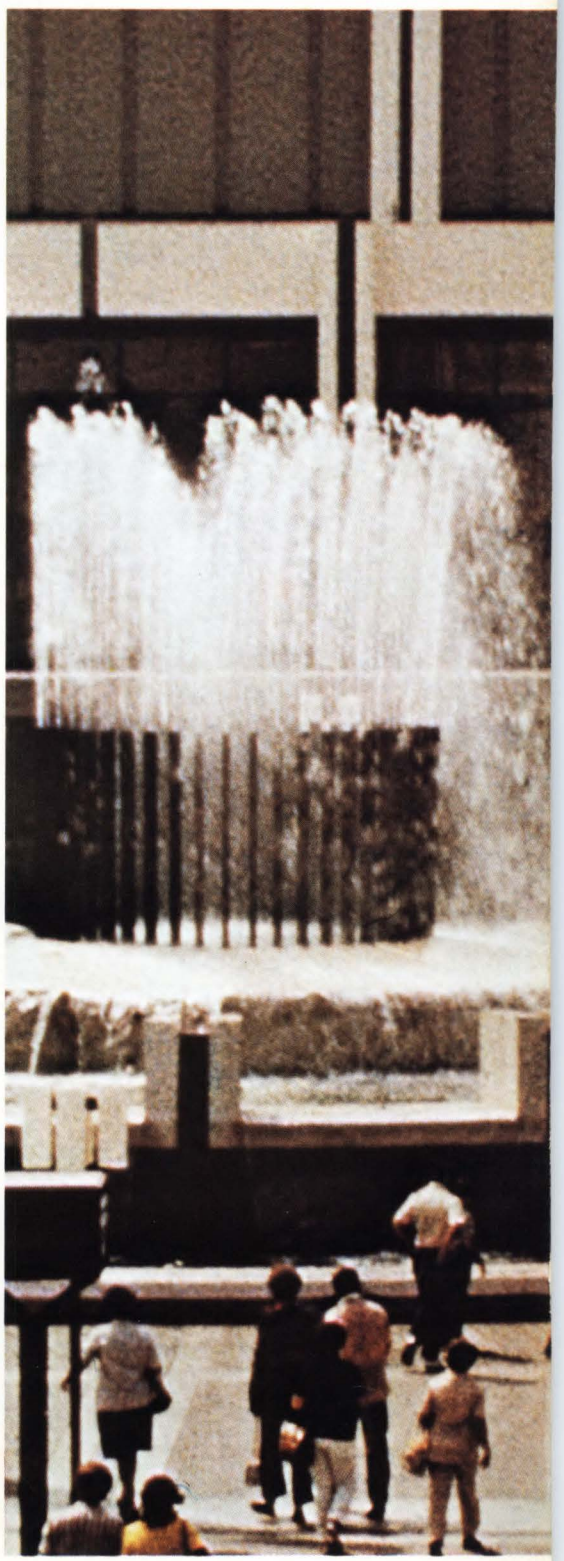
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

Battery-operated instruments: a look at what's available

Speakout warns IC users to buy, not make

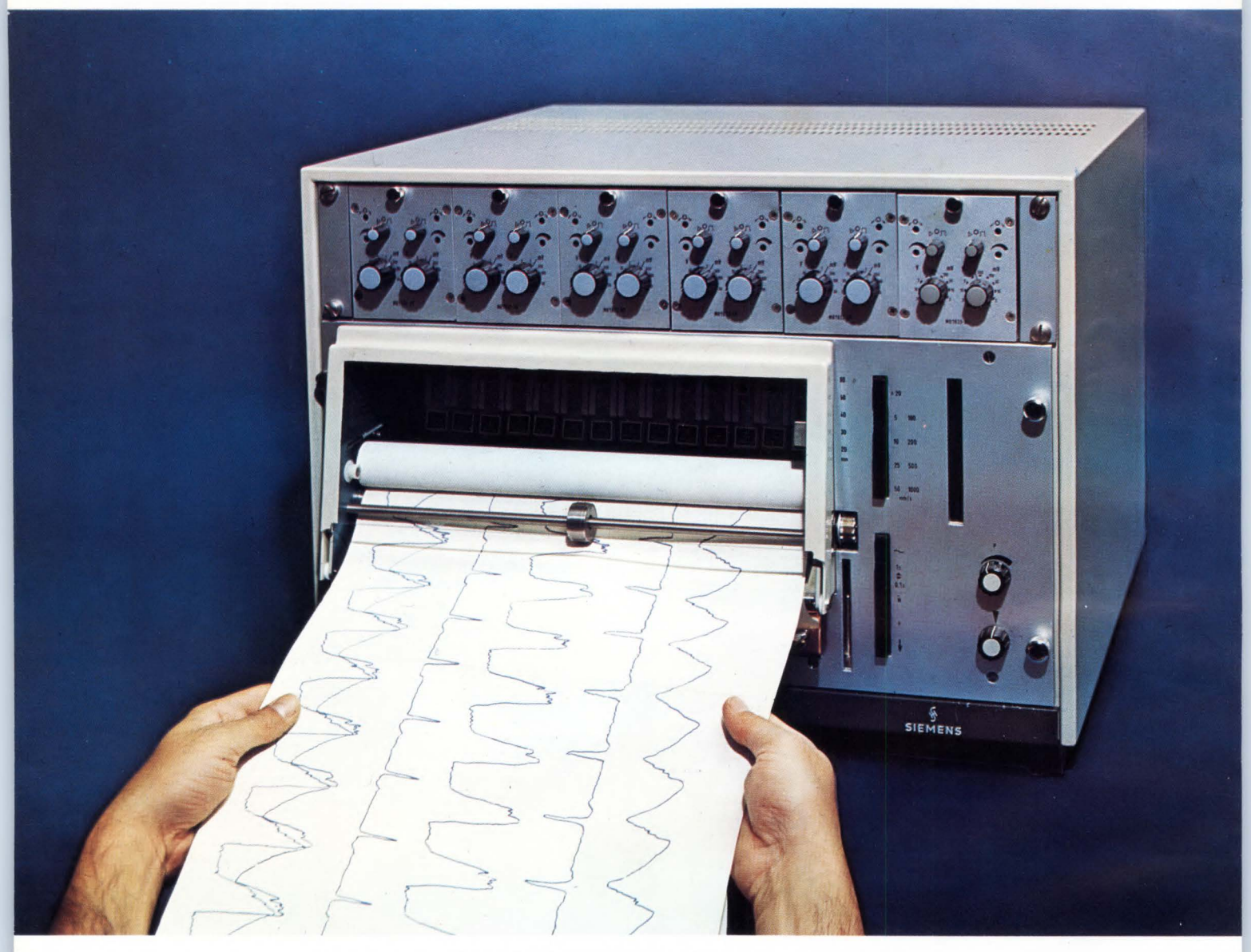
WESCON/72 all together under one roof



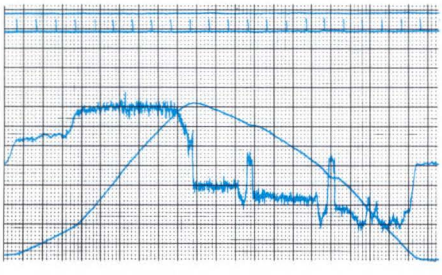
A CAHNERS PUBLICATION

SEPTEMBER 15, 1972

Siemens



This new ink jet system does the work of more expensive pen arms and light beams.



Actual ink-jet recording of overlapping traces.

Like pen arm recorders, Siemens new jet recorders write with ink on low-cost Z-fold paper. Like light beam recorders, they write fast. Up to 3,000 inches a second.

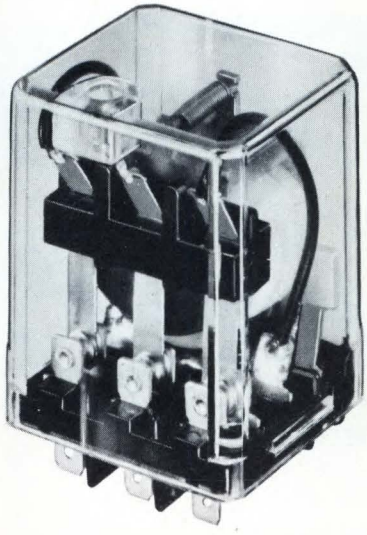
They easily record time-synchronized overlapping traces (such as the one at left) at frequencies from dc to 1,000 Hz.

Four basic models provide for 2, 6, 12 or 16 channel recording. To learn more, send for our comprehensive brochure describing these new low-cost recording systems. Write to Siemens Corporation, 186 Wood Ave., So., Iselin, N.J. 08830. Call 201-494-1000.

SIEMENS

CHECK NO. 1

GP



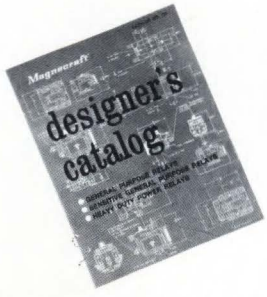
MAGNECRAFT'S NEW CLASS 388 GENERAL PURPOSE RELAY

Magnecraft is pleased to introduce the new Class 388 General Purpose Relay. This inexpensive, high performance line of stock relays offers many quality features found only in custom built versions. Available in either a covered plug-in or open style with a wide choice of AC or DC coil voltages and SPDT, DPDT, or 3PDT 10 amp contacts.

All Class 388 relays have 3-way pierced terminals. While spaced for standard plug-in mounting, the flat terminals (0.187″ x 0.020″) also accept quick-connect receptacles or direct soldering. For plug-in use, three types of chassis mounted sockets are available; quick-connect, solder, or printed circuit terminals. Covered plug-in version has a tough clear polycarbonate plastic cover.

In a highly competitive business, delivery can be a deciding factor. If delivery is important to you, be aware that Magnecraft ships better than 90% of all incoming orders for stock relays, received before noon, THE SAME DAY (substantiated by an independent auditing firm). In addition to our shipping record, most stock items are available off-the-shelf from our local distributor.

FREE!



DESIGNER'S CATALOG

The purpose of this 36-page catalog is to assist the design engineer in specifying the proper relay for a given application. The book completely describes General Purpose, Sensitive General Purpose, and Mechanical Power Relays. New products include the complete line of Class 388 General Purpose Relays.

See Us at WESCON, Booth 2400

Magnecraft® ELECTRIC COMPANY

5575 NORTH LYNCH AVENUE • CHICAGO, ILLINOIS 60630 • 312 • 282-5500 • TWX-910-221-5221

CHECK NO. 4

NEW 3½ DIGIT PORTABLE DMM

GOT THE MESSAGE?

□ 3½ Digit LED Display □ Rugged All Metal Case □ Battery & Line Operation Standard
□ Basic Accuracy .05% □ Off Shelf Delivery □ Priced at only $375.

Our DigiTec engineers got the message. We told them to take a good multimeter and make it better. We didn't put any restrictions on them, just gave them a free hand. Now instead of an improved meter, we have a new meter, from the inside out!

They started with a new A to D board which gave the meter improved basic accuracy (.05%), greater stability, and a 3½ digit LED display.

Next they tackled the metal case; building it stronger, more rugged to house and protect. Controls were simplified and redesigned to provide the best possible human engineering factors.

They might have stopped there and been satisfied with an almost-totally new meter, but they had steam up and went on. A new 8 hour battery operation was made integral with a self check status, at no increase in price. That's right... all these improvements plus the battery operation and still only $375.

Our model 262C Multimeter carries its own message and DigiTec Representatives carry a model 262C. **HAVE YOU GOT OUR MESSAGE?**

Representatives throughout the world. For complete specifications, request new catalog.

DigiTec by United Systems Corp.
918 Woodley Rd.
Dayton, Ohio 45403
(513) 254-6251

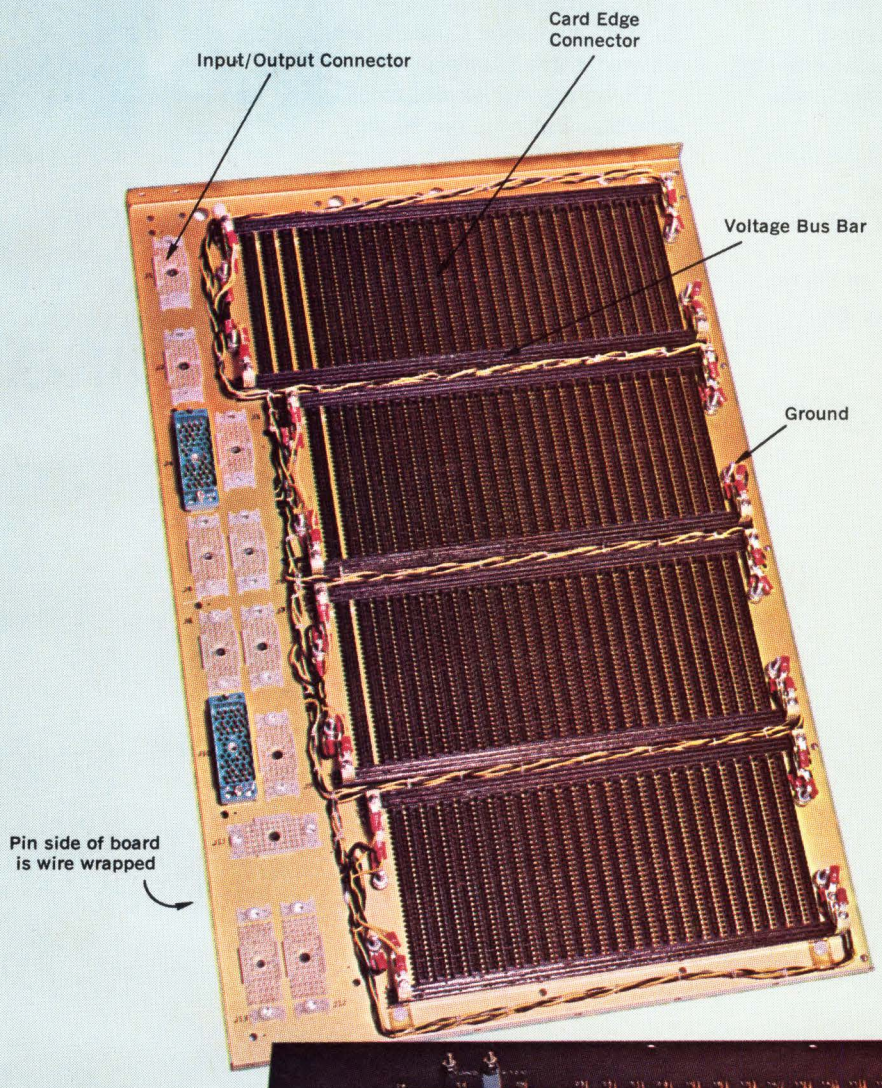
DIGITEC®
UNITED SYSTEMS CORPORATION
subsidiary of Monsanto

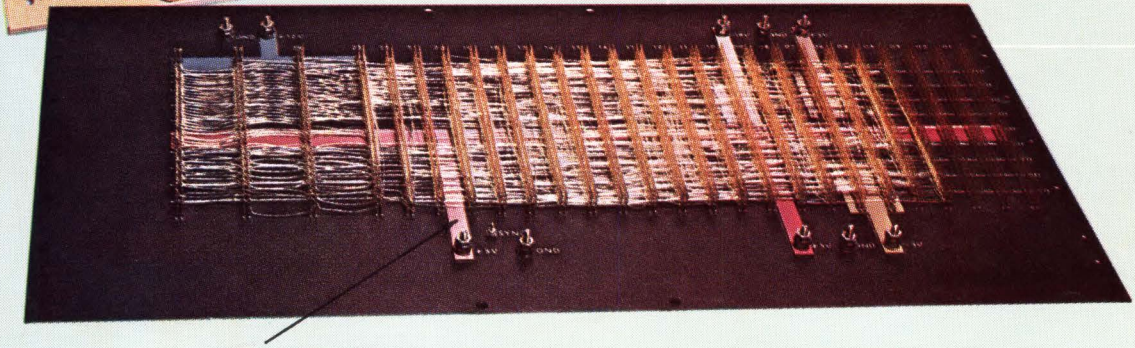
DigiTec: precision measurements to count on.

CHECK NO. 5

EVERYBODY WANTS YOUR BACKPLANE CONNECTOR BUSINESS...

ELCO offers more to earn it.





Variplate™ board with color coded voltage bus bars

THERE ARE 10 REASONS WHY:

1. Elco is the largest manufacturer of metal plate backplanes.
2. We became the largest by offering more variations than anyone.
3. Elco has another cost-saving design approach with a printed circuit press fit backplane system.
4. Elco can provide a full service by wire wrapping the backplane for you at our own facilities—no split responsibilities.

One of our representatives will be happy to explain reasons five through ten. Invite him over soon. Or call our General Sales Manager Fred Inacker at (215) 659-7000.

Elco, Willow Grove Division
Willow Grove, Pa. 19090
(215) 659-7000

Elco, Pacific Division
2200 Park Place
El Segundo, Calif. 90245
(213) 675-3311

ELCO™

Operations in USA, Australia, Belgium, Canada, Denmark, England, France, Germany, Israel and Japan. Sales offices throughout the world. In Europe, Elco Belge, 77 Blancefloerlaan, Antwerp, Belgium, Tel. 03-190064. In the Far East, Elco International, TBR Building, 2-10-2 Nagata-cho, Chiyoda-ku, Tokyo 100, Japan, Tel. 580-2711/5.

CHECK NO. 6

14,000,000 CORDIP™ component networks can save you 12 olympic swimming pools, 8 tennis courts, and a polo field of board space.

Get out your slide rule and prove us right or wrong.

All you need to know is that CORDIP component networks are only one-quarter square inch each. And they can save you approximately 50% over discretes in size and space.

And since one CORDIP network can contain up to a 23-component combination of resistors, capacitors and diodes, you save hours of insertion time. And time is money.

And while your slide rule's working, keep this in the back of your mind. They're also economical at low volume. Standard pull-ups and in-outs are as low as 76¢ in 1000 piece lots. Custom resistor-capacitor-diode networks are economical too. Try us and see.

Obviously, we expect more in the thousands than in the millions. But even one hockey rink of space saved is money saved.

Think about it.

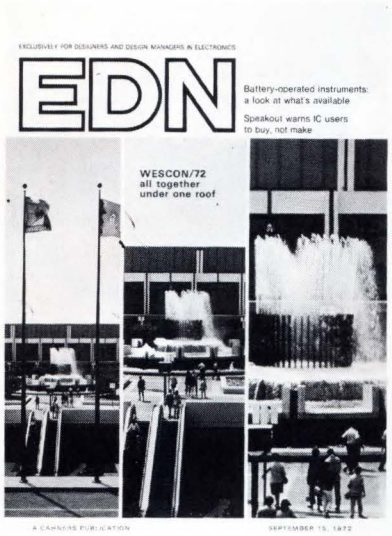
For additional information on our Corning CORDIP component networks, check your EEM catalog. Or write the Electronic Products Division of Corning Glass Works, Corning, N.Y. 14830 for our technical brochure.

CORNING
ELECTRONICS

CHECK NO. 7

SEPTEMBER 15, 1972
VOLUME 17, NUMBER 18

EDN with EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



COVER

This year's Wescon show not only has a new date but a new location as well. For details on everything from the technical program to the new products, see the special section that begins on pg. 62.

DESIGN NEWS

Virtual memory storage systems move into production computers . . 16
N-channel MOS shrinks size of computer . . . New portable man-to-computer interface eliminates light pens and special keyboards . . . Desktop calculator uses color TV for display.

DESIGN FEATURES

A look at the field of battery operated portable instruments 22
Thanks to low-power MOS/LSI ICs and new displays, battery operated portables have been finding their way into nearly every measurement function.

Rolland Smith of Signetics speaks out on whether to make or buy ICs. 30
Many companies today are considering making their own ICs in-house, as aerospace firms did 10 years ago. A new factor indicates that this is an ill advised course.

Analyze circuits easily with a phase meter that also measures gain . . 38
Whether you're characterizing integrators and differentatiors, measuring impedance or checking delay-line parameters, the phase method can come in handy.

EDN DESIGN AWARDS 42
Battery-saving, remote-command detector . . . Op amp makes variable-frequency triangular wave generator . . . Exclusive-OR gates simplify modem designs . . . Single IC

COMPUTER HARDWARE

Processor interrupt scheme lowers overhead, speeds response time . 49
Systems must react rapidly to interrupts to be effective in a real-time environment. An architecture that reduces both hardware and software overhead achieves this.

Sample and hold, or high-speed A/D converters, how do you decide? . 56
This is the most critical price/performance decision in data-acquisition designs. Take the guesswork out of it by looking at the whole system.

WESCON 1972 SPECIAL REPORT 62
This year the Wescon Show is all together under one roof in Los Angeles.

PROGRESS IN PRODUCTS

Sample-and-hold amplifier has top performance at moderate price . . 86
3-1/2 digit DPM mounts on front of panel instead of through it . . . Rugged high-level logic probe characterized for industrial use.

DESIGN PRODUCTS

Equipment . . . 92 **Semiconductors . . . 94** **Circuits . . . 98**
Computer Products . . . 102 **Components/Materials . . . 108**

DESIGN DEPARTMENTS

The Editor's Column . . . 9 **Literature . . . 114**
Signals and Noise . . . 116 **Application Notes . . . 119**
Index to Ads, Products, Application Notes and Lit 120

 EDN/EEE (formerly Electrical Design News) is published semi-monthly. Editorial, Advertising offices, 221 Columbus Ave., Boston, Mass. 02116 (617) 536-7780. Subscription offices, 270 St. Paul St., Denver, Colo. 80206 (303) 388-4511. Printed at 85 W. Harrison St., Chicago, Ill. 60605. Controlled circulation postage paid at Chicago, Ill. Send form 3579 to Subscription office. EDN/EEE is circulated to electronic design engineers and engineering managers in electronic OEM industries. Plants having more than twenty employees and manufacturing electronically operated or controlled equipment of their own design are considered part of this industry. Engineers in such plants responsible for specification of components, materials and test equipment for electronic application may receive EDN/EEE without charge. Completed qualification form and company letterhead required. Subscriptions to others in continental United States, $2 per copy. $20 per year. Send requests for qualification forms and changes of address to subscription office in Denver, Colo.

Everybody wants your components business.

But we're doing 6 things to earn it.

1 We build extra reliability into all our components. Documented reliability from ER through industrial, from precision through general purpose. To let you build extra reliability into all of your systems.

2 Our pricing is more than just competitive. If it weren't, why else would our customers have made us the largest supplier of metal film resistors in the country? And that metal film market includes glazed resistors.

3 We insist on delivery you can count on. Our "ball parks" are dependable. And our distributors provide off-the-shelf delivery from an inventory in excess of 50,000,000 components. To let you reduce expediting and inventory levels.

4 Our QC and unique product configurations make your production more efficient. Many of our customers find they can totally eliminate incoming QC testing of our parts. Others find our parts greatly simplify both hand insertion and automatic insertion operations.

5 Our new products can give you better alternatives. Like our FAIL-SAFE™ flame proof resistors. They open – never short – under overload. Plus they're economical replacements for non-inductive and semi-precision power wirewounds.

6 We back everything with the best support team in the business. We have the industry's largest technically-trained field force. And a select team of the industry's most service-oriented distributors. Because we know it takes top service to compete for your business.

Like everyone, we want your components business. But we're intent on doing more to earn it. Let us prove how much more on your next project. Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830 or Call: (607) 962-4444, Extension 8381

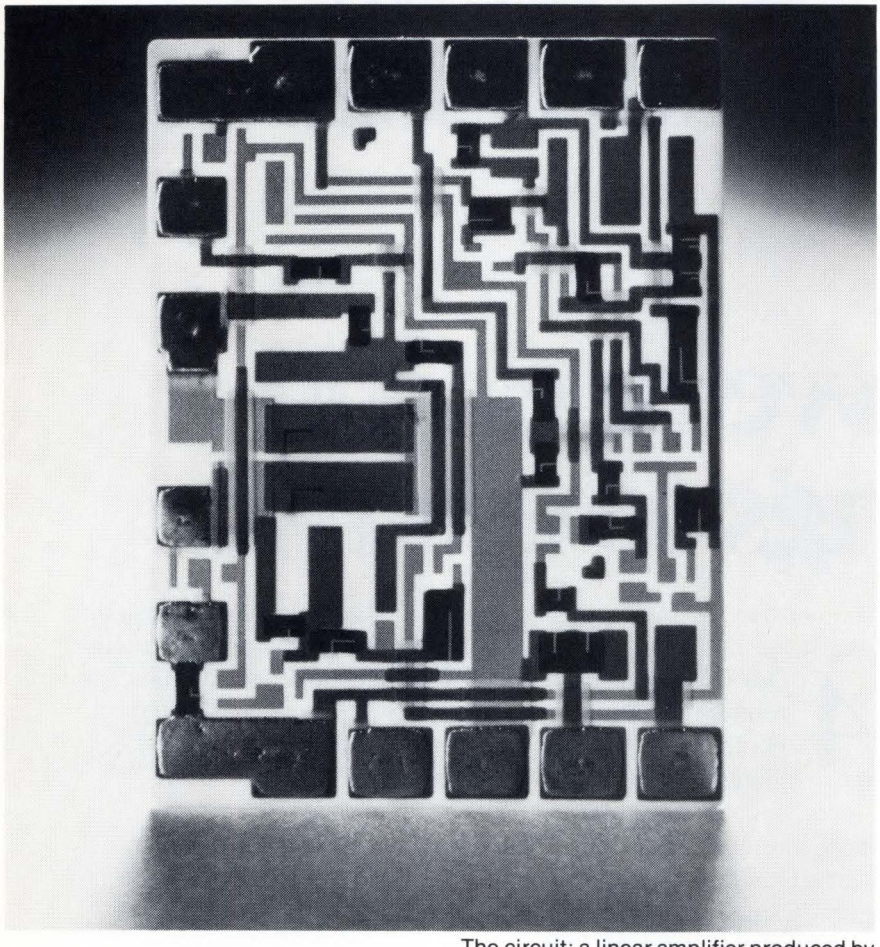
CORNING
ELECTRONICS

Resistors & Capacitors

for guys who can't stand failures

CHECK NO. 8

22 trims, 44 cuts, 5 seconds.



The circuit: a linear amplifier produced by RCA's Solid State Division, Mountaintop, Pa. 11 resistors are double-cut, 11 are L-cut. All trims are to 1% of nominal value or ratio. Throughput: better than 700 an hour. System datalogs before and after resistance values and deviations from nominal.

In laser trimming, you expect things to happen fast. But the Teradyne Laser Adjust System is *fast* fast.

Its unique beam deflector can move a laser beam from any location on a 2 x 2 substrate to any other in 30 milliseconds.

Its automatic handler indexes in less than 500 milliseconds.

Put it all together and you get the kind of productivity you need to stay cost-competitive in today's fast-moving hybrid business.

You also get the ability to make the kinds of cuts you need to produce high-quality resistors...double cuts, scanning cuts, serpentine cuts...in no more time than other systems take for compromise trims.

And that's not all. Industry's fastest laser trimmer is backed up by industry's most complete hardware and software for computer-controlled functional trimming. A trim station can be supplied, for example, as part of Teradyne's new J271 Analog Circuit Test System, for the active trimming of hybrid audio or rf circuits.

Learn more. Write Teradyne, 183 Essex St., Boston, Mass. 02111.

In Europe: Teradyne Europe S.A., 11 bis, rue Roquépine, 75 Paris 8^{e}, France. Tel. 265 72 62.

IN THE U.S.: CHICAGO (312) 725-2011
DALLAS (214) 231-5384
NEW ENGLAND (617) 245-5340
NEW YORK (201) 871-4052/PALO ALTO (415) 493-2340
IN EUROPE: LONDON (093-28) 61111/PARIS 265 72 62
ROME 59 47 62/MUNICH (0811) 33 50 61

TERADYNE

CHECK NO. 9

Could it happen here?

A few years ago the widget industry in Upper Slabovia was very healthy and successful. Widgets were being used ever increasingly in industrial and consumer areas, and were having a profound effect on the people and their everyday lives.

Most Slabovians didn't know what a widget was, and wouldn't recognize one if they saw it. This was understandable, though, since widgets were quite small and innocuous, and were designed into the things that the people bought and saw.

Now widgets were very tricky things—and the engineers who designed them into products were hard pressed to keep abreast of their rapid development. Luckily, though, the widget manufacturers provided a wealth of applications assistance in the form of application notes, data books, design handbooks, and applications engineers who were always ready to lend a hand. As a result, widget technology from both a development and use standpoint was constantly being improved. And everyone benefited.

It happened that there were numerous widget manufacturers, all of whom were in a constant battle for market position. Eventually, this, coupled with the fact that there was little to choose between similar widgets from different manufacturers, led purchasing people from many large user companies to an obvious conclusion—namely, that price is the answer. The lowest price gets the business. Even if it meant overruling the design engineer, who generally specified the widget manufacturer who supplied him with the data and applications assistance without which he couldn't have completed his design.

Now everyone knew that this was just good business—even the engineers, who didn't protest the purchasing peoples' choice.

Eventually, the widget manufacturers realized that to compete successfully on this basis they had to find ways to cut costs, and one logical way to do this was to do away with applications assistance. So gone were the application notes, the data books and the design handbooks.

And it came to pass that the widget industry in Upper Slabovia was still healthy and successful. But the pace of development was slowed. And more importantly, designers no longer applied widgets as easily, creatively and innovatively as before. The people still made wide use of products containing widgets. But the products were traditional and unexciting. The real state-of-the-art products had to be imported from Lower, East and West Slabovia.

Frank Egan

Editor

STAFF

Publisher
E. Patrick Wiesner

Editorial Staff
Frank Egan, *Editor*
Steven A. Erenburg, *Managing Editor*
Bob Cushman, *Special Features Editor*
Roy Forsberg, *Senior Editor*
Roger Allan, *Associate Editor*
Bill Furlow, *Associate Editor*
Jerry Moseley, *West Coast Editor*

Art Staff
Dan Kicilinski, *Director*
Roy Nelson, *Illustrator*
Patricia Rawlins, *Illustrator*
Ezio Mattassi, *Illustrator*
Elizabeth Garrenton, *Illustrator*

Production Manager
Wayne Hulitzky

Production Assistant
Susan Kennedy

Circulation Manager
Ron Kinnes

Marketing Services Manager
Ira Siegel

Editorial Consultant
John Peter

Editorial Office Addresses
Executive (617) 536-7780
221 Columbus Ave.
Boston, Mass. 02116

New York (212) 689-3250
205 E. 42nd St.
New York, N.Y. 10017

West Coast (415) 383-4220
404 Wellesley Court
Mill Valley, Calif. 94941

Now, Helipot offers covered cermet trimmers for low-budget projects.

There's not much sense in using cheap wirewound or carbon trimmers anymore. Not when the new Helipot Series 91 Cermet Trimmers are available *off-the-shelf* for a few cents more.

These single-turn, ⅜″, covered trimmers come in 10 different mounting styles and 19 standard resistance values from 10 ohms to 2 megohms. Covered construction helps protect against moisture, corrosive atmospheres, dust, oil and other contamination. Which means, in addition to cermet stability and better resolution, you get long-term dependable performance.

The breakthrough price is just 35¢ each in the 50,000 piece quantity, and they're equally well-priced in other quantities.

Send now for complete data on the Series 91 Trimmers... the finest of their class. We've made them for your projects where the budget may be tight, but you don't want to compromise performance.

Beckman®
INSTRUMENTS, INC.
HELIPOT DIVISION
Fullerton, California

HELPING SCIENCE AND INDUSTRY IMPROVE THE QUALITY OF LIFE

INTERNATIONAL SUBSIDIARIES: AMSTERDAM; CAPE TOWN; GENEVA; GLENROTHES, SCOTLAND; MEXICO CITY; MUNICH; PARIS; STOCKHOLM; TOKYO; VIENNA

CHECK NO. 12

Careful there . . . you're likely to start something.

Just a "flutter" of pressure . . . and SNAP!

Less than 2 grams of force actuates this Cherry snap-action miniature switch. Outside, the external aluminum actuator is purposely 2⅜" long to provide this unusually low operating force. Inside, an extra internal actuator further reduces operating force while maintaining solid contact mating pressure for reliable performance.

The "flutter force" switch is only one of Cherry's E22 series of unique miniatures. All are rated 3 amps, 125 VAC. All are also available in gold "crosspoint" configuration for low energy solid state circuits.

A switch in your hand is worth two in the tree, so . . . SNAP UP A FREE SNAP-ACTION SAMPLE.

Just TWX 910-235-1572 . . . or PHONE 312/689-7704 and ask Frank to give you facts on miniature switches . . . or circle appropriate reader service number.

E22-75HX
5 grams LIGHT FORCE actuation
Circle No. 67 for Free Sample

E22-55HX
3.5 grams LIGHTER FORCE actuation
Circle No. 68 for Free Sample

E22-85HX
Less than 2 grams "FLUTTER FORCE" actuation
Circle No. 69 for Free Sample

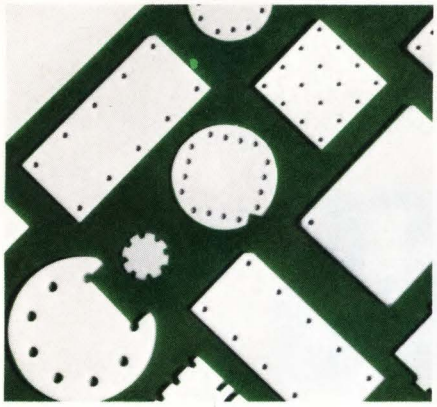
CHERRY®

CHERRY ELECTRICAL PRODUCTS CORP.
3622 Sunset Avenue, Waukegan, Illinois 60085

Makers of patented Leverwheel/Thumbwheel Switches, Matrix Selector Switches, Snap-Action Switches and Keyboards.

See us at WESCON in Booth No. 2704-06

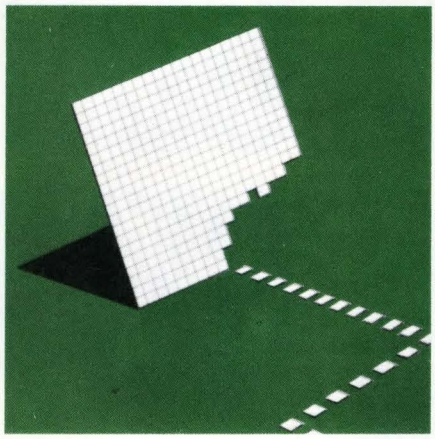
AlSiMag® BRAND COMPONENTS FOR HYBRIDS



SUBSTRATES

Many advanced ceramic substrate materials for thick film, thin film and microwave applications are available to suit your exacting requirements. Many sizes are stocked for immediate delivery. Custom prototypes can be quickly manufactured. High volume production fulfills your needs. New Bulletin 712 on request or phone 803/682-3215.

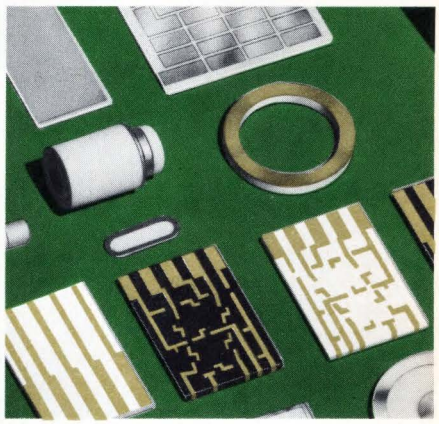
CHECK No. 37



SNAP-STRATES

Originated by American Lava, these monolithic parts can be snapped into individual substrates after circuit work is completed. Tooled Snap-Strates permit odd shapes, holes, slots, etc. Laser Snap-Strates permit very small or thin parts of great accuracy.
Phone 803/682-3215.

CHECK No. 38



CUSTOM METALLIZING

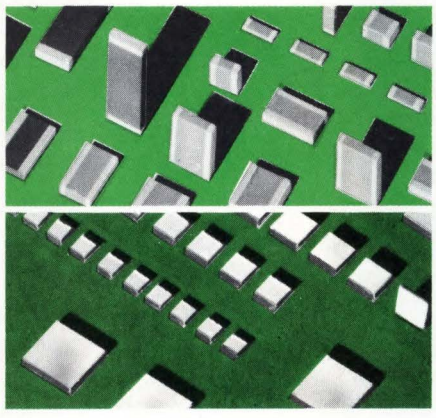
Tailored for maximum bond strength on wide choice of our own ceramic compositions including Black Alumina, White Alumina and Beryllia. All popular metallizations are offered applied by both precision generation and photoetching. Phone 615/265-3411.

CHECK No. 39

BERYLLIA SUBSTRATES

Heat dissipation your major problem? Investigate beryllia substrates. We are in volume production on BeO substrates and heat sinks and can meet "fast turn-around" requirements. Stock items for immediate shipment let you make quick and economical tests.
Phone 615/265-3411.

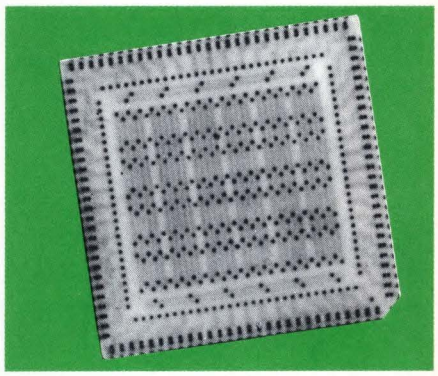
CHECK No. 40



CAPACITOR CHIPS

Single or multilayer, custom made or stock. Diced chips from 1 pf to .05 mfd. Sizes .020″ square and up. Multi-Cap® capacitors in all EIA preferred sizes, .080″ x .050″ and up. Available in TC compositions from P120 to N5600 and in all high dielectric constant materials. Bulletins 689 and 694 on request.
Phone 803/682-3215.

CHECK No. 41



APPROX. ACTUAL SIZE

MULTILAYER COMPOSITE SUBSTRATES

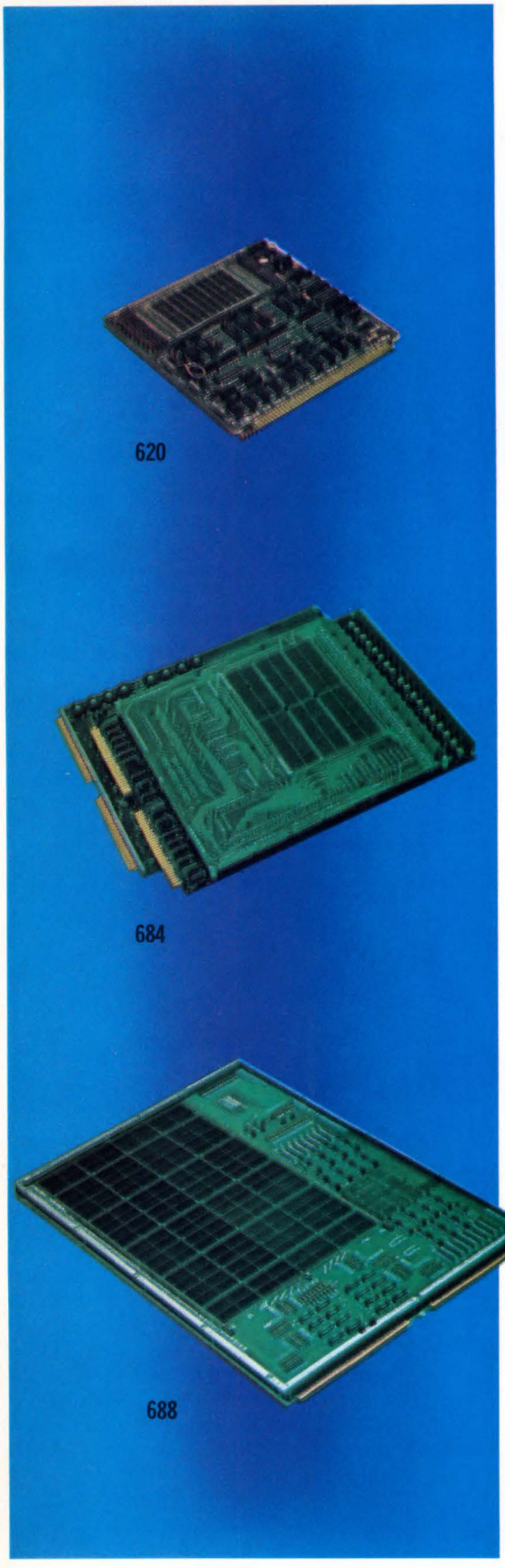
Monolithic multilayered structures with buried conductors permit a customized top layer for complex, custom designed, high reliability thick or thin film circuits. The conductive patterns are separated and insulated by planes of high alumina ceramic . . . NO glass. Also used for high quality hybrid packages and bases for complex Multi-Chip circuits. Phone 615/265-3411.

