 46

ations in the core-profile parameters—core radius, index of refraction variations, and the shape of the core profile. Even if mismatch losses are reduced in the future, Miller believes that optical connection losses will still contribute much more to end-to-end system losses than do conventional, wired-system connectors.

LEDs better up to 50 Mbits/s

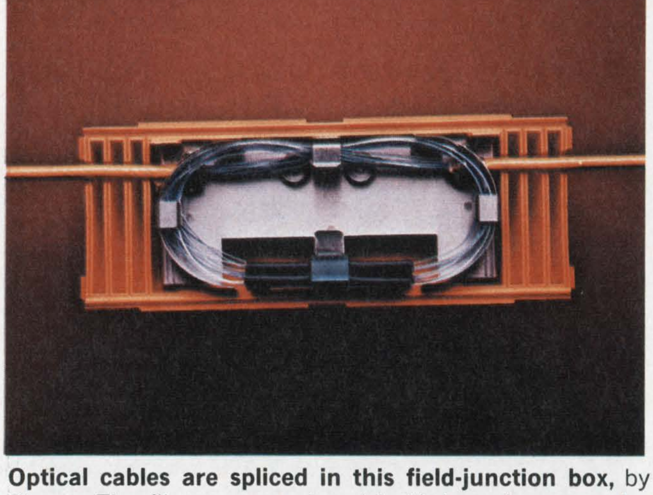
One problem that can be solved more satisfactorily is how to get substantially higher yields than can be drawn from solid-state-laser emitters. For systems requiring bit rates less than 50 Mbits/s and fiber-coupled powers in the tens of microwatts, LEDs are superior to lasers, says R.B. Lauer, of GTE Laboratories (Waltham, MA), in "High-radiance LEDs for Optical Communication Systems."

Better yields aren't the only advantage. LED driving circuitry is not as complex as laser-diode circuitry, Lauer notes. And LEDs have much longer operating lifetimes because their output decreases gradually over a period of time. Once laser diodes have aged enough to drop below the threshold level, the output abruptly decreases by several orders of magnitude.

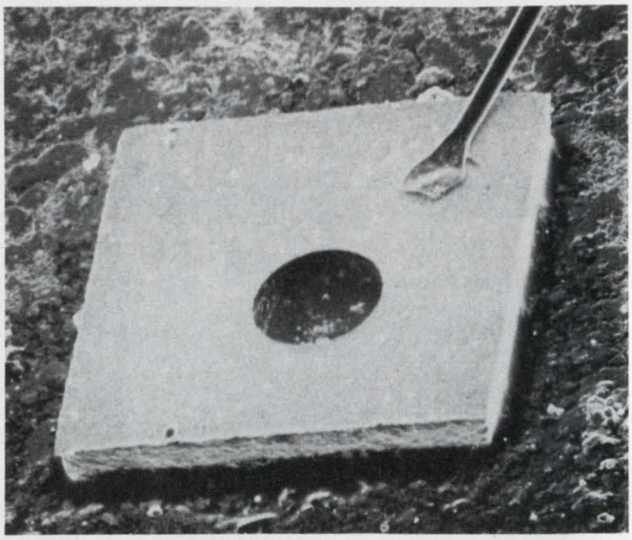
Another thing: Laser-diode output is very temperature-dependent. For this reason even more complex circuitry is needed to monitor the output continuously in real time and to compensate for changes in output with device temperature by varying laser drive current.

LEDs aren't nearly as temperature sensitive. A change of a few degrees means a decrease (or increase) of just a few tenths of a milliwatt.

High-radiance (Al, Ga) As/GaAs LEDs of the type first described by Burrus of Bell Laboratories have proved the most suitable for coupling optimum power into a fiber. This double-heterostructure LED has been produced in quantities for General Telephone and



Optical cables are spliced in this field-junction box, by Siecor. The fibers are centered in V-shaped grooves for precise alignment, and bonded together by a quick-set adhesive. A plastic sleeve protects the joint.



The best emitters for optical communication systems up to 50-Mbits/s are Burrus-type diodes, like this General Telephone and Electronics diode chip.

Electronics, is being used in experimental telephone systems in California and Hawaii, and is being installed in Belgium, Lauer reports. The Belgium installation will operate at 41 Mbits/s.

The double-heterostructure LED was chosen for GTE's systems because it improves device efficiency and also increases optical power output. The diodes are formed by sawing the LED wafer into 0.5×0.5 mm^2 chips. Each chip is epoxy or indium-die-mounted with the epitaxial side down on a TO-5 copper header for heat dissipation. The fiber is then positioned over the maximum radiation intensity and epoxied into place.

For easy use in a variety of situations, emitter packages are available with standard BNC connectors and with both fly leads and polished-capillary end pieces.

The double-heterostructure LEDs are coupled to 2-meter lengths of graded-index fiber whose nominal numerical aperture is 0.16. Optical output as a function of drive current agrees closely with the theoretical maximum efficiency. Lauer points out that for these devices, there isn't much room for further improvement.

To evaluate the reliability of these LEDs, two groups of devices are under test at General Telephone and Electronics. One group is being operated at 50 mA (2.5 kA/cm^2) and a peak of 50% duty factor, while a second group is being operated at 75 mA (3.7 kA/cm^2) and the same duty factor. The 50% duty-factor operation corresponds to the greatest average power that the devices will dissipate when operated with digital pulse-code modulation techniques.

The first group has operated over 8000 hours without its performance degrading. The second group began to show a small decrease in output at 7000 hrs. Accelerated aging studies predict a mean-time-to-failure of over 200,000 hours for devices operated at 75 mA, 50% duty factor.■■

Computers in the home are only as good as their peripherals

With computers these days, it's not so much which computer you use as what you have hooked up to it. This is especially true for computers aimed at consumers. Not surprisingly, then, the focal point at the Electro '78 computer sessions is not computers themselves, but peripherals.

At the consumer end, "the challenge to peripheral designers is to develop add-ons to the new wave of computers that have comparable performance per dollar ratios as the machines to which they are to be connected," says Steven Leininger, project manager at Tandy Advanced Products (Ft. Worth, TX) at Session 16. "Now that at least one manufacturer is delivering a computer system for less than $600," he adds, "the need for peripherals to enhance and expand the capabilities of this new class of systems is apparent." Consumers' demands are being heard.

The kinds of peripherals that are needed for home use, says Leininger, are hard-copy devices, mass-storage media, communications interfaces, and sense and control components.

"The ideal hard-copy device for the consumer/small-business environment would be a low-cost device that prints with typewriter quality on standard paper," says Leininger. "While many fine printers exist today, most users find it difficult to justify buying a $3000 printer for use on a $600 computer."

Home computers like this Radio Shack TRS-80 require low-cost peripherals. Consumers would balk at paying more for the peripheral than for the computer itself.

Leininger speculates that the most exciting computer peripherals for the developing home computer market will be system add-ons that allow all aspects of the household environment to be monitored and controlled by a home computer. Indoor and outdoor temperature, light, and security factors such as fire, freeze, and breaking and entering could all be monitored by computer, says Leininger.

To gain acceptance in the consumer market, peripherals will have to be reliable, cost-effective, and have UL recognition, Leininger goes on. A "wish list" of home-computer peripherals includes a $300 printer, a 10-Mbyte mass-storage system, and a $10 remote-controllable air damper that would allow the home computer to regulate the weather inside the house.

Memory is the bottleneck

Of the restraints to the growth of home computers, perhaps the most restraining is memory, says Dennis Speliotis of Advanced Development Corp., Lexington, MA. The typical system will require a memory of 10^7 to 10^9 bits, enough to store several thousand pages of information plus several high-level language compilers and other special programs and data.

The average access time to any record should not exceed a few seconds and the throughput rate should be 0.1 to 1 Mbit per second, says Speliotis. And the most critical parameter is cost—it shouldn't exceed about 0.2 millicents/bit.

Will one of the new developing technologies—magnetic bubbles, charge-coupled devices, and electron-beam-addressed memories—provide the solution?

"The answer is a very certain No," says Speliotis. None can provide low enough cost. Magnetic recording comes the closest to meeting the cost and performance objectives, and offers the best potential for the proposed mass-storage device, he adds. But it's currently too expensive.

As for the computer itself, Jerry Wasserman of Arthur D. Little Inc. (Cambridge, MA) writes a somewhat different scenario than is popular among hobby computerists. They see the computer as an

Have You Mailed Your Requalification Card? See Page 45

PRICE/PERFORMANCE	IMPACT PRINTERS	PEN PLOTTERS	NON-IMPACT				
			ELECTROSTATIC	THERMAL	INK-JET	ELECTRO-PHOTOGRAPHIC	FILM
SPEED - PRINT PLOT	30CPS-1000LPM -------------	---------------- UP TO 40 IN/SEC.	1000 LPM 2 IN/SEC.	100 CPS 20 SEC/PAGE	92 CPS .04 IN/SEC.	13,000 LPM 17 IN/SEC.	---------- 200 IN/SEC.
RESOLUTION (POINTS/INCH)	100	500	100 & 200	50	127 PLOT 250 PRINT	300	2000
QUALITY	FAIR	EXCELLENT	GOOD	FAIR	GOOD	GOOD	EXCELLENT
RELIABILITY	FAIR	FAIR	EXCELLENT	GOOD	?	FAIR	GOOD
VERSATILITY IMAGE	LIMITED	LINE GRAPHICS, COLOR	ANY B/W INCL. HALF TONES	LIMITED	ANY	B/W LINE GRAPHICS	ANY
SUBSTRATE	STOCK & CUSTOM FORMS	ANY	BOND, & TRANSLUCENT PAPER	THERMAL PAPER	ANY	PLAIN PAPER	FILM
COLOR	NO	YES	NO	NO	YES	NO	YES
GRAY-SCALE	NO	NO	YES	NO	YES	--------------	YES
COST - SYSTEM ($K)	1 - 100	22 - 40*	30 - 50*	1 - 5	45K*	100 - 300	150 +
CONSUMABLES	1/2¢/FT^2	1/2¢/FT^2	2¢/FT^2	1.7¢/FT^2	1/2¢/FT^2	1/2¢/FT^2	50¢/FT^2

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There are all kinds of printers to solve all kinds of computer output problems. The most promising technology for the widest range of applications is electrostatic printing, says Alan Dawes of Versatec.

extension of the video game, Wasserman says. But he believes that unless home computers are better aimed to meet consumer needs, the hobby computer boom will end—and soon.

The major stumbling block is programming, says Wasserman. "It is difficult to accept that a world that has been unable to provide enough software engineers to satisfy the needs of industry will suddenly inspire the vast number of nonmathematically-oriented people to learn a new discipline just to play games or even to educate themselves."

Wasserman hopes the computer will evolve as a command and control device for the home, responding to consumers' real needs. The computer could minimize energy use, provide security, cut water use, and simplify cooking.

Distributed processing at home

But so could something else. The functions that could be performed by a central computer in the home could also be performed by microprocessors in each home appliance—one in the hot-water heater, another in the oven, and others in the other appliances throughout the house. The cost of microprocessors has come down enough to make distributed intelligence possible and economical. Distributed processing could become as commonplace in the home as it is now becoming in commercial installations, and for the same reason—flexibility.

One problem area common to home and commercial computers is hard-copy output. At Session 23, Alan Dawes of Versatec (a Xerox Company), Santa Clara, CA, describes the needs for hard-copy devices and some approaches to providing them.

Providing hard copy

"Ideally, a digital hard-copy device should conserve the versatility of handwriting," says Dawes. It should be able to draw any image with one recording instrument—and be fast, reliable, reasonably priced and quiet—to meet most needs.

Electrostatic writing seems to hold the greatest promise because of its inherent simplicity, says Dawes. A slightly conductive paper, coated with a dielectric film, passes beneath a conductive stylus. A rear electrode is placed behind the paper, and a voltage difference above 300 V is applied so that some charge transfer takes place. A colloidal suspension of carbon is applied to the paper, and the black-carbon particles migrate to the charged areas. The particles are fixed as the paper dries.

Thermal and ink-jet printing offer some special benefits to some applications, says Dawes. Conventional impact printing and pen plotters will continue to serve other applications best. No one process will capture all opportunities. Those that get the most, however, will be the simplest and most versatile in rendering information visible.■■

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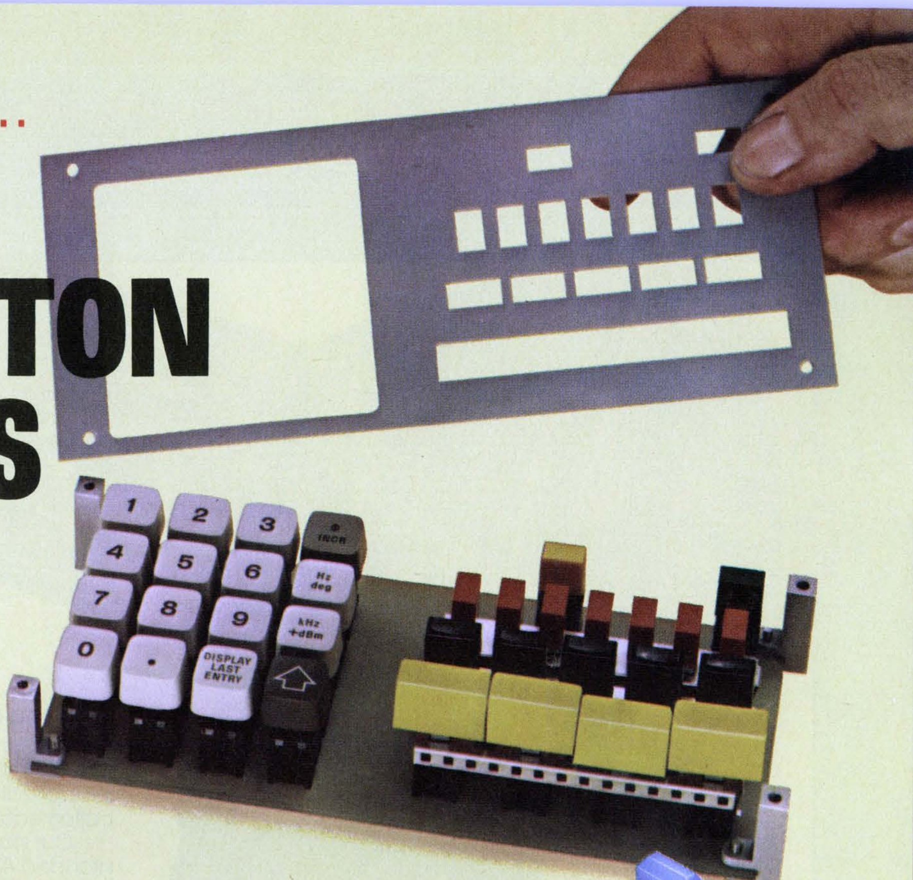

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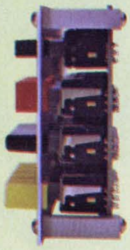

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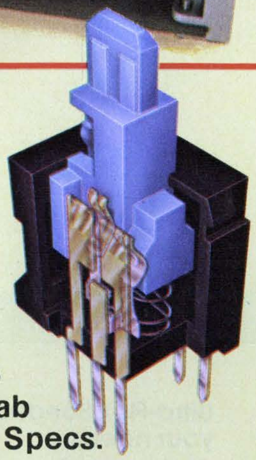

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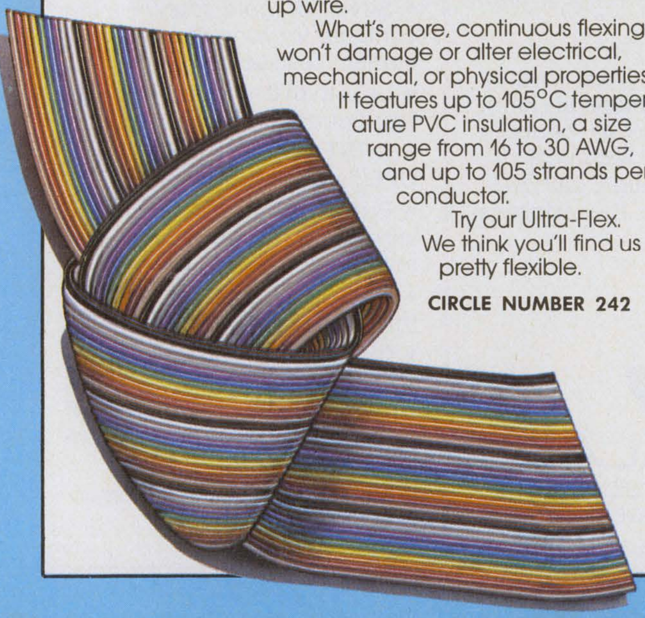

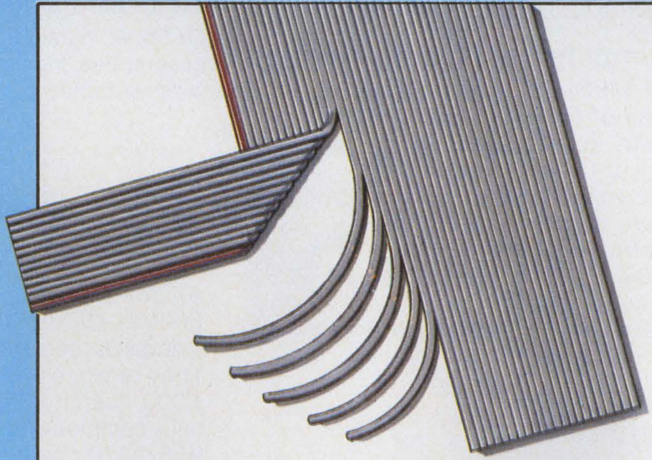

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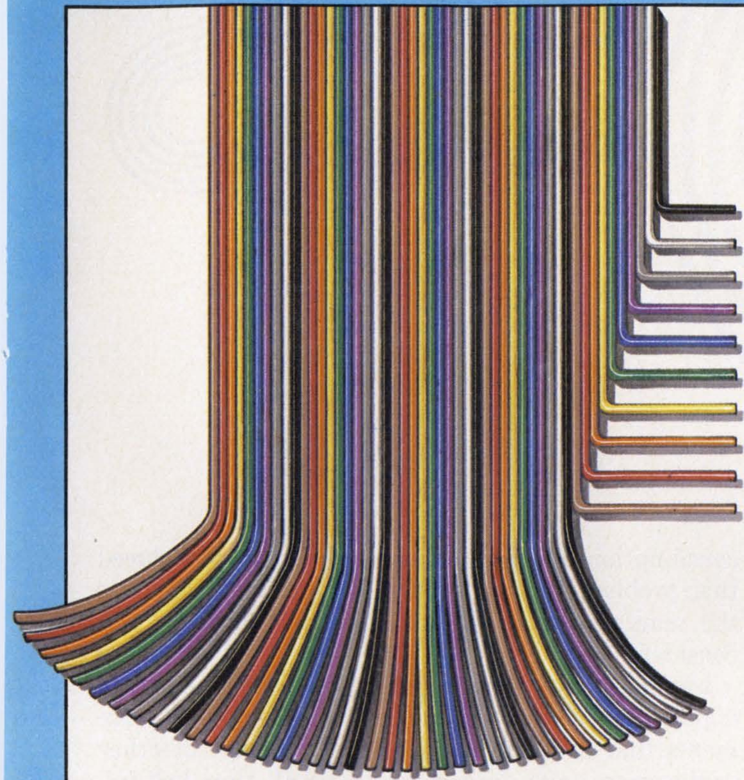

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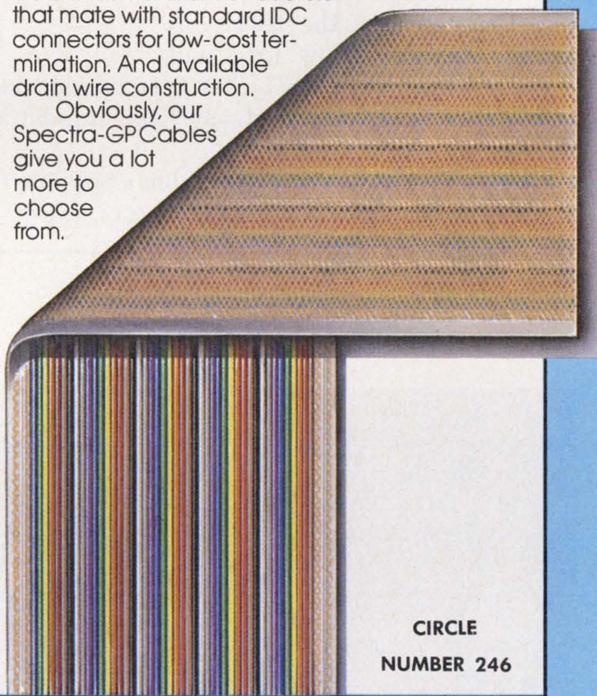

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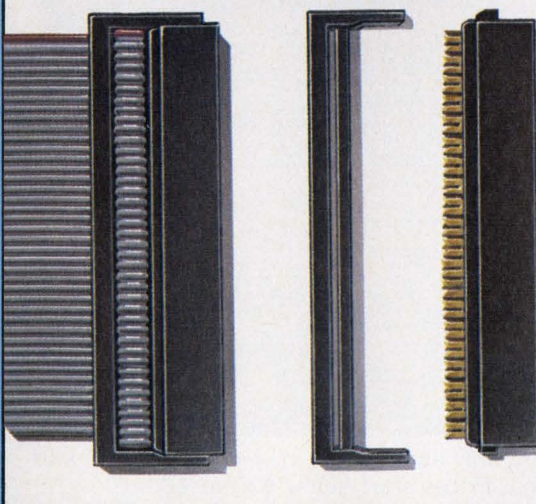

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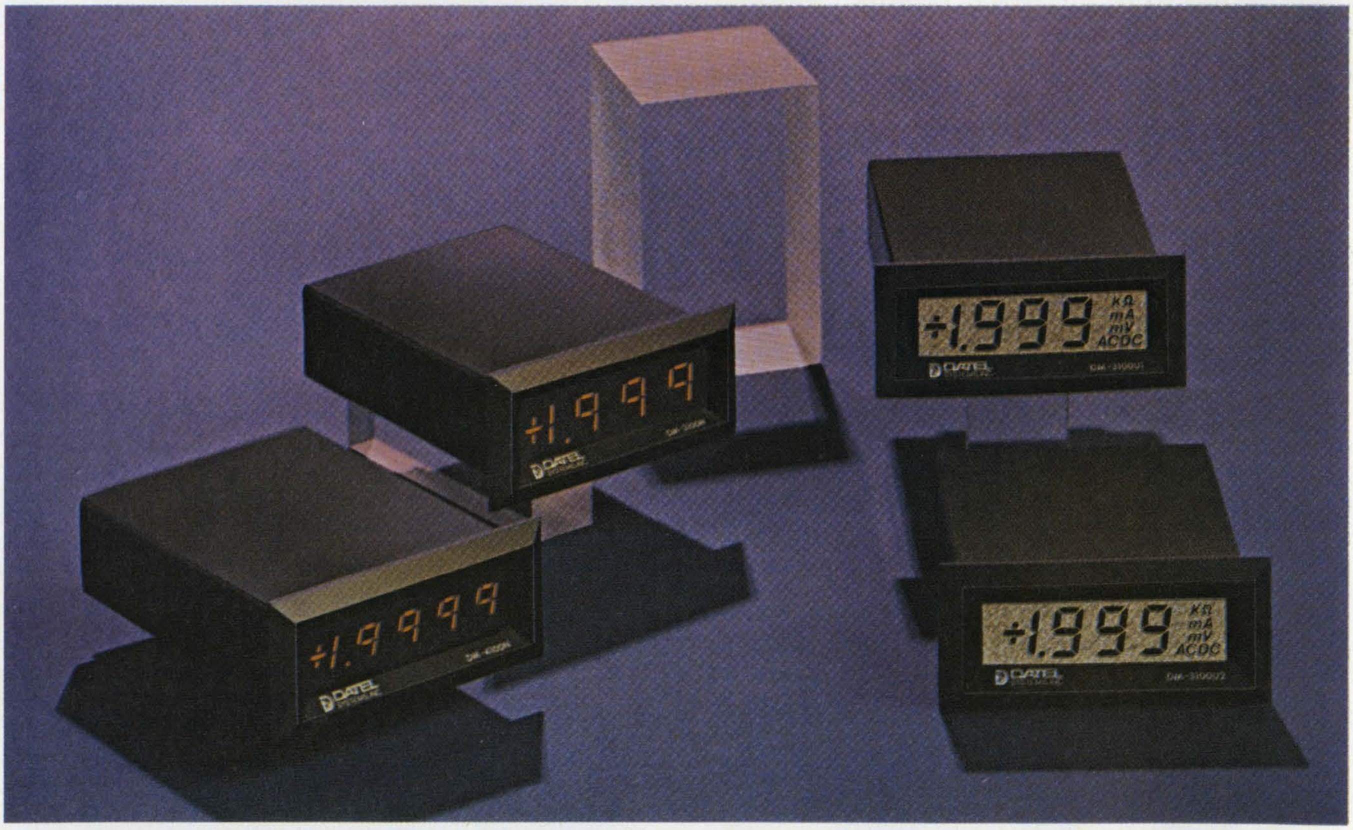
FOCUS on Digital Panel Meters

You still have to worry about reliability when you set out to buy a digital panel meter. But the traditional concern—"How long will the DPM keep working?"—has been overshadowed—though not totally replaced—by "How reliable are the readings?"

You can't completely forget about possible instrument failure. But lower parts counts, lower power consumption, and more extensive testing have reduced that problem. Now you have more time to consider the readings you'll be making—and there's lots to consider.

Andy Santoni
Associate Editor

Not that manufacturers of simple, voltage-reading digital panel meters—or even of fairly complex instruments that measure temperature, pressure or other engineering units—are going to be all that helpful.



Small size and low price have always been the goals of digital-panel-meter makers and users. These diminutive Datel units are only about 2 1/2 in. wide, 1 in. high, and 3 1/4 in. deep. Prices start below $30 in 100s.

Data sheets, when you can get them, are filled with specifications and test conditions, but rarely with the particular information you need to determine how well an instrument will work in your application.

"There's a lot of hype in this business," says Bernard Gordon, chairman of the board of Analogic Corp. It's up to you to cut through the overblown claims and figure out how a DPM will do in the real world.

Is it true?

Take accuracy. What you're really interested in is how far the reading on the meter may wander from the value you're trying to measure—regardless of whatever ambient conditions or noise may be around. You shouldn't have to measure all these perturbations and factor them in every time you take a reading.

You can factor in all the error-producing factors just once—if you have all the specifications. And, as always, the specifications should be taken under worst-case conditions since you cannot guarantee that your instrument will meet "typical" performance standards.

You'll also want to be sure your DPM will maintain its accuracy from day to day. How often does it require calibration to meet its stated specs? It makes no sense to design a product to need calibration no more than once a year, then incorporate a DPM that has to go back to the cal lab every 30 days. Worse yet, some DPM suppliers don't specify long-term accuracy at all. Ask for it.

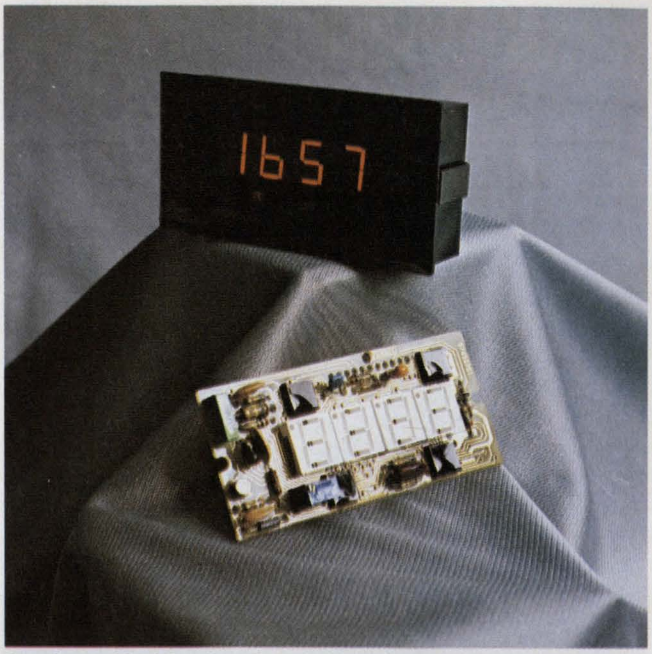
Temperature changes wreck readings

Some suppliers don't say much about temperature, either. The accuracy they claim may be attainable only at one temperature—room temperature, somewhere below normal room temperature, or wherever a manufacturer was able to get the best performance. What you really should know is the worst-case accuracy over the temperature range your product is likely to encounter. That may be stated as an accuracy at one temperature and as a temperature coefficient, or as a single spec covering a range of temperature.

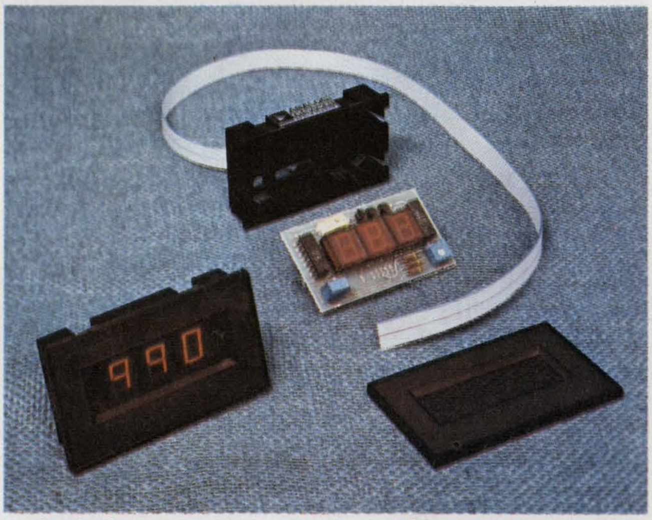
Temperature effects are most important for products that are going to be moving from place to place, especially outdoors. Humidity, too, can affect portable instruments enough to make readings meaningless, so see if your supplier will guarantee operation over a reasonable humidity range. "Reasonable" may be as high as 90% if you expect to work outdoors.

Readings shouldn't wander

Even the most efficient DPMs consume some power and generate some heat, so sensitivity to ambient temperature isn't the whole story. How stable is the reading if the internal temperatures of the unit are changing? More important, how long does it take the instrument to warm up? It takes a few minutes for the innards of most instruments to rise from room temperature to a stable operating temperature, and readings taken during this period are unreliable.



One board holds all in Fairchild's low-cost DPM. Integrated circuits are bonded directly to the board, which also holds discretes and displays. Behind-panel depth is only 3/4 in.



A single integrated-injection-logic chip is at the heart of Analog Devices' three-digit Model 2026. The chip is available separately for do-it-yourself OEMs.

Few manufacturers spell it out, but the time it takes for an instrument to stabilize can be very important to you, especially if you (or your customer) don't leave the meter on all the time.

Readings can wander too if the power-supply voltage varies. With the possibility of power brownouts increasing, or simply with operation from batteries, resistance to power-supply fluctuations can be important.

Check especially for stability with no measuring input voltage. Many applications call for making an

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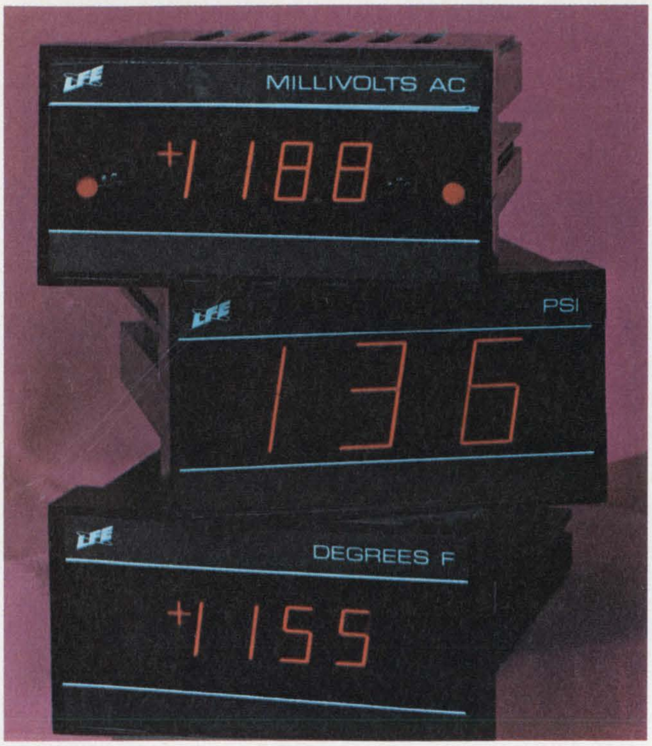


For process-control applications, DPMs like these LFE units include signal-conditioning and direct readout in engineering units. Meter relay-like setpoints are available.

You can color your DPM display any way you like with a transmissive LCD display and color filters. These Ballantine DPMs are made under license from Tekelec Airtronic.

adjustment until the meter reads zero, and that's next to impossible to do if the reading is jumping from +1 through 0 to −1 and back again.

On the other hand, the problem might be that you've chosen a meter with too much resolution. A 1-mV full-scale, 3 1/2-digit (1999-count) instrument, if you could buy one, changes one count in the least-significant digit for every 1-μV change in the signal to be measured, so you couldn't very well expect to adjust a signal for a reading of precisely 0.000 if the signal itself wandered by a few microvolts. Unnecessary resolution costs unnecessary dollars—a 4 1/2-digit instrument costs about 50% more than a similar 3 1/2-digit device—so don't buy more resolution than you really need.

Don't forget, either, that a 3 1/2-digit meter actually has the same resolution as a 4 1/2-digit meter with a decade-higher full-scale range. Readings of 19.99 V on the 3 1/2-digit and 199.99 V on the 4 1/2-digit have the same 0.01-V resolution, so the less expensive instrument may be good enough if the range of input voltage is small.

Above all, remember that resolution isn't the same as accuracy. Don't be embarrassed if you forget—it's the most common error made when specifying any digital product. But just because a digital panel meter can resolve 0.1 V doesn't mean it can do so accurately. A 3 1/2-digit meter that has error sources adding up to more than 1% of full-scale has a least-significant digit that is meaningless—it can read any value, regardless of what it is measuring, and still be within resolution and accuracy specs.

Note the expression "full-scale." Most DPM suppliers specify accuracy as a percentage of full scale plus a percentage of reading, then add any temperature or other effects. Others specify the allowable variation in the least-significant digit. That's the same thing—if full-scale is adequately defined.

So what is it?

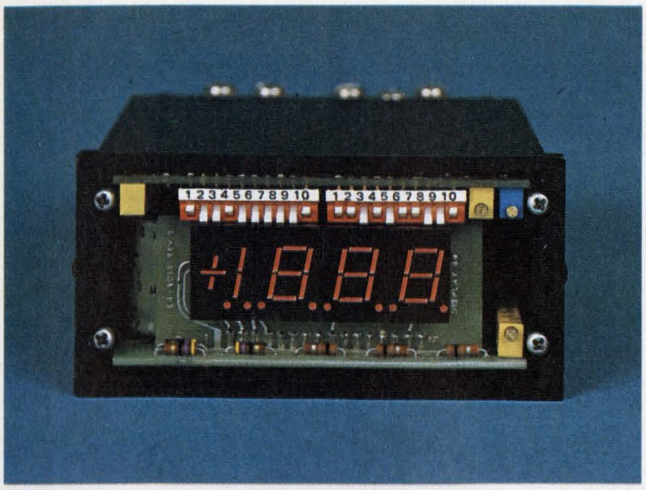
Some manufacturers say a 3 1/2-digit instrument has a 100.0-V full-scale range, then add an "overrange" of 100% for a maximum reading of 199.9 V. In another case, the overrange may be 20% above a 100.0-V full-scale, so the maximum reading is 120.0 before the instrument's readings become unreliable. Yet another variation has more than 100% overrange so that the maximum reading may be 299.9 V, 399.9 V, or even 699.9 V. The safest way to specify full-scale is to specify count. That way, for example, you'll know a 100.0-V instrument can accurately measure a 120-V line. Ask for a "3 1/2-digit (1999-count)" instrument, and you should get what you need. Otherwise, you may be in for a surprise.

Speaking of definitions, try to use the term "accuracy" correctly. Accuracy and correctness are synonymous—so a meter with an accuracy *of* 1%, say, can be incorrect *by* 99%. A better term is "uncertainty," since that's what you're trying to determine—"How uncertain am I of this reading?" An uncertainty of 1% is the same as an accuracy *to within* 1%—but not the same as an accuracy *of* 1%.

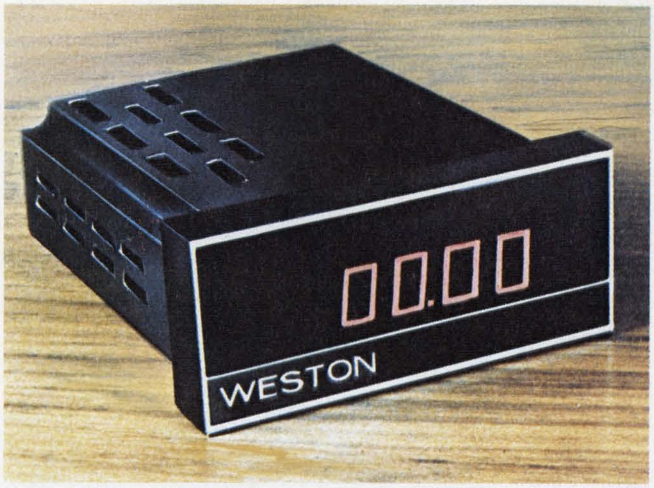
Does it keep working?

Even though reading reliability has become the paramount concern, you can't stop there. It's still possible that the instrument you choose—no matter how dependable the information it gives—won't work long enough for you to appreciate its accurate readings.

Fortunately, this is not nearly the concern it used to be. "The industry for years was notorious for



Programming controls, accessible through the front panel, tailor the Analogic AN2573 digital rate indicator. Switches select data averaging and other functions.



Zero means zero on Weston's 4 1/2-digit Model 2470. The unit has ±1-count stability at zero over a 0 to 50 C operating range, and no dead band at zero.

quality," recalls Michael J. Ryan, product specialist in display and control instruments at LFE Corp. In the old days, instruments would die shortly after the first time they were turned on.

Times have changed. The major DPM makers have put a lot of effort into improving instrument reliability. Maybe that's why they've become the major manufacturers. But there are still things to look for to make sure you don't get a DPM that's going to fall apart.

Check power consumption first. DPMs are very compact these days, so there isn't much room for air to circulate and dissipate heat. If the instrument draws more than a couple of watts, it may heat up enough to shorten its life considerably. Or you may have to provide external means—fans or heat sinks—to cool the box. These can add substantial costs to your design. At any rate, you shouldn't have to supply the crutches for an ailing panel meter.

Naturally, the power consumption you measure should be worst-case. Consumption can vary with ambient temperature and humidity, line voltage and input signal—and greatly with the number of display-digit segments lit. Don't settle for a single, simple number without qualifiers.

If you can get a sample of an instrument like the one you're planning to buy, get into it and check the temperature of the power transformer. It should be warm to the touch, but it shouldn't burn your fingers. Hot transformers don't live long, and may shorten the life of other components mounted nearby.

If the DPM's case has holes for heat dissipation, take care in selecting a mounting location. You don't want contaminants falling through the holes and shorting out internal lines.

If the case is plastic, look out for fragile tabs that can break off and leave the meter dangling in midair. If you're going to use the meter in an environment that demands protection against EMI, buy one with a metal case or a plastic case with a metalized coating that shields.

The standard interface with a digital panel instrument is through a card-edge connector. That's good enough for most applications. But if you expect to change input leads often, or need a fairly heavy-gauge wire, look for screw terminals instead. If the card-edge is better for your needs, check to see that the fingers are gold-plated to prevent corrosion.

Preconditioning cuts failures

There are some things you can't see that affect DPM reliability. Most important is how much testing the manufacturer does to weed out "infant mortality" and out-and-out failures.

Some DPM makers simply assemble the instrument—or have it assembled for them—then perform a perfunctory functional test to make sure it works. When they say "works," they mean the digits light up, though not necessarily in any meaningful way, or for long. So ask your prospective supplier exactly what he means by testing.

The most careful suppliers test all the components that go into the meter, test each board going inside as it is assembled, then burn in the completed meter. Only then, after a final test and calibration, is the meter prepared for shipment. All that effort virtually assures the meter will work.

Be careful, though, to find out what a supplier means by "burn in." Some simply turn the meter on at room temperature and with no input signal, and leave it on just a few hours. It's better to use a controlled-temperature chamber and operate the meter at a high ambient, better yet to have an input signal exercising the meter's circuitry. Even better still, burn-in should include varying the temperature and the input voltage over the instrument's rated ranges. Whatever is done, the manufacturer's burn-in cycle should last at least a day.

One performance spec that doesn't mean much is

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Neither rain nor sleet nor boiling water shall stay the Velonex ruggedized DPM from the swift completion of its appointed measurements. It's designed to meet military specifications. Warranty is two years.

Digital processing allows the 7000 Series DPM from Dynamic Sciences to work with any nonlinear transducer. It can even handle double-valued functions.

mean time between failures. The MTBF is almost always calculated from theoretical formulas that have little real meaning. And Analogic's Gordon notes that a 20-year MTBF implies a failure rate of about 5% —much too high for a component you're using in a system, despite the relatively high MTBF figure. It's better to look at the failure data the manufacturer has compiled. Gordon claims that one Analogic model has had a failure rate of less than 0.7% in the 15 months since the instrument was introduced.

But suppose your meter fails. Can it be repaired? For that matter, should it?

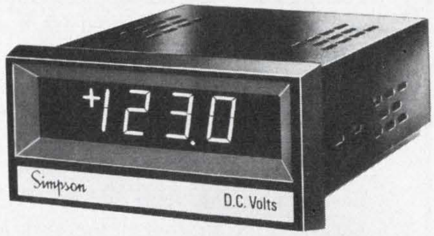
If a low-cost (under $39 or so) DPM fails, "throw it away," advises Fred Katzmann, president of Ballantine Laboratories Inc. It's probably cheaper to buy another $39 meter than to take the time—and money —to repair a broken unit. And the supplier of a low-cost meter probably won't want to fix it either, says Katzmann. But check the warranty. If it's still in effect, press for a free replacement.

Maintaining your meter

More expensive instruments should be repairable in the field or, at least, at the manufacturer's plant. To make sure the instrument you're planning to buy can be maintained, look for modularity and working space. It's almost impossible to unsolder a suspect IC or display without destroying it in the process. Plug-in display boards, displays and ICs make it much simpler to track down a fault and, once located, to repair it. And while small size has always been a design goal in DPMs, overly dense packaging will frustrate your attempts to probe the interior of a failed meter.

Modularity also extends to options like BCD outputs. If you're planning to use the DPM as part of a feedback loop or data-acquisition system, you'll want to be able to get data out of the instrument in a format that's most convenient for downstream processors.

It may even be valuable to buy a DPM with field-installable interface boards—you can add or change the board for different end uses.



Take your choice of features in digital-panel meters. Working with 240-V lines? See Electro Numerics' 3999-count full-scale range (lower left). Tekelec's LCD units draw little power (left). The tiny Non-Linear Systems DPMs are priced from less than \$50 (above left). Action Instruments adds process-oriented circuitry to Data Tech DPMs (above right). Distributors can tailor Simpson DPMs to specific applications (right). Newport Labs' Series 214 DPM draws about a watt, costs about \$32.50.

Check carefully to make sure digital outputs are compatible with your system. At one time, TTL-compatible outputs were the norm in DPMs, but higher-density, large-scale MOS chips have changed that. As a result, some DPMs now have digital interfaces with voltage swings of 12 V instead of the TTL standard 5 V.

Check the output

And even TTL-compatible outputs have problems. Ask about fanout: How many inputs can the DPM's output drive? Just as important, how long a cable can you connect between the DPM and the next input? An instrument that can drive only one low-power TTL load within a few inches of the output won't be worth much in a process-control system where cable lengths are measured in yards. But it may be good enough in a benchtop instrument, where the DPM's output is processed further on an adjacent board.

Consider also how long the data remain available. If the DPM doesn't include output latches, the data may disappear before your circuitry can grab them. You'll have to design—and pay for—your own output latches.

Check the format of the data. Some DPMs feed information out serially, and leave you to perform a serial-to-parallel conversion. Others multiplex the data from each digit, so you have to unscramble the signals. It may cost more for you to perform these functions than to buy a more expensive DPM, with these facilities built-in. In addition, multiplexed data take longer to update, so take some delays into account in your designs.

Worry about delays at the instrument's input terminals, too. To help cut the meter's susceptibility to noise, most manufacturers mount an RC-filter network at the instrument's input. True, this cuts down on an instrument's gyrations in response to spikes and noise signals, but it also slows response to changes in the input signal that you may want to measure.

Look for a settling-time spec that's compatible with your needs. In a control system, the rest of your components may not be able to react quickly enough to take advantage of a fast-settling DPM, and the lack of input filtering may make the instrument overly sensitive to noise and normal-mode signals. The settling-time spec should refer to the normal-mode rejection ratio, since input filtering affects both.

Common-mode rejection ratio and common-mode voltage are two more specs you'll have to study carefully. As with any voltage measurement, common-mode voltage has to be referred to some zero point—earth ground, signal ground or some other point. The differences can be substantial—a maximum common-mode voltage to signal ground is usually tens of volts and a maximum common-mode voltage to earth ground usually hundreds of volts.

There's another reason for checking grounds carefully. A digital panel instrument has lots of points marked "ground," and they may or may not be the same. Measurement-input low, digital circuit ground (usually for the BCD conversion circuitry), analog ground (for the instrument's power supply), and case or earth ground are all part of a DPM's circuitry. Some of these grounds may be tied together somewhere else in your system, so tying them together again inside the DPM may create a ground loop that can throw off your readings. "You can't say 'a ground is a ground

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DPI? DPM? DPI? DPI?

What's a DPM? If you think the answer to that question is simple, think again.

Back in the old days (a couple of years ago, at least), you could define a DPM fairly simply, as a voltage or current-measuring device that was small and had a single full-scale range. If you wanted to change ranges, you had to add external switching or, at least, get inside the box to reconnect jumpers or flip switches. A DPM differed from a digital multimeter (DMM) and a digital voltmeter (DVM), which had front-panel switches for range changing.

Inside a DPM, there was often enough room to wire some special-purpose circuitry so that the device read out directly in different units of measure—temperature, time, and so on. The instrument then became a digital thermometer or a digital clock/timer. For some process-control applications, these upgraded devices were called digital-process indicators (DPIs), a name you still see sometimes.

Meanwhile, back at the other end of the scale are simple readout devices, with no measurement circuitry of their own. These are also called DPIs—for digital panel indicators. Sometimes, the lowest-cost, simplest DPMs were called digital panel indicators, and sometimes the phrase was used derisively to characterize a DPM that performed so poorly it wasn't really a meter, "just an indicator."

Now there's another "DPI" to worry about: the digital panel instrument. Functionally, it's about the same as a digital-process indicator. The major difference is that its specialized circuitry is added by a DPM maker, not by an OEM buyer or a specialty firm. Digital-panel instruments include digital thermometers, digital clock/timers and even some devices—such as small, panel-mountable printers—that have no relation to other DPMs except for packaging.

What's the best way to refer to these devices? It depends on how you look at it.

You can say—rightly—that since the DPM is the ancestor of everything referred to as a DPI, "DPM" is the general term and the others are subcategories. Or you can say that a DPM is really a digital-panel voltmeter or a digital-panel ammeter, and that these two categories, along with digital-panel thermometers, digital-panel counters, digital-panel printers and the like, are classes of digital-panel instruments. All that remains is for "digital-panel indicator" to mean a readout device with either low-performance or no measurement circuitry, and "digital-process indicator" to mean a DPI that is aimed at specific applications in process-control systems.

For now, make sure you know what your supplier means by "DPI," at least until all the definitions are sorted out.

is a ground'," says George Greenfield, new-product development engineer for digital panel meters at Weston Instruments.

If you're going to be taking measurements across points that aren't referenced to earth ground, make sure the meter has true differential inputs. You can't measure across one leg of a three-phase power line, for example, with an instrument that has the low side of its measuring terminals tied to earth ground.

Check the instrument's input impedance, too. It may vary enough with temperature changes to affect measurements significantly, as well as create problems in the circuitry under test. And find out if the DPM's inputs are buffered to prevent signals from feeding out of the instrument and into the unit under test.

Some instruments have high enough offset currents to drive your external equipment haywire. Weston's Greenfield suggests shorting the meter's input terminals through a large-value resistor to check for bias currents; the meter should read no more than a couple of counts out of a 1999 full-scale.

Greenfield also suggests that you check for reversal error with a battery hooked up one way then the other. If the meter's readings don't agree except for sign, the inversion circuitry may be faulty. That could cause problems when the signal passes through zero: The instrument might not be able to track cleanly, which makes it difficult to adjust for zero readings.

Keep asking questions. For example, how does the instrument sample the input signal?

Take enough samples

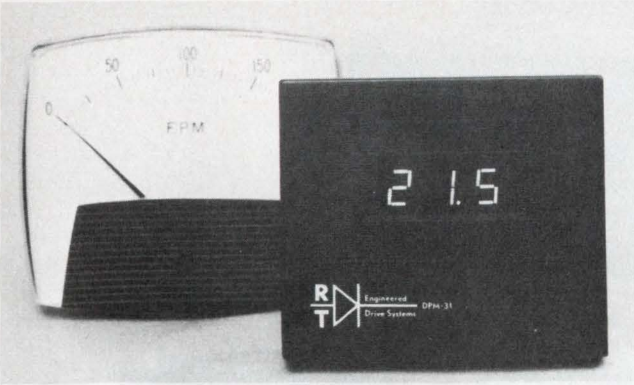
Sampling at the line frequency helps cut the effects of line-generated noise, but be sure the sampling period is appropriate for the line frequency where the instrument will be operating. Rejection of 60-Hz signals doesn't help much in a 50-Hz environment.

Very high sampling rates don't help much either if the settling time is high. Low-speed front ends make high-speed sampling meaningless.

You may want to vary the sampling rate to handle different conditions. In this case, look for a DPM with external clock controls or an external clock input.

Your product may have to operate with varying ambient lighting, too, so be sure that the DPM's display has the right brightness. The most common DPM display type, light-emitting diodes, are bright enough for most applications, but even the best LEDs get washed out in direct sunlight. If you expect ambient light always to be high, choose instead a liquid-crystal display that operates in the reflective mode. Such a display also consumes less power than a LED.

Transmissive LCDs, which have segments that turn



Replacing analog meters is another long-sought goal of DPM makers. This unit, from R.T. Engineering Service Inc. (Mansfield, MA) incorporates an Analog Devices DPM in a package designed to fit analog-meter slots.

clear when on, can be back-lighted with an incandescent lamp to make them very bright. The tradeoff is the higher power consumption of the lamp. Nevertheless, LCDs are becoming more popular in DPMs as their prices become more competitive with LED prices.

Digital-panel instruments themselves are getting to be less expensive, especially simple, voltage-reading digital-panel meters. The shift to large-scale integrated circuits has just about been completed now, so any more drastic price reductions on that score are unlikely. But LCD prices are falling. And DPM manufacturers are coming up with more efficient, less costly manufacturing techniques.