CHECK No. 42

American Lava Corporation

PHONE 615/265-3411 • CHATTANOOGA, TENN. 37405, U. S. A.

A SUBSIDIARY OF 3M COMPANY



Here's FABRI-TEK's New

600 SERIES

of Core Memory Systems.

You expect a memory system to provide maximum performance and fast access times. You expect off the shelf items to be reliable and to perform at minimum cost. Well, Fabri-Tek's new 600 Series combines all the above . . . and more.

For starters, consider the modular construction of the 600 Series. Ferrite core memories designed on a single card to permit operation of up to eight core modules from a single timing and control assembly. Developed for a wide variety of data application, the entire 600 Series is completely compatible with TTL logic. You get the flexibility so important in meeting a wide range of memory system requirements. Plus this: All Fabri-Tek 600 Series Core Memories are available for immediate delivery.

The 620 Core Memory System. Capacity up to 1024 words by 10 bits on a single card. Planar 3-D, 4- wire configuration measures just 6.0 X 6.4 inches. High-speed. Expandable. Access time: 350 usec. Cycle time: 10 usec. (full cycle).

The 684 Core Memory System. Basic module capacity of 8,192 words by 18 bits. Expandable to 32K, 64K or 128K by 9, 18, or 36 bits. Planar 3-D, 3-wire module is a compact 11.0 X 14.75 inches. Options include enclosures, printed circuit back panels, power supplies and test exerciser. Access time: 300 nanoseconds. Cycle time: 650 nanoseconds (full cycle).

The 688 Core Memory System. Single card capacity of 32,768 words by 20 bits. Expandable to 64K, 128K, 256K or 512K by 10, 20, or 40 bits. Maximum storage capacity from a single control assembly is over 5 million bits. Planar construction 3-D, 3-wire configuration. System options include enclosures, printed circuit back panels, power supplies and test exerciser. Access time: 500 nanoseconds. Cycle time: 1.2 microseconds (full cycle).

For more details, see your Fabri-Tek Salesman or contact: Fabri-Tek Inc., 5901 South County Road 18, Minneapolis, Minnesota 55436. Phone 612/935-8811. TWX: 910-576-2913.

Leader in Memory Technology For over a Decade

FABRI-TEK INC.

REGIONAL OFFICES: Boston (617) 969-5077 · Chicago (312) 437-4116 · New Jersey (201) 263-2330 · Phoenix (602) 266-4448 · Long Beach (213) 420-2493

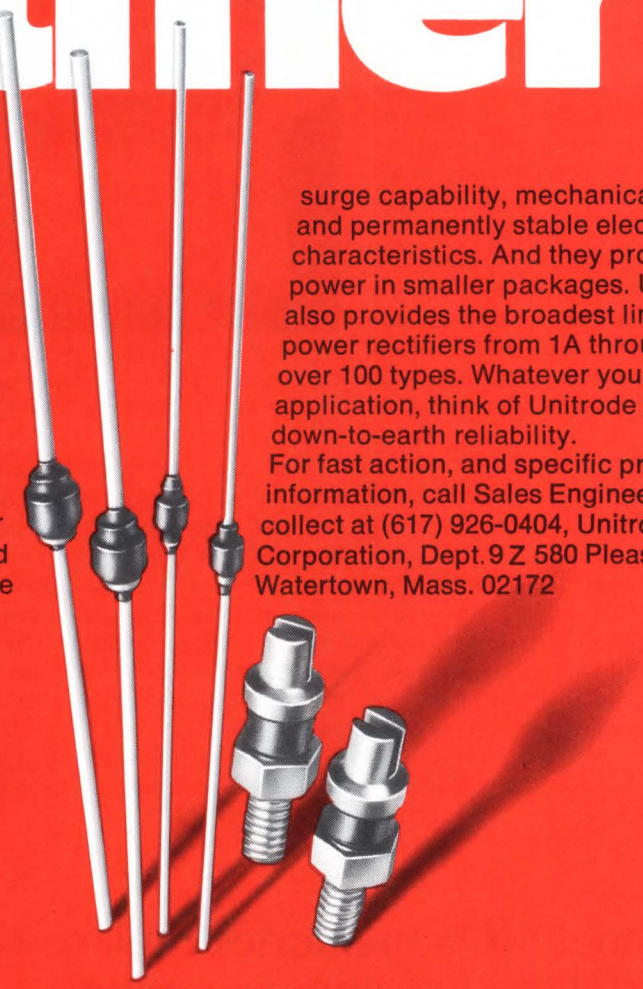
CHECK NO. 15

fail-proof rectifiers

UNITRODE IS SPECIFIED IN ALL MAJOR MISSILE AND SPACE PROGRAMS ...WHERE THERE IS NO MARGIN FOR FAILURE.

From HAWK to SAM-D, from MERCURY to VIKING, thousands of Unitrode rectifiers have been operating dependably for millions of hours under the most extreme environmental conditions. In Apollo alone, over three thousand Unitrode components have been used in everything from the Saturn booster and capsule telemetry system to the lunar module and cameras. Some reasons why? Unitrode's unique fused-in-glass construction for monolithic devices that are void-free and bonded, with very high forward and reverse surge capability, mechanical strength and permanently stable electrical characteristics. And they provide more power in smaller packages. Unitrode also provides the broadest line of power rectifiers from 1A through 20A — over 100 types. Whatever your rectifier application, think of Unitrode for down-to-earth reliability.

For fast action, and specific product information, call Sales Engineering collect at (617) 926-0404, Unitrode Corporation, Dept. 9 Z 580 Pleasant Street, Watertown, Mass. 02172



CHECK NO. 16

UNITRODE

For free Reliability Calculator (while supply lasts) write and let us know your particular application needs.

New portable man-to-computer interface eliminates light pens and special keyboards.

A major innovation in man-machine communications, providing a direct interface between man and a computer or other digital systems, has been introduced by Instronics Inc., of Ogdensburg, NY.

Called the TSD for Touch Sensitive Digitizer, the radically new unit consists of a piece of glass which can be placed over a tv-type CRT display or hard copy in the form of maps, drawings, etc. It can also be used in conjunction with projection systems.

The TSD's electronic circuitry automatically determines the location of a finger, felt-tipped pen, or other passive probe placed on the glass, and converts the co-ordinates of the probe's location into binary or BCD format for transmission directly to a computer or control system.

The TSD works on a principle similar to radar. Prisms with ceramic transducers driven from a 4 MHz pulse source are located along two edges of the device. The x-y axis transducers are time shared and transmit elastic surface waves along the glass. When an object is detected on the glass surface, the time for the reflected pulses to be received back at the transducers is measured, and X-Y coordinates calculated.

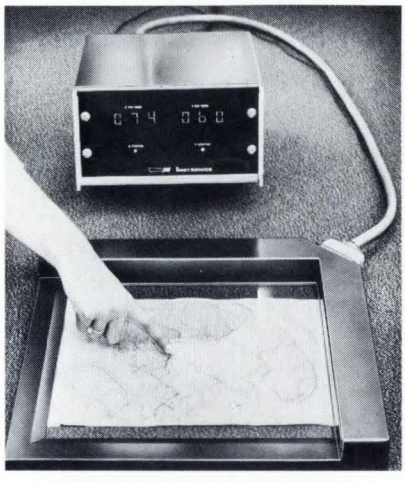


Fig. 1 – The Touch Sensitive Digitizer (TSD) can be teamed with an X-Y display digitizer as shown, or linked directly to a computer.

Objects as small as 0.02 in. can be detected with a resolution of 0.02 in. For best operation, a pliable object like the tip of a felt-tip pen should be used. Although ball-point pens have been detected, they are not recommended for use with the TSD because they won't have as firm a contact with the glass, and the surface wave could pass it by.

The TSD was developed by the National Research Council of Canada and has been patented by the Canadian Government. Instronics, Ltd holds worldwide license rights to manufacture it.

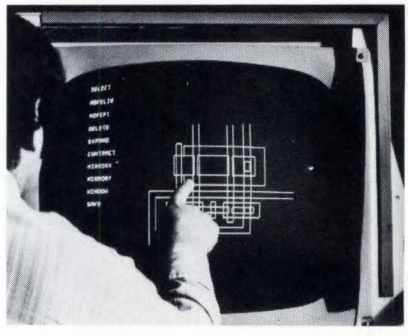


Fig. 2 – Interactive graphics design directly on a CRT display is possible with the TSD without having to use a light pen.

It features a clear glass digitizing area, requires only a passive unencumbered probe, such as a finger or pencil, is free of interference effects common to sound wave systems, and is extremely flexible. Interfacing is available for most computers, and digital logic and control systems.

The Touch Sensitive Digitizer can be made in sizes up to two feet on a side (no minimum size), and costs from $2-5000, depending on size and electronics. For more information check **296.**

N-channel MOS memories replace cores and shrink size of new computers.

Models 158 and 168 are the first computers to use main storage made with metal oxide semiconductor field-effect transistor (MOSFET) technology. In the new systems, 1024 MOS storage circuits are fabricated on a single silicon chip about one-eighth-inch square, compared with 128 circuits-per-chip in the bipolar main storage announced with the Models 135 and 145.

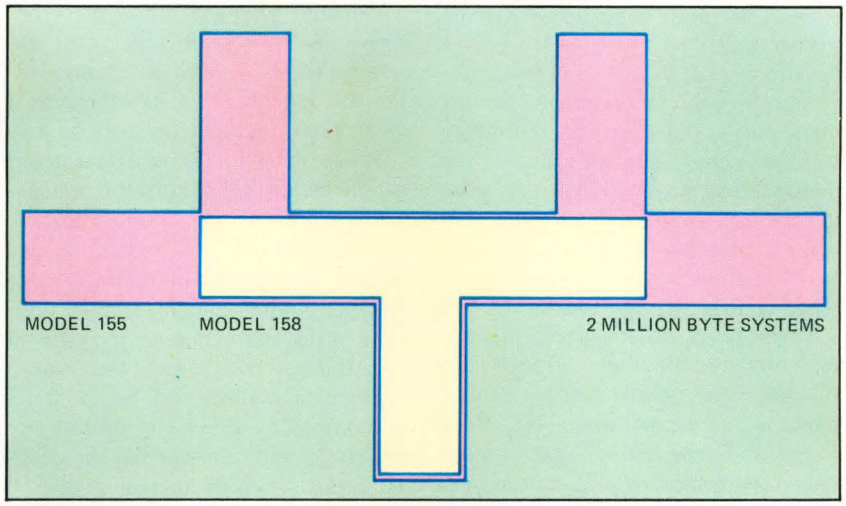
The MOS storage circuits help reduce space requirements and make the Model 158 and 168 faster in operation than the Models 155 and 165, which use magnetic core storage. For example, a Model 168 requires about 40% less floor space and executes instructions at a rate from 10 to 30% faster than a similarly programmed and configured Model 165. The Model 158 can execute instructions at a rate from

20 to 40% faster than a similarly programmed and configured Model 155.

The new models also use high-speed monolithic buffer storage to reduce the effective main-storage cycle by closely matching it to the processing cycle time. The buffer storage, which is made of bipolar monolithics, holds large blocks of data and instructions for processing by the central processing unit (CPU).

Model 158 is available with four main storage sizes—512k, 1-million, 1.5-million or 2-million bytes. Its buffer storage capacity is 8k bytes.

Model 168 is available in million-byte increments up to 4-million, a maximum main storage capacity one million bytes higher than for the Model 165. Buffer storage is available in sizes of either 8k or 16k bytes. □



Reduction in floor space required is dramatically shown by contrasting Models 155 and 158 which have the same main storage capacity.

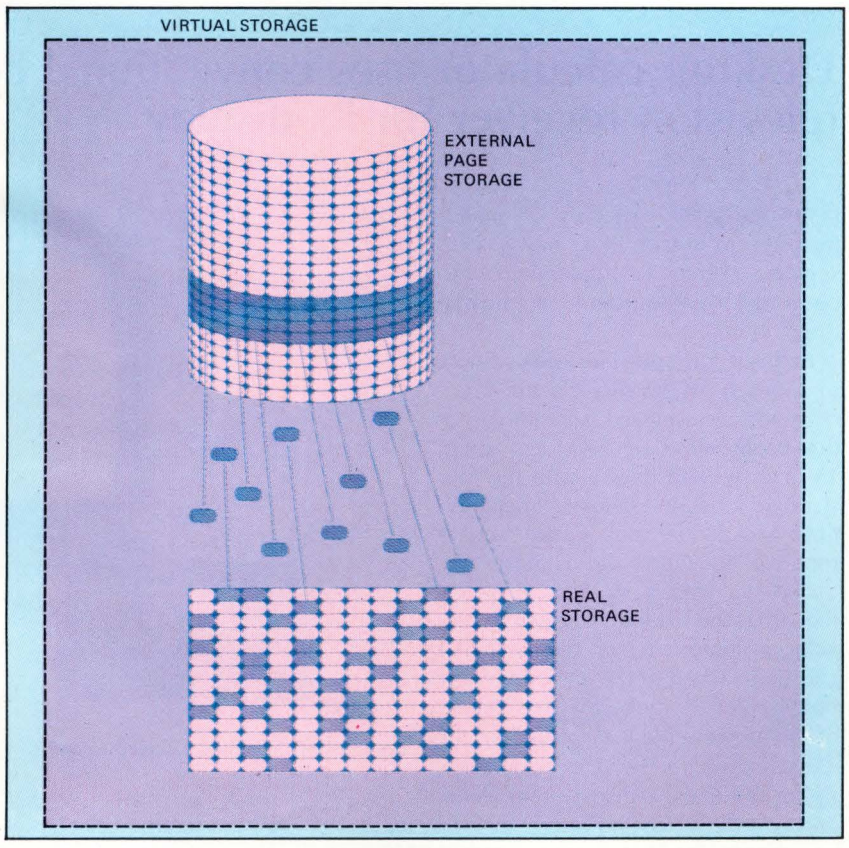
Virtual memory storage systems move from realm of technical session papers into production computers.

With the announcement of two new System/370 computers, Models 158 and 168, IBM has made true virtual storage available to computer users. Additionally, the availability of the machine facility called dynamic address translation, allows virtual storage to be added to existing Models 155 and 165.

Virtual storage links as many as 16 million bytes, or characters, of direct access storage to a computer's main storage through a combination of circuitry and programming. This fully automated resource allows programmers, computer operators and other users to work with their computer as if it had up to 16 million bytes of main storage—even though the computer's real main storage may be only a fraction of that capacity.

Essentially, virtual storage is a means of managing a computer's main storage dynamically so that a program—or more than one in a multi-programming environment—can be run on a computer even though total program size exceeds main-storage capacity.

In conventional computer operations, programs being executed generally must be in main storage in their entirety, even though large sections of each program are idle for lengthy



Virtual storage management: A dynamic link between a computer's main storage and high-capacity direct-access devices is the key to virtual storage. To meet a program's demands for main, or real storage space, program sections are transferred automatically from the direct-access external-page storage. Similarly, inactive pages can be transferred out if real storage space is called for by other programs.

periods of time, tying up vital main storage space.

With virtual storage, only the active sections of each program need occupy main storage, the rest of each program can be stored automatically on the direct access device, like a disk. Main storage space is automatically allocated to meet the changing demands of each program as it is being executed.

How virtual storage works

When programs are placed into virtual storage, they are automatically divided into small sections called **pages**. For ease of addressing, these pages are assigned to larger groups called **segments**. Initially, a page must occupy real storage—the computer's main storage—but as real storage space becomes needed elsewhere, the page is transferred to external page storage on the direct access device. When required again by an operating data processing job, one or more pages are automatically copied back into real storage. The ongoing transfer of pages between real storage and external page storage is termed **demand paging**.

Demand paging can take place because all instructions and data are referenced by their virtual storage addresses regardless of whether, at a given time, they occupy real storage.

When an instruction or a data record is referenced by a program, the dynamic-address-translation facility automatically breaks the virtual storage address into segment number, page number within segment, and the position of the instruction or record with regard to the beginning of the page.

Segment tables and page tables maintained by the system control programming indicate whether the needed page is already in real storage. If this is the case, program execution continues. If the page does not exist in real storage, then paging takes place under supervision of the system control programming.

To speed program execution, the dynamic address translation facility contains a **translation lookaside buffer** which holds the addresses of previously referenced pages located in real storage. If the real storage location of a referenced page is found in this manner, a search of segment and page tables is not required.

The system control programming and circuitry automatically monitor page usage in main storage to identify inactive pages. These are paged out when necessary to meet demands for main storage space. If a page has been changed during the run of a program, it is written over the former version that exists on external page storage. If a page has not been changed, no transfer of data need take place. This helps keep paging time to a minimum.

Monitoring of paging activity also helps prevent programs from being reduced below their optimum real storage space. Thus, if too much paging activity takes place, the system-control program will free additional real storage space by temporarily deactivating the lowest priority program. This helps ensure that the actual processing of programs is not impacted by abnormal paging rates. □

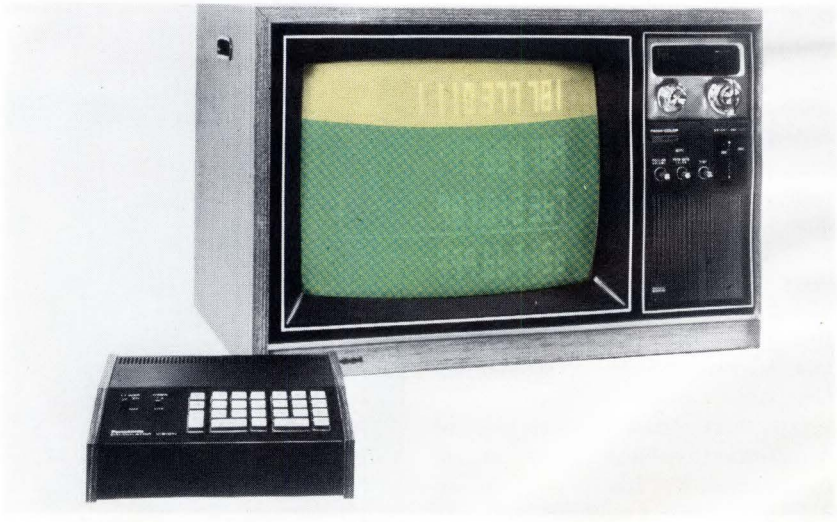
Desktop calculator uses conventional color television receiver for its display

If anyone really expected US manufacturers to retain their newly won supremacy in the calculator field without a major battle from Japan, he can forget it!

At the Consumer Electronics Show in Chicago, Matsushita Electric Corp. of America displayed a prototype of the Panasonic Calculator TV. It's a 14-digit desktop device with the four standard functions, (add, subtract, multiply and divide) plus square, square root exponentiation and memory.

The big feature of this calculator, though, is the readout. Through a character generator/adaptor, the calculator can be attached to the antenna of any home color TV receiver. The content of the memory file is displayed on the TV screen in yellow. The calculation, up to four lines, is displayed in green, and overflow is indicated by red characters.

Obviously any savings in the cost of standard LED or gas-discharge readouts is offset by the character generator, but the advantages should also be apparent. First, a large group can easily read the display, making the calculator a natural for classroom or conference use. The constant display of the memory contents is also an advantage.



Contents of this novel calculator can be read on the screen of any ordinary television set.

The calculator is only a prototype, and may never reach the market. It should, however, be interpreted as the tip of the iceberg—only an indication of the depth of calculator designs Japan is now formulating in her attempt to recapture the market. □

Fluke problem solvers

At .002% guaranteed accuracy, our 8400A is the ultimate bench and systems DVM

Built with an accuracy for all seasons, every season.

With a guaranteed accuracy of 0.002%, true RMS AC, 1 microvolt resolution, resistance measurements down to 100 micro ohms, auto polarity and ranging, you will find it's the top DVM in the field. And, in the Fluke tradition, you'll find this member of your measurement team won't be technically obsolete or out of style next year or the year after, because of its wide choice of systems and measurement options.

It's built to last. It's built to use.

It's the DVM to use for low-level, high speed measurement of distorted AC waveforms, physiological measurements, transducer calibration and virtually every other laboratory or field application demanding "state-of-the-art" digital measurement.

Here's what you get for $2450: ☐ Five ranges of DC from 0.1v full scale to 1,000v with up to 0.002% accuracy. ☐ 5½ digits with 20% overrange. ☐ Recirculating remainder A-to-D conversion for low power consumption and high reliability. ☐ 1500v peak overload resistance and the ability to meet tough environmental specs. ☐ Switched filter for DC, AC, resistance and ratio with better than 65 dB noise rejection.

Wide choice of options: Fluke uses single main frame construction with all options field installable. Get them when you buy or anytime later.

☐ Choose from seven ranges of 4-terminal resistance. ☐ Four ranges of true RMS AC from 1 to 1,000 volts. ☐ Well isolated and buffered serial or parallel data outputs. ☐ Multiplexing or analog input, data output or remote control. ☐ Automatically adaptive time-outs with status flags.

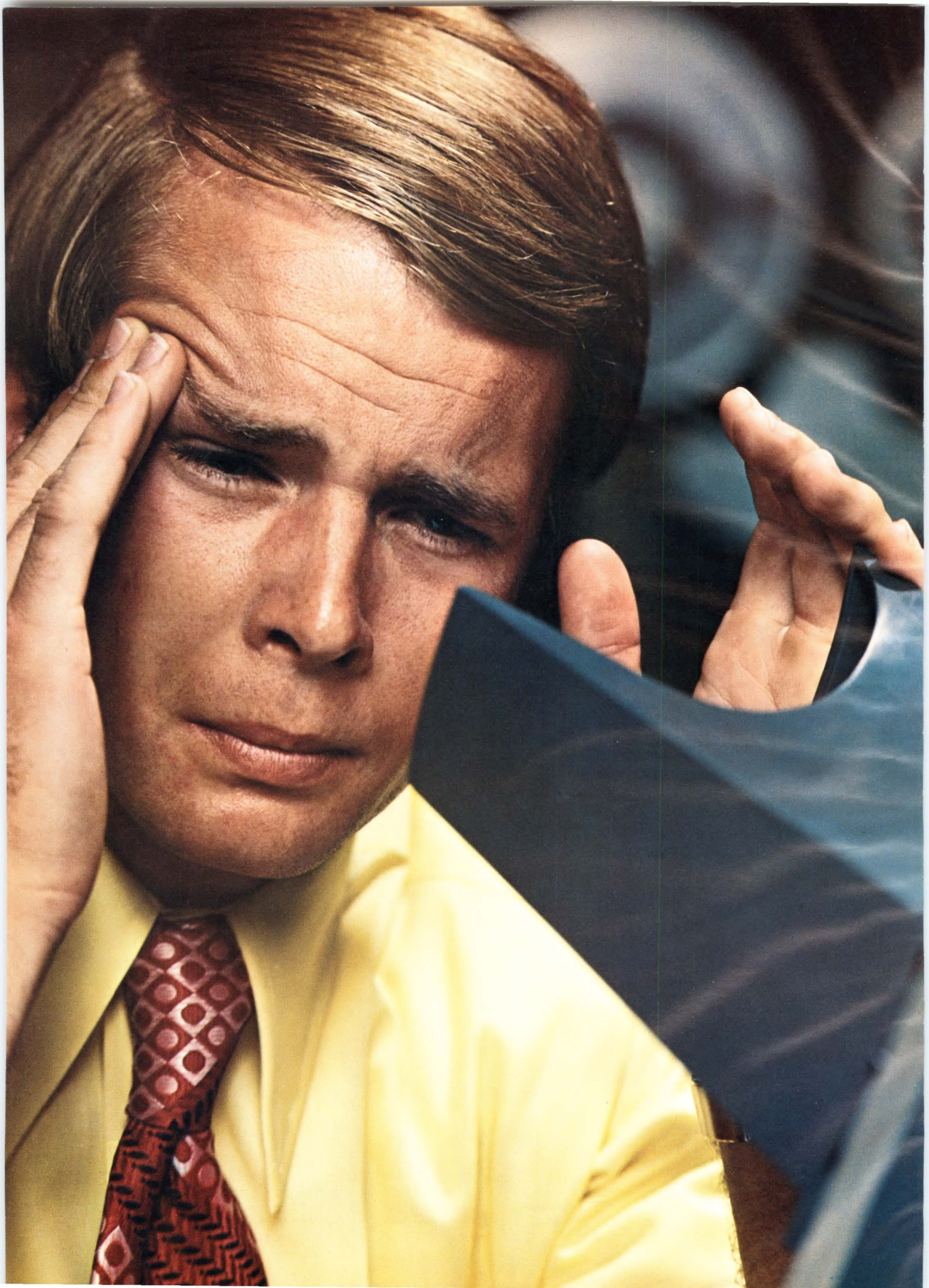
For more information, call your nearby Fluke sales engineer or contact us directly.

SEE ALL THE NEW FLUKE INSTRUMENTS AT WESCON

FLUKE®

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850/In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Phone: (04250) 70130. Telex: 884-52337/In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2, 4TT. Phone: Watford, 33066. Telex: 934583.

CHECK NO. 17



Think Twice:

What's one of the biggest measurement problems in the computer industry today?

Low Duty-Cycle Measurements— Making timing-pulse adjustments, and finding noise pulses in, or locating missing bits from low duty-cycle digital signals. Countless lost hours and eyestrain have resulted from this problem—trying to view low rep-rate signals like those found in disc, tape, or drum peripheral units. But with your refresh cycle occurring at such long intervals, coupled with short phosphor persistence, it's no wonder that you've spent an inordinate amount of time making such measurements. And it's no wonder that you often came out from under your scope hood rubbing your eyes. Well, no more!

Storage CRT With Unmatched 400 cm/μs Writing Speed. Hewlett-Packard just made it possible for you to throw away your scope hood by developing a new bright, burn-resistant, high-speed, variable-persistence CRT—available in either 100 cm/μs or 400 cm/μs writing speeds. Placing these new CRT's into an all new mainframe that's optimized for high-writing-speed storage measurements, HP now gives you a new dimension in storage scopes—the HP 184A. This unique combination offers the highest writing speed available, and a display with brightness as great as you can find anywhere. For the first time you can find those elusive transients that before were too fast for your storage scope to follow—like nanosecond noise pulses.

Display True Replicas of Your Waveforms. You'll appreciate being able to adjust persistence down to 0.2 seconds; that's 75 times lower than a major competitive unit. For those measurements that require faster sweep times, you'll know you are displaying true replicas of your waveforms when you're using an HP 184A. Capture low duty-cycle pulse trains, through repetitive sweeps, simply by adjusting the persistence to "maximum," to build up the intensity of dim traces. This feature in the new 184A oscilloscope lets you do many jobs you previously allocated to expensive, single-shot scope/camera systems.

Variable-Persistence Storage and Standard in One Scope. Further, you'll find that your 184A is a true general purpose scope that offers you the capability to choose, by way of plug-ins, all the functional features of the HP 180 Series of oscilloscopes, including such items as selectable-input impedance, and sampling to 18 GHz. And for simplicity of operation, we think you're in for a pleasant surprise when you compare the 184A against the competitive unit.

Superior Technology. HP believes the most important part of a scope system is the CRT—the interface between you and your measurement. As the pioneer in practical applications of dome-mesh magnification, HP was first to expand the size of high-frequency CRT's to 6 x 10 cm; first to 8 x 10 cm; and first to 10.4 x 13 cm—all in high-frequency mainframes. HP was also the first to use dome-mesh technology to substantially lower power requirements for CRT deflection (making possible the only line of 35 and 75 MHz portable scopes with built-in battery packs—scopes that really are portable).

From The Storage Leader. HP was first with variable-persistence mesh storage for commercial applications—to give you a stored trace many times brighter than bi-stable tubes, and without annoying flicker. Variable-persistence, with its ability to build up waveform brightness, was the first CRT innovation that gave you a trace bright enough to let you tackle most single-shot or low rep-rate measurements problems. All you do is adjust persistence until the integrating storage effect brings your waveform up to a bright, clear display.

Burn-Resistant CRT's. HP placed variable-persistence in many of its scopes including the 181A, 1702A, and 1703A storage units. And now HP has developed, for its current line of storage instruments, carefree CRT's so highly burn resistant they require little more care than conventional CRT's. The new 184A high-writing-speed scope also has unprecedented inherent resistance to burns.

Yes, Scopes Are Changing. How many times have you wished for a scope that could display a low rep-rate digital signal brightly and clearly, and one that could also be used for a variety of general purpose measurements. That scope is here now in HP's 184A storage mainframe, $2200 (for only $500 more, you can boost your 184A's writing speed to 400 cm/μs), with plug-in capability to 100 MHz real time, or 18 GHz sampling. Think twice; put away your scope viewing hood and call your local HP field engineer for a demo today. Or write for our "No Nonsense Guide to Oscilloscope Selection." It covers the other members of HP's variable-persistence storage scopes. Hewlett-Packard, Palo Alto, California 94304. In Europe: P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: YHP, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

Scopes Are Changing; Think Twice.

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

CHECK NO. 18

A look at the field of battery operated portable instruments

Thanks to low-power MOS/LSI ICs and new displays, battery operated portables have been finding their way into nearly every measurement function

Roger Allan, Associate Editor

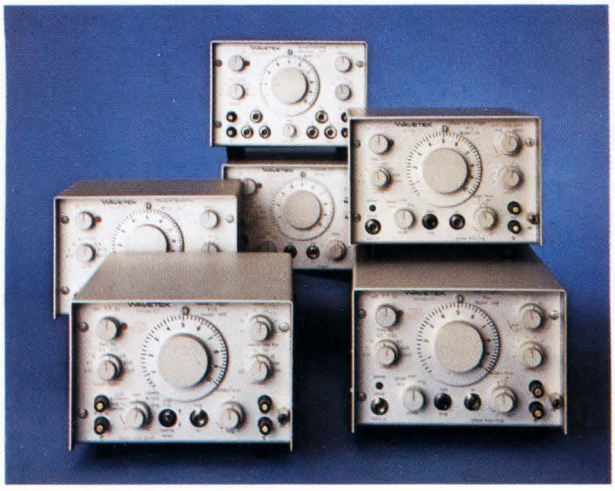


Fig. 1—Multi-function generators that operate from Ni-Cd batteries are available in the Wavetek 110 Series. Used for geophysical applications where ac-line isolation is critical, the generators provide sine, square and triangular outputs over a frequency range of 0.0015 Hz to 1 MHz.

Spurred on by a boom in computer, CATV, data telemetry and communications applications, portable battery operated instruments are increasingly finding their way into more and more types of measurements. These applications have created a large demand for light, low-power-consumption, independently powered instruments useful for field-service applications. Helping this battery operation along has also been the increasing use of MOS/LSI ICs and LED and liquid-crystal displays that have made it possible to pack an entire instrument's circuits on one or two printed-circuit boards save for the power-supply section.

This last factor, the shrinking size of instrument circuitry, with resultant savings in power dissipation, overall weight, cost and an increase in reliability over equivalent discrete-component designs, has tended to show up the traditional power supply with its large and bulky power transformer and electrolytic capacitors. In some instrument designs, the power supply portion takes up more space and weighs more than all of the rest of the instrument's circuitry. This made it attractive to go the battery route through the use of available hybrid power ICs and dc-to-dc converters that are not only light and compact, but dissipate little power.

To be sure, line operated portable instruments have been on the scene for quite a few years. Here, the manufacturers' definition of portability centers on lightness of weight. But these instruments still require ac line cords and sources from which to operate. Equally important as weight is the form factor. Many so-called portables are not truly portable because they are not very mobile due to a poor form factor, despite the fact they are quite light in weight. Clearly, for an instrument to be truly portable, it should have the capability of being independent from an external power source, be lightweight and should have mobility.

Thanks to FETs, the familiar and handy VOM was one of the first instruments to achieve true portability with high input impedances and low power dissipation. Within the last few years, battery operated instruments have picked up momentum. Today an engineer can avail himself of nearly every measurement function in a battery operated case. These include such traditional laboratory instruments as sensitive and wideband oscilloscopes, high-frequency electronic counters, R/L/C bridges, high-resolution digital multimeters and even multi-function signal sources (see **Fig. 1**).

A look at the applications

In general, applications of battery operated portable instruments fall into two categories: field service and calibration applications where no ac power is available, and sensitive low-level signal measurements in the laboratory where isolation of the measurement from the line is not only desirable but sometimes imperative, since high common-mode noise and interference can obscure low-level signals.

The former category encompasses many fields, chief among them being computer servicing, CATV line testing, microwave field installations and calibration, avionics and a limited number of marine service applications. The latter category involves a growing number of sensitive-measurement applications. These include the measurement of semiconductor resistivity, contact resistance, thermocouple potentials, biologically generated emfs, electro-chemical potentials, strain-gauge outputs, transducers, radiation sources and phototube currents. Geophysical instrumentation requires not only line isolation of measurement equipment but also line isolated excitation sources. One important application requiring freedom from ac-line noise is in the measurement of power-supply ripple. Other applications include inplant production-line testing and Q.C. testing and screen rooms where a noisy environment can cause inaccurate low-level readings.

It can be argued that for many field-service applications, such as computer servicing, battery operation is not essential, since ac power to run the computer is always available. In such applications battery operation is more a convenience to increase the instrument's mobility. Nearly all oscilloscopes designed specifically for computer servicing

operate from ac as well as battery power. However, for field applications where no ac power is available and those applications requiring ac line isolation, battery operation is the only way.

A look at the design

An engineer should not expect a battery operated instrument to have the same capabilities as an ac operated one for the same purchase price. It will either cost more for the same performance features or will have less capability for the same price. Two of the more important reasons for this are the dc power supply and the instrument's housing.

The design of the dc power supply, usually a dc-to-dc converter, is critical. A large constant source of energy is not always available from a battery for long periods of time. Power dissipation must be kept to an absolute minimum. As a result, expensive, sophisticated and highly efficient power supplies—typically 75% and higher—are used.

Many design schemes are utilized to keep power dissipation at a minimum. Keithley's Model 167 Auto-Probe digital multimeter (see **Fig. 2**) utilizes a push-to-read switch housed within the LED-display probe that turns on only when the measurement is being made. Weston Instruments' Model 4440 digital multimeter (see **Fig. 3**) uses a circuit that automatically blanks those display digits not in use. For example, 1 mV on a 200-mV range would read 1.0. Similarly, Dana Laboratories eliminates all insignificant zeros in the display of its Model 4300 digital multimeter (see **Fig. 4**).

Some manufacturers credit their unique a/d conversion schemes for dramatically lowering power schemes. For example, John Fluke Mfg. uses recirculating remainder conversion for typical power dissipation of under 10W for most of its battery operated instruments. Data Precision Co. has a 5-1/2-digit digital multimeter (see **Fig. 5**), the largest battery operated unit of its type, that is said to dissipate 12W thanks to some radical new front-end designs.

Oftentimes, to make a portable instrument stand up to the physical and environmental abuses it should take, a ruggedized case is used. This case may be slightly larger than an ac-operated-only version because it has to house additional space for the dc power supply and associated

Fig. 2—Incorporating a LED-display probe with a push-to-read switch, Keithley's Model 167 Auto-Probe digital multimeter reaches new heights in portability. Operating on a set of six alkaline batteries, this fast-warmup unit has a dc-to-dc converter that shuts off whenever the batteries drop below a predetermined voltage level to guard against erroneous measurements.

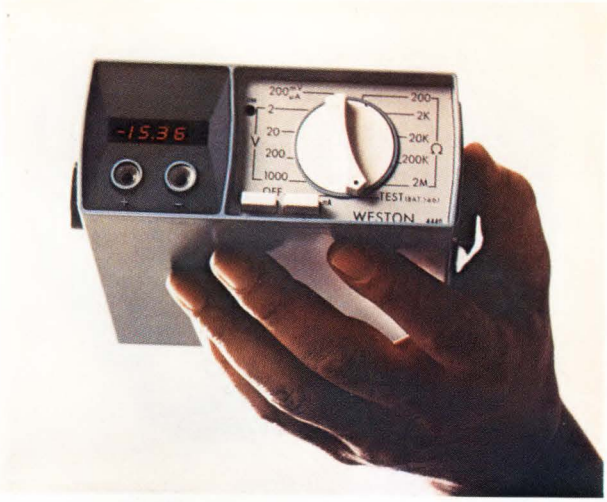


Fig. 3—Form factor is just as important as weight in portability. Weston's Model 4440 digital multimeter uses standard "C" cell batteries and weighs a mere 2-1/2 lbs. It also uses one MOS/LSI IC chip and an LED display that blanks out digits not in use for power conservation. Note the use of an adjustable tilt handle to facilitate the multimeter's mobility and setup.

charging circuits. All this could mean an additional expense due to case re-tooling.

The trend today is to use lightweight and high-impact plastic cases, notably Lexan, that can withstand severe shock and beatings. Weston's Model 660 analog VOM is guaranteed to withstand a five-foot drop and still function normally—a far cry from the days of the first plastic-case VOMs. Weston's is by no means the only one. Several other manufacturers offer drop-proof instruments.

The battery

By far, the most widely used battery type is of the rechargeable Ni-Cd variety. At present it offers the best tradeoff between performance and cost when compared to other battery types. Some manufacturers prefer to use limited or non-rechargeable throw-away mercury, alkaline or carbon batteries. They report that many users do not like the inconvenience of having to wait the usual 16 to 24 hours (usually done overnight) to get 8 to 12 hours of con-

Fig. 4—Designed to withstand dropping, banging and many other stresses, Dana's tough little Model 4300 digital multimeter is made of rugged Lexan and contains no ventilation louvers, permitting it to operate in dust, dirt and water environments.

Fig. 5—The only 5-1/2-digit multimeter that operates from a battery (rechargeable lead oxide) is Data Precision's Model 2540 which dissipates only 12W of power. The meter incorporates three new major circuit advances—Triphasic conversion, Ratiohmic resistance and Isopolar reference—to cut the instrument's cost and enhance its performance.

tinuous operation from Ni-Cd batteries. If the user forgets to plug the instrument in for night charging, he couldn't use it the next day. Non-rechargeable batteries make the power supply design much simpler—no charging circuit—leading to lower cost. However, only in low-power-consumption instruments, such as some multimeters, can non-rechargeable batteries be used. In some cases, the Ni-Cd battery is offered as an option.

Applications involving outdoor work, such as telephone, CATV and data telemetry line testing, can involve a wide range of temperatures. Even though Ni-Cd batteries are rated to operate at sub-zero temperatures down to the freezing point of the battery's electrolyte, they will not supply the same amount of continuous energy as they do at higher temperatures. A Ni-Cd battery rated for 8 hours of continuous operation at room temperatures, can drop down to only 1 or 2 hours at freezing temperatures.

Lead-acid type batteries are available for low-temperature work. They are low in cost but suffer from leaking-

Fig. 6—The largest bandwidth and most sensitive oscilloscopes to operate from rechargeable batteries are the Models 465 and 475 from Tektronix, Inc. Model 465 is rated for 100 MHz at 5 mV/div. and the 475 shown here, operates up to 200 MHz with a sensitivity of 2 mV/div. They are slated to replace the popular 453A/454A oscilloscopes.

Fig. 7—A 20-MHz oscilloscope that fits into a briefcase is Vu-Data Corp.'s PS-900 unit. It offers 10-mV/div. sensitivity and weighs only 7 lbs (including batteries). A choice of Ni-Cd, alkaline or carbon zinc "C" cells are available for power. An internal recharge circuit is provided to cut-off batteries when fully recharged, so they can be placed in a recharge mode indefinitely without any damage.

acid disadvantages and are quite heavy. An instrument using this type of battery couldn't be operated in every position. Gould, Inc., Burgess Division has recently developed a promising sealed lead-lead dioxide battery (the Gelyte PB660) that can be operated in any position, requires no maintenance and is low in cost. It also has about the same number of recharge cycles that Ni-Cds do—anywhere from 100 to 300 cycles.

Ballantine Laboratories' president Fred Katzmann sees one use for this new Gelyte battery as an ac power source. He is currently working on such a power center, which is powered by a Gelyte cell no larger than a cubic foot, that can supply anywhere from 100 to 200W of continuous 115V ac power for a few hours to several instruments at once. The battery can be recharged from an ac line during the night. Katzman foresees the entire package of battery and converter circuit with charging elements weighing no more than 15 to 20 lbs and capable of being strapped to an engineer's shoulder in the field much like a camera is

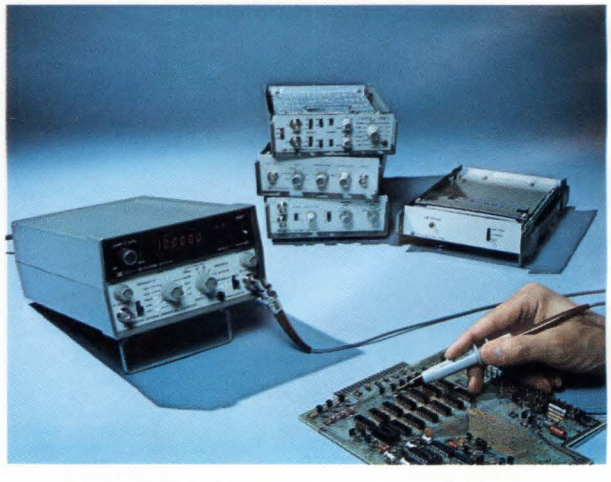


Fig. 8—The plug-on approach is used in Hewlett-Packard's 5300A electronic counter which allows the addition of either 10, 50 or 100-MHz modules as the need arises for maximum versatility and non-obsolescence. The system weighs only 3-1/3 lbs and operates from rechargeable Ni-Cd batteries (middle module).

Fig. 9—The widely popular 1650 impedance bridge from General Radio with its unique flip-tilt case is one handy instrument that is sure to be found in nearly every laboratory. Using throw-away "D" cell batteries, the bridge is completely self contained and can be carried anywhere thanks to its light weight of 14.5 lbs and smartly styled carrying case.

carried. A dc output provision would also be available directly from the battery for those instruments requiring dc power.

Currently, work is going on to provide silver-zinc batteries that have high energy densities, are quite small and light and can be operated in any position. Their only drawback is cost—usually 2 to 3 times more than Ni-Cds.

How to choose

If an engineer were to pick up a trade magazine or study the various manufacturers' product literature, he'd be amazed at the bewildering array of claims made on behalf of battery operated portable instruments. But more important, some of the most important considerations are often not even mentioned. These would include the instrument's environmental capabilities, the number of useful battery recharge cycles, the weight of the instrument with the battery, not without it, as most manufacturers neglect to point out. It's one thing to have an oscilloscope that has a weight claim of 20 lbs, but quite another when the battery weight of 6 or 7 lbs is added on. And what about other necessary accessories such as instrument probes, covers, cables and adapters? Are they included in the total weight? Of course, the ultimate test is to try the instrument first hand, but a few hints as to what to look for first can save an engineer many a headache later.

Listen to what Glenn Patterson, product manager for John Fluke, Mfg., Co., has to say: "An engineer should have a clear understanding of how the instrument will be used, and the environment in which it will be expected to operate. While this seems like an obvious point, it's been my experience that most specifying engineers have been primarily responsible for selecting non-portable, laboratory instrumentation. Because of this orientation, it is easy to forget the tough environmental conditions which often face portable units, and the sometimes unusual measurements expected of them as well."

To assist the engineer in specifying the proper battery operated instrument, the following pointers should always be considered before purchasing one:

1. The true test of an instrument's portability is how easily it is transportable. Does the case form factor lend itself to good mobility? Does the case contain a tilt handle so the instrument can not only be carried easily, but set up with relative ease? Is a cover provided?

2. Check the type of display and see if it agrees with the kind of environment you'll be using the instrument in. Is it bright enough for direct sunlight when used outdoors? Are the display's characters large enough to be clearly seen from a distance? In many portable field and production-line applications, the distance between the operator and the display can be quite lengthy. A display with large characters can be more suitable here.

3. Since portables in general take a worse beating, both physically and environmentally than non-portables, check to see whether or not the instrument's case is designed to handle repeated shocks and drops. The type of case used is not always the answer, since the case may survive a nasty fall while the instrument's circuitry may not, but it can be a clue. Also, will the instrument tolerate wide temperature ranges? Ruggedness of construction can sometimes provide the answer.

4. Batteries should be self-contained within the instrument for maximum flexibility. However, some instruments use strap-on or plug-on batteries. Is this a cumbersome method for your application? How many recharges can the battery take during its lifetime? Can the battery be recharged while the instrument is operating from the ac line? Not all instruments have this capability. Does the instrument have a way of indicating a low battery level and if so how? Some instruments have battery check positions available on the front-panel switch while others incorporate circuitry that automatically cuts out power when the battery drops below a predetermined level.

5. Know your application. Since most battery operated portables are designed for service work where qualitative rather than quantitative checks are needed, are all the performance parameters sold with the instrument needed? Do you need a digital multimeter with BCD output and programmable features when all you're going to be using it

Fig. 10—Thanks to plug-on modules, Hewlett-Packard's Model 3470 digital measuring system can be configured as either a 4-digit multimeter or a 4-digit voltmeter, with the appropriate selection of the bottom module. A plug-on rechargeable Ni-Cd module can also be added to the system to allow for battery operation.

Fig. 11—The latest portable function generator, the Krohn-Hite Model 5600, provides sine, square and triangle waveforms from 0.002 Hz to 2 MHz. It will operate on battery power for approximately 5 hours.

for is to check a few voltages on a production line or in the field? Low-cost logic probes are competing earnestly with more expensive oscilloscopes for servicing digital circuits. All unused extras cost money, so cut out the fancy frills whenever possible.

6. Does the instrument contain provisions for easily converting to ac power-line operation, should battery operation cease to be needed? This assumes that the instrument operates solely from a battery.

7. Is the instrument's operation simple? Does it take a trained person to operate it? Since most service personnel do not have the time to fiddle with many knobs and switches, this point can be essential in cutting down on service time and subsequent costs. □

Who are the manufacturers?

Space limitations precluded the discussion of every manufacturer's battery operated portable instruments. Readers are advised to use the following list of companies and persons to contact should more information be desired.

Ballantine Laboratories, Inc.,
P.O. Box 97,
Boonton, N. J. 07005.
(Fred Katzmann, president).
Phone (201) 335-0900.

Boonton Electronics Corp.,
Route 287 at Smith Rd.,
Parsipanny, N. J. 07054.
(Frank Stevens, marketing mgr.).
Phone (201) 887-5110.

Dana Laboratories, Inc.,
2401 Campus Dr.,
Irvine, Calif. 92664.
(Brian Franklin, advertising and sales promotion manager).
Phone (714) 833-1234.

Data Precision Co.,
Audubon Rd.,
Wakefield, Mass. 01880.
(Robert Scheinfein, sales manager).
Phone (617) 246-1600.

Electro-Scientific Industries,
13900 N.W. Science Park Dr.,
Portland, Ore. 97229.
(Jack Henderson, comm. mgr.).
Phone (503) 646-4141.

John Fluke Mfg. Co., Inc.,
P.O. Box 7428,
Seattle, Wash. 98133.
(Glenn Raterson, product manager).
Phone (206) 774-2211.

Krohn-Hite Corp.
580 Massachusetts Ave.,
Cambridge Mass. 02139.
(Richard Haddad, V.P., marketing).
Phone (617) 491-3211.

General Radio Co.,
300 Baker Ave.,
Concord, Mass. 01742.
(Carl Alsen, advertising manager).
Phone (617) 369-4400.

Heath Co.,
Benton Harbor, Mich. 49022.
(Bill Hannah, marketing manager).
Phone (616) 983-3961.

Hewlett-Packard Co., Colorado Springs Div.
(oscilloscopes),
1900 Garden of the Gods Rd.,
Colorado Springs, Colo. 80907.
(Chuck Donaldson, product manager).
Phone (303) 598-1900

Hewlett-Packard Co., Delcon Div.
(telephone and cable-testing equip.),
333 Logue Ave.,
Mountain View, Calif. 94040.
(Ray Baribeau, product manager).
Phone (415) 969-0880.

Hewlett-Packard Co., Loveland Div.
(voltmeters and multimeters),
815 14th St., S.W.,
Loveland, Colo. 80537.
(Craig Walter, product manager).
Phone (303) 667-5000.

Hewlett-Packard Co., Santa Clara Div. (electronic counters),
5301 Stevens Creek Rd.,
Santa Clara, Calif. 95050.
(Bernard Belkin, product manager).
Phone (408) 246-4300.

Hickok Electrical Instrument Co.,
10514 Dupont Ave.,
Cleveland, Ohio 44108.
(J.S. Prosek, advertising manager).
Phone (216) 541-8060.

Julie Research Laboratories, Inc.,
211 W. 61st St.,
New York, N.Y. 10023.
(Matthew Eichenbaum, sales mgr.).
Phone (212) 245-2727.

Keithley Instruments, Inc.,
28775 Aurora Rd.,
Cleveland, Ohio 44139.
(David Bartos, advertising and sales promotion manager).
Phone (216) 248-0400.

Monsanto Electronic Instruments,
c/o United Systems Corp.,
918 Woodley Rd.,
Dayton, Ohio 45401.
(Fred Pummill, marketing manager).
Phone (513) 254-6251.

RCA, Electronic Components Div.,
415 S. 5th St.,
Harrison, N. J. 07029.
(R. A. Rainboth, electronic instruments operation).
Phone (201) 485-3900.

Sencore, Inc.,
3200 Sencore Dr.,
Sioux Falls, S.D. 57107.
(Anton Grzempa).
Phone (605) 339-0100.

Siemens Corp.,
186 Wood Avenue South,
Iselin, N. J. 08830.
(Herbert Lambrechts, prod. mgr).
Phone (201) 494-1000.

Simpson Electric Co.,
5200 W. Kinzie St.,
Chicago, Ill. 60644.
(Mel Buehring, sales manager).
Phone (312) 379-1121.

Systron-Donner Corp.,
888 Galindo St.,
Concord, Calif. 94520
(Jerry Hartman, product manager).
Phone (415) 682-6161.

Tektronix, Inc.,
P.O. Box 500.
Beaverton, Ore. 97005.
(Lew Loebe, program supervisor).
Phone (503) 644-0161.

Triplett Corp.,
286 Harmon Rd.,
Bluffton, Ohio 45817.
(Stanley Naylor, assistant advertising manager).
Phone (419) 358-5015.

United Systems Corp.,
918 Woodley Rd.,
Dayton, Ohio 45401.
(Fred Pummill, marketing mgr.).
Phone (513) 254-6251.

Vu-Data Corp.,
7595 Convoy Ct.,
San Diego, Calif. 92111.
(William Krause, V.P. of marketing).
Phone (714) 279-6572.

Wavetek,
9045 Balboa Ave.,
San Diego, Calif. 92123.
(Thomas Kurtz, inst. sales mgr.).
Phone (714) 279-2200.

Weston Instruments, Inc.,
614 Frelinghuysen Ave.,
Newark, N. J. 07114.
(Jack Stegenga, prod. mkt. mgr.).
Phone (201) 243-4700.

Wiltron Co.,
930 E. Meadow Dr.,
Palo Alto, Calif. 94303.
(Wally Oliver).
Phone (415) 321-7428.

Adar Associates, Inc.
85 Bolton Street, Cambridge, MA 02140

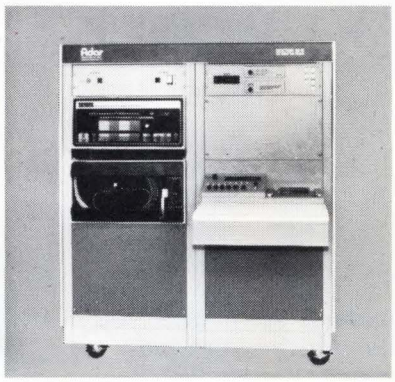
Gentlemen:
Please send me details on ☐ Dr. 12 ☐ Dr. 32-II ☐ Dr. 64 ☐ Look, while you're at it, tell me about the whole series.

NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ STATE_____ ZIP_____
A3

THE DOCTORS.

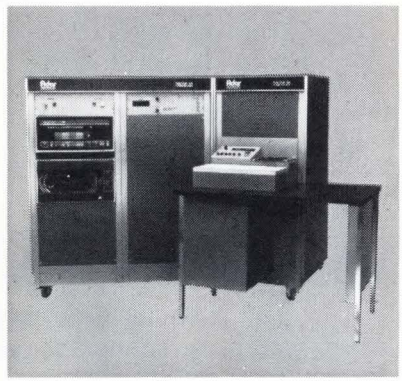
Doctor 12.

The smallest and newest in the Doctor series provides the most complete functional testing available. Dr. 12 tests core memories for mini and maxi computers, semi-conductor add-on memories, memory cards, Shift Register memories, ROM's and RAM's. Up to 72 bits wide and down to 125 nanoseconds. Test programs are activated via a CRT-keyboard link. That means flexibility. But it means about half what you'd expect to pay. Send for more facts.



Doctor 32-II

Doctor 32 was the first of our Doctor series. More of them have been sold than any other computer-controlled, high speed functional test system in existence. And the most important customer requested options have been incorporated into the new -II configuration. Doctor 32-II tests 95% of all digital IC's. And it does it functionally, parametrically, and dynamically. Dr. 32-II has a highly refined software package which includes data logging, automatic device characterization, and schmoo plotting. Send for more facts.



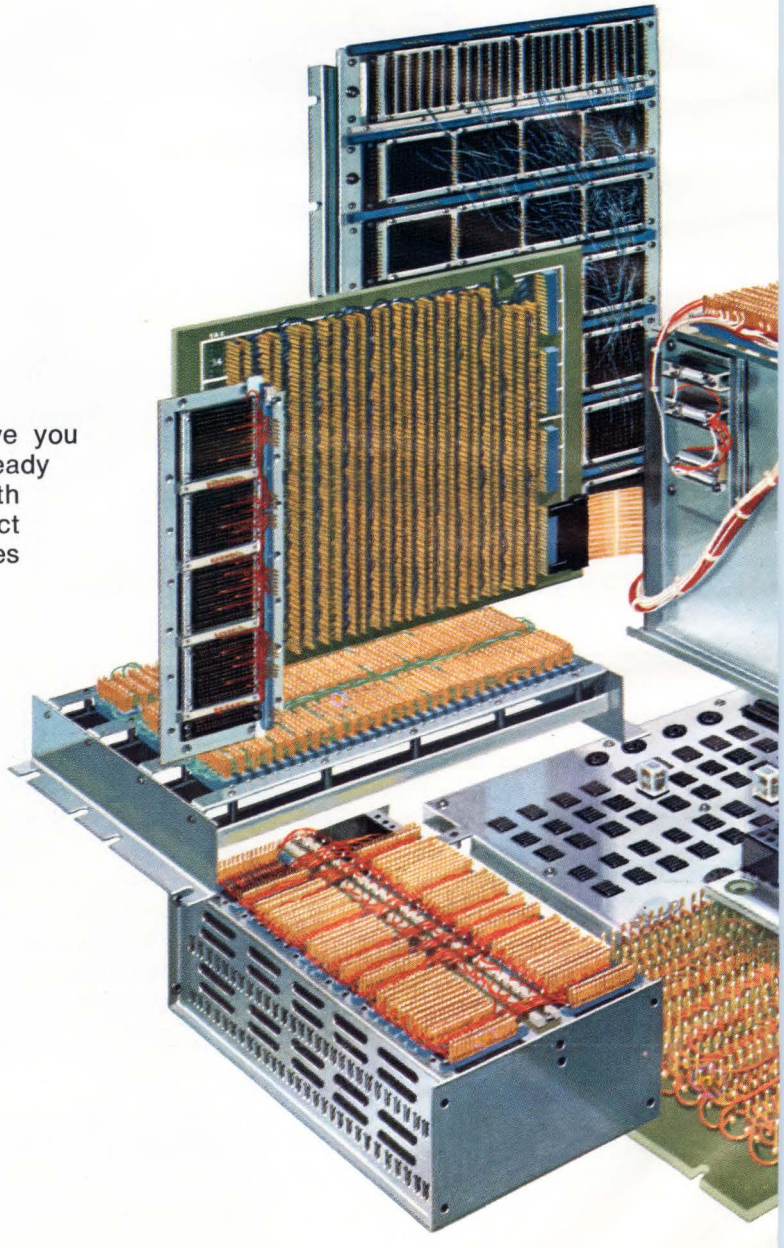
Doctor 64.

This is the big one. It tests everything. SSI, MSI, LSI, MOS, Bipolar, Hybrid, ROM's, RAM's, Shift Registers, Logic Arrays. Dr. 64 tests functionally, parametrically and dynamically. It does all of today's testing, and most of tomorrow's as well. Dr. 64 is the most cost effective system available. It does production testing, device characterization, engineering evaluation, incoming inspection. Everything. Send for more facts. Or call.

Adar Associates, Inc.

85 Bolton Street, Cambridge, MA 02140, Call Fran Bigda collect: (617) 492-7110
See a Doctor at WESCON, Convention Center, Los Angeles. Adar's booths are 1911 & 1912.

We can m
any panel



Wired or unwired.

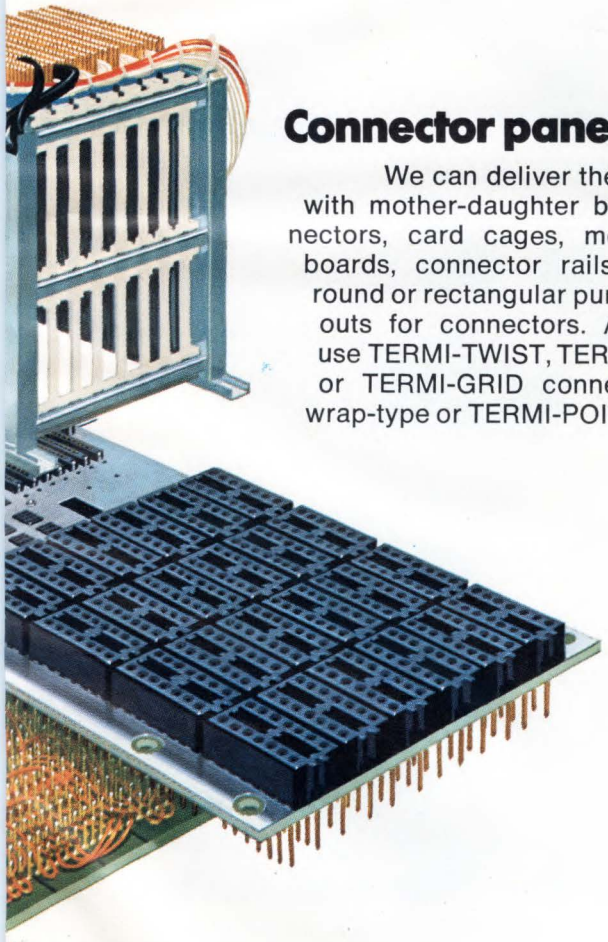
Just give us your parameters. We'll give you *assembled* IC or connector panels, prewired or ready for you to wire—by hand or machine. Panels with the kind of built-in reliability you've come to expect from AMP. With pricetags and turnaround times you absolutely can't afford to pass up.

Here are a few of the things in our bag.

IC panels.

We'll build anything you need in custom panels. Single-, double-, or multilayer. Complete with IC receptacle packaging, feed-through posts, miniature spring sockets, or DIP headers. Or, if it's standard panels you need, we'll supply them, too. With 30, 60, 90, or 120 DIPS per panel. We can prewire both types of panel. Or supply them ready for wrap-type or TERMI-POINT machine wiring.

ake you need.



Connector panels.

We can deliver these panels with mother-daughter board connectors, card cages, metal plugboards, connector rails, or with round or rectangular punched cutouts for connectors. All panels use TERMI-TWIST, TERMI-PLATE or TERMI-GRID connectors for wrap-type or TERMI-POINT wiring.

Full-range capability.

When you buy an assembled panel from AMP, you get more than just another source of supply. You get a quality product. Quality that begins with computer-generated artwork which provides the most efficient utilization of precious panel area. Manufacturing techniques like selective solder predeposition that assures highly reliable board-to-receptacle connections and leaves posts clean and solder-free for wrap-type or TERMI-POINT clip wiring. And a 100% quality check that relieves you of the burden of incoming inspection.

Want to know how we're able to make any panel you need? Write on your company letterhead for our Panel Packaging Kit. It contains full documentation of our various processes, with suggestions of how they can work best for you. **AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105.**

AMP
INCORPORATED

Manufacturing and direct sales facilities worldwide: Barcelona, Brussels, Buenos Aires, Frankfurt, London, Mexico City, Paris, Puerto Rico, Sao Paulo, s'Hertogenbosch (Holland), Sydney, Stockholm, Tokyo, Toronto, Turin, Vienna.

CHECK NO. 20

Rolland Smith of Signetics Corp. speaks out

on the decision to make or buy ICs

Many companies today are considering making their own ICs in-house, as aerospace firms did 10 years ago. A new factor indicates that this is an ill advised course.

Many manufacturers today are in danger of making a disastrous mistake which could cost them the loss of many millions of dollars. These firms are now considering the manufacture of integrated circuits with in-house facilities, and the results could clearly be as ruinous as those that drove Viatron Computer Systems Corp. into Chapter 11. Viatron invested several million dollars to produce MOS devices for use in the company's computer terminals, but the task was far greater than they were able to foresee. This article will explore some of the fallacies of which companies should be aware when deciding whether to make or buy.

Experience curve effect says no

The make-or-buy decision should take into consideration a factor known as the Experience Curve Effect which clearly indicates that manufacturers of data processing and consumer equipment, among others, are in danger of repeating the subtle but disastrous errors made by aerospace firms ten years ago. Defined by the Boston Consulting Group, the effect is different from "learning curves" and "progress functions." It encompasses all costs—including capital, administrative, research and marketing—and traces them through technological displacement and product evolution. The effect can explain price and competitive behavior in segments of the electronics industry which are growing extremely fast, and it provides a reasonable explanation of consequences which otherwise appear chaotic. Applied to the integrated circuit industry, the experience curve effect clearly shows that unless a producer has a substantial portion of the total IC market, it is economically unfeasible to enter into the manufacture of integrated circuits.

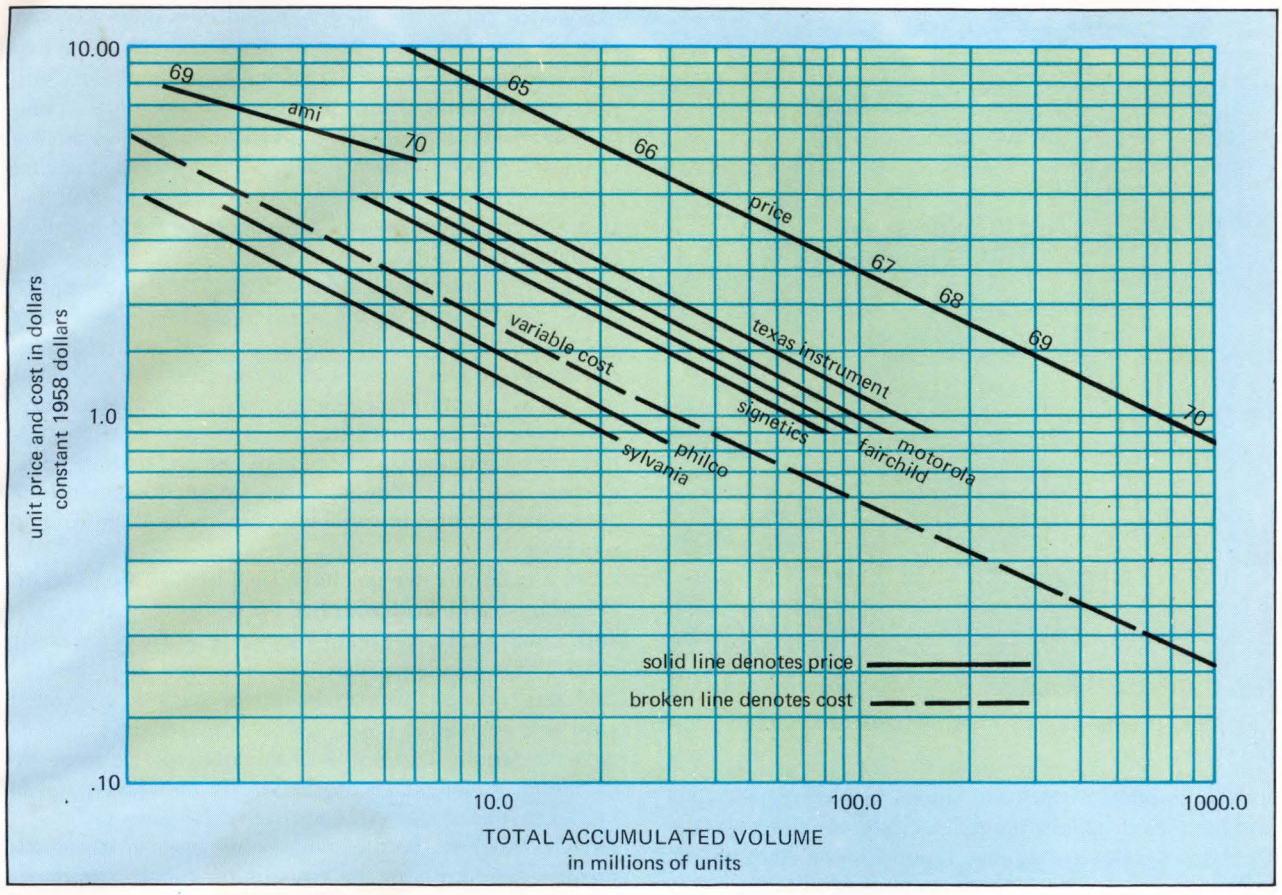
The present enviornment in the integrated circuit industry, especially in the area of MOS memory technology is deceptive and falsely tends to invite users to manufacture their own IC components. The MOS memory sector of the IC industry is still in the developmental phase; prices appear high and no producer dominates the market. Thus, a manufacturer of EDP equipment could easily misread industry conditions and attempt to enter the field. However, in-house operations are always the first to close shop when their technology matures. The reason for this is that prices and unit costs decrease markedly when a popular new technology shifts from a developmental phase to a state of volume production. For each cumulative doubling of unit volume, cost and price drop 25 to 30 percent. Consequently, in-house manufacturing becomes increasingly more costly because of lower volume, as compared with large commercial producers thus causing the in-house plants to fall behind technologically as well as financially.

Aerospace IC facilities—a disaster

Several precedents were set during the decade of the 1960's which should warn equipment manufacturers away from making their own ICs. In 1963, bipolar ICs emerged from their developmental phase as a stable, standard technology. Several users of the devices, including large manufacturers of military aerospace systems, were enticed into production of integrated circuits in-house. The aerospace industry appeared to be in a favorable situation to establish in-house facilities because high-reliability aspects of these devices tended to sustain average selling prices over a long period of time.

When the technology was in the developmental stage,

"The make-or-buy decision should take into consideration the Experience Curve Effect."



average selling prices were close to twenty dollars. The aerospace firms surmised that they could make the same units for about one dollar each, although they realized that they would first have to go through the same "learning curve" cycle that merchant producers had already completed. Consequently, the in-house facilities were producing ICs at a cost close to twenty dollars apiece while the merchant manufacturers were able to build the same devices for less than one-fourth as much. By the time the in-house plants finished the learning curve cycle and brought their costs down, the merchant companies were manufacturing at such a high volume that the others could never hope to catch up.

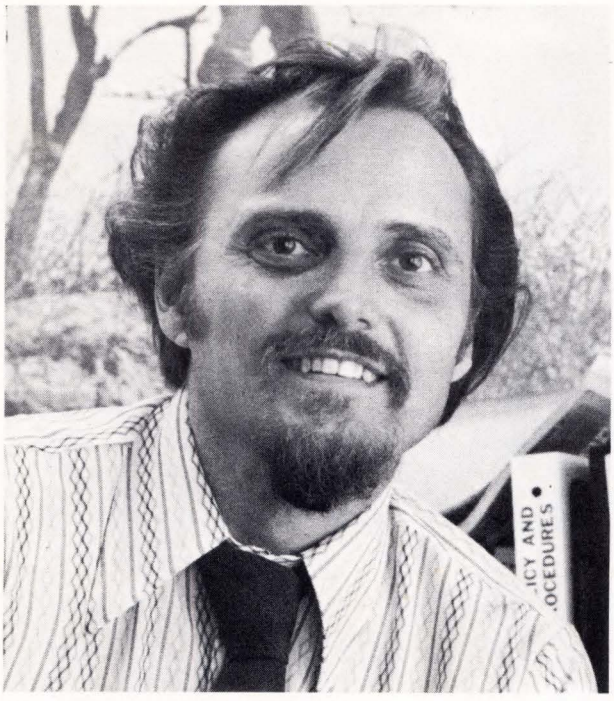
In the developmental phase of the bipolar IC processes, initial yields were so low that there was a tendency to develop tremendous capacity in an effort to produce enough usable circuits to assemble and package. Subsequent increase in fabrication efficiency increased the yields so much that any one of the in-house plants could have supplied the needs of the entire aerospace industry. At that point, it became obvious that the cost of producing bipolars would always be much greater than prices on the open market, so the aerospace firms closed their IC facilities. Many firms, including Lockheed and United Technology Corp., found themselves with large amounts of extremely expensive, obsolete equipment, much of which had never been used. The aerospace industry began IC production as early as 1961, and by 1965 some companies were still establishing IC production facilities. But, by 1967 they had all abandoned the field to merchant companies. It was obvious that they had blundered.

The same environment exists in the MOS field today. And when the cost-price break occurs, the rate of change will be much higher than the rate experienced in the bipolar field because of some related experience to bipolars. A largely deceptive element in MOS revenue forecasts today involves the different ways in which companies view average selling prices of the future. Those who see them as not going down very rapidly forecast a very high revenue, but those who are being more realistic forecast modest revenues. The experience curve effect provides some rationale for predicting future behavior of this segment of the IC industry. It indicates that future prices will reflect the change in the cost experiences of the manufacturer. Those with larger shares of the market will tend to have lower costs. Once leaders become prominent in the marketplace, they will retain their supremacy—unless they make a major error—because they will be able to produce a great quantity of goods more efficiently than others—and at a lower price.

Experience curves show historical trends

The experience curve of **Fig. 1** shows the relative past performance of the major producers and a few of the former producers of bipolar ICs. Companies which produce only MOS devices are represented by one typical company (AMI).

Note the shallow slope and low volume that places them in a unique if temporary position. As soon as MOS competition volume grows, the slope will drop sharply to the same rate as the bipolar technologies, and unless the specialized merchant producers have diversified into the



"By 1967 it was obvious that the aerospace industry had blundered."

standard product market and bipolar technology, they will find themselves rapidly approaching the variable cost line. Similarly, in-house or captive production facilities will be unable to achieve the volume to sustain unit cost below the open market price.

The present environment is deceiving and tends to invite newcomers to manufacturing, particularly in the MOS memory technology. This sector is still in the developmental phase and no merchant producer dominates the market in terms of standard product volume. However, experience shows that the price and cost slope tends to steepen with the onslaught of the production phase. When a technology matures the rate increases until cost and price are dropping 25 to 30% for each doubling of unit volume. When that occurs, the first to close shop are the in-house captive producers. Philco and Sylvania struggled to achieve the volume needed to cross over the variable cost line but failed, as will other merchant and in-house producers.

Tektronix and Hewlett-Packard, unlike the aerospace firms, correctly assessed the situation and began producing circuits which they could not obtain from the large producers. Even after an exhausting search of the merchant market as a source, production was begun reluctantly. Their in-house capability is a developmental function, performing system, logic and circuit design and a limited production of custom circuits. They make no pretense of competing in terms of variable cost with the large volume producers.

For a computer manufacturer, such as IBM, the in-house decision is valid. With over half the computer market, IBM will certainly realize an efficiency of scale equal to or greater than the large merchant producers; but even so, IBM uses multiple sources to reduce the risk associated with sole-source, in-house production. Multiple sources typically require 25 to 50% of the total volume to be attracted to produce a custom circuit. For the small in-house producer, this drives costs up further because volume is diluted. Multi-source merchant producers can frequently manufacture far below the costs of the in-house producer because they obtain an efficiency of scale from large volume. It is merely a matter of time before the multiple source merchant producers are called upon to supply 75% of the units, and eventually they will supply them all.

Let's explore some assumptions

In an environment of a rapidly growing market, it is im-

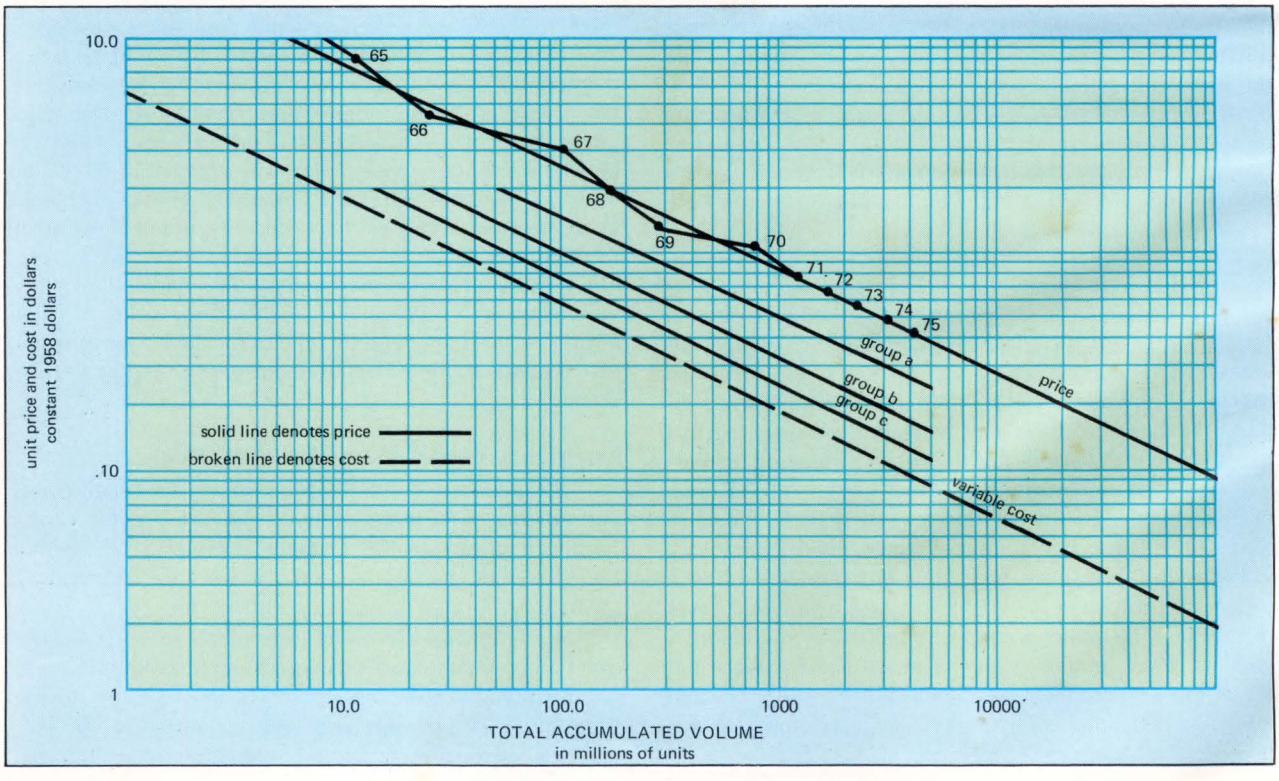


Table I – Typical Income Statements for IC Industry in 1975 for 3 Classes of Producers Derived Using Experience Curves

	GROUP A over 150 million units				GROUP B 100-150 million units				GROUP C less than 100 million units				INDUSTRY TOTAL	
	Total units	Variable cost/ unit	$10^6	% Sales	Total units	Variable cost/ unit	$10^6	% Sales	Total units	Variable cost/ unit	$10^6	% Sales		%
Total units (MM)	660.0				346.0				76.0				1081.0	
Net sales			429.0				225.0				49.4		703.4	
Cost of goods sold		.22	145.2			.34	117.6			.45	34.2		297.0	42
Variable margin			283.8	66.0			107.4	47.7			15.2	30.8	406.4	58
Fixed costs			150.0				83.3				19.7		253.0	36
Gross margin			133.0	31.0			23.7	10.6			(4.6)	(9.3)	153.0	22
G & A			85.8				49.5				11.9		151.5	22
Net profit before taxes			47.2	11.0			(25.8)	(11.0)			(16.5)	(33.0)	1.5	2.1
Net profit after taxes			23.6	5.5									0.8	1.0

Typical balance sheet

Assets (10^6)			Liabilities (10^6)	
Total current assets		58.4	Total Current Liabilities	19.5
Plant & Equipment	27.9		Capitalization	52.0
less Depr.	14.9			
		13.1		
Total Assets		71.5	Total Liabilities	71.5

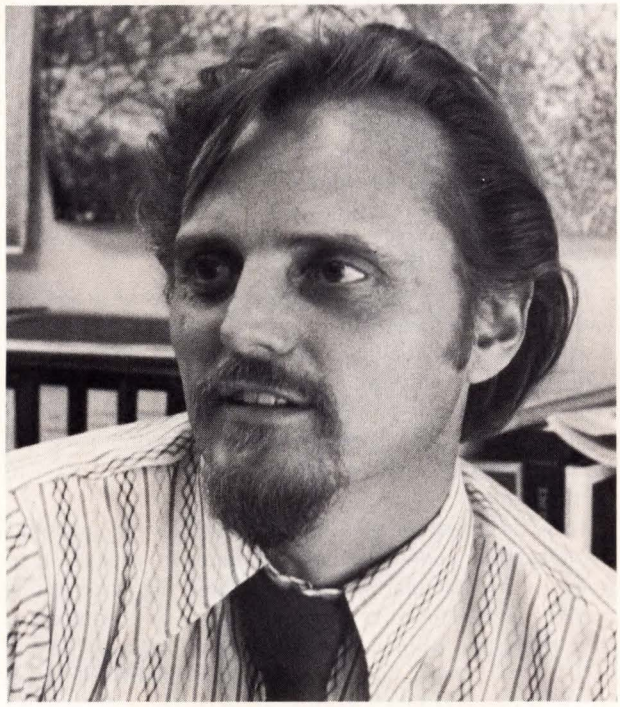
portant that a company maintain its market share and increase it if possible. In fact, penetration is initially more important than profit. This means that an in-house producer, which essentially is a small manufacturer, will not be able to compete because it will not be possible to make integrated circuits any cheaper than they could be purchased outside the company. The assumptions about competitive in-house production capabilities are invalid because such operations do not have the efficiency of scale. Small facilities cannot afford to buy multi-million dollar machines to make hundreds of millions of units an hour because the company would not need such quantities in a year.

There are several assumptions, all fallacious, that lead an in-house producer to believe that he can manufacture ICs at a lower cost.