For example, a digital-panel meter just developed by Fairchild Camera and Instrument Corp.'s Instruments and Systems Group contains "chip and wire" packaging. Four IC dice, a handful of discrete devices, and the display are mounted on a single PC board, with interconnects made directly to the board. Eliminating the IC packages cuts size as well as cost. Fairchild's present line uses LED displays, but "chip and wire" DPMs with LCDs are on the way.

Low-cost DPMs use LSI chips that you can buy to build your own instrument. The I^2L chips in Analog Devices' three-digit 2026, for example, are available separately. Semiconductor suppliers, too, sell DPM chip sets.

As a result, Ballantine's Katzmann foresees users of low-cost DPMs taking on the task of designing the meter themselves. He calls excitement over low-cost DPMs "a supernova: brilliant but temporary."

That's why many DPM firms have chosen to stay away from the low-cost end of the market and concentrate on higher-priced, feature-oriented instruments. Going for hundreds of dollars, these DPMs offer custom interfaces to tie into systems for measuring temperature, pressure, and other parameters besides dc voltage. And the reading comes to you directly in engineering units like °C, psi, and gal/min.

The choice is up to you. You can get almost anything you want, but only if you know what you want—and you ask for it.■■

For more information

Not every manufacturer of digital-panel meters has been cited in this report, nor have all the variations of DPMs been described in detail. Moreover, not all firms make all types of DPMs. For more information, circle the appropriate number on the reader-service card and consult the GOLD BOOK.

Action Instruments Co. Inc., 8601 Aero Dr., San Diego, CA 92123. (714) 279-5726. (James J. Pinto) **Circle No. 501**

Amplicon Electronics Ltd., Lion Mews, Hove, East Sussex, United Kingdom. Brighton (0273)720717. **Circle No. 502**

Anadex Instruments Inc., 9825 De Soto Ave., Chatsworth, CA 91311. (213) 998-8010 (Kenneth A. Mathews) **Circle No. 503**

Analog Devices Inc., Box 280, Norwood, MA 02062. (617) 329-4700. (Steve Castelli) **Circle No. 504**

Analogic Corp., 1 Audubon Rd., Wakefield, MA 01880. (617) 246-0300. (Robert M. Shipione) **Circle No. 505**

Ballantine Laboratories Inc., Box 97, Boonton, NJ 07005. (201) 335-0900. (Marty Crowley) **Circle No. 506**

California Instruments (Cimron), a Norlin Technology Co., 5150 Convoy St., San Diego, CA 92111. (714) 279-8620. (Don Chilcoat) **Circle No. 507**

Chauvin Arnoux, 190 Rue Championnet, 18 Paris, France. 252 8255. **Circle No. 508**

Control & Readout Ltd., Timerlaine Estate, Decoy Rd., Dominion Way, Worthing West Sussex, BN14 8 ND, United Kingdom. 090 320 7116. **Circle No. 509**

Data Tech Div. of Penril Corp., 2700 S. Fairview St., Santa Ana, CA 92704. (714) 546-7160. (Robert E. Britton) **Circle No. 510**

Datel Systems Inc., 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. (Lawrence D. Copeland) **Circle No. 511**

Dynamic Sciences (Digilin), 16150 Stagg St., Van Nuys, CA 91406. (213) 893-6341. (Roger Swire) **Circle No. 512**

Electro-Numerics Inc., 1811 Reynolds St., Irvine, CA 92714. (714) 549-8821. (Philip E. Beaudoin) **Circle No. 513**

Electroplan Ltd., Box 19, Orchard Rd., Royston, Herts. SG8 5HH, United Kingdom. Royston (0763)41171. **Circle No. 514**

Exel Electronics Ltd., Wolterton Rd., Branksome, Poole BH12 1LR, United Kingdom. (0202)767373. (E. V. Newman) **Circle No. 515**

Fairchild Camera & Instrument Corp., Instrumentation & Systems Group, 1725 Technology Dr., San Jose, CA 96110. (408) 998-0123. (Don Purkey) **Circle No. 516**

Farnell Instruments Ltd., Sandbeck Way, Wetherby, West Yorkshire LS22 4DH, United Kingdom. (0937) 63541. (Peter Harland) **Circle No. 517**

Gossen GmbH, Nagelsbachstrasse 25, D-8520 Erlangen, West Germany, (09131)827-1. **Circle No. 518**

Gralex Industries Division of General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. (516) 694-3600. (Harold Steinberg) **Circle No. 519**

Industrial Timer Corp., subsidiary of Esterline Corp., U.S. Highway 287, Parsippany, NJ 07054. (201) 887-2200. (David Day) **Circle No. 520**

Integrated Photomatrix Ltd., The Grove Trading Estate, Dorchester, Dorset, United Kingdom. Dorch 3673. **Circle No. 521**

International Microtronics Corp., 4016 E. Tennessee St., Tucson, AZ 85714. (602) 748-7900. (Otto Fest) **Circle No. 522**

LFE Corp., Process Control Div., 1601 Trapelo Rd., Waltham, MA 02154. (617) 890-2000. (Michael J. Ryan) **Circle No. 523**

Metrix Instrumentation Division, ITT Instruments and Components, Chemin de la Croix Rouge BP 30, F 74010 Annecy Cedex, France. (50) 528102. **Circle No. 524**

Nationwide Electronic Systems Inc., 1536 Brandy Pkwy., Streamwood, IL 60103. (312) 289-8820. **Circle No. 525**

Newport Laboratories Inc., 630 E. Young St., Santa Ana, CA 92705. (714) 540-4914. (Mike McGaughy) **Circle No. 526**

Non-Linear Systems Inc., Box N, Del Mar, CA 92014. (714) 755-1134. (Ben W. Fisher) **Circle No. 527**

Orbit Controls Ltd., Lansdown Industrial Estate, Gloucester Rd., Cheltenham GL51 8PL, United Kingdom. (0242)26608. (P. Vlcek) **Circle No. 528**

Simpson Electric Co., 853 Dundee Ave., Elgin, IL 60120. (312) 261-8000. (Irv Linker) **Circle No. 529**

Takeda Riken Ind. Co. Inc., 1-32-1 Asahi-cho, Nerima-Ku, Tokyo, Japan. 03-930-4111. **Circle No. 530**

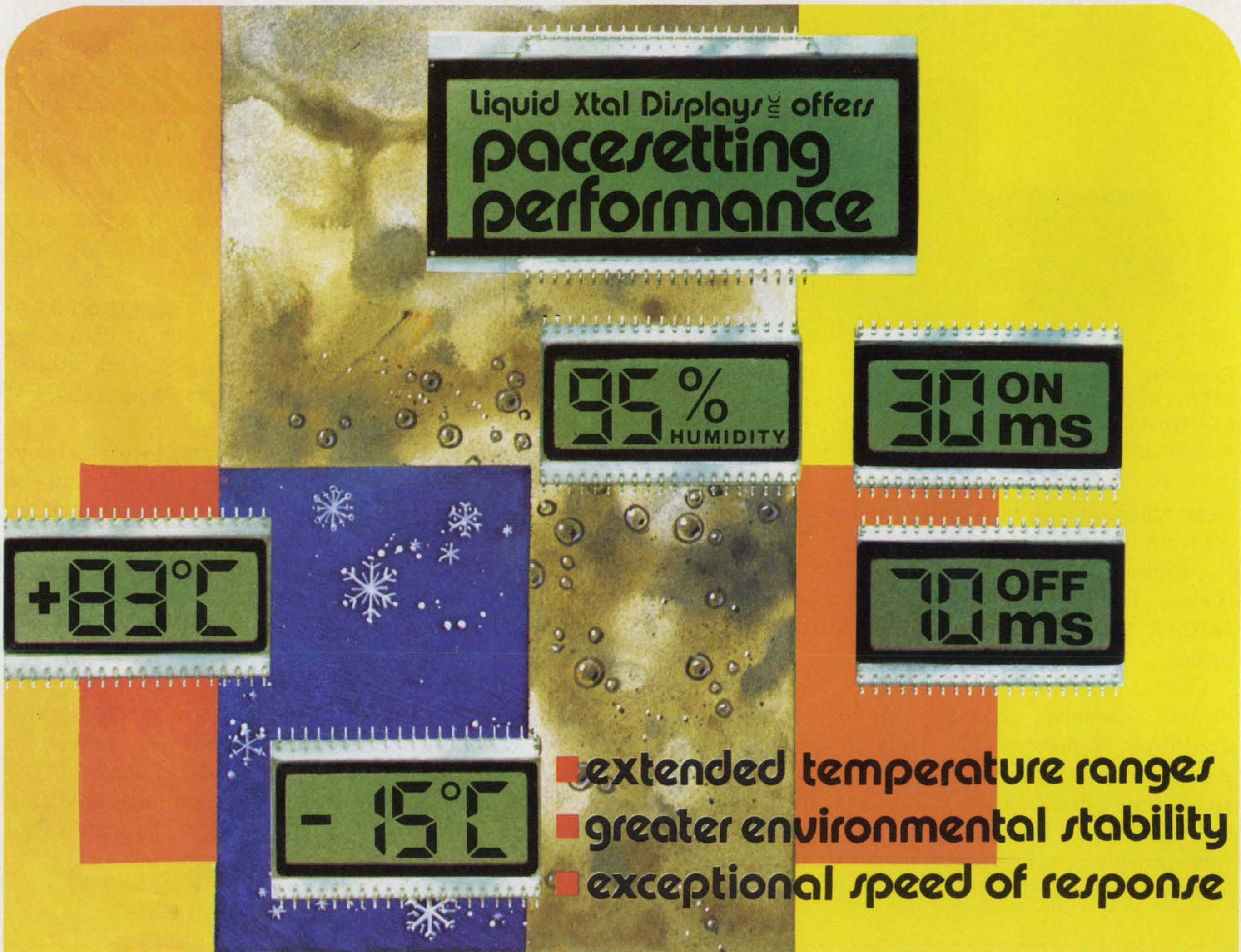
Tekelec Instruments Division, 6 Rue Louis Pasteur, (F) 92100 Boulogne, France. (1)604-81-42. (Rene Gervais) **Circle No. 531**

United Systems Corp. (Digitec), 918 Woodley Rd., Dayton, OH 45403. (513) 254-6251. (Richard Dale) **Circle No. 532**

Velonex Division of Varian Associates, 560 Robert Ave., Santa Clara, CA 95050. (408) 244-7370. (George Obinger) **Circle No. 533**

Weston Instruments Division of Schlumberger/Sangamo Weston Inc., 614 Frelinghuysen Ave., Newark, NJ 07114. (201) 242-2600. (P. Mark Rehnborg) **Circle No. 534**

Have You Mailed Your Requalification Card? See Page 45



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CIRCLE NUMBER 48

Put memory into your card reader and send data down the line serially. You'll be able to do parity checking and you'll save on cabling and hardware.

Design a serial card reader with on-board memory and error flags, and you'll avoid cumbersome, bulky cables and expensive I/O sections. With temporary storage to read the data cards (Fig. 1), serial data can be transmitted to a CPU at 9300 baud, complete with start and stop bits.

The reader tests parity first as the card data are read into memory, again as they are transferred from memory to the UART, and once more as they travel from the UART to the transmission line—this time in serial form. All the while, data are being read back into the reader. Additional checks are made for framing and overrun errors.

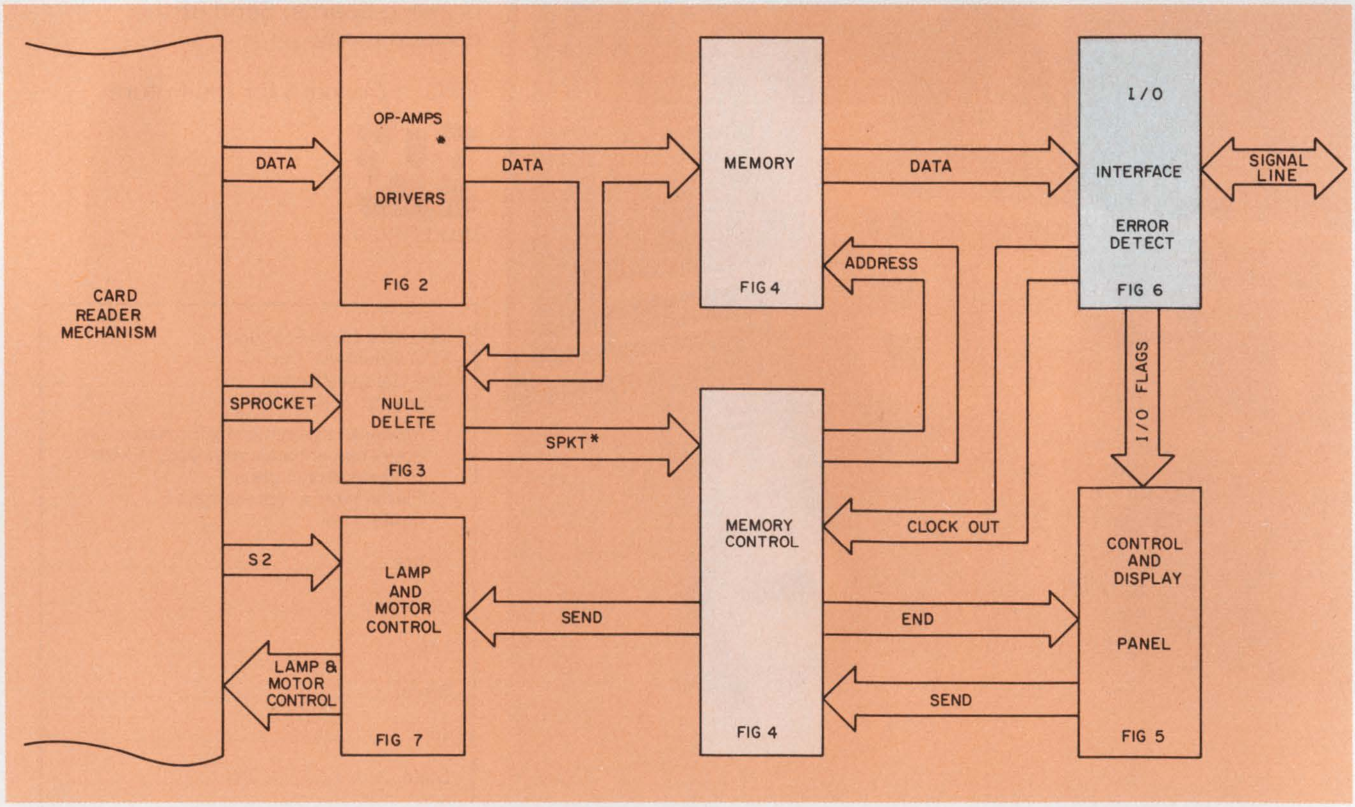
Transmission status is reported to the data terminal sending the message via the same coaxial signal line. Any number of data cards can be read into the unit prior to transmission, provided the number of characters, less NULLs, equals 255 or less.

Robert J. Stetson, Engineer, Storage Technology Corp., 10 Clay Court, Aurora, IL 60538

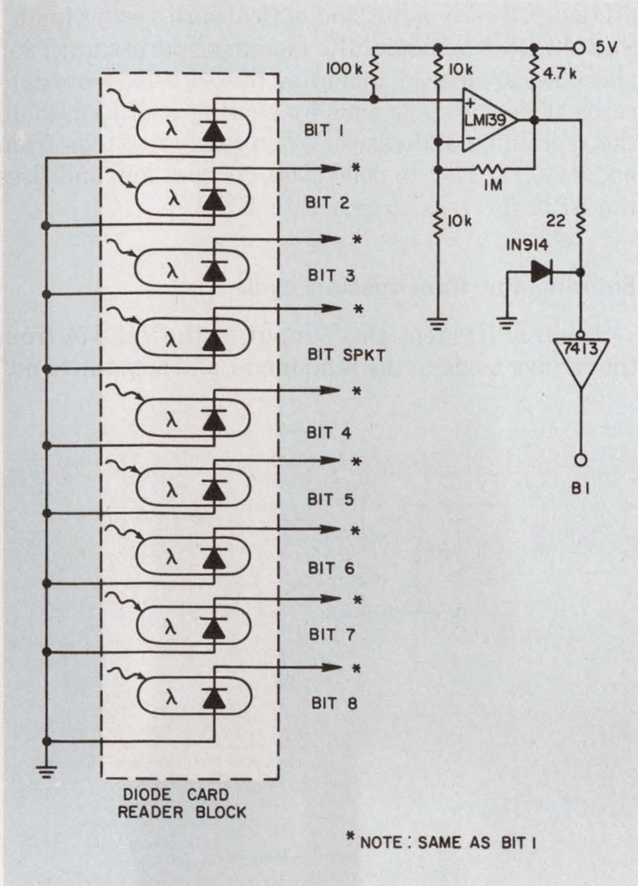
A common diode block-and-lamp assembly senses data as the card passes through (Fig. 2). All nine reader channels are identical.

The LM139 comparators in Fig. 2 are medium-speed, TTL-compatible units requiring only 5 V at about 1 mW per gate (bias circuits excluded). Noise immunity is provided with ±5 mV of hysteresis. The comparator, coupled to a 7413 Schmitt trigger by a 22-Ω resistor and a bypass diode, provides zero-crossover protection for the 7413 input, as well as a squelch circuit to dampen ringing.

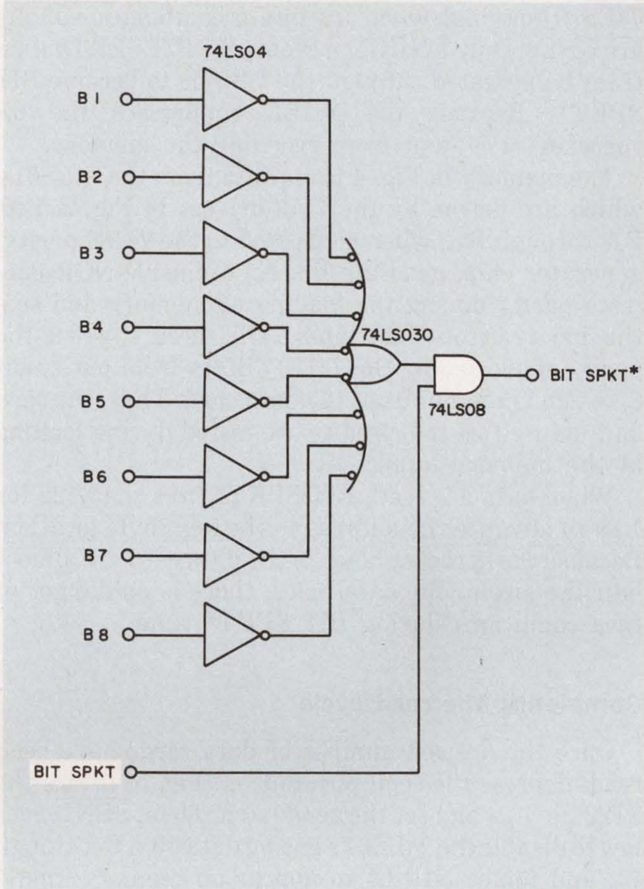
A NULL-delete circuit samples the outputs of the 7413s (Fig. 3). Bits 1 through 8 are inverted and applied to the eight inputs of a 74LS30, which acts as an OR



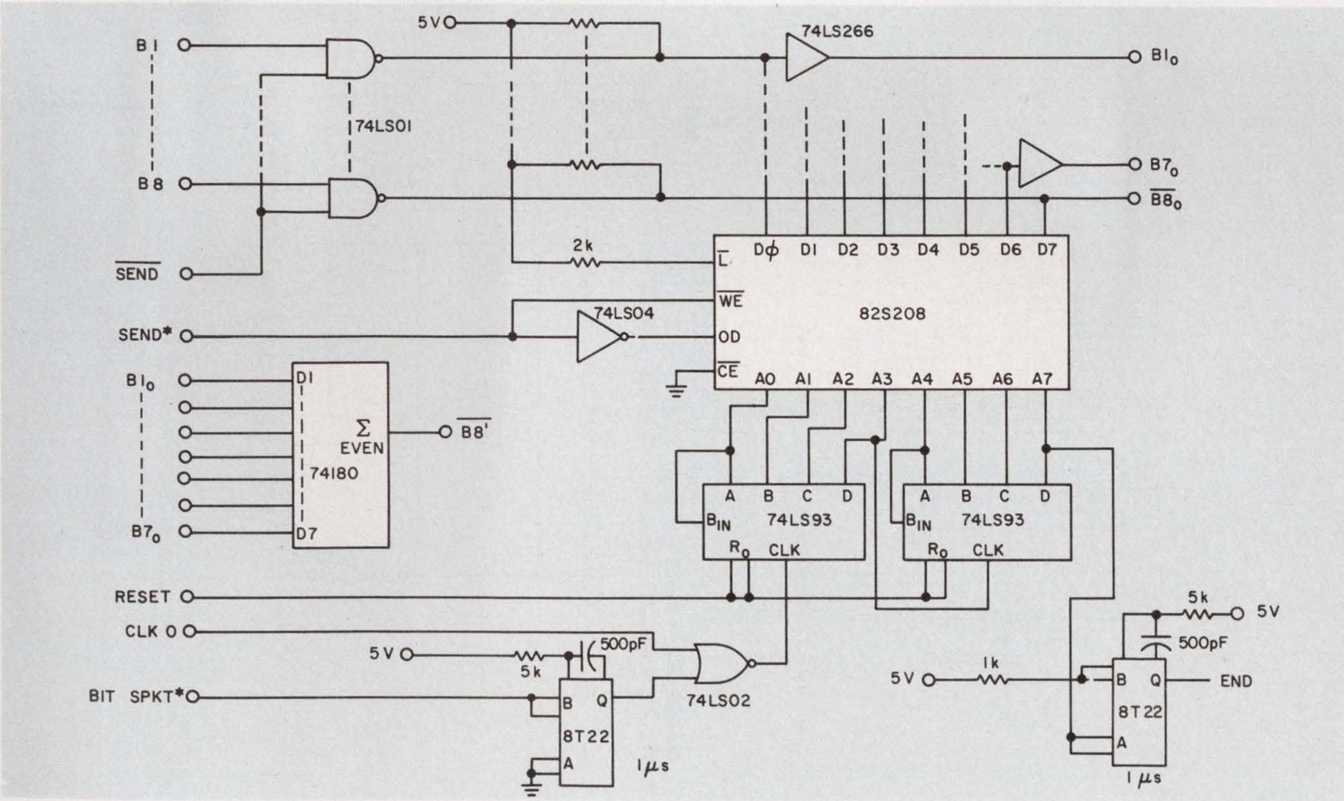
1. **Internal memory in a card reader** accepts parallel input data, delivers serial data, and simplifies the I/O design.



2. **Cards are read by a standard diode-block** assembly. IC comparators form the necessary TTL-level signals.



3. **A simple "delete" circuit** keeps the NULL signal from reaching the memory.



4. **Data are checked for parity errors** by an exclusive-NOR gate during memory loading. If the parity bit, as read in from the card, differs from that generated in the 74180, a latch is set.

gate with the inputs normally high. The output of the 74LS30 goes high when any bits or combination of bits are ONEs. Only a NULL prevents the BIT SPKT signal from being gated through the 74LS08 to become BIT SPKT*. Because the NULL suppresses the bit sprocket, it is kept from reaching the memory.

The memory in Fig. 4 loads data from the 74LS01s, which are driven by the 7413 drivers in Fig. 2. Bits $B1_0$ through $B7_0$, when connected to the 74180 parity-generator chip, generate $\overline{B8}'$. An exclusive-NOR gate tests parity during the loading of memory and sets the parity-error (PE) latch. This occurs when the parity generated by the 74180 differs from parity-bit 8, which is read in from the data card. Thus, the card data as well as the circuits are tested during loading at the memory input.

When data are read, BIT SPKT* fires the 8T22 for 1 μs to advance the address to the next byte location. Because the sprocket holes in the data card are almost half the size of the data holes, there is no danger of race conditions during BIT SPKT* time.

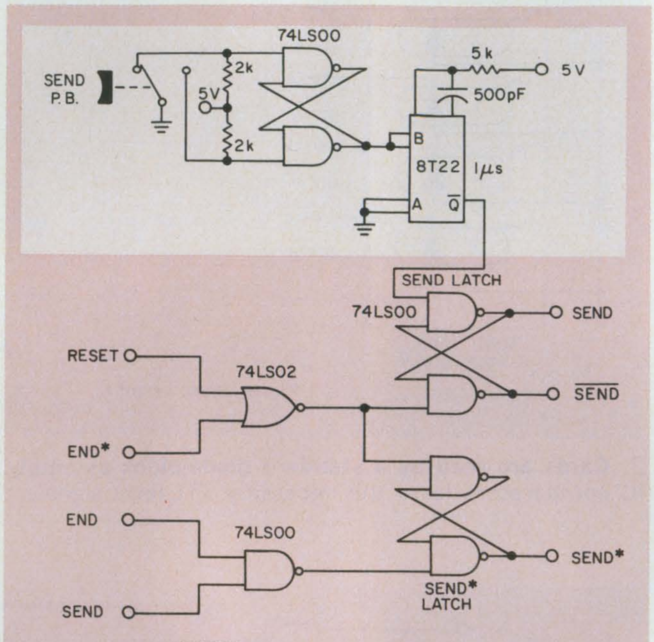
Completing the read cycle

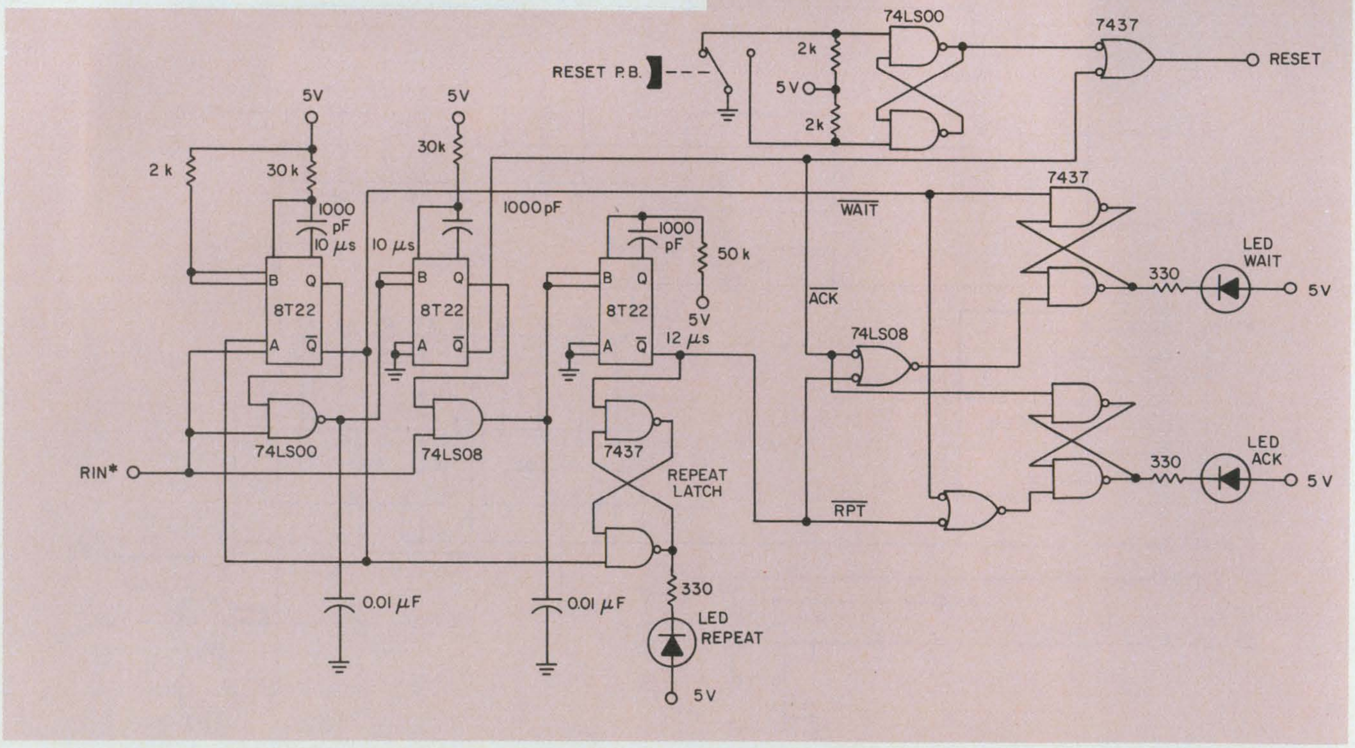
Once the desired number of data cards have been read, depress the send pushbutton (Fig. 5) to fire the 8T22 for 1 μs and set the send latch. Then, $\overline{\text{SEND}}$ goes low to disable the 74LS01's gating data bits, B_1 through B_8, and forces NULLs to appear on memory inputs D_0 through D_7. Also, $\overline{\text{SEND}}$ goes low to the Master-Reset (MR) to enable the UART (Fig. 6).

When SEND goes high at the 74LS74s in Fig. 6, it enables the timing shift registers to generate CLK 0 from the 8T22 timer. (It also resets a latch to turn off the card-feed motor and optical card-reader lamp.) Signal CLK 0 advances the memory address until 256 addresses are loaded, including those loaded from data cards. The load cycle ends by writing NULLs into all the remaining addresses. When memory steps from address 1111 1111 to 0000 0000, A_7 goes low and fires the 8T22 for 1 μs to generate END.

Entering the transmission cycle

Signal END steps the T input of the 74LS74 from the receive mode to the send mode, and sets the Send*





5. **After all cards have been read,** the send pushbutton shuts down the feed motor and read lamp, and sets up the sequence to switch from the receive to the send mode. The 8T22 fires for 1 μs.

latch. This switches the 82208 memory from the write to the read mode and enables outputs D_0 through D_7 to drive the data lines.

With the contents of address 0000 0000 on D_0 through D_7, the data drivers (74LS266s) place the contents of memory on $B1_0$ through $B8_0$. The 74LS266s are exclusive-NOR gates with one input tied to ground. In this configuration, the circuit acts as an inverting driver. Bits $B1_0$ through $B7_0$ serve as the transmitter-register inputs (TR_1 through TR_7) of the UART, where they are clocked out of TR_0 as serial data. The bits also go to the 74180 parity generator to generate $\overline{B8}'$.

An exclusive-NOR compares parity bit $B8_0$ from memory with the generated parity bit $\overline{B8}'$. Thus, data parity is tested as data are read, from the memory output to the point where the data enter the UART. But only bits 1 through 7 are read into the UART, which generates a new bit (8) along with one start bit and two stop bits. The 8T26 line-transmitter/receiver drives data out of TR_0 to the coaxial send/receive line.

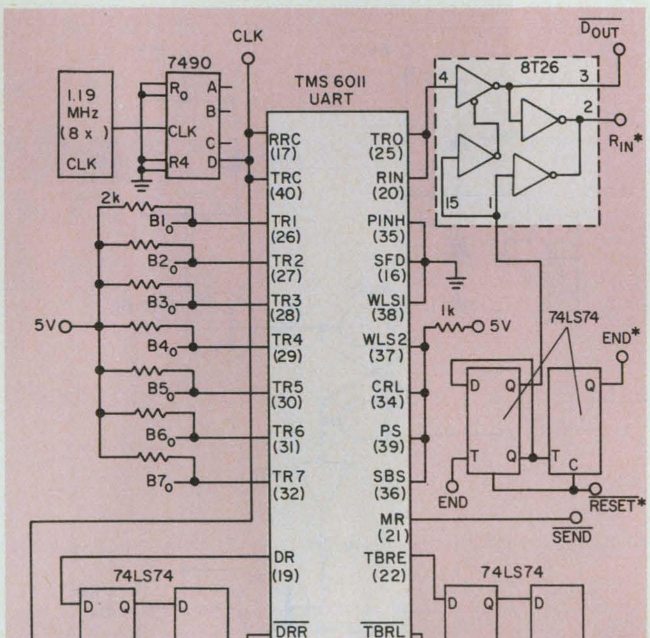
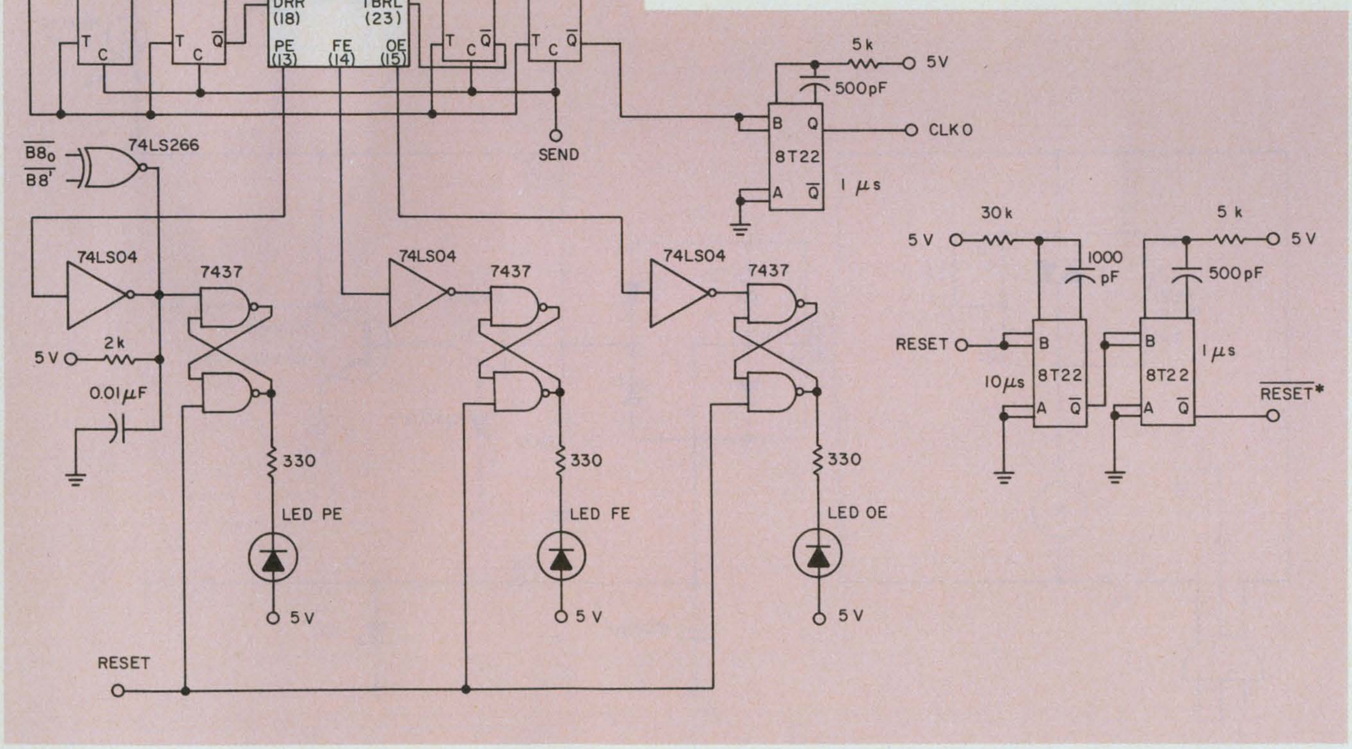
The TR_0 signal also couples back into the UART on RIN, where it is tested for proper parity in the receive side of the UART. As a result, any possible overrun error or framing error is detected. In this way, the UART and associated support circuits are tested, with each data byte, for error or malfunction out to the line driver.

Signal CLK 0 cycles the data out of memory until the address counter cycles around to 0000 0000. At that time, END is again generated on the negative transition of A_7; END also toggles the 74LS74 to switch the 8T26 from the send to the receive mode. The next 74LS74 is toggled, by $\overline{Q}$s going high again, to generate END*.

Signal END also resets both the Send Latch and Send* latch, which restores MR of the UART high and clears the 74LS74 located in the UART timing-support shift registers. The 74LS09 data gates are enabled again to read cards, and the memory switches from the read to the write mode.

Getting a message-status reply

After a 256-character data transmission, consisting of data and the appropriate number of NULLs, the

6. **Data parity is tested again** as information leaves the memory and enters the UART. The CPU acknowledges or rejects the data by feeding back a series of NULL signals. A transmitter-receiver feeds the coax output.

CPU sends back a single NULL to indicate a WAIT. Signal RIN* fires the first 8T22 only, to set the Wait latch. This tells the operator that the CPU possesses the data and to await evaluation.

When the CPU completes the successful transfer of data from the input memory, it makes one of two responses: It may acknowledge data by sending two successive NULLs back over the signal line to the card reader; or it may reject the data by sending back three successive NULLs.

For an affirmative response, RIN* fires the first 8T22 for 10 μs. Approximately 7 μs later, the second NULL gates through the 74LS00 to fire the second 8T22 also for 10 μs. This generates a RESET and an $\overline{\text{ACK}}$, which sets a latch to light the acknowledge LED. The $\overline{\text{WAIT}}$ signal goes high before $\overline{\text{ACK}}$, and, with RESET remaining on the latch, the Wait LED extinguishes. The operator now knows that good data have been processed.

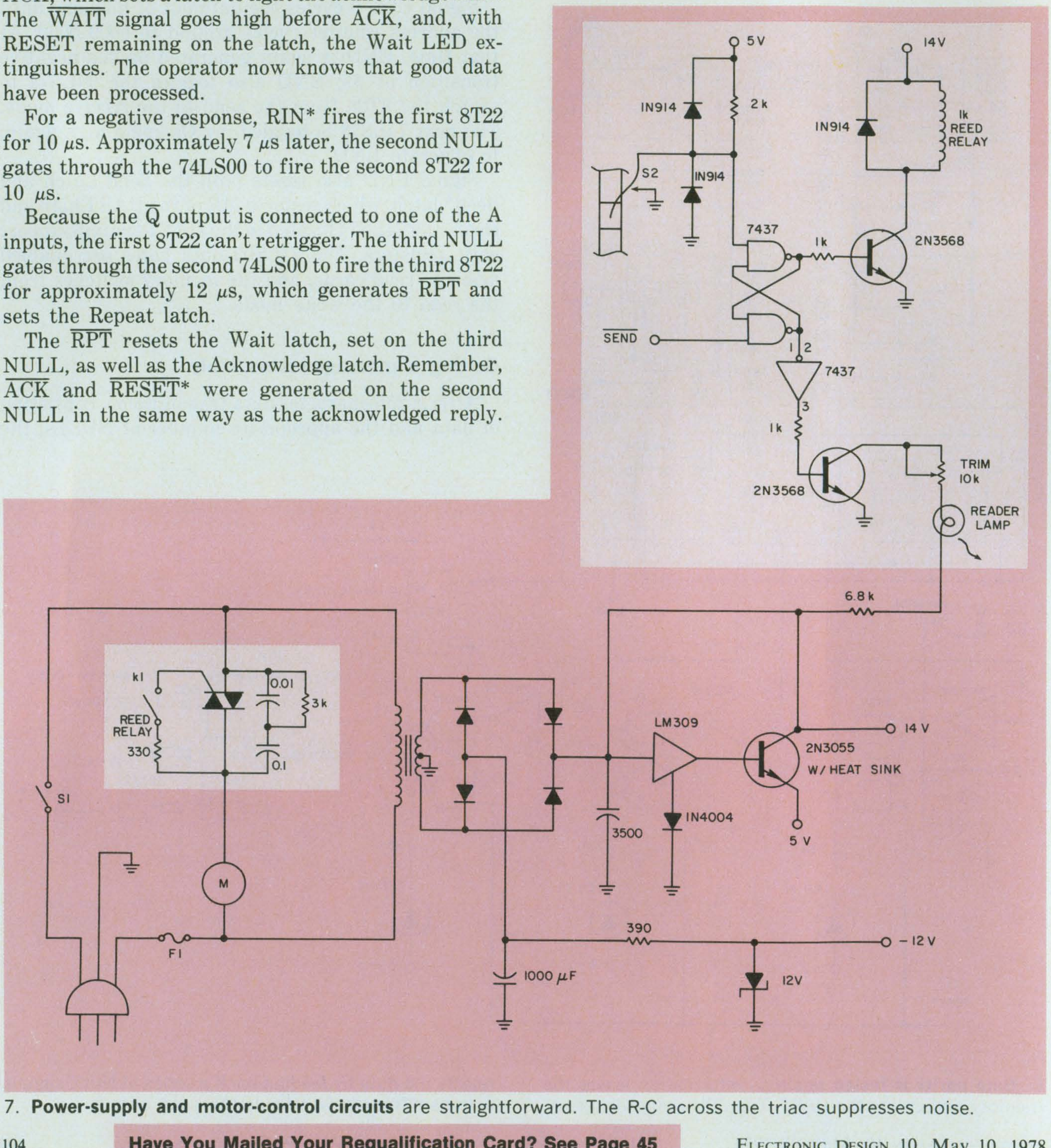
For a negative response, RIN* fires the first 8T22 for 10 μs. Approximately 7 μs later, the second NULL gates through the 74LS00 to fire the second 8T22 for 10 μs.

Because the $\overline{\text{Q}}$ output is connected to one of the A inputs, the first 8T22 can't retrigger. The third NULL gates through the second 74LS00 to fire the third 8T22 for approximately 12 μs, which generates $\overline{\text{RPT}}$ and sets the Repeat latch.

The $\overline{\text{RPT}}$ resets the Wait latch, set on the third NULL, as well as the Acknowledge latch. Remember, $\overline{\text{ACK}}$ and $\overline{\text{RESET}}$* were generated on the second NULL in the same way as the acknowledged reply.

The card-reader lamp turns on along with the motor when you insert the data card. A microswitch, with an arm extended into the path of the data card, makes contact to ground (Fig. 7) to set the latch and turn on the lamps and motor (through a reed relay and triac). (A noise-suppression network is recommended in the triac circuit.) A straightforward power supply develops 5 V for the logic and −12 V for the UART.

Shop around for a transport mechanism—a model that can read both cards and tape can automatically read and transmit tape 255 bytes at a time with only minor design changes.■■



7. **Power-supply and motor-control circuits** are straightforward. The R-C across the triac suppresses noise.

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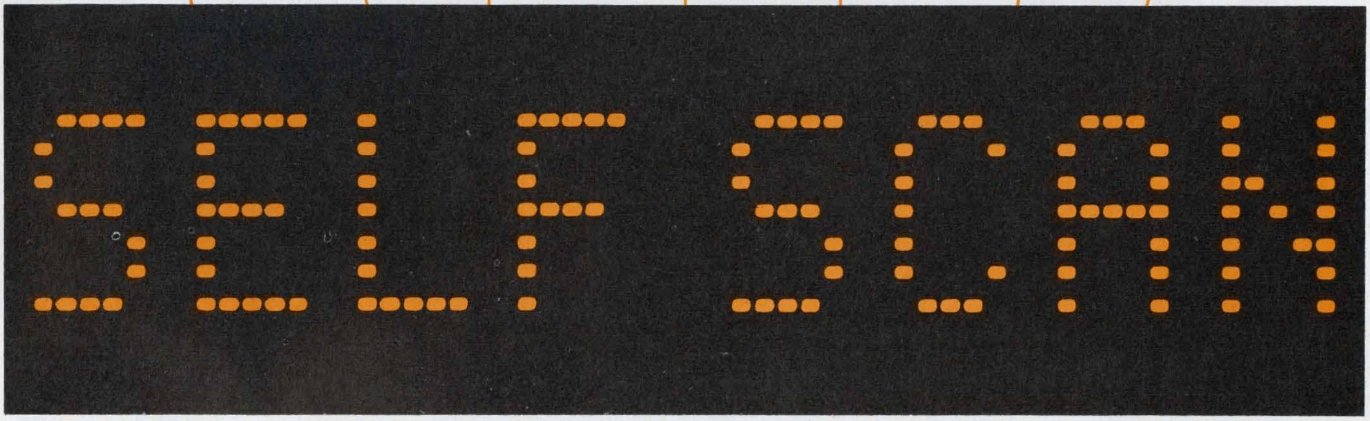

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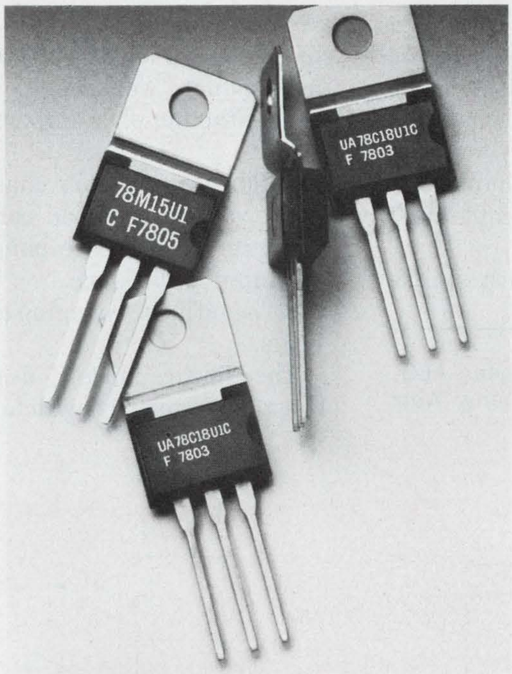
CIRCLE NUMBER 50 FOR GENERAL INFORMATION

CIRCLE NUMBER 51 FOR DETAILED SPECIFICATIONS

high in packaging pricing.



bent tab and straight tab TO-202 configuration. Either way, it only costs you forty-five cents in quantities of 100. That makes it the lowest priced 1/2-amp positive voltage regulator on the market.

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CIRCLE NUMBER 52

Upgrade your switchers analytically.

Use equivalent circuits to avoid "cut-and-try" stabilization and ripple suppression for switch-mode regulation loops.

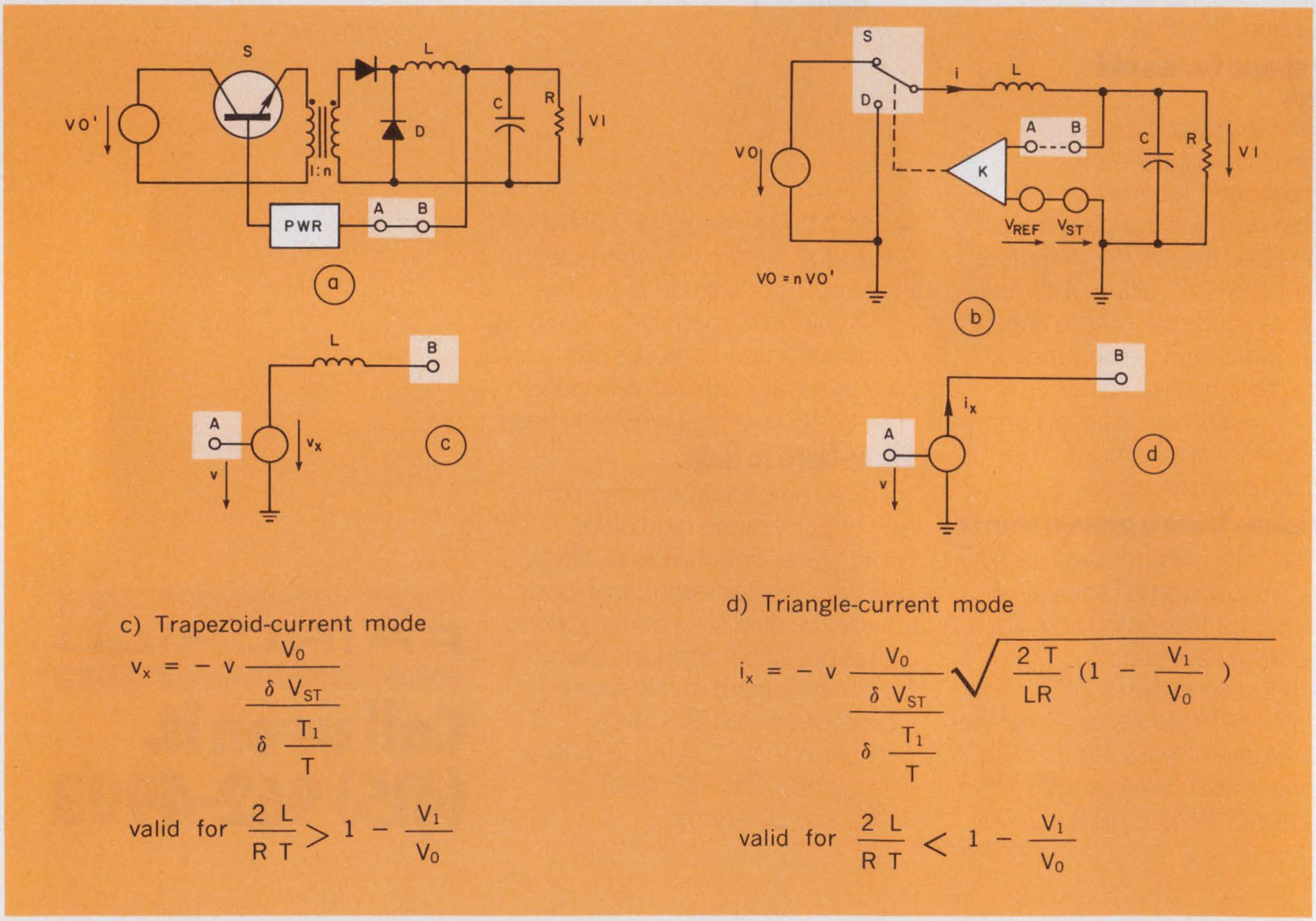
When designing switched-mode power supplies, you often have a hard time stabilizing the regulation loop and suppressing input-voltage ripple. Solutions up to now have been based on empirical data only, because there weren't any simple analytic tools available. But now, you can use recently developed linear equivalent circuits[1] for pulse-width regulators.

Using these linear models, together with simple linear-network analysis, you can simulate a switched-mode supply well enough to calculate and even optimize the supply's important properties. These include:

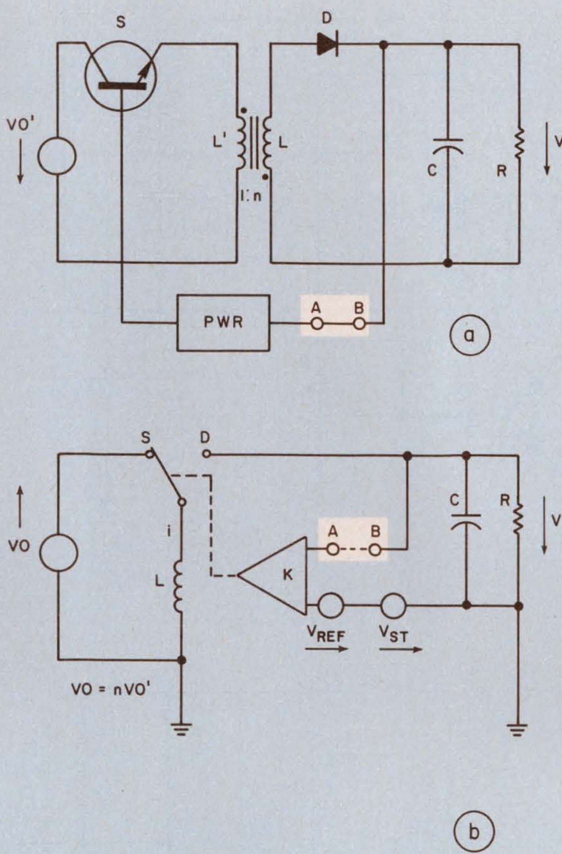
- Phase-versus-gain characteristics under various input voltage and load conditions.
- Output-voltage response to a pulsed load.
- Input impedance.
- The influence of aging and temperature on components.