Marketing: The first assumption is that marketing costs and processor's profit are eliminated. However, in fact, much of the cost of marketing is incurred by functions that are performed in both the in-house and merchant producer operations. Differing only in name, these functions include: quality control, reliability, specification control, specification development, product development, warehousing, shipping and distribution. Perhaps the only functions the in-house producer does not have are sales and advertising, but these covertly exist and represent a true expense.

How much does marketing cost and what part of these costs are attributed to sales and advertising? Even if they could be eliminated, the cost of sales and advertising in a highly technological product area are relatively insignificant compared to the other costs incurred by the in-house and merchant producer alike. When the merchant producer allocates the two costs over his volume, they represent about 2% of the unit price.

Design control: Another fallacious assumption is that the in-house producer can maintain better control of proprietary designs. However, control becomes academic after a second source is brought in to provide back-up for the in-house facility. Multiple sourcing requires complete divulgence of the circuit design, masks, fabrication procedures, testing, specifications and everything else there is to know about the circuit. Secondly, the art and engineering of copying an integrated circuit is very refined.



"If a company is a small equipment manufacturer, the decision to produce in-house can be not only costly but disastrous."

Design latitude: The in-house producer only appears to have more latitude in designing circuits and in optimizing them in terms of pin configurations, packages and specifications. Actually, this latitude is exactly the kind of thing which increases in-house costs. Invariably, a great effort is directed toward packaging the circuit. Complex package designs usually evolve that are optimized for the particular system in which they are to be used. Custom lead frames and package material usually drive the in-house producer to the small custom package parts supplier at best, or at worst, result in an in-house production center. In either case, the cost sky-rockets to a point close to that of the merchants' open-market prices.

Joining the merchant market: The in-house producer appears to be capable of entering the open market at any time to increase volume and achieve an efficiency of scale, but this would be fatal. For conversion, the in-house producer would need an appropriate sales and advertising staff, and must re-organize other functions into a marketing team. In the case of the aerospace industry, the experiments lasted one painful year. Today, the in-house producer would still find that market penetration takes more in capital and expertise than he would be willing to expend.

Return-on-investment: It is absurd to believe that the in-house producer can earn back the return on investment before the facilities become obsolete. The large integrated circuit merchants are successful at this because they can produce quantities of units fast enough to realize a return on their capital equipment before the machines become technologically obsolete. Very seldom does the in-house producer achieve the unit volume needed to justify the capital expenditures associated with an IC fabrication facility. Technological changes come very fast, and machine efficiency is improved by orders of magnitude every few years. Unless a producer is manufacturing tens of millions of circuits annually, he will not be competitive.

Superior skills: The in-house producer may appear to be in a superior position because of technological skills or patent positions, but this is only academic in value. Superior skills have a way of turning over and migrating to competition, especially in the IC industry. Technological superiority is only good for a short time. If the in-house producer has not reached the unit volume needed to reduce costs by the end of that time, the game is lost.

A projection of the future

In the merchant market, competition is very strong because each producer knows that maximum revenue production and profitability are a function of unit volume. Basically, there are two technologies that differ only in processing: bipolar and MOS. Any manufacturer with a typical mix of products made with these technologies will have to produce in excess of 150 million units in 1975 to be profitable.

This year there are very successful, relatively smaller IC manufacturers generating large revenues in selected technologies, in particular in MOS; but those highly profitable markets are on the verge of drying up and can be expected to fall into line with such mature technologies as TTL and DTL by 1975. Manufacturers who fail to offer a full line of technologies will find it hard to survive. The variable cost per circuit for all technologies in 1975 will be $0.21 per unit. Large merchant producers—T.I., Motorola, Fairchild, Signetics and National—will experience a revenue of over $100 million, and each will sell over 150 million circuits at an average price of $0.65. Manufacturers with sales between 100-150 million units will be struggling to remain profitable. Those with production under 100 million units will be losing money and closing shop, whether merchant or captive in-house manufacturer.

In 1970, large producers typically reported a 1 to 2% net income as a percent of sales and 2 to 4% net income as a percent of capital investment. These statistics are not very encouraging, especially when compared with the steel industry which reported 6 to 8% return on investment; or all manufacturing which reported 8 to 12%. Capital investment typically runs 30 to 40% of annual sales in the IC industry for items that include equipment and inventories.

By 1975, the producers will be divisible into three broad categories based on unit volume: winners, strugglers and losers. The winners, represented as Group A in Table 1 will produce over 150 million units per year at an average selling price of $0.65. The strugglers, shown as Group B, will produce between 100-150 million units per year and the losers, Group C, will produce less than 100 million units per year.

An income statement can be developed for each group. For 1975 we forecast 1081 million units will be shipped at an average selling price of $0.65 and will produce $703

Some background

This article began as an in-house report to Signetics management. The corporate staff requested Rolland Smith, Manager of Market Research, to analyze the effects that would be caused if original equipment manufacturers were to build their own integrated circuits with in-house facilities. In making his initial study of the leading EDP equipment manufacturers, Smith applied a new tool: the Experience Curve Effect. This effect comes closer to bringing order out of chaos than does the older Learning Curve Effect. The result of Smith's study was that almost anyone, especially the OEMs, who try to compete with the IC industry's commercial manufacturers will fall on economic terms. After submitting his report, Smith felt motivated to author an article for publication.

"Having lived through the aerospace industry's flirtation with in-house IC production," Smith said, "and having seen many fine companies and people adversely affected, I was prompted to express my views concerning these pitfalls when the EDP manufacturers expressed their intent to produce IC memories in-house. "It's now apparent he added, that the consumer equipment manufacturer is contemplating a make-or-buy decision. Each generation of high-volume producers—aerospace, commercial equipment, and consumer electronics—it tempted to repeat old mistakes. If the present generation of equipment manufacturers can be spared the cost and frustration associated with an in-house IC production facility, then a valuable service will have been performed for the electronics industry."

million in revenue.

From the experience curve (**Fig. 21**), a variable cost for each of the groups for 1975 can be derived. These are the costs directly associated with the manufacture of circuits. Group A, variable cost will be $0.15 in constant 1958 dollars per unit; assuming an inflation rate of 1.44 for 1975, variable cost in actual dollars will be $0.21. For Group B, variable cost will be $0.35, and Group C variable cost will be $0.45.

Fixed cost will be approximately 35% to 40% of sales and will include plant and equipment depreciation and other items indirectly related to the production of circuits. Further, fixed costs will represent a larger percentage of sales for the small producers.

General administration costs will be approximately 17.0% of sales for Group A, 18.0% of sales for Group B, and 19.0% of sales for Group C.

What of the fourth producer; the in-house captive IC manufacturer? Exclusive of IBM, in-house IC operations will manufacture less than 100 million circuits per year by 1975 under conditions very similar to those of Group C. The equivalent selling price of ICs produced by in-house facilities would be approximately $0.77 per unit, provided the facility has been operational long enough to have the fabrication process under control and is experiencing yields typical of producers with less than 100 million units per year. The composite of these small in-house producers will probably manufacture 100 million units at $0.65.

Had these same in-house users purchased these circuits on the open merchant market, they would have paid $65 million dollars rather than the $77 million it actually cost them. Working capital would not have been tied up in equipment and overhead. Instead of a loss on their investment, they could have realized 6 to 10% return in a more lucrative activity.

If a company is a small equipment manufacturer, the decision to produce in-house can be not only costly but disastrous. In more specific terms, what are the factors which will drive the in-house producer's variable costs to $0.45 per unit? Because of his limited volume, the in-house producer will not be justified in mechanization of his fabrication, assembly and test areas. The result is a labor intensive operation. All in-house circuits will probably be produced domestically or by subcontract, resulting in effective labor rates much higher than the rates which larger merchant producers experience in Asia. The real test to the small producer will occur when he is required to manufacture and ship 16,000 units and produce $10.5k revenue per employee. Fairchild Camera and Instrument reported $10.8k sales per employee in 1970. The median for all industries was about $20k of sales per employee. Clearly the in-house captive producer will have to assemble off-shore to be able to compete or automate at a substantial capital equipment outlay. □

Bibliography

"Experience Curves," Boston Consultant Group, Boston, Mass. 1969.

"Steel Companies Improve Profit," *San Jose Mercury*, April 28, 1971, p. 36.

"They said it couldn't be done but Viatron did it with dispatch," *Wall Street Journal*, April 30, 1971, p. 1.

"The 500 Largest Corporations," *Fortune* magazine, May, 1970, p. 202.

Who is Rolland F. Smith?

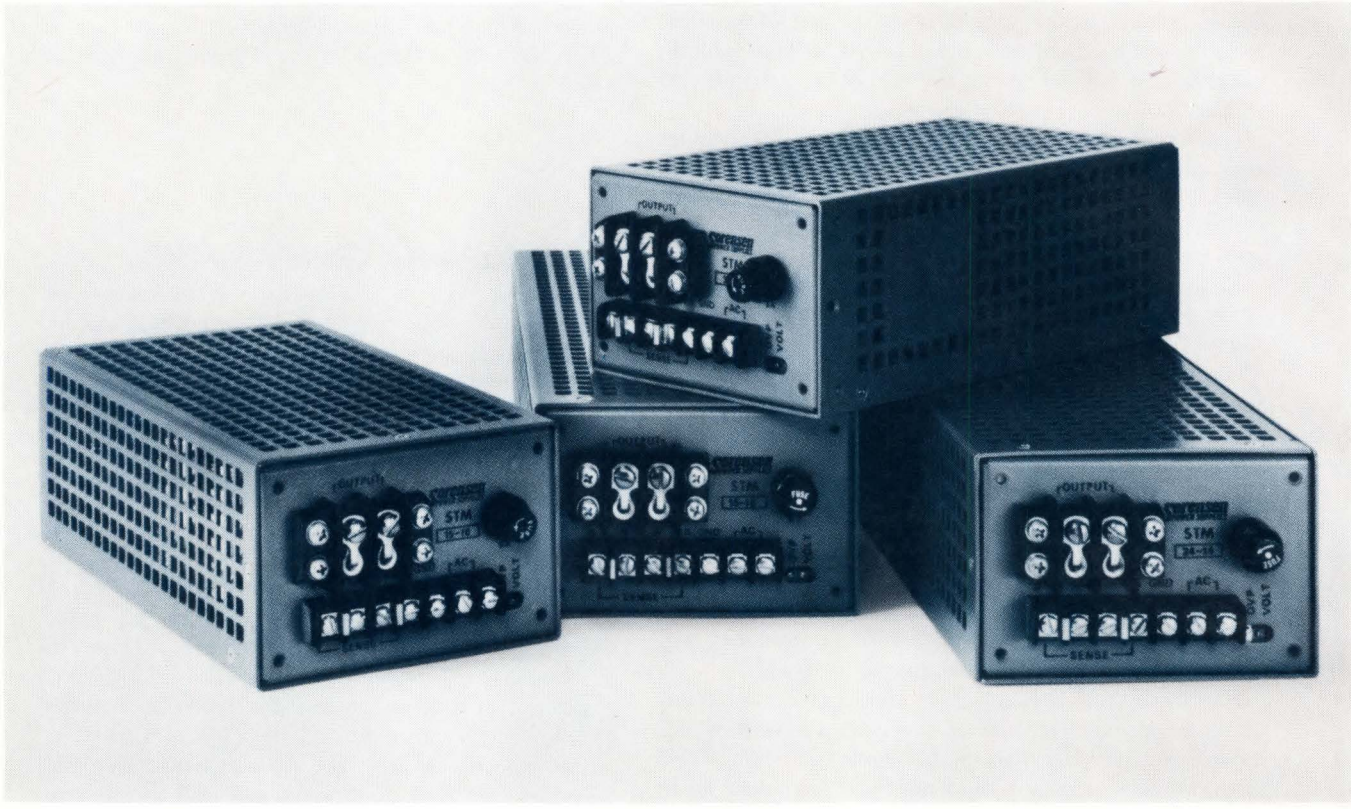
Rolland F. Smith is Director of Market Research and Planning for Signetics Corp., a position that he has held for the past five years. An economic forecaster, Rolland keeps tabs on the condition of the electronics industry and how changes in various economic factors affect Signetics and the company's markets. He analyzes the competitive abilities of other companies and prepares long-range forecasts of the integrated circuit industry for use by market strategists.

Comparison of events with Mr. Smith's forecasts attests to the accuracy of his work. He has never been wrong. In 1968, a period which elated many IC manufacturers, he read signs of gloom among many positive business indicators. He predicted that the following year would be a time of great instability in the industry. He warned that yields would plummet but that the marketplace would not be affected immediately because buyers would double and triple order to gain leverage with supplies. In addition, he pointed out that full impact would be felt in 1970 and 1971, when excess capacity would grow along with booking rates, resulting in severe price cutting in the industry. He also forewarned that it would be a period of lay-offs and that market strategy would have to be built around survival and growth rather than profit. All has come to pass.

A native of Elizabeth, New Jersey, Mr. Smith is a graduate of the Institute of Advanced Technology in New York City, and he studied business administration and applied economics at Portland State College. He began his career as a design engineer with the New Jersey Communications Corp., where he was given project responsibility. After four years, he moved west and joined Tektronix, Inc., in Portland, Ore., where he took charge of a marketing group. Nine years later he joined Signetics Corp. in Sunnyvale, Calif.

Rolland and Judith, his wife, reside with their two-year-old son in Sunnyvale, Calif.

STM. Not just



Sorensen's new modular DC power supplies give you twice the efficiency, half the size, for equivalent power ratings.

- **Efficiencies as high as 75%.**
- **Unequalled power outputs — standard package sizes.**
- **Low heat dissipation — eliminates external cooling.**
- **Excellent performance — check the specs.**
- **Built-in overvoltage protection — all units.**
- **Computer optimized filtering — superior RFI and noise performance.**
- **20 models now available — 20 more to come.**

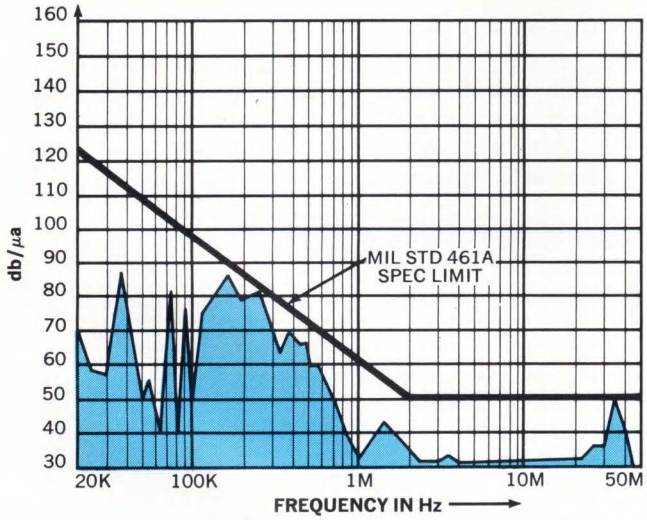
Compared with competitive series-pass power supplies, Sorensen's STM switching-transistor power supplies provide unequalled space and money-saving benefits. And, unlike competitive units, STM power supplies offer overvoltage protection as a standard rather than an optional extra-cost feature.

Sorensen STM's are backed by our world-wide reputation for excellence. For more information write Sorensen Company, a unit of the Raytheon Company, 676 Island Pond Road, Manchester, New Hampshire 03103. Telephone (603) 668-1600. Or, TWX 710-220-1339.

another black box.

Package Size: Module III – 3-5/16″ x 5-1/8″ x 9-1/2″ – Weight: 6.5 lbs.														
	OUTPUT VOLTAGE Set Range		OUTPUT CURRENT (Adc)*				VOLTAGE REGULATION (comb. line and load)	RIPPLE	INPUT POWER					
									AC			DC		
Model	min.	max.	40°C	50°C	60°C	71°C		rms p-p**	Volts	Amps at 115 V	Freq. (Hz)	Volts	Amps at 150 Vdc	Price†
STM3.5-24	3.0	4.5	24	19.4	14.9	9.6	.05%	5 mv 50 mv	105-132	1.8	50-440	150±15%	1.5	$229
STM5-24	4.5	6.0	24	19.4	14.9	9.6	.05%	5 mv 50 mv	105-132	2.3	50-440	150±15%	1.5	229
STM9-12	6.0	10	12	9.7	7.5	4.8	.05%	3 mv 50 mv	105-132	2.1	50-440	150±15%	1.5	239
STM12-12	9.5	13.5	12	9.7	7.5	4.8	.05%	3 mv 50 mv	105-132	2.9	50-440	150±15%	1.5	249
STM15-10	13	17	10	8.1	6.2	4.0	.05%	3 mv 50 mv	105-132	2.7	50-440	150±15%	1.8	239
STM18-10	16	20	10	8.1	6.2	4.0	.05%	3 mv 50 mv	105-132	3.2	50-440	150±15%	1.8	249
STM24-8.5	19	25	8.5	6.8	5.3	3.4	.05%	3 mv 50 mv	105-132	3.3	50-440	150±15%	1.9	249
STM28-7	24	30	7.0	5.6	4.3	2.8	.05%	3 mv 50 mv	105-132	3.2	50-440	150±15%	1.9	249
STM36-4	29	43	4.0	3.2	2.5	1.6	.05%	3 mv 50 mv	105-132	4.0	50-440	150±15%	1.9	259
STM48-4	42	56	4.0	3.2	2.5	1.6	.05%	3 mv 50 mv	105-132	4.0	50-440	150±15%	1.9	269
Package Size: Module IV – 3-5/16″ x 5-1/8″ x 14″ – Weight: 9.0 lbs.														
STM3.5-36	3.0	4.5	36	29.1	22.3	14.4	.05%	5 mv 50 mv	105-132	3.8	50-440	150±15%	2.2	319
STM5-36	4.5	6.0	36	29.1	22.3	14.4	.05%	5 mv 50 mv	105-132	4.2	50-440	150±15%	2.5	324
STM9-20	6.0	10	20	16.2	12.4	8.0	.05%	3 mv 50 mv	105-132	3.8	50-440	150±15%	2.2	299
STM12-20	9.5	13.5	20	16.2	12.4	8.0	.05%	3 mv 50 mv	105-132	4.8	50-440	150±15%	2.8	289
STM15-15	13	17	15	12.1	9.3	6.0	.05%	3 mv 50 mv	105-132	4.3	50-440	150±15%	2.6	289
STM18-15	16	20	15	12.1	9.3	6.0	.05%	3 mv 50 mv	105-132	5.0	50-440	150±15%	3.0	299
STM24-13	19	25	13	10.5	8.0	5.2	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM28-11	24	30	11	8.9	6.8	4.4	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM36-6	29	43	6.0	4.8	3.7	2.4	.05%	3 mv 50 mv	105-132	4.5	50-440	150±15%	2.6	329
STM48-6	42	56	6.0	4.8	3.7	2.4	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	329

*Free – air rating – no external heatsink **Worst case. Typically less than 30 mv †U.S.A. list prices



DC Load Leads. Conducted Current Level in db above a Microamp/ MHz

Specification	Sorensen STM5-24	Brand "X"
Size	$3\frac{5}{16}$ x $5\frac{1}{8}$ x $9\frac{1}{2}$	$4\frac{15}{16}$ x $7\frac{1}{2}$ x $9\frac{3}{8}$
Volume	160 in^3	344 in^3
Price	$229	$235
Efficiency	58%	29%
Regulation (line & load combined)	0.05%	0.2%
Temperature Coefficient	0.01 %/°C	0.03%/°C
Overload Protection	Current limiting-adjustable electronic	
Overvoltage Protection	Built-in adjustable, all models	Optional @ $30 (except built-in, fixed, on 5-volt model only

Compare this point-by-point spec-check between Sorensen's STM5-24 and Brand "X."

Sorensen POWER SUPPLIES

CHECK NO. 21

Analyze circuits with a phase meter that also measures gain

Whether you're characterizing integrators and differentiators, measuring impedance or checking delay-line parameters, the phase method can come in handy.

Dave Luttropp, Hewlett-Packard

How often have you bemoaned the shortcomings of your test equipment when attempting to solve a circuit problem? Perhaps your test equipment leaves something to be desired. However, before you get hung up on your test equipment, think about your measurement technique. In many cases, a change in technique can spare you the expense of buying better equipment, and as an additional bonus, give you valuable information that better equipment would not provide. A change in technique can be the key to solving many measurement problems at minimum cost. A few examples will illustrate how some traditional measurements can be improved and simplified by using a gain-phase meter; a meter that measures phase and amplitude or gain.

Characterizing integrators and differentiators

The classical method for characterizing an integrator or differentiator is to apply a square-wave input to the circuit and monitor its response on an oscilloscope. This method has severe limitations where accuracy and resolution are required. The size of the oscilloscope face alone limits the resolution of a nonlinearity measurement to 5% and precludes high-accuracy measurements. The square-wave input can also introduce a slew-rate limitation in the circuit under test to produce high-frequency responses that mask low-frequency characteristics of interest.

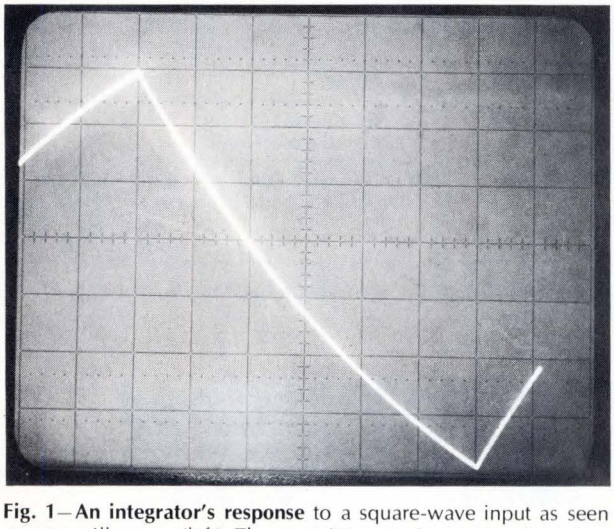
Since there is no such thing as a perfect integrator or differentiator due to physical limits on component values, part of your characterization should tell you how far an integrator or differentiator deviates from perfect performance. It should give a time-constant or a frequency to indicate low or high-frequency cutoffs.

Typically, oscilloscopes can indicate triangle-wave sags of roughly 20% below that of ideal linear traces. Sags of 1% could certainly not be quantified on an oscilloscope to evaluate a waveform for a time-constant or the location of a low-frequency pole. It is clear that the time-domain method of measurement is difficult for good accuracies. The answer is a simple change in technique. Phase measurements can add insight and the additional resolution needed for better measurements.

Theoretically, an integrator shifts a sine-wave input by −90 degrees while a differentiator shifts the same input by +90 degrees. By making a phase measurement, deviations from the theoretical phase-response curve can be easily investigated without calculations of slopes and linearity from oscilloscope measurements.

Another advantage to the phase technique over an oscilloscope is that the latter cannot distinguish between the source of high frequency problems in an integrator. (Is the problem in the integrator itself or is it from the signal source?) Phase measurement eliminates source errors and exposes only integrator problems.

Fig. 1 (right) shows the gain and phase response of an integrator to a sine-wave input. At the low-frequency end, phase is not ideally −90 degrees and the amplitude curve is not rolling off by 6 dB/octave. The oscilloscope trace in **Fig. 1** (left) is the same integrator's response to a square-wave input. Using it to measure the slope to find deviations from the theoretical amplitude response is obviously



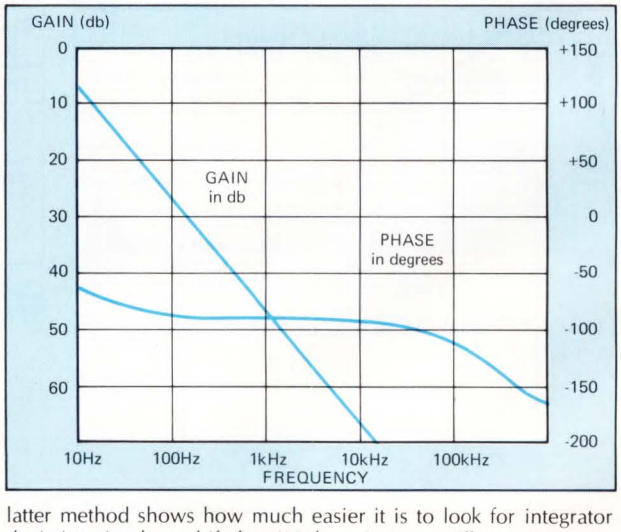


Fig. 1—An integrator's response to a square-wave input as seen on an oscilloscope (left). The same integrator's response to a sine-wave input can be plotted with a gain-phase meter (right). This latter method shows how much easier it is to look for integrator deviations in phase shift than it is by using an oscilloscope.

quite difficult. Two points have to be looked at and calculations are required. The phase method as shown in the response curve is obviously much easier.

For general applications, the response curve allows integrator characterization at a frequency range where phase is within 5 degrees of −90 degrees. Alternatively, the frequency of the integrator pole can be found easily with a single phase measurement. For example, a phase reading of −84.3 degrees automatically tells us that the integrator's stimulation frequency is ten times its pole frequency. At a phase reading of −87.1 degrees, the pole frequency is 1/20th that of the stimulating frequency.

Impedance measurements

Traditional impedance-measuring instruments cannot always accurately measure complex and active-device impedances. Multimeters cannot measure the impedance of active components with dc bias or complex-amplifier input impedance. A vector impedance meter solves the dc bias problem by making an ac measurement and blocking the dc. It also solves the problem of making complex measurements at different frequencies. Because the measurement is tied to the internal oscillator of the impedance meter, it is not possible to accurately measure impedances inside such working circuits as oscillators. It is all too easy for the circuit under test to induce disturbing harmonics into the impedance meter. Here again, a phase-measurement technique can solve this problem (**Fig. 2**).

Low-impedance measurements bring out another shortcoming of conventional impedance meters. For example, it is difficult to measure the 20-mΩ impedance of a ground bus using a conventional impedance meter with a 1Ω fullscale range. This type of measurement can be made, however, with a gain-phase meter, as shown in **Fig. 3**.

As long as R_t is much larger than the unknown impedance, voltage V_a will be directly proportional to the constant current flowing through the unknown resistance and voltage V will vary with the unknown impedance. The voltage ratio of V to V_a will be proportional to the complex impedance. With R_t = 50Ω, a gain rading of −60 dB on the meter corresponds to 50 mΩ, and that of −80 dB to 5 mΩ. All that is needed for calculation is the value of R_t.

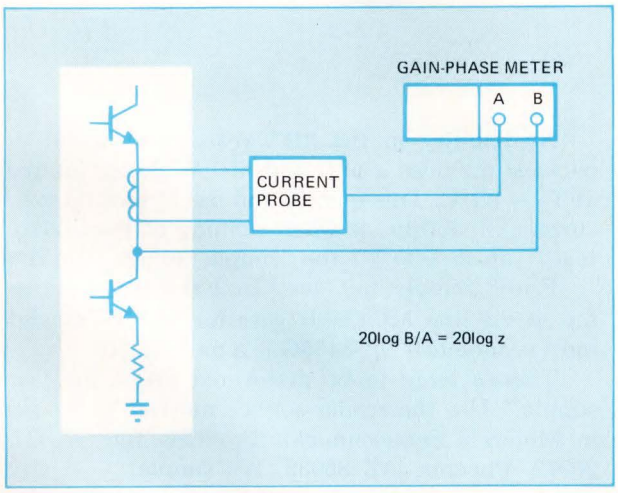


Fig. 2—A gain-phase meter can simplify impedance measurements. Here, a current probe converts current to voltage, allowing the meter to read a circuit's impedance, gain and phase by the use of the relationship 20 log B/A = 20 log Z. The advantage of this setup is that the measurement is independent of any source variations allowing in-circuit measurements.

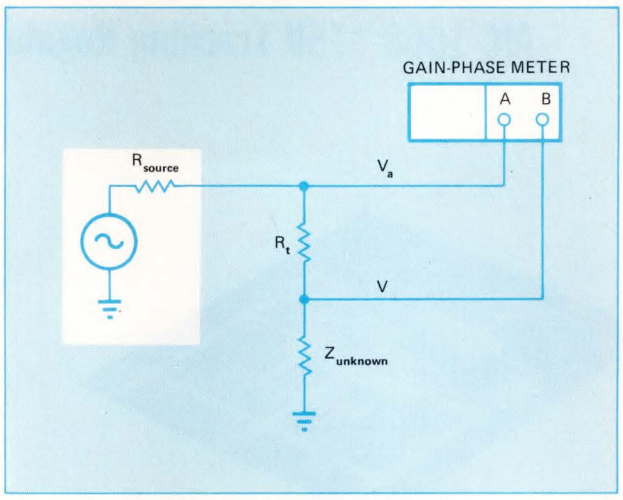


Fig. 3—Low impedances can be measured with a gain-phase meter using this setup. As long as R_t is much larger than the unknown impedance, voltage V_a will be directly proportional to the constant current flowing through the unknown resistance and voltage V will vary with the unknown impedance. The ratio of V to V_a will be proportional to the complex impedance.

Delay-line measurements

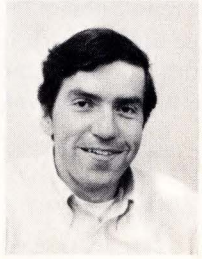
Delay lines present another opportunity for solving problems with a phase-meter method. A common method for measuring delay is to use a time-interval counter or an oscilloscope to measure the time lag between two transition points.

Resolution of any time-interval counter, however, is limited by the counter's internal clock frequency. With a standard 10-MHz clock having a 100-nsec time period, the resolution of one count will be 100 nsec, which is the shortest delay time that can be measured.

A simpler and more accurate way of measuring time delay is to translate phase-meter phase readings into time. For example, a one-degree phase shift in a 2.77-MHz sine wave corresponds to a 1-nsec delay time; and a 100-degree phase shift to a 100-nsec delay time. Phase meters are available with 1/10th of a degree resolution to give 1/10-nsec delay measurements. The usual 5-degree phase-accuracy specification for most phase meters means a 5% specification in time-delay measurements. For longer delays, the accuracy will be as good as 0.5%.

By using a gain-phase meter, gain as well as phase can be measured in a delay line to obtain delay-line loss and time-delay in one measurement. □

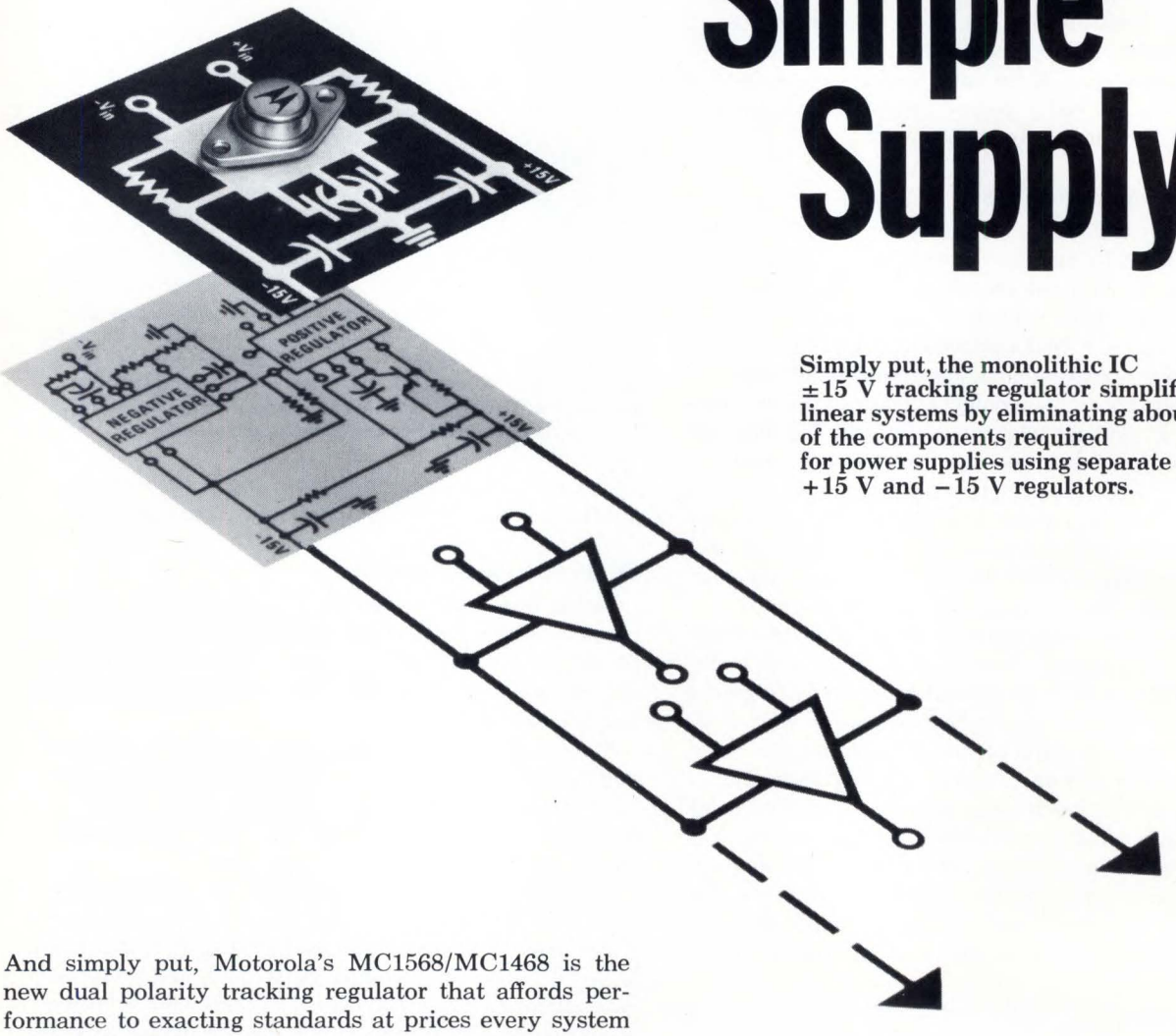
Author's biography



Dave Luttropp is a product engineer at the Loveland Instrument Div. of Hewlett-Packard. He started at the Division as a product designer of digital voltmeters and then transferred to marketing as a product engineer. Dave received a BSEE from the University of Wisconsin and an MBA from Colorado State University.

MC 1568 ±15V Tracking Regulator Is

The Simple Supply



Simply put, the monolithic IC ±15 V tracking regulator simplifies most linear systems by eliminating about 2/3 of the components required for power supplies using separate +15 V and −15 V regulators.

And simply put, Motorola's MC1568/MC1468 is the new dual polarity tracking regulator that affords performance to exacting standards at prices every system can afford. Three package variations to accommodate differing power requirements bring the price/performance combinations to six. Simple to use and simple to choose. The "simple supply."

It's simple to buy, too; off-the-shelf from both the factory and the nationwide network of outstanding franchised Motorola distributors.

A rudimentary characterization of this exciting new regulator includes excellent tracking with output voltages balanced to ±1% output voltage variation due to temperature change held to 1% maximum, and line and load regulation of 0.06%. The balanced outputs are preset to ±15 V with initial tolerance of 0.2 V (max), but output voltages can be changed with a single, simple, external adjustment if desired.

Availability in the "R" (case 614) metal power package provides a unit with 9.0 W power dissipation at $T_C = 25°C$. This permits full use of the 100 mA load current capability, as when running at the higher voltages (up to ±30 V) the "simple supply" can handle.

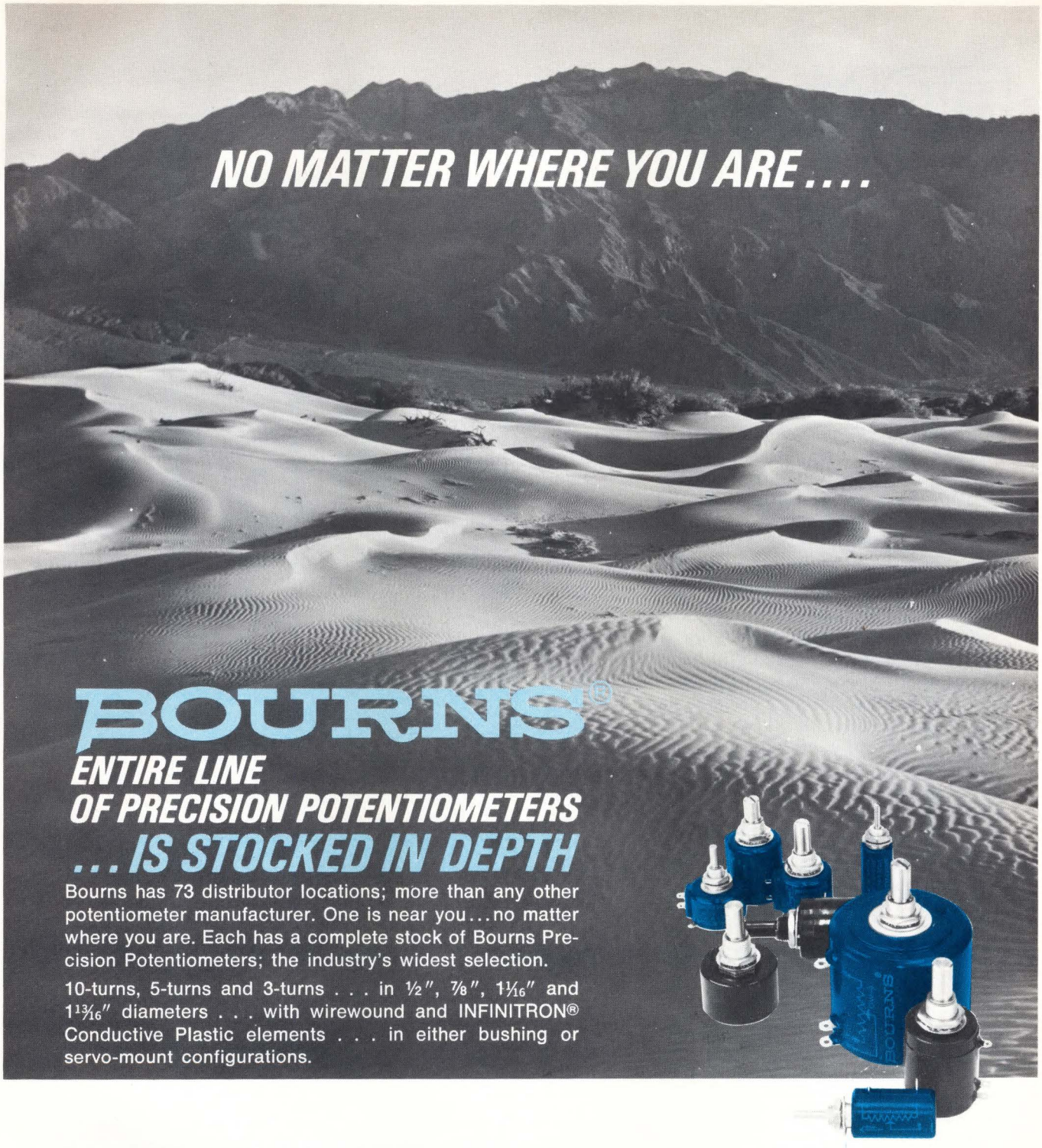
Price? Simply put, low. In 100-999 quantities the top of the line MC1568R goes for just $7.00, and the most economical MC1468G is a mere $2.80.

There's more to be discovered about the "simple supply." Use the reader service number or by writing to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036. It's simple.

MOTOROLA LINEAR

— Serving a greater range of analog designs

CHECK NO. 22



For complete details, or to enter your order, contact your local Bourns distributor, a Bourns sales office, representative or the factory-direct.

BOURNS INC

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

BOURNS DISTRIBUTORS —

ALABAMA/Cramer/E. W. **ARIZONA**/Kierulff Elect. **CALIFORNIA**/Westates Elect. Corp. • Hamilton Electro Sales • Liberty Electronics • Elmar Elec. Inc. • Hamilton/Avnet • Electronic Supply Corp. • Western Radio **COLORADO**/Hamilton/Avnet • Kierulff **CONNECTICUT**/Conn. Electro Sales • Cramer Elect. Inc. **FLORIDA**/Cramer/E. W. • Hamilton/Avnet • Hammond Elect. Inc. **GEORGIA**/Jackson Elect. Co. **ILLINOIS**/Allied Elect. Corp. • Newark Elect. Corp. • Hamilton/Avnet **INDIANA**/Ft. Wayne Elect. Supply Inc. • Graham Elect. Supply Inc. **KANSAS**/Hall-Mark Elect. Inc. **LOUISIANA**/Southern Radio Supply Inc. **MARYLAND**/Cramer/E. W. • Pioneer/Washington Elect. Inc. **MASSACHUSETTS**/Electrical Supply Corp. • Cramer Elect. Inc. **MICHIGAN**/Harvey-Michigan **MINNESOTA**/Lew Bonn Co. • Hamilton/Avnet **MISSISSIPPI**/Ellington Electronic Supply, Inc. **MISSOURI**/Hamilton/Avnet • Hall-Mark Electronics Corp. **NEW JERSEY**/General Radio Supply Co. • Hamilton/Avnet • Eastern Radio Corp. **NEW MEXICO**/Electronic Parts Co. **NEW YORK**/Standard Electronics Inc. • Cramer/Binghamton • Cramer/Esco • Cramer/Eastern • Hamilton/Avnet • Federal Elect. Inc. • Schweber Electronics • Harvey Radio Co. **NORTH CAROLINA**/Cramer/E. W. **OHIO**/Hughes-Peters, Inc. • Pioneer **OKLAHOMA**/Hall-Mark Elect. **PENNSYLVANIA**/Pyttronics • Powell Elect. • Cameradio Co. **RHODE ISLAND**/Wm. Dandreta Co. **TEXAS**/Hall-Mark Elect. Co. • Hamilton/Avnet • Harrison Equip't Co. **UTAH**/Cramer **WASHINGTON**/Liberty Elect. **WISCONSIN**/Taylor Electric Co. **CANADA**/Varatronics • Cesco Elect. • Zentronics Ltd.

CHECK NO. 52

EDN DESIGN AWARDS

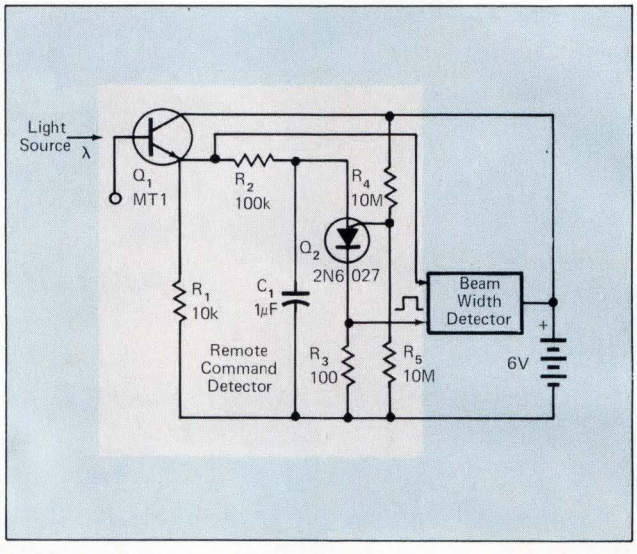
Battery-saving remote-command detector

Peter J. Hof
Battelle-Pacific Northwest Labs., Richland, Wash.

This simple remote command detector requires only 2μW of standby power. It features electrical isolation, excellent noise immunity, CMOS compatibility, and can be hermetically sealed. No physical connection to the outside world is required.

The circuit provides excellent results for remotely controlled equipment requiring a low-command duty cycle. A single 6V battery provides power for both the command detector and the equipment it controls.

Phototransistor Q_1 detects light from an LED or incandescent light source. Light enters the hermetically sealed unit via a light pipe or line-of-sight. Resistor R_1 sets the sensitivity. R_2 and C_1 integrate the input signal to provide noise immunity. R_2 can be as great as 330kΩ and C_1 can be as small as 0.001μf. The PUT (programmable UJT) Q_2 provides a 3V pulse to set a power-up latch which in turn powers the beam width detector. Resistors R_4 and R_5 in the gate circuit of the PUT form a 20 MΩ impedance across the battery until light enters the detector, resulting in a leakage current of approximately 300 nA. Resistor R_3 determines the pulse amplitude. □



Light activated command detector for remote control devices uses an inexpensive PUT to achieve near zero power consumption in standby mode.

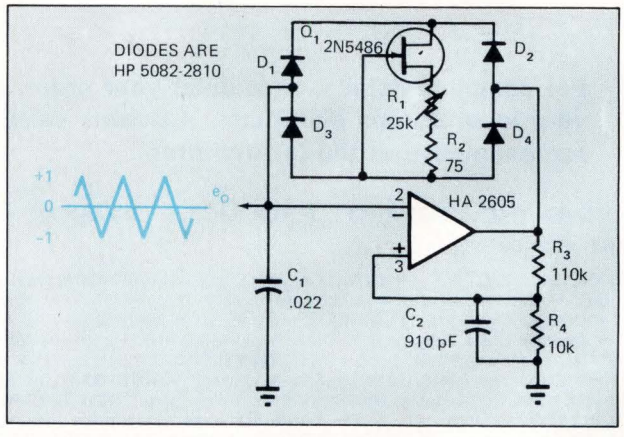
To Vote For This Circuit Check 150.

Op amp makes variable-frequency triangular wave generator

Geroge R. Begault
Harris-Intertype Corp., Melbourne, Fla.

The circuit in **Fig. 1** is a new twist to an old theme. If the diode/FET bridge were replaced with a single feedback resistor, the circuit would be the classic textbook op-amp squarewave generator. The output of the op amp would toggle between + and ÷ Vcc whenever C_1 charged to the voltage at the junction of R_3 and R_4. The operation of the circuit as shown is exactly the same, with the exception that the diode/FET arrangement causes C_1 to charge from a constant current source (Q_1), thereby forcing the voltage across C_1 to change at a linear rate. The linearity of the triangular waveform is surprising, considering the simplicity of the circuit.

For a more detailed look at circuit operation, assume power has been applied, C_1 has acquired no charge, and the op amp has been driven into its upper bound by the positive feedback. Pin-6 now sits at about +12V and pin-3 because of the divider action of R_3 and R_4 is at +1V. Current flows through C_1 to pin-6. Note that the arrangement of the diodes allows current to flow through the FET in only the source-to-drain direction, and current path would be through D_3, R_2, R_1, Q_1 and D_2 into the op amp. When the voltage at pin-2 exceeds the +1V level of pin-3, the amp output is driven to its negative bound (about



Triangle wave generator is adjustable from 500 Hz to 25 kHz. By removing C_2 and shorting D_1 and D_4, the circuit can be changed to a ramp generator.

−12V).This puts pin-3 at −1V, the current flow through C_1 reverses (this time through D_4 and D_1) and the voltage across C_1 (pin-2) now charges toward −12V.

Then the voltage at pin-2 drops below the −1V level of pin-3, the op amp output switches again to +12V and the process repeats.

With the component values shown, the frequency can be adjusted from 500 Hz to greater than 20 kHz at constant output amplitude. The short term stability is better than ±1 part in 10,000. Also since the same R and C are used to generate both sections of the waveform then the positive slope must be the same as the negative slope (assuming diodes are matched and the amplifier + and − bounds are the same.)

At higher frequencies (above 25 kHz approx.) the waveform will increase in amplitude because the time it takes the amp to slew to the new bound becomes an appreciable portion of the ramp. This can be compensated by C_2, which will reduce the voltage to which C_1 must charge by decreasing the rise time of the voltage at the junction of R_3 and R_4. The value of C_2 will depend upon ramp frequency, amplifier slew rate and ramp amplitude.

To generate a sawtooth, simply remove C_2 and replace a diode pair with a short. For positive going ramps replace D_1 and D_4; for negative ramps short D_2 and D_3. The same of linearity is obtained since C_1 must still charge through a constant current source in forming the ramp.

The circuit output (C_1) should work into an impedance of at least 200 kΩ. □

To Vote For This Circuit
Check 151

Exclusive-OR gates simplify modem designs

Peter Alfke,
Fairchild Semiconductor, Mt. View, Calif.

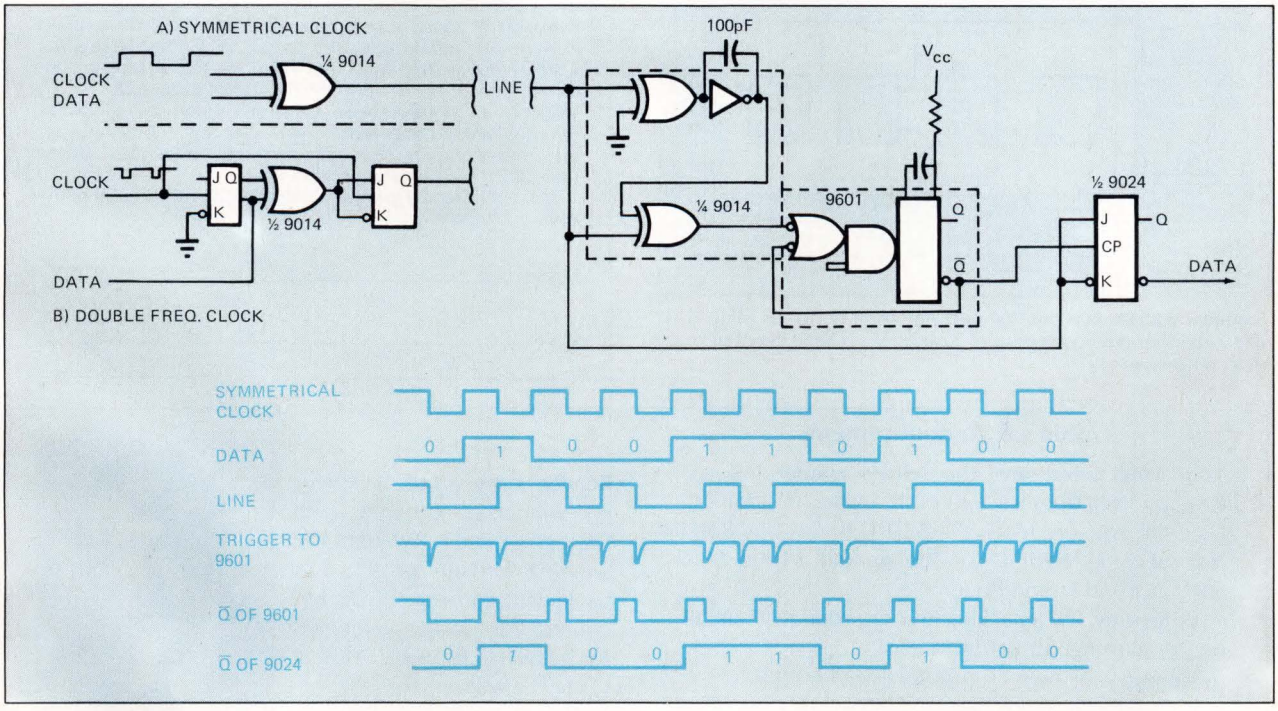
The inherent self-clocking property of binary phase modulation makes it the most popular technique for transmitting digital data over a single line. Exclusive-OR (NOR) integrated circuits and a retriggerable monostable will simplify design of both the transmitter and the receiver.

In transmitters with a 50% duty cycle clock, a simple Exclusive-OR tie between the clock and the data generates the output signal. Without a symmetrical clock, the output signal can be generated by a toggling flip-flop and a double frequency clock source. In fast systems, data propagation delay could cause spikes on the output; these can be eliminated by another flip-flop operated by the same double frequency clock.

The receiver must regenerate the clock and the data stream. A 9601 adjusted to 3/4 of the data-bit time is connected in the non-retriggerable mode. Any incoming level change will trigger the 9601. One Exclusive-OR and an Exclusive-NOR connected as an inverting delay element will perform this function. The output of the monostable can be used as a clock. The level of the incoming line at the end of the pulse (the rising edge of Q) defines data, retrieved by an edge triggered flip-flop.

This system remains synchronized as long as the monostable pulse width is between 50% and 100% of the data-bit time. □

To Vote For This Circuit
Check 152



Exclusive-OR/NOR gates and a retriggerable monostable multivibrator greatly simplify designs of both data transmitters and receivers. Circuit timing functions are shown with the schematic.

Single IC compares frequencies and phase

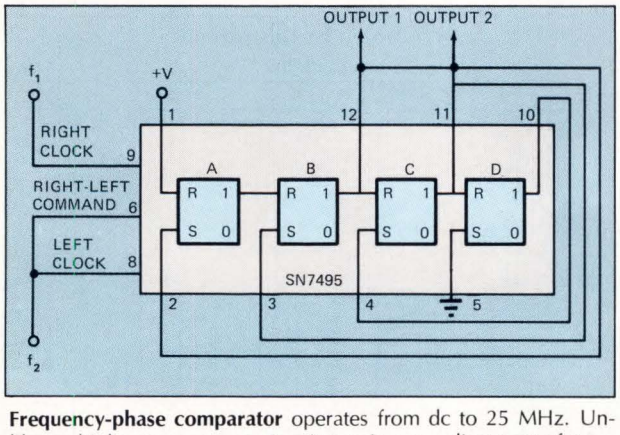
James Breese
Ampex Computer Products, Marina Del Ray, Calif.

A universal shift register, such as the 5495/7495 shown here can be connected to yield a frequency and phase determined signal as follows:

For: $f_1 > f_2$ Output = "1"
$f_1 < f_2$ Output = "0"
$f_1 = f_2$ Output is a square wave, the duty cycle of which varies linearly with the phase relationship between f_1 and f_2.

This configuration has several advantages over multiplier-type phase comparators. The carrier frequency can vary from dc to 25 MHz with no adjustment of reactive components; there are no tradeoffs of response time and acquisition range (the range is unlimited) and the frequency and phase comparisons are virtually instantaneous (requiring only two carrier cycles, worst case, for comparison).

Operation is as follows: Input f_1 shifts "1"s toward the right, and input f_2 shifts "0"s toward the left. The state of any given binary depends on its input (shift right f_1; or shift left, f_2) and the states of its neighbors. Consequently the output of binary C, for example, will be "1" if "shift-right" commands are coming along more often then "shift-left" commands. If f_1 exactly equals f_2, then one of the binaries will be toggled at the carrier rate. A closed phase locked loop, which this comparator is especially suited for, acts to ensure that the binary used for feedback, either B or C, will toggle, with output A = 1 and output D = 0. □



Frequency-phase comparator operates from dc to 25 MHz. Unlike multiplier-type comparators it requires no adjustment of reactive components.

To Vote For This Circuit
Check 153

Circuit Design Entry Blank

U. S. Savings Bond Awards ● $25 for all entries selected by editors ● An additional $50 for winning circuit each issue, determined by vote of readers ● Additional $1000 bond for annual Grand Prize Circuit, selected among semi-monthly winners by vote of readers.

To Circuit Design Program Editor
EDN/EEE
Cahners Publishing Co., Inc.
221 Columbus Ave., Boston, MA 02116.

I hereby submit my entry for the CIRCUIT DESIGN AWARD PROGRAM of EDN/EEE.

Name_____
Title_____
Company_____
Division (if any)_____
Street_____
City_____ State_____
Circuit Title_____

Print full name (no initials) and home address on line below exactly as you wish it to appear on Bond, if entry is selected for publication.

Entry blank must accompany all entries. Circuit entered must be submitted exclusively to EDN/EEE, must be original with author(s) and must not have been previously published (limited-distribution house organs excepted).

Circuit must have been constructed and tested. Exclusive publishing rights remain with Cahners Publishing Co., Inc., unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Award Program.

Signed_____

Date_____

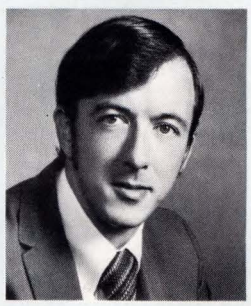
Rules & Announcements

Your vote determines this issue's winner. All circuits published win a $20 cash award. In addition, all issue winners receive a $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by checking the appropriate number on the Information Retrieval card.

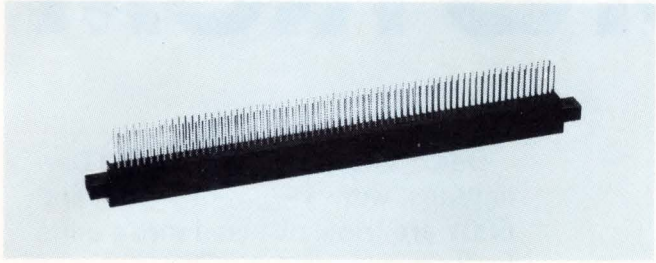
Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN, 221 Columbus Ave., Boston, MA 02116.

Readers have voted: Jack Sellers winner of the June 15th Savings Bond Award. His winning circuit is "2 TTL packages convert BCD up-counter for down counting." Mr. Sellers is with Mostek Corp., Carrollton, Tex.



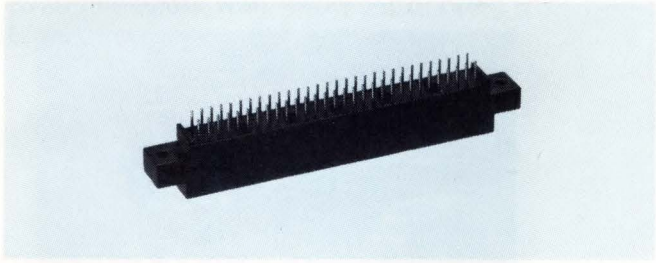
TWO PIECE, OR NOT TWO PIECE...

EITHER WAY, WE HAVE THE ANSWERS



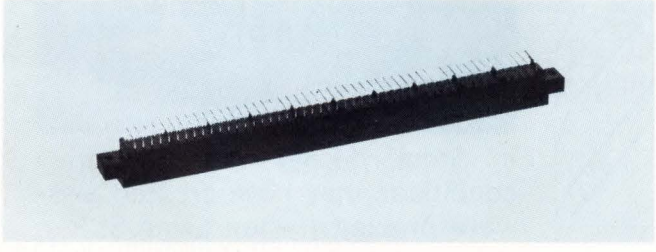
WIRE WRAP * SERIES

.100 - .125 - .150 - .156 contact spacings . . . 1/16" and 1/8" (.100 sp only) P.C.B. - .025 square terminals . . . various mounting configurations . . . multi-contact positions available (through 70/140 positions on .100 spacing) . . . low insertion forces . . . glass filled Phenolic and Diallyl Phthalate insulators . . . Phosphor bronze contacts. .031 x .062 terminals also available on .156 spacing.



FLOW SOLDER SERIES

.100 - .125 - .150 - .156 contact spacing . . . 1/16" P.C.B. — .026 diameter contact to fit .030 hole - .175 long various mounting configurations - staggered configuration available in .100 spacing with .025 square terminals .250 minimum length.



RIGHT ANGLE SERIES

.100 - .125 - .150 - .156 contact spacing . . . 1/16" P.C.B. Various contact positions available . . . side hole mounting available . . . .025 square posts right angled to varied contact lengths for extender cards and board-on-board applications.

TWO PIECE SERIES

.100 contact spacing — through 53/106 contact positions . . . closed entry receptacle contacts - .025 square posts both plug and receptacle . . . right angle terminations available . . . jackscrews and mounting hardware . . . Rear insertion and removable crimp-box contacts available for receptacle for I/O (input/output) applications with stranded wire.

DISTRIBUTORS

Acacia Sales, Inc.
Sunnyvale, California
(408) 735-0100

Newport Industries
Santa Ana, California
(714) 540-2283

SALES REPRESENTATIVES

James J. Backer Co.
Seattle, Washington
(206) 285-1300

Cable Associates, Inc.
Hartford, Connecticut
(203) 525-5016

Cindel Sales
Santa Clara, California
(408) 249-4424

Electro-Tech Marketing
Chicago, Illinois
(312) 588-4535

Geotronix Marketing Assoc.
Cleveland, Ohio
(216) 238-8520

Jolt Electronic Sales
Somerville, New Jersey
(201) 526-1857

William M. Jones Co., Inc.
Towson, Maryland
(301) 823-5721

Orion Sales
Northridge, California
(213) 886-4761

Tustin, California
(714) 832-9687

Sierra Madre, California
(213) 355-6638

Rope & Williamson
Denver, Colorado
(303) 756-0011

Sterling-Lowell Co.
Southfield, Michigan
(313) 352-8881

Techno Associates
Dallas, Texas
(214) 357-9213

W.M.M. Associates
Clearwater, Florida
(813) 446-0075

To get the full story on P.C.B. Connectors, just write or call Mr. David R. Davidson, Marketing Manager.

CONTROL DATA CORPORATION

Connector Operation
Control Data Corporation
31829 W. La Tienda Drive
Westlake Village, California 91361
Telephone: 213/889-3535

CHECK NO. 24

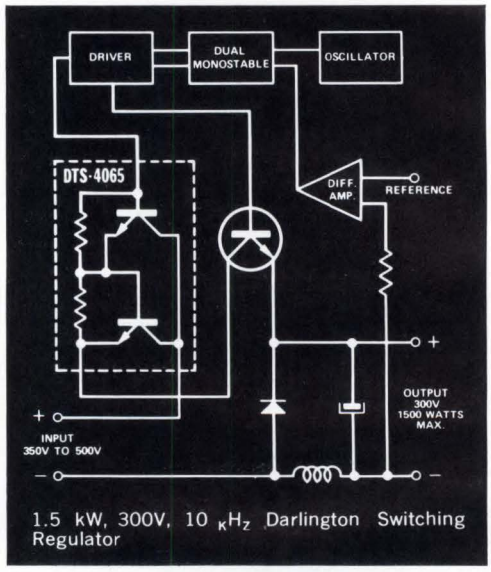
NOW, 400V & 600V DARLINGTONS FROM

Delco Electronics

DIVISION OF GENERAL MOTORS CORPORATION, KOKOMO, INDIANA

Delco's new DTS-4000 series Darlingtons with $V_{CEO's}$ of 400V and 600V are triple diffused mesa units built for rugged duty. They come to you with a practical 15 Ampere rating that you can depend on all the way up to the high voltage requirements of ac motor speed controls, for instance—or the 1.5 kW switching regulator in the illustration.

And they offer new possibilities

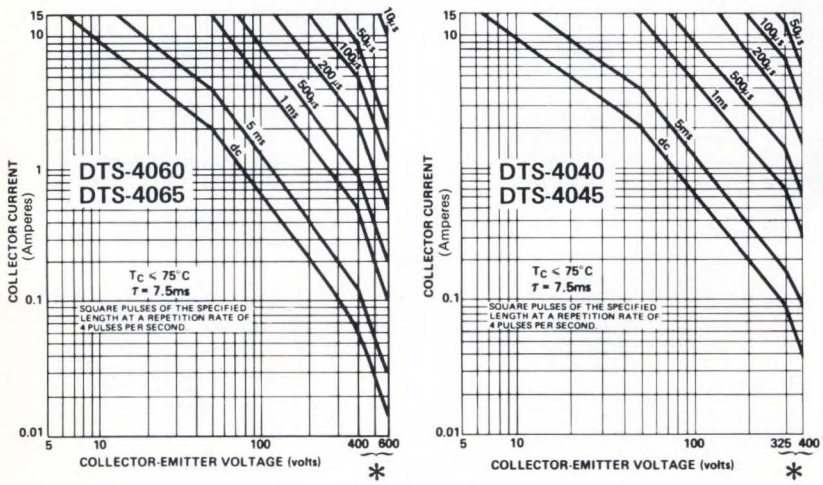


1.5 kW, 300V, 10 $_{K}H_{Z}$ Darlington Switching Regulator

in circuit design where dc drive conditions may have created awkward problems when using SCR's.

Our new Darlingtons can save you space and give you more design flexibility. The high energy capability of the DTS-4000 series is

SAFE OPERATING CURVES

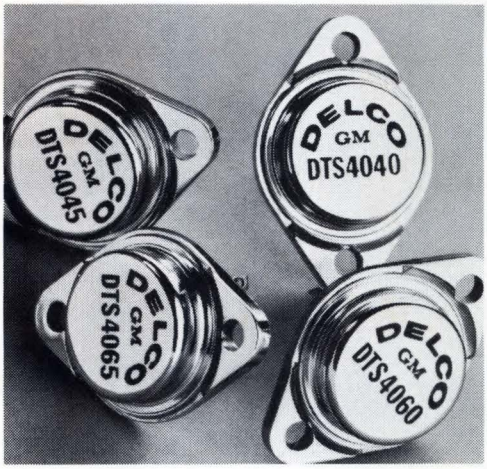


*Reverse Bias Required

TYPE	V_{CEO}	I_C (Cont.)	V_{EBO} (Max.)	$V_{CEO(sus)}$	h_{FE} @ I_C	t_f (com. base)	P_D(max.)
DTS-4040	400V	15A	20V	325V	250/3A	0.25μs	100W
DTS-4045	400V	15A	20V	325V	500/3A	0.25μs	100W
DTS-4060	600V	15A	20V	400V	250/3A	0.25μs	100W
DTS-4065	600V	15A	20V	400V	500/3A	0.25μs	100W

NPN—Triple diffused Darlington transistors packaged in solid copper TO-204MA (TO-3) cases.

HIGH ENERGY THE KOKOMOANS.



backed by safe operating curves up to 600 volts, as shown at left. And to further aid your circuit design h_{FE} is plotted continuously from 15mA to the maximum collector current rating of 15A.

As you expected, the new DTS-4000's are in stock and ready for delivery. Contact us or your nearest Delco distributor for complete details. Ask for Application Note 52 on the switching regulator.

Now available from these distributors in production quantities:

ALA., BIRMINGHAM • Forbes Distributing Co., Inc. (205)-251-4104
ARIZ., PHOENIX • Sterling Electronics (602)-258-4531
CAL., LOS ANGELES • Kierulff Electronics, Inc. (213)-685-5511 • Radio Products Sales, Inc. (213)-748-1271
CAL., PALO ALTO • Kierulff Electronics, Inc. (415)-968-6292
CAL., REDWOOD CITY • Cramer/San Francisco, (415)-365-4000
CAL., SAN DIEGO • Radio Products Sales, Inc. (714)-292-5611
CAL., SAN DIEGO • Kierulff Electronics, Inc. (714)-278-2112
COLO., DENVER • Cramer/Denver (303)-758-2100 • Denver Walker Electronics (303)-935-2401
CONN., NORWALK • Harvey/Connecticut (203)-853-1515
FLA., MIAMI SPRINGS • Powell/Gulf Electronics (305)-885-8761
ILL., ROSEMONT (Chicago) • Kierulff Electronics (312)-678-8560
ILL., SKOKIE (Chicago) • Merquip Electronics (312)-282-5400
IND., INDIANAPOLIS • Graham Electronics Supply, Inc. (317)-634-8202
MD., BALTIMORE • Radio Electric Service Co. (301)-823-0070
MASS., NEEDHAM HEIGHTS • Kierulff Electronics, Inc. (617)-449-3600
MASS., NEWTON • The Greene-Shaw Co., Inc. (617)-969-8900
MICH., ROMULUS • Harvey-Michigan (313)-729-5500
MINN., MINNEAPOLIS • Stark Electronics Supply Co. (612)-332-1325
MO., KANSAS CITY • Walters Radio Supply, Inc. (816)-531-7015
MO., NO. KANSAS CITY • LCOMP-Kansas City, Inc. (816)-221-2400
MO., ST. LOUIS • LCOMP-St. Louis, Inc. (314)-647-5505
N.J., CLIFTON • Eastern Radio Corporation (201)-365-2600, (212)-244-8930
N.Y., BINGHAMTON • Harvey/Federal (607)-748-8211
N.Y., EAST SYRACUSE • Cramer/Eastern (315)-437-6671
N.Y., ROCHESTER • Cramer/Rochester (716)-275-0300
N.Y., WOODBURY • Harvey/New York (516)-921-8700, (212)-582-2590
OHIO, CINCINNATI • United Radio, Inc. (513)-761-4030
OHIO, CLEVELAND • Pattison Supply (216)-441-3000
OHIO, DAYTON • Kierulff Electronics (513)-278-9411
OKLA., TULSA • Radio, Inc. (918)-587-9123
PENN., PHILADELPHIA • Almo Electronics (215)-676-6000
PENN., PITTSBURGH • RPC Electronics (412)-782-3770
S.C., COLUMBIA • Dixie Radio Supply Co., Inc. (803)-253-5333
TEXAS, DALLAS • Adleta Electronics Co. (214)-741-3151
TEXAS, FORT WORTH • Adleta Electronics Co. (817)-336-7446
TEXAS, GARLAND • Kierulff Electronics, Inc. (214)-271-2471
TEXAS, HOUSTON • Harrison Equipment Co., Inc. (713)-224-9131
UTAH, SALT LAKE CITY • Cramer/Utah (801)-487-3681
VA., RICHMOND • Meridian Electronics, Inc., a Sterling Electronics Company (703)-353-6648
WASH., SEATTLE • Kierulff Electronics, Inc. (206)-763-1550
WASH., TACOMA • C & G Electronics Co. (206)-272-3181
CANADA, ONT., SCARBOROUGH • Lake Engineering Co., Ltd. (416)-751-5980
ALL OVERSEAS INQUIRIES:
General Motors Overseas Operations
Power and Industrial Products Dept.,
767 Fifth Avenue, New York, N.Y.
10022. Phone: (212)-486-3723.

Kokomoans' Regional Headquarters.
Union, New Jersey 07083, Box 1018, Chestnut Station, (201) 687-3770.
El Segundo, Calif. 90245, 354 Coral Circle, (213) 640-0443.
Kokomo, Ind. 46901, 700 E. Firmin, (317) 459-2175 (Home Office)

GM
MARK OF EXCELLENCE

CHECK NO. 25

Testing digital IC's?

8013A, $625

8007A, $1600

HP's new pulsers give you the most capability per dollar

If digital IC's are your big interest, HP's new 8000-Series pulse generators are for you. You not only get **versatile capability,** but you **save money** as well! These new pulsers offer you a choice of price/performance packages to meet your needs, within your budget—whether you're working with computers, communications, telemetry, or any other digital system.

The new 8007A gives you rep rates from 1 kHz to **100 MHz, variable transition times** (2.5 ns to 250 μs), $\pm$5 V amplitude, and $\pm$2.5 V dc offset—all for **$1600**. With the 8007A, you can design and test the fastest of today's digital devices—ECL IC's and bi-polar memories—and have "speed to spare" for tomorrow's advances.

If you don't need 100 MHz, you can save. For only **$875**, you can get the new 8012A, which gives you rep rates from **1 Hz to 50 MHz.** Like the 8007A, it offers **variable transitions** from 5 ns to 0.5 s, with $\pm$5 V amplitude and $\pm$2.5 V dc offset.

If you don't need variable transitions, you can save even more. Our 8013A gives you rep rates from **1 Hz to 50 MHz** with a fixed transition time of $<$**3.5 ns,** $\pm$5 V with dc offset, and dual outputs—all for **$625.**

All three of these new pulsers give you pulse-shaping capabilities, allowing control of NRZ or RZ waveform parameters with the output width determined by the input waveform width. Normal external triggering and gating are also supplied.

The 8007A also gives you a double-pulse mode, and all three models have square-wave capabilities. And the 8013A offers simultaneous positive and negative outputs, with $\pm$5 V amplitude across 50Ω ($\pm$10 V open-circuit or with high-impedance internal source).

Other HP pulse generators, listed in the catalog, begin **as low as $225.**

For further information on any of these new 8000-Series pulsers, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

081/11

HEWLETT hp PACKARD

SIGNAL SOURCES

CHECK NO. 26

COMPUTER HARDWARE

Processor interrupt scheme speeds response and minimizes overhead

Systems must react rapidly to interrupts to be effective in a real-time environment. An architecture that reduces both hardware and software overhead achieves this goal.

Michael I. Davis, IBM

Applications for real-time systems seem to increase daily as computer users find these systems valuable for solving a variety of problems. Yet this variety of applications presents an enigma to the real-time system designer. Unlike the designer of a traditional data processing system, he is usually unaware of the eventual application of his computer. Market research will certainly indicate that the variety of requirements placed upon the system is so large that specific optimization is impossible.

Six components affect interrupt response time

The processor designer is required to be all things to all men. As the requirements for the processor are further expanded, it becomes clear that one particular parameter, responsiveness, is the most important. It can be quantified by *interrupt response time* as a figure of merit. Although the term is familiar to most computer engineers, no one generally accepted definition exists. For the purpose of discussion, **Fig. 1** illustrates the components which, when summed, constitute the time required to respond to external stimulus, defined as the interrupt response time.

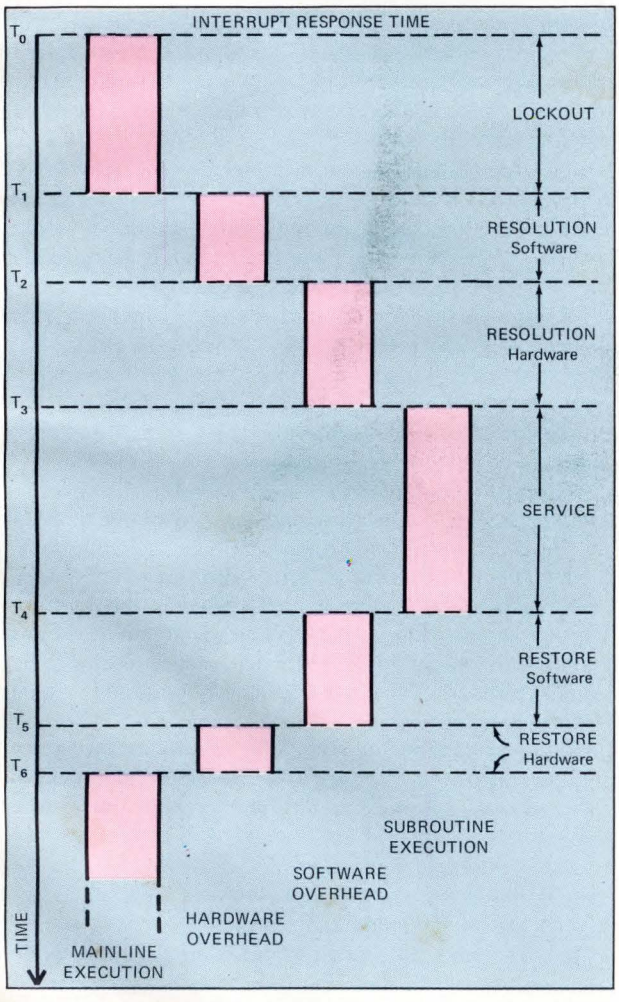


Fig. 1—System responsiveness is governed by the six components that make up interrupt response time.

At time T_0, an external event occurs. $(T_1 - T_0)$ is termed the lockout time and has several components. One is the device's reaction time (the time between the occurrence of the external event and activation of an interrupt request by the device to the CPU). A further component is any interface activity required to signal the processor of the interruption. This circumstance can be worsened due to other interface activity going on at the time. A third component includes all time for which this interrupt may be disabled or suppressed. This time component may be reduced by providing better resolution on interrupt masking.

The final component of lockout time is caused by the necessity of waiting until the end of the current instruction's execution before accepting the interrupt. Thus, this component is equal to the duration of the longest instruction executable on the system.

From T_1 to T_3, the system hardware and software attempts to resolve the reason for interruption. In this period, some form of hardware status switch will commonly take place. This will be followed by a software first-level interrupt handler to identify the interrupting device and to determine the conditions which led to the interruption. Any necessary software "save and restore" of machine status will also take place in this period. The time T_2 is shown to indicate that resolution time is split between hardware and software components.

The System/7 interrupt mechanism provides a great deal of the function normally executed by software on first level interruption handling, greatly reducing the overhead in both resolution and restoration on the occurrence of an interrupt. Rapid instruction execution times further permit reduction of the duration of the $(T_3 - T_2)$ period.

The interval $(T_4 - T_3)$ is the service time, the duration of which is totally dependent on the application. It can be reduced by the system designer by provision of a powerful instruction set and as many hardware registers as possible to reduce the save/restore overhead in computing.

The period T_4 through T_6 is the restore time, which essentially provides the reverse set of circumstances from those in T_1 through T_3. In this case, hardware and software combine to restore the machine to its original status as

recognized at T_1. T_5 represents the time at which the software restoration is complete. The hardware then performs its portion of restoration. By design, the System/7 interrupt mechanism provides most of this function in the hardware without excessive program overhead.

At T_6, the next sequential instruction of the main line code, which was being executed at T_1, will be fetched and executed. Main line programming can now continue.

Thus, the interrupt response time is the sum of lockout time, resolution time, service time, and restore time. Understanding this, it becomes easier to deal with the way a design can be evolved to minimize the sum of these times by tackling them individually.

Responsiveness reduces peripheral hardware

The greatest advantage of minimizing interrupt response time in a real-time CPU is that the total system becomes more flexible, and is able to handle varying applications. If, for example, the system will be used as a controller, it can be demonstrated that there is a direct tradeoff between the system's responsiveness, and the amount of external hardware that must be interposed between the processor and the device to be controlled. Some of this hardware will include powering and level conversion of the circuits, and cannot be avoided. But a considerable portion may be used to buffer the processor from the device itself. This buffering is commonly required if the processor is incapable of responding fast enough to provide control at the detailed level of change required by the basic device. If the processor could respond, at the rate demanded, to each individual state change within the device, then additional hardware would *not* be required.

This same point is magnified when multiple devices are connected to one processor. Here the asynchronous nature of the devices and their inherent differences further complicate the requirements placed on the processor for responsiveness.

A further need for rapid response occurs when data must be collected and time stamped at high frequency. Under these circumstances, the direct memory access or cycle stealing mode of data transfer may not be usable since, by definition, it is asynchronous to the processor execution and is not capable of being time-related. One may wish, for instance, to read an incoming field based on an external stimulus from a contact closure, a pulse, or a timer. State-of-the-art gas chromatography is a good example of the need to read an analog value at timed intervals. The higher the sampling rate, the greater the resolution.

An interesting comparison between traditional data processing systems and real-time systems shows up here. In the data processing system, a well balanced configuration will reduce the amount of time that the "Wait" light is on to a very low figure. In a totally effective real-time system, the "Wait" light will be almost always on, indicating availability and readiness to respond to a new event. In practice, low priority jobs would be run to use up this available system time, and some form of priority interruption would discontinue them when a higher priority job must be executed.

Breaking the bottlenecks

The first part of the solution consists of identifying principle bottlenecks in a proposed design. In most systems, the bottleneck area will center around the overhead involved in changing machine status when an interrupt occurs. This overhead will almost always have both a hardware and software time component. The first decision the designer must make concerns the basic nature of the interrupt mechanism. For example, on System/7, a multilevel preemptive priority-interrupt mechanism was selected. This permits the allocation of relative importance to external events, and reduces the number of serially reusable resources in hardware and software. In such a system, the sources of interruption are graded according to importance, and all sources have the opportunity to present their interrupt requests to the processor. The processor uses the algorithm that it is interruptable only by the interrupting sources which have a priority level higher than the one currently in progress.

In System/7, there are four priority interrupt levels. These are termed 0, 1, 2, and 3. Zero has the highest priority and level three is the lowest. When execution is not taking place on one of these levels, the machine is in the wait state. Thus, the algorithm dictates that if, for instance, execution is taking place on level two, only levels zero and one are capable of interrupting the activity currently in progress. Level two must complete before another level two interruption or a level three interruption can take place.

Most priority interrupt systems also provide a finer resolution of interruption, commonly termed a sublevel. On System/7, there are sixteen such sublevels for each level. A device is normally assigned a level and sublevel combination upon which to request an interrupt. Usually there is no priority discrimination between the various sublevels of any one interrupt level.