The linear models describe supplies that use constant-frequency switching ($f = 1/T$) and variable-

Dr. Erich Pivit, Engineer, and **J. Saxarra**, Engineer, AEG-Telefunken N2, Gerberstasse 35, F 15, Backnang, West Germany.



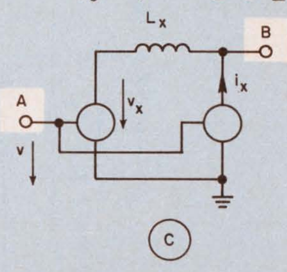
1. **A down-converter switching supply** (a) relies on constant-frequency switching. Varying the switching-pulse width regulates the output. The equivalent circuit for the entire supply (b) shows that the PWR responds to a combination of voltages: output, reference and the sawtooth, V_{ST}. The response between points A and B can be simulated by an equivalent circuit for either the trapezoidal-current (c) or triangular-current (d) modes.



c) Trapezoid-current mode

$$v_x = -v\,\frac{\dfrac{V_0}{\delta V_{ST}}}{\delta\,\dfrac{T_1}{T}}\left(1+\frac{V_1}{V_2}\right)^2$$

$$i_x = \frac{v}{R}\,\frac{\dfrac{V_0}{\delta V_{ST}}}{\delta\,\dfrac{T_1}{T}}\,\frac{V_1}{V_0+V_1}\left[\left(1+\frac{V_1}{V_0}\right)^2-\frac{R\,T}{2\,L}\right]$$

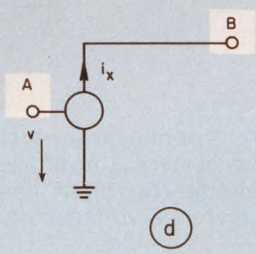


$$L_x = L\left(1+\frac{V_1}{V_0}\right)^2$$

$$\text{valid for } \frac{2\,L}{R\,T} > 1-\frac{V_1}{V_0}$$

d) Triangle-current mode

$$i_x = -v\,\frac{\dfrac{V_0}{\delta V_{ST}}}{\delta\,\dfrac{T_1}{T}}\sqrt{\frac{2\,T}{L\,R}}$$



$$\text{valid for } \frac{2\,L}{R\,T} < \left(\frac{V_0}{V_0+V_1}\right)^2$$

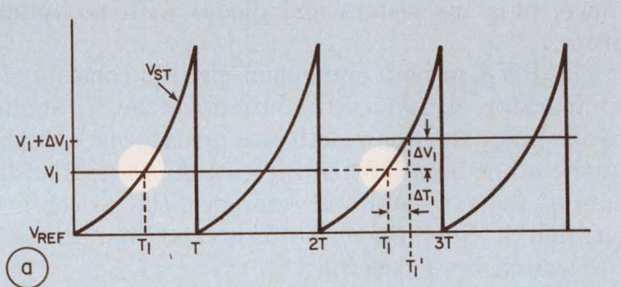
2. **An up-converter switching supply** (a) relies on the same combination of voltages (b), at K, as the down-converter. Up-converters also operate in the trapezoidal (c) or the triangular (d) current modes, depending on the load.

width pulses. The pulses come from a pulse-width-regulator (PWR) circuit that compares the supply's output voltage with an internal reference.

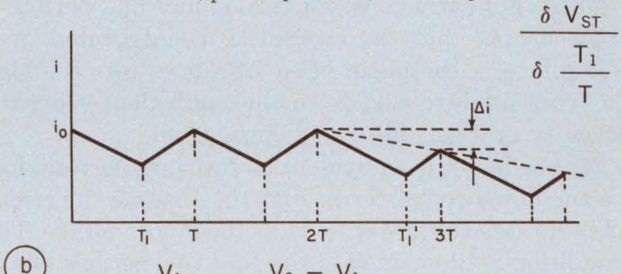
Variable-pulse-width switching supplies use one of two kinds of switching circuits: a down-converter (Fig. 1a) or an up-converter (Fig. 2a). Each can operate in either of two output-current modes—trapezoidal or triangular—depending on load resistance.

In the mode

In the trapezoidal mode, the current in the inductor, L, is always greater than zero; in the triangular mode, the inductor current can drop to zero. This difference makes the equivalent circuits for each mode of both converters different from one another.



$$T_1' = T_1 + \Delta T_1 \qquad \Delta T_1 = \frac{\dfrac{\Delta\, V_1 T}{\delta\, V_{ST}}}{\delta\,\dfrac{T_1}{T}}$$

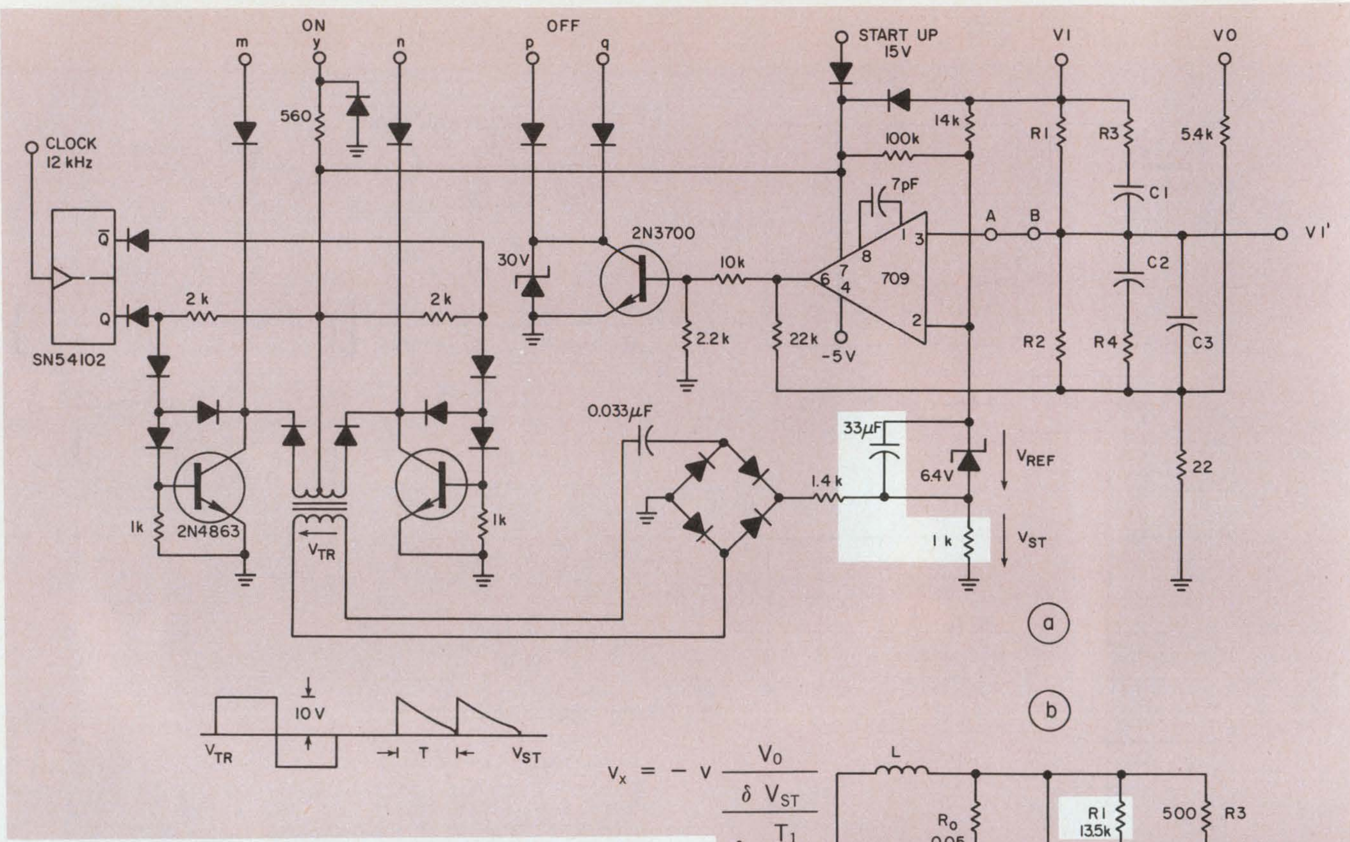


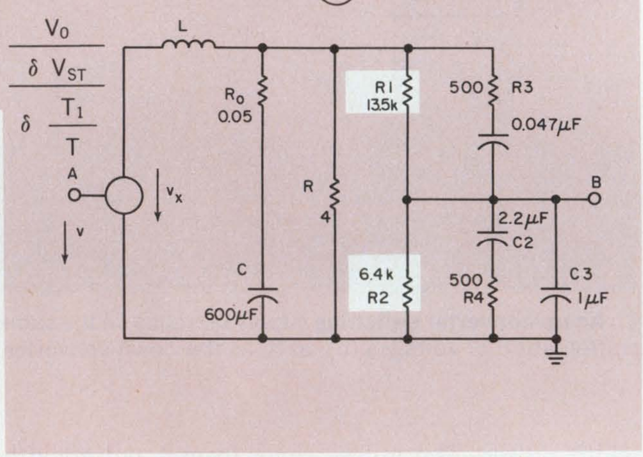
$$i_0 - \frac{V_1}{L}T_1 + \frac{V_0 - V_1}{L}(T - T_1) = i_0$$

$$i_0 - \frac{V_1}{L}T_1' + \frac{V_0 - V_1}{L}(T - T_1') = i_0 - \Delta i$$

3. **Voltage waveforms at the comparator input** (a) in the down-converter of Fig. 1b are nonlinear sawtooths. The corresponding current (b) that passes through the inductor and into the load is further smoothed by integration in the converter's output filter capacitor, C.

Have You Mailed Your Requalification Card? See Page 45





4. **A nonlinear sawtooth compensates the PWR** in a down-converter (a). A voltage divider, as shown in the equivalent circuit (b), often helps by balancing the output and reference voltages against each other.

The equivalent circuit for the down-converter is shown in Fig. 1b, for the up-converter, in Fig. 2b. Both these equivalent circuits assume that the components are ideal: lossless transformers with no leakage inductance, plus transistors and diodes with no voltage drops.

The PWR in both equivalent circuits consists of a comparator, K, that has the output voltage, V_1, applied to one input and a sawtooth plus the reference voltage at the other input. When the output is less than the sum of the sawtooth and reference, the switch is in position S. When the output is greater than the sum, the switch is in position D.

Capacitor C is large enough so that the output voltage is nearly constant throughout one period, T. This means that the current, i, is integrated in C. Therefore, $\bar{i}$, the mean value of i, goes into the load, R. This analysis[1] leads to the equivalent-generator circuits of Figs. 1c, d and Figs. 2c, d.

To see how the equivalent circuits are derived, look at the down-converter in Fig. 1b. Assume the circuit is in its steady state with V_0 as the input voltage. This condition is illustrated in the first two periods of Fig. 3. Then, using periods T and T_1 as in Fig. 3,

$$\frac{V_1}{V_0 - V_1} = \frac{T - T_1}{T_1}.$$

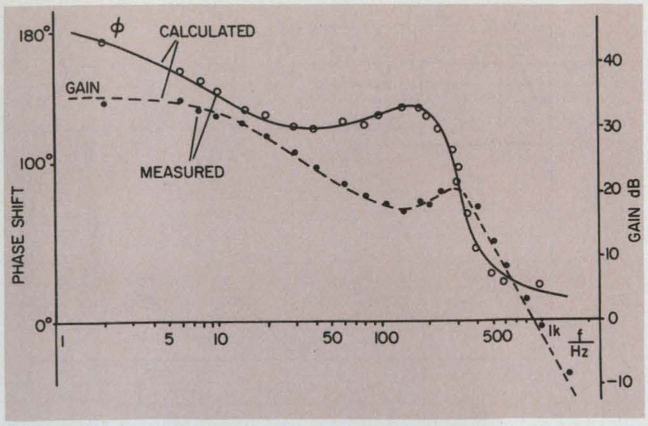
Next, open the regulation loop between A and B and apply the dc voltage, V_1, at A. The same V_1 then appears at B, which means that the circuit's steady state isn't disturbed by breaking the loop.

Take the A

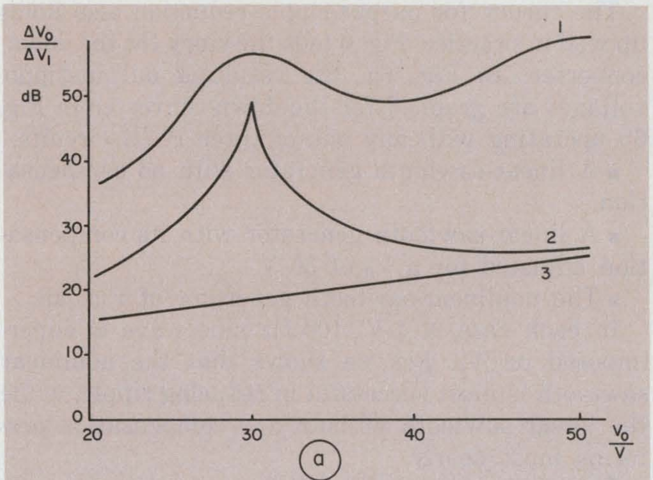
The goal of all this is to find the transfer function, from A to B, of a small, superimposed voltage. To this end, use a small step function, ΔV_1, as a probing function at A. Then calculate the short-circuit current and open-circuit voltage responses at B by using the linear equations shown in Fig. 3.

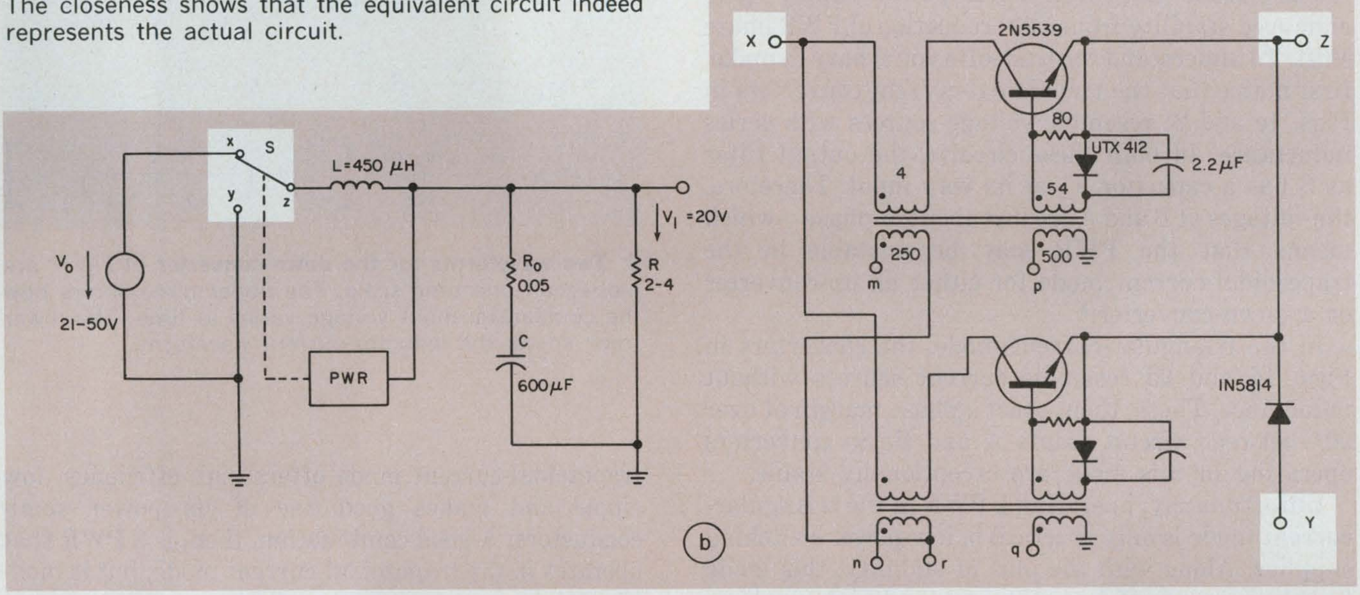
In this case, a short circuit at B means that V_B is equal to V_1, and both are constant. So the response to the probing function is shortened without disturbing the dc conditions.

Fig. 3 shows clearly that the short-circuit response at B decreases linearly with time, even though the sawtooth waveform (Fig. 3a) is nonlinear. Therefore, this response can be represented by a negative voltage-step source in series with an inductance. The response



5. **Calculated and measured gain and phase-shift** values for the down-converter PWR of Fig. 4 correspond closely. The closeness shows that the equivalent circuit indeed represents the actual circuit.





6. **Ripple reduction in a down-converter** (a) is most effective with the nonlinear sawtooth (1), less so with the linear sawtooth adjusted for best compensation (2), and least effective with the uncompensated linear sawtooth (3). The down-converter (b), including the switch, S, is operated with all three types of PWR circuits.

to the step function applied at A can be represented by a voltage-step source at B. The slope of the sawtooth voltage, V_{ST}, in Fig. 3a is

$$\delta V_{ST}/\delta(T_1/T),$$

at the switching time, T_1. Adding the equivalent-generator circuits (Figs. 1c, d and 2c, d) to complete the equivalent circuits of Figs. 2b and 3b, ensures that they represent the actual circuits between points A and B, for all frequencies.

To appreciate its utility, put your linear model to work analyzing two improved PWR circuits.

The first of these switchers develops its improved regulation from a compensation circuit. To compensate a down-converter like the one in Fig. 1, feed-forward the PWR input voltage, V_0, using the circuit in Fig. 4a. Use nonlinear sawtooth compensation

$$V_{ST} = \frac{\beta V_1}{1 - (T_1/T)}, \quad \delta = \frac{dV_1'}{\delta V_0}.$$

Though at first it may seem difficult to generate the proper time function for compensating the PWR, in most cases you'll need only the wave portion that corresponds to the input-voltage range.

This segment is easier to generate than the entire waveform. Usually, an e-function can approximate the required segment closely enough.

Fig. 4a shows how to generate the nonlinear sawtooth with an RC circuit. If needed, a decreasing sawtooth can be generated as easily as an increasing one. The up-converter of Fig. 2 can be compensated by the same sawtooth as the down-converter.

Often, a voltage divider between V_1 and the comparator input serves to match the output and reference voltages. An analog preamplifier also can increase the loop gain. Fig. 5 shows the theoretical open-loop phase and gain of the equivalent circuit (Fig. 4b) of the down-converter using a nonlinear-sawtooth PWR and measured values of the actual circuit (Fig. 4a and 6b). As you can see, the actual circuit's performance closely corresponds to the theoretical model's.

The theory for output-ripple reduction also holds up well in practice. Fig. 6 tells the story for the down-converter. In Fig. 6a, the resulting output-ripple voltages are graphed for the down-converter in Fig. 6b operating with any one of three PWR circuits:

- A linear-sawtooth generator with no compensation.
- A linear-sawtooth generator with its compensation adjusted for a V_0 of 30 V.
- The nonlinear-sawtooth generator of Fig. 4a.

In each case, a 1-V, 100-Hz sine wave is superimposed on V_0. Fig. 6a shows that the nonlinear sawtooth is most successful in reducing ripple, while the linear sawtooth without any compensation performs most poorly.

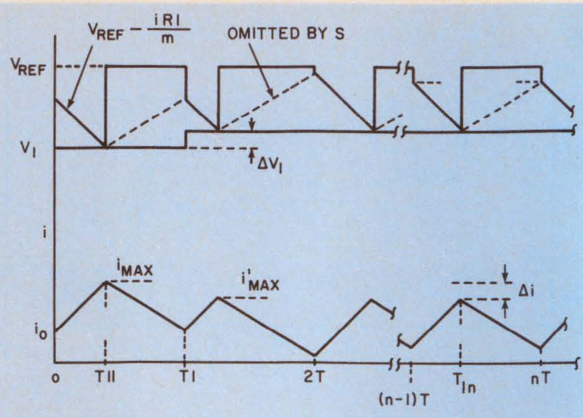
The second improved PWR power supply[2] gets enhanced stability from a 90° reduction of PWR phase shift. To understand the tradeoffs you'll have to make, first notice that the trapezoidal-current converters in Figs. 1c and 2c resemble voltage sources with series inductance. In both these circuits, the output filter at B has a capacitor, C, at its very input. Therefore, the voltages at B and A are just about in-phase—which means that the PWR may be unstable in the trapezoidal-current mode for either an up-converter or a down-converter.[3]

In the triangular-current mode, the converters in Figs. 1d and 2d resemble current sources without inductance. These, then, boast a phase margin of over 90° between circuit points A and B. So converters operating in this mode are exceptionally stable.

Unfortunately, operating a PWR in the triangular-current mode is only practical in low-power switching supplies. Along with the plus of stability, this mode has the minuses of low efficiency and high ripple as well as semiconductor-power problems.

On the other hand, a PWR that operates in the trapezoidal-current mode offers high efficiency, low ripple and makes good use of its power semiconductors. A good combination, then, is a PWR that operates in the trapezoidal-current mode, but is modified to be a current rather than a voltage source.

The down-converter circuit in Fig. 7 is an example of this combination. Here, circuit behavior is modified

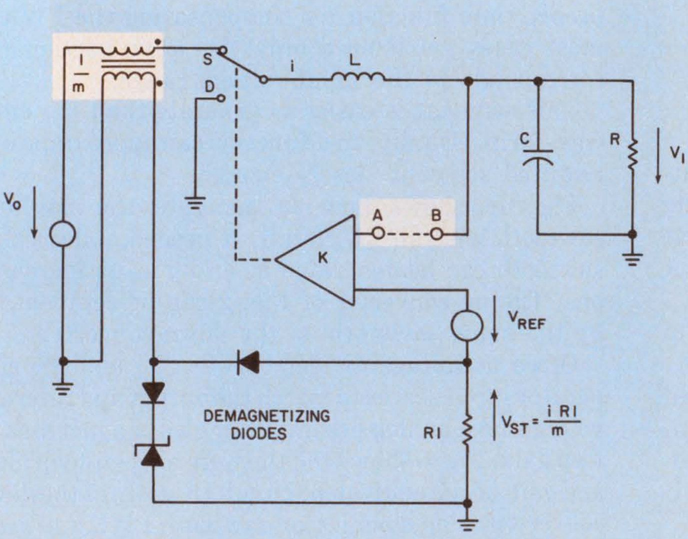


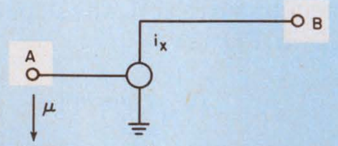
$$i_{(T_{11})} = i_0 + \frac{V_0 - V_1}{L} T_{11}$$

$$i_{(T)} = i_{(T_{11})} - \frac{V_1}{L} (T - T_{11}) = i_0$$

$$i_{(nT)} = i_0 - \frac{\Delta V_1 m}{R_1} \left[1 + \left(\frac{-V_1}{V_0 - V_1} \right)^{n-1} \right]$$

8. **Two waveforms for the down-converter** of Fig. 7 are plotted on one time scale. The upper trace shows how the comparator-input voltage varies in time. The lower trace shows the inductor-current waveform.





Trapezoid-current mode

$$i_x = -\frac{v\ m}{R_1}$$

valid for

$$\frac{2L}{RT} > 1 - \frac{V_1}{V_0} \qquad V_0 > 2\ V_1$$

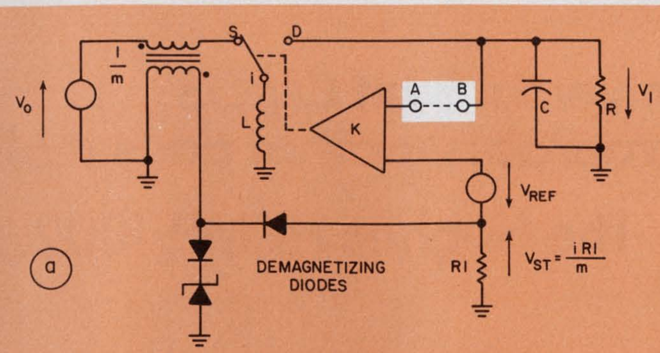
Triangle-current mode

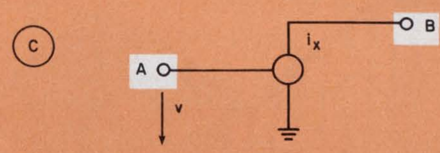
$$i_x = -\frac{v\ m}{R_1} \sqrt{\frac{2L}{RT} \left(1 - \frac{V_1}{V_0}\right)}$$

valid for

$$\frac{2L}{RT} < 1 - \frac{V_1}{V_0} \qquad V_0 > 2\ V_1$$

7. **This down-converter combines the best features:** It operates in the trapezoidal-current mode and acts as a current source. The added transformer's primary current increases linearly with time.





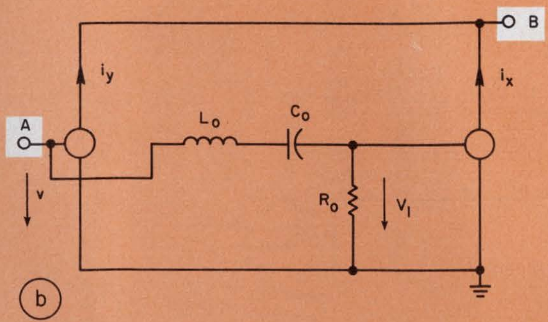
c) Triangle current mode

$$i_x = -v\frac{m}{R_1}\sqrt{\frac{2L}{RT}}$$

valid for

$$\frac{2L}{RT} < \left(\frac{V_0}{V_0 + V_1}\right)^2$$

$$V_0 > V_1$$



b) Trapezoid-current mode

$$i_x = \frac{V_1}{R_0} \qquad i_y = -v\frac{m}{R_1}\frac{V_0}{V_0 + V_1} \qquad R_0 = \frac{2\ln\frac{V_0}{V_1}}{a} \qquad L_0 = \frac{T}{a} \qquad C_0 = \frac{aT}{\pi^2 + \left(\ln\frac{V_0}{V_1}\right)^2}$$

$$a = \frac{m}{R_1}\left[\pi^2 + \left(\ln\frac{V_0}{V_1}\right)^2\right]\left[\frac{L}{RT} - \frac{1}{2}\left(\frac{V_0}{V_0 + V_1}\right)^2\right]\frac{V_1}{V_0}$$

valid for

$$\frac{2L}{RT} > \left(\frac{V_0}{V_0 + V_1}\right)^2 \qquad V_0 > V_1$$

9. **An up-converter with current-proportional-sawtooth** (a) works in the trapezoidal-current mode (b), so the supply uses its semiconductors efficiently. The triangular mode (c) has only low-power uses.

by adding a transformer between V_0 and the switch. The transformer-primary current, i, rises linearly.

The secondary winding develops a V_{ST}, that is equal to i times R_1, divided by the turns ratio, m. This voltage develops across R_1 and, of course, increases linearly with time. In either an up-converter or a down-converter, this modified V_{ST} replaces the sawtooth.

Let's get down

To see in detail how the current-source type of converter works, look at the down-converter in Fig. 7 together with the waveforms for comparator-input voltages and transformer-primary current in Fig. 8. Notice that the current and voltages are all plotted on the same time scale, to emphasize their interaction.

Open the loop between A and B in Fig. 7 and, at A, apply a dc V_1, superimposed on a probing step voltage, ΔV_1. The circuit response to this stimulus is shown in Fig. 8. After ΔV_1 is applied at A, the mean output current drops by $\Delta\bar{i}$. Neglecting second powers of ΔV_1, Fig. 8 and its equations give

$$\Delta\bar{i} = -\frac{V_1 m}{R_1}$$

Applying the same method to the up-converter in Fig. 9 uncovers similar behavior. Here, the response to a step function of ΔV_1 at A is a step function of current plus a damped oscillating current.

Fig. 9b gives the equivalent circuit for the trapezoid-current mode. For comparison the equivalent circuit for the triangular-current mode is shown, with its limits, in Fig. 9c. Both the down-converter of Fig. 7 and the up-converter of Fig. 9 have properties needed for high performance: trapezoidal-current-mode operation and current-source behavior. ■■

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1. Pivit, E., "Some Topics on the Stability of Switched Mode Power Supplies" (in German), *Frequenz 30*, No. 4, 1977, pp. 96-100; No. 5, 1977, pp. 153-156.

2. Grünsch, E., and Saxarra, J., Patent Application No. 15, 571.1, April 27, 1977, p. 27.

3. Pivit, E., "Junction Capacitances Cause Instabilities in Switched-Mode Power Supplies" (in German), *Frequenz 30*, No. 1, 1976, pp. 15-19.

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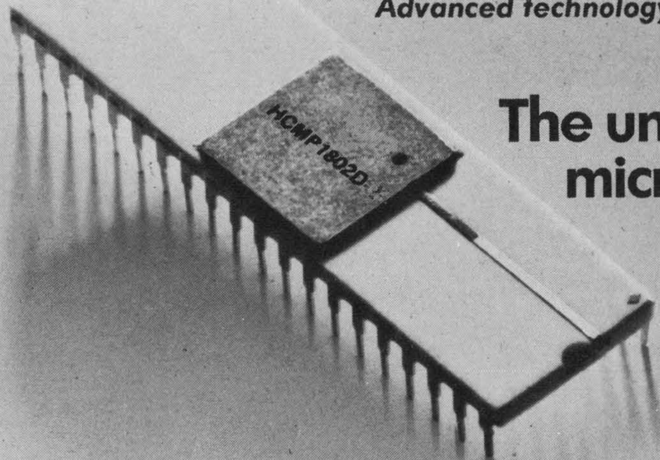

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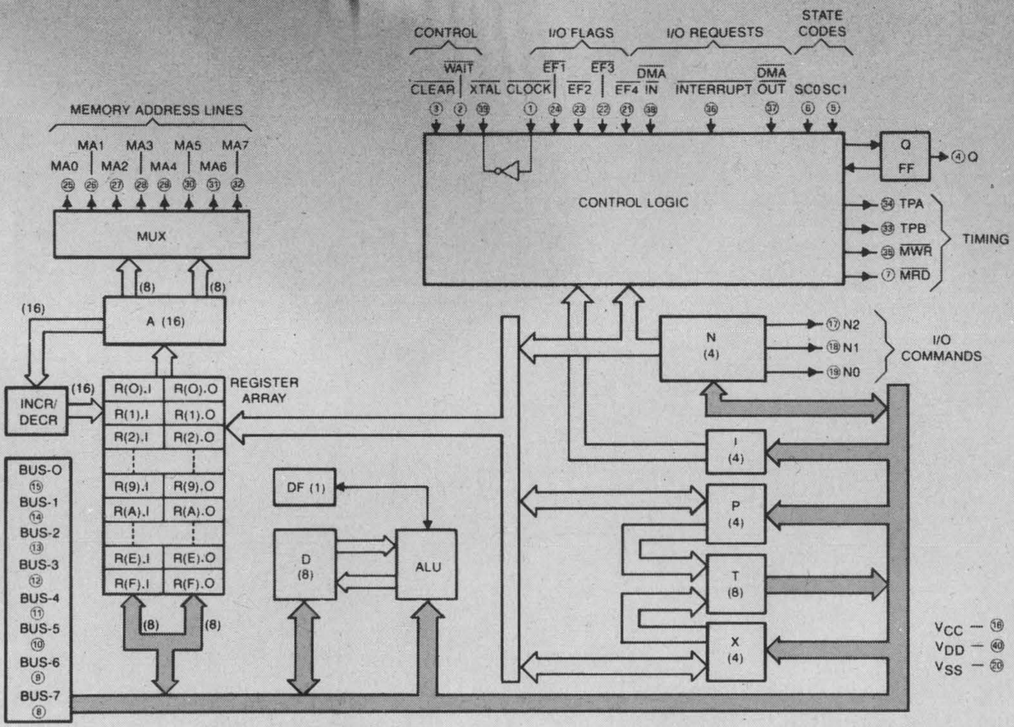

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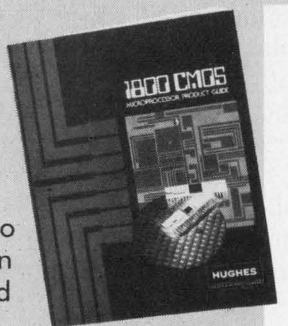

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Keep your rectifiers cool by calibrating and monitoring the forward voltage drop. This way you can keep an eye on junction temperature—and prevent burnouts.

If your high-voltage silicon rectifier is failing—even though it seems to be operating within specs—check the junction temperature. It may be too high. A simple measurement lets you determine a rectifier's in-situ junction temperature or forward-current capabilities. If the thermal capabilities of the rectifier are exceeded, the silicon will be damaged.

Since a silicon rectifier's junction temperature is linearly related to forward-voltage drop, the drop can serve as a monitor during testing. But first you should calibrate the diode voltage-temperature relationship. To do that, you'll need a temperature-test chamber and a constant-current supply with a control range of 1 to 5 mA.

Place the diode in the chamber, then measure and record the forward drop with a sensing current of approximately 1% of the normal operating current. If that value is too small to achieve a stable voltage reading, you can use a relay with a 99%/1% duty cycle, and a higher sensing current. Bring the chamber up to the rectifier's maximum operating junction temperature. Allow several minutes for the diode temperature to stabilize, apply the sensing current, and hold it for a few minutes to allow stabilization.

The sensing current won't be much—perhaps 1% of the normal operating current—so it will cause little internal junction heating. After the unit reaches stability, record the oven temperature and the forward voltage at the sensing current.

Select two or three oven temperatures, each at least 25 C below the last selection, and repeat the process. Plot the data obtained from these tests. The calibration curve you develop will help determine the thermal impedance.

Be sure to operate the test rectifiers in a draft-free atmosphere, and to monitor the ambient constantly about one inch away from the rectifier.

Fig. 1 shows a typical setup for running thermal impedance with the rectifier in air. The thermometer should be below the rectifier under test, and its accuracy should be consistent with data requirements. Calibration marks of 1 C should suffice.

Current wave shape plays a key role

The current wave shape in the rectifier should be similar to that of the intended application. Note that all tests can be made with a low-voltage circuit and the results applied to the high-voltage application.

Test circuits for a half-wave rectifier and for a single-phase, full-wave bridge are shown in Figs. 2 and 3. In both circuits, the sensing current and the simulated operational current can be applied simultaneously to the rectifier.

If the circuit doesn't permit simultaneous application, you must use a relay. With a relay, you can arrange the circuit so the rectifier operates 99% of the time with a current waveshape similar to that of the intended application, and the other 1% with the sensing current (Fig. 4). Don't forget to monitor the sensing current and voltage during the 1% calibration period.

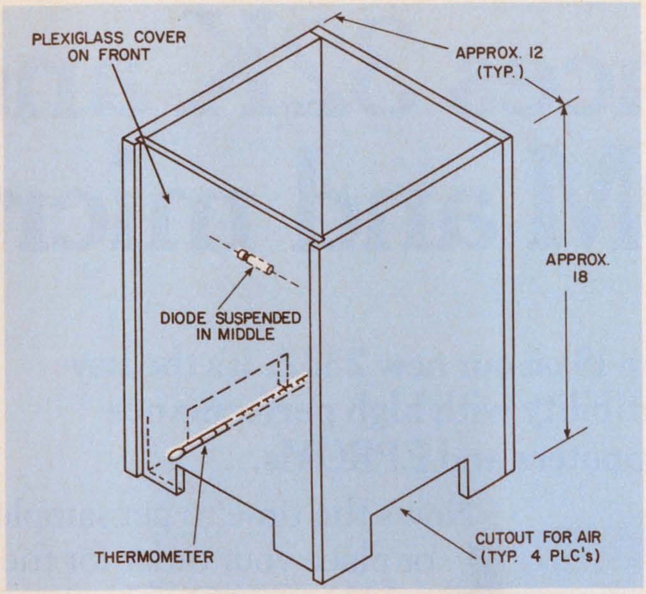
Whether you use one of the circuits shown or a circuit of your own, the sense voltage will directly relate to the junction temperature. You can increase the simulated application current or ambient temperature by one step and hold the value until junction-temperature equilibrium is reached. Then go up one step. Repeat until the forward drop indicates that the junction has reached its maximum operating temperature. At that point, record the simulated application-current value and the forward-voltage drop during the simulated current wave.

Getting the results

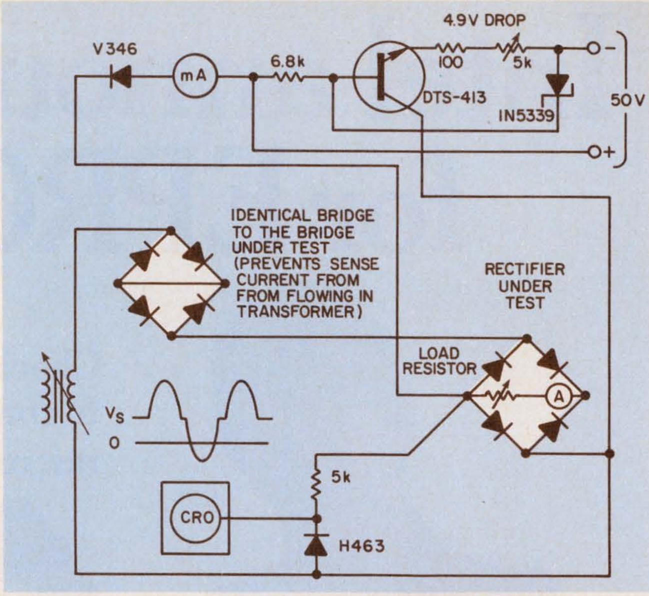
Now you can calculate the thermal impedance: Subtract the ambient temperature from the junction temperature to obtain a junction-to-ambient differential. Divide the differential by the power dissipated within the silicon to get the thermal impedance of the rectifier in °C per watt.

The added power drawn by the rectifier in blocking the high voltage can be subtracted from the forward-current power. This will reduce the forward-current limit to a safe level. (Note that switching losses, which

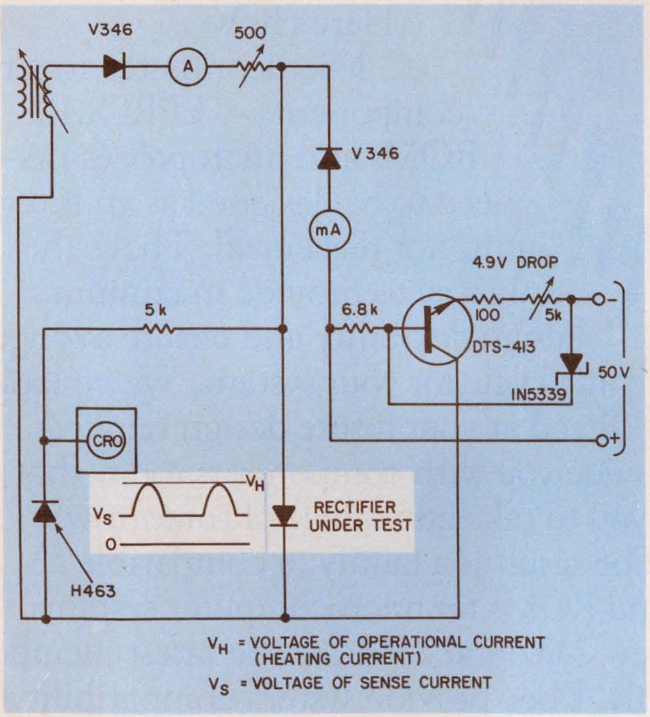
Walter Wills, Product Engineering Manager for High-Voltage Rectifiers, Varo Semiconductor, P.O. Box 676, 1000 N. Shiloh, Garland, TX 75040.



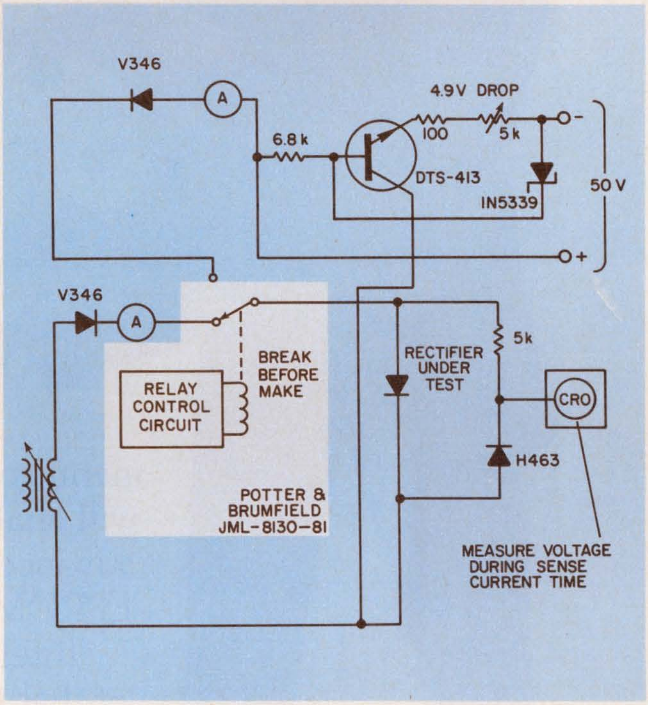
1. **A rectifier test chamber** for making thermal-impedance measurements in still air suspends the diode in the center and the thermometer beneath.



3. **Acting like a full-wave bridge rectifier,** this test circuit treats the diode as if it were in actual use in its intended circuit and applies sensing current as well.



2. **A typical test circuit for a rectifier** intended for a half-wave-circuit application applies both sensing current and a simulated operational current.



4. **When sensing and operational currents can't be applied together,** a relay arrangement switches to a sensing mode for 1% of the operating period.

may be significant, aren't included unless the simulated current wave shape includes such losses.) But bear in mind that thermal impedance may not be the main point of interest—it's usually the junction temperature during worst-case conditions.

If the rectifier is to be tested in an oven, you must keep the oven's air flow from cooling the rectifier package. Even small amounts of air flow add significant cooling, and this should be considered in light of the rectifier's final application. If the rectifier is to have air flow, then the test circuit should approximate it as closely as possible, including the amount of turbulence.

All the thermal tests can be applied no matter if the rectifier is potted, in oil or in any other environment. And since you can test the rectifier in a simulated environment, you can select the best rectifier for your application.■■

Intel announces 32K and for EPROM and micro

Check Pin 18 on our new 2332. It's the key to compatibility with high performance microcomputers and EPROMs.

Now's the time to get samples or place your order for the 2332 or 2364. They're our new 32K and 64K ROMs that will change the way you design your system. Here's how.

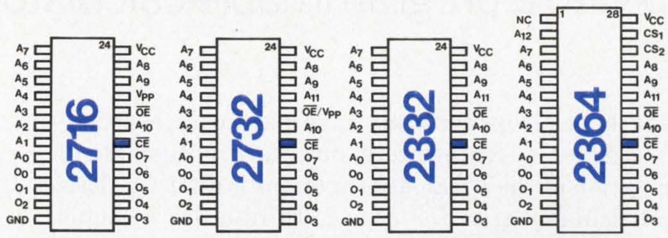
Microcomputer system components—EPROMs, ROMs and microprocessors—need to be designed as an integral unit, not piecemeal. That's the only way to provide maximum design flexibility and ensure a longer life cycle for your system. We've looked ahead at your future design requirements to provide you with components today that will enable you to take advantage of tomorrow's advances. The result is a family of compatible 5V EPROMs and ROMs for microcomputer systems.

Intel's new 2332 and 2364 are the latest members of that family. They provide system compatibility in three important ways.

First, these new ROMs have a guaranteed access time of 300 ns—fast enough to take full advantage of new, advanced microprocessors. To achieve 300 ns speed with low power dissipation, our parts are Edge-Enabled. That's where Pin 18 comes in. It provides the Chip Enable function necessary for the internal clock circuitry.

64K ROMs designed computer compatibility.

Second, the 2332 and 2364 are compatible with our 2716 industry-standard 16K EPROM and will be compatible with our 32K EPROM when it is introduced. Again, Pin 18 is the key. Note that Pin 18 performs the same power control function on all devices. So you can prototype with EPROMs and go directly to high density ROMs for production.



	16K EPROM	32K ROM/EPROM	64K ROM
Organization	2Kx8	4Kx8	8Kx8
Active Icc (max)	100 mA	40 mA	40 mA
Standby Icc (max)	25 mA	15 mA	15 mA
Access Time (max)	350-450 ns	300 ns	300 ns

Engineering the 2332 and 2364 for microcomputer system compatibility led us to the third important advance—the end of bus contention problems. In new multiplexed microprocessor systems, such as the MCS-85 and MCS-86, the Output Enable (Pin 20) needs to be independent of the Chip Enable (Pin 18) which is the power control and selection function. So the 2332 and 2364 have an Output Enable ($\overline{OE}$) for independent control of the data bus, with no possibility of multiple device selection. And input latches on all Edge-Enabled devices allow direct interface with new multiplexed microprocessors.

Low power is essential to meet today's design requirements. We've achieved low power in our 32K and 64K ROMs that can't be matched by fully static parts. Active current of the 2332 and 2364 is 40 mA (maximum). And Intel's Edge-Enabled devices have the added benefit of using Pin 18 for the power control function. So standby current is automatically reduced to 15 mA (maximum).

To get complete details on this important and complex subject, send for our 2332/2364 applications note AP-30, "Applications of Intel's 5V EPROM and ROM family for microcomputer systems." It provides board layout recommendations, system design applications, timing diagrams, function explanations and discusses PL/M modular software compatibility. Write: Intel Corporation, Literature Dept., 3065 Bowers Avenue, Santa Clara, CA 95051. Or for samples of these new parts, contact your local Intel representative.

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Analyze, don't estimate, phase-lock-loop

performance of type-2, third-order systems. You can do the job with a programmable-calculator in 48 steps, or less.

Phase-lock loops certainly have many uses, especially in frequency synthesizers, but exact mathematical calculation of their transfer functions is difficult. This is particularly true for type-2, third-order systems (Fig. 1), which don't produce steady-state phase errors for step-position or velocity signal inputs. However, a small programmable calculator, the HP-25, easily—and exactly—determines the complete loop transfer function in 48 steps. In addition, the program data reveals the noise reduction you can expect for the loop's voltage-controlled oscillator (VCO), as well as the loop's stability.

Most other design approaches must resort to second-order loop approximations to simplify calculations; a more exact method manually would take too long.

Unlike a type-1 loop, a type-2 loop has two *true* integrators within the loop—a VCO and an integrator/filter after the phase detector. Replacing the integrator/filter with a passive-RC, low-pass filter results in the more common type-1 response, which doesn't have the phase coherence for step and velocity inputs between the two signal inputs to the phase comparator that the type-2 has.

Moreover, a third-order loop—the order is usually determined by the transfer function of the integrator/filter ($F_{(s)}$)—can reduce VCO noise substantially, without increasing reference-frequency sidebands in the output signal. These sidebands hamper simpler loop-circuit performance.

The transfer function of a generalized phase-lock loop can be represented as follows (Fig. 2):

$$\frac{\theta_o\ (s)}{\theta_i\ (s)} = \frac{G_{(s)}}{1 + G_{(s)}H_{(s)}} \tag{1}$$

where, from Fig. 1

$$G_{(s)} = (K_p)(F_{(s)})(K_v/s) \tag{2}$$

and

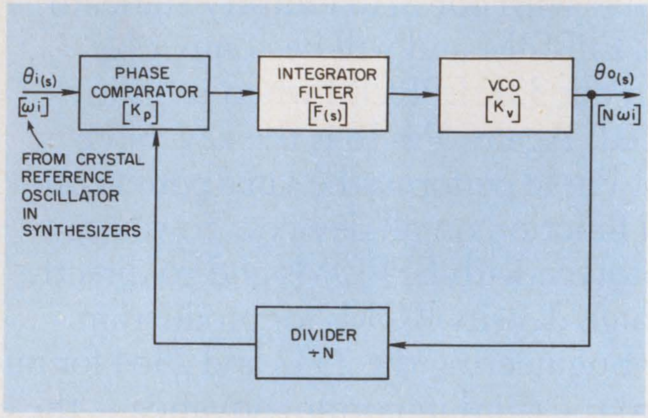
$$H_s = 1/N. \tag{3}$$

The phase comparator transfer function is K_p and N is a digital counter/divider factor.

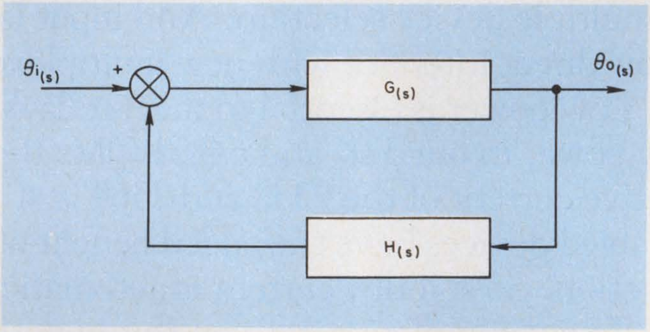
A typical integrator/filter built around an op amp (Fig. 3) has a transfer function determined by the amplifier-circuit's closed-loop gain,

$$A_{CL} = -\frac{Z_f}{Z_l},$$

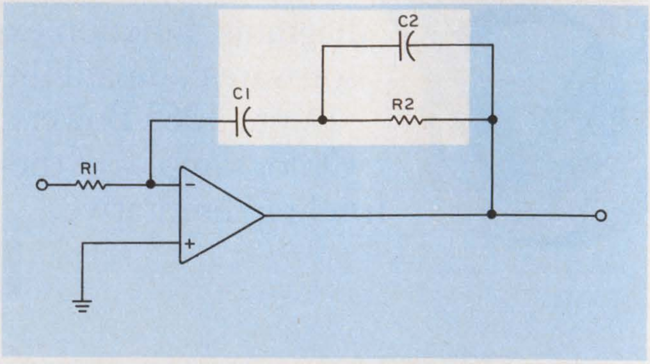
Andrzej B. Przedpelski, Vice President of Development, A.R.F. Products Inc., 2559 75th St., Boulder, CO 80301.



1. **A type-2 phase-lock loop** has two true integrators—the integrator/filter (F_s) and the VCO (K_v). Replacing the integrator/filter with a passive-RC network converts the circuit to a type-1 system.



2. **The phase-lock loop's generalized open-loop transfer function,** $G_{(s)}$ $H_{(s)}$, has a third-order denominator—from which the circuit's name is derived.



3. **An integrator/filter circuit** can be built with a wideband op amp and RC feedback network.

where $Z_1 = R_1$ (4)

Z_f = impedance of feedback network

The transform of the feedback network is

$$Z_f(s) = \frac{s(C_1+C_2)+\dfrac{1}{R_2}}{sC_1(sC_2+\dfrac{1}{R_2})}, \tag{5}$$

and the integrator/filter transfer function is then

$$F_{(s)} = -\frac{s(C_1+C_2)+\dfrac{1}{R_2}}{C_1R_1(sC_2+\dfrac{1}{R_2})}, \tag{6}$$

Multiply Eq. 6 by R_2/R_2, then

$$F_{(s)} = -\frac{s(C_1R_2+C_2R_2)+1}{sC_1R_1(sC_2R_2+1)} \tag{7}$$

or

$$F_{(s)} = -\frac{sT_2+1}{sT_1(sT_3+1)}, \tag{8}$$

where $T_1 = R_1C_1$

$T_2 = R_2(C_1 + C_2)$

$T_3 = R_2C_2$

The open-loop transfer function of Fig. 2 is $G_{(s)}H_{(s)}$; therefore, from Eqs. 2, 3 and 8

$$G_{(s)}H_{(s)} = \frac{s(T_2)(K_vK_p) + K_vK_p}{s^3NT_1T_3 + s^2NT_1} \tag{9}$$

Note the third-order denominator, from which the circuit's name—third-order-loop—is derived. Note also the deletion of the minus sign: the circuit configuration (a phase inverter) provides the negative feedback. Both K_p and K_v are positive.