At this point, the designer must decide how many levels and sublevels should be provided. In general, levels are more costly than sublevels, but permit additional resolution of priority. However, there is a crossover point. While the distinction in priority between levels 1 and 2 of a four-level system is evident, the decision as to whether a given device should be assigned level 29 or 30 on a thirty-two level system is virtually academic, and will have little, if any, effect on the operation of the system. There are various methods for use of sublevels. The system/7 method is particularly suited to rapid response.

The most common source of overhead in first-level interrupt handling is the saving and restoring of machine status. Registers, instruction address and indicators must have their contents moved to a "save" area in main storage. New machine status must then be loaded for the interrupted-to program before execution can commence. The procedure must then be reversed when control returns to the original program. Thus, this overhead is incurred twice per interruption.

To provide a powerful arithmetic and logical instruction set and still permit the use of register based addressing of main storage, System/7 architecture provides an instruction address register, an accumulator and seven index registers. Six testable indicators are also provided. For response and speed, none of these registers are in main storage; all are implemented in hardware.

To overcome the save-restore overhead, this entire complement of registers and indicators is duplicated for each interrupt level. Thus, there are in hardware, four instruction address registers, four accumulators, 28 index

registers and four sets of indicators. Status switching on an interrupt is then accomplished by simply switching from one hardware "bank" to another. In essence, four program-addressable CPUs are provided, thus realizing in hardware, the software "virtual machine" concept. This status switch takes a few tens of nanoseconds and is buried in the 800 nsec automatic sublevel branch.

There are no relative priorities between sublevels on a given level in System/7, so they are handled on a first-in-first-out (FIFO) scheme on a per-level basis. Since operations within the processor and the occurrences of interrupt requests are asynchronous, one buffer per level is provided as an adjunct to the CPU to queue the first outstanding interrupt request for each level. Each buffer contains descriptive data relating to the source of the interrupt.

The presence of these buffers insures the availability of this data to the processor immediately when a decision to accept an interrupt occurs: the CPU will not be "hung" waiting to solicit this data over the I/O interface. This data is termed the interrupt ID. It includes the address of the interrupting device, its sublevel, and a summary status indicator. When the interrupt is accepted, the device address and sublevel are placed into the accumulator for the interrupted-to level, making the information usable by the software. The summary status indicator is set into the carry indicator, which can be tested by the software.

The function of the summary status indicator is to obviate the overhead, under normal conditions, of interrogating the interrupting device for status information. Thus, the program will not usually need to address the interrupting device to determine its status. If the summary-status bit is a zero, then the interruption was due to a normal ending condition, and no error or exception conditions have been encountered. The device is now available for reinstruction and status need not be collected. If the summary status bit is a one at interruption time, then an error or exception condition has occurred, and the program will address the device to read additional status information in order to permit retry or correction of the error (one 16-bit status word is provided per device for this purpose).

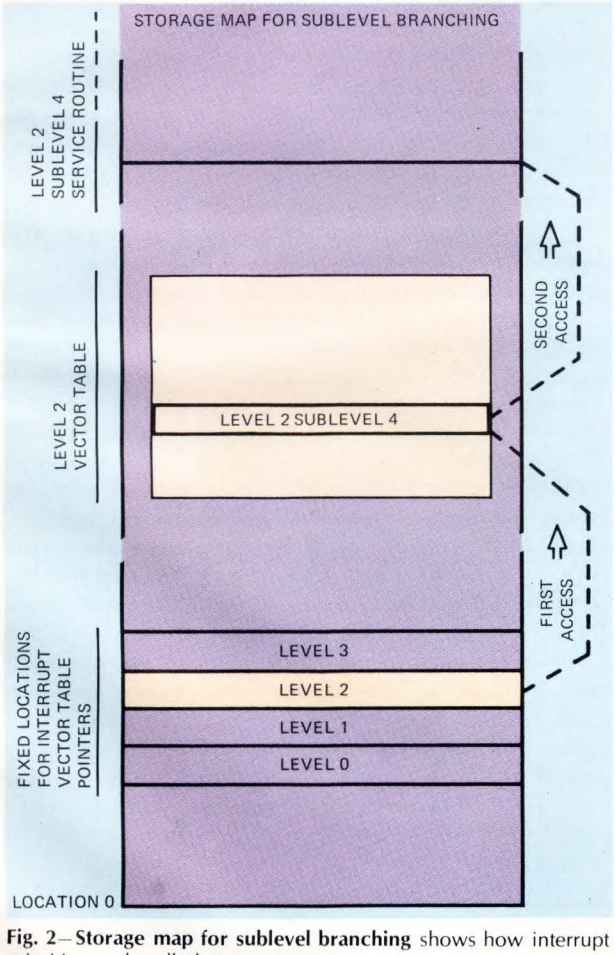


Fig. 2—Storage map for sublevel branching shows how interrupt priorities are handled.

To avoid a further time-consuming process which involves software analysis of the interruption source and a linkage to the appropriate subroutine, automatic sublevel branching is provided. Each of the interrupt levels provides 16 sublevels, and each sublevel is a four-bit binary number. It is presented to the processor by the interrupting device during the acceptance of the interrupt. **Fig. 2** shows that the lower part of System/7 main storage contains four fixed locations, which are termed interrupt vector table pointers. Let us assume that the new interrupt level is to be level 2 sublevel 4. Notice that due to the interrupt algorithm, we must either be operating on level 3 or in the wait state for this interrupt to be accepted.

When level and sublevel information is transmitted to the processor, the pointer for level 2 is fetched from the appropriate fixed location in storage. This pointer is used as an address base, and the sublevel (in its binary encoded form) is added to this base. This has the effect of indexing up the table of sublevel vectors for level 2 (shown in **Fig. 2**). There are three other such tables in main storage for the other three levels. Their location is floating, defined simply by the contents of the vector table pointers. When this piece of address arithmetic is complete, the processor uses the result to fetch the sublevel vector for level 2 sublevel 4. This is loaded into the instruction address register for level 2, and execution commences. Consequently, with no software action, the level 2 sublevel 4 interrupt subroutine has been initiated. The four-level, sixteen-sublevel combination provides 64 such unique interrupt entries.

To terminate a routine, the program issues a level exit instruction (PLEX) which releases the level in process, and permits the processor to accept other interrupts on that level or on any other level.

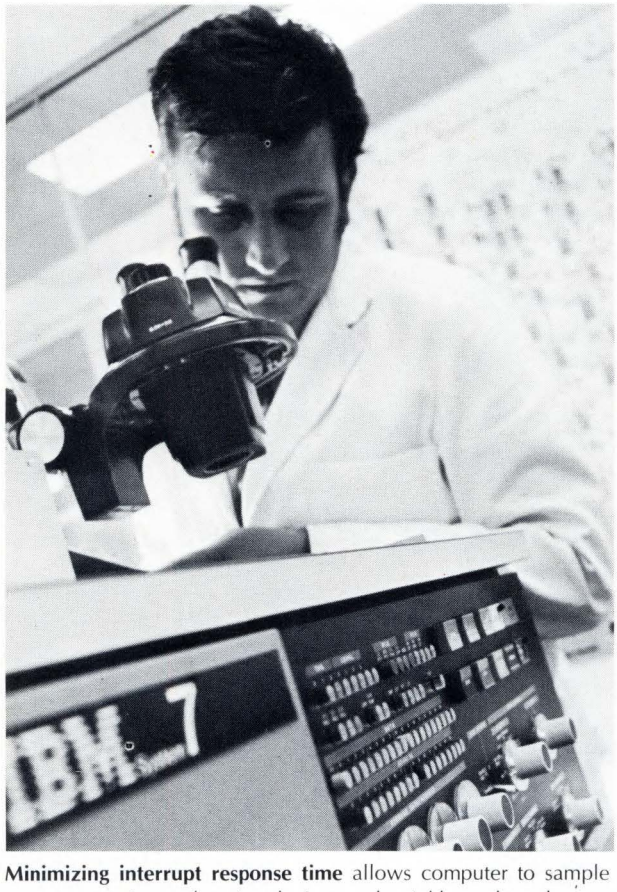
The automatic sublevel branching is executed in parallel with the switching of register banks from the old to the new level and the setting of the interrupt ID and summary status bit into the new level's bank. This whole operation takes place in two storage cycles or 800 nsec. Restoration from the interrupting level to the interrupted level, following completion of the interrupt subroutine, does not require access to main storage. This status switch takes place in only 400 nsec. For many applications, the hardware provides a complete first level interrupt handler, and the whole process of task switching takes place in less than one μsec.

Adequate compute power is the key

Of course, none of these aids to responsiveness will be effective unless the overall compute power of the processor is high enough to match the application requirements. Referring back to **Fig. 1**, the service time is completely unknown to the CPU designer. All he can attempt to do is

maximize the compute power of the system for a given cost in order to reduce this time as much as possible.

While the average instruction execution time will affect the service time within the realm of responsiveness, the longest instruction execution time will affect the lockout. Lockout is due to the fact that new interruptions cannot usually be accepted while the execution of an instruction is in process. Commonly, computer systems will only accept interruptions in between instructions. Thus, if our longest instruction is for instance 5 μsec, the user cannot be guaranteed a lockout time which is less than 5 μsec, since this instruction may have just started when the interruption condition was presented to the processor. For example, the majority of instructions in System/7 take 400 nsec to fetch and execute. Some take 800 nsec (two storage cycles), and there are three which take 1.2 μsec. A rather serious question in instruction-set selection comes up at this point: should the designer elect to provide instruction "X" in hardware, or should he permit it to be executed by a subroutine using more simple instructions. Floating point operations, storage-to-storage moves, and multiplication and division instructions are examples which all enter the realm of questionability at this point. Clearly, when one considers the instruction on its own, hardware implementation will provide the most rapid execution time; however, since the instruction will probably be non-interruptable, hardware implementation will also provide the greatest lockout time. There is no easy solution to the problem of deciding which complex instructions shall be implemented in hardware and which shall be implemented by software subroutine. The best guideline appears to be the generation of an exhaustive and comprehensive instruction frequency mix by application. At this point, the efficiency of the instruction set with a given instruction implemented in hardware or software can be evaluated.



Minimizing interrupt response time allows computer to sample many measuring and testing devices and quickly analyze them.

Table One
Typical Interrupt – Driven Subroutine

		Execution Time (nsec)
Status	Switch	800
PSKC	Skip if no error	400
PB	Branch to interrupt error routine	—
PID	Read data into accumulator	2,000
PSKC	Skip if no I/O error	400
PB	Branch to I/O error routine	—
PST	Store data using R_1 as address	800
PAI	Decrement R_2	400
PSKC	Skip if count non-zero	400
PB	Branch to end	—
PLEX	Level Exit	400
		6,000

In many cases, the execution frequency of these complex instructions is surprisingly low. If the CPU has sufficient compute power to permit the subroutine to be executed rapidly, the subroutine approach is the more attractive from a responsiveness point-of-view. Since the subroutine can normally be written in such a fashion that it is interruptable, lockout time can be reduced.

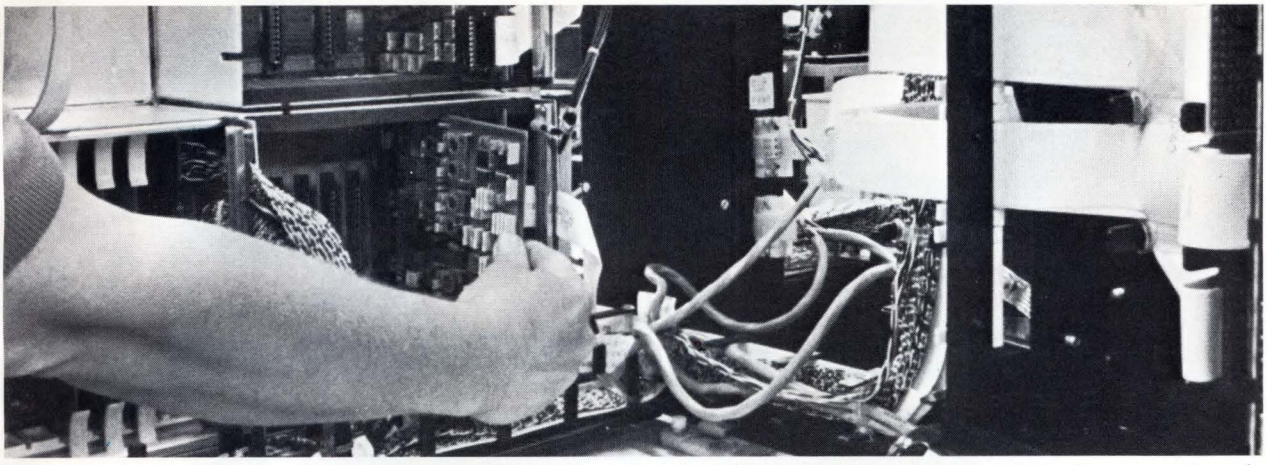
To increase the compute power of the processor still further, the instruction architecture should supplement the interrupt architecture by providing as many program-addressable registers as possible. Fortunately, trends in technology seem to make this approach increasingly more attractive. An analysis of the number of load/store combinations executed in most small computers, will indicate that

It should not be inferred that interrupt architecture consists solely of hardware considerations. While a system which executes simple interrupt-driven subroutines may be programmed by a user in an extremely efficient manner with the architecture described above, more complex sys- the efficiency of the code in terms of time and storage utilization could be improved by adding more registers.
tems require the provision of control programs where similar considerations of responsiveness have been basic tenets of design. The code shown in **Table 1**, for instance, is a typical simple interrupt-driven subroutine whose function is to acquire data on a timed external stimulus (note that register 1 has been set to the data table address and register 2 contains the word count). Such an interrupt-driven subroutine is essentially self-sufficient because, except for storage allocation for instructions and a data table, virtually no system resources are required for support. The routine does not depend upon any common I/O devices, nor does it require any system software services.

For general applications, the control software provided must be structured specifically with responsiveness in mind, in the same manner that the hardware has been designed. Typical software characteristics include the provision of re-entrant routines callable from multiple levels, minimum disable times, priority queueing, and the efficient use of programmed interrupts to dispatch subroutines at another level.

Assignment of interrupt levels

Since the requirements for a real-time system are so diverse, the system designer is frequently at a loss to know



A variety of plug-in modules gives the System/7 modular computer flexibility to be easily configured to meet a particular customer's needs. These devices perform the necessary conversions from external devices and then interrupt the processor.

how to assign interrupt levels and sublevels. This can lead to significant manufacturing and installation problems. The priority of a given device-type cannot, for instance, be hard-wired on the manufacturing floor of the computer vendor if true configuration flexibility is to be provided at the customer's plant site.

Even more important, many real-time systems are required to operate in a heuristic (trial and error) manner. The priority of a given interrupting source may vary depending on other stimuli perceived by the system. To illustrate this, let us consider the periodic measurement of the level of acid in a tank, which is of moderately low priority until it is determined through other sensors that the outlet pipe has become blocked. As the level approaches the tank's capacity, corrections which must be applied will require that the level parameter be treated as the highest priority in the system. Under normal conditions, this parameter will change relatively slowly and is not a particularly significant item.

A method has been provided within System/7 to permit software allocation of level and sublevel information. The "Prepare I/O" instruction causes interruption control parameters to be passed to the device. These parameters include level and sublevel. Thus, for any given job or mixture of jobs, the significance of the interruption and the code to which it links (using the automatic sublevel branch technique) may be varied dynamically by the software. Thus, great flexibility is provided in the overall system configuration.

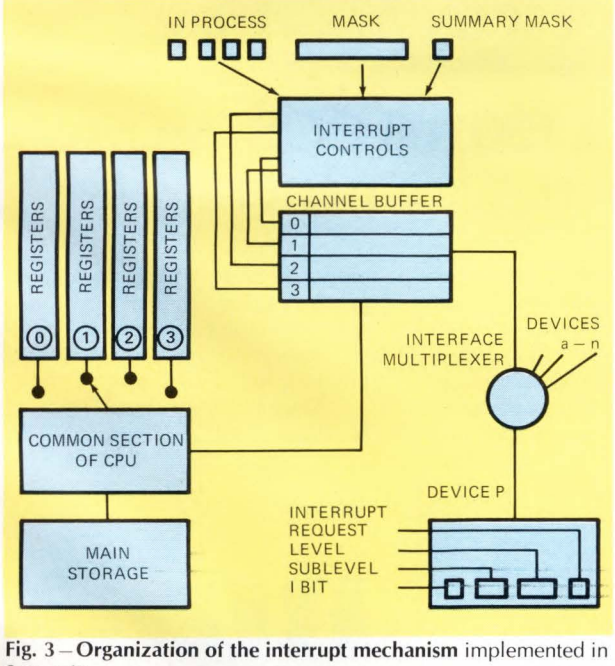


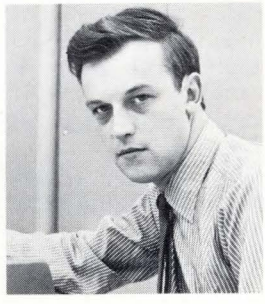
Fig. 3 – Organization of the interrupt mechanism implemented in System/7.

No discussion of interrupt architecture should end without discussing masking facilities. System/7 provides masking at three resolution levels (**Fig. 3**). The first level is a summary mask which is capable of disabling all priority interruptions. In addition, a program-addressable mask register provides per level masking similar to that of System/360. A one-bit in the mask register for a given level, permits an interrupt on that level. The "Prepare I/O" instruction provides further resolution of the masking facility by including with its interrupt control parameters, a device mask. If this mask is a one, the device is permitted to request an interrupt. Thus, individual devices within a level may be selectively enabled or disabled. This capability of close resolution of interrupt masking provides the greatest availability of the system to enable the devices, since it is not necessary to disable more devices than those required.

Interrupt architecture essence of responsiveness

The essence of a real-time computer system's responsiveness centers around its processor interrupt architecture. This responsiveness, coupled with compute power and the use of appropriate software techniques, permits the system to meet the challenges of multiple stringent real-time applications. □

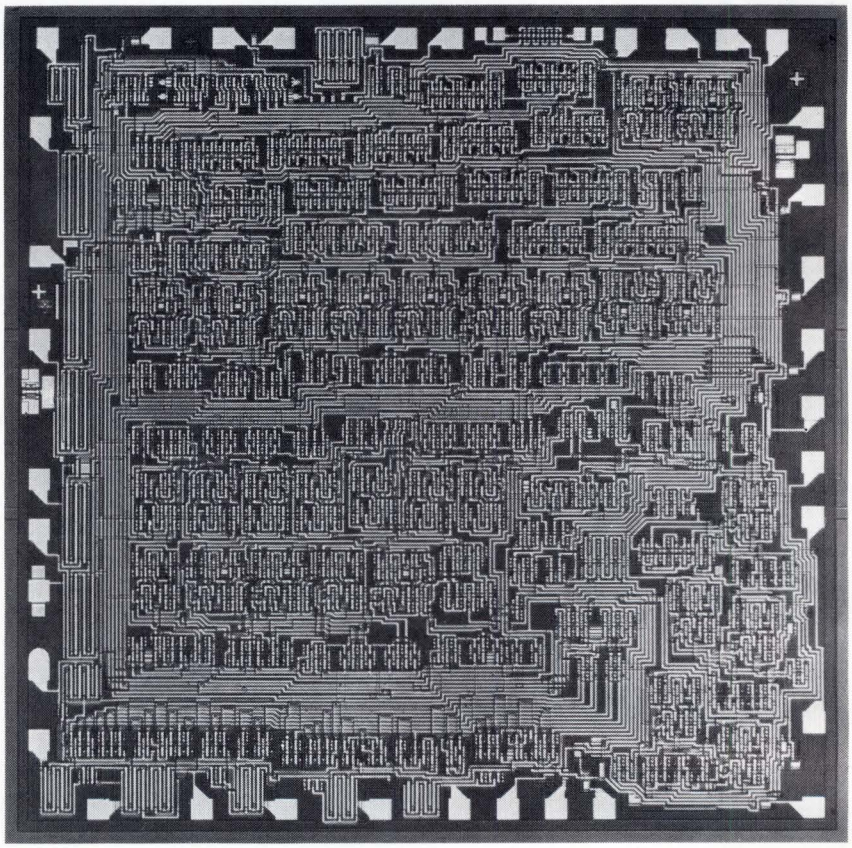
Author's biography



Michael Davis is manager of system design and architecture at IBM, General Systems Division, Boca Raton, Florida. Prior to this he was employed at Plessey, UK Ltd. Mr. Davis received his Bachelor of Science degree – Electronics, from the University of Southampton, England.

Chip

off the old breadboard.



RCA put 1,238 devices on a 150 mil COS/MOS chip. What are your LSI requirements?

The move is toward LSI. And RCA is ready now to develop custom COS/MOS circuits to your most demanding requirements.

For example, the 149 x 150 mil timing circuit above was integrated from a breadboard containing 1,238 discrete devices. Just one of many custom chips designed with RCA's unique silicon interconnect process to provide high packaging density.

RCA maintains a staff of systems engineers who are experienced in the development of complex micropower arrays. They are backed by extensive facilities to speed the process of IC design and development.

These facilities consist of computers for logic simulation, artwork digitizer-plotter systems that can cut turnaround time by 33% in typical circuits, Mann Pattern Generator facilities to speed mask preparation, and Teradyne Model J-283 digital IC systems which functionally evaluate complex arrays.

Put RCA's COS/MOS team to work to help reduce package count, cut assembly costs, and achieve excellent cost effectiveness in your systems.

When it comes to COS/MOS LSI, come to RCA.

Contact your local RCA Representative or RCA Distributor, or write RCA Solid State Division, Section 171115, Box 3200, Somerville, New Jersey 08876.

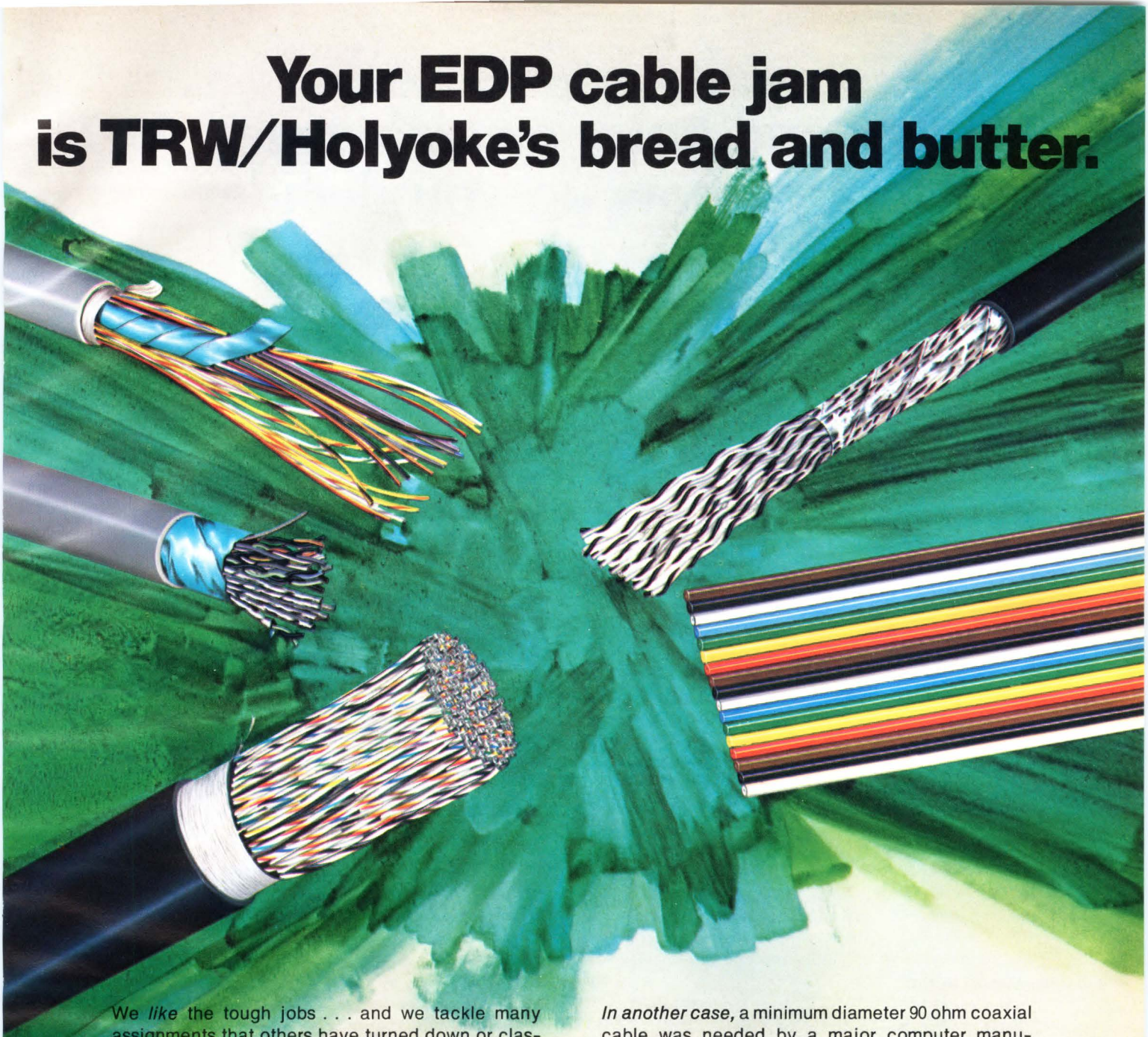
RCA Solid State

products that make products pay off

International: RCA, Sunbury-on-Thames, U. K., or Fuji Building, 7-4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Canada.

CHECK NO. 29

Your EDP cable jam is TRW/Holyoke's bread and butter.



We *like* the tough jobs . . . and we tackle many assignments that others have turned down or classified as too difficult. Manufacturing EDP wire and cable is a science, which requires experience, expertise and equipment. But it is also an art, which requires imagination, ingenuity, and an attitude of *willingness.*

That's what sets us apart—the willingness to handle the difficult designs—combined with the ability to closely control the production process to provide high volume output of precision cables.

For example, the 32 pair .363″ diameter cable illustrated upper right is a redesign of an existing cable that maintained equivalent flexibility, crush resistance, abrasive resistance and cable diameter, held impedance to closer tolerances yet costs less than the original!

In another case, a minimum diameter 90 ohm coaxial cable was needed by a major computer manufacturer. Other cable sources stated that a 30 ga. center conductor was the minimum they would consider, resulting in a .125″ OD cable. TRW/Holyoke designed it with a 32 ga. center conductor producing a .086″ OD cable that met all mechanical and electrical parameters—and shipped it a week ahead of schedule!

Our comprehensive service to the EDP industry also includes harnesses and cable assemblies with PC board, molded connectors, terminals, plugs, sockets and other hardware.

Your cable jam is our bread and butter—so call us at (413) 533-3961 when you need help, or write for more information to TRW/Holyoke Wire & Cable, an Operation of TRW Electronic Components, 720 Main Street, Holyoke, Massachusetts 01040. CH-7250

TRW®
HOLYOKE WIRE & CABLE

CHECK NO. 30

Sample and hold, or high-speed A/D converters, how do you decide?

This is the most critical price/performance decision in data-acquisition designs. Take the guesswork out of it by looking at the whole system.

Ron Gadway, Burr-Brown Research Corp.

In sampled digital data-acquisition systems with data channels that have frequency bandwidths appreciably higher than dc, the conversion speed of the A/D converter must be considered when computing throughput accuracy of each sampled data point. If data is changing while the A/D conversion is in process, aperture errors due to dynamic data movement will occur, and consequently degrade the accuracy of each sample. One way to reduce this error is to speed up the conversion time of the A/D converter. However, high speed A/D converters cost much more than lower speed models. For example, a 30 μsec 12-bit A/D converter costs $175 to $300 in small quantities, but a 2 μsec 12-bit A/D converter can run over $750 in small quantities.

Let's look at a typical example of a data-acquisition system to determine a method of making the choice between the 2 converters:

You have to measure 64 data channels in a 0°C to +70°C environment, 4 of which have a 100 Hz bandwidth, and 60 have a 50 Hz bandwidth. You require 0.07% or better system throughput accuracy over the temperature range but want 12 bit resolution (1 part in 4000+). Should you use a slower speed A/D converter with a sample-hold, or should you use a high speed A/D converter instead?

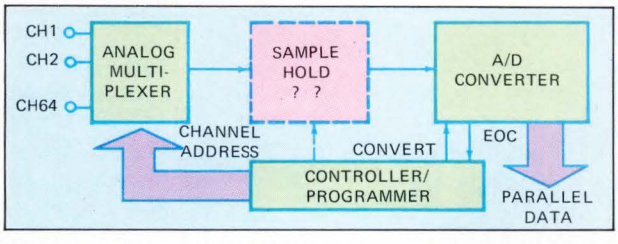


Fig. 1—64 Channel digital data-acquisition systems such as the one described here often present a designer with his toughest tradeoff decisions. High speed A/D converters cost a lot and the sample and hold may limit system throughput. Only a careful evaluation of the entire system will give you the correct balance.

The basic system would look like the block diagram shown in **Fig. 1**. To simplify this example, assume that the analog multiplexer is single-ended and will settle to ±0.01% in 10 μsec (100 kHz maximum sampling rate for ±1/2 LSB settling) and you are looking at a 30 μsec 12 bit A/D converter. Sampling theory, which we don't have time to cover here, tells us that for adequate data reconstruction accuracy, a minimum of 6 samples per cycle will be required.

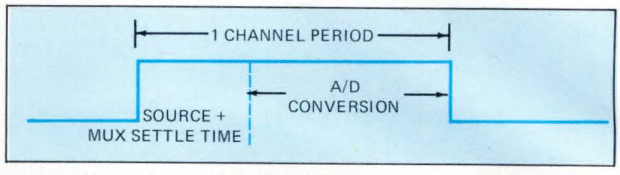


Fig. 2—Channel period, which is the reciprocal of the sampling rate, must provide adequate time for accurate sampling—after all settling times are considered. This is a key point to consider when deciding between sample and hold or high speed conversion.

Sampling rate depends on input bandwidths

The minimum throughput sampling rate required is the number of samples/cycle times the combined maximum frequency of the sum of all input data channel bandwidths, i.e.

$$\text{Throughput rate} = [\Sigma\,(f_{ch_1} + \cdots + f_{ch_1})] \times \text{samples/cycle} = 20{,}400 \text{ samples/second.} \quad (1)$$

The minimum channel period, depicted in **Fig. 2**, is the reciprocal of the sampling rate, or 49 μsec. In this time period, allowances must be made for source plus multiplexer settling and A/D conversion speed. The conversion can be allowed as long as 39 μsec in this example.

Dynamic errors occur when data changes during A/D conversion; this error is also called aperture error. Now, let's consider the dynamic error before deciding on the A/D converter speed. To achieve 0.07% accuracy, the dynamic *and* static errors of a digital data acquisition system must be examined. In this example, if a 39-μsec A/D converter was used, the throughput speed requirement would be satisfied, but the system accuracy would probably suffer. With data bandwidths up to 100 Hz the maximum data change (and error) during conversion is:

$$\Delta V = (V_{fs})\,(t_A)\,(f_{max}) \quad (2)$$
(dynamic)

where V_{FS} = full scale range of ADC input
t_A = system aperture (ADC speed or sample-hold aperture)
f_{max} = bandwidth of highest frequency channel

For the 100 Hz channels, and a 39 μsec ±10 V range A/D converter, this change is 78 millivolts. For a 12 bit A/D converter this error, referenced to full scale, represents a dynamic worst case error of almost 0.4%. Obviously, this is unacceptable because we haven't considered static errors, and this error alone exceeds the 0.07% requirement.

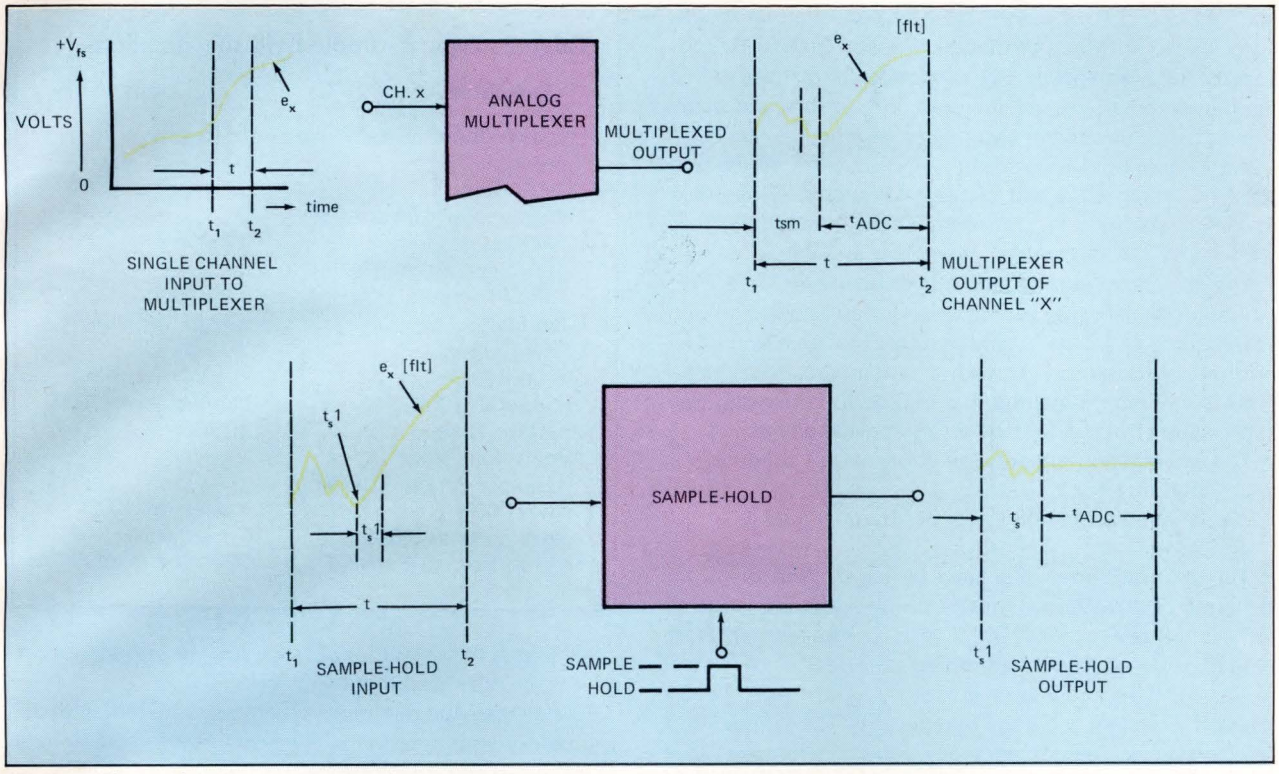


Fig. 3 – High speed A/D converters can be susceptable to errors caused by changing data input during the conversion period, as shown in the top example. To minimize these dynamic errors, the data conversion period must be kept as short as possible. Sample and hold circuits, as shown in the lower position, also avoid these dynamic errors.

There are two ways to reduce or almost eliminate this dynamic error:

1. Use a high speed A/D converter
2. Use a sample-hold in front of a slower A/D converter

Many times, the lower cost solution is to put a sample-hold amplifier in front of the A/D converter. The sample-hold unit will hold the data sample steady (**Fig. 3**) while the A/D conversion is underway. So in effect, you eliminate system aperture errors.

System error budget must be evaluated.

A rigorous error analysis of data-acquisition systems is beyond the scope of this article, but many papers and textbooks on error analysis of systems have been written.[1, 2, 3] Some knowledge of this subject is assumed, in order to be more concise and practical.

Calculate the peak errors of all subsystem components, keeping in mind drift coefficients over the operating temperature range. Having done this, you may be tempted to algebraically sum all of these errors to obtain a worst-case peak error. The odds of all errors being additive, though, are very small, and the widely accepted root-sum-squared (RSS) error better describes the system errors, from a statisical viewpoint. Thus, for sampled data systems the RSS error equivalent to a 99.9% confidence level (3σ) is:

$$\text{RSS error} = \sqrt{P_1^2 + P_2^2 + \cdots + P_n^2} \qquad (3)$$

where P_i = peak errors from each system component

Table 1. Typical 12-bit A/D converter specifications

Specification	Unit
Quantization Error	±1/2 LSB
Resolution	12 Bits
Linearity @ 25°C	±1/2 LSB
Gain Drift (0°C to 70°C)	±7ppm/C° (max.)
Offset Drift (0°C to 70°C)	±2ppm/°C
Linearity Drift (0°C to 70°C)	±3ppm/°C
Conversion Speed	30 μsec
Input Impedance	10^8 Ω
Dynamic Signal Range	±10 V

A 12-bit A/D converter has an inherent 1/2 LSB quantization error, plus offset, gain and non-linearity errors. An analog multiplexer has ON resistance errors which are referenced to the input impedance of the following device (amplifier, sample-hold, or A/D converter), and settling errors due to node capacity if used at maximum speed (this assumes a single-ended multiplexer). The source resistance also creates system errors if the system input impedance is not high enough.

The specifications for a typical low-cost, medium speed 12-bit A/D converter is shown in **Table 1**. The RSS error over a 0°C to 70°C temperature range for this converter calculated with eq. (1-3) is 0.058%. Adding the multiplexer errors to this, and assuming a maximum ON resistance of 500Ω and a maximum source resistance of 1000Ω, the *static* system RSS error is 0.059%. The allowable dynamic error (RSS) is 0.011%. The algebraic sum of dynamic and static errors must be equal to or less than the error budget.

Determining the maximum system aperture

A dynamic error budget of 0.011% for 100 Hz sources and a 12-bit A/D converter requires a minimum conversion speed of 1.1 μsec. It would require either a 1.1 μsec or faster 12-bit A/D converter, or a sample-hold with combined accuracy, droop and aperture error not exceed-

ing 0.011%. High speed 12-bit A/D converters at speeds faster than 100 nsec per bit sell for over $1000. The advantage of high speed A/D converters is realized when high throughput rates are required. But, in this, and many similar cases, this higher cost device may not be needed.

If a sample-hold is used, the static accuracy of the unit must be included as part of the total system static error. Specifications for a typical sample-hold, designed for use with 12 bit A/D converters, are shown in **Table 2**.

The peak error of this sample-hold over a 0°C to +70°C operating temperature is computed for an acquisition and settling time of 5.5 μsec, and assumes that gain and offset error are adjusted to zero with a system gain adjustment. (This is a common method that is used to eliminate these sub-system errors.) The static errors considered are:

1. Dynamic non-linearity (all errors except aperture)
2. Aperture error
3. Gain and offset drift errors over temperature
4. Droop

The aperture error calculated by eq (2) gives us a ΔV dynamic of 80 μV, or 0.0004% of full-scale and the peak error is 0.002% over 0°C to +70°C. Computing this error with the A/D converter and multiplexer peak errors results in a static system RSS error of 0.061%. This is well below the 0.07% system accuracy requirement. The sample-hold thus preserves system accuracy, almost eliminates the aperture error and in addition, allows us to use the lower-cost A/D converter.

Keep in mind that the sample-hold input impedance becomes the *system* input impedance—so, if your source impedance is high (1000Ω typical), you need a high input impedance at the sample-hold in order to keep source loading errors negligible. The sample-hold aperture time also becomes the system aperture time—in this case, 40 nsec. Using this sample-hold with the A/D converter and analog multiplexer we started with, our channel period is 49 μsec, leaving 5.5 μsec for sample-hold acquisition and settling and 3.5 μsec for the data to remain stable on the A/D converter output for acceptance by an external-storage register or peripheral device. Thus, our throughput channel rate requirement can also be met.

How much does a Sample-Hold like the one in **Table 2** cost? This one sells for $135 in small quantities. So, when you can use this device and the $225 A/D converter instead of the $1000 A/D converter, you've saved $600 or more.

This trade-off paid dividends, as you can see, and it will pay you to consider this evaluation when you are faced with the same dilemma.

Checklist for determining your needs

Obviously, the example discussed here will not cover all situations. If you're faced with this same problem, just follow these steps:

1. Determine system throughput (sampling) rate by using eq.(1)
2. If you're considering a specific A/D converter, determine the dynamic system error of that A/D converter, allowing for multiplexer settling and A/D conversion speed.
3. If the A/D converter speed is not high enough, compute the RSS static error of the A/D converter and analog multiplexer.

Table 2. Typical sample-hold specifications

Specification (@ 25°C)	Units
Dynamic Input Signal Range	±10 volts
Input Impedance	10^8 Ω
Bias Current	30 nA
Dynamic Non-Linearity @ 1000 μsec Hold Time	±0.005% of 20V
Gain Accuracy (Adjustable to zero in system)	±0.02%
Gain Drift	±1 ppm pf 20V/°C
Offset Drift	±25 μV/°C
Droop Rate	20μV/msec(max.)
Droop-Rate Drift	Doubles every 10°C
Aperture Time	40 nsec
Acquisition Time (Sample Period) 10V Steps to 0.005%	4 μsec (max.)
20V Steps to 0.005%	5 μsec (max.)
Settling Time to 1 mV	500 nsec (max.)

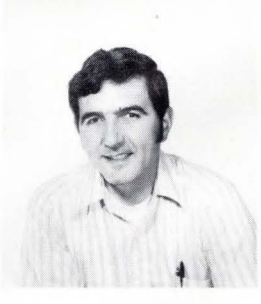
4. Subtract the static error from your error budget—the remainder is your dynamic error budget.
5. Calculate the minimum system aperture required.
6. Make your decision whether to use a sample-hold or high-speed A/D converter.
7. Be sure to recalculate your system error with the approach you've selected, because some specifications (drift, input impedance, etc.) will change.

Selection of the correct configuration is not an easy one—many engineers prefer to pick a high speed A/D converter, and just don't worry about whether a sample-hold is needed. This article should help make that decision easier and save you and your company money. □

References

1. Schwartz, M., *"Information, Transmission, Modulation and Noise,"* Chapter 7, McGraw-Hill, 1959.
2. Gadway, J. R., *"C5 Aircraft Flight Test PCM Multiplexer/Encoder,"* 14th Internation ISA Conference, Volume 14, 1968.
3. *"Analog-Digital Conversion Handbook,"* DEC., 1964.
4. Freeman, Jay, *"Specifying A/D Converters,"* Electronic Engineer, June, 1968.

Author's Biography



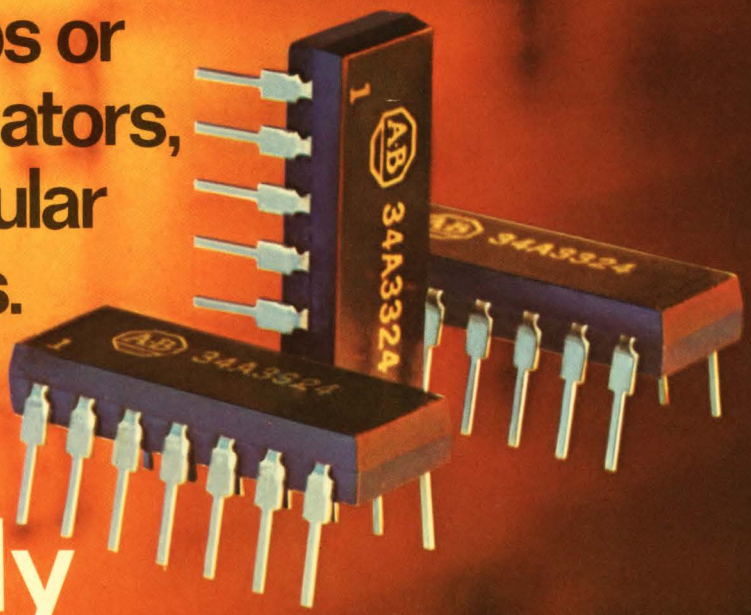
Ron Gadway is Product Marketing Engineer for data conversion products and active filters at Burr-Brown Research Corp., Tucson, Arizona, where he's been employed since 1971.

Prior to joining Burr-Brown, he spent 7 years with EMR-Telemetry in design, project engineering and marketing for avionics telemeters and computerized digital acquisition systems. He also spent two years as an aerospace engineer at Cape Kennedy.

Ron received his BEE degree from the University of Florida in 1961, and has done post graduate study in marketing and business management.

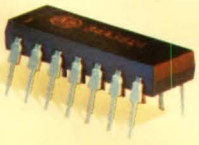
Quality resistor networks now available off-the-shelf.

Pull ups or terminators, in popular values.



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

Now our most popular thick-film resistor networks are ready and waiting, in quantity, at your A-B electronics distributor. Pull-up networks and terminator networks with tolerances of ±2% in popular values from 68 ohms to 22K ohms. All in compatible 14 lead .300 series DIP's. Or if you need something special we'll quickly custom design any circuit that'll fit into a 14 or 16 lead DIP. And we mean quickly. Overall specs include: absolute tolerances to ±.5%. Tracking ±50 ppm/°C (and lower). TCR to ±100 ppm/°C. Write for free technical publications 5850 and 5851. Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Limited, Galt, Ontario. United Kingdom: Morganite Resistors Limited, Jarrow, Durham.



Actual Size

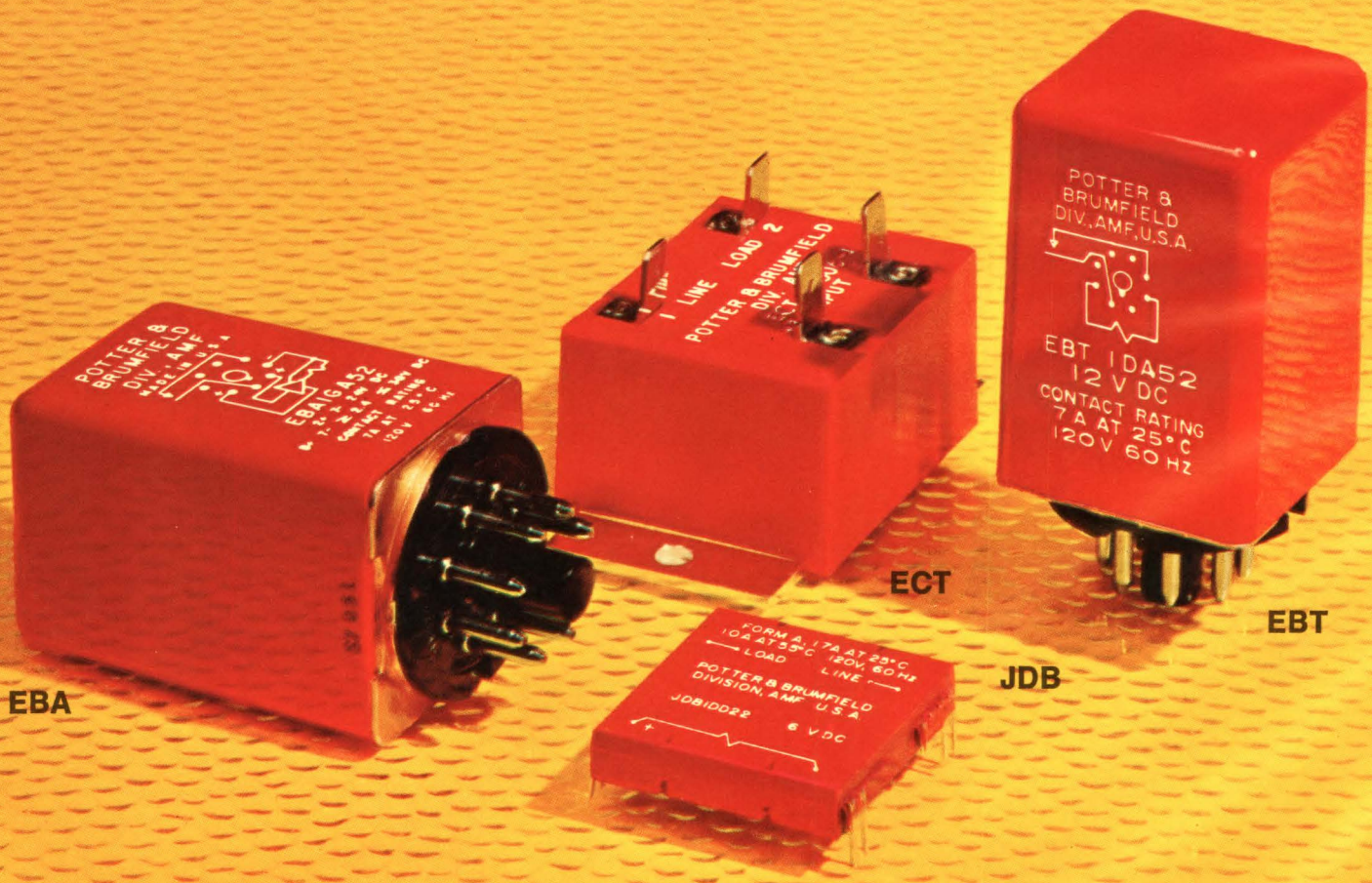
CHECK NO. 31

A-B QUALITY

Allen-Bradley
Milwaukee, Wisconsin 53204

P&B solid state hybrid relays work up to 100 times longer than conventional relays.

More than 10^7 operations.



The expected minimum life of P&B Solid State Hybrid Relays is in excess of 10 million operations for standard load current and ambient temperature combinations.

This uncommon longevity, plus exceptional reliability and a wide range of switching options, offers solutions to many critical switching problems. For example, you can interface semiconductor logic circuits with inductive loads like motors, solenoids and contactors.

P&B Solid State Hybrids will switch up to 7 ampere loads with input control signals as low as 60 microwatts. And they come in a variety of package sizes and terminal styles.

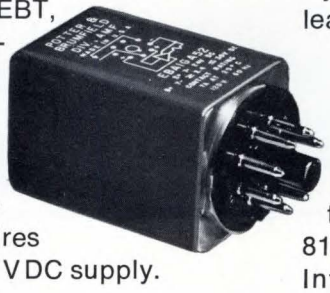
Special triac, special reed

P&B Hybrids owe much of their reliability and outstanding performance to the combining of a reed relay and triac, each having characteristics specially selected to complement the other. This careful mating of semiconductor and relay greatly enhances the reliability of each and, in combination, produces a switching function of consistently superior performance.

Special snubber network

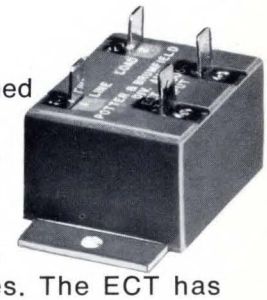
The internal RC network across the "contact" is tailored to the triac specifications and "contact" load ratings to limit sporadic, transient-induced conduction, to provide reliable turn-off of inductive loads, yet to minimize the off-state 60 Hz leakage current.

EBT Series switches 7 amps, 60 Hz @ 25° C ambient with normal load voltage of 120 V. Rated 5 amps. rms 60 Hz @ 55° C ambient. Operate time, 2 msec. Release time, 10 msec. Coil voltages from 6 to 48 VDC at nominal power of 290 mW. Has conventional octal-type plug-in terminals for mounting convenience. Fits P&B KR Series 8-pin sockets for conversion to screw terminals.

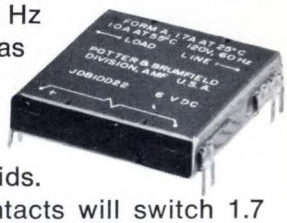


EBA Series has the same switching characteristics, package and mounting of EBT, but with control signal amplifier. Standard sensitivity is 60 microwatts. Requires 12, 18, or 24 VDC supply.

ECT Series has similar specifications as EBT but with a special package designed for direct to chassis mounting. Widely used in business machines and appliances. The ECT has quick-connect terminals. Screw-terminal adapters available.



JDB Series is a Dual Thin-Line reed-triggered triac for use on printed circuit boards. Designed for interfacing solid state circuits to 120 V 60 Hz loads such as contactors, fractional HP motors and solenoids. Form A contacts will switch 1.7 amps. at 25° C ambient or 1.0 A rms 60 Hz at 55° C ambient.



Potter & Brumfield Solid State Hybrid relays are available from leading electronic parts distributors. For complete information call or write your nearest P&B representative or Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385-5251. In Europe, AMF International Limited, Oxford, Oxon, England and AMF Electrica, S.p.A., Milan, Italy.

AMF
Potter & Brumfield

P&B makes more of more kinds of relays than anybody in the business.

Anybody.

CHECK NO. 32

WESCON/72

All together under one roof in LA

This year visitors to the 21*st* annual WESCON convention will not wait in long registration lines, nor will they need to spend much time getting embossed inquiry cards. Waiting at the main entrance to the Convention Center, and at remote parking areas will be computer controlled registration consoles, requiring approximately 25 seconds for operators to enter data from the visitor's registration card. The system, developed by Jacquard Systems of Santa Monica, California (with much encouragement from WESCON staff), controls 5 high speed embossers which are much quieter than the pounding manual embossers used at previous shows. The inquiry card, in a vinal pouch is an integral part of the visitor's badge and is waiting for him a few seconds later as he reaches the port of entry. This will not eliminate lines altogether, at least not on the morning of opening day, Tuesday, September 19*th*. But the computerized registration will greatly reduce waiting and assure that everyone has an inquiry card as well as a badge.

This is but one example of WESCON's effort to streamline the show to meet the needs of the electronics industry that it serves.

Robert Anderson, president of North American Rockwell Corp. is the featured speaker at the opening day WESCON Luncheon in the Convention Center. About 500 of our industry's leaders are expected to attend.

There will be 28 half-day speaker sessions during the 4-day convention at Los Angeles' new Convention Center, September 19-22. In addition to the sessions and exhibits, social events, seminars, technical demonstrations and other special programs are to be held in the voluminous Center. This year for the first time, the Los Angeles Convention Center will house the entire convention and show, eliminating the inconvenience of the event being held in parts at separated locations, as was the last L.A. WESCON program. WESCON/70 was held in Hollywood Park, hotel locations, and the Sports Arena—a 25-mile loop. No doubt WESCON/74 will also be held in the spacious, carpeted, air conditioned Convention Center, designed to accomodate such programs. The exhibit area on the lower level will house about 550 booths on a floor space of 150,000 sq. ft. The sessions and other events are to be held on the

upper level with 24 rooms ranging in capacity from 1800 persons down. A number of major exhibitors have increased their display space dramatically, and several are using the available rooms on the upper level for special seminars and demonstrations.

The session topics have been chosen to meet the current needs of the industry in marketing, unemployment, and many areas of technology relevant to the course of our industry in the next years. These sessions will explore some of the most vital trends and technical developments effecting the future of electronics in the dynamic '70's.

The expected attendance is 25,000 to 30,000 visitors and exhibitors, probably greater than the attendance at last year's show held in San Francisco's Civic Auditorium. (The annual event is held alternately in San Francisco and Los Angeles). Attendance is difficult to predict, although patronage of the show tends to indicate confidence in the convention and show on the exhibitors' part. Companies that have not attended the last few shows have returned this year, and several of the larger exhibitors are using more space and upper level rooms. The facilities at the new Convention Center are tailored to meet the needs of events like WESCON. For the first time this 21*st* show has been scheduled in September (previous shows have been held in the third week of August), which puts it out of conflict with summer vacation plans. It probably puts it into conflict with heavy post-vacation work loads. The effects of the change on attendance remain to be seen.

The traditional Distributor-Manufacturer-Representative Conference will be enjoined by upwards of 500 marketing executives. It will be held all day Thursday, during the show and at the Convention Center. Previously it has been conducted in a hotel on the Monday prior to opening of the show. It is a set of pre-scheduled two-party meetings. Holding the DMR Conference during the show makes participation in the 1 on 1 discussions convenient for component vendors and buyers involved in booth manning on Thursday. Besides, the Monday prior to opening is Yom Kippur.

The popular science film theater has grown larger for the '72 show. Over 100 films have been screened for the film theater, which will be shown each day of the 4-day convention. It is anticipated by WESCON spokesmen that the 250-seat theater may be filled to standing room only.

Featured in the solid-state fabrication section of the exhibit is a nitride P-channel MOS production line, manned and operated according to safety regulations. About 20 companies have participated to provide this P-MOS demonstration, similar to the "solid-state production line" at the show in San Francisco last year.

The big IC manufacturers remain absentees

As expected, the high-volume semiconductor manufacturers shall not be there. They have been conspicuously absent for several years. But the big semiconductor manufacturers may have good reason to return to the trade shows in succeeding years, not in their best known capacity as producers of inexpensive standard parts, but as systems specialists. There are indications that major semiconductor manufacturers shall further expand their capabilities into microelectronic systems-engineering services in the near future. General-purpose standard circuits are proven 'bread and butter' for the big semiconductor houses. But the growing market for high-performance, specialized, and custom circuits may be very appealing to the big semis.

Foreign and domestic exhibitors number about 300

There are manufacturers, distributors, and representatives returning to WESCON this year after 3 or 4 years of absence. Some major exhibitors, such as Hewlett-Packard, Leeds and Northrup, and Systron-Donner will have more booth space than they had in the past few lean years. The economy is on the upswing and exhibitors have more confidence. WESCON told EDN that virtually no booth cancellations have been made as had been the custom at past shows. Apparently the number of new products wanting a show place is up this year. The industry has perhaps recovered a piece of its vitality lost in the recession.

About 15 British companies will be at the show. About the same number of German companies will be there (more than the German attendance of the last WESCON show). Japanese companies will number about 20. In all, about 300 companies foreign and domestic are exhibiting.

New markets should provide greater stability

No business would be secure with but one customer, regardless of the customer's wealth and cherity. Should that customer decide not to buy, the business must undergo painful changes to find another customer, or perish. The electronics industry is still heavily dependant on federal spending, but defense/aerospace cuts in '69 and '70 remind us of the insecurity in heavy reliance on DOD and NASA dollar. Tens of thousands of professionals displaced by the cutback are looking for jobs, and hundreds of companies are seeking new products and new customers.

The 28 session professional program has been prepared to aid the engineering, marketing, and management personnel meet the challenges of this decade. Here is a brief overview of the sessions:

•Eight of the sessions reveal *new devices and systems*. The session topics include computer hardware, software and networks, new semiconductor memories and magnetic-bubble memory research, digital-readout devices, microelectronic packaging, and advances in microwave sources.

•*New applications and design ideas* using known technologies are discussed in nine of the sessions. Topics include programmable calculators as system components, uses of graphic displays in effective places, microwaves in automotive safety and traffic control, the engineering/manufacturing interface, and digital processors in on-board flight control and navigation.

•*Management and marketing* concerns are featured in eight of the sessions. (There is, of course, overlap and mixing of topics in the 28 sessions which is not detailed in this 4-category breakdown.) Some of the topics: consumer ICs in a growing market, aggressive marketing in a climate of change, competition from abroad, electronics in medicine, venture capitalism after the recession and marketing in the dynamic '70's.

•*Career opportunities* in auto safety and control, medical electronics and health-care delivery, and consumer and industrial products engineering are topics in the program, as well as tips on how to land a new job.

For a look at the technical highlights of the show, turn to page 66. WESCON products begin on page 74. □

MAKE IT WITH

thinsheet

WHEN METAL QUALITY IS VITAL

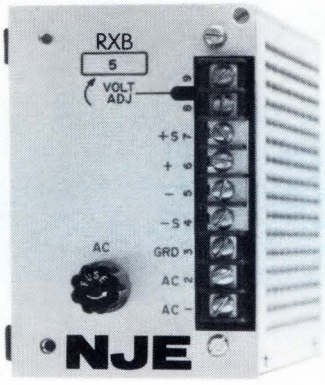
Thinsheet is a name that you can trust when quality and uniformity of thin gauge strip are critical to the reliability factors of your components, printed circuits and conductors. Our thin gauge strip is the finest available. We supply copper, brass, bronze, phosphor bronze, nickel silver and aluminum in gauges from .014" to .0006" with tolerances of ± .0001" and width 1/16" to 26". We also supply tin coated metals and edge tinning processed exclusively on equipment of our own design. In many areas fast deliveries are made with our own fleet of trailer trucks. Write for our full color brochure or phone (203) 756-7414. (In Newark, N.J. area phone direct 642-1624.) The Thinsheet Metals Company, Waterbury, Conn. 06720.

CHECK NO. 35

at $89 it has "built-in" ~~economy~~ Quality

It's our new RXB-5/OVP modular power supply—one of five in the new RXB series from NJE. This new OEM modular series offers current protection, remote sensing, .1% load and line regulation, 5 mV ripple, and is system compatible with our RS series and Lambda's LM and LX series:

Voltage Rating	Current 40°C	Voltage Range	Model	Unit Price	OVP
5V	7	4.75 to 5.5	RXB-5/OVP	$89.00	incl.
6V	6	5.75 to 6.5	RXB-6	$89.00	$5.00
12V	4.2	11 to 13	RXB-12	$89.00	$5.00
15V	3.4	14 to 16	RXB-15	$89.00	$5.00
24V	2.2	23 to 25	RXB-24	$89.00	$5.00



For our new system catalog, write or call NJE Corporation, P.O. Box 50, Dayton, N.J. Phone: (201) 329-4616.

CHECK NO. 36

Employee Drug Abuse

A Manager's Guide to Action

by Carl D. Chambers and Richard D. Heckman.

This book has two objectives: (1) To document the reality of employee drug abuse and its potential proportions and (2) to provide management with information that will help in formulating and implementing company-specific policies and programs to minimize the problem.

For the first time, drug survey specialists measured the incidence of on-the-job drug use. Projections for the use of various drugs, both legal and illegal, are made for seven occupational groups: (1) Professionals, technical workers, managers and owners; (2) Clerical and other white collar workers; (3) Skilled and semi-skilled workers; (4) Unskilled workers; (5) Service and protective workers; (6) Sales workers; (7) Farmers. The most workable aspects of existing policies and programs have been analyzed and evaluated, along with the pitfalls of implementation.

The book offers the actual experiences of companies and employees-a base on which to create one's own policy and programs.

Contents: The Extent of Drug Abuse in Business and Industry; Policy in the Making; Treatment and Rehabilitation of Drug Abuser; About Employee Education and Yours; Communicating with Supervisors; An Avocation Ends; Organizing a Community Drug Council; References and Audio Visual Materials; Drug Glossary; Sources of Information About Drug Abuse. 256 pp.

$12.50

Cahners Books
89 Franklin St.,
Boston, Mass. 02110

Please send me a copy of Employee Drug Abuse: A Manager's Guide to Action for a free 15-day examination. If not completely satisfied, I may return the book and owe nothing. Otherwise I will send my check for $12.50 plus any applicable sales tax.

☐ Bill me ☐ Bill Company
☐ Payment enclosed
(Cahners pays shipping)

Name _____
Company _____
Address _____
City _____
State _____ Zip _____

S58/MO809

CUTLER-HAMMER SNAPS INTO ACTION WHEN YOU NEED PROTOTYPES.

Just watch our action when you call for service! The old-fashioned, dependable kind that just could be brand new to you. With fast application help, fast action on prototypes, and delivery dates you can count on.

Fact is, we *have* snapped into action in a big way. Coming up with new lines of precision snap-action switches, designed and manufactured in the Cutler-Hammer quality tradition. We have samples in stock for immediate inspection.

But remember. If we don't have exactly what you want already, tell us and we'll snap into action to get you a prototype promptly.

Call your Cutler-Hammer Sales Engineer or Switch Distributor and ask him how our snap-action switches (and service) can help you meet your product development schedules on time.

Action you want.

Action you'll get!

Miniature—Five different types with U.L. rating up to 15 amps. Four terminal styles. Choice of actuators—straight lever, roller lever, simulated roller lever.

Sub-miniature—Four basic types with U.L. rating up to 10 amps. Four terminal styles. Same actuator choice as above.

Sub-subminiature—Four basic types with U.L. rating up to 7 amps. Four terminal types. Actuators—a variety of lever, leaf and roller lever types.

Switch to No.1

More than just switches; prompt availability, field help, innovation, quality assurance, too.

CHECK NO. 33

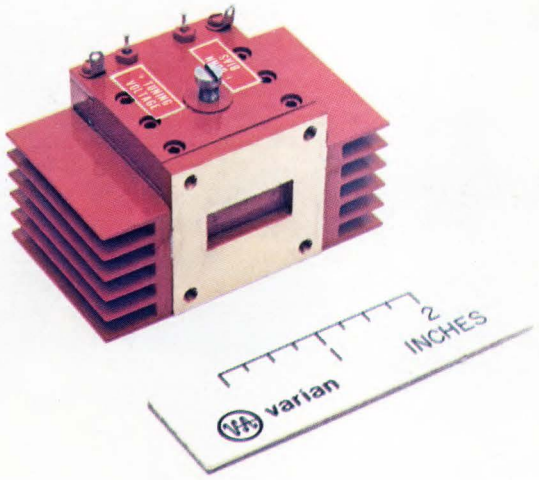
CONTROL

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

WESCON/72 TECHNICAL SESSIONS

Communication links to meet the growing need for digital transmission



The many papers given on communications, terrestrial, vehicular, and satellite, reflect a challenge in meeting the expanding military and commercial needs of the decade. Digital communications systems are highlighted for a wide variety of applications in both direct digital use and in voice and video transmission through digital channels. High-speed digital equipments can meet the needs of analog as well as digital communications. The high-speed digital carriers hold great promise for relieving the overburdened voice and video carriers. PCM techniques are already in use on commercial aircraft for distributing stereo music to the multi-channel head sets enjoyed by the passengers.

And yet, while analog signals are going digital, digital signals are getting into voice and video carriers. An example of one such hybrid communication link is given in a paper by Edwin H. Mueller of Western Union Telegraph Company. His paper, "Hybrid TDM/FDM Transmission over Analog Facilities," describes a method implemented by Western Union to provide 6.3 MB/sec digital capability and 600 voice channels on a wide-band microwave carrier. "The hybrid configuration is found to have an efficiency advantage when new route requirements demand both analog and digital capability," says Mueller, "and [is found] to be particularly applicable to Western Union plans to assemble a digital network." Mueller explains that the 6 GHz hybrid microwave system implemented by Western Union illustrates the practicality of such a hybrid technique. As for the 600 voice channels in the hybrid system described, Mueller says, "The FDM performance objectives using Hybrid operation are identical to those for standard operation. . . . long-term noise performance may actually benefit from the more constant digital load which would reduce busy hour intermodulation.

"Digital long-term performance is good enough over any section to contribute no significant quantity to system errors."

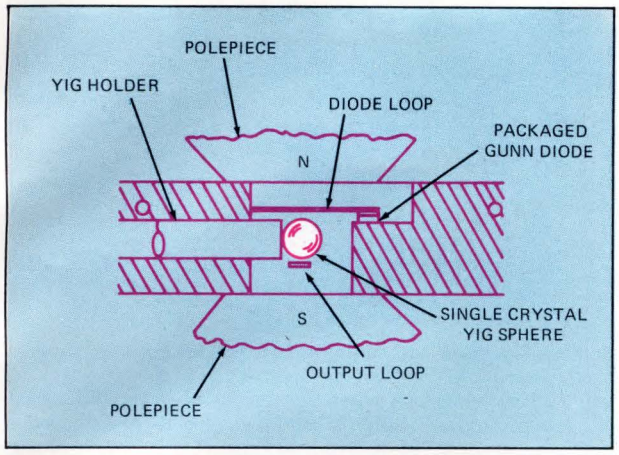
The coaxial cable is a hybrid carrier of two-way digital and two-way analog signals in a system described by engineering faculty members of Japan's Osaka University. Toshihiko Namekawa, Masao Kasahara, and Masashi Murata have co-authored a paper on two-way information distribution systems for local communities and cities of the future. Signals for several services are transmitted over a single coaxial cable to each subscriber. A joint research effort by Osaka University, KEC, and four manufacturing companies in the Kansai area has produced a working model which handles 24 TV channels, 40 CCTV channels, a 2.5 MB/sec two-way digital channel and 60 Hz ac power. The cable developed for the model system has proven to give low signal loss to 300 MHz. The digital signaling is of the synchronous PSK type with error checking and correcting redundancy. The two-way analog information is multiplexed onto the cable by frequency allocation within the 300 MHz bandwidth.

Some probable subscriber benefits of such a system suggested in the paper are TV telephones, fire and burglar alarms, automated utility meter reading, FM and television, and computer terminals. The potential of coaxial transmission, 300 MHz of non-radiating spectrum, will not be long undersold. Present CATV facilities utilize only a minor portion of this broadband medium's capability.

What will be the equipment and service needs in the future of communications? Most certainly digital capability shall be in ever increasing demand in military, commercial, and industrial areas. Serial digital transmission up to 1 GB/sec carried at the speed of light has been implemented. On the opposite extreme, short range transmission, control signaling, and other unburdened links often find the "slow bit" most practical.

A motorist distress signaling system described by L. Schiff and H. Staras of RCA Laboratories has no need for the speedy bit stream. "A Microwave System for Distress Signaling by Disabled Vehicles" describes a short-range (about 100 ft.) vehicular data link that could be implemented on busy highways to speed assistance to injured or disabled motorists. This system, according to Schiff and Staras, would be of greatest value on high-speed, limited-access highways, particularly at night when few passing motorists are willing to stop and offer help.

The system Schiff and Statas describe calls for in-vehicle transceivers and highway-side transceiver units, both



Cross-sectional view of a YIG-tuned Gunn oscillator circuit shows the diode loop and the output loop located orthogonally so that coupling is null in the absence of the YIG sphere. (Varian Associates)

types requiring only a low-power limited range output appropriate for digital messages. Messages are exchanged between passing vehicles and the side of the highway, either with a distressed vehicle, or with a highway-side unit. Thus, a range of about 100 feet is adequate. The stationary units are placed at appropriate intervals along the highway, determined to facilitate the operation of the system. "X-band was chosen for a number of technical and economic reasons," explain the authors. "Perhaps the most compelling reason was the fact that compared to lower frequencies, X-band is a relatively uncongested band that would be ideal for the short range, low power communication links used by the system."

The principle of the system is that cars passing a disabled car transmitting a distress message carry the message to the next interrogator transceiver along the highway. Motorists equipped with this distress signaling capability would have a transmitter for repeat sending of a distress signal, and transmission upon request of stored distress messages. In addition, they would have a receiver for accepting and storing in memory a message from a disabled motorist, and receiving the interrogator unit's request to transmit the data, if any, stored in memory.

The disabled motorist at the side of the highway would press one of several buttons, such as "need ambulance," "need tow truck," "send police," etc. which would then activate his transmitter to repeatedly send the selected distress message to be received and stored in registers of passing vehicles. At the next interrogator location down the highway, the carrier vehicles transmit the stored message upon request signaling, and clear their memory registers. From the location of the interrogator receiving a distress message, rapid dispatch of appropriate aid is possible.

Acknowledgment that help is on the way could be carried to the distressed motorist by passing cars having received and stored an acknowledge message from the highway-side interrogator transceiver on the other side of the distressed vehicle.

Other uses of such vehicular data system are possible in addition to distress signaling. But the authors illustrate the magnitude of the problem revealed by statistics from the New York Thruway Authority. "The New York Thruway is a 559-mile toll road of the interstate type that carried 3.9×10^9 vehicle miles in 1969," Schiff and Staras report. "In that year there were 94,158 vehicle breakdowns that necessitated emergency service and 5442 accidents that required police and/or ambulance service."

Microwaves seem to be of key interest at the WESCON sessions this year, in satellite and terrestrial communications as well as in other applications such as electronic counter measures (ECM).

"The YIG tuned Gunn effect oscillator made its debut in mid-1968 when Varian delivered a 10 mW, X-band oscillator for use in an all solid state X-band microwave sweeper," declare Bob Oyafuso and Don Zangrando of Varian. They are co-authors of a paper describing advances in YIG tuned oscillators. The YIG tuned Ku-band source became available in '69, and a C-band Gunn oscillator is presently under development according to Oyafuso and Zangrando." □

Semiconductors for automotive and consumer use come under close scrutiny

Session 2 of the Wescon program will examine the "Present and Future Potential of ICs in Consumer Electronics."

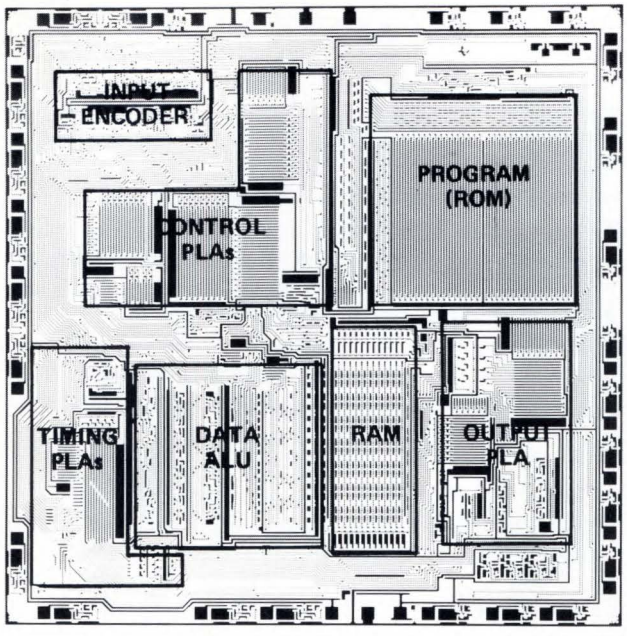
According to the session chairman: "Integrated circuits for consumer applications are of substantially growing interest to the designer and to the electronics manufacturer for two reasons. First, the expansion of ICs into the consumer area offers a potential new market to replace that lost by the reduction of military and aerospace spending. And second, there is a strong trend in the industry to replace discrete or hybrid components with ICs because of such advantages as reduced cost, improved performance and increased reliability.

"Currently, manufacturers are producing a host of new ICs either adapted to or specially designed to replace discrete or hybrid functional subsystems in television receivers, FM/AM radios, stereos, and other types of consumer devices. This includes ICs for automotive electronics, wrist watches, calculators, and other low-power units.

Also in session 2, the present status of the consumer IC industry will be reviewed. In addition, an in-depth look will be taken at the future potential of consumer ICs for providing a strong industrial growth rate.

"The present status of consumer ICs in the entertainment field—TV, radios, stereos—will be reviewed. New technological developments in producing ICs with higher performance by the use of techniques such as ion implantation, will also be described and evaluated."

To accomplish this, the coordinator has arranged for four



One-chip calculators, such as this TMS0100 from Texas Instruments, have reduced the labor content of a typical calculator to 15 minutes. ICs for other consumer products are expected to bring equally impressive reductions in labor, and return much of the consumer market to US manufacturers.

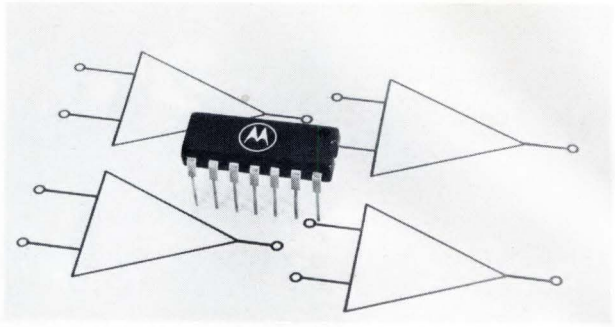
speakers from the semiconductor industry. The first of these is Joe Obot, Consumer Marketing Manager at National Semiconductor Corp. His paper, "Consumer ICs—Tomorrows Promised Land" first examines the causes (eroding technological leadership and expensive labor) of the US slide from first place in the manufacture of consumer electronics and the key whereby this lead can be regained. That key, he feels, is the consumer IC, owing to the fact that the US still maintains a technological edge in the production of MSI and LSI circuits, and that ICs will remove most of the labor content of consumer products. The five major segments of the consumer market, as outlined by Mr. Obot, are:

1.—Entertainment
2.—Automobiles
3.—Calculators
4.—Appliances
5.—Cameras

The single-chip calculator has reduced the labor content of a typical unit to 15 minutes. The same gain can be made in the other fields, Mr. Obot concludes.

Many new ICs for the entertainment segment of the consumer market are covered by Messrs Lutz, Mac Dougall, Hanson and Tkal from the Sprague Electric Co., Semiconductor Div. in their paper "New Developments in Consumer Integrated Circuits." Devices described in this second paper include dual 2 and 4W audio amplifiers and a monolithic 3W TV-FM sound channel.

R. W. Russell of National Semiconductor delivers a paper entitled "Automotive ICs—A Whole New Ballgame." Mr. Russell points out that many of the present ICs accepted as standard by our industry are not readily adaptable to automotive use primarily because of the available power supply—a single voltage battery. In attempting to penetrate the automotive field, Mr. Russell predicts a new series of "building blocks" such as the quad op amp, LM3900, recently introduced by National.



Building blocks for automotive use, such as the quad op amps recently introduced by National and Motorola point the way to future developments. A whole new series of linear and digital ICs designed for use with 12V battery supplies is presently under development by most IC manufacturers. Op amps, requiring ±15V supplies were simply unacceptable to automotive designers.

The concluding paper in session 2 will be "An Engineering Assessment of Low-Power Digital ICs for Consumer Products" presented by Donald Carley of RCA's Solid State Div. Although EDN didn't have a preliminary copy of this paper for review, it's reasonably certain that the topic is CMOS (or COS/MOS as it's called at RCA). This should certainly be a paper of interest to EEs involved in consumer or automotive designs because the inherent advantages of CMOS in such areas are hard to deny.

Session 9, on Wednesday, will cover "Electronics for Automotive Safety and Control" and will begin with Todd Rachel, Manager of Engineering at the Bendix Corp., delivering his paper on electronic fuel injection.

The second paper, "Environmental Problems of Vehicular Electronics" by W. J. Wash of the Eaton Corp., deals with the harsh realities of the life of a semiconductor installed in an automobile. The power bus variations are horrendous, and learning to cope with them will be one of the most difficult challenges that the IC makers have encountered for a long time.

The third paper of session 9, "The Practical Aspects of Electronic Braking" by John Frait, of Kelsy-Hayes begins with a thorough analysis of anti-lock braking systems. Such brake systems today cost the consumer about $180 to $200. Mr. Frait admits that only an IC braking system can bring this cost down to a practical level.

Laws are creating markets

It is ironic that markets that the electronics industry could never penetrate on a "look-at-the-wonders-we-can-perform" basis, are now being progressively forced open by present or expected government regulations. The automotive safety market is the current prime example of this. At least three Wescon sessions—9, 20 and 2—will touch upon this enforced shotgun wedding; with topics such as the following:

- Collision sensing warning to give drivers a chance to brake before tail-gate impact (Session 20).
- Imminent crash sensing to automatically inflate air bags (Session 20).
- Logic to truly assure that safety belts are on before car is started (Session 2).

And beyond these obvious examples there will be mentions of secondary effects. For example, the author of a paper in session 2 (Carley of RCA) told us that the automo-

bile manufacturers are now seriously considering transmissions controlled by electronics because then the speed changes can be more readily changed to meet future legislation on pollution that affects engine design.

Electronics may not always be the cheapest way, but it is decidedly the best way, if one has to remain flexible to react to last-minute laws.

Of all the systems being encouraged under this new turn of events, the short-range crash sensor that will be discussed by John Hopkins and others from the U.S. Dept. of Transportation's research center, Cambridge, Mass., (session 20) has attracted the most interest. Detecting an imminent collision soon enough to inflate an air bag and save passengers, even when the auto is travelling at 60 mph, is an exciting, appealing concept. Only some electronic scheme that reaches out ahead of the vehicle and "anticipates" the crash can do the job at speeds over 30 mph—the speed that represents the limit of the present mechanical sensors being considered for air-bag deployment, Hopkins says.

The approach Hopkins will describe uses a 10 GHz microwave radar to look three feet ahead of the vehicle, and then a comparator to detect the doppler shift that indicates the presence of a "dangerous object." Tests have shown that the concept has basic feasibility and that the sensors might even be mass produced for as little as $10 per vehicle. At present Hopkin's group is letting small contracts to industry to further define the hardware components and is making an exhaustive study of the danger of false triggering of the airbag (a problem that might occur as two cars start up in a parking lot).