If you substitute $j\omega$ for s in Eq. 9, you can get the equation for plotting the magnitude and phase of the circuit's open-loop gain as a function of frequency:

$$G_{(j\omega)}H_{(j\omega)} = -\frac{j\omega(T_2)\,(K_vK_p) + K_vK_p}{j\omega^3NT_1T_3 + \omega^2NT_1}. \tag{10}$$

Table 1. Third order type-2 PLL

Display Line	Display Code	Key Entry	Remarks	Registers
00				R_0
01	15 73	(g) π		
02	61	x		
03	02	2		R_1 T_1
04	61	x		
05	23 07	STO 7		
06	24 03	RCL 3		R_2 T_2
07	61	x		
08	01	1		
09	15 09	(g)→P		R_3 T_3
10	23 04	STO 4		
11	22	R↓		
12	24 02	RCL 2		R_4
13	24 07	RCL 7		
14	61	x		
15	32	CHS		R_5 $\frac{K_p K_v}{N}$
16	01	1		
17	32	CHS		
18	15 09	(g)→P		R_6
19	24 04	RCL 4		
20	71	÷		
21	24 05	RCL 5		R_7
22	61	x		
23	24 01	RCL 1		
24	71	÷		
25	24 07	RCL 7		
26	15 02	(g) x^2		
27	71	÷		
28	23 04	STO 4		
29	14 08	(f) log		
30	02	2		
31	00	0		
32	61	x	$\lvert G_{j\omega}H_{j\omega}\rvert$	
33	74	R/S		
34	22	R↓		
35	21	x ≷ y		
36	41	—	∠θ	
37	74	R/S		
38	24 04	RCL 4		
39	14 09	(f)→R		
40	01	1		
41	51	+		
42	15 09	(g)→P		
43	15 22	(g) 1/x		
44	14 08	(f) log		
45	02	2		
46	00	0		
47	61	x	e/en	
48	13 00	GTO 00		
49				

Step	Instructions	Input Data/Units	Keys			Output Data/Units
1	Enter program					
2	Store T_1	R_1	ENTER			
		C_1	X	STO	1	
	T_2	C_1	ENTER			
		C_2	+			
		R_2	X	STO	2	
	T_3	R_2	ENTER			
		C_2	X	STO	3	
	$(K_p K_v)/N$	K_p	ENTER			
		K_v	X			
		N	=	STO	5	
3	Calculate	F	(f)	PRGM	R/S	$G_{j\omega}H_{j\omega}$
			R/S			∠θ
			R/S			(e/en)
4	Repeat step 3 for other values of frequency, F					

Table 2. Calculated loop response

Frequency Hz	Open-loop response dB	Open-loop response $\angle\theta$	Loop response to VCO noise dB
100	116.01	−179.94	−116.01
1000	76.01	−179.44	−76.01
10,000	36.06	−174.44	−35.92
94,650	0*	−139.85	3.27
100,000	−0.71	−138.58	3.30**
1,000,000	−26.25	−139.59	0.32
10,000,000	−63.21	−174.68	0.01

*Unity-gain point **Maximum overshoot

A servo-loop damping factor that appears in lower-order loops is not defined in third-order loops. Instead you determine stability by the phase margin between −180° and the phase at a frequency where the gain is unity in the open-loop gain function, $G_{j\omega}H_{j\omega}$. The larger the phase margin, the more stable the system. A phase margin of about 45° produces an adequately damped loop. More than 45° means greater stability and, of course, the system may oscillate when the margin approaches zero.

Feedback also reduces noise

Not only does feedback determine the system's stability, but it also delineates its noise-output characteristics. When running free, the VCO is considerably more "noisy" than is the circuit's reference crystal oscillator. But the circuit's feedback loop substantially reduces the VCO's output-noise spectrum, especially, at low frequencies. This particular reduction is fortunate, because the VCO's noise output has 1/f characteristics: high-frequency noise tends to fall off without outside help, but the low frequency needs the help.

An approximate expression for the loop's output phase noise is

$$\sqrt{[(|e/e_n|)(e_v)]^2 + [(N)(e_x)]^2}, \qquad (11)$$

where e_x = crystal-oscillator noise.
e_v = VCO noise.
(e/e_n) = loop's response to VCO noise.

And the loop's response to the VCO noise is

$$(e/e_n) = \frac{1}{1 + G_{(s)}H_{(s)}}. \qquad (12)$$

Although $G_{(s)}H_{(s)}$ determined from Eq. 9 is complex, only the magnitude of (e/e_n) from Eq. 12 is used in Eq. 11. Note: The greater the open-loop transfer function, $G_{(s)}H_{(s)}$, the smaller the (e/e_n), and the lower the loop's output noise. However, note also that the reference crystal oscillator's noise contribution is multiplied by the divider constant, N, though, hopefully, the crystal-oscillator noise is low.

In addition, you can get a check on the system's stability by plotting the loop's response to VCO noise (e/e_n), obtained from Eq. 12, versus frequency. You'll find that the curve has a high-pass response with a 12-dB/octave slope. For best stability, any overshoot at the cutoff frequency should be less than 6 dB. Of course, lower overshoot represents higher stability.

Clearly, the loop's mathematical analysis depends mainly upon calculation of $G_{(j\omega)}H_{(j\omega)}$ in Eq. 10.

Now comes the program

To make the calculator program simpler, rewrite Eq. 10 as follows:

$$G_{(j\omega)}H_{(j\omega)} = \frac{K_vK_p}{NT_1\omega^2}\left[\frac{-j\omega T_2 - 1}{j\omega T_3 + 1}\right] \qquad (13)$$

Table 1 contains the program that solves Eq. 13. It provides both the magnitude and phase angle, $\angle\theta$, of the open-loop response, $G_{(jw)}H_{(jw)}$, given T_1, T_2, T_3, K_pK_v/N and frequency, $f(\omega=2\pi f)$. The open-loop response magnitude is given in dB and its phase in degrees. Also, the magnitude of the loop's VCO noise response (Eq. 12) is given in dB. If answers in dB aren't required, however, seven steps can be eliminated.

To see how the program works, consider a 960-MHz transmitter recently proposed for a Navy application. It calls for a phase-lock loop with the following characteristics to generate the 960 MHz:

$$\begin{aligned} N &= 64 \\ R_1 &= 10{,}000\ \Omega \\ C_1 &= 4700 \times 10^{-12}\ F \\ R_2 &= 330\ \Omega \\ C_2 &= 470 \times 10^{-12}\ F \\ K_p &= 0.25\ V/rad \\ K_v &= 3 \times 10^9\ (rad/s)/V \end{aligned}$$

The stable crystal-oscillator reference frequency used is 15 MHz. The frequency divider and phase comparator are built with ECL logic. From the circuit component values and transfer constants we obtain:

$$\begin{aligned} T_1 &= 4.7 \times 10^{-5}\ s \\ T_2 &= 1.706 \times 10^{-6}\ s \\ T_3 &= 1.551 \times 10^{-7}\ s \\ (K_vK_p)/N &= 11.72 \times 10^6/s \end{aligned}$$

The calculator program provided the results in Table 2. Note that the phase margin at unity gain corresponding to 94,650 Hz is 40.15°; thus the loop is fairly stable. Further, the loop's response to VCO noise shows a maximum overshoot of 3.30 dB at 100,000 Hz, which confirms the loop's stability (less than 6-dB overshoot). If the phase margin is too small or you want overdamped loop operation, the program allows you to check the effects of parameter changes and get the performance you want, quickly. However, keep all additional circuit poles above the area of interest, since they reduce phase margin and stability. In addition, don't ignore the effects of stray capacitances. And use a high-gain op amp with a wide frequency response and a VCO with a wide modulation bandwidth. ■■

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Build hardware that keeps working.

Right along with functional performance, design the reliability and maintainability into your equipment.

Take care of your system's reliability and maintainability early—even as you design the logic and circuits. You can't start too soon or make the hardware trouble-free enough or too easy to service—especially in computers and related peripherals.

Once the equipment goes into use, excessive down time can damage your reputation. And hurt your customer's business. Equipment failures cost rightfully irate computer users more than just the time and charges for the repairs themselves. Error-recognition time, waiting-for-service time, retry time, system-reconfiguration time and the inefficiencies of abnormal operation all add to the bill, even when troubles are fixed quickly.

To reduce the failure rate (FR) of your hardware:

- Reduce the number of components—except where judicious redundancy lowers the FR.
- Derate components—but
- Don't underrate.
- Select low-FR components.
- Reduce temperature stresses: if necessary, provide cooling.
- Protect wire insulation.

Occasionally, even the best components fail or suffer damage. Then, your equipment should be easy to maintain. And it will be, if you provide the three major aids:

1. Planned packaging for easy access using
   - functional modules;
   - servicing-oriented cabling,
   - cable routing,
   - quick-disconnect cable terminations; and
   - well-identified components.
2. Error indication and detection using
   - LEDs, for long life;
   - sense bits;
   - test points;
   - trapping circuits, for transient errors.
3. Support documentation.

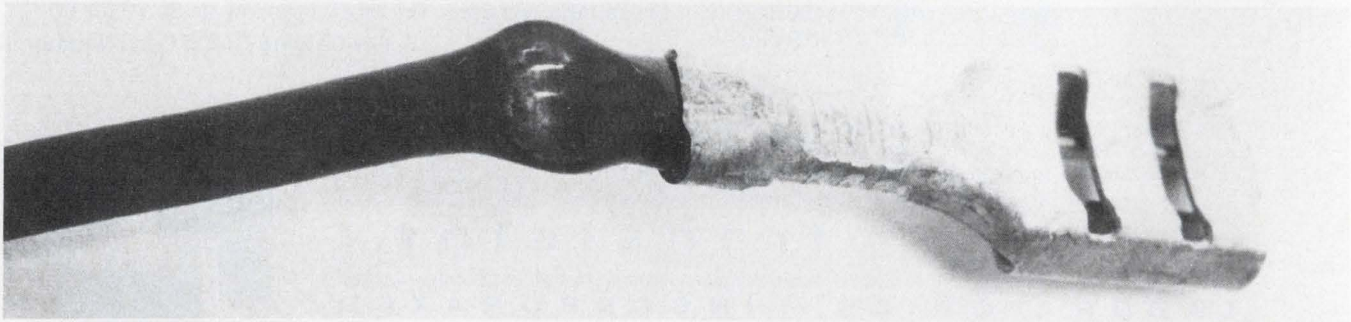
Henry B. Cary, Advisory Engineer, IBM General Products Div., San Jose, CA 95193.

Well-designed packaging is the prime ingredient. Every component, no matter how good, should be easily accessible. But this is often easier said than done. An equipment's size, shape and (as in mobile equipment) weight, often constrains the packaging designer. Most often, the box size dictates the size of the components that go into it.

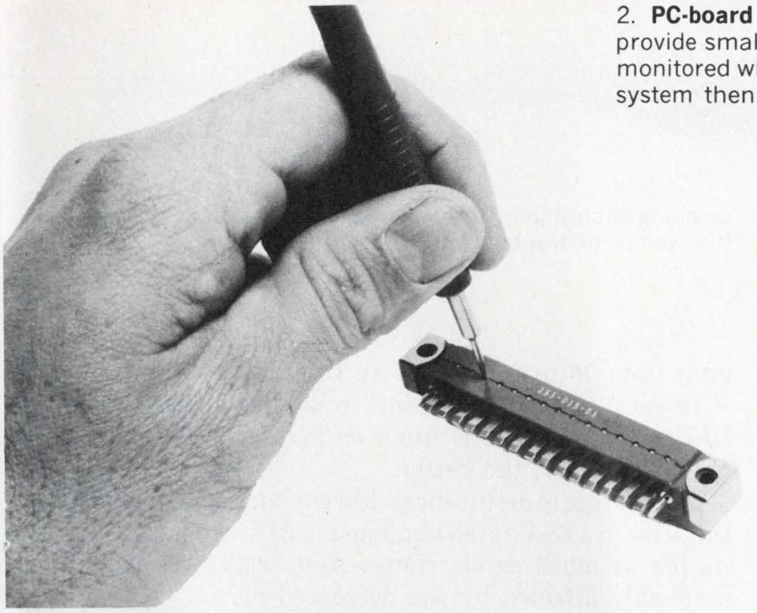
But when it's just a question of aesthetics, "form follows function." Use pluggable modules (field-replaceable units) whenever possible. For one thing, they speed malfunctioning equipment back into operation. Also, FRU substitution quickly isolates a problem to the level of the malfunctioning module.

Keep things simple

Modules should be small and functionally simple. Put a test point at each functional branch. Though fault isolation is fastest with equipment made of the fewest FRUs, don't make your FRUs too large. Every component increases both the failure rate and cost of its FRU. Cram too many components in, and you'll



1. **Slip-on terminals** that make secure connections can help save servicing time and money. In general, these terminations should be used only on dc lines and not for high voltage or for currents over 15 A.



2. **PC-board connectors,** like this one from Amphenol, provide small probe-access holes so that the pins can be monitored while the board is in place. The malfunctioning system then becomes its own test bed.

have an expensive FRU that must be replaced often.

But if you must use large and densely populated modules, make sure each component has a very low failure rate, so that the over-all FRU performs reliably. These low failure-rate components are, of course, expensive. To make matters worse, such modules are hard (and costly) to test during production.

Problems, right? Here are the solutions. Isolate components with high failure rates from the other modules. Put troublesome components on small, low-cost, single-function FRUs.

The same goes for wiring. Hand-wired circuits tend to fail more often than printed circuits. If your equipment needs both hand and PC wiring, try to put each kind into its own FRU.

Design your cable routings while laying out components, not after. Don't put off to the last minute the design of your cabling and then just stuff the cables into whatever space is left. Design your cable layout early and you'll be much better able to do so.

- Separate ac and dc wiring.
- Twist and/or shield internal ac lines.
- Minimize ac-wiring length.
- Isolate signal and power lines.
- Provide only a single ground-return point in the power-distribution system.
- Limit cables to only a single function, when cost allows.

But of course, like components, wiring can malfunction. Field-service technicians will smile if they find that you've installed brightly and distinctly-colored wires in discrete cables. Then they won't have to spend so much time tracing. Along the same line, try to put in several small cables instead of a single large one. Small cables help with tracking and aid isolation.

Don't let unplugging a cable—say, while isolating a fault—cause multiple functions to fail. Try to keep the signals for one function in one cable. And, to protect against mispluggling cables that are close together, use different or keyed connectors. For single-wire terminations use slip-on spade terminals (Fig. 1) but never for ac power.

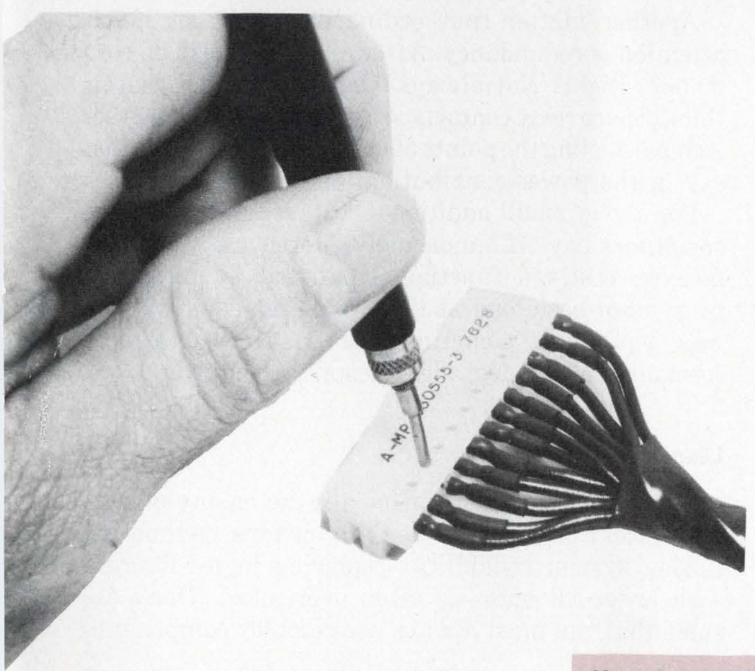
Do not disturb

With discrete-wire cables, use connector housings or termination hardware like those in Figs. 2 and 3. These provide for test-probing the wire terminals without unplugging the connector. For even more checking capability, make terminal blocks and the terminal sides of circuit protectors readily accessible. Not only will you have an easier time testing, you will be able to eliminate some on-board test points.

Cables contribute heavily to those annoying "no trouble found" service calls. In fact, intermittent faults in cables have been responsible for some of the longest calls. Flat signal cables are notorious. To reduce the possibility of these intermittents, make sure that the flat cables are and remain seated.

But be careful. Holding cables in place with one-time ties often leads to servicing problems. Ties must be cut to install engineering changes or to allow fault tracking or cable tracing. Once the ties are cut they're gone forever—and the cables are left exposed.

The thing to do is anticipate. Make your cables long enough so they can be routed away from hazards. Stretching or pressing cables against sharp frame members can mean trouble. When pressed or



3. **Quick-disconnect-type connectors** from AMP mate a PC card to a cable and provide test-probe holes so the cable can be accessed while it is connected to the circuit.

4. **Exposed insulated wire** can short to the equipment frame due to "cold flowing" of the insulation. Pressing, pinching or stretching the wire can cause this fault—often the source of troublesome intermittent failures.

squeezed, wire insulation can "cold flow," which eventually leaves an uninsulated spot as in Fig. 4. Then the wire is free to contact the frame, and cause a ground in that circuit.

But this doesn't happen all at once. The ground usually develops gradually enough that a system experiences trouble intermittently. These fitful problems are as hard to isolate as they are annoying.

Be careful when routing cables that are subject to motion. Another source of intermittent failure is weakened or fractured wires and bonds due to undue flexing. Allow adequate flexing plus secure restraints.

For circuit tracing, not only should wiring be identified clearly, but all components as well. Labels or locating decals will do the trick. Of course, the callouts on the parts and in the support documentation must be the same.

Complete and easy-to-follow support documentation should clearly identify all FRUs, test points and cable connectors. Termination points such as terminal blocks, edge connectors and ground points should be included in a complete documentation package.

But even the easiest-to-service equipment isn't satisfactory if it needs servicing constantly. Make your easily-maintainable system reliable as well.

A stitch in time

The key to highly reliable equipment is highly reliable FRUs. To make them reliable, minimize the number of parts used for each function. Specify the components you do use so they operate well-below their rated values. This applies to all stress-sensitive parts, whatever the stress—temperature, voltage, current or power. Power-handling is usually critical for inductors, transformers and resistors; voltage for capacitors; and temperature for solid-state devices. You can usually find life-expectancy versus rated-stress data on component-specification sheets.

Resistors, run at 50% of rated power, last, on an average, seven-times longer than those run at 100% (see Table 1). And this applies to resistors of various compositions, including the popular carbon, wire-wound and deposited-carbon types.

Capacitors that must withstand only 50% of their rated voltages last from 6 to 14 times longer than units under 100% of rated voltage (Table 2). To appreciate the dramatic increase in life expectancy for silicon transistors and diodes as the junction temperatures drop from 75 to 25 C, look at Table 3.

To get "life-of-the-machine" reliability, derate all LEDs. To prolong LED life even further, keep them cool. The cooler, the better.

Don't forget to derate incandescent lamps. Reducing the drive to a 28-V rated lamp just to 24 V can increase its life as much as six times. And brightness isn't noticeably affected by the decreased drive.

Too much of a good thing

Derating, like all virtues, can be carried too far. Some components suffer when underrated—relays are an excellent example. Indeed, being overcautious with relay-contact current can cause more insidious problems than operating at the upper limit. Relay contacts, rated for 2 A but operated at just 50 to 250 mA, often show a marked increase in contact resistance early in life. Interestingly enough, these same contacts often perform well when operated in the low-μA (dry-circuit) range—even for long periods.

This current sensitivity comes from arcing, but only in one current range. Arcing causes resistive organic film to build-up on the points; and milliamps aren't enough to break the film down. But in the low-microamp range, arcing is too small to cause significant film growth, so the contact resistance remains low. For low-reliability zones, unfortunately, the data aren't normally published.

Another matter that ordinarily won't get much attention is redundancy. After all, extra parts do cost money. Right? Not always. Or not as much as you think. Spare relay contacts are often available for free. And paralleling the points of critical sequencing paths, say in the power-distribution, can avoid trouble.

For a very small additional cost, redundant diodes sometimes pay off handsomely. Moreover, at little or no extra cost, one function or path can be paralleled by a more basic one at little or no extra cost. This way, equipment sometimes can deliver some performance, albeit degraded, despite a failure.

Less is more

Component failure is, after all, the enemy of performance. Surprisingly then, an obvious method for raising system reliability—replacing high-FR units with lower-FR ones—is often overlooked. Don't assume that you must always use complex components

Table 1. Normalized random failure rate percentages for various types of resistors, coils and transformers as a function of power stresses at 25° C.[1]

Percent rated power	Percent of failures at rated power			
	Resistors			Inductors and transformers
	Deposited carbon	Wire-wound	Carbon composition	
10	3.0	3.3	2.5	13.0
20	4.5	5.0	4.0	16.0
30	6.6	7.5	6.0	20.5
40	10.0	10.5	9.0	26.0
50	14.0	15.5	13.5	32.5
60	21.5	22.2	20.5	40.5
70	31.0	32.5	30.0	51.5
80	46.0	47.0	46.0	63.5
90	66.6	70.0	68.0	80.0
100	Use component failure rates for rated power			

Note: For each 10-C rise in operating temperature:
Multiply the carbon-composition and wire-wound resistor failure rates by 2.0;
Multiply the deposited-carbon resistor and the inductor and transformer failure rate by 1.5.

Table 2. Normalized random failure rate percentages for various types of capacitors as a function of voltage stesses at 25° C.[1]

Percent of rated voltage	Percent of failures at rated voltage			
	Mylar	Mica	Ceramic	Paper, polystyrene and high-stability
10	1.0	2.0	3.0	0.5
20	1.5	3.0	4.5	1.0
30	3.0	5.0	7.5	2.0
40	5.0	7.5	11.5	4.0
50	9.0	12.0	16.0	7.0
60	15.0	19.0	24.0	13.0
70	24.5	29.0	34.0	22.0
80	42.5	44.0	50.0	37.0
90	63.5	67.5	71.5	61.0
100	Use component failure rates for rated voltage			

Note: Multiply all capacitor failure rates by 1.6 for each 10-C rise in operating temperature.

Table 3. Normalized random failure rates of silicon transistors and diodes as a function of junction temperature stress.

Junction Temperature	Cumulative failures per 10^6 hours	
	Transistors	Diodes
25	0.7	0.09
30	1.0	0.13
35	1.4	0.19
40	2.0	0.27
45	2.8	0.40
50	3.9	0.57
55	5.5	0.82
60	7.8	1.20
65	11.0	1.70
70	15.5	2.50
75	22.0	3.60

or assemblies, which have a greater tendency to fail.

For example, where the system permits, use unregulated rather than regulated power supplies—and as few supplies as possible. For reliability, the ideal is one unregulated supply for all the system's power. Similarly, examine all close-tolerance components with an eye to using units, with looser specifications.

Another way to prolong the life of just about every system component is to remove all excess heat. Internally-generated heat, if allowed to stagnate, raises component operating temperature. And high operating temperature usually compounds operating stresses in all electrical components.

The effect of temperature on semiconductor life is dramatic. The failure rate of power transistors doubles for each 10-C increase in junction temperature (Table 3). The useful life of LEDs falls sharply with high-temperature operation. ICs are susceptible to large changes in substrate temperature. With a 40-C rise in substrate temperature, the failure rate of the bonding to I/O pads in some LSIs may increase as much as 10 times.

Cooling, then, is often the answer. But you've got to do more than just blow air past or through the various subassemblies. When designing either the FRUs or a complete system, make sure you place your power transistors, LEDs, ICs and other temperature-sensitive components in the coolest possible environment. Do not put them near heat-generating devices or in an area where the air is dead.

Nothing's perfect

Even with the best components, derating and proper cooling, there will be failures—though fewer, of course. Design-in error-indication and detection features and problems can be isolated quickly and down time shortened. In addition, work-in error-trapping circuitry and address-tracing aids, which you'll need, to reduce the number of "no trouble found" calls.

To make your equipment much easier to service, especially the power-distribution system, use the following:

- LEDs to indicate each successive step of a sequence, especially the sequence for power turn-on. Provide a separate indicator LED that shows if each voltage is on or off. This is a logical extension of the generally-accepted practice of using separate indicators for main-power on, dc on, and ready.
- Sense bits to indicate power failures, particularly where partial power on can make the machine appear to be operating normally. For example, sense the special voltages for servo functions, read/write circuits and biasing.
- Latches and manual resets to trap faults that cause a machine to go down.
- Test points at functional-decision branches of the logic. Make test points easily accessible so that all FRUs can be checked—especially those that are enclosed or give no visible or audible indication than their operation is other than normal.■■

Have You Mailed Your Requalification Card? See Page 45

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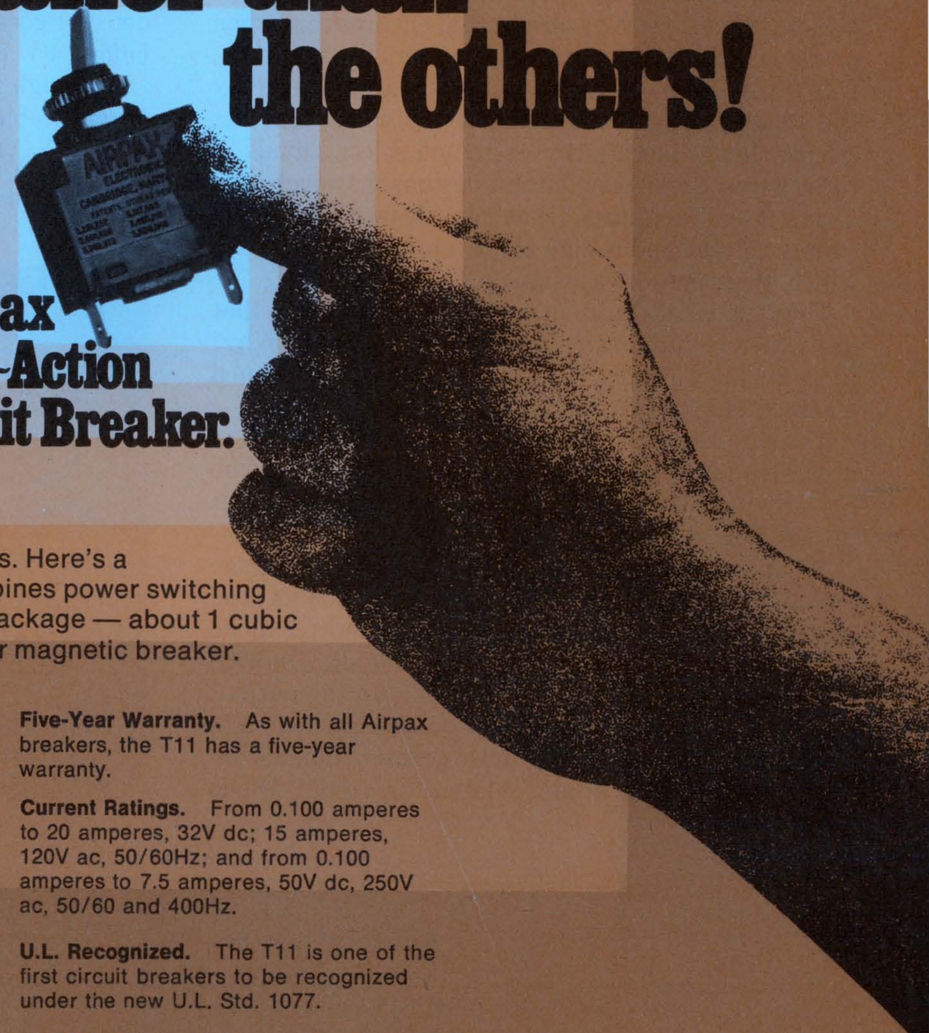

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CIRCLE NUMBER 59

Avoid losing data when line power returns to a battery-backup RAM system

Line-operated systems with semiconductor RAMs that must retain their contents when power goes off use a battery to provide standby power. Sometimes, however, data in the RAM can be disturbed when power returns. Here's a circuit that ensures that when power comes back on, memory contents won't suffer.

A typical backup circuit includes gates powered by the RAM supply. The output of the power-on reset circuit should block stray write and select signals at these gates. Some reset-circuit designs, however, produce a premature output that coincides with the rising supply voltage and is high enough to enable the gates, which then pass stray signals on to the RAM.

The problem crops up in power-on reset circuits that use an active pull-down transistor at the output. Why? Because the output transistor generally isn't turned on until the supply reaches 3 V or so.

The improved circuit in Fig. 2 uses resistor R_8 as a passive pull-down to keep the output low until the power-supply voltage is high enough to pull the output up solidly.

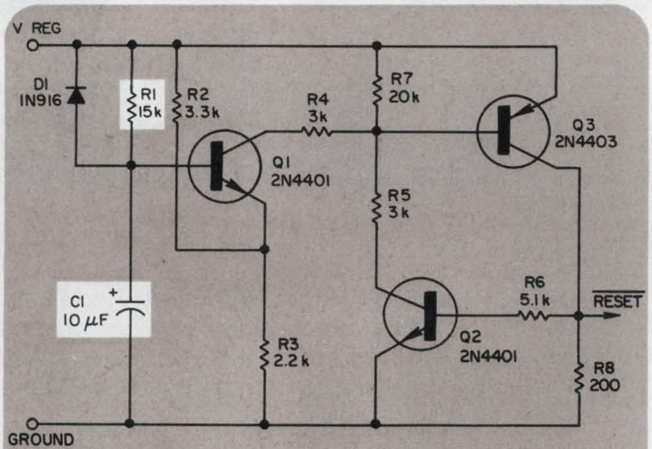
When power turns on, R_1 and C_1 delay the voltage rise at Q_1's base. Transistor Q_1 turns on when its base reaches a threshold, which is one base-emitter diode drop above the voltage set by divider R_2-R_3. Once Q_1 turns on, it turns on Q_3, which pulls up the output, and also turns on Q_2 to keep the output latched high. Once the output is latched, noise greater than 3 V on the +V REG line will not unlatch the output. Diode D_1 discharges C_1 when power is removed, so the circuit will reset quickly.

When power goes off and +V UNREG goes toward zero volts, the power-on signal from the low voltage detector goes low, and disables the inputs to the RAM before +V REG goes out of regulation.

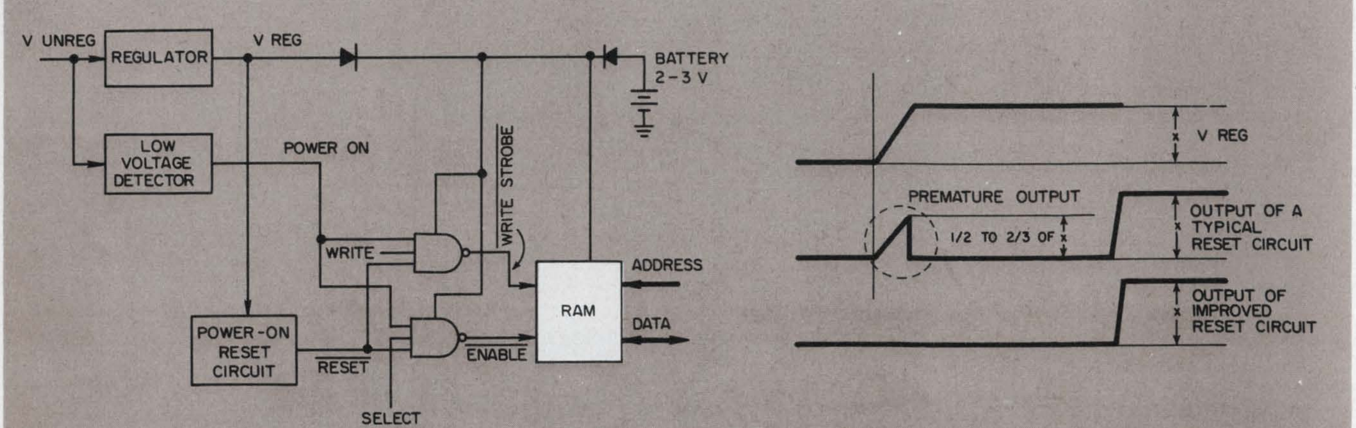
Although this circuit is designed for a 5-V system, it is suitable for use with higher supply voltages.

Alan W. Barman, Senior Engineer, Bendix EECSG, 900 W. Maple, Troy, MI 48084.

CIRCLE No. 311

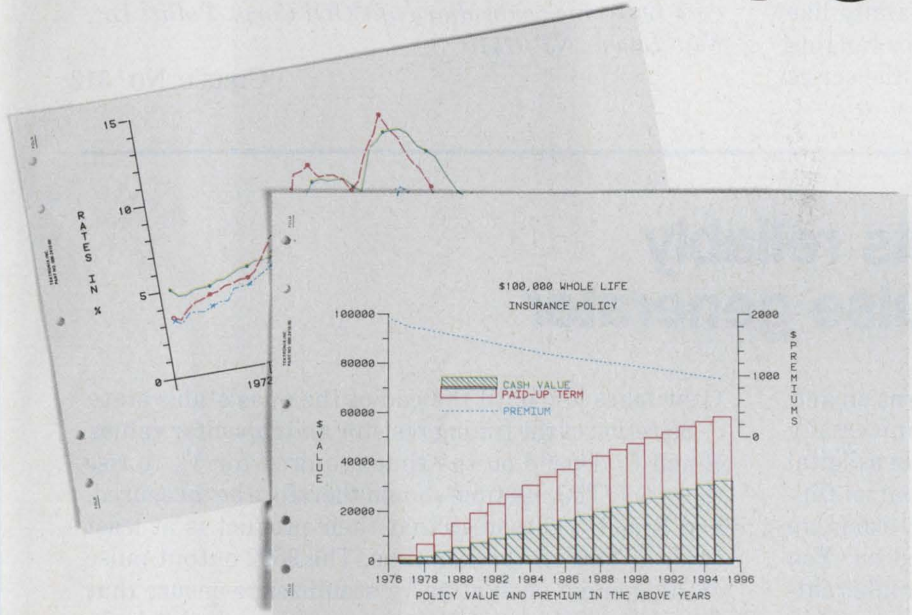


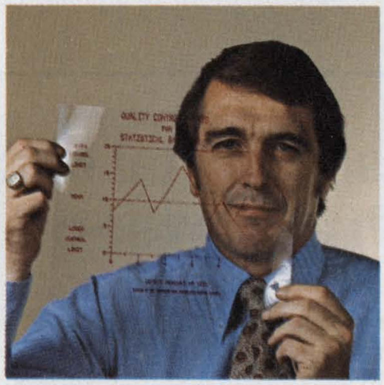
2. This power-on reset circuit has no premature output signal, and its output has a low impedance to ground when no power is applied.



1. A battery-backup RAM circuit has gates that are powered by the battery when +V REG is off. Typical power-on reset circuits generate premature outputs, which let stray signals on the write and select lines pass through to the RAM, and disturb its contents. Premature outputs coincide with rising voltage.

"There's no plotter like it. My terminal easily commands any graphics."





The 4662 can draw precise plots on Mylar® polyester film or acetate, offering an especially valuable graphic assist to overhead projectors.

Problem: You'd like computer graphics, but not at the price of adding more terminals.
So you continue to use paid personnel to hand-plot charts, graphs and diagrams.

Solution: Tektronix 4662 Interactive Digital Plotter. Plugs into most terminals for precise, multi-colored graphics.
The 4662 plugs into almost all RS232-C or GPIB-compatible terminals. Use the 4662 to prepare graphics on paper or Mylar® polyester film for sales meetings, program presentations. With computer accuracy and unexpected economy. Plus multiple colors from felt tip or wet ink pens.

Easy interface to timeshare environments. Thanks to its built-in microprocessor, Tektronix modems, and Plot 10 software, operation is simple, accurate, and faster than any other plotter at the 4662's low price.

Don't ask your people to do a plotter's job. Get a graphics specialist that pays for itself. Because the 4662 is from Tektronix, the worldwide graphics leader, you're assured of exceptional reliability and fast service wherever you are. Talk to your local Tektronix Sales Engineer now.

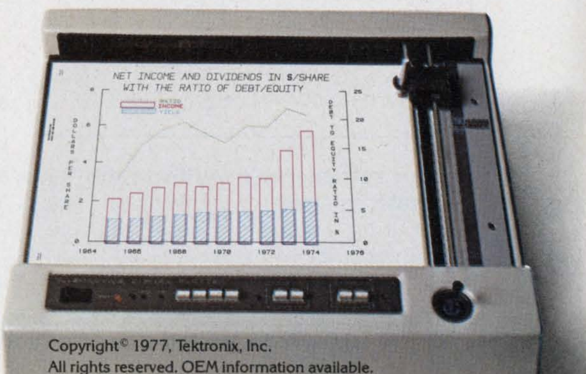
"See us at N.C.C., Booth #2309"

CIRCLE NUMBER 60

Tektronix
COMMITTED TO EXCELLENCE

Tektronix, Inc.
Information Display Group
P.O. Box 500
Beaverton, Oregon 97077
In Europe write:
P.O. Box 159
Badhoevedorp, The Netherlands

Get the 4662. Teach your old terminal new graphics.



If you want a high-accuracy zener, specify time stability, not temperature coefficient

Voltage reference diodes, for use in accurate a/d and d/a converters, must be able to hold their zener voltages reasonably constant for a long time to maintain the converter's accuracy. To get guaranteed time stability, either specify it, or do your own testing to verify that your device meets the requirements of the equipment. Don't think you get time stability by specifying tempco—there's no direct link between the two characteristics.

If you examine a common zener-diode family like the 1N821 to 1N829 series, you'll see tempcos ranging from 100 ppm/°C down to 5 ppm/°C. But the series is not rated for time stability.

Fortunately, a couple of manufacturers—Motorola and Standard Reference Labs, subsidiary of CODI—offer precision reference-device families that have guaranteed voltage-time stability. Some devices are specially processed to hold the zener voltage change as low as 5 ppm over one year, or about 9000 hours.

Ken Koep, VP/General Manager, Standard Reference Labs, Inc., subsidiary of CODI Corp., Pollitt Dr., Fair Lawn, NJ 07410.

CIRCLE NO. 312

Reset digital circuits reliably with a power-on pulse generator

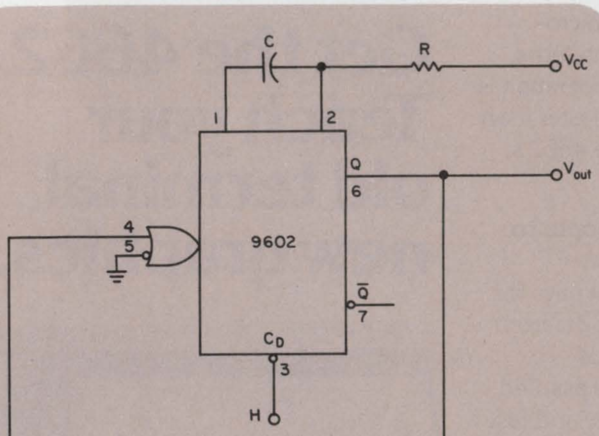
Generate only one pulse each time V_{cc} turns on and you have a power-on reset function almost universally useful in logic circuits. Start-up procedures in a digital system are considerably simplified when control flip-flops, registers and counters automatically come up in predictable states when power is turned on. You can't depend on storage elements to be either inherently asymmetric or automatically preset.

However, the circuit in Fig. 1 can ensure circuit reset. The Q output of the 9602 retriggerable multivibrator rises with V_{cc} and stays high until the end of a quasistable period. The $\overline{Q}$ output at first also rises with V_{cc} but only to about +2.3 V (Fig. 2). Thereafter, $\overline{Q}$ switches low until the end of the quasistable state.

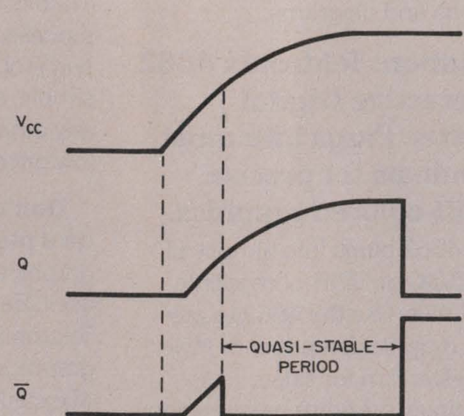
Selection of the timing resistor and capacitor values, R and C, depend on the time required for V_{cc} to rise to +4.5 V. The rise time should therefore be measured, and R and C chosen so that their product is at least twice as long as the rise time. The 9602 output pulse should persist until after V_{cc} stabilizes to ensure that the various storage elements are properly latched.

Charles Alford, Applications Manager, Fairchild Camera & Instruments, 464 Ellis St., Mountain View, CA 94040.

CIRCLE NO. 313



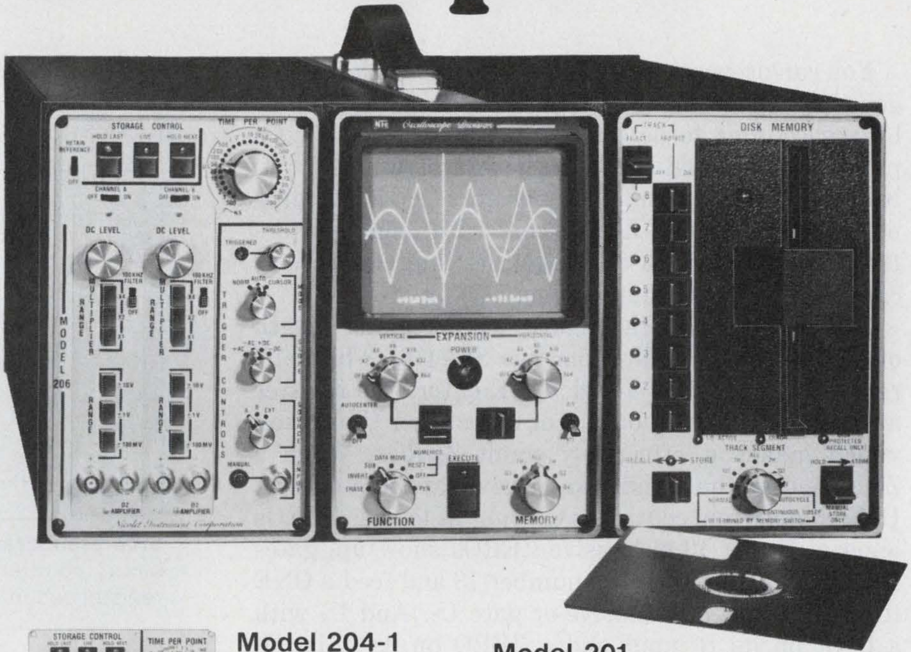
1. This retriggerable multivibrator generates a single pulse whenever V_{cc} comes on. The pulse can be made long enough to reset storage elements in digital circuits.



2. A single pulse from the multi's Q output rises with the applied supply voltage. The $\overline{Q}$ output also begins to rise, but reaches only 2.3 V before going low.

Have You Mailed Your Requalification Card? See Page 45

A welcome new concept in oscilloscopes



HAVE YOU HEARD?

Digital Oscilloscopes Now Thoroughly Outperform Analog 'Scopes, **both storage and non-storage, in the bandwidth range to about 10 MHz.**

The improved performance appears in many ways. Accuracies from 5 to 50 times greater (depending on plug-in unit). Resolution 2 to 160 times greater. Storage that's superb; non-volatile, adjustment-free, quick, to provide from 400 to 3200 times as much stored information.

Digital oscilloscopes are easier to operate than any remotely comparable analog 'scope. And, they are amazingly versatile; doing just what you'd expect any 'scope to do, plus many extraordinarily useful measurements that are impossible with analog 'scopes.

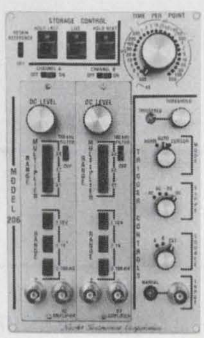
Without question, the best digital 'scopes in the world, by a wide margin, are Nicolet's EXPLORER series oscilloscopes. There's one to meet your needs, in the models and plug-ins described below.

THE PLUG-IN UNITS

Each Has Touch-Button Storage Control. Touch a button to store your choice of the next, or the last preceding, waveform. Touch another button to return to live action. All plug-ins have retroactive sweep trigger. This means that when you wish, the waveforms displayed show what preceded the sweep trigger—and also what followed. Each has conventional trigger controls, sweep speed controls, and amplifier controls. All models permit you to see live waveforms superimposed on a stored waveform for high precision comparisons. The two input models display and store both signals simultaneously.

Model 204-1 and 204-2

These are one and two input units, with 50 ns rise times, and 10 MHz bandwidth (3 db norm). Resolution is 0.4% and accuracy ±0.5% of F.S. Equivalent storage writing rate (ESWR) 50 cm/μsec.



Model 206-1 and 206-2

These are one and two input units with differential amplifiers, 500 ns rise time and ESWR 5 cm/μsec. Resolution is 0.025%, accuracy 0.2%. Minimum observable signal amplitude 50 μv. Sweep speeds from 500 ns to 200 sec/point.

SEEING IS KNOWING...

To really appreciate these new digital 'scopes you have to see them in action. For a demonstration in your lab, on your bench, with your signals call Jim Bartosch at 608/271-3333 or send the reader service card for descriptive literature.

Model 201

This unit provides two input channels, 50 KHz bandwidth, ESWR 500 cm ms, 5 μv minimum observable signal. Other features are 5 μv/hour; 2 μv/°c drift; 10^9 input impedance; excellent CMRR; and ±0.05% accuracy and 0.025% resolution.

MAIN FRAME

Both EXPLORER II and EXPLORER III Provide Zoom-In Display Magnification Of Up To X64, with numerical voltage and time values displayed for any selected point. Both have YT or XY displays and automatic vertical trace centering. They allow you to store up to 8 separate waveforms, and display one at a time or two or more superimposed. They provide pen-drive signals for pen recorders.

EXPLORER III has a third bay, which can accept either a plug-in disk recorder, or interface buss circuits, or both. Choice of IEEE 488, RS 232 or parallel 12 binary.

NICOLET INSTRUMENT CORPORATION
OSCILLOSCOPE DIVISION
5225 Verona Road, Madison, Wisconsin 53711
Telephone: 608/271-3333

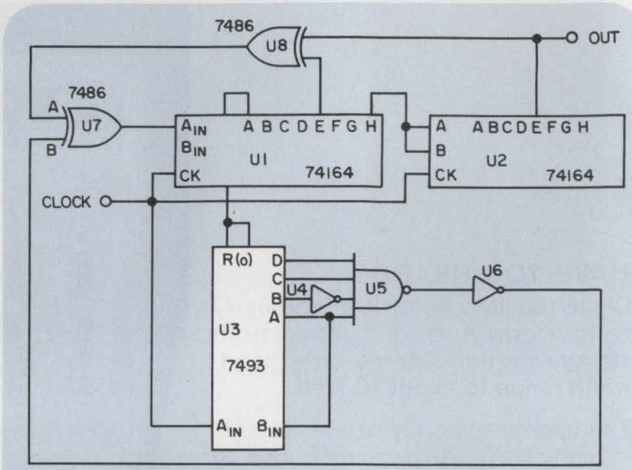
CIRCLE NUMBER 61

Binary counter allows a pseudorandom generator to run without interruption

You can prevent a shift-register type pseudorandom generator from hanging up by adding an SN7493 binary counter to detect and correct the all-ZEROs pattern that would cause the generator to interrupt. Normally, pseudorandom generators use a decoding network to sense all-ZEROs, but with long registers the number of gates and resulting interconnections can become quite cumbersome.

The generator in the figure has a register length of 13 bits, and is built from two SN74164 8-bit shift registers. Each time a logic ONE enters the register and appears at the A output of U_1, counter U_3 is reset, which makes it effectively count ZEROs. When a ZERO enters the register and arrives at the A output, U_3 is enabled and continues to count as long as ZEROs appear. But if 13 successive ZEROs show up, gates U_4 through U_6 decode the number 13 and feed a ONE to the B input of exclusive-or gate U_7. And U_7 with a ONE on its B input and a ZERO on its A input, outputs a ONE to the register. This breaks the all-ZEROs pattern, and the circuit continues to generate pseudorandom numbers. The circuit will also start by itself when all register cells are reset to ZERO.

For a register length greater than 15 bits, two or more counters can be cascaded. And you can use counters and shift registers that work on the same edge of the clock. Then you have to decode counter state n−1, rather than state n, and make sure that the clock pulse at the counter is not delayed with reference to the pulse at the shift register.



Stop pseudorandom generator interruptions with a binary counter that feeds a logic ONE into the shift register when too many zeros occur.

Heinrich Pangratz, Dr. Techn., Institut für Datenverarbeitung, Technical University of Vienna, Gußhausstraße, 27, A-1040, Austria.

CIRCLE NO. 314

IFD Winner of January 4, 1978

David Weigand, Consulting Engineering, 904 Tyson Dr., West Chester, PA 19380. His idea "Solve Test Problems Caused by Switching-Type Power Supplies" has been voted the most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the 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 and 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.

Our Model 3001 starts at $2,980. For that you get a signal generator that's already frequency programmable with 0.001% accuracy over the 1 to 520 MHz frequency range. If you also want to program your output power, we have a programmable attenuator option available for $500.

If you'd like to spend a little more, add our external frequency standard option for $150. That makes the accuracy the same as your standard. Or spend another $500 for an internal reference frequency standard with 5 x 10^{-9} day stability. But if you want to spend much more than that, you're going to have to buy somebody else's signal generator. Count on at least $10,000. Frankly, we think your money would be better spent buying another Wavetek Model 3001.

Here's another advantage. If you need to get on the bus (now or later), our new Model 3910 Converter makes you GPIB compatible. But before you spend anything on any signal generator, get a demonstration of our Model 3001. That won't cost you a cent.

SPECIFICATIONS

Frequency Range: 1-520 MHz
Accuracy: ±.001%
Resolution: 1 kHz
Stability: 0.2 ppm per hour
Output Range: +13 dBm to −137 dBm
Flatness: ±0.75 dB
AM Modulation: 0-90%
FM Deviation: 0-10 kHz and 0-100 kHz
Internal Modulation Rates: 400 Hz and 1 kHz

WAVETEK Indiana Incorporated, P.O. Box 190, 66 North First Avenue, Beech Grove, Indiana 46107, Phone (317) 783-3221, TWX 810-341-3226.

CIRCLE NUMBER 89

WAVETEK®

You can pay a lot more for a programmable signal generator.

But why?

THE BEST VALUE IN OSCILLOSCOPES COMES IN MANY MODELS.

When you choose a Gould oscilloscope—regardless of the model—you get reliability, versatile performance and a modest price tag. All of which adds up to true value. Over the years, Gould has earned a well-deserved reputation for building reliable instruments. Prompt, efficient service is available through a worldwide network of service centers. And all Gould oscilloscopes carry a full two-year warranty covering all parts and labor exclusive of fuses, calibration and minor maintenance. Look to Gould for your best value in oscilloscopes.

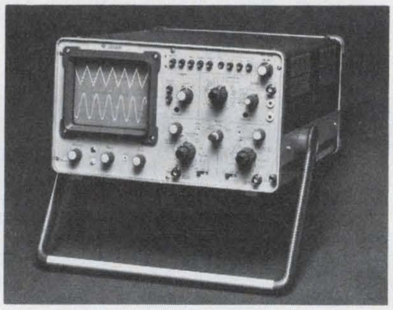
For more information contact Gould, Instruments Division, 3631 Perkins Ave., Cleveland, OH 44114. In Europe contact Gould Instruments, Roebuck Rd., Hainault, Essex, CB10 1EJ England.

For brochure call toll-free (800) 325-6400, Ext. 77. In Missouri: (800) 342-6600.

GOULD

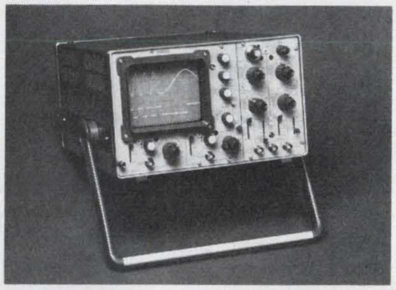
Gould OS 245A
- DC to 10 MHz
- Dual trace
- 4 inch CRT
- 5 mV/div sensitivity
- Only 11 pounds

Circle No. 141



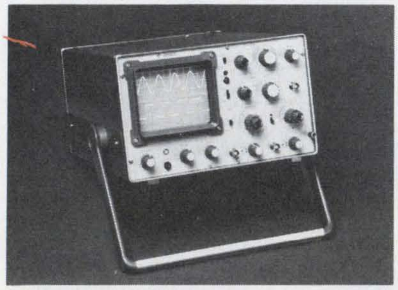
Gould OS 1100
- DC to 30 MHz
- Dual trace
- 1 mV/div sensitivity
- Delayed timebase
- Channel Sum and Difference

Circle No. 143



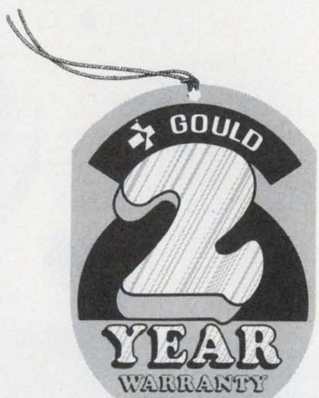
Gould OS 3300 B
- DC to 50 MHz
- Dual trace
- Two independent timebases
- Mixed sweep
- 1 mV/div sensitivity
- Channel Sum and Difference

Circle No. 144



Gould OS 260
- DC to 15 MHz
- True dual beam
- High brightness CRT
- 2 mV/div sensitivity
- Single Sweep
- Switched X—YY

Circle No. 142



Gould OS 4000
- DC to 10 MHz—dual trace—digital storage (RAM)—no deterioration of stored trace—pre-trigger viewing—output to analog and digital recorders—simultaneous stored and real time viewing.

Circle No. 145

Whatever you can conceive, Norplex can help you achieve.

While the sages of yore could only ponder the infinite, modern man literally is reaching for it.

With the advent of space-age circuitry comes the need for base materials of unexcelled reliability and consistency.

The manufacture of highest-integrity industrial laminates has been our only business for more than a quarter-century. No other company has the combined experience, technical resources, and exhaustive quality-assurance program that Norplex offers you.

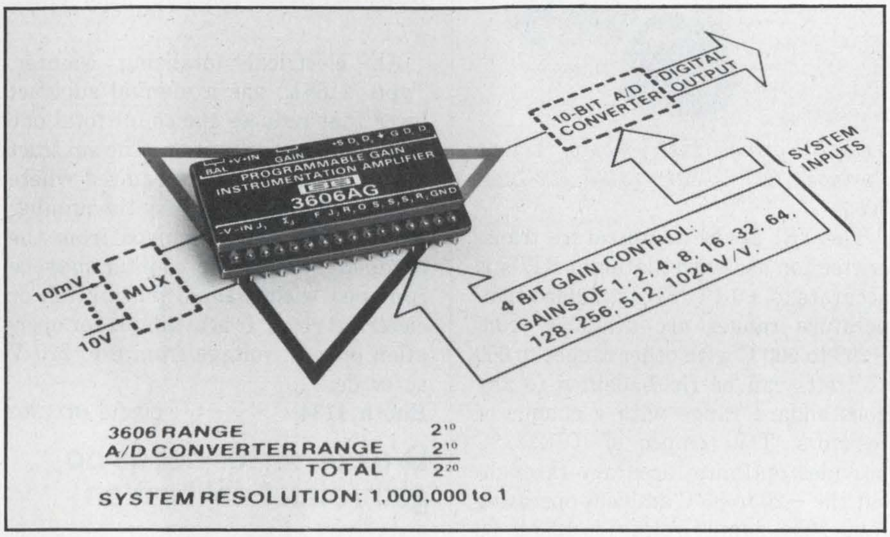
At Norplex, the creative engineering and development of new products—and the improvement of existing ones—is an ongoing process. We are continually designing and manufacturing laminates and other base materials for unique applications, helping customers find new ways to produce systems better and faster. And so we can for you.

At Norplex, imagination knows no earthly limits.

Norplex Division, UOP Inc. U.S. operations: LaCrosse, Wisconsin (World Headquarters); Black River Falls, Wisconsin; Franklin, Indiana; Postville, Iowa. European Headquarters: Wipperfürth, West Germany. Pacific Headquarters: Kowloon, Hong Kong. CIRCLE NUMBER 62

New products

Instrumentation amplifier programs gain digitally



Burr-Brown, International Airport Industrial Park, P.O. Box 11400, Tucson, AZ 85734. (602) 294-1431. P&A: See text.

The first commercial instrumentation amplifier to offer digitally controlled, programmable gain is Burr-Brown's 3606. Sound good? There's more. The offset voltage almost stays put as the gain changes: At room temperature, E_{os} doesn't vary more than 25 mV—with no external adjustments. If that figure isn't good enough, you can slash it to a maximum 1 mV with just two offset adjustments.

A 4-bit TTL input varies the 3606's gain from 1 to 1024 V/V, in 11 binary-weighted steps. A latch holds the gain while the control word changes. Gain inaccuracy stays below 0.05% and nonlinearity below 0.01%. Gain tempco doesn't go higher than 10 ppm/°C. A "B" version delivers even tighter figures.

Applications for instrumentation amplifiers usually require stiff specs, and the Burr-Brown instrumentation amp gives them. Apparently, performance hasn't been compromised for the gain benefits. A few examples:

Input impedance is 10^{10} Ω; E_{os} is 2 mV max at a gain of one; 22 μV max at a gain of 1024. And E_{os} drift is limited to 21 μV/°C and 1.1 μV/°C at those two gains.

Another key spec, input bias, doesn't get beyond ±20 nA at 25 C, with a maximum drift of ±0.03 nA/°C over the rated −25 to 85 C. Common-mode rejection is high—100 dB min at all gains above 32, and 80 dB below. Typical input noise is specified at 1.4 μV pk-pk, 0.01 to 10 Hz, and 1 μV rms up to 1 kHz.

The 3606 stands alone with its packaging—a 32-pin DIP, either ceramic or a hermetically sealed metal. Size is 1.75 × 1.15 × 0.23 in., with 0.9 in. between pin rows.

Nominal rated output is ±12 V at ±5 mA. The 3606's ±3-dB response is 10 kHz, and full-power response is 5 kHz. Both values are typical. Settling time takes 100 μs max for a change in gain at a fixed input level or an input change at constant gain. Required power is ±15 V at 10 mA.

One of the main benefits of programmable gain is that you can process signals over a very wide dynamic range, yet retain resolution and accuracy. Without such capability, you may need an a/d converter that doesn't exist (see photo).

The 3606 ranges from $51.50 to $87.50 (both in 100s), depending on the model and the package. Delivery takes two weeks.

CIRCLE NO. 301

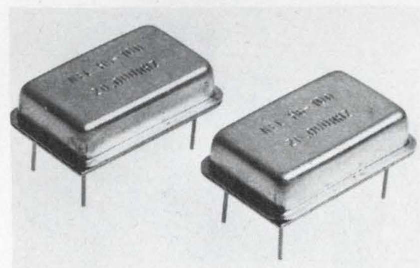
Tiny isolation amp mates with 10-bit data systems

Intronics, 57 Chapel St., Newton, MA 02158. Rich Sakakeeny (617) 332-7350. $44 (100 qty); 4 to 6 wks.

The IA184 isolation amplifier is compatible with 10-bit data-acquisition systems and is only 1.5-in. square by 0.63-in. high. The amplifier has 0.025% linearity, 126-dB common-mode rejection and 2.5-kV input/output isolation. Input noise is held to 1 μV and 10 pA from 10 to 1000 Hz. The 1 to 1000 gain is externally programmable. An internal ±15-V dc, 15-mA supply in the input section is used to power an external transducer or preamplifier.

CIRCLE NO. 302

Clock oscillators are in sealed DIPs



Northern Engineering Lab., 357 Beloit St., Burlington, WI 53105. Dick Griebel (414) 763-3591. $15; stock to 4 wks.

CMOS and TTL oscillators are provided in glass-to-metal, DIP-compatible, welded enclosures. Covering a frequency range of 600 Hz to over 25 MHz, the standard tolerance is ±0.01%, 0 to 70 C. Maximum dimensions are 0.815 × 0.515 × 0.2 in.

CIRCLE NO. 303

Quad J-FET switch is housed in 16-pin DIP

HyComp, 146 Main St., Maynard, MA 01754. Norm Palazzini (617) 897-4578. $34 (100 qty); 2 wks.

Analog switches in the HC-S310 series contain four independent spdt JFET switches connected to two common busses and are housed in 16-pin DIPs. Signals may be applied to either of the two busses or to the poles of the JFETs. FET gates are operated in a break-before-make mode and are direct driven. The HC-S310-10 has an on-resistance of 15Ω max with input signals to ±5 V, and less than 2-nA leakage from the signal channel in both on and off states.

CIRCLE NO. 304

MODULES & SUBASSEMBLIES

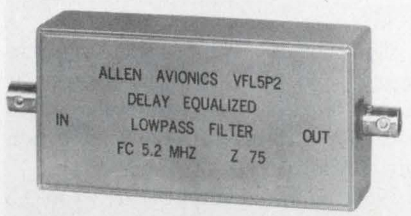
Temperature transmitter is highly accurate

Yellow Springs Instruments, Yellow Springs, OH 45387. (513) 767-7241. $265.

The YSI 2-wire temperature transmitter for use with platinum RTDs is accurate to ±0.1%. Five standard-temperature ranges are available from −200 to 500 C with other ranges to 660 C. Units can be field-adapted to any nonstandard range with a change of resistors. The tempco of 0.012%/°C provides optimum accuracy throughout the −20 to 85 C ambient operating range. The supply voltage is 12.5 to 80 V dc. The output is linear from 4 to 20 mA.

Booth 2421 **CIRCLE NO. 305**

Filters operate on video signals



Allen Avionics, 24 E. 2nd St., Mineola, NY 11501. Les Jacobson (516) 248-8080. From $125; stock.

A line of L-C filters includes delay-equalized NTSC lowpass filters having sharp roll-offs and good passband-delay linearity with cut-off frequencies from 0.1 to 10 MHz. Also available are NTSC rejection filters. An NTSC bandpass filter is a low-distortion unit that attenuates the luminance information in color-TV signals.

Booth 1538 **CIRCLE NO. 306**

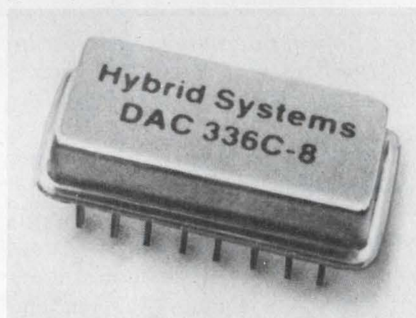
Totalizing counter has manual subtract lever

Kessler-Ellis Products, Atlantic Highlands, NJ 07716. (201) 291-0500. $40; 2 wks.

An electrical totalizing counter, Type M16SL, has a manual subtract lever that reduces the count total one count for each actuation. The subtract lever feature is often required where totals must be reduced by the number of defective units removed from the production line. The counter may be equipped with manual pushbutton or electrical reset. It is available for operation on any voltage from 6 to 220 V ac or dc.

Booth 1134 **CIRCLE NO. 307**

D/a converter needs no gain/offset calibration



Hybrid Systems, Crosby Dr., Bedford, MA 01730. Larry Lauenger (617) 275-1570. $24/$44; 2 to 4 wks.

Compact, ready-to-use and adjustment-free each DAC336-8, 8-bit d/a converter, includes a precision reference, ladder network, switches, output amplifier and input-storage register. The converter frees systems of costly and troublesome gain and offset-calibration requirements. The hybrid IC is pre-trimmed to ±0.05% accuracy. Pin jumping allows the choice of 0 to −10, 0 to +10, ±5 and ±10-V outputs. Only 200 mW is required. Other features include 4-μs settling time, ±1/2 LSB linearity and an accuracy tempco of ±50 ppm/°C from −55 to 125 C.

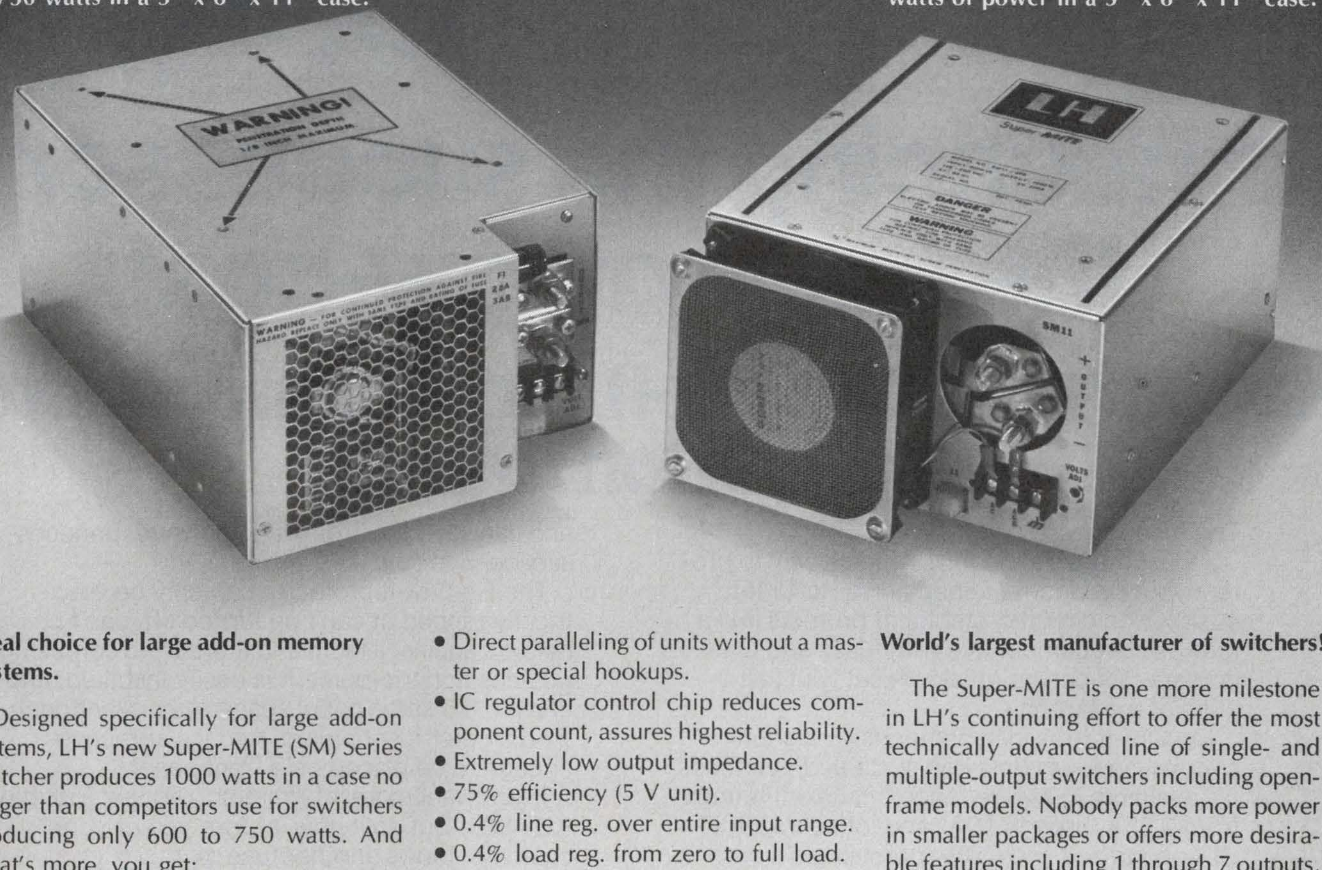
CIRCLE NO. 308

Have You Mailed Your Requalification Card? See Page 45

LH's NEW Super-MITE Switcher packs up to 67% more power in the same space!

Competitive switchers produce only 600 to 750 watts in a 5″ x 8″ x 11″ case.

The New Super-MITE produces 1000 watts of power in a 5″ x 8″ x 11″ case.



Ideal choice for large add-on memory systems.

Designed specifically for large add-on systems, LH's new Super-MITE (SM) Series switcher produces 1000 watts in a case no bigger than competitors use for switchers producing only 600 to 750 watts. And what's more, you get:

- Choice of four single-output voltages*: 2 V @ 225 amps, 5 V @ 200 amps, 12 V @ 84 amps, or 15 V @ 67 amps.
- Wide input range — 85 - 130 V AC or 166 - 250 V AC — for brown-out protection.
- 50-msec hold-up time if AC power fails.
- Power-fail signal triggered 40 msec after AC power loss.
- Direct paralleling of units without a master or special hookups.
- IC regulator control chip reduces component count, assures highest reliability.
- Extremely low output impedance.
- 75% efficiency (5 V unit).
- 0.4% line reg. over entire input range.
- 0.4% load reg. from zero to full load.
- 1% p-p ripple and noise.
- 2% max. deviation for a load change of 25% at 5A/μsec.
- 0°C to 50°C operating temperature.
- Remote automatic voltage margining (optional).
- Designed to meet UL 478.

World's largest manufacturer of switchers!

The Super-MITE is one more milestone in LH's continuing effort to offer the most technically advanced line of single- and multiple-output switchers including open-frame models. Nobody packs more power in smaller packages or offers more desirable features including 1 through 7 outputs, up to 2.26w/in.^{3}, up to 80% efficiency, and a 2-year guarantee — at less than 60¢/w in quantity. For price and delivery information, call or write today!

*Three new multiple output models (2, 3, and 4) also available.

LH RESEARCH

LH RESEARCH, INC.
1821 Langley Avenue
Irvine, CA 92714
(714) 546-5279
TWX 910-595-2540

CIRCLE NUMBER 65

Announcing the successor to the fuse–at low-cost.

Heinemann Re-Cirk-It® protector. Just press the button to reset.

The fuse is passé.

At last there's a modern, reliable way to protect your product—Heinemann's Re-Cirk-It® pushbutton circuit protector. It protects like a fuse, is cost-competitive with fuses and fuseholders, but can be quickly reset with just a push of the button.

Re-Cirk-It trips instantaneously on short circuits, and with delay on sustained overloads. It's available in a wide range of current ratings from 0.25A through 10A. And, of course, it's UL-recognized and CSA-approved as a component circuit protector.

There's a good chance today that your product will be used by non-technical personnel who may not know a spent fuse from a dead battery. But when Re-Cirk-It trips, the button pops out, exposing a white band around the pushbutton shaft. So Re-Cirk-It forever ends the frustration of blown fuses, eliminates the danger that your customer will use a wrong size replacement, and can save you from an expensive, unnecessary service call.

The Re-Cirk-It protector can only be electrically tripped. It can't be turned off, can't be held on against a fault, and there is no confusing mid-position trip-point. It is easily installed, and fits into the same panel space as conventional ⅝"-diameter fuseholders. And it's attractive enough to be placed on a front panel.

If you want more information, request Bulletin KD-4001. But do it now, before you or your customer blows another fuse.

SPECIAL OFFER

Send us a blown fuse and $1.00 and we'll send you a 3A or 5A* Re-Cirk-It to try. Send your request to Heinemann Electric Co., Special Re-Cirk-It Offer, P.O. Box CN 01908, Trenton, New Jersey 08608.

*Other ratings available under this offer on special request. Offer expires December 31, 1978.

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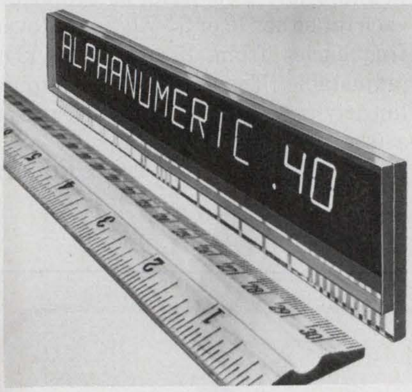
6985

CIRCLE NUMBER 66

MODULES & SUBASSEMBLIES

Plasma panel displays 16 characters



Dale Electronics, P.O. Box 609, Columbus, NE 68601. (402) 564-3131. $13.46 to $14.63 (1000 qty). Stock.

Type PD-14A050 and PD-16A040 are alphanumeric plasma displays made up of 14 and 16 characters, respectively. The character segments are bussed together internally for multiplexed operation. The character height is 0.5 in. for the 14-character display and 0.4 in. for the 16-character display. The units operate at a typical peak current of 630 μA/segment. Typical light output is 50 ft lamberts.

CIRCLE NO. 309

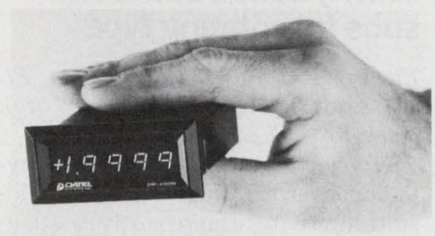
V/f converters match logic level by resistor

Burr-Brown, P.O. Box 11400, Tucson, AZ 85734. Steve Howard (602) 294-1431. $10.90 (100 qty).

Model VFC42 voltage-to-frequency or frequency-to-voltage converters are internally complete and need only a pull-up resistor to match TTL or CMOS-logic levels. The maximum nonlinearity is ±0.01% at 0 to 10 kHz with 0 to 10-V input. Drift is ±100 ppm/C below 20 C and ±30 ppm/C above 20 C. Model VFC52 generates 0 to 100 kHz for 0 to +10-V input with 0.05% nonlinearity max. Drift is ±150 ppm/C below +20 C and ±30 ppm/C above 20 C. Offset and gain errors are less than 0.001% and 0.1% of full scale, respectively. A 6-decade dynamic range (0.5 Hz to 0.5 MHz) is provided. The units are in 12-pin epoxy DIPs.

Booth 2441 **CIRCLE NO. 310**

Low-cost DPM displays 4-1/2 digits

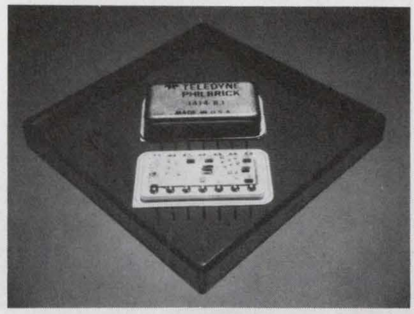


Datel Systems, 1020 Turnpike St., Canton, MA 02021. Eugene Murphy (617) 828-8000. $59 (100 qty); 2 to 4 wks.

A low-cost digital panel meter, Model DM-4100N, resolves 100 μV in the last of its 4-1/2 digits. The meter displays analog input voltages up to a full-scale reading of ±1.9999 V dc. The display uses red LED digits having a height of 0.5 in. The accuracy at 25 C is ±0.02% of reading, ±1 count. The meter is autozeroed, yielding a temperature drift of zero setting within ±1 count from 0 to 50 C. The unit fits a 0.97 × 2.562-in. panel cutout and requires a +5-V supply at 350 mA.

CIRCLE NO. 320

Hybrid op amp gets rigid tests



Teledyne Philbrick, Allied Dr., at Route 128, Dedham, MA 02026. Frank Goodenough (617) 329-1600. $120; stock.

The -83 on the Model 1414-83 means that the hybrid op amp is inspected and tested to MIL-STD-883 Method 5004 Class B. It means that each unit has been temperature cycled 10 times from −55 to 125 C and has been burned in for 160 h at 125 C. Specifications include a settling time of 1 μs max, initial offset voltage of 5 mV max, open-loop gain bandwidth of 8 MHz min. The slew rate is 50 V/μs min and common-mode rejection is 60 dB min. Output is ±10 V at ±20 mA.

CIRCLE NO. 321

Have You Mailed Your Requalification Card? See Page 45

MODULES & SUBASSEMBLIES

Thrifty solid-state tach subs for rotating type

Electro, P.O. Box 3049, Sarasota, FL 33578. (813) 355-8411. $29.50 (100 qty); stock to 6 wks.

A low-cost tachometer (frequency-to-dc converter), Micro-Tach, is a solid-state alternate to more-costly rotating-tach generators. The tachometer operates from inputs supplied by electromagnetic sensors or any device providing sinusoidal signals and drives any conventional meter, speed-control circuit or recorder. Accuracy is ±0.5% of full scale. Two series of 10 models each for either 12 or 24-V dc input cover frequencies from 15 Hz to 60 kHz (adjustable). The units furnish outputs linearly-proportional to frequency over a 0-to-5 or 0-to-10 V dc range.

Booth 1021 CIRCLE NO. 322

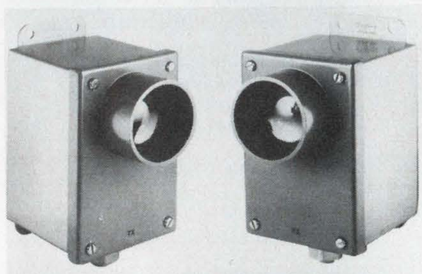
Digital control meter gives adjustable trip

LFE, 1601 Trapelo Rd., Waltham, MA 02154. (617) 890-2000.

The digital control meter, Model DCM, combines solid-state switching circuits with a digital meter and has the features of an analog meter-relay and a digital panel meter. The relay trip points are adjusted by turning setpoint knobs located on the front. When a knob is depressed, the digital display monitors the setpoint level. When the knob is released, the display transfers back to monitoring the input signal. A front-panel-LED status indicator lights when a relay de-energizes. Spdt relay contacts provide closures on either side of the set point.

Booth 2323 CIRCLE NO. 323

Pulsed-LED-beam system operates indoor/outdoor



Scanning Devices, 266 Broadway, Cambridge, MA 02139. Lou Goldenberg (617) 354-7226.

This long-range infrared pulsed-LED-beam system, Model Tx-Rx operates indoors or outdoors at distances up to 250 ft. A broad LED beam minimizes alignment problems. The units are housed in Scotchkote-coated 6 × 4 ×4-in. JIC boxes fabricated from 14-gauge steel. The units can be used in highly corrosive atmospheres. Power input is 115 V ac, 50-60 Hz. The output dpdt-relay contacts handle 5-A resistive at 115 V ac or 28 V dc. The ambient-light immunity is 10,000 ft candles. Available models include on-off, delay-on, delay-off, one-shot and double-delay.

Booth 2104 CIRCLE NO. 324

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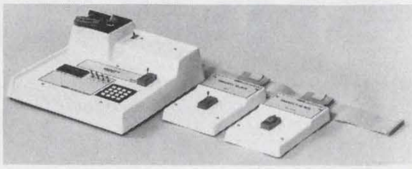
CIRCLE NUMBER 68

PROM simulator expands with slave units



Sunrise Electronics, 307-H S. Vermont Ave., Glendora, CA 91740. (213) 963-8775. $1595 (master), $195 to $450 (slave); 3 to 6 wks.

Permanently connected slave units are available for use with the Smarty expandable PROM programming, simulating and testing system. The master unit has a built-in 2704/08 programmer, 1 k × 8 PROM simulator-editor, RS-232C and 20-mA serial interface and punched paper-tape reader controller. The simulator includes an intelligent editor and is optionally expandable to 2 k × 8 or 8 k × 8 with 350-ns access times. An optional micro-cassette drive stores 30 1 k × 8 or 15 2 k × 8 programs in one cassette. Permanently connected personality slaves are available for all PROM families. Up to 15 slaves of the same or different types may be daisy chained to the system for single or multiple-unit programming.

Booth 2128 **CIRCLE NO. 325**

Program does assembly and linking

Microtec, P.O. Box 60337, Sunnyvale, CA 94088. (408) 733-2919. $1200.

The assembler in the 8080/8085 relocatable assembler and linking loader includes such features as conditional assembly, macro assembly and a cross reference table. The linking loader combines independently assembled relocatable object modules into one absolute module according to user commands. The object module output of the assembler is compatible with the assembler used by the Intel MDS system. Both programs are written in ANSII standard FORTRAN IV and operate on any computer with a word length greater than or equal to 16 bits.

CIRCLE NO. 326

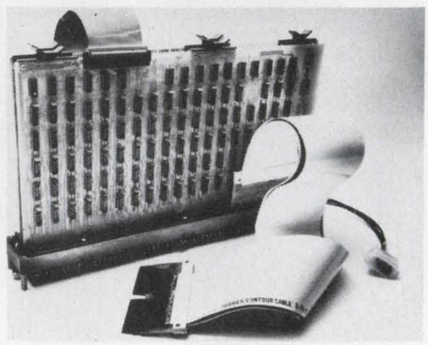
Memory boards employ error correcting logic

Mupro, 424 Oakmead Pkway, Sunnyvale, CA 94086. (408) 737-0500. $605 to $2595; 4 wks.

A line of Intel Multibus compatible memory boards contain error-correcting logic circuitry. The line includes memory sizes of 4, 8, 12, 16, 32, 48 and 64 kbytes. The 4 to 16-k boards are available with 4-k dynamic RAM. The 16-k and larger memory boards are available with 16-k RAMs. All eight sizes also come without error detection, with single-bit parity or with single-bit error correction and double-bit error detection. All error-correcting configurations are equipped with diagnostic indicators to pinpoint the memory chip in which any correctable error occurred. Each board is provided with on-board refresh of the dynamic RAM.

Booth 2017 **CIRCLE NO. 327**

Disc controller handles 20 Mbytes per drive



Aviv, 300 Sweetwater Dr., Bedford, MA 01730. Haim Brill (617) 275-2848. $3000; 4 to 6 wks.

The DFC-803 imbedded controller provides modular storage of up to 20 Mbytes per drive and is compatible with PDP-11 Unibus computers as well as DEC's RK11/RK05F diagnostics. The system consists of two hex-slot boards and operates with a variety of disc drives including Diablo's Model 31 and 44, Pertec's 3000 family and CDC's Hawk and Falcon. Other features include 16-word data buffer, transfer of up to 65 kwords in a single operation, compatibility with either front or top-loading disc drives, switch-selectable platter zero and use of 2400-rpm fast-positioning drives.

CIRCLE NO. 328

Have You Mailed Your Requalification Card? See Page 45

The Portable Data Logger

10 Analog Channels • Thermal Printer • 4-1/2 Digit DPM • 99 Min/Sec Timer

Datel has it, Model PDL-10—the portable approach to measuring, scanning and logging analog signals. It's small size allows it to be positioned near sensors and test apparatus. That means less cabling, lower noise, and lower cost. And the convenience of operating your data logger right next to laboratory equipment. Weighing only 12 lbs. (5,5 Kg), the PDL-10 is easily carried to different measurement sites.

But Datel hasn't sacrificed performance for portability. Ten input channels are provided, along with a 4-1/2 digit panel meter, a 7-column thermal printer for instant hard copy printout, scan electronics, and a 99 Min/Sec Scan Interval clock. Other features include multirange capability for each channel ($\pm$200 mV, $\pm$2V, $\pm$20V), relay-switched differential inputs, and for further flexibility, individual SKIP controls for each channel. Thus, the user may monitor any desired number or combination of channels.

The high performance and versatility of the PDL-10, together with its small size and weight, make it ideal for bench-top operation in laboratory and industrial applications where slowly varying signals from bridge transducers such as thermocouples, strain gages, and pressure sensors are to be monitored and recorded. In addition, the excellent common-mode rejection of the PDL-10 provides high noise immunity in industrial applications.

Input connections are made through convenient screw terminals on the rear panel. Operation requires no special training or knowledge and will usually be mastered within a matter of minutes.

Send today for the free 12-page brochure detailing PDL-10's capabilities.

DATEL SYSTEMS, INC.

CIRCLE NUMBER 70

1020 TURNPIKE STREET, CANTON, MASS. 02021 / TEL. (617) 828-8000 / TWX: 710348-0135 / TELEX: 924461
anta Ana, (714) 835-2751, (L.A.) (213) 933-7256 • Sunnyvale, CA (408) 733-2424 • Gaithersburg, MD (301) 840-9490 • Houston, (713) 932-1130 • Irving, TX (214) 256-4444
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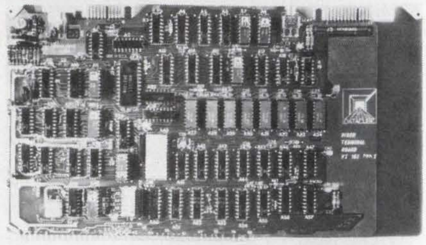
Large memory interfaces four computers

Electronic Memories & Magnetics, 20630 Plummer St., Chatsworth, CA 91311. Dick Shively (213) 998-9090.

A semiconductor memory system, the SEMS-17, contains 1.8×10^6 words $\times$ 16 bits of RAM and interfaces with four independent external computers. The memory system holds 56 memory cards, each capable of providing 32 k $\times$ 16 bits of storage, four ANEW and two DMA interface cards; four control cards; and four error detection/correction cards. The control cards monitor system performance and relays fault information to the primary computer. A backup power source retains all data within the memory for a minimum of 5 min after primary power failure.

CIRCLE NO. 331

Video terminal board buses into SBC 80



Datacube/SMK-I, P.O. Box 405, Reading, MA 01867. Stewart Dunn (617) 944-4600. $275 (100 qty); stock.

The VT 103 video terminal board interfaces directly to the system bus of the Intel SBC 80 and National BLC 80 computers. The board provides a 96-character ASCII subset in 7 $\times$ 9 font on a 64-character, 16-line external monitor. There is direct cursor addressing and 11 other cursor control functions. Composite and direct-drive video outputs are available. An input port provides for an optional external keyboard. Inputs for a strobe and seven data lines are provided at a 26-pin edge connector. The composite video drives a 75-Ω coaxial cable with a 1.4-V pk-pk signal and meets RS-420 standards.

CIRCLE NO. 332

PROM programmer operates in three modes

International Microsystems, 638 Lofstrand Lane, Rockville, MD 20850. (301) 340-7505. $1695; 4 wks.

The Series 1000 microprocessor-controlled PROM programmer offers fully interactive operation in any of three programming modes: keyboard entry, terminal control or remote computer control. A 32-kbit buffer RAM permits fast, reliable data transfer and allows the user to edit any data in the internal RAM, from the keyboard of the programmer, prior to the actual programming operation. A 14-digit hexadecimal display gives 4 digits each of address, RAM data, and PROM data, plus a 2-digit entry and error code. Standard features include TTY and RS-232 interfaces. Personality modules are available for all standard MOS and fusible-link PROMs.

Booth 2049 **CIRCLE NO. 333**

MICRO/MINI COMPUTING

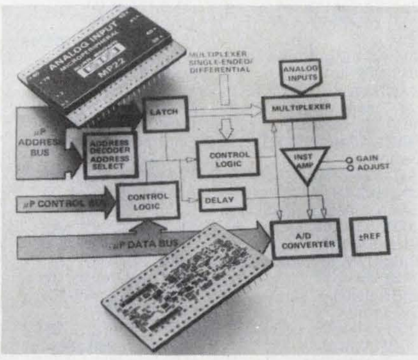
Modules interconnect sensors to μP systems

Midtex, 1650 Tower Blvd., North Mankato, MN 56001. J. Wallace (507) 625-6521.

A microprocessor-system designer can select from a wide variety of Microinterface digital and analog modules, all packaged in a standard color-coded enclosure. LEDs are visible on the top of each digital module to facilitate field troubleshooting. The modules may be used at any interface location, but are especially suited to be located near sensors, permitting the module output to be transmitted by low-cost cable to the I/O interface of the μP.

Booth 1302 **CIRCLE NO. 334**

Analog input module mates with popular μPs

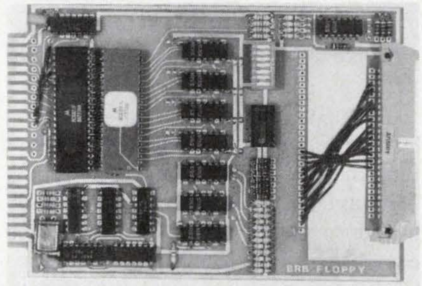


Burr-Brown, P.O. Box 11400, Tucson, AZ 85734. Steve Harward (602) 294-1431. \$245; stock.

MP22 is an analog input module that interfaces directly with 8080A, 8048, Z80 and SC/MP μPs. With minimal external logic it is compatible with 6800, 650X, F8 and 8085 μPs, and also with PDP-8, PDP-11, Nova and Eclipse minicomputers. The unit consists of a 12-bit a/d converter, instrumentation amplifier, input multiplexer, address decoder and control logic. Interrupt, halt and direct-memory-access request signals are generated by internal logic. The MP22 accepts 16 single-ended or eight differential analog signals and the system digitizes low or high-level inputs. The conversion time is 35 μs.

Booth 2441 **CIRCLE NO. 335**

Floppy controller uses MCM6843 chip



Wintek, 902 N. 9th St., Lafayette, IN 47904. (317) 742-6802. \$199.

A low cost but versatile floppy-disc controller uses the Motorola MCM6843 IC in a 4.5 × 6.5-in. module that interfaces to any full-size or mini floppy-disc drive. The module supports both hard and soft sectoring, IBM 3740 or user programmable read/write format, automatic CRC generation or checking, and programmable step and settling times.

Booth 2344 **CIRCLE NO. 336**

Personal computer uses fast minidisc

Olivetti, 500 Park Ave., New York, NY 10022. Britt Tabak (212) 371-5500. From $2300.

A 17-lb programmable minicomputer and calculator, P6040, features a fast minidisc for program and file storage and easy programming with a mini Basic language. The unit prepares, executes and debugs programs, performs diagnostic checks on syntax and logic errors and monitors the workings of its own internal components. The 2.5-in. Mylar minidisc is a little larger than a silver dollar. It has a 3-kbyte capacity and a typical program can reside on one disc. The basic system includes a 16-column alphanumeric printer, keyboard, minidisc unit, 16-character LED display, hardwired mini Basic interpreter and a 3-k random-access memory.

CIRCLE NO. 337

Single-board computer has 4 serial I/O ports

Control Logic, 9 Tech Circle, Natick, MA 01760. Hiram French (617) 655-1170. $950; 4 wks.

A single-board computer, Model MM1-MSC, has four serial I/O ports that can communicate asynchronously at rates of 110 to 9600 baud or synchronously at data rates in excess of 50 kbaud. Processing is provided by a Z80 CPU with 1 kbytes of 2708 EPROM or 2 kbytes of 2716 EPROM and 1280 bytes of RAM. A priority interrupt controller provides interrupt capability upon receipt of data from all four ports as well as three external interrupt states.

Booth 2233 **CIRCLE NO. 338**

Emulator supports 8085A μP

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $2950 to $3450.

When inserted in the Model 8002 or 8001 microprocessor development system, the 8085A emulator card develops, edits and tests software for the 8085A microprocessor. Using the prototype control probe, the finished breadboarded system may be connected to the development system for in-circuit emulation, in real time.

Booth 2012, 2111 **CIRCLE NO. 339**

Monitor helps program 8085 μPs

Spectrogram, 385 State St., North Haven, CT 06473. (203) 281-0121.

Micro Mate-85 is a hardware-connected system monitor for the 8085 microprocessor. When operating with a keyboard terminal, it provides a convenient means of examining and modifying memory locations and microprocessor registers at any point in an operating program through the implementation of addressable traps. The operating program may be started or stopped at any location or the program may be stepped one location at a time. Additionally, it provides a means of loading or punching a paper tape of memory data for microprocessor systems that do not contain a conventional peripheral I/O.

CIRCLE NO. 340

Rigid-disc drive stores up to 29 Mbytes

Shugart Associates, 435 Oakmead Pkway, Sunnyvale, CA 94086. Ferrell Sanders (498) 733-0100. $2550 to $3500.

SA4000 fixed-disc drives have 14.5 and 29-Mbyte capacities (unformatted) with an optional 144 kbytes of additional head-per-track storage. The drives use Winchester read/write heads and media technology. The transfer rate is 889 kbytes/s and the average access time is 87 ms. The drives rack mount using a panel height of 5.25 in.

CIRCLE NO. 341

Have You Mailed Your Requalification Card? See Page 45

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CIRCLE NUMBER 78

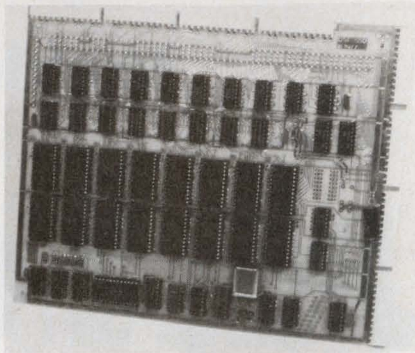
Cross assembler works on PDP-11 or LSI-11

Automated Logic, 2675 Cumberland Pkway. Atlanta, GA 30339. (404) 433-0505. $250.

Five microprocessor MicroSeries cross assemblers are for use on DEC's PDP-11 minicomputers and LSI-11 microprocessors. The cross assemblers can be used for any of the Intel 4000 and 8000 family of processors. The assemblers run in 12 kwords of memory and enable programs to be developed using the PDP-11 with the RT-11 operating system. A companion program enables the output from the cross assembler to be shipped directly to burn-in the PROMs.

CIRCLE NO. 342

Serial I/O board provides 16 ports

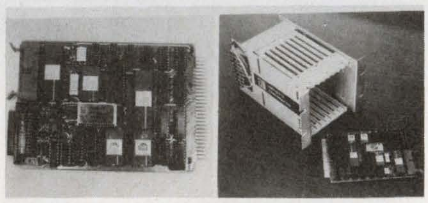


Ohio Scientific, 1333 S. Chillicothe Rd., Aurora, OH 44202. (216) 562-3101. See text; 6 to 8 wks.

A 16-port serial I/O board, for use on any Ohio Scientific computer, is fully assembled as the CA10-X where X specifies the number of serial ports on the board from 2 to 16. The board has RS-232 and high-speed synchronous interfaces which can be mixed in any combination. The transfer rate of each port is selectable from 75 to 19,200 baud asynchronous or 250 to 500 kbits in a synchronous mode. The board is priced at $200 for the first two ports. It costs an extra $50 for each additional port up to 16.

CIRCLE NO. 343

Single-board computer boasts low cost

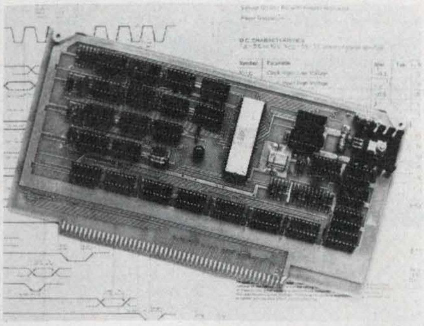


Omnibyte, 2711B Curtiss St., Downers Grove, IL 60515. Greg Urban (312) 852-8320. $237 (100 qty).

Model 0B8001 is a low-cost single-board computer that contains a processor, memory and I/O on a 4.5 × 6.5-in. card. Included on the board are a MC6800 processor, a crystal-controlled clock, 1 kbyte of RAM, sockets for 2k/4k of PROM, serial interface with selectable baud rate, an MC6821 peripheral interface adaptor that provides 2 bytes of programmable binary I/O along with four programmable control bits. Also included are fully buffered address, data and control lines for off-board expansion, full decoding for eight pages of off-board I/O addressing and a separate 128-byte RAM for scratchpad memory.

CIRCLE NO. 344

Z80 CPU board operates at 2 or 4 MHz

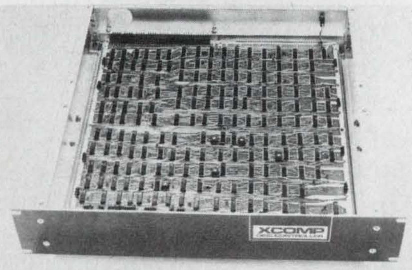


Vector Graphic, 790 Hampshire Rd., Westlake Village, CA 91361. (805) 497-6853. $215 (assembled), $175 (kit); stock.

The Z80 CPU board offers a fully-blocked design with on-board wait-state select, and is jumper-selectable for operation at 2 or 4 MHz. The board operates standard 8080 software without modification. All Z80 lines are fully buffered.

CIRCLE NO. 345

Controller/formatter handles hard-disc drives



XComp, 7571 Convoy Ct., San Diego, CA 92111. John Costello (714) 560-4415. $1260 (100 qty); stock.

The DCF10 hard-disc controller/formatter provides a cost-effective interface for microprocessor-based computer systems and conforms to industry standard 3, 6, 12 and 24-Mbyte disc drives. The disc drives may use an IBM 2315 or 5440 removable cartridge and up to three fixed platters. The DCF10 may also be used with fixed-only disc drives. Overlapping seek/restore operations are accommodated on up to four drives. The controller may be used with virtually any microcomputer by means of a universal 8-bit CPU interface.

CIRCLE NO. 346

Disc drives handle 5 to 67-Mbyte storage

Digital Equipment, Maynard, MA 01754. Steve Kallis (617) 493-2777. $3800 to $23,000; 4 wks.

Three disc drives span storage requirements for a wide spectrum of computer systems. The units are the RL01, a 5-Mbyte disc; the RK07, a 28-Mbyte disc; and the RM02, a 67-Mbyte disc. The RL01 employs a removable-disc cartridge and transfers data at a rate of 512 kbytes/s. The RK07 uses a disc cartridge and has a peak data transfer rate of 538 kbytes/s. The RM02 uses a disc pack and transfers data at a rate of 806 kbytes/s. Both the RK07 and RM02 can add up to seven additional drives per controller.

CIRCLE NO. 347

Add-in memory board plugs into DEC systems

Dataram, Princeton-Hightstown Rd., Cranbury, NJ 08512. John Gilligan (609) 799-0071.

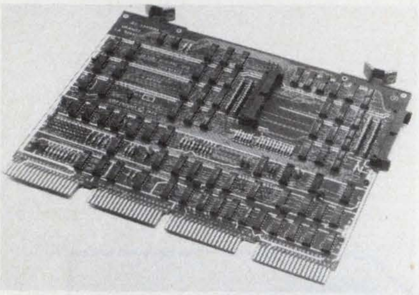
The DR-115 single-board 16 k × 18 core add-in memory is for use with DEC's LSI-11, LSI-11/2 and PDP-11/03. The memory is also offered in an 8 k × 18 configuration. The 18-bit word length allows either parity or nonparity operation. Access and cycle times are 425 ns and 1.15 μs, respectively, and the board operates on +5 and +12 V. A DIP switch is provided for address strapping. Packaging is on a DEC quad board.

CIRCLE NO. 348

Have You Mailed Your Requalification Card? See Page 45

CIRCLE NUMBER 80 ▶

Module transfers data between PDP-11s

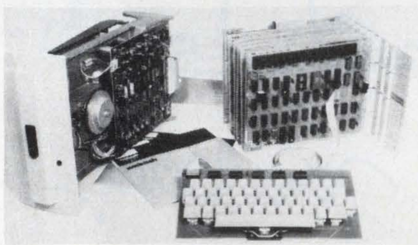


MDB Systems, 1995 N. Batavia St., Orange, CA 92665. Gene Sylvester (714) 998-6900. $615; 2 wks.

The TA-528 general-purpose interface module provides for bidirectional 16-bit transfer over distances up to 100 ft between the DEC PDP-11 computer and a peripheral device, or between two PDP-11s. The module has interrupt request and control logic, address selection, input and output buffer registers and a control/status register. Line drivers and receivers are integral to the module. Convenient data exchange between two PDP-11s can be achieved by cabling two modules together. Each module maintains transparency to its host computer.

CIRCLE NO. 349

Computer systems are based on floppy disc



Ohio Scientific, 1333 S. Chillicothe Rd., Aurora, OH 44202. (216) 562-3101. $1590/$2090.

Two fully assembled but unbundled floppy-disc based computer systems feature a 6502A microprocessor, 16 k of dynamic RAM and a full-size 8-in. floppy-disc drive and interface. Both systems have an 8-slot backplane that accommodates system expansion. The computers are available as C2-8SK which includes an RS-232 serial I/O port and Model C2-8VS which includes a 32 × 64-character video display board and a keyboard.

CIRCLE NO. 350

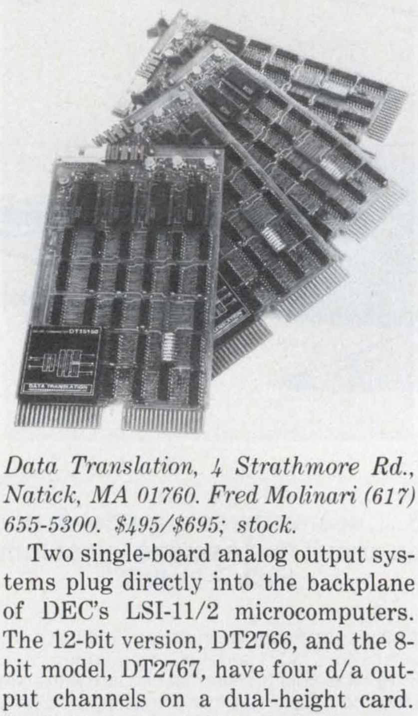
Desktop computer is self-contained

Odell Industries, 2351 Charleston Rd., Mountain View, CA 94043. Andy Nester (415) 961-1090. $8350; 4 wks.

System 85 is a totally self-contained desktop computer with a programmable keyboard, built-in 1920-character display, dual floppy-disc drives, communications interface and up to 64 k of RAM. The system can be adapted to handle both word and data processing applications. The computer uses Shugart floppy diskette storage devices and can be specified to include either the mini diskettes having 80,000 characters of storage or the standard-size diskettes having 200,000 character capacity. Communications can be asynchronous, bisynchronous or synchronous at rates from 50 to 19,200 baud.

CIRCLE NO. 356

Analog output boards mate with LSI-11/2

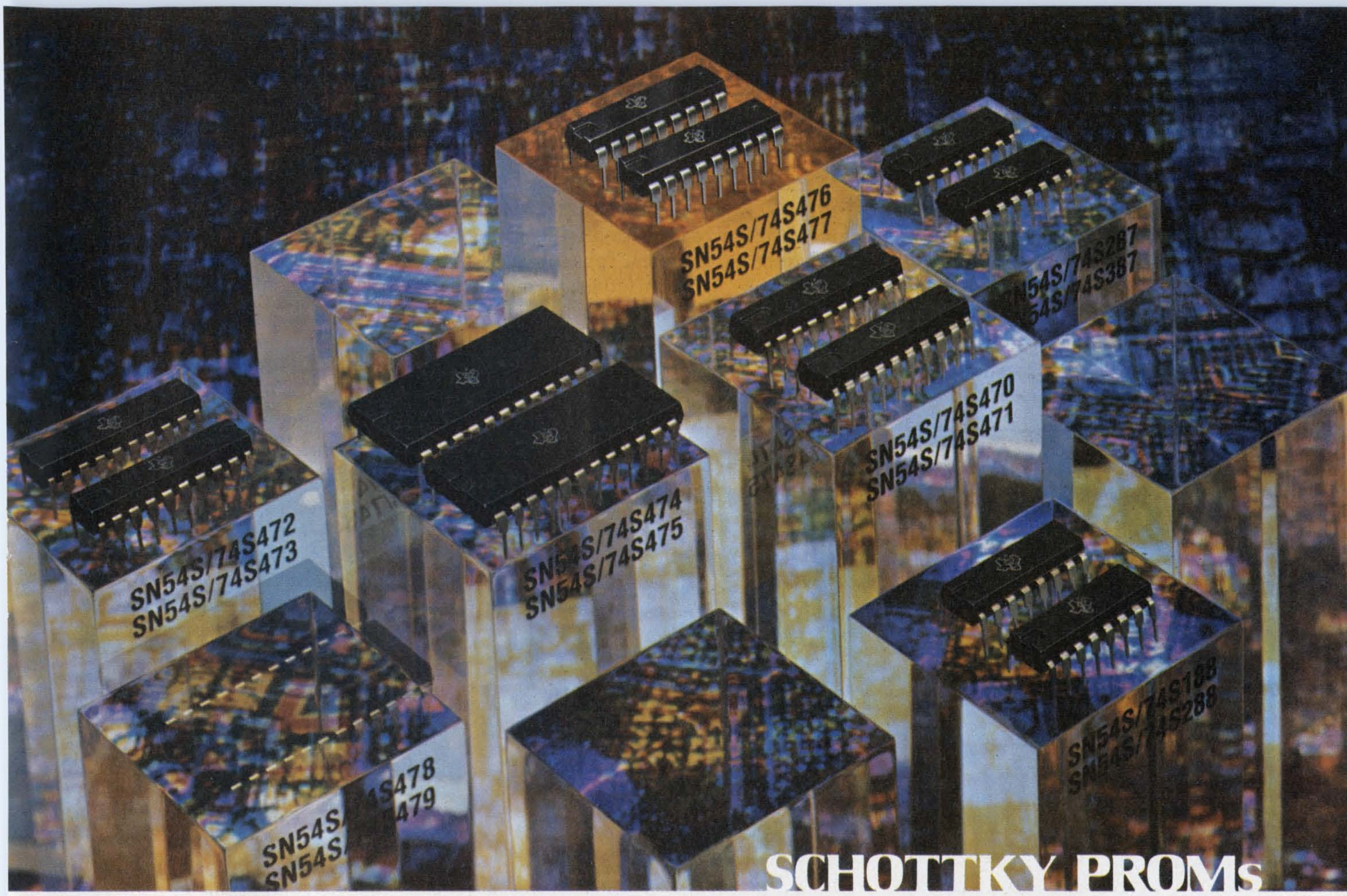


Data Translation, 4 Strathmore Rd., Natick, MA 01760. Fred Molinari (617) 655-5300. $495/$695; stock.

Two single-board analog output systems plug directly into the backplane of DEC's LSI-11/2 microcomputers. The 12-bit version, DT2766, and the 8-bit model, DT2767, have four d/a output channels on a dual-height card. Each d/a converter is fully buffered to avoid intermediate outputs. In addition, four digital outputs are available for TTL control signals. A special feature on each model is the use of read/write word and byte addressable registers, allowing full use of the PDP-11 instruction set.

CIRCLE NO. 357

Have You Mailed Your Requalification Card? See Page 45



Now, 18-pin 4K Schottky PROMs from Texas Instruments. Speedy. Space-saving. Off-the-shelf.

They pack 4096-bits of memory into an industry standard 18-pin package. An extremely high-density, cost-effective approach to large, fixed memory needs. They're TI's new SN54S/74S476 and SN54S/74S477 Schottky PROMs.

Functionally and efficiently organized, 1024 words by 4 bits, they maximize board-area utilization and simplify system expansion by means of dual enables.

They're top performers. A speedy 35 ns typical, 60 ns maximum from 0° C to 70° C, and 75 ns over the full temperature range (−55° C to 125° C). They're also only $9.30 in 100-piece quantities in plastic DIPs.

Output configurations can be either three-state (S476) or open-collector (S477).

The wide, wide TI line

With these additions, TI now offers the widest choice of high performance 4K PROMs in 18, 20, and 24-pin plastic or ceramic packages with by 4 and by 8 organizations. An even dozen – plenty of options for greater flexibility and efficiency.

TI's BROAD PROM FAMILY

0° C to 70° C Plastic

Device	Description	Price (100 up)
SN74S476N	1024 W x 4 B, 3-S, 18 Pins	$9.30
SN74S477N	1024 W x 4 B, 0-C, 18 Pins	9.30
SN74S474N	512 W x 8 B, 3-S, 24 Pins	9.30
SN74S475N	512 W x 8 B, 0-C, 24 Pins	9.30
SN74S472N	512 W x 8 B, 3-S, 20 Pins	9.00
SN74S473N	512 W x 8 B, 0-C, 20 Pins	9.00
SN74S470N	256 W x 8 B, 3-S, 20 Pins	4.50
SN74S471N	256 W x 8 B, 0-C, 20 Pins	4.50
SN74S287N	256 W x 4 B, 3-S, 16 Pins	1.88
SN74S387N	256 W x 4 B, 0-C, 16 Pins	1.88
SN74S188N	32 W x 8 B, 0-C, 16 Pins	1.50
SN74S288N	32 W x 8 B, 3-S, 16 Pins	1.50

SN54S versions available in ceramic (J) DIPs.

All TI PROMs share the same design rules and have proven programming techniques. All are Schottky-clamped for superior speed/power characteristics. All have low-current pnp inputs for interface with MOS as well as bipolar microprocessors.

All have the proven titanium-tungsten fuse links that make programming fast and reliable. All TI PROMs are available in versions to operate over the full military temperature range.

It's a broad family growing broader. Coming soon: TI's new 1024 x 8 bit PROM in a 24-pin package (SN54S/74S478 and SN54S/74S479). Others on the way.

Off-the-shelf delivery

TI's entire PROM family, including the newest members, are now in distributor stocks for fast delivery. And for a copy of TI's Schottky Memory brochure, write Texas Instruments Incorporated, P. O. Box 225012, M/S 308, Dallas, Texas 75265.

TEXAS INSTRUMENTS MOVING AHEAD IN MEMORIES

TEXAS INSTRUMENTS
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84307

CIRCLE NUMBER 83

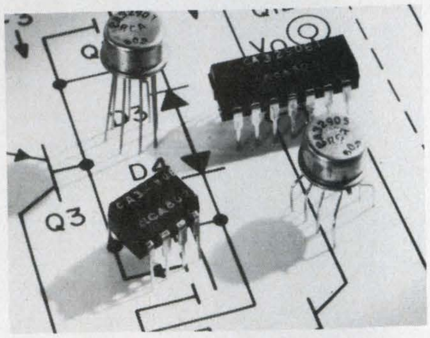
Inverter SCRs have high dv/dt ratings

FMC Semiconductor Products, 800 Hoyt St., Broomfield, CO 80020. Brian Bachman (303) 469-2161. See text; 3 to 4 wks.

Two lines of TO-94 size inverter SCRs in the Series 076 and 079 are rated at 70 and 80 A average and offer a choice of performance classifications including 200, 500 and 1000 V/μs. The Series 076 units are available in seven 100-V incremental blocking ranges from 600 through 1200 V and with turn-off times of 10, 20 or 30 μs. The Series 079 has six blocking ranges from 100 through 600 V with turn-off times of 10, 20 or 30 μs. A typical Type 076 SCR with 1200-V blocking, 10-μs turn-off and 200 V/μs performance is typically priced at $40.55 in quantities of 10 to 99.

CIRCLE NO. 358

Dual-voltage comparators boast of being first

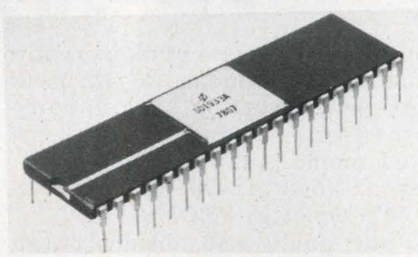


RCA Solid State, P.O. Box 3200, Somerville, NJ 08876. (201) 685-6420. $0.99 to $1.39; stock.

Claimed to be the first multiple-technologies dual-voltage comparators, the CA3290 series of BiMOS devices feature two independent single or dual-supply circuits on a single chip. The devices have gate-protected MOSFET (MOS) transistors in the input circuit to provide high input impedance (1.7 TΩ typical), low input current (3.5 pA typical at +5 V), and high-speed performance. The dc supply-voltage ranges from 4 to 36 V and the common-mode input voltage range is typically 1.5 V below the negative supply rail. The chips are compatible with all logic systems and operate over a temperature range from −55 to 125 C.

CIRCLE NO. 359

IC chip controls SDLC protocol



Western Digital, P.O. Box 2180, Newport Beach, CA 92663. (714) 557-3550.

An IBM/SDLC communications circuit, the SD 1933, gives complete control of SDLC protocol. The device provides zero insertion and deletion, CRC check and generation, abort and flag insertion and delete plus invalid frame detect. Also built in is transmission error detection for CRC, underrun and overrun, diagnostics loop command, a go-ahead option for loop applications and an NRZI encode/decode option. All popular generalized computer interface control signals are present. The device operates from dc to 1.5 Mbits/s on a single +5-V supply.

CIRCLE NO. 360

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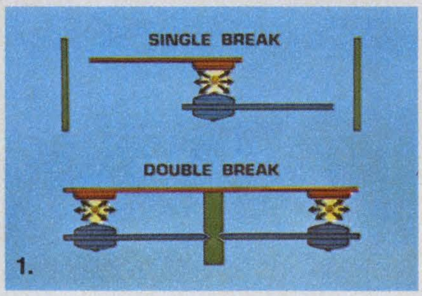
CIRCLE NUMBER 221

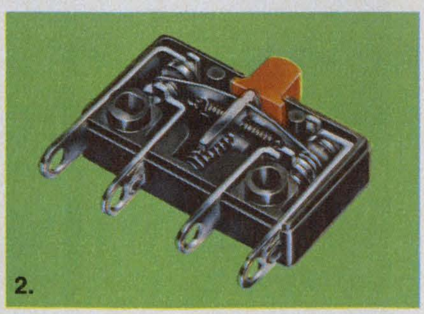
Things you should know about double break switches:

Double control...greater reliability and electrical ratings with Licon® Double Break Switches!

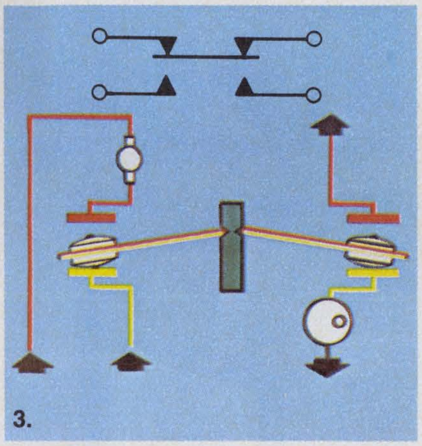
Licon specializes in producing small, rugged, double break, snap-action switches for specific, tough jobs. That's why we think there are *unique* things you should know about *double break switches*.



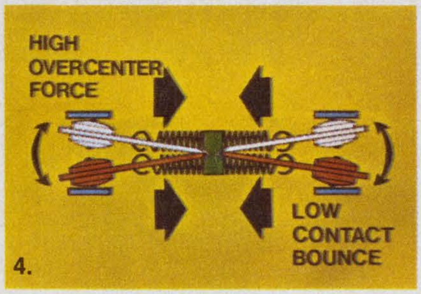
1. The Licon double break design offers twice the arc breaking and current interrupting ability with a bonus of much better heat dissipation than single break switches of similar size.



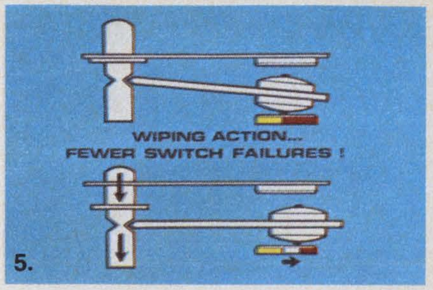
2. Coil spring snap-action mechanism extends life of switch. (Outlasts stressed blades in terms of metal fatigue.) Overcenter and compression springs are not stressed to their limits even under full overtravel as are stressed blades. Coil springs retain characteristics longer under usage than stressed blades.



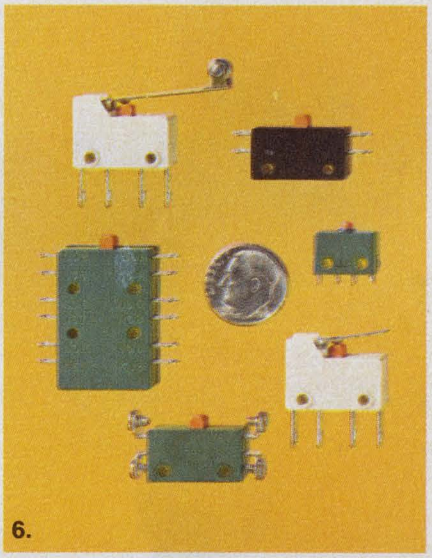
3. Dual circuit capability—with two normally open and two normally closed contacts, two isolated circuits can be controlled with one single pole Licon switch. That's a unique advantage of Form Z switching.



4. High overcenter force, small contact mass and short blade length maintain high contact pressure longer than usual stressed blade assemblies. This results in better resistance to shock and vibration. It also provides high contact pressure essential to low contact resistance for low level current use. Extremely short rebound time, when contacts collide minimizes bounce (mechanical) to increase (electrical) life.



5. Wiping action helps clean away surface contamination in low level circuits, where contact resistance must be kept low. Breaks through minor contact welds that cause switch failure under high current conditions.



6. Licon can supply a variety of U.L. and C.S.A. Listed small double break switches with "big switch" ratings up to 20 Amps for applications where size is important.

For more control, reliability and electrical load carrying capacity and more for your money double break switch details, contact your local Licon Distributor, or call or write for Switch Catalog: Licon, 6615 West Irving Park Road, Chicago, IL 60634. Phone (312) 282-4040. TWX: 910-221-0275.

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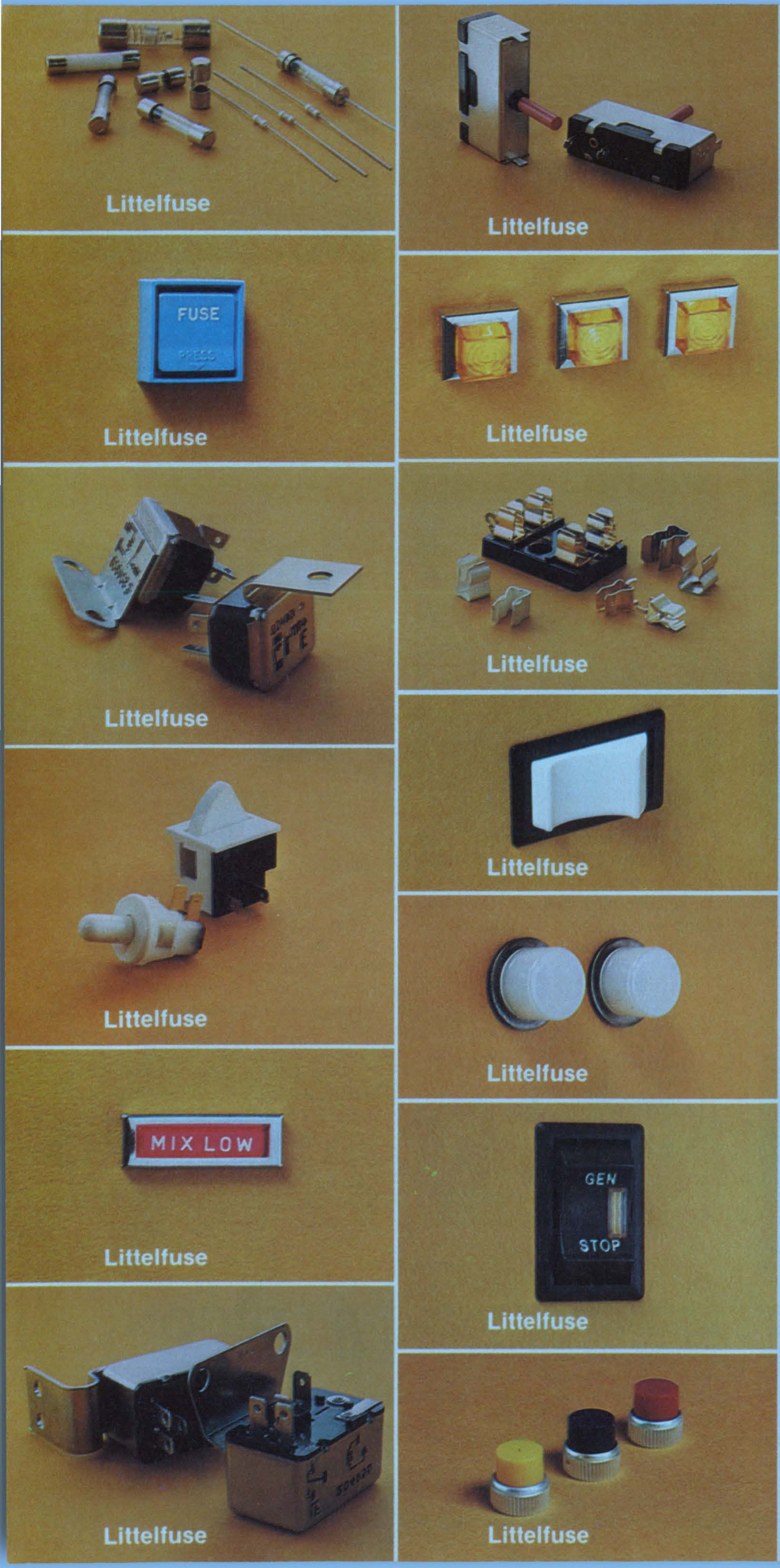

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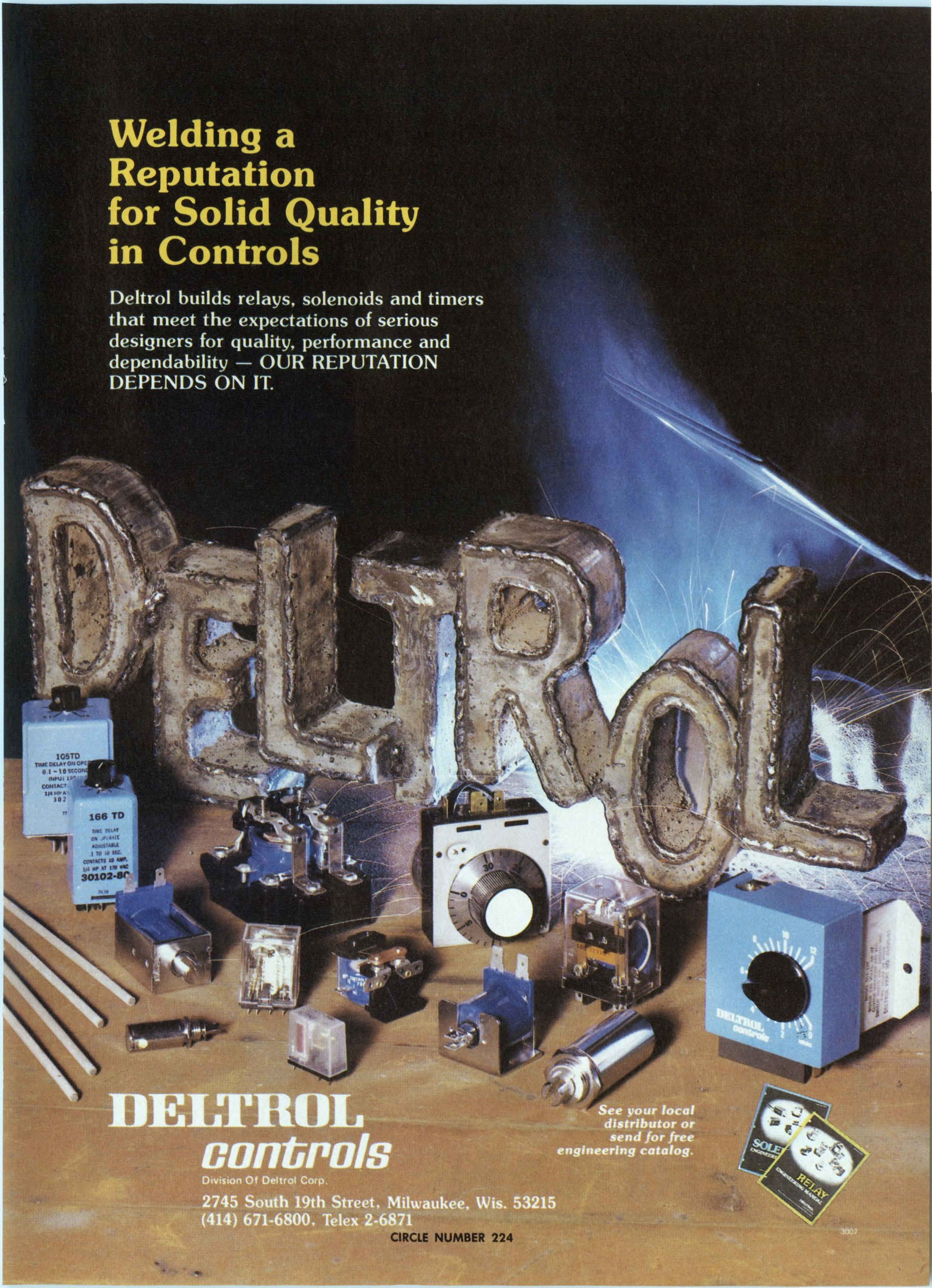
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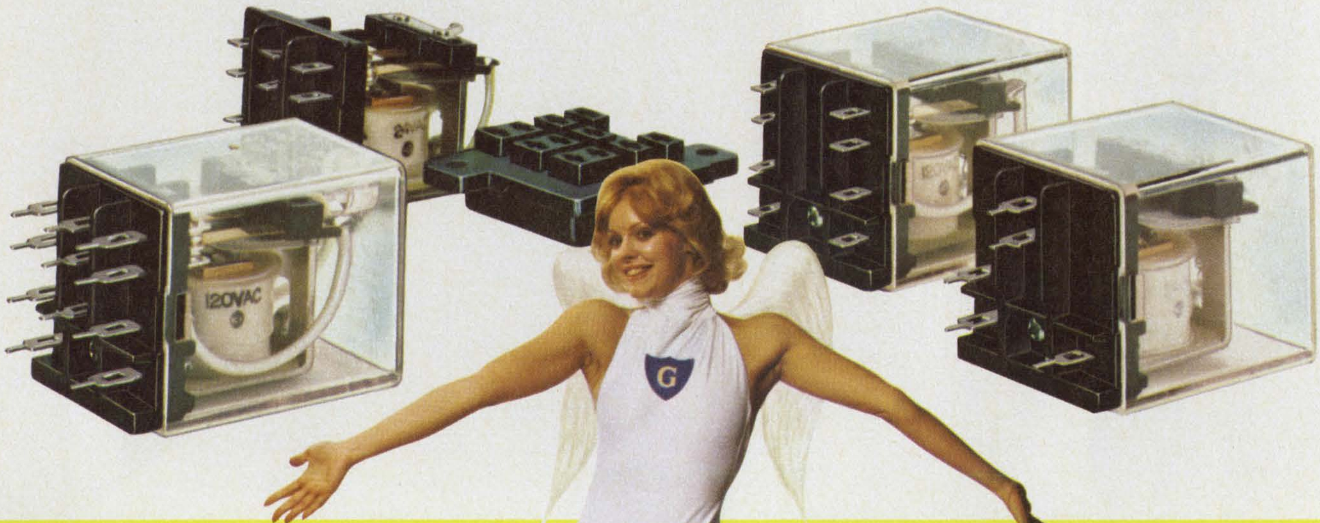

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PICK .187" or .205" quick connect/ solder lug, or PC termination.

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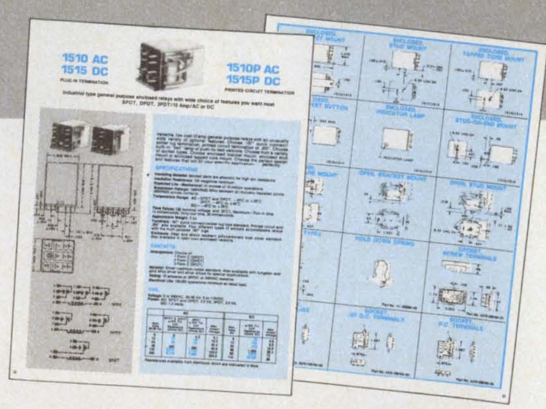

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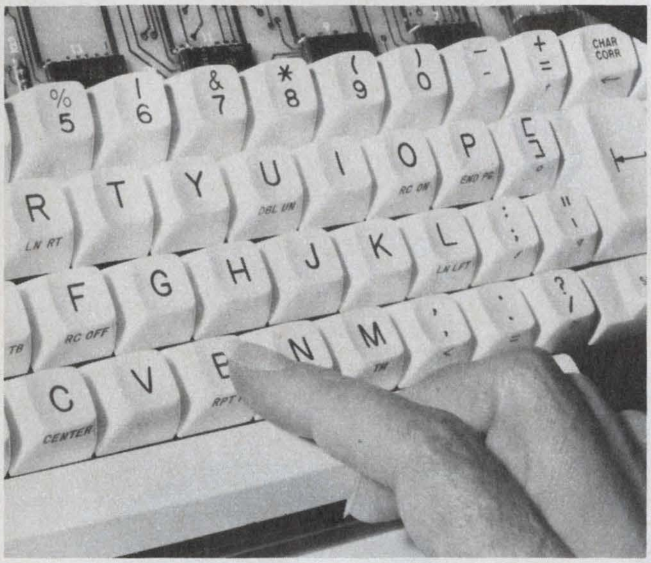
CIRCLE NUMBER 225

the "Dumb Keyboard"

for smart designs



"Dumb" can be smarter than "intelligent"

"Dumb" can be smarter than "intelligent" In 1975 Cortron developed and released a new keyboard principle of design that has given many design engineers a very real competitive edge. It is so simple we call it the "ABC" principle (Address Binary Code). If you haven't heard of it we suggest you read on to find out what many of *your* competitors are already doing. There is an alternative to the expensive "intelligent" keyboard design. We manufacture both, but we feel dumb is generally smarter.

"ABC" principle An address encoded keyboard simply outputs a unique 8 bit binary code for each key station. This code directly enters the main system which, through various software routines, determines what each specific key switch is and does. This provides a keyboard that is both simple and versatile. Cortron has various subsets of this principle to give the designer "trade-offs" between system and keyboard such as PROM conversion, etc. Call us before you design, so these "trade-offs" can be discussed and your information bank complete before costly designs are finalized.

Upstroke/downstroke We also supply a unique "ABC" for both key depression and release. Thus, not only can you determine what character, function, etc. you want, you can also control which keys auto repeat — any or all—and also which keys are mode control.

Advantages ***Lower keyboard cost:*** Eliminates electronics on board with little or no added cost to system.

Versatile: One basic keyboard can be customized for virtually any customer configuration with only software or PROM conversion and key top change.

Inventory savings: Now you can satisfy all those special foreign language and function requirements with one keyboard and a stock of key tops.

Fast turnaround: No more 20 week wait for a new LSI mask for the special requirements. Virtually "off-the-shelf" availability.

Reliability: Less electronics on keyboard means improved reliability and long term cost savings to your system.

Call us today to find out why most new designs utilize the "ABC" principle. We will explain the various "trade-offs" and costs of keyboard design and even help with your software routines, if required.

Of course, if you feel intelligent is smarter for your system, we can also aid you in those design decisions. Cortron has developed and manufactured microprocessor based keyboards using the most popular single chip microprocessors. We have the modern system development aids and staff capability which has allowed us to write the highly flexible keyboard handling routines for the cases when "intelligent" is intelligent. For full details and literature, call or write: CORTRON, A Division of Illinois Tool Works Inc., 6601 West Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040. TWX 910-221-0275. Toll free line: 800-621-2605.

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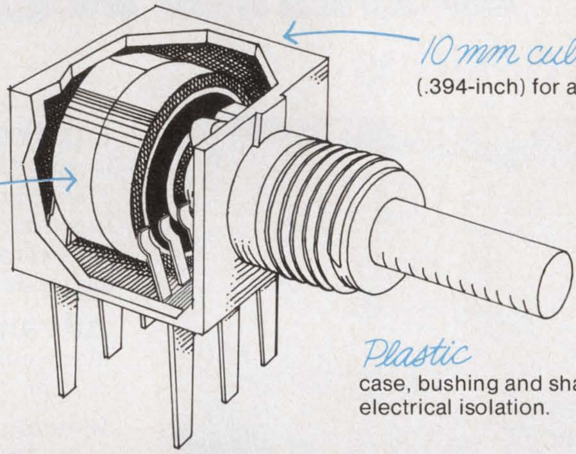

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Milwaukee, Wisconsin 53204

CIRCLE NUMBER 228

EC131

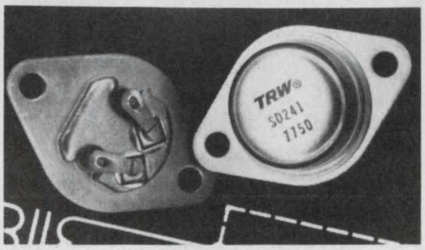
Analog multiplier doesn't cost a bundle

Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94040. (415) 968-9211. $2.75/$3.75 (100 qty); stock.

The RC4200 low-cost analog multiplier has a circuit that compensates for nonlinearity. At room temperature, the standard device achieves a maximum non-linearity of ±0.3%, while an "A" version has a ±0.1% maximum nonlinearity. The chip contains three compensated op amps and a precision log-antilog transistor array. A bandwidth of 4 MHz and a tempco of ±0.005% are provided. The unit multiplies two input currents and divides by a third.

CIRCLE NO. 361

Dual Schottky diode handles up to 25 A



TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. (213) 679-4561. $6.50 (100 qty); stock.

A single TO-3 package contains two Schottky power diode chips and allows a full-wave rectifier output of up to 20 A dc. The SD241 has a peak inverse voltage rating of 45 V and has a forward voltage drop of 0.6 V at 20 A and 125-C junction temperature.

CIRCLE NO. 362

Low-cost op amp delivers high power

Burr-Brown, P.O. Box 11400, Tucson, AZ 85734. Dennis Haynes (602) 746-1111. $19.80 (100 qty).

An op amp IC, Type 3573, delivers 100 W peak, 40 W continuous. The current output is 5 A peak, 2 A continuous from a supply voltage of ±10 to ±34 V. No external components are needed for frequency compensation and the amplifier is unconditionally stable with capacitive loads to 3300 pF. The open-loop gain is 94 dB min so that a separate preamp isn't necessary. The input stage has a 40-nA max bias current and 10^7-Ω input impedance. Offset voltage is 10 μV/°C typical. The amplifier is in an 8-pin TO-3 package.

CIRCLE NO. 363

8085A μP upgraded to 5-MHz speed

Intel, 3065 Bowers Ave., Santa Clara, CA 95051. Rob Walker (408) 249-8027.

Completely compatible with other MCS-85 family members, the 5-MHz 8085A-2 is a selected upgrade from the standard 3-MHz 8085A. Typical instruction time in an 8085-2-based system is 0.8 μs with a 5-MHz clock rate that can be set with a crystal or a TTL clock input. System performance overlaps that of TTL logic systems, allowing it to be used in high-performance applications.

CIRCLE NO. 364

Uhf transistors yield low noise

TRW RF Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. Dan Faigenblat (213) 679-4561. $1.55 to $1.73 (100 qty); 4 to 6 wks.

A pair of rf silicon transistors has high cut-off frequencies and low noise figures. The LT3046 and 3047 have cutoff frequencies of 3 and 3.2 GHz, respectively. Typical noise figure for the LT3046 is 2.5 dB at 200 MHz. For the LT3047, it is 1.7 dB at 500 MHz. Max collector current for the LT3046 is 200 mA and for the LT3047, 50 mA. The 3046 has a forward insertion gain of 10 dB at 400 MHz and the 3047's is 14 dB at 500 MHz. The transistors are packaged in TO-46 cans.

CIRCLE NO. 365

Voltage regulator is in low-cost package

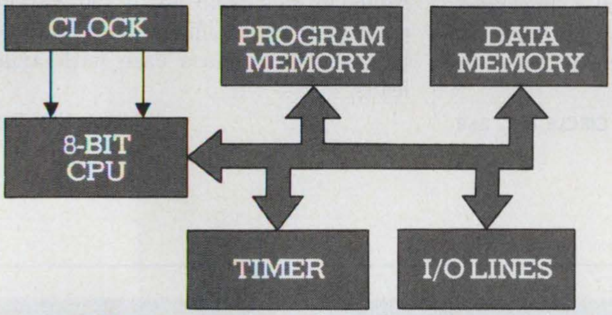
Fairchild Seminconductor Products, 464 Ellis St., Mountain View, CA 94042. Bill Callahan (415) 962-3816. $0.42 (100 qty); stock.

A series of 3-terminal, 0.5-A voltage regulators, μA78C, is a low-cost version of the μA78M. The device's U1C package has a bent heat-sink tab with dimensions that allow it to be used as a direct replacement for the TO-220 package with greater convenience than the TO-202 design. The μA78CXXU1C is offered in nine voltage options: 8, 10, 12, 15, 17, 18, 20, 22 and 24. The XX designation determines voltage, so that a μA78C12U1C would be a 12-V part.

CIRCLE NO. 366

Introducing the first Intelligent keyboard.

It thinks like you do.



Designing a full-function keyboard for your system used to have a major problem. A full-function price.

MICRO SWITCH has changed all that with the intelligent keyboard. It's the first microcomputer-based keyboard. Ever.

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The intelligent keyboard can perform more functions more efficiently because less hardware is needed. You get lower total system cost. Pin for pin compatible EPROM for faster design turnaround. Plus greater reliability since there are fewer components.

Just let us know what your particular needs are. And through MICRO SWITCH Value Engineering we'll work with you closely to create a cost effective solution that interfaces with your total system.

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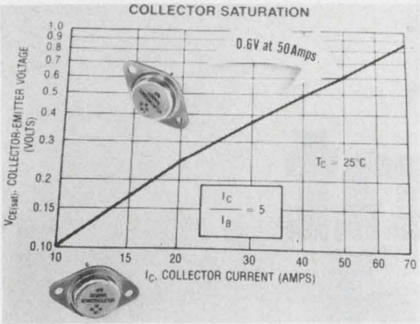
FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

In Europe MICRO SWITCH has keyboard application engineers in Germany, England, France and Sweden.

CIRCLE NUMBER 87 FOR DATA

50-A transistor switches fast

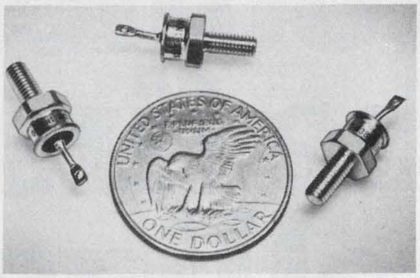


General Seminconductor Industries, P.O. Box 3078, Tempe, AZ 85281. Jim Williams (602) 968-3101. $24 (100 qty); stock.

The GSDS50020 transistor handles 50 A and has a V_{CEO} of 200 V. Peak collector current is rated at 75 A. Collector saturation voltage is typically 0.6 V and switching speeds are typically less than 1 μs at the 50-A rating.

CIRCLE NO. 367

Power rectifiers recover fast

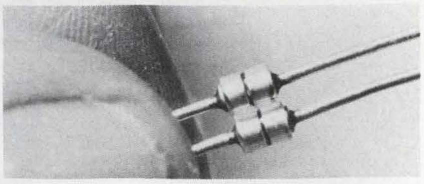


Solid State Devices, 14830 Valley View Ave., La Mirada, CA 90638. Dee Peden (213) 921-9660. $ 0.98 to $3.45 (100 qty).

Fast-recovery rectifiers, numbered 1N3889 to 1N3893, are 12-A units with blocking voltages of 50 to 400 V. The rectifiers have a typical reverse-recovery time of 100 ns with a maximum of 200 ns. Instantaneous forward-voltage drop is 1.5 V and maximum reverse current at 25 C is 25 μA. Non-repetitive peak surge current is 200 A. Packaged in a D04 case, the rectifiers have an operating temperature range of −65 to 175 C.

CIRCLE NO. 368

Ultra-fast rectifiers handle up to 6 A

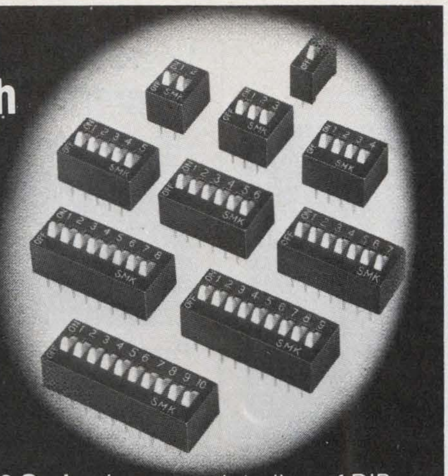


Microsemiconductor, 2830 Fairview St., Santa Ana, CA 92704. Phil Frey (714) 979-8220. $1.90 to $6.50 (100 qty); stock.

Two series of ultra-fast switching rectifiers provide switching speeds of 25 ns for the 2.5-A series and 30 ns for the 6-A series. The 1N5802 to 5806 series has an average rectified current of 2.5 A and a maximum surge current of 35 A (single cycle, 8.3 ms). The 1N5807 to 5811 series has an average rectified current of 6 A and maximum surge current of 125 A. Both series range in PIV from 50 to 150 V. The package is a subminiature, hermetically sealed hard-glass case with axial leads.

CIRCLE NO. 369

DIP Switch Line from SMK



The JS-8722 Series is a complete line of DIP Switches, from 1 to 10 positions, featuring sealed construction to prevent flux contamination during wave soldering. A clip-type wiper design assures positive 2-sided contact to provide excellent shock and vibration characteristics.

Available in SPST configuration, the switches are rated at 24V DC at 300mA switching, resistive load, and will operate from −20°C to +60°C.

Typical price for a 4 position DIP Switch in 100 piece quantity would be $1.16 each.

SMK Electronics Corporation of America
118 East Savarona Way Carson, California 90746
Tel: (213) 770-8915

"See Us At Electro Booth 1238"
CIRCLE NUMBER 137

THE INCREDIBLE BEI DIVIDED CIRCLE MACHINE

FOR THE ULTIMATE IN ENCODER ACCURACY

BEI accuracy begins at our code disk generating device. The BEI Divided Circle Machine presently attains pattern section centerline to centerline absolute position accuracy of better than 0.3 second of arc! BEI's commitment to accuracy is evident in every aspect of encoder design. Check these features from our absolute position series: Non-ambiguous code formats • Linear and nonlinear codes • Reference amps compensate for variations in temperature and supply voltage • Dual readout stations of Optical Resolver™ Series cancel effects of bearing eccentricity and shaft loading.

BEI Electronics, Inc.

Controls and Instruments Division
Little Rock, Arkansas

Industrial Encoder Division
Goleta, California

Exclusive manufacturers of the BALDWIN® encoder
1101 McAlmont Street Little Rock, AR 72203
(501) 372-7351 TWX 910-722-7384

CIRCLE NUMBER 175

Now! The higher frequency response of ink recorders and the reliability of thermal writing

Gulton's new generation of oscillographic recorders gives you clear crisp traces, 140 Hz frequency response, compact size and light weight. And they don't give you the puddles, smudged fingers and aggravation of ink recorders. Or their higher price.

Now all Gulton recorders have an eight speed pushbutton chart drive. Sturdy coaxial styli are standard, and nearly indestructible ceramic tip styli with two year guarantees are available. Automatic stylus heat compensation varies the stylus heat in proportion to the chart speed to maintain constant trace density.

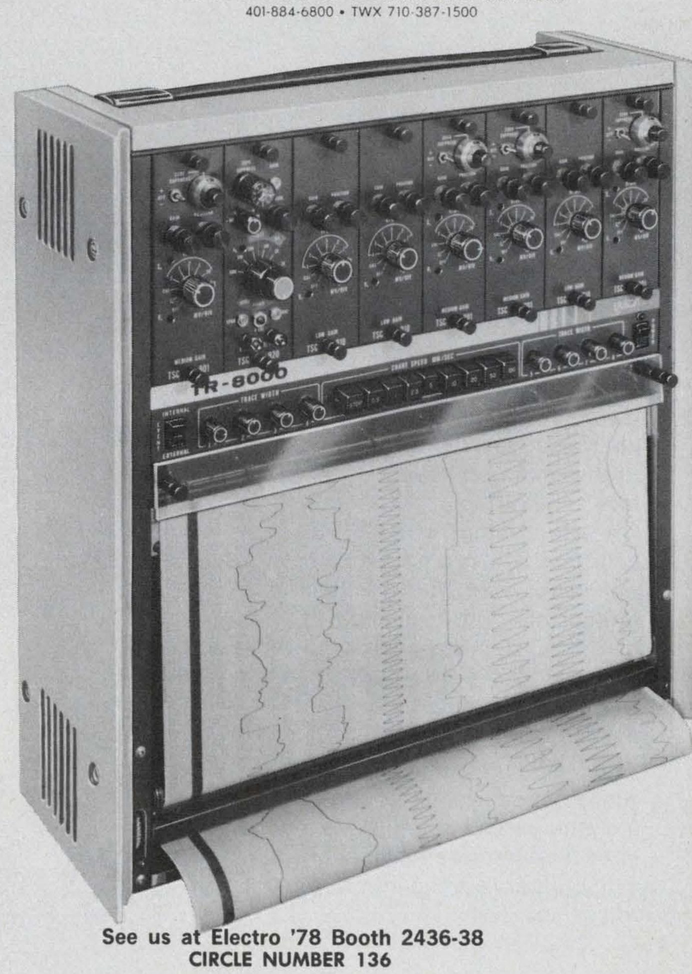
With one Gulton recorder, and your choice of plug-in signal conditioners (30 are presently available), you can record volts, amps, temperature, strain, ac to dc, frequency to dc, EKG, watts, log to dc, current to dc, ac to log . . . and more.

Two, four, six and eight channel models are available for lab or field use, or rack mounting.

Write or call today for our fact-filled 16 page recorder catalog!

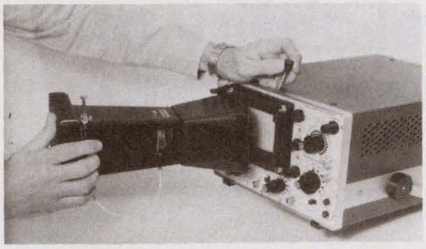
gulton®

Measurement & Control Systems Division
Gulton Industries Inc., East Greenwich, Rhode Island 02818
401-884-6800 • TWX 710-387-1500



See us at Electro '78 Booth 2436-38
CIRCLE NUMBER 136

Scope camera allows choice of mounting

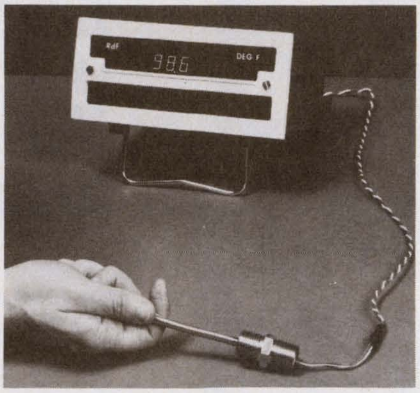


Shackman Instruments, Mineral Lane, Chesham, Buckinghamshire HP5 1NU. G.J. Bennet (02405) 4451.

The budget-priced (£130 to £160) oscilloscope camera, Model 7000, has shutter speeds from 1/125 to 1 s and an f/3.5 lens. Ten hoods are available for hand-held operation to suit almost any oscilloscope. A spacer and adapter allows the camera to be permanently mounted. The camera produces 3 1/4-in. square Polaroid pictures with no focusing.

Booth 2427 **CIRCLE NO. 372**

Digital display reads temperature to 0.1°

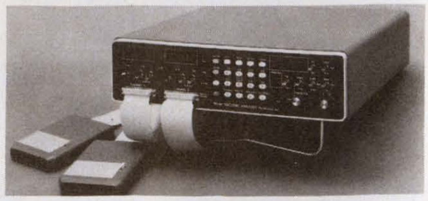


RdF, 23 Elm Ave., Hudson, NH 03051, Bob Warnick (603) 882-5195.

A digital temperature indicating system with 0.1° resolution combines a Type 21 platinum-resistance bulb with the Model 2000 digital indicator. The resolution of 0.1° is obtained from 0 to 195 F or C. Above 195° the system automatically overranges to a 1° resolution. Accuracies of ±1° throughout the range of −200 to 1200 F are possible with the system.

Booth 2334 **CIRCLE NO. 373**

Logic-state analyzer programs itself



Paratronics, 800 Charcot Ave., San Jose, CA 95131. Ira Spector (408) 263-2252. From $1500; 6 wks.

The 32-channel Model 532 intelligent logic-state analyzer programs itself for automatic operation. Using an auxiliary memory board, the instrument stores individual tests; one in RAM and seven in PROMs. The analyzer connects to a known good system and the conditions for triggering are programmed using its keyboard. With the known good system operating and the triggering conditions satisfied, a set of data is collected by the main memory. To reproduce the test, the RECALL key causes the automatic set up of the front panel.

Booth 2237 **CIRCLE NO. 374**

INSTRUMENTATION

Spectrum analyzers memorize input data

Polarad Electronics, 5 Delaware Dr., Lake Success, NY 11040. E. Feldman (516) 328-1100. $9900 to $11,950; 8 to 10 wks.

The 600 series rf/microwave spectrum analyzers span 100 kHz to 40 GHz. Built-in memory provides nonfading, flicker-free display storage. It also retains data for recall at will. Precise on-screen comparisons can be made between incoming signals versus stored reference displays. An I/O memory interface provides for data storage and signal-processing accessories. Each analyzer has a 4-digit LED frequency readout, direct-reading absolute level calibrations, 70-dB dynamic range, 300-Hz to 1-MHz resolution bandwidths and phase-locked LO stabilization.

Booth 2221 **CIRCLE NO. 375**

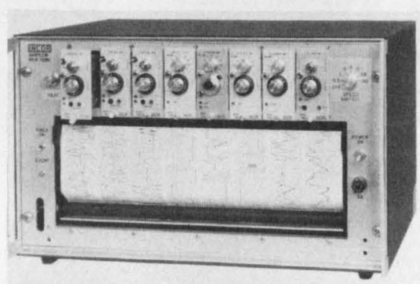
Frequency synthesizer provides 4 outputs

Syntest, 169 Millham St., Marlboro, MA 01752. (617) 481-7827. $3388; stock to 4 wks.

The Model SI-880 multiple frequency synthesizer provides up to four independently selectable signal outputs within the range of 0.1 Hz to 16 MHz with a resolution of 5-1/2 digits. Each of the square-wave outputs provides low phase noise and spurious signals at TTL levels into 50-Ω loads. Nonharmonic spurious signals are no greater than −60 dB. Optional internal crystal reference oscillators can be supplied to provide either ±10-ppm or ±1-ppm accuracy from 0 to 50 C. The unit is mounted in a case measuring 17 × 10 × 13 in.

CIRCLE NO. 376

Signal conditioners plug into 8-channel recorder

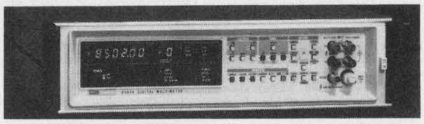


Incor Instrumentation, 144 Lamar St., W. Babylon, NY 11704. M.T. Swift (516) 643-7070. See text; stock to 3 wks.

Modules plug into the Model 3000 six or eight-channel analog recorders to provide signal conditioning. A variety of modules handle 1 μV to 500 V, thermocouples, f/v converters and the excitation for strain, load and pressure transducers. All modules contain their own power supplies. The recorders are inkless, thermal-writing types with dc to 100-Hz response on 40-mm wide channels. Multi-speed chart drives from 1 mm/h to 200 mm/s and event-timer markers are available. The 6-channel recorder is priced at $2299; the 8-channel unit at $3075. Signal conditioning modules are $195 to $430.

Booth 2334 **CIRCLE NO. 377**

Bench digital voltmeter includes math functions

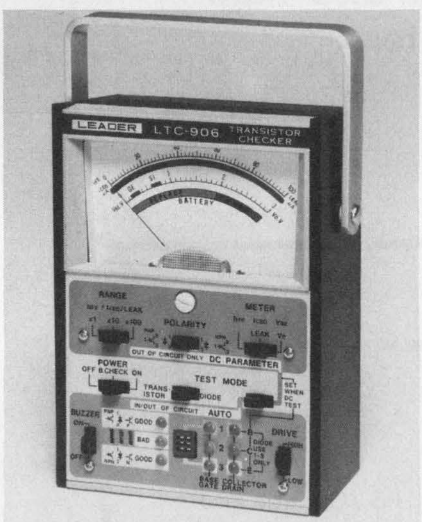


John Fluke, P.O. Box 43210, Mountlake Terrace, WA 98043. (800) 426-0361. $2494.

In addition to basic DVM functions, the 8502A bench digital voltmeter incorporates math functions that process input information into a format for readout. The functions include simultaneous offset values and scaling factors according to the formula y = ax + b, where a is the scaling factor, x is input data and b is the offset value. In addition, other applications are satisfied with this math package, such as percentage error. The meter provides 6-1/2-digit resolution. A variety of options is available, ranging from true rms, ac/dc current, ohms and calibration memory measurement to systems interfaces.

CIRCLE NO. 378

Transistor checker indicates audibly



Leader Instruments, 151 Dupont St., Plainview, NY 11803. Pat Redko (516) 822-9300. $160.

A multipurpose, portable transistor checker, the Model LTC-906, automatically tests a broad range of parameters and produces an audible tone along with the LED display to indicate good or bad performance. The instrument identifies germanium or silicon characteristics and reads out gain and leakage. Absolute metering of dc parameters is also provided.

CIRCLE NO. 379

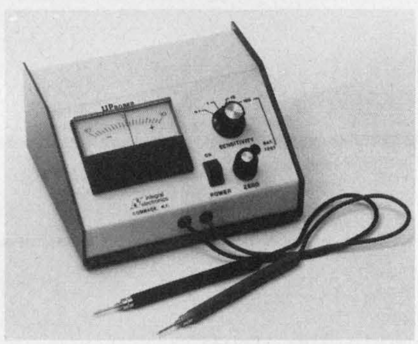
Function generator spans 0.1 Hz to 1 MHz

B & K Precision, 6460 W. Cortland Ave., Chicago, IL 60635. Myron Bond (312) 889-9087. $175; stock.

Frequency coverge of the Model 310 function generator spans 0.1 Hz to 1 MHz in six ranges, with each range providing linear 100:1 frequency control. The instrument generates sine, square, TTL square and triangle waveforms. If a 0 to 5.5-V ramp is applied to the voltage-controlled oscillator input, the 3010 provides a 100:1 output frequency change. Used in this manner, the unit serves as a sweep generator. An audio signal applied in place of a ramp produces a direct fm output. The variable-output square-wave rise or fall time is 100 ns and the TTL square-wave rise/fall time is 25 ns.

Booth 2411 **CIRCLE NO. 380**

Current-tracing meter isolates defective ICs

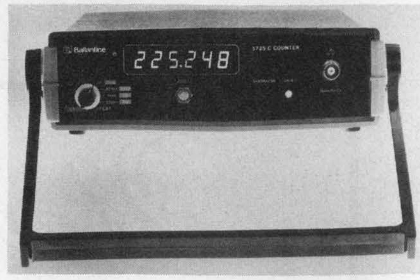


Integral Electronics, P.O. Box 286, Commack, NY 11725. Marcy Talbot (516) 269-9207. $94.50; stock.

A current-tracing meter, Microprober Model 42, isolates defective ICs on assembled PC boards. Detection of random solder shorts and identification of extraneous wires in back planes and wrapped-wire assemblies is simplified with the aid of this device. The sensitivity of the current tracer, spanning a 10,000:1 range, permits effective isolation of faulty TTL, DTL, CMOS or ECL circuits. The instrument is portable and powered by a 9-V battery.

CIRCLE NO. 381

Thrifty counter operates on portable dc power



Ballantine Labs, P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. $295; stock.

A compact, portable, EMI-proof economy instrument, the Model 5725C frequency counter, operates from any external 9 to 15-V-dc source. The instrument measures to 225 MHz and shows the result on an 8-digit LED display. A single switch selects readings in Hz, kHz and MHz over the direct count range of 10 Hz to 225 MHz or down to 1 Hz on square wave. The nominal sensitivity is 50 mV. Resolutions from 1 kHz to 0.1 Hz are obtained with four selectable gate times.

CIRCLE NO. 382

Portable scope sports dual trace

B & K Precision, 6460 W. Cortland Ave., Chicago, IL 60635. Myron Bond (312) 889-9087. $750; stock.

A compact portable dual-trace scope, Model 1432, has a bandwidth of 15 MHz. Vertical sensitivity is 2 mV/div and the usable response extends beyond 30 MHz. A built-in power supply operates on 117 V ac, 234 V ac, 12 V dc or optional internal batteries. Algebraic addition and subtraction of channel A and B input signals are provided to view distortion products. Nineteen calibrated sweep ranges cover 0.5 μs to 1.5 s with $\pm 3\%$ linearity. A 5 $\times$ magnifier extends the sweep range to 0.1 μs.

Booth 2411 **CIRCLE NO. 383**

Visit us at Electro'78 and see what our competition might be showing by Electro'79

Until now, trade shows have been easy to figure out. You'd visit one booth, and count on the others to have pretty much the same thing.

But not this year. Not since International Microsystems, Inc. developed the PROM programmer that's probably going to be the highlight of our competition's booths next year.

It's the IM 1000 Universal PROM Programmer. And it's our biggest reason for being at Electro '78.

Surprised that International Microsystems could get the jump on those other companies? Don't be. Since our inception, we've been specializing in innovation. That's how the IM 1000 came about. And while those other companies are saying "Wait til next year," we're already looking to the year after that.

But don't take our word for it. Check the chart. Then come to booth 2049 and see for yourself. See what those other companies are trying to keep up with.

IM VS. THE COMPETITION...

Requirement	Features	IM 1000	Data I/O IX	Pro-Log 90
Editing	Keyboard	**Yes**	Yes	Yes
	Selectable Address Field	**Yes**	Opt.	Yes
	Visual Display (Digits)	**14**	6	6
	Internal RAM Size (Bytes)	**4K**	1K	0
Interfaces	TTY (20 ma)	**Yes**	Opt.	Opt.
	RS232	**Yes (2)**	Opt.	Opt.
	Switch Selectable Baud Rates	**7**	1	1
	Parity Check	**Yes**	Yes	No
Costs	Personality Modules	**$250-330**	$400	$325-450
	Generic Adaptors	**$50**	$50	$100
	Programmer Base Price	**$1695**	$1975	$1800

International Microsystems, Inc.
638 Lofstrand Lane
Rockville, Maryland. 20850
or call: (301) 340-7505

Electro/'78 booth 2049.

CIRCLE NUMBER 99

Multimeter sports 5-1/2 digits

California Instruments, 5150 Convoy St., San Diego, CA 92111. Jack Kope (714) 279-8620. $795; stock to 4 wks.

The DMM 53 is a 5-1/2-digit dc, ac and resistance meter. The meter has five ranges of dc and ac measurement plus six ranges of 4-wire resistance measurement. Accuracy on dc is 0.003% of input plus 0.005% of full scale. Accuracy on ac is 0.1% of input ±0.1% of full scale and resistance accuracy is 0.01% of input and 0.0015% of full scale. The multimeter is autoranging on all functions. The instrument has a BCD option for applications requiring external printout.

CIRCLE NO. 384

Function gen sweeps lin/log to 200 kHz

Exact Electronics, P.O. Box 160, Hillsboro, OR 97123. (503) 648-6661. $250; 2 wks.

Control of frequency of the Model 117 function generator is by dial or, when sweep is selected, it automatically sweeps over a 1000:1 (3-decade) range. The sweep is either linear or logarithmic. The instrument operates over a range of 2 Hz to 200 kHz in three steps. Outputs are sine, square, triangle, ramp and pulse with the main output variable up to 15 V pk-pk open circuit, 7.5 V into 600 Ω. Sweep rate can be 25 s, 250 ms or 2.5 ms. The sweep rate can be modified by applying an external capacitor to the ramp timing terminals on the rear panel.

Booth 2013 **CIRCLE NO. 385**

Pulse generator programs remotely

Velonex, 560 Robert Ave., Santa Clara, CA 55050. George Obinger (408) 244-7370.

The Model 1012 pulse generator features complete programmability through three rear-panel connectors. Programming can be either a ground closure or an open circuit in a standard BCD format. Other formats can be provided for special applications. The instrument provides single or double pulses, internal or external trigger, one-shot and synchronous or asynchronous gating. With internal trigger, the range is 10 Hz to 9.99 MHz for single pulses and 20 Hz to 19.9 MHz for double pulses. Pulse widths are from 40 ns to 9.99 ms.

CIRCLE NO. 386

Waveform generator sweeps wide range

Krohn-Hite, Avon Industrial Park, Avon, MA 02322. (617) 580-1660. $295; 4 wks.

With adjustable sweep durations from 1 ms to 1000 s, the Model 1200 sweep generator provides 20-V pk-pk sine, square and triangle waveforms. The frequency range is 0.2 Hz to 3 MHz. Frequency can be swept up or down. Other features include a 1500:1 manual tuning dial, 5% fine-tune vernier, variable dc offset, external voltage-control input, a control voltage output proportional to frequency, auxiliary TTL output with less than 15-ns rise and fall, flat response of less than 0.1 dB and typical distortion of 0.25%.

Booth 2230 **CIRCLE NO. 387**

Storage scope joins plug-in tester family

Tektronix, P.O. Box 500, Beaverton, OR 97077. Abe Taghioff (503) 644-0161. $2200; 14 wks.

A bistable storage oscilloscope, the SC 503, has joined the TM 500 family of plug-in test instruments. This 10-MHz dual-trace instrument has a normal stored writing rate of 50 cm/ms and can be enhanced to 250 cm/ms by trading off storage time. Maximum storage time is 4 h. In the auto-erase mode, viewing can be varied from 1 to 10 s. The SC 503 can also be operated in nonstorage mode. Other features include 3% vertical deflection and time-base accuracy, 1-mV/div sensitivity and a full range of input modes.

Booth 2012, 2111 **CIRCLE NO. 388**

Scope camera suits low budgets

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $265.

A low-cost CRT camera that fits many oscilloscopes and small monitors, the Model C-5B, uses a Polaroid pack-film back and a xenon flash unit to illuminate the graticule. The camera has an electric shutter with speeds from 0.1 to 5 s and a fixed-focus three-element f/16 lens. The CRT display can be viewed through a door without removing the camera.

CIRCLE NO. 389

Word generator provides two channels

Dytech, 2725 Lafayete St., Santa Clara, CA 95050. (408 241-4333. $795; stock to 6 wks.

The Model 8000 provides dual-channel word generation with a 16-bit word-length capability for each channel. Both RZ and NRZ data are available from each word output at all times. Two rows of data-content switches provide the capability to select a binary 1 or 0 for each bit of both words. First and last bits are available for both words at all times. The instrument also provides pseudorandom binary sequencing from 7 to 65,535 bits. In this mode, word A data may be sequenced after every word A or after every complete A-B cycle.

CIRCLE NO. 390

Frequency counters cover vhf and uhf spectrum

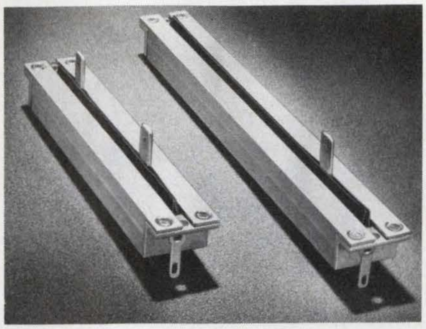
Davis Electronics, 636 Sheridan Dr., Tonowanda, NY 14150. (716) 874-5848. $349.95/$549.95.

Wide-range vhf and uhf frequency counters in the CTR-2A series measure up to 1 GHz. The Model CTR-2A-500 covers 10 Hz to 512 MHz and the CTR-2A-1000 range is 10 Hz to 1 GHz. The units include an 8-digit display, built-in preamp and prescaler, TCXO time base and automatic input. Selectable gate times are 0.1 and 1 s, and resolution is 1 Hz.

CIRCLE NO. 391

Have You Mailed Your Requalification Card? See Page 45

Slide pots convert linear motion



Waters Mfg., Longfellow Center, Wayland, MA 01778. Bab Waters (617) 358-2777. $10/$12 (100 qty).

The MM4 and MM6 linear-motion slide potentiometers provide equipment designers with a linear-motion alternative to rotary potentiometers. Linearity of the potentiometers is 1% and resistance values are 1, 5 and 10 kΩ. The stroke length is 2.6 and 4.12 in.

Booth 2518 CIRCLE NO. 392

Transformer terminals suit solar heat controls

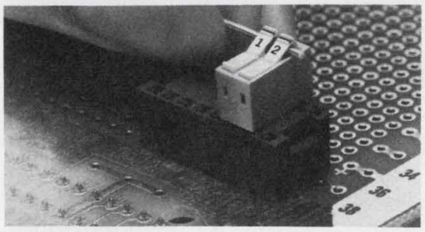
Dormeyer Industries, 3418 N. Milwaukee Ave., Chicago, IL 60641. (312) 221-3831.

A 30-V rms Class-2 output transformer has a variety of terminations to suit custom solar-heating control-circuit packaging. The transformer is bobbin wound with terminals primarily designed for PC mounting. However, it may be furnished with leads for channel mounting. The transformer has primary ratings of 115 and 230 V or 115/230 V. Secondary ratings are 0.6 to 24 W.

Booth 1727 CIRCLE NO. 393

COMPONENTS

Coded DIP switch saves space

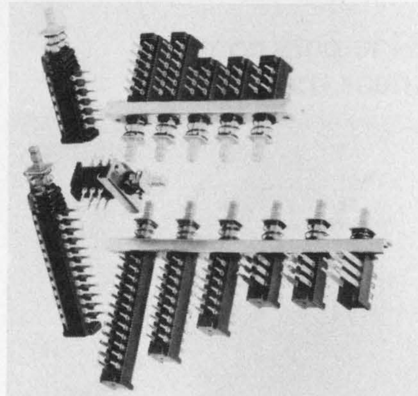


EECO, 1441 E.Chestnut Ave., Santa Ana, CA 92701. (714) 835-6000.

The Micro-DIP switch is so small that it occupies only one-half of a 14-pin IC socket. Fully-coded DIP switches are available in 10 and 16-position binary codes. The units mount directly to a PC board or insert into DIP sockets. Gold contacts are screw-driver actuated in either direction and are color-coded for easy identification.

Booth 1730 **CIRCLE NO. 394**

Multi-pushbutton switch comes in many varieties

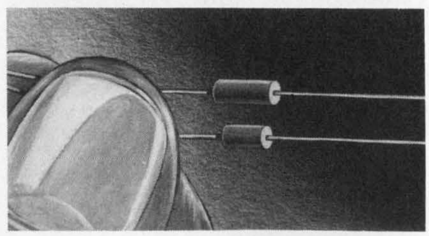


SMK Electronics, 118 E. Savarona Way, Carson, CA 90746. (213) 770-8915.

The JP-7000 series of multi-pushbutton switches includes interlocking, self-locking, momentary or reset types in standard 15, 17.5 or 20-mm spacing. The switches are sealed at both the rear and bottom surfaces and use Valox 94V-O material with terminals molded and secured into the housing. Four types are available in DPDT, 4PDT, 6PDT and 8PDT with contacts rated at 300 mA at 30 V dc. There also are six different terminal configurations with lengths ranging from 6.4 to 18 mm. Up to a maximum of six switch stations can be interlocked and up to 12 switches can be mounted on the same frame.

Booth 1238 **CIRCLE NO. 395**

NPO capacitors are QPL to MIL-C-20G



Republic Electronics, 176 E. 7 St., Paterson, NJ 07524. George Walter (201) 279-0300. Stock to 12 wks.

A line of tubular and radial-lead NPO capacitors is QPL approved to MIL-C-20G. The military designations are CCR05 through CCR09 and CCR75 through CCR79. The units are approved to failure-rate level M (1%/1000 h). The capacitors have a minimum Q of 1000 and a maximum capacitance change of ±0.3% from −55 to 125 C. Tolerances as close as ±1% are available.

Booth 1432 **CIRCLE NO. 396**

METSHIELD™ Fabric. The first major advance in magnetic shielding in 50 years.

This is the magnetic shielding product whose time has come.

Increased sales of electronic equipment, a trend toward miniaturization and intensified regulatory considerations have put increased emphasis on EMC.

Consequently, electronics manufacturers need cost-effective magnetic shielding not plagued by fabrication problems and use limitations associated with conventional nickel alloys.

Now you have such a shielding. METSHIELD™ magnetic shielding fabric—a wholly new flexible product made from Allied Chemical's METGLAS® amorphous metal alloys.

Because of its exceptional strength and flexibility, METSHIELD fabric retains its full shielding effectiveness during fabrication and use.

This reliability of performance—plus the ease with which METSHIELD fabric can be fabricated—enables you to use magnetic shielding as a preferred method to achieve electromagnetically compatible system designs. And METSHIELD fabric now comes in 40" (1 meter) widths for even greater design flexibility.

Discover how this remarkable material can help meet your shielding needs. Phone John Dismukes at 201-455-4031 or Jack Thorp at 201-455-3306. Or return the coupon.

Check boxes for information on METGLAS® alloys and METSHIELD™ fabric.

- ☐ Technical data
- ☐ Fabrication
- ☐ Grounding and contacting
- ☐ Other (specify)__________
- ☐ Send me sample of METSHIELD fabric

Name/Title__________

Company__________

City/State/Zip__________

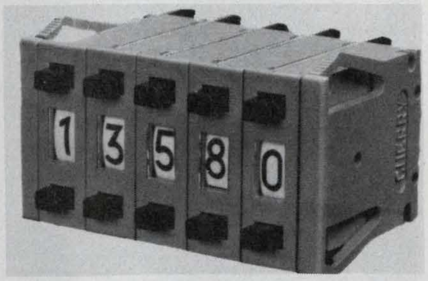
Mail to: Metglas Products, Allied Chemical Corporation
7 Vreeland Road, Florham Park, NJ 07932

Allied Chemical
Metglas Products

CIRCLE NUMBER 102

COMPONENTS

Thumbwheel switch employs pushbuttons

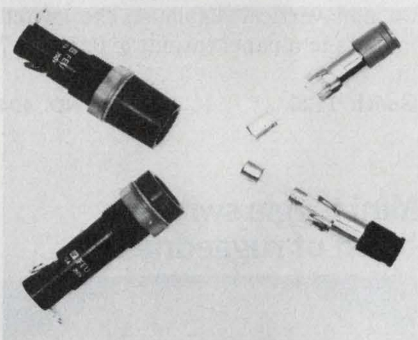


Cherry Electrical Products, 3600 Sunset Ave., Waukegan, IL 60085. Frank Amendola (312) 689-7600. \$3.40 (1000 qty) stock to 12 wks.

Wheel indexing on the T56 bidirectional, pushbutton, thumbwheel switch is controlled by two plungers, one above and one below the legend. The switch is available in six codes including decimal, BCD, BCD plus complement and 1 common, BCD complement only, BCD with diode provision and single-pole repeating. The rating in logic-level circuits is 50-V max at 0.1 A. Maximum current-carrying ability is 1 A max.

Booth 1219 **CIRCLE NO. 397**

Fuseholder meets U.S. and foreign safety specs

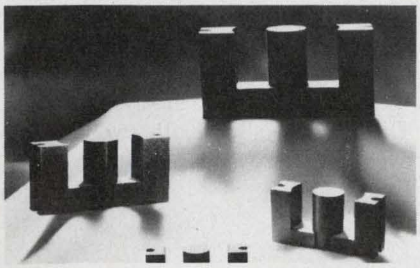


Panel Components, 2015 Second St., Berkeley, CA 94710. (415) 548-1966.

The FEU fuseholder can be used on all electronic equipment made for North American and foreign markets. It has component recognition at UL, is certified or approved by CSA, VDE, SEMKO and SEV, and conforms to IEC publications 65 and 257. All current carrying contacts are recessed or protected so that they are inaccessible when the fuse carrier is removed. The carrier is insulated so that accidental contact with a high-voltage source during fuse replacement is impossible and fuse access requires the use of a screwdriver. The holder accepts 3 AG and international 5 × 20-mm fuses.

Booth 506 **CIRCLE NO. 398**

E-cores have round center legs



Stackpole Carbon, St. Marys, PA 15817. Don Almquist (814) 781-1234. \$0.21 to \$0.45 (1000 qty); 4 to 5 wks.

E-cores with round center legs are suitable for automatic bobbin winding. Made of Ceramag 24B, the cores may be specified in four sizes of 35, 41, 52 and 70 mm. The material is popular for switch-mode power supplies because of its low core loss and high permeability characteristics.

Booth 1122 **CIRCLE NO. 399**

COMPONENTS

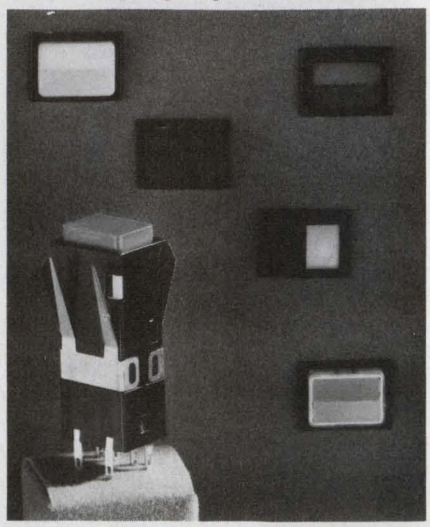
µP-based keyboard tailors to specific need

EECO, 1441 E. Chestnut Ave., Santa Ana, CA 92701. Scott McVay (714) 835-6000.

This microprocessor-based keyboard offers the capability of tailoring keyboard needs to specific applications. The keyboard has 106 keys with additional keys available for expanded features. Benefits derived from this programmable unit include high operator comfort offered by its stepped arrangement and a positive response click to the operator with each key depression. The keyboard has both two-key rollover and N-key depression.

Booth 1730 **CIRCLE NO. 403**

Pushbutton switch offers 190 display options

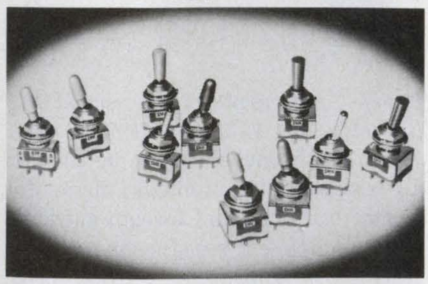


Licon, 6615 N. Irving Park Rd., Chicago, IL 60634. (312) 282-4040.

The 06 series of lighted pushbutton switches with its 190 display options allows designers a great number of switch-array possibilities. The design uses the standard T-1¾ flange-base bulb and is available with two lamps or a centrally located single lamp. Display modules are available in solid color, projected color, insertable and hidden legend. Other options are obtained by choosing from a variety of colored filters for full-screen, horizontal and vertical displays. The switch mounts in a panel cut-out of 0.92 × 0.7 in.

Booth 1125 **CIRCLE NO. 404**

Mini toggle switches boast of ruggedness



SMK Electronics, 118 E. Savarona Way, Carson, CA 90746. (213) 770-8915. From $1.18 (100 qty).

A line of mini toggle switches, all UL approved, features rugged construction using dialphthalate material with the terminals molded and secured into the housing. The JU 4000 switches are either SPDT or DPDT, and are rated at 6 A at 125 V ac or 12 V dc, resistive load.

Booth 1238 **CIRCLE NO. 405**

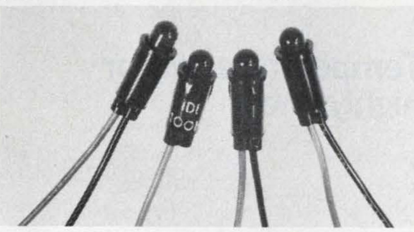
Resistors shed heat through finned housings

Inter-Technical Group, P.O. Box 23, Irvington, NY 10533. (914) 591-8822.

Stable resistors in the HS series dissipate high power in a limited space through finned aluminum housings. The resistors have ratings from 5 to 300 W with resistances from 0.05 Ω to 86 kΩ. The type HSA50, rated at 68 kΩ, 50 W, has a length between terminals of 3 in. The units meet MIL-R-18546 and can be supplied with standard or noninductive windings.

CIRCLE NO. 406

Tiny indicators provide point sources of light



Industrial Devices, 7 Hudson Ave., Edgewater, NJ 07020. (201) 224-4700. $0.76 (1000 qty).

Tiny Glo-Dot 5100 indicators provide point light sources. Self-contained assemblies snap-fit into 1/4-in. panel openings. The lamps are red, green or yellow super-bright LEDs. Wire-lead incandescent lamps may also be used. The indicator assemblies can be used on panel thicknesses from 0.031 to 0.062 in. You merely insert them into 0.249-in. holes until they snap securely into place.

CIRCLE NO. 407

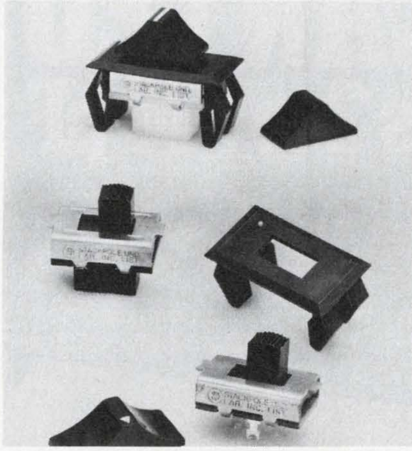
Relays combine high capacity with sensitivity

Aromat, 250 Sheffield St., Mountainside, NJ 07092. (201) 232-4260. $2.15 (1000 qty); stock to 8 wks.

Half-size Amber R relays switch currents up to 1 A, yet have pull-in power requirements of only 40 to 100 mW. The relays are available in 1-form-C contacts that carry 1 A, 20 W and resist welding at higher inrush currents. This dry-circuit-type unit switches current as low as 100 μA. The relays are housed in gas-filled sealed-plastic cases.

Booth 1503 **CIRCLE NO. 408**

Snap-in switch reduces assembly cost

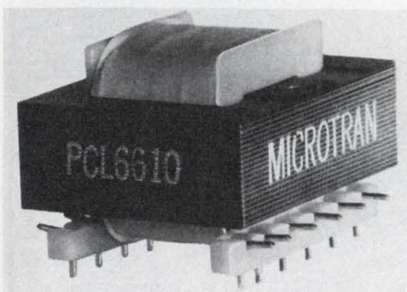


Stackpole Components, P.O. Box M, Farmville, VA 23901. Steve Smith (804) 392-4111.

A nylon snap-in adapter plate, which fits 2-position Series 20, 22 and 25 switches, reduces assembly costs by eliminating mounting hardware. Assembly time can be further reduced by specifying this snap-in mounting in combination with the S-25 push-in lead switch. Leads can be connected to the nylon switch base without tools. And special grippers prevent them from being inadvertently removed.

Booth 1122 **CIRCLE NO. 409**

Dual-primary Xformers feed power supplies



Microtran, P.O. Box 236, Valley Stream, NY 11582. (516) 561-6050. $5.50 typical (100 qty); stock.

A series of 230/115-V, dual-primary 50/60-Hz PC power transformers encompasses 83 different units. The transformers provide step-down and isolation at power ratings of 0.8, 1.5, 4.5, 7.5 and 24 VA. Output voltages from 4.5 to 150 V and currents to 2 A are available. Units provide regulated or unregulated outputs of ±5 and ±15 V dc when used with transistor regulators.

Booth 215 **CIRCLE NO. 410**

Have You Mailed Your Requalification Card? See Page 45

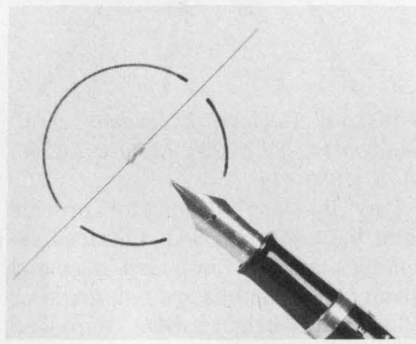
Keyboard encodes full ASCII set

George Risk Industries, G.R.I. Plaza, Kimball, NE 69145. (308) 235-4645. $75.95.

All 128 ASCII characters and control functions are encoded by the Model 756 keyboard. A line of accessories includes a numeric pad, custom cables and connectors. The keyboard interface allows selection of parity, positive or negative-logic data and strobe outputs, alpha-lock operation and both dc-level and pulse-strobe signals. A latching shift-lock key is included, and all outputs are TTL, DTL and MOS compatible.

CIRCLE NO. 411

Temperature sensor highly linear



Midwest Components, P.O. Box 787, Muskegon, MI 49443. (616) 777-2605.

Tempsistor is a solid-state temperature sensitive device having a highly linear tempco of resistance, +0.7%/°C. The linearity is maintained from −65 to 200 C. Zero power resistances at 25 C are available from 10Ω to 10 kΩ.

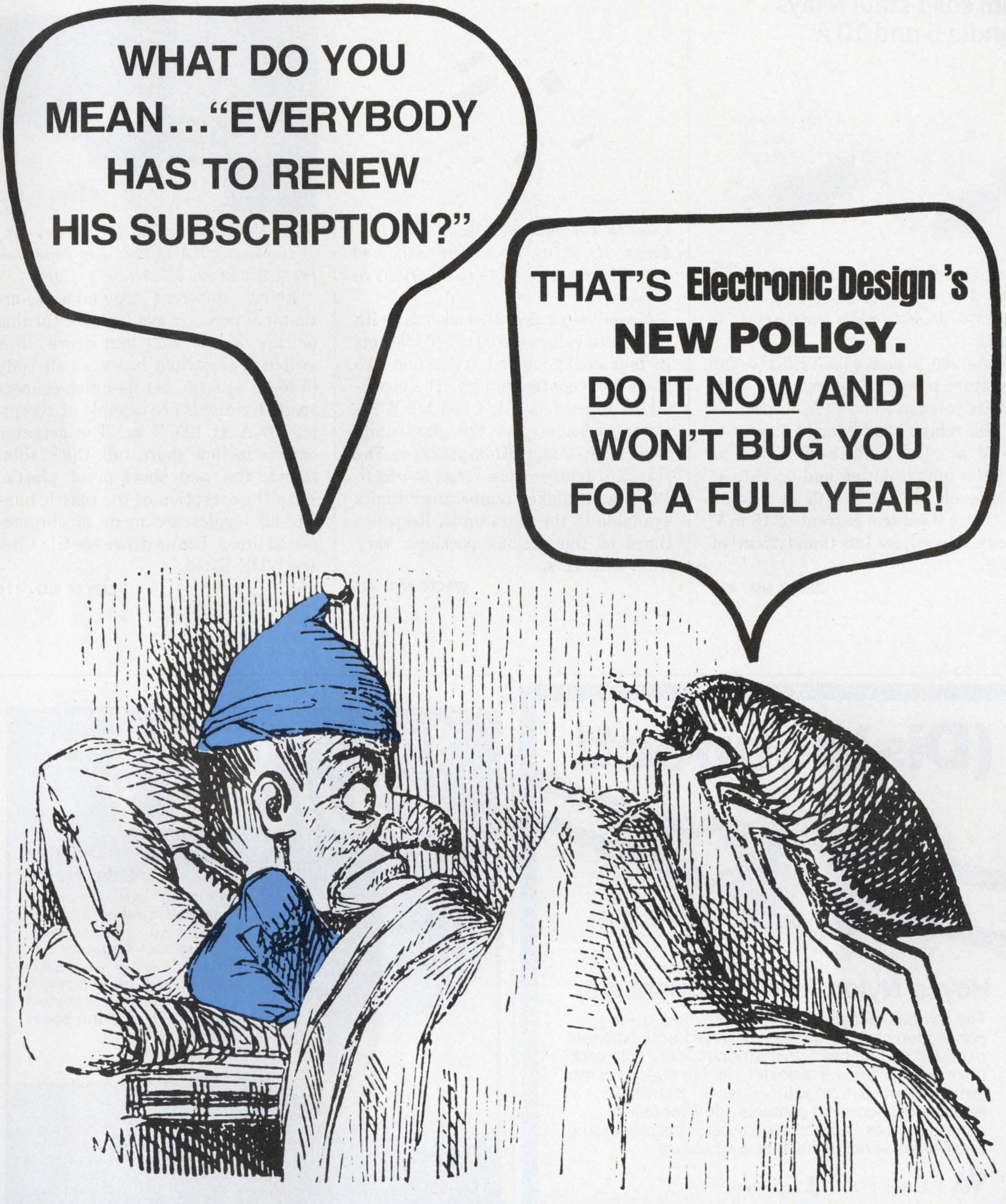
Booth 1337 **CIRCLE NO. 412**

Thick-film networks need only ¼-in. space

Stackpole Components, Raleigh, NC 27610. Charles McGill (919) 828-6201.

Mini-SIP networks require only about ¼ in. on a PC board, while holding up to 28 resistors. They are available in single and dual-in-line packages with 4 to 16 pins. The height above standoff is 0.175 in. Sixty-four standard resistance values are offered, ranging from 33Ω to 270 kΩ. Standard tolerance is 2%, but 1% matching is available.

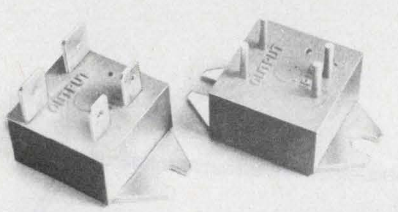
Booth 1122 **CIRCLE NO. 413**



RENEW IMMEDIATELY!

YOUR ANNUAL RENEWAL FORM APPEARS ON PAGE 49 OF THIS ISSUE

Mini solid-state relays handle 5 and 10 A

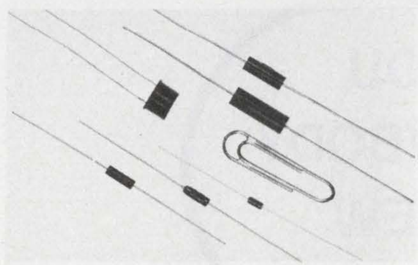


Theta-J Relays, 1 DeAngelo Dr., Bedford, MA 01730. Allan Mowatt (617) 275-2575. $3.60 to $5.00 (1000 qty); 4 to 5 wks.

JTA-1205-1 and JTA-1210-1 J-Tab miniature power relays are solid state and are rated at 5 and 10 A, respectively. The relays handle load voltages to 280 V ac. The units have 3750-V-ac input/output isolation and operate at logic levels of 4 to 8 V dc or 9 to 16 V dc with a control current of 15 mA. The relay occupies less than 0.25 in³ of space.

CIRCLE NO. 414

Thermistors offered in glass/epoxy packages

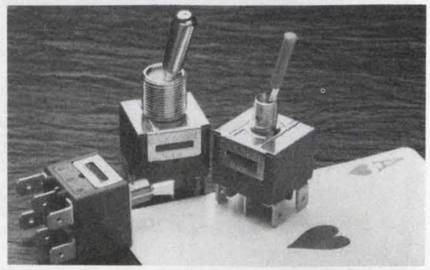


Quality Thermistor, 2096 S. Cole Rd., Boise, ID 83705. Jack Kitlinski (208) 377-3373. $0.69 to $0.79 (1000 qty); 4 to 6 wks.

Negative-tempco thermistors with resistance values of 100 to 500 kΩ come in four epoxy-molded styles and two glass-style configurations. The epoxy-styles approximate 1/4 and 1/2-W resistor packages and the glass units come in DO-7 and DO-35 packages. The standard temperature range is −60 to 125 C with higher temperature limits available in the glass units. Response times of the various packages vary from 3 to 12 s.

CIRCLE NO. 415

10-A switch offered in 11 toggle-handle styles



C & K Components, 103 Morse St., Watertown, MA 02172. Jim Martinec (617) 926-0800. $2.99 (1000 qty).

Eleven different toggle-handle-actuator options are available for turning on the Model 9221 miniature 10-A switch. The switch has a small body (0.75-in. square), yet its quick-connect spade terminals are capable of accepting 10 A at 125 V ac. The actuator options include short, tall, thick, thin, round, flat and shock-proof plastic. With the exception of the plastic handle, all toggles are made of chrome-plated brass. The switches are UL, CSA and VDE listed.

CIRCLE NO. 416

AT LAST—
A STORAGE OSCILLOSCOPE WITH NO FLICKERING, FADING OR FOGGING.

If you're involved in electromechanical testing, dynamic testing, vibration analysis, transducer measurements or medical research, the Gould OS4100 is ideal for you. It not only offers outstanding performance over a wide range of frequencies but also low cost digital storage.

A dual trace digital storage oscilloscope, the OS4100 is sensitive to 100μV per division with sweep rates as fast as 100μ sec per division. The unit employs an 8 bit x 1024 RAM with a sampling rate of 1 MHz. Thanks to Gould's unique dot joining technique, it allows meaningful trace presentations of signals beyond the frequency capability of the scope.

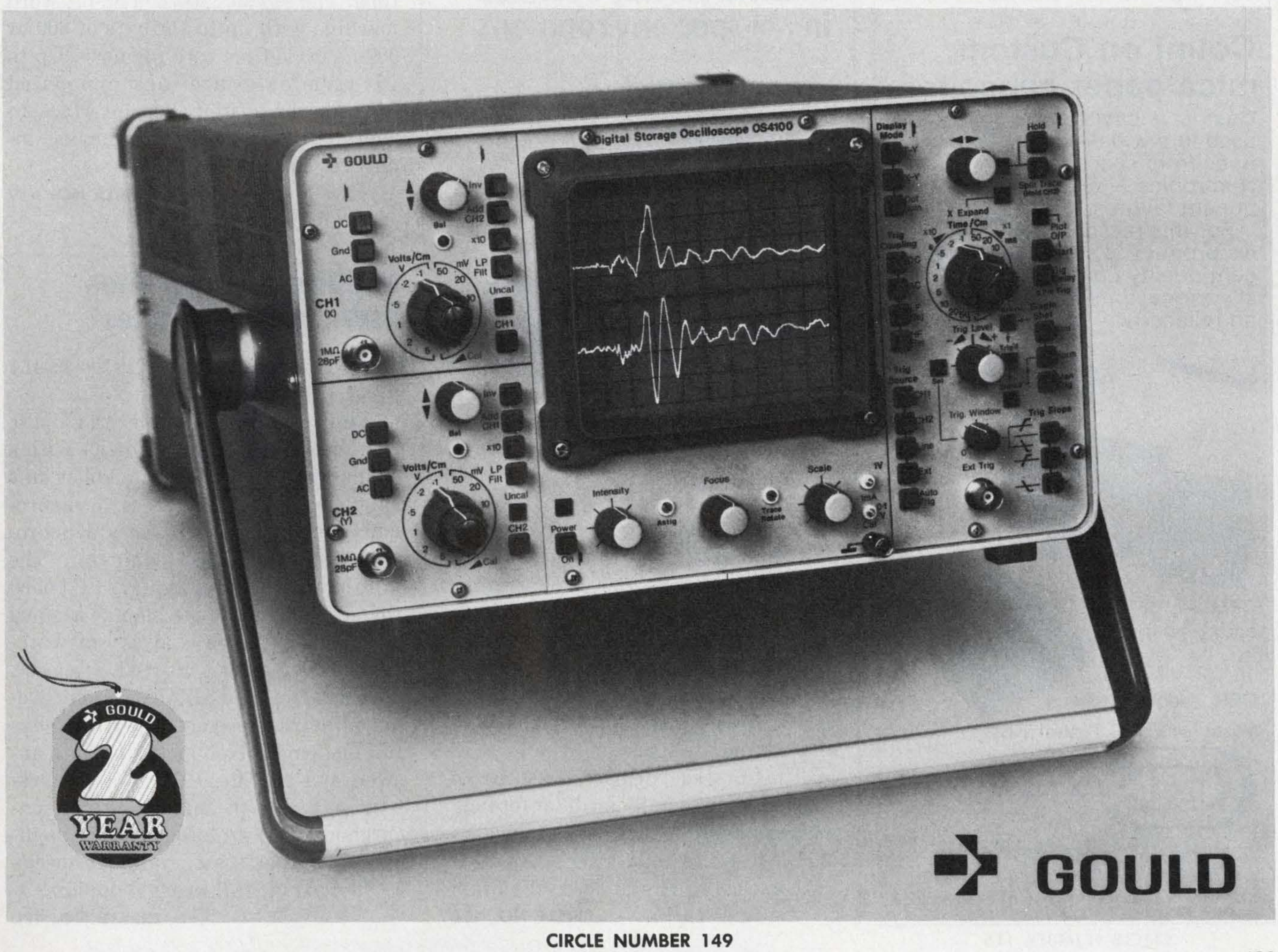
Outstanding features include X-Y mode plotting on the screen. Stored trigger point for use with repetitive signals or transients. High gain amplifier with noise suppression. Standard positive, negative and bi-polar triggering.

The sum or difference of channels can be displayed with one of either of the two channel waveforms. For comparative measurements, you can store one channel and compare it against the incoming signal on the other.

The Gould OS4100 is built to Gould's demanding standards of quality and carries a full two-year limited warranty covering all parts and labor exclusive of fuses, calibration and minor maintenance.

For details, contact Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Phone: (216) 361-3315. Or in Europe, Gould Instruments, Roebuck Road, Hainault, Essex, CB10 1EJ, England.

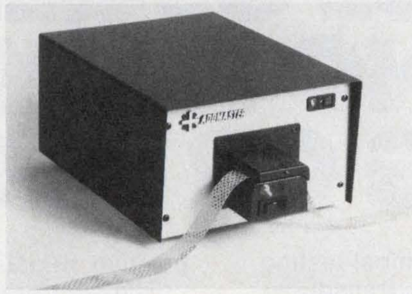
For brochure call toll free (800) 325-6400, Ext. 77. In Missouri: (800) 324-6600.



CIRCLE NUMBER 149

DATA PROCESSING

Paper-tape reader sends up to 9600 baud



Addmaster, 416 Junipero Serra Dr., San Gabriel, CA 91776. (213) 285-1121. $625 to 725.

Model 612, a stand-alone paper-tape reader, reads 5 to 8-level tape and transmits 7 to 11 frames/char at 50 to 9600 baud. Other features include starting and stopping on character at all speeds, choice of manual control or X-on, X-off, 90 to 260-V power and even, odd or no parity. RS-232, current-loop or parallel outputs are available as is a choice of desktop or rack mounting.

Booth 2342 **CIRCLE NO. 417**

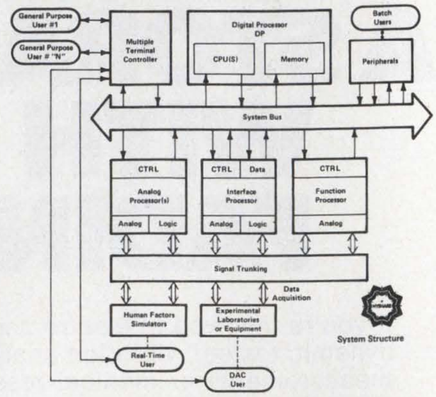
Plasma display operates in Mil-spec environment

Interstate Electronics, P.O. Box 3117, Anaheim, CA 92803. (714) 772-2811. $12,000; 13 wks.

A plasma display terminal, Model PD3000, reliably operates in airborne and shipboard Mil-spec environments. The terminal has a 20,000-ft operating, 70,000-ft nonoperating, high-altitude capability and displays high-resolution graphics with more than 4000 characters. The operating temperature range is −32 to 55 C. The unit weighs 53 lb and occupies a space of 13 × 14 × 12 in. The flat-panel display measures 8.5 × 8.5 in. Functionally modular for field maintainability, the display has an MTBF in excess of 10,000 h. An RFI-EMI enclosure is standard.

CIRCLE NO. 418

Computer takes analog and digital at same time



Electronic Associates, West Long Branch, NJ 07764. (201) 229-1100.

A hybrid analog plus digital computer system, called Hyshare, consists of an EAI 3200 digital computer and up to six high-speed analog processors. The analog/digital and digital/analog communications interfaces employ on-line dynamic resource allocation techniques that allow analog processors to be assigned to separate tasks, or linked together in almost any combination to meet specific application requirements. Hyshare functions as a digital, analog and hybrid system at the same time. The Model 3200 is a 32-bit word machine with up to 1 Mbyte of 600 or 900-ns cycle-time core memory. Up to 16 terminals are accommodated through the system bus interface to which all peripherals and analog interfaces are addressed.

CIRCLE NO. 419

Multiplexer combines async and sync lines

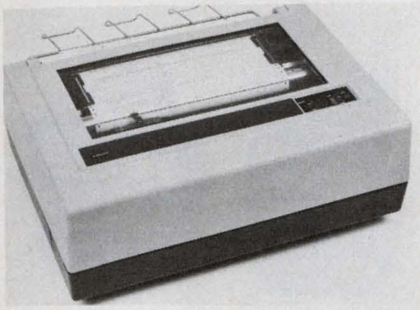
Data General, Route 9, Westboro, MA 01581. (617) 366-8911.

A universal line multiplexer, ULM-5, combines a 4-line asynchronous with a single-line synchronous controller on a single board. It interfaces asynchronous terminals as well as a synchronous line to a host computer. The multiplexer is a 15-in. square PC board that occupies a single slot in a Nova or Eclipse chassis and is software-compatible with the ALM series asynchronous and SLM series synchronous-line multiplexers. The ULM-5 has full modem control, including auto answer, and provides CRC to assist system software in implementing synchronous-line protocols. Each asynchronous interface operates at speeds to 9600 baud, full or half duplex.

CIRCLE NO. 420

Have You Mailed Your Requalification Card? See Page 45

Serial printer uses hammers not needles

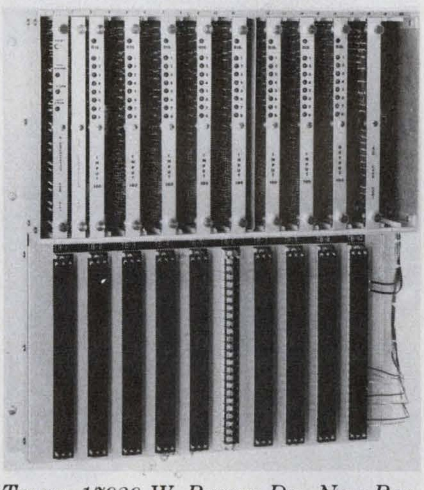


Facit-Addo, 66 Field Point Rd., Greenwich, CT 06830. (203) 622-9150.

A printhead that has hammers instead of needles or wires is used in the Model 4540 serial page printer. The printhead is based on a stored-force principle in which the print hammers are mounted on flexible arms held back by electromagnets. For each impact, the holding current is cut off and the hammer snaps forward. Using a pull-back impulse instead of a print impulse results in a small head, guaranteed to produce 5×10^8 characters. The printer provides 12 character sets including OCR-A numerics and Katakana.

Booth 2212 **CIRCLE NO. 421**

Multiplexer sends 128 channels 3000 m



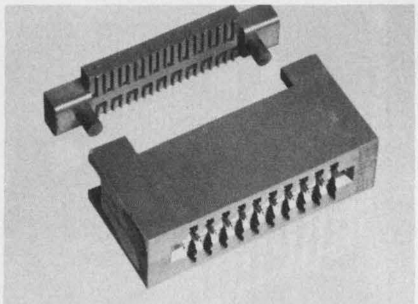
Tenor, 17020 W. Rogers Dr., New Berlin, WI 53151. (414) 782-3800.

The T-Wire industrial-grade multiplexing system consists of two units interconnected by a 3-wire cable for distances up to 3000 m maximum. T-Wire is full duplex and accepts 128 digital and 16 analog signals at each end and reconstructs those signals at the other end. The system detects and annunciates faults such as broken or shorted transmission cable or loss of system power at either end. The scan rate for a system is variable between 75 and 1200 baud.

Booth 2405 **CIRCLE NO. 423**

PACKAGING & MATERIALS

Edge connectors feature built-in strain relief

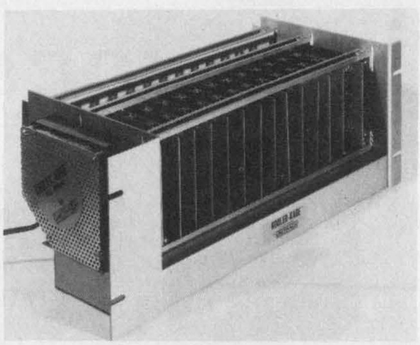


Alpha Wire, 711 Lidgerwood Ave., Elizabeth, NJ 07207. (201) 925-8000.

A series of PC card-edge connectors features built-in strain relief to prevent the flat cable from being pulled out. The connectors mate with standard 0.062-in. PC boards but will also accommodate boards ranging in thickness from 0.032 to 0.075 in. They accept 28 or 30 AWG solid or stranded conductors on 0.05-in. centers and provide connections to pads on 0.1 in. centers. The connectors are available in 10 to 50 contacts, both with and without mounting flanges. The current rating is 1 A max and breakdown voltage is greater than 500 V dc.

Booth 1329 **CIRCLE NO. 424**

Card rack contains blower for cooling



Unitrak, 8738 W. Chester Pike, Upper Darby, PA 19882. (215) 789-3820. $99.50; 2 to 3 wks.

Kooler-Kage, for standard 19-in. cabinets has a built-in centrifugal blower and plenum chamber for cooling PC cards within the cage. The blower moves 25 cfm into a baffled plenum chamber to reduce the velocity and distribute the air over the entire area. As the cool air flows from bottom to top, displacing the heated air, each card is cooled on both sides and all cards are cooled equally. The narrow blower leaves 15 in. for card racking.

Booth 1612, 1711 **CIRCLE NO. 425**

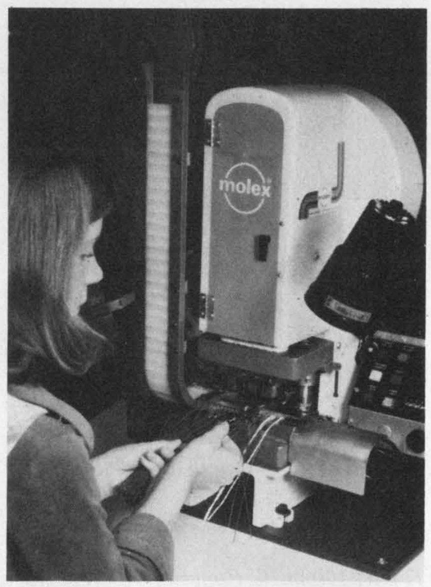
Breech-locking connector provides rugged mating

G & H Technology, 1649 17th St., Santa Monica, CA 90404. (213) 450-5823.

The Breech-Lok provides a rugged foolproof mating system in a miniature connector. The mechanism distributes the coupling load over solid metal locking lands, while drive threads on the inside of the coupling ring provide the mechanical advantage to mate the plug shell, contacts and interfacial seals. The EMI shielding is 70 dB at 10 GHz and standard shell types, sizes, contacts and arrangements are available.

Booth 1821 **CIRCLE NO. 426**

Machine assembles wires to connectors

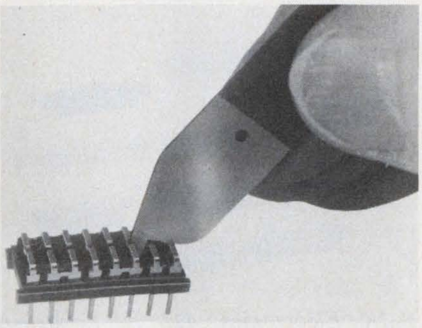


Molex, 2222 Wellington Ct., Lisle, IL 60532. Ken Kufner (312) 969-4550.

The CAM 1 assembly machine semiautomatically crimps a terminal to a wire and inserts it into a connector housing. A control box monitors all machine functions including circuits desired and terminals inserted into each housing. The machine allows for any gauge wire to be terminated. An adjustable housing magazine for KK housings from 4 to 24 circuits is available for easy loading. The device handles up to 1800 insertions/h.

Booth 413 **CIRCLE NO. 427**

DIP headers let you program

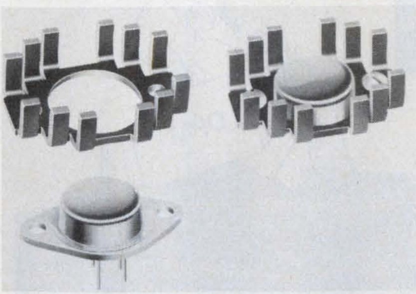


Aries Electronics, P.O. Box 231, Frenchtown, NJ 08825. (201) 996-4096. From $0.53.

Available in 8, 14 and 16 pins on 0.3-in. centers, DIP program headers present versatility for programming within the header itself. The headers are available preprogrammed, or they can be programmed by the user with needle-nose pliers or a program-header tool to remove interconnecting sections. Adjacent pins, as well as opposing pins, are interconnected until the pre-slotted section is snapped out. A complete program can be provided by leaving or removing interconnecting sections. A snap-on cover is provided that can be marked to identify the program.

Booth 1630 **CIRCLE NO. 428**

Heat dissipators add to TO-3 cooling efficiency

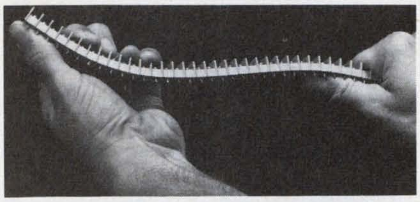


IERC, 135 W. Magnolia Blvd., Burbank, CA 91502. (213) 849-2481. $0.181 (10,000 qty); stock.

The LA 363 heat dissipator, for use with all TO-3 semiconductor devices, performs up to 23% more efficiently in the higher power ranges than conventional push-on heat sinks. It attaches to the TO-3's base where most of the heat originates. The LA 363 is diamond-shaped to reduce the amount of board space it occupies.

Booth 1730 **CIRCLE NO. 429**

Mini terminal strips provide 36 positions

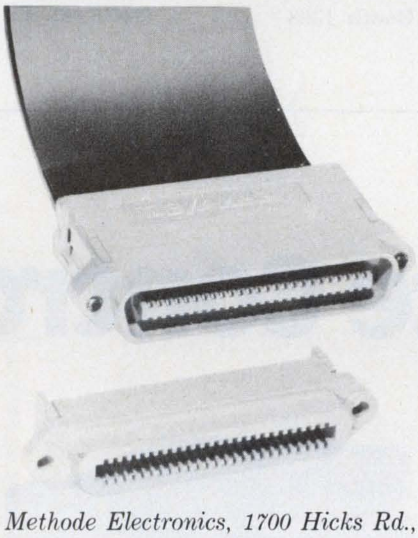


Magnum Electric, 6385 Dixie Highway, Erie, MI 48133. (313) 848-2555.

Flexible miniature terminal strips in circuit-board, wrapped-wire, right-angle and chassis-mount versions are available with up to 36 positions. The 0.5 × 0.5-in. strip with 0.325-in. center spacing is made from UL94VO unbreakable thermoplastic. The strip is rated at 15 A, 150 V per UL1059 and uses 6-32 screws. Its chemically resistant body moldings are cored to minimize heat absorption during wave soldering.

Booth 1338 **CIRCLE NO. 430**

Ribbon-cable connector cuts down on shorts



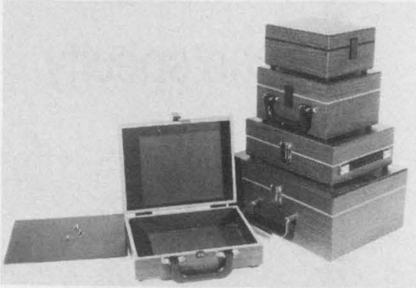
Methode Electronics, 1700 Hicks Rd., Rolling Meadows, IL 60008. (312) 392-3500.

Cable-to-board ribbon cable may be mass-terminated on 0.1-in. centers with the insulation piercing Term-Apierce connector. Straight-on and right-angle versions are available. The connectors handle double the current rating of presently available mass-termination products designed for 0.05 centers. The additional dimension practically eliminates scrap caused by shorts to adjacent conductors.

Booth 1727 **CIRCLE NO. 431**

Have You Mailed Your Requalification Card? See Page 45

Stock cases available off-the-shelf

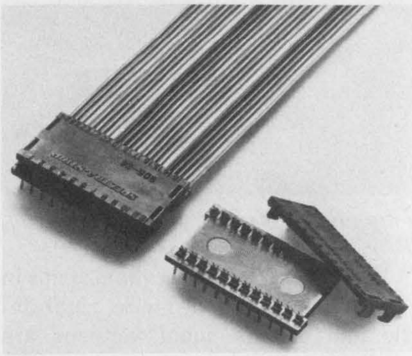


W.A. Miller Co., Mingo Loop, Oquossoc, ME 04964. Dick Hunger (207) 864-3344. See text.

Stock cases and enclosures are available off-the-shelf for shipment within two weeks. A choice of over 600 sizes range from 4 × 4 to 13 × 13, with depth variations up to 12 in. in increments of ⅛. Prices start at $35 to $80 depending on size. Several styles of hardware are offered to suit cost and application. The cases are made of sandwich-type laminated wood with decorative plastic laminate on exposed surfaces.

Booth 109 CIRCLE NO. 432

Contacts in DIP plugs pierce wire insulation

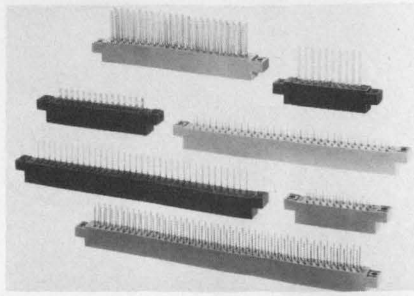


Spectra-Strip, 7100 Lampson Ave., Garden Grove, CA 92642. (714) 892-3361.

Preinstalled insulation-piercing contacts in male DIP plugs provide easy mass-termination to planar cables on 0.05-in. centers. The plug has an installed height of 0.195 in. and mates with any standard IC socket. The contacts are heat-treated phosphor bronze plated with 30 μin of gold. The cover permits cable entry from the top or side, within the over-all dimensions of the connector.

Booth 1308 CIRCLE NO. 433

Edge connectors offer up to 50 terminals

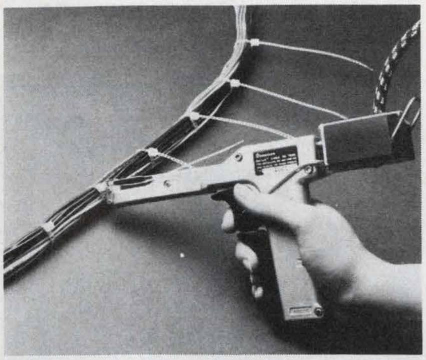


SMK Electronics, 118 E. Savarona Way, Carson, CA 90746. (213) 770-8915.

PC-board edge connectors in the S-400 series have 0.156-in. spacing and are available with 10 to 50 positions. The connectors accommodate single or double-sided boards from 1.4 to 1.8 mm thick. Body material is either polycarbonate or polysulfone. The units are available in a number of different mounting configurations and with eight different terminal types. Each contact post, position and row is numbered and removable plastic polarizing keys are available for locations on or between contact positions.

Booth 1238 CIRCLE NO. 434

Cable-tie installer operates on air power

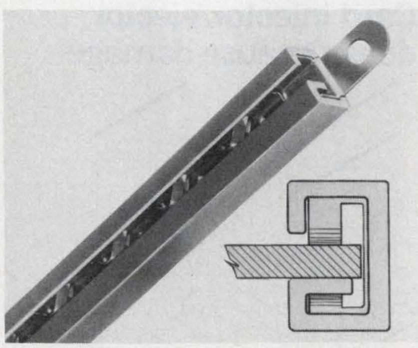


Dennison, 300 Howard St., Framingham, MA 01701. F.T. Wright (617) 879-0511.

The pneumatic Bar-Lok cable-tie installation tool reduces operator fatigue when handling miniature, intermediate and standard-size cable ties. The unit is supplied with a wear-resistant, 6-ft air hose with a quick-disconnect fitting. Once the operator has put the cable tie around the cable bundle and pulled the tie hand tight, the tool is applied to the cable-tie head. The operator pulls the tool's trigger which tightens the tie to a pre-set tension and cuts the end off in one operation.

Booth 418 CIRCLE NO. 435

PC-card guide acts as heat sink

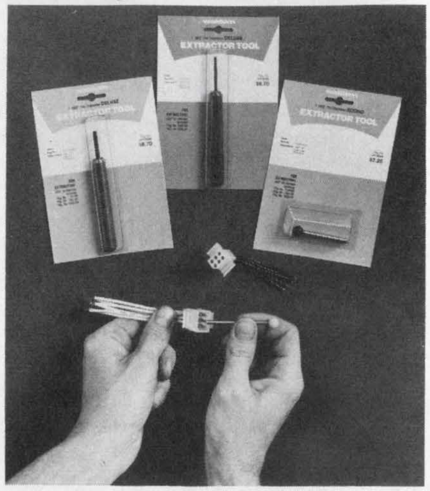


Unitrak, 8738 W. Chester Pike, Upper Darby, PA 19082. (215) 789-3820. From $0.065/in.

Series 1000 metal PC-card guides allow exceptional heat dissipation when assembled into an aluminum heat-sink guide bar. The spring-finger action of the card guide firmly presses one edge of the card into contact with the guide bar over its entire length. A large contact area is thus used for heat transfer. Both metal card guide and guide bar can be furnished to any specified length or in 6-ft lengths for cutting and assembly.

Booth 1612, 1711 CIRCLE NO. 436

Tool easily removes pins from nylon connectors

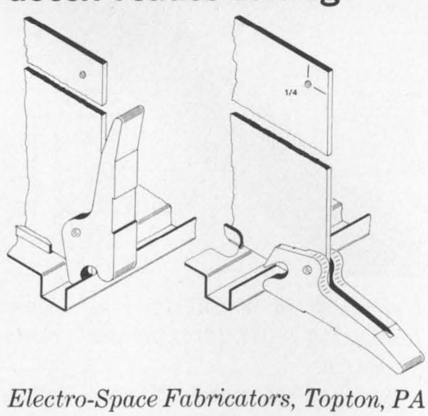


Waldom Electronics, 4301 W. 69 St., Chicago, IL 60629. (312) 585-1212. $2.25/$6.70.

Extractor tools quickly and easily remove male or female pin terminals from Molex nylon connector housings. The Model HT-2285 tool handles 0.062-in. pins and the Model HT-2038 removes 0.093-in. pins. Both models have anodized aluminum handles and are spring loaded. Sure-grip replacement extractor tips are also available.

CIRCLE NO. 437

Card injector/ejector doesn't cause damage

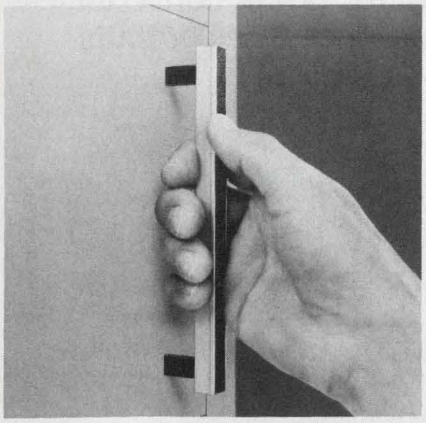


Electro-Space Fabricators, Topton, PA 19562. (215) 682-7181.

Electro-Flex injector/ejectors provide damage-free insertion and extraction of PC boards. The units use both surfaces of a single blade to eliminate the need for close tolerances. A full ⅝-in. travel in each direction assures straight-line card movement. The units are molded of UL-approved nylon and fit boards having thicknesses of 1/16 to ⅛ in.

Booth 1304 CIRCLE NO. 438

Door pulls go on electronic cabinets

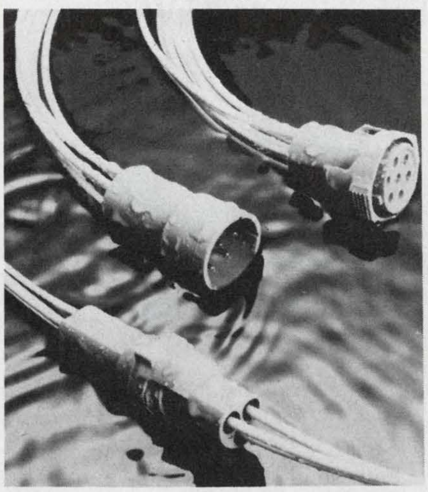


Southco, Brinton Lake Rd., Concordville, PA 19331. (215) 459-4000.

B6 door pulls come in four lengths to match the height of standard electronic modules. Each unit consists of a brush-finished, clear-anodized aluminum pull, trimmed in walnut-grained or black-pebble finish vinyls, plus two black thermoplastic stand-offs.

Booth 304 **CIRCLE NO. 439**

Seals protect connectors from fluid entry



AMP, Harrisburg, PA 17105. Jim Pletcher (717) 564-0100.

Replaceable, factory-installed, rear-wire seals and fixed peripheral interfacial seals protect mated Econoseal connectors against intrusion by fluids. The polarized and keyed rigid thermoplastic housings latch together and panel mount with a simple snap ring. Available in 3, 4, 7 and 9-position sizes, these connectors accept five types of contacts to accommodate solid or stranded wire, miniature coaxial or fiber-optic cables with outside diameters from 0.07 to 0.14 in.

Booth 1111, 1211 **CIRCLE NO. 440**

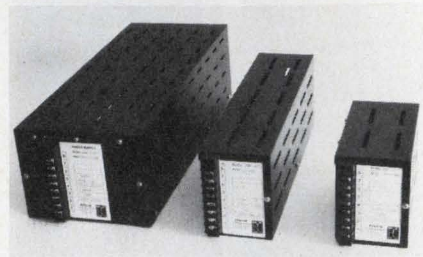
Connector with cable meets IEEE standard

Component Mfg. Service, Component Park, W. Bridgewater, MA 02379. (617) 580-0111.

Interface Bus is a cable assembly that is provided with both a plug and receptacle connector integrally molded at each end of the cable. It meets requirements of IEEE 488. The cables are multiple conductor, stranded bare copper and shielded. The connectors are made of self-extinguishing thermoplastic material with permanetly embedded terminations. A stacked-connector arrangement allows more than one cable to be attached to an instrument, permitting either star or daisy-chain configurations.

Booth 1615 **CIRCLE NO. 441**

Dc/dc power converters produce three outputs



Bikor, 23970 Madison St., Torrance, CA 90505. Ron Pizer (213) 378-8284. $438.88 (100 qty); stock to 4 wks.

Standard models of triple-output dc-to-dc converters offer a choice of +5 V dc at 25 A with ±12 V dc at 2 A or ±15 V dc at 2 A and +12 V dc at 15 A. Regulation is 0.2% for line and load variations. Efficiency varies from 65 to 80% depending on voltages. Other models with single and dual outputs from 5 to 250 V dc are also available. Models provide a choice of 12, 24, 48 or 115-V-dc input power.

Booth 2409 **CIRCLE NO. 442**

Solid-state regulators handle up to 4 kVA

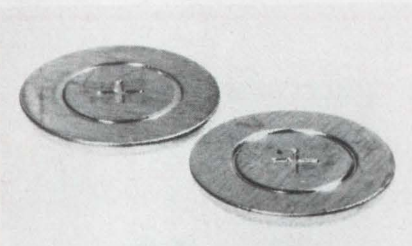
Superior Electric, 383 Middle St., Bristol, Ct 06010. Ivan Bourgoin (203) 582-9561. $275 to $695; stock.

Four solid-state Stabiline automatic ac-voltage regulators in the SVR series have ratings from 0.75 to 4 kVA. A unit provides a regulated output of 115 V from an input-voltage range of 100-to-135-V ac. Accuracy is ±3.5% for line, load and power-factor variations. All four types have an efficiency of 95% at 60 Hz, and a correction rate of 1/2 cycle per step without overshoot or undershoot. The regulators operate in 0 to 50-C ambient. They have virtually-zero waveform distortion, are insensitive to load power factor and have virtually no effect on system power factor.

Booth 2511 **CIRCLE NO. 443**

POWER SOURCES

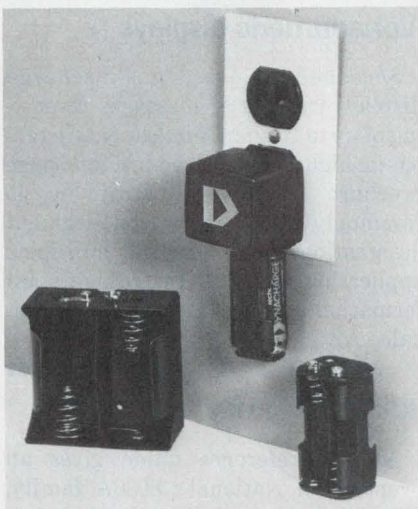
Long-life lithium cells shrunk to coin size



Panasonic, 1 Panasonic Way, Secaucus, NJ 07094. Dave Berend (201) 348-7277.

A coin-size long-life lithium battery has the same profile as other coin units (0.098 in. thick) but it has a smaller diameter of 0.785 versus 0.906 in. Nominal voltage of the battery is 3-V and its capacity is in excess of 90 mAh. The cell is hermetically sealed and its shelf life is in excess of 5 yr. Price of the cell is compatible with the price for silver-oxide cells. **CIRCLE NO. 444**

Module recharges small batteries



Dynamic Instrument, 933 Motor Pkway, Hauppauge, NY 11787. Dave Baum (516) 234-2900.

The modular battery charger is compatible with battery holders having snap terminals. The charger permits the low-end OEM product to become rechargeable by the addition of the modular charger and the substitution of rechargeable NiCd cells for the dry cells. The unit, which measures 1.75 × 1.75 × 1.5 in. and plugs directly into a wall socket, has snap terminals that mate with the terminals of standard-battery holders.

Booth 1637 **CIRCLE NO. 445**

Application notes

Semiconductor mounting

Proper mounting methods of power semiconductors for adequate cooling and optimum operation at ever-increasing circuit and device-power levels is the topic of a seven-page data sheet. The data sheet includes diagrams and tables that support and amplify the text. Westinghouse Electric, Semiconductor Div., Youngwood, PA

CIRCLE NO. 446

OEM devices

"New Solutions for Old Problems" covers industrial and biomedical OEM devices for filtration, separation and isolation applications. Gelman Medical Device Div., Ann Arbor, MI

CIRCLE NO. 447

Wire and cable

A Wire & Cable Handbook comes in a loose-leaf type vinyl binder and includes complete applications, specifications and configurations for five types of wire and cable. Icore International, Sunnyvale, CA

CIRCLE NO. 448

High-speed op amps

"Integrated High Speed Operational Amplifier" explains how modern high-speed, high-stability circuits can be constructed using semi-custom IC technology. Interdesign, Sunnyvale, CA

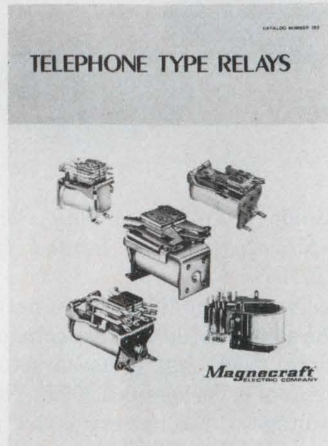
CIRCLE NO. 449

Mixer preamplifiers

A 16-page mixer and mixer-preamplifier catalog is prepared in a concise, tabular format in an attempt to present all the information at a glance. A series of easy-to-use nomographs is provided. Microwave Associates, Burlington, MA

CIRCLE NO. 450

New literature



Telephone-type relays

A 56-page catalog describes telephone-type relays. The addition of a relay-selection chart guides the user to the proper relay class which will fit his particular requirements. Magnecraft Electric, Chicago, IL

CIRCLE NO. 451

Alphanumeric displays

Screened-on-glass, gas-discharge displays capable of messages consisting of up to 16 alphanumeric characters 0.5-in. high are described in a four-page brochure. Diagrams illustrate the 55 commonly used characters, segment designations, and a typical multiplex application. Beckman Instruments, Information Displays Operation, Scottsdale, AZ

CIRCLE NO. 452

8080A μP family

A quick-reference guide gives an overview of National's 8080A family, describing the basic functions of each component, the pin numbers and signal names and how the components interface to National's system bus. The booklet includes a description of the 8080A CPU group, as well as its series of peripheral-control, communications, digital input/output, and memory components. National Semiconductor, Santa Clara, CA

CIRCLE NO. 453

Have You Mailed Your Requalification Card? See Page 45

NEW LITERATURE

Dual-trace recorders

Key performance features, specifications and pricing on five dual-trace oscilloscopes are found in a four-page catalog. Gould, Instrument Div., Cleveland, OH

CIRCLE NO. 454

Trimming capacitors

Precision, miniature, piston-trimmer capacitors; fixed and variable inductors; and LC networks are described in a 24-page catalog. The catalog includes electrical and mechanical specifications, voltage ranges and dimensional information. JFD Electronic Components, Brooklyn, NY

CIRCLE NO. 455

Detector video amplifiers

General and electrical specifications, outline drawings, features and suggested applications of detector video amplifiers are given in a 12-page catalog. Aertech Industries, Sunnyvale, CA

CIRCLE NO. 456

CMOS 12-bit d/a converters

Specific features, block diagrams, and specifications for two μP-compatible d/a converters are given in a 10-page catalog. Logic diagrams illustrate 12-bit parallel loading, connection and timing for serial loading, unipolar and bipolar operation with and without a 10-V reference. Beckman Instruments, Helipot Div., Fullerton, CA

CIRCLE NO. 457

Infrared emitters

A 24-page product guide provides tabulated data and outline configurations for infrared emitters and injection lasers. RCA Solid State-Europe, Middlesex, England

CIRCLE NO. 458

Test accessories

Test hooks, probes, connectors, jumpers, test-lead and coaxial-cable assemblies, adapters, breadboarding and harness-board components are illustrated in a 92-page catalog. E-Z Hook, Arcadia, CA

CIRCLE NO. 459

Semiconductors

Power-semiconductor products, including diodes, SCRs, assemblies, power modules and surge suppressors, are described in a short-form catalog. The catalog includes photos and descriptions of hardware, series numbers, package configurations, and performance specifications such as voltage range and operating temperature. FMC Semiconductor Products, Broomfield, CO

CIRCLE NO. 460

Power supplies

A full range of power supplies are shown in a 50-page catalog. Acopian, Easton, PA

CIRCLE NO. 461

Switches

Nine digital switches for industrial and commercial users and low-profile keyboards are featured in a six-page guide. Digitran, Pasadena, CA

CIRCLE NO. 462

Test, measuring products

Technical specifications and illustrations of the company's test and measuring instruments are featured in a catalog. Philips Test & Measuring, Mahwah, NJ

CIRCLE NO. 480

4096-bit dynamic RAM

Features, electrical characteristics, and timing waveforms of the 4027 4096-bit dynamic RAM can be found in a 16-page catalog. ITT Semiconductors, Dallas, TX

CIRCLE NO. 481

Variable transformers

A 60-page variable-transformer catalog gives ratings, dimensions, performance curves and schematic-connection diagrams in an easy-to-read, efficient format. It includes metric equivalents for universal use and easy reference. The Superior Electric Co., Bristol, CT

CIRCLE NO. 482

NEW LITERATURE

Thumbwheel switches

"No-hardware" thumbwheel switches are featured in a 12-page brochure. The brochure contains truth tables for all the switches, as well as functional descriptions and ratings. Unimax Switch, Wallingford, CT

CIRCLE NO. 463

Electronic counters

A six-page selection guide summarizes specifications and characteristics of 15 counters in HP's electronic-counter line. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 464

Measuring setups

The technology and applications of sweep-measuring setups WM-20 and WM-30 are given in a 28-page catalog. Wandel & Goltermann, Eningen u.A., West Germany

CIRCLE NO. 465

Terminals

Technical details and plating information on all "Bullet-Nose" terminal styles and types are provided in a 12-page catalog. Sealectro, Mamaroneck, NY

CIRCLE NO. 466

Mask-alignment systems

Third-generation Micralign projection mask-alignment systems are detailed in an eight-page brochure. Perkin-Elmer, Electro-Optical Div., Wilton, CT

CIRCLE NO. 467

Power supplies

Standard off-the-shelf power supplies are described in a 140-page catalog. A selection guide, features, package sizes, specifications and dimensional drawings are included. Lambda Electronics, Melville, NY

CIRCLE NO. 468

Rental test instruments

Over 1000 electronic test instruments available for monthly rental are described in a 56-page catalog. Full specifications and monthly rates are included. Continental Resources, Bedford, MA

CIRCLE NO. 469

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.

Information International. Distributed typesetting, electronic illustrations.

CIRCLE NO. 470

Anixter. Wire and cable; CATV components.

CIRCLE NO. 471

Loral Corp. Electronic communications and electronic-warfare systems, aerospace and nuclear components, plastic packaging.

CIRCLE NO. 472

Telefile. Computer-enhancement products.

CIRCLE NO. 473

Siemens. Components, data systems, power engineering, electrical installation, medical engineering, telecommunications.

CIRCLE NO. 474

Park Electrochemical. Electronic-circuitry materials.

CIRCLE NO. 475

Lloyd's Electronics. Audio-entertainment products, electronic calculators, home video games.

CIRCLE NO. 476

Wyle Laboratories. Electronic components, R&D.

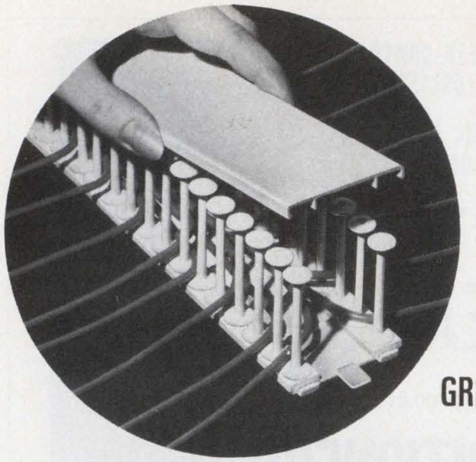
CIRCLE NO. 477

Logicon. Defense, process systems, printing and publishing.

CIRCLE NO. 478

Medtronic. Medical devices.

CIRCLE NO. 479



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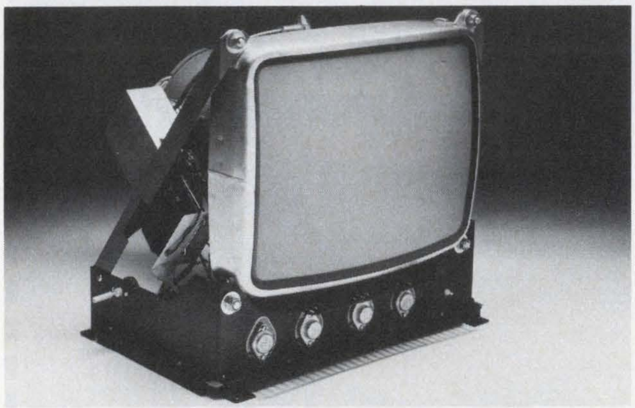
CIRCLE NUMBER 157 FOR FREE EVALUATION UNIT



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quick ads

New and current products
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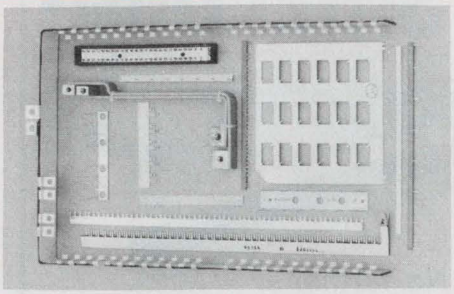
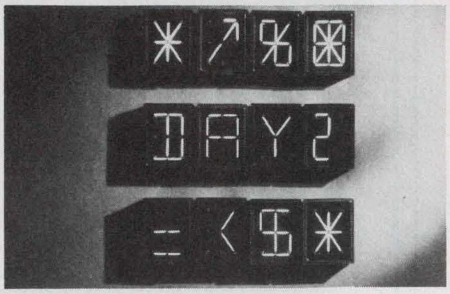


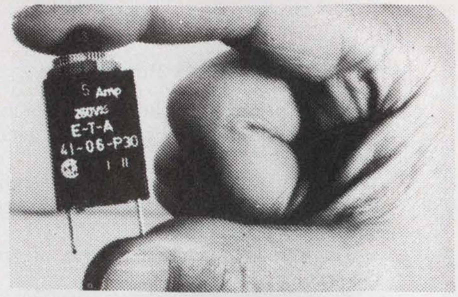
Methode Electronics' "OMNY-Bus"® Bars eliminate problems associated with cable harnesses. Can be soldered, welded or mechanically affixed to insulation or conducting layers. Uniform current distribution assured eliminating intermittencies, cross-talk, stray EMI. Methode has over 15 years experience in designing and manufacturing "OMNY-BUS"® Bars from 1 to 21 layers, 4" to 100' long, weighing 1/2 oz. to 200 lbs. FREE Catalog. Methode Electronics, Inc., 1700 Hicks Rd., Rolling Meadows, IL. 60003 312/392-3500.

"OMNY-BUS"® BARS 181



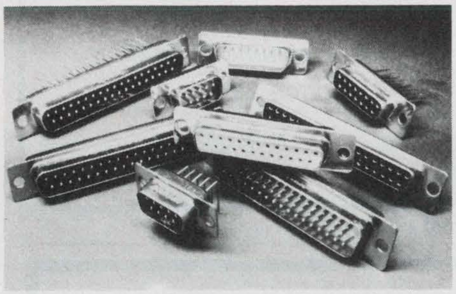
ALPHANUMERIC DISPLAY, 16 Segment - Day 2 series offers a large, bright 5/8" character that can be read in high ambient light, including direct sunlight. Rated @ 5 volts, 18ma per segment, the DAY-2 plugs into a standard 18 pin DIP socket. Withstand a wide temp. range, −55° C to +100° C. Color can be displayed w/ filters. Uniglass construction insures high reliability, 100,000 hr life rating. DAYLIGHT DISPLAY CORP., 11 Fairfield Pl., P.O. Box 1231, West Caldwell, N.J. 07006 (201) 575-1045 184

16 SEGMENT ALPHANUMERIC DISPLAY



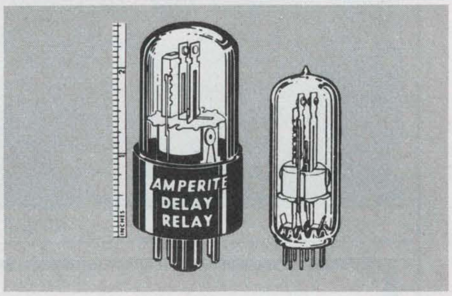
Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 19 fractonal ratings from 0.1 to 5 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost, $1.61 ea. in 1000 lots. E-T-A Circuit Breakers, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

CIRCUIT BREAKER 187



SOURIAU Sub "D" Series 8634 NORMAN-D connectors are low cost, crimp type, w/ stamped & reeled contacts for lower install. costs; intermateable w/ all "D" connectors. SOURIAU has "D" connectors in 1-piece thermoset, 2-piece thermoplastic insulator, non-removable solder contacts, rigid & float mount shells, crimp, rear release contacts, operating temp of −55°C to +125°C qualified to MIL-C-24308. SOURIAU, INC., 7740 Lemona Ave., Van Nuys, CA 91405 (213) 787-5341.

SERIES 8634 CONNECTORS 182



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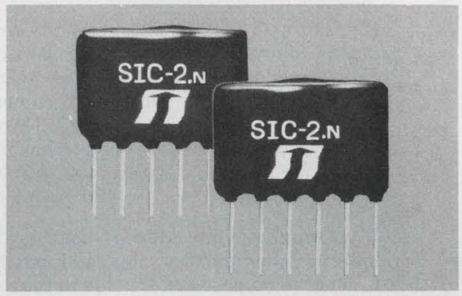

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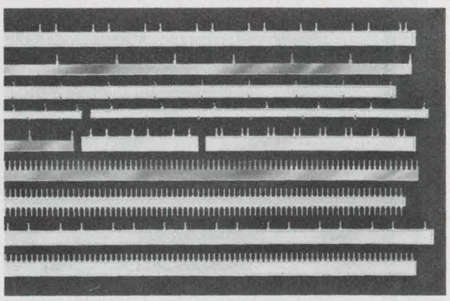

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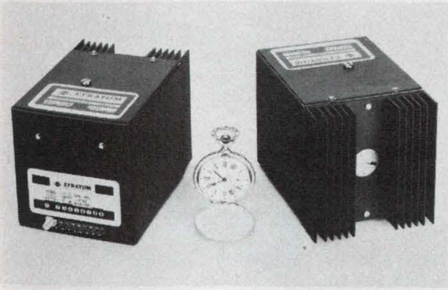

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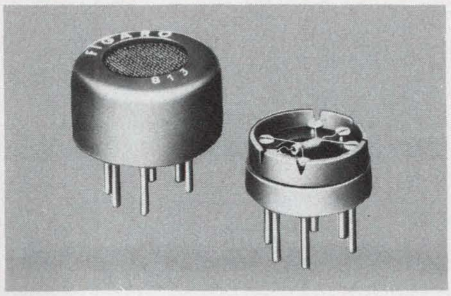

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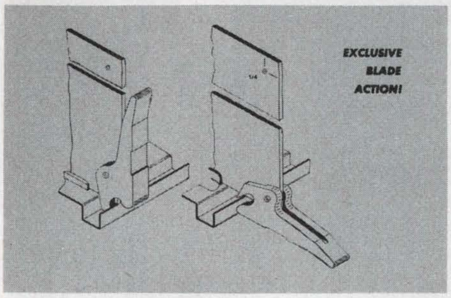

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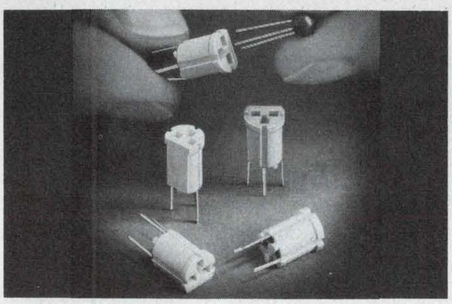

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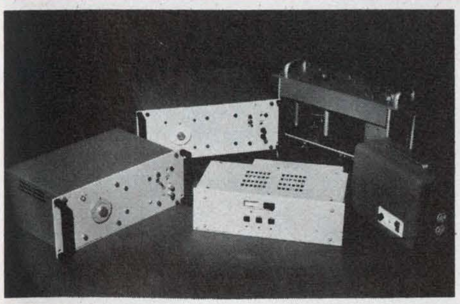

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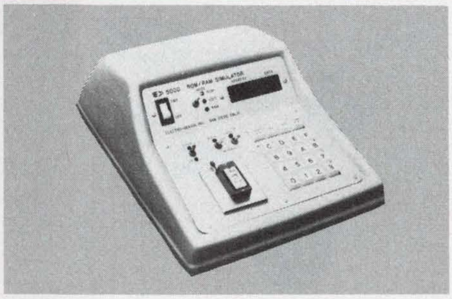

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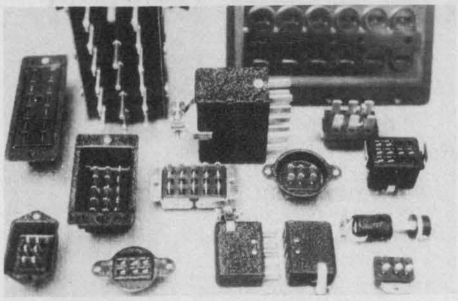

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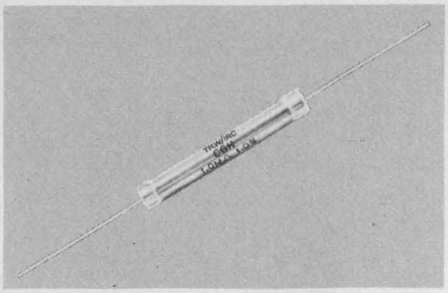

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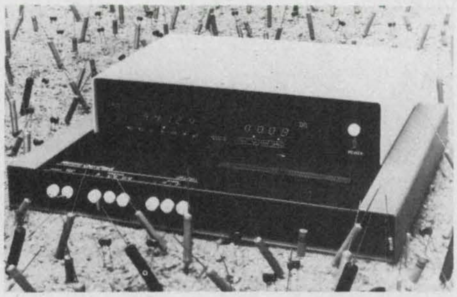

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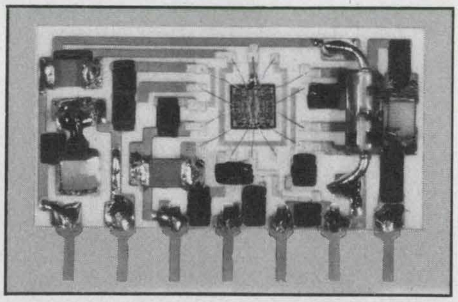

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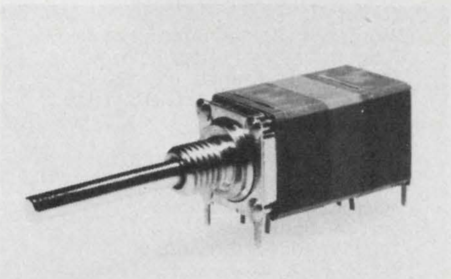

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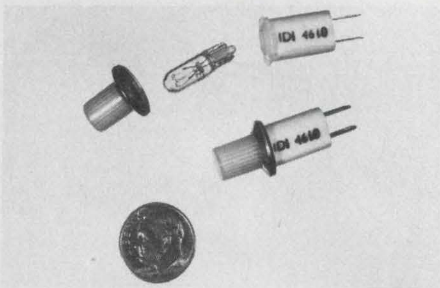

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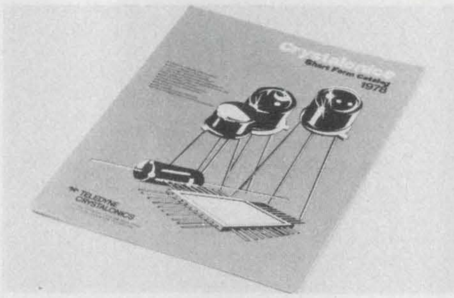

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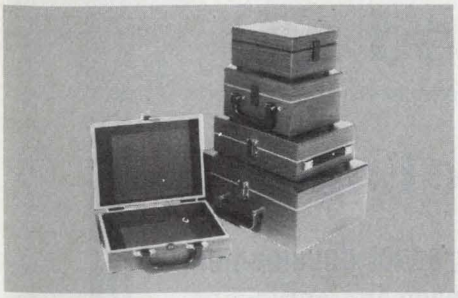

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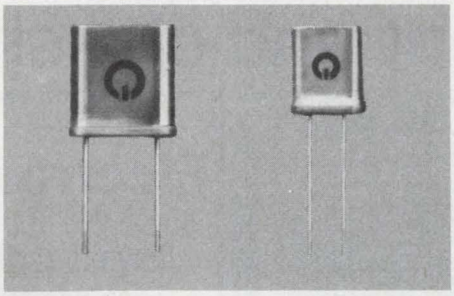

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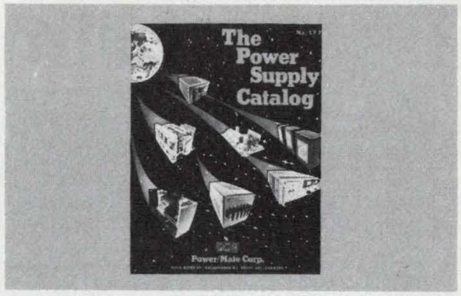

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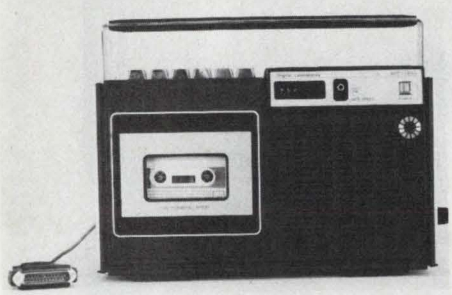

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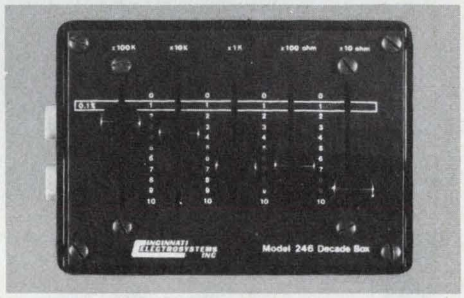

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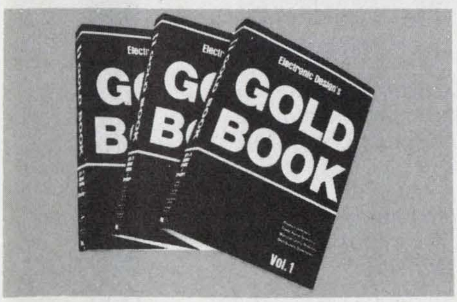

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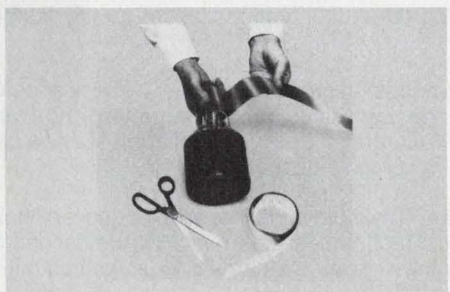

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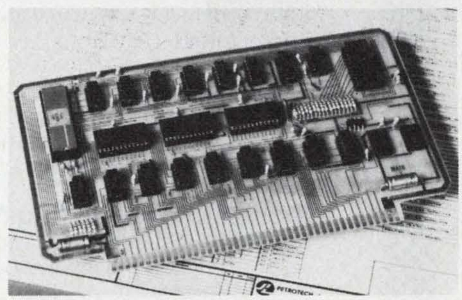

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Sales Engineer
Microprocessor Development Systems

Experience as a design engineer, applications engineer or sales engineer working with minicomputers, minicomputer systems or microprocessor systems will provide you the opportunity to join the Tektronix sales team.

We need professionals with hardware, software and microprocessor experience. Product and sales training will be provided for you.

Applicants should have a current knowledge of digital hardware systems and assembly language programming experience. In addition, a strong interest and aptitude in customer oriented sales is necessary. BSEE or equivalent is desirable.

Competitive salary program includes incentive compensation. Benefits programs include a substantial retirement plan.

Call Mike Jones at (301) 948-7151, or send a complete resume to TEKTRONIX, INC., 2 Research Court, Rockville, Maryland 20850.

An Equal Opportunity Employer M/F/H.

Tektronix®
COMMITTED TO EXCELLENCE

Project Engineers Electrical

Engineers with varying experience and length of service backgrounds sought to expand Project Engineering - Electrical Group. BSEE required.

Projects include process control, high-speed packaging automation, relay, programmable controller, mini-computer application, industrial power supply and distribution, building services.

Scope includes preliminary through final designs, oversight of consultants, contractors, equipment supplies, supervision of equipment installation and start-up.

Experienced Engineers must be capable of executing complete projects from conceptual stage through efficient production operation.

Outstanding potential for personal growth with industry leader during growth and expansion program.

We offer an excellent starting salary and outstanding benefits package as well as advancement opportunities based on your achievements. For immediate consideration, send complete resume outlining salary history in confidence to:

Anheuser-Busch, Inc.

Manager, Salaried Employment
Department J-4
721 Pestalozzi
St. Louis, Missouri 63188

An Equal Opportunity Employer M/F

Engineers

Boston Interviews with Technical Management May 23, 24 and 25

Our Hunt Valley complex, located in the northern suburb of Baltimore, has immediate openings in two engineering departments.

The Nuclear Instrumentation Control Department has requirements for engineers with experience in analog and digital circuit design. Responsibilities include the development and design of instrumentation and control equipment and systems for commercial and naval nuclear programs.

Requirements:

- BSEE with minimum of 5 years design experience.
- Ability to analyze designs and present results.
- Desire to apply innovative solutions to complex engineering problems.

The Integrated Logistics Support Engineering Department is involved in a variety of long-term automated test projects and has needs in the following areas:

Software

Applicants should have BSEE and major specialization in computers or with BS in Computer Science and a knowledge of digital and analog circuit design and at least 2 years experience in one or more of the following areas:

Design and generation of analog/digital test application software

Design and generation of ATE executive and support software.

Logistics and Maintenance

Applicants should have BSEE with advanced statistics and/or numerical analysis courses with a minimum of 2 years experience in one or more of the following: logistics models, simulation models, logistic support analysis, support equipment requirements, maintenance planning.

Digital Hardware Design

Responsibilities include systems specifications and design utilizing advanced microprocessors and microcomputers as applied to sophisticated electronic test problems. Minimum of 2 years experience and BSEE degree.

Electronic Design

Requires capability in solid state electronic design. Should have at least 2 years experience in analog and digital testing of military avionics subassemblies. BSEE required.

IF or RF Electronic Design

At least 2 years design experience involving very stable oscillators and other RF circuitry operating at X-band. BSEE degree.

Also, professionals with electronics background are needed in the following areas:

Field Engineering
Engineering Writers
Industrial Engineering
Product Evaluation
Test Engineering
Electromagnetic Compatability
Product Reliability/Maintainability
Quality Assurance
Manufacturing Processes

Attractive foreign assignments are also available for your consideration.

Boston Interviews

To arrange a Boston interview with technical management, call:

T. K. Brown
at 617/536-5700

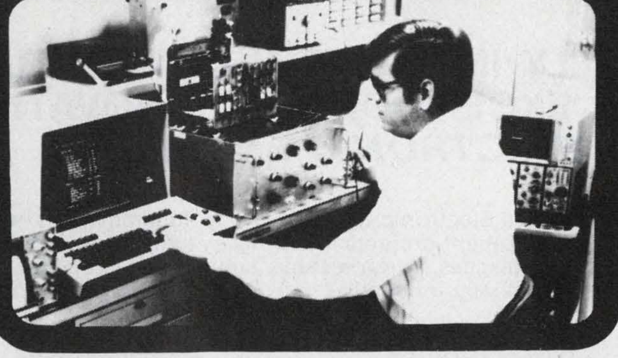
Tues., May 23, 10 A.M. to 8 P.M.
Wed., May 24, 10 A.M. to 8 P.M.
Thurs., May 25, 10 A.M. to 5 P.M.

If unable to arrange an interview at this time, please send resume, stating present salary, and indicating department of interest, to:

R.A. Richmond, Dept. 425
Westinghouse
P.O. Box 1693
Baltimore, MD 21203

An Equal Opportunity Employer

Westinghouse



Systems/Design ENGINEERS

A Halliburton Company -Welex Division

Welex, the wireline service division of Halliburton Company, is assisting the energy industry in its search for and development of oil and gas resources. Welex designs and manufactures the electronic surface and subsurface equipment used in its field operations. Research is the backbone of Welex growth and is why we consider our Engineers to be so vital to the success of our operations.

We are initiating a major expansion of our technical staff and many challenging opportunities exist for Engineering Programmers and Electrical or Mechanical Engineers with recent creative experience in some of the following areas:

- Real Time Software
- Digital Circuits Assembly
- Assembly Language
- Analog Circuits
- Data Acquisition
- Microprocessors
- Graphics Displays
- Microcomputer

These permanent positions require minimum BS degree with graduate degree preferred.

Welex is headquartered in Houston, Texas, the 5th largest city in the U.S. The climate is mild and sunny on the Texas Gulf Coast, where cultural events, sports and recreational activities at nearby beaches and lakes are available year round. Houston's lower cost of living and no local or state income taxes make it more than comfortable to pursue your profession.

JOIN our team of professionals in helping this vital industry to keep AMERICA moving. If you are interested in the career opportunities we have to offer, please send resume in confidence to Employment Supervisor, Dept. ED, P.O. Box 42800, Houston, Texas 77042.

We Are An Equal Opportunity Employer M/F

A Halliburton Company

Hardware/Software Engineers

Qyx is the rapidly expanding new business arm of Exxon Enterprises Inc. We've just introduced our new Intelligent Typewriter to the market.

We are seeking ambitious professionals who are attracted by a practical technical challenge. These same professionals must be willing to work long hours to develop both an exciting new concept in the word processing field . . . and their own personal advancement. Excellent positions are currently available at our facilities, located in the attractive Pennsylvania countryside, near Philadelphia. We presently have these engineering openings:

HARDWARE ENGINEERS

- **SEMICONDUCTOR MEMORY DESIGN — RAM, ROM, PROM, Board Design, Device Selection Test Methods**
- **FLOPPY DISK ELECTRONICS — Microprocessor experience, Motor Drive and Control, Read/Write Electronics**
- **DATA COMMUNICATIONS — Real Time Programming, microprocessor experience, knowledge of Modems, Protocol: TTY, BSC, SDLC.**
- **LOW INERTIA STEPPING MOTOR DESIGN — Drive and Control, Circuitry Design, Closed Loop Microprocessor Control.**
- **KEYBOARD ELECTRONICS**
- **DISPLAY TECHNOLOGY SELECTION/INTERFACE**

SOFTWARE ENGINEERS

- **TEXT EDITORS**
- **DISPLAYS**
- **OPERATING SYSTEMS**
- **COMPUTER AIDED INSTRUCTION**

BS/MS in Electrical Engineering/Computer Science or equivalent required for all positions. Directly related industrial experience is mandatory in most cases, but outstanding recent graduates will be considered.

Send resume, including salary history, to: Mr. G. Mathern, Qyx, Division of Exxon Enterprises Inc., P.O. Box 429, Exton, Pa. 19341. Minorities and females are encouraged to apply.

LOCAL INTERVIEWS CAN BE ARRANGED

Qyx™

Intelligent Typewriter Systems
A Division of EXXON Enterprises Inc

We are an equal opportunity employer, m/f

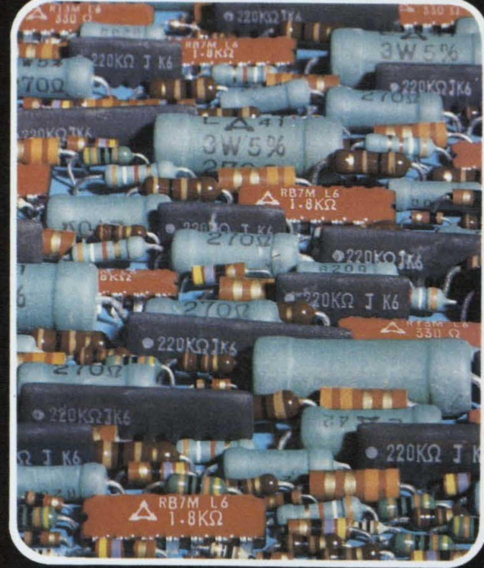
YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer • Project Engineer • Electronic Engineer • Engineer-Supervisor • Section Leader • Staff Engineer • Systems Engineer • Test Engineer • Standards Engineer • Master Engineer

Advertiser's index

**Advertisers in International Edition*

Panasonic resistors-for everything from rock 'n roll to numerical control



It goes without saying, what you need in a resistor depends upon your application and your design criteria. Which means your resistor needs are rarely cut and dried. The product you want today probably won't fit your requirements next week.

That's why we'd like to tell you about the Panasonic line. Take another look at the headline of this ad. We mean it! Whether your application is in Consumer Products or Professional Equipment; EDP or Communications; Instrumentation, Control Equipment or even Automotive—chances are there's a Panasonic resistor to meet your needs. And at prices you'll find hard to ignore.

Our product line includes molded, conformal coated, DIP and SIP packages. All meet the same rigid quality standards Panasonic products are noted for. And they can be ordered from our headquarters in Secaucus, N.J. or a Panasonic distributor near you.

For samples, prices and technical information, call or write: Panasonic Electronic Components, One Panasonic Way, Secaucus, N.J. 07094, (201) 348-7266.

	Power Rating	Resistance Range	Tol.
Carbon Film	1/8, 1/4, 1/2W	4.7Ω-5.6MΩ	2%, 5%
Carbon Composition	1/8, 1/4, 1/2W	2.2Ω-22MΩ	5%, 10%
Metal Oxide	1/2, 1, 2, 3W	.20Ω-100KΩ	2%, 5%
Metal Film	1/4, 1/2W	10Ω-2MΩ	0.5%, 1%
DIP/SIP Networks	Contact Local Sales Office		

Panasonic.®
just slightly ahead of our time