Hopkins told EDN that to some degree his paper will be a repeat of the one he gave in Detroit in May to the SAE conference on crash sensors (SAE paper No. 720423). However he will put more emphasis on the electronic aspects for the Wescon audience. Neither he nor others believe these high-performance crash anticipators will be on all the '76 autos, even if those end up having air bags. But they might be offered as delux items on top-of-the-line models.

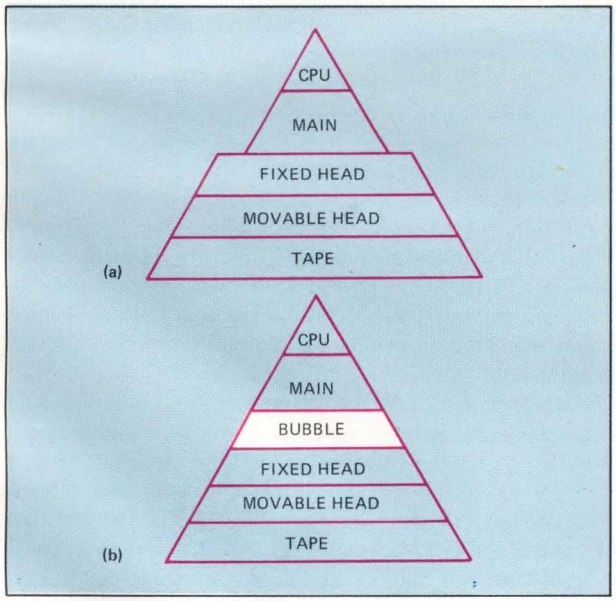
Practicality and usefullness are the bywords in computer sessions

For those whose interests lie in some area of the computer field, there is a great variety and wealth of practical information to be had in the WESCON technical sessions.

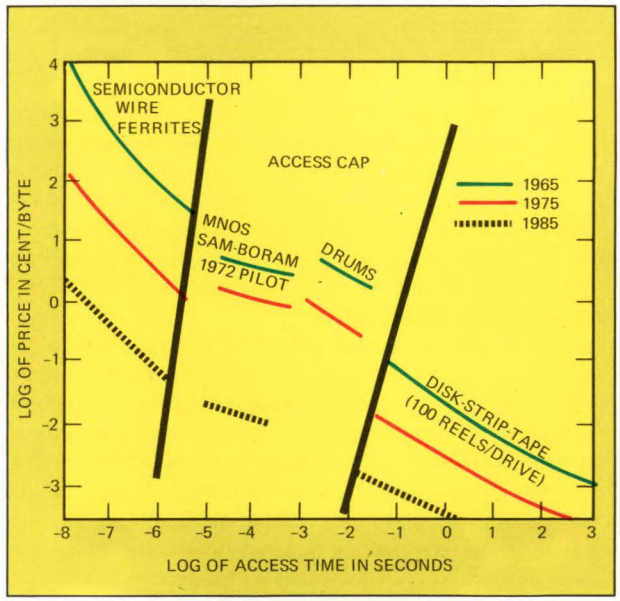
As always, the subject of memories is popular; however, topics discussed are essentially limited to MOS ROMs, more specifically electrically alterable ROMs, and magnetic bubbles. Notable by their absence are bipolar memories and mass-storage systems. This should not be taken to mean that both of these technologies are on the wane but rather that more activity is taking place in the featured areas.

In the session on electrically-alterable non-volatile ROMs (EAROM), different forms of nitride MOS (MNOS) processes appear to be the prevelant technology used (session 4).

There are basically two classes of storage mechanisms described: one using a charge stored in deep energy states at the interface between two dielectrics in the gate structure, and the other using a floating electrode buried in the



Bubble memories are anticipated to fill the discontinuity in performance between random access main memory and serial access secondary memory. This relationship depicted in the above memory hierarchies.



One way to fill the memory access gap between semiconductor and electromechanical memory systems is to use electrically alterable ROMs. Litton Systems shows how their sequential-access block-oriented memory performs this function.

gate dielectric. However, EAROMs made with these technologies must be "block-erased", have reduced speed, and require extra care for reading and writing.

Other methods for making EAROMs are also covered in this session.

Another full session (session 8) is devoted to the magnetic bubble. From the tone of the papers presented, it looks like the bubble is moving closer to being a competing mass-storage technology. It is expected that the bubble will fill the void between 3D semiconductor memories and 1D discs, drums and tapes as a means of storage, and also fill the access time slot between 1 μsec and 10 msec (100 μsec-10 msec range).

For those interested in programmable calculators, session 13 should answer many questions for prospective users. The calculator vs. the minicomputer or time-share terminal, keyboard vs. algebraic calculators, and peripherals for calculators are some of the subjects covered. An added question and answer session should fill all other voids.

Criteria for selection or different types of graphics for minicomputers, as well as a discussion of communications guidelines between graphics terminals and computers highlight session 17.

An emerging area which is generating high interest is the development of LSI/MSI microcomputers. A discussion of some different approaches to the design of a microcomputer set of chips as well as considerations and uses of microcomputer sets are well covered in session 26.

Prospects and problems for EEs in medicine

The interdisciplinary gap between electronic and medical professionals has been and remains a stymie to the more effective use of electronics in health care. Hospital administrators have difficulty recognizing the roll of engineers and instrumentation in the overall picture of health-care delivery. Equipment manufacturers do not always know what is most needed and what special features should be designed in.

Job-hunting defense/aerospace engineers looking at a career in bioengineering find few positions offered without a need for academic training in the biological sciences. Patient safety considerations are not always well recognized by medical equipment designers, and the need for training the health-care staff in the use of computers and instruments is another issue. Electronics in medicine is a disciplinary mix that calls for a better interface. Professionals trained and experienced in both the life sciences and electronic engineering are the missing link.

Speakers from academic institutions, hospitals, and research centers have been gathered by WESCON to probe the problems and potentials of electronics in medicine. Two sessions in the program (sessions 12 and 16) have been planned to cover both the areas of marketing and career possibilities.

Session 16, "Biomedical Engineering: Educating Engineers for Careers in Health Care Delivery" was organized by Major Richard J. Gowen of the U. S. Air Force Academy in Colorado Springs, with cooperation from the Biomedical Committee of the American Society for Engineering Education. A closer look at equipment and market potentials in medical electronics is given in session 12, "Needs and Trends in Medical Electronics 1972."

Cautious optimism and ambivalence typify many remarks made by the speakers. "The current wave of public disillusionment with technology has combined with recent economic pressures to depress the market for many medical electronic products," says Malcolm G. Ridgway, of the University of Southern California's Biomedical Engineering Institute. But the same forces create an increased demand for biomedical engineering support now being placed in clinics and community hospitals Ridgway continues. But, "By using these new groups of in-hospital engineers to assist in determining the priority needs in medical and other health service areas . . . it appears possible that we can recover some of the lost ground. New markets may even be opened up to help offset the reduced growth rate to be expected in some of the established product markets." In a less sanguine tone, Ridgway points out that medical electronics now amounts to "considerably less than 1%" of the total national health-care market.

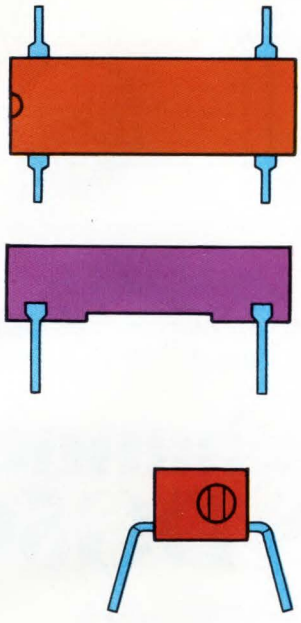
On the other hand, less than 1% of an enormous market is not being ignored by the electronics industry. According to Morton D. Schwartz, of California State University, Long Beach, the health care dollar value will be well over $100 billion and 8% of the projected GNP by 1975.

Doctor Schwartz points out the growing need for computers and automated equipment in hospitals, and the associated need for technical personnel. He says:

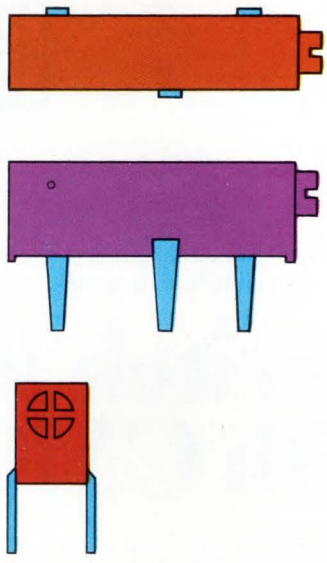
"Although today there are relatively few engineers working in hospitals, the demand for greater capacity in health care facilities may change that. Perhaps opportunities in medicine will open up to displaced defense/aerospace professionals as well as jobless new graduates. In addition, if electronics in health-care centers becomes more prominent, as many marketing analysts anticipate, more job openings in equipment and systems design will result. And the bioengineer is a requisite part of an efficient health care staff, a fact not yet universally accepted among hospital administrators."

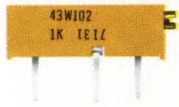
"A major thrust of technology that defines the need for bioengineers in hospitals is medical instrumentation," says Bruce Barkalow in relating his experiences with a health care team. Barkalow is currently with Sutter Community Hospital and California State University, both in Sacramento. His excellent paper, "Bioengineering in a Community Hospital" presents the spectrum of tasks performed by a bioengineer, and the skills required for this type of employment.

Barkalow describes the responsibilities and duties of bioengineering in three major categories: instrumentation (selection, maintenance, design, and user training), patient care, and research. He says that the bioengineer is often regarded as a misfit in the hospital. "Few people are sure who he is or what he does." "A conservative view of some hospital administrators acquainted with bioengineering seems to be that the bioengineer is a luxury item, and although he is convenient to have, the hospital can not afford to hire him." □



THE NEW MODEL 45
actual size





THE MODEL 43
actual size

- **Improved Setability and Stability** — Twenty turns, brush contacts, and unique "T" slider block design.
- **Improved CRV and RT Tolerance** — Three percent or three ohms CRV and ±10% tolerance.
- **Sealed Case** — Permits cleaning in common solvents.
- **Resistance to Shock and Vibration** — Meets pertinent MIL-R-22097 requirements.
- **Low Cost** — Priced to sell competitively.

- **Improved Setability and Stability** — Twenty turns, brush contacts, and unique "T" slider block design.
- **Improved CRV and RT Tolerance** — Three percent or three ohms CRV and ±10% tolerance.
- **Sealed Case** — Permits cleaning in common solvents.
- **Resistance to Shock and Vibration** — Meets pertinent MIL-R-22097 requirements.
- **Low Cost** — Priced to sell competitively.

Now, all the superior features of our Model 43 trimmer in a DIP package... the new Model 45!

Fact is, if you liked our Model 43 rectangular cermet trimmer, you'll love our Model 45 DIP cermet. It's virtually a mirror-image of the 43 when it comes to specs and performance. It's essentially the 43 laid on its side with conventional dual-in-line pin spacing. It stands only .190 inch off the board for compatible assembly with IC's, and it can be supplied in plastic magazines for automatic insertion machines. You can be sure that both units are priced very competitively. For data sheets, just use the reader service card.

Spectrol

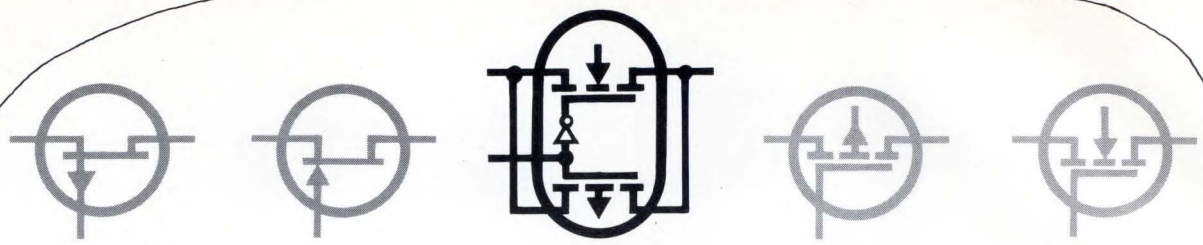
SPECTROL ELECTRONICS GROUP

UNITED KINGDOM
Spectrol Reliance Ltd.
Drakes Way
Swindon, Wiltshire, England
Swindon 21351 • TELEX: 44692

UNITED STATES
Spectrol Electronics Corporation
17070 E. Gale Avenue
City of Industry, Calif. 91745, U.S.A.
(213) 964-6565 • TWX (910) 584-1314

ITALY
SP Elettronica spa
Via Carlo Pisacane 7
20016 Pero (Milan) Italy
35 30 241 • TELEX: 32242

CHECK NO. 23



Since 1962, Siliconix has evolved FET technology and applied it to a complete line of singles, duals, arrays, and IC's. So what's new?

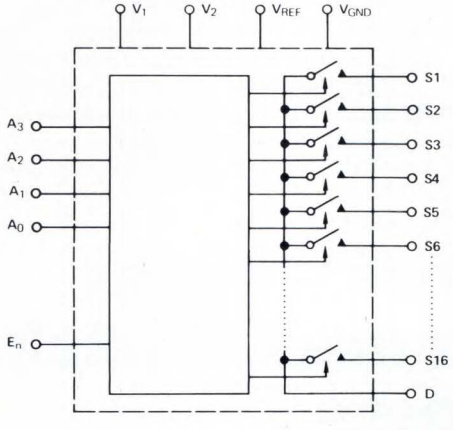
Switch 16 channels with CMOS DG506.

Here is a single-pole 16-channel multiplexer using paired CMOS FETs, with drivers controlled by a 4-bit binary word input plus an Enable-Inhibit input — all on one chip! Check the functional diagram and then refer to the decode truth table to see what binary word input selects which switch.

The DG506 features:

- ±15 V Analog signal range
- Break-before-make switches
- ON resistance <500 ohms
- TTL, DTL, and CMOS direct control interface
- 36 mW standby power

DG506 Function Diagram



Decode Truth Table

A_3	A_2	A_1	A_0	E_n	ON SWITCH
X	X	X	X	0	NONE
0	0	0	0	1	1
0	0	0	1	1	2
0	0	1	0	1	3
0	0	1	1	1	4
0	1	0	0	1	5
0	1	0	1	1	6
0	1	1	0	1	7
0	1	1	1	1	8
1	0	0	0	1	9
1	0	0	1	1	10
1	0	1	0	1	11
1	0	1	1	1	12
1	1	0	0	1	13
1	1	0	1	1	14
1	1	1	0	1	15
1	1	1	1	1	16

Our catalog line of drivers and switches will cover most applications. If your switching problems are unique — and whose aren't — call our applications people. They're eager to help. For complete information,

write for data

Applications Engineering: (408) 246-8905

Siliconix incorporated

2201 Laurelwood Road, Santa Clara, California 95054

CHECK NO. 19

SIL-686 DOMESTIC

series 1400

illuminated push button controls

a versatile concept that gives you flexibility in designing interrelated switching combinations . . . plus prototypes in 72 hours

Momentary . . . push/push . . . reciprocal release . . . master release . . . interlock . . . one assembly does the job of several.

Mount vertically or horizontally. Up to 20 stations on a single frame. Contacts are DPDT, 2 amps, 250 VAC. Single series 1400 push buttons and indicator lights to match.

For details, or to order a custom 72-hour prototype, write or call:

LEDEX the total technology people

LEDEX INC.
123 Webster Street
Dayton, Ohio 45401
(513) 224-9891

POSITIONING SWITCHING MICROELECTRONICS

CHECK NO. 14

VHF generators have synthesizer stability

Low noise, broad frequency coverage and precision modulation are the foremost attributes of two new AM/FM signal generators from Hewlett-Packard. Covering 450 kHz to 550 MHz with calibrated modulation and +19 to −145 dBm output levels, they can perform complete RF and IF tests on virtually any kind of VHF receiver. How well they perform these tests is where HP feels the new generators, Models 8640A and 8640B, make their major contribution.

Both units deliver low-noise signals that are state-of-the-art for solid-state signal generators. Non-harmonic and sub-harmonic outputs are down more than 100 dB, and wideband signal/noise ratio is better than 140 dB/Hz. Close-in noise, critical in mobile radio adjacent-channel selectivity tests, is specified at −130 dB/Hz at 20 kHz offset. These figures are at least an order of magnitude better than other solid-state signal generators, and they rival the noise performance that previously only the best tube-type generators could offer.

One version of the new signal generator, HP Model 8640A, has a slide-rule tuning dial with 0.5% frequency accuracy and drift of less than 10 ppm per 10 minutes. The other, Model 8640B, has a 6-digit LED display (useful separately as a 550 MHz frequency counter) and a built-in phase-lock synchronizer to achieve output stability of better than 5×10^{-8} per hour; in other words, this signal generator has synthesizer stability.

Even when the 8640B is locked, the spectral purity and precision FM of the unlocked mode is preserved. This permits meaningful tests on narrowband and crystal controlled receivers. Provision is also made for locking to an externally applied 5 MHz standard for even higher stability or for locking two 8640Bs together for various two-tone tests.

In the unlocked mode the built-in counter can display the 8640B's frequency to a resolution of 100 Hz at 500 MHz and 0.1 Hz at 500 kHz. The counter can also measure external signals between 20 Hz and 550 MHz, eliminating the need for separate frequency measuring equipment in many test applications.

Except for the counter and lock features, the overall performance of the 8640A and 8640B Signal Generators is identical. Power output is calibrated from +19 to −145 dBm (2V to 0.03 μV) and leveled to ±0.5 dB. The maximum output of +19 dBm permits high level tests on receiver IFs, amplifiers, and mixers without additional power amplification. Accurate low level measurements down to −145 dBm have been assured through extensive RFI shielding and use of an accurately calibrated step attenuator. The output level is displayed on both a direct reading dial and a built-in meter that autoranges for high resolution.

The modulating precision of these generators matches their CW performance. Independent AM and FM are metered and calibrated for all RF output frequencies and levels. AM is adjustable from 0 to 100% with the bandwidth, accuracy and low incidental FM required for the most stringent AM measurement applications. Distortion is <1% to 50% AM and <3% at 70% AM. Provision is also made for external pulse modulation with pulse widths down to 1 μsec.

The FM mode provides calibrated and metered deviation that remains constant with frequency or band changes. Peak deviations to at least 0.5% of carrier frequency are available. Important for accurate narrowband FM measurements, there is negligible frequency shift from the CW to the FM mode and no degradation in spectral purity. With the 8640B in the phase locked mode, full FM capability is preserved at modulating rates from 50 Hz to 250 kHz.

The price of the HP 8640A is $3100; and the 8640B is $4450.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.

Booth 1208 **Check No. 290**

Hand-held calculators offer computer performance

The first four models in a new line of Micro Computers which combine the power and versatility of desktop computers with the small size and low cost of hand-held calculators are available from Computer Design Corp.

The new machines are the nonprogrammable Models 320 Scientist and 340 Statistician, and the programmable Models 322 and 342.

The Micro Computers offer a range of powerful key functions previously found only on much larger and more costly machines. Each model has multiple storage registers, calculates with true 13-digit accuracy, and displays 10 digits with sign and 2-digit exponent. The displays are easily readable even from a distance and in bright sunlight.

The Micro Computers measure 5 x 9 x 2 in. and weigh less than three lbs. They are readily portable for professional use in the field and the home, and still are too large to be misplaced.

The keyboards are fully algebraic and have keys for right and left parentheses, which can be double-nested. Models 322 and 342 feature an 80-step "scratchpad" programmer which is extremely simple to operate and allows the user to verify his program while he is entering it.

Prices begin at $595 for the Scientist and $795 for the Statistician, with volume discounts.

In addition to arithmetic and storage and recall keys, the Micro Scientist has special keys for sine, cosine, tangent, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, to polar, to rectangular, a^x, square root, $\log_e$, e^x, $\log_{10}$, 10^x, radian-degree and degree-radian conversion, decimal angle to degrees-minutes-seconds and degrees-minutes-seconds to decimal angle with a single stroke.

Computer Design Corp., 1734 21st. St., Santa Monica, CA 90494. Phone (213) 828-7597.

Booth 4914 **Check No. 291**

CMOS A/D converters require only 80 mW maximum

The ADC-CM Series are low power analog-to-digital converters that have been developed to solve the problems of operation in remote areas with limited power.

The ADC-CM Series, when operating in a conversion mode, have a total power consumption of about 1/60th of that of a conventional design. However, in the standby mode of operation, there is essentially zero power drain.

CMOS logic is the key behind the lower power consumption. The overall result: The complete converter draws only 7 mA maximum from a 12V supply at a 400 Hz conversion rate and less than 3.5 mA at 200 Hz.

In its environmental state, the converter does not have to be fast, because data taken from ocean buoys, meteorological sensors and pollution detectors usually vary slowly with time. However, over a long period of time that data taken may vary widely, so a broad dynamic range in many applications is essential. The ADC-CM Series satisfies this requirement: Its 12-bit resolution permits accuracy of one part in 4096.

The ADC-CM Series utilize the successive approximation conversion technique. They contain a CMOS programmer, output register, electronic switches and clock plus a low power linear comparator and active voltage reference source.

The entire A/D converter is contained in a 3.2 cu. in. humidity/shock resistant module measuring 2 × 2 × 0.375 in. Prices range from $395 for the 8-bit version to $495 for the 12-bit model.

Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395.

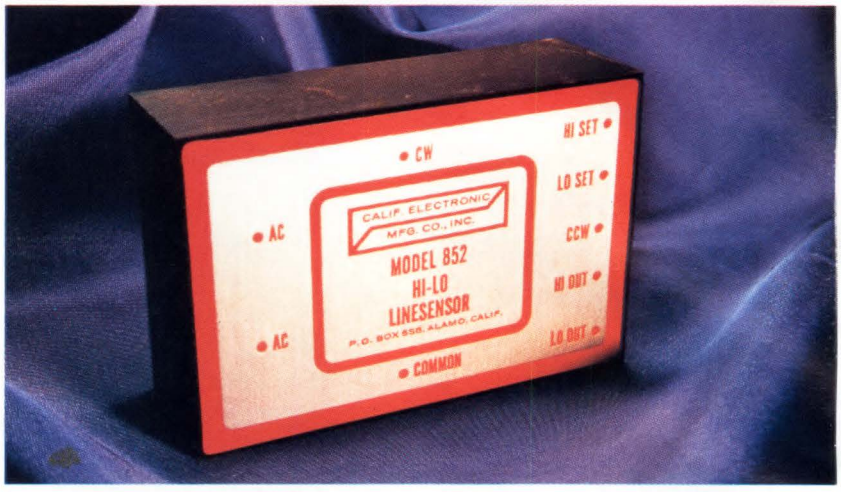
Booth 4900 **Check No. 292**

Line-voltage monitor has 1V accuracy

Logic compatible ac voltage comparator/monitor, Model 852-5V, has two setpoint circuits which can monitor line voltages (110 or 220) with better than 1V rms accuracy and repeatability. The two setpoints are completely independent and provide fail-safe signals in response to excursions through the high or low setpoints.

The outputs, separately available from each trip point, are a TTL compatible +5V dc. Power for the Model 852-5V LINESENSOR comes directly from the line it is monitoring. No external power supplies are required. A rising voltage will trigger a response in better than 1 msec, a falling voltage within 10 msec. The Model 852-5V is packaged in a 2 × 3 × 1 in. high case.

Specifications include: trip point range of 80-115V ac (low set) and 115-150V ac (high set) (220V ac range optional); repeatability and sensitivity of better than 1V rms; trip point stability of better than 25 mV rms/°C. Priced at only $58 each



CALEX, P. O. Box 555, Alamo, CA 94507. Phone (415) 932-3911.

Booth 1802 **Check No. 277**

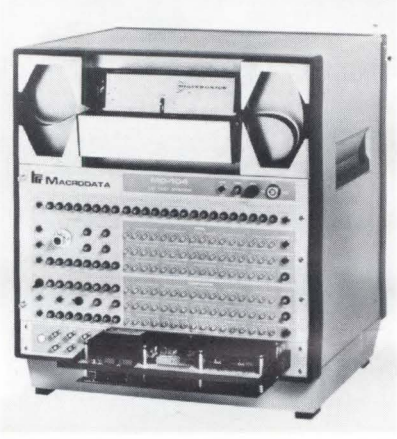
Low-cost LSI test system has 10 MHz rep rate

Macrodata has announced the introduction of the MD-104 LSI Test System, said to be the first true, low-cost, 10-MHz system. Features of the MD-104 include: a 10-MHz rep rate which more than doubles the throughput capability presently offered by most other testers and which allows the user to test bipolar memories on-line at system operational speeds; a standard random-access control memory of 64 words by 24 bits wide—expandable to 128 words; a high-speed, built-in paper tape reader; a direct and immediate display of failure conditions, allowing call-up of the exact error condition in both address and data; an improved instruction set and enhanced subroutine and loop capability, including automatic refresh for dynamic memories.

Prices on the MD-104 start at $24,950; and delivery is 60 to 90 days from date of order.

Macrodata Co., 20440 Corisco St., Chatsworth, CA 91311. Phone (213) 882-8880.

Booth 1600 **Check No. 278**



Transmission/reflection analyzer reads gain, loss and VSWR

Model TRA-1001 is a permanently calibrated, two channel comparison power meter which has greater than 60 dB of differential dynamic range. It combines capability in one instrument of fast, accurate measurements by unskilled operators, of transmission and reflection properties (referenced to a 50Ω system) of networks and systems.

Gain, loss and VSWR are read directly during test or alignment of both passive and active components, instruments and transmission lines. These parameters are read on a central, wide-scale meter calibrated in VSWR and dB, with input power simultaneously displayed on a separate meter from either channel as selected by a panel push button.

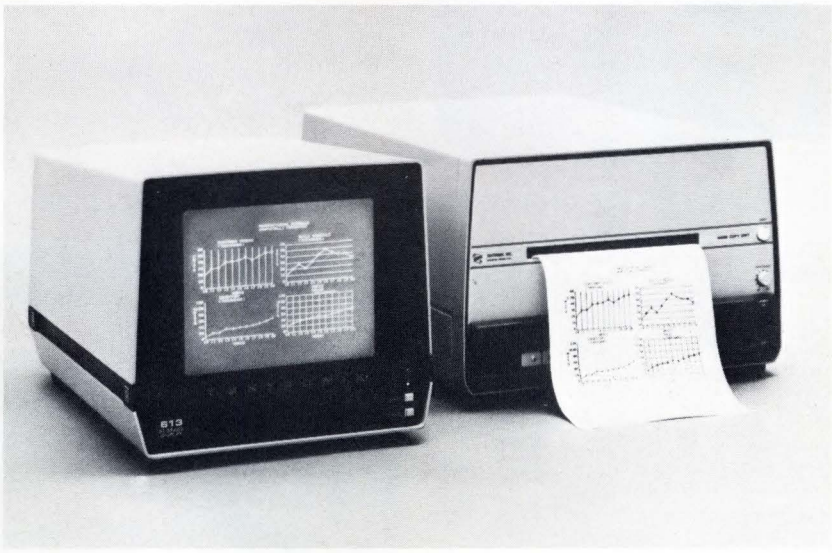
The Vari-L Co., Inc., 3883 Monaco Pkwy., Denver, CO 80207. Phone (303) 321-1511.

Booth 2203 **Check No. 279**

CRT display has hard-copy compatibility

The 613 storage display is a bright, low-cost, large-screen data-storage and display unit. Use includes any environment where a substantial amount of data is stored and presented in a single display. Use of a newly designed, 11-in. storage cathode-ray tube provides a bright trace for easy viewing of high density alphanumeric and graphic displays in high ambient light conditions. The 613 storage display provides high information density without flicker. Direct view storage eliminates the need for memory devices required in refreshed information displays. Permanent hard copies of the displayed information are available by using the fully compatible 4610 Hard Copy unit, which provides full screen copies in 18 sec.

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161.

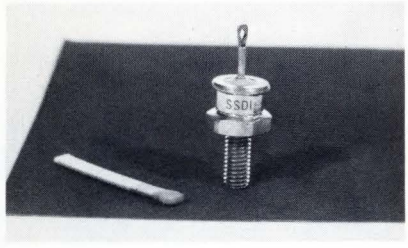


Booth 1101 **Check No. 280**

3A rectifier series are radiation hardened

The HSR-2A series of 3A stud mounted rectifiers, feature a forward recovery of 1 nsec max. and reverse recovery of 10 nsec max. and a forward voltage drop of 0.90V max. The new series is available in 5 separate types with PRV of 10, 25, 50, 87 and 100. Maximum I_r at 0.5 PRV for all types is 25 μA. Package configuration is DO4 stud mounting.

Solid State Devices, Inc., 12741 Los Nietos Rd., Santa Fe Springs, CA 90670. Phone (213) 689-3711.

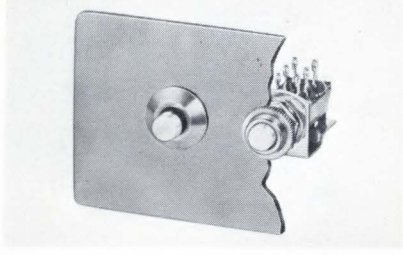


Booth 2408 **Check No. 281**

Push-button switch aids man-machine interface

A low-cost multifunction push-button switch features immediate, continuous recognition of "in" and "out" positions without lamps or indicators. There is no possibility of a false identification caused by a malfunctioning lamp. Series DVR-2000 is especially suited to computer and peripheral equipment, multi-channel communications equipment, sophisticated laboratory equipment and instrumentation. DVR switches, which feature up to 4-C switching, are available with momentary (non-lock) and push-lock/push-release actuation. Prices for the new components range from $1.50 (1-C) to $2.50 (4-C). Recognition Cap Kits (25 Caps per kit) are $2.50.

Switchcraft, Inc., 5555 No. Elston Ave., Chicago, IL 60630. Phone (312) 792-2700.



Booth 2312 **Check No. 282**

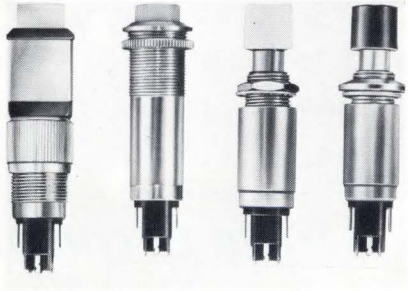
Lighted switches match styling of indicator lights

Series 80 lighted decorator line push-button switches available with round or square buttons, for subpanel or decorative bezel front panel mount. Five button colors or combinations of colors. Two-color buttons available to indicate switch position. Relampable from front without removing switch. Takes standard T-1-3/4 flange base lamp. Independent lamp terminals.

Circuitry from SPST to DPDT. Momentary or alternate action (push-on/push-off). Styling matches Series 81 indicator lights and Series 30 and 46 unlighted decorator line switches.

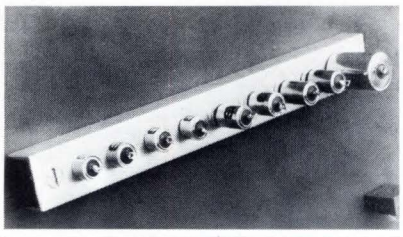
Rated at 1/4A 115V ac resistive for 250,000 operations minimum. Priced from $2.28 (100 pieces).

Grayhill, Inc., 561 Hillgrove, La Grange, IL 60525. Phone (312) 345-1040.



Booth 2605 **Check No. 283**

Subminiature emi/rfi filters provide up to 90 dB of signal rejection



Designed to supress both conducted and radiated EMI/RFI interference, the "mini"-filters are available in four basic circuits. All circuits are extremely small and lightweight (5 to 12g), hermetically sealed and meet or exceed appropriate MIL-F-15733 and MIL-STD-202 environmental requirements. Voltage ratings of 200V dc or 115V ac give unique performance capabilities at line frequencies up to 400 Hz with current ratings of 0.1, 0.5, 1.0, 5.0 and 10A. Mini-filters are rated to 125°C at full load and full-line voltage.

Genisco Technology Corp., 18435 Susana Rd., Compton, CA 90221. Phone (213) 537-4750.

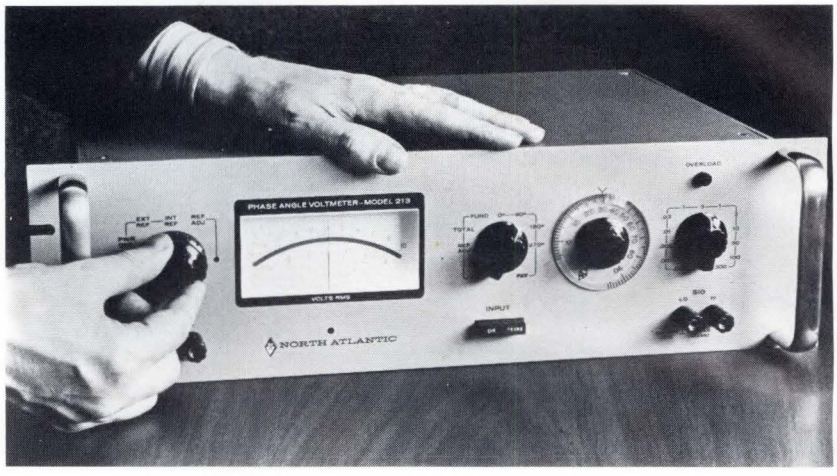
Booth 2210 **Check No. 284**

Phase angle voltmeter performs 5 different measurements

Model 213 solid-state phase-angle voltmeter performs complex measurements on ac signals in the 300 μV-300V amplitude range and within the 30 Hz to 10 kHz frequency band at any customer selected single frequency. Model 213 measures in-phase voltage, quadrature voltage, and phase angle, relative to an arbitrary reference voltage. It uses a built-in filter to measure the harmonic-free "fundamental" component of input voltages; and bypasses the filter to measure "total" input voltage like an ordinary ac voltmeter.

North Atlantic Industries, Inc., Terminal Dr., Plainview, N Y 11803. Phone (516) 681-8600.

Booth 1500 **Check No. 285**



Shaft encoder has output of 2500 pulses per revolution

Series 880 optical encoder measures approximately 2 in. in diameter, uses all solid state circuits and is available in a number of versions to accommodate a wide range of design problems. The basic encoder may be specified with pulse rates as high as 2500 per revolution and with sine or square wave output. Accuracy is ±2.5 minutes of arc for all versions.

Among the many options the user may select are light sources, indexing, output, and shaft size. The "standard" encodel uses incandescent lamps for light sources, but LED sources may be specified where reliability is paramount. Phototransistors are used for sensing and indexing is available to provide a constant reference for every revolution of the encoder disc. Priced from $150 with discounts in quantity. Delivery is approximately 30 days.

Disc Instruments, Inc., 2701 S. Halladay St., Santa Ana, CA 92705. Phone (714) 549-0343.

Booth 1713 **Check No. 286**

500 MHz counter features direct gating

The first 5 mV, 9-digit frequency counter with direct gating up to 500 MHz is Philips' claim for the PM 6645. The use of direct gating gives measurement times that are much less than with the more commonly employed direct prescaling approach. For example, to measure 500 MHz to a resolution of 1 Hz with the direct gating approach requires only 1 sec whereas with the prescaling approach it takes 10 secs.

Another noteworthy feature of this counter is that its input sensitivity is very high—namely, 5 mV rms—resulting from automatic noise suppression being employed on all input signals.

An optional YIG-tuned converter extends range to 12.6 GHz.

Test and Measuring Instruments, Inc., 224 Duffy Ave., Hicksville, N Y 11802. Phone (516) 433-8800.

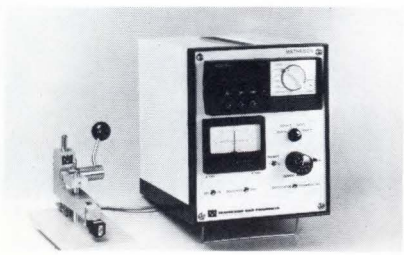
Booth 1944 **Check No. 287**

Resistivity/type meter boasts low price

The RTM-101 Resistivity/Type Meter sells for $1450.00, (reportedly, approximately half the cost of the equivalent competitive models). In addition to price, its main features are extreme versatility and compact size.

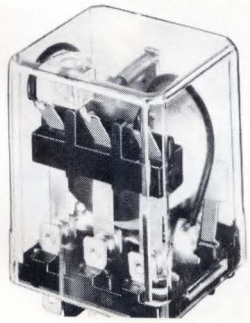
The basic unit is capable of measuring resistivities as low as 0.05 Ωcm and as high as 2000 Ωcm. An accessory module, the model LRM-200, low resistivity module, sells for $900 and allows the user to expand the instrument capability to measure resistivities as low as 0.0005 Ωcm.

Matheson Gas Products, P.O. Box 85, E. Rutherford, N J 07073. Phone (201) 933-2400.



Booth 4308 **Check No. 288**

General purpose relays provide high performance



Class 388 general purpose relays offer many quality features found only in expensive custom-built versions.

Available in either a covered plug-in or open style with a wide choice of ac or dc coil voltages and SPDT, or 3PDT 10 amp contacts. All Class 388 relays have 3-way pierced terminals.

While spaced for standard plug-in mounting, the flat terminals (0.187 in. × 0.020 in.) also accept quick-connect receptacles or direct soldering.

For plug-in use, three types of chassis mounted sockets are available: quick-connect, solder, or printed circuit terminals. The armature and contact blades are inserted molded in phenolic. The entire assembly is mounted on the molded phenolic base which features internal and external arc barrier strips designed to meet UL standards.

Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, IL 60630. Phone (312) 282-5500.

Booth 2400 **Check No. 289**

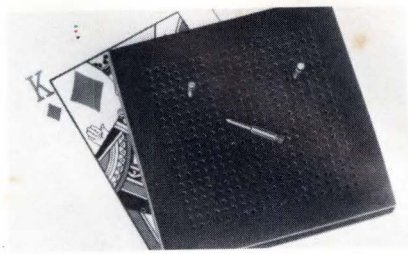
Matrix board size is miniaturized

Series 65000 miniature program board packs 400 programming positions into an area of only 2-1/2 x 2-1/2 in. With programming holes on 0.1 in. centers, this board offers a 50% reduction in both size and weight over standard matricies. This new configuration is said to be the smallest electrical matrix board produced.

Contact configuration is bussed on both decks. The miniature board uses shorting or component holder pins that are inserted into the program holes at selected points as desired. Priced at $0.07 a cross-point on quantity orders.

Co-Ord Switch, 102-48, 43rd Ave., Corona, NY 11368. Phone (212) 899-5588.

Booth 2405 **Check No. 269**

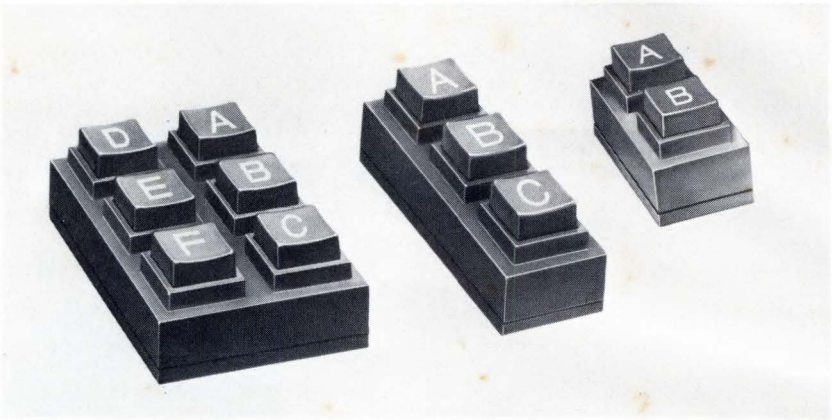


Push button switch modules duplicate telephone keyboard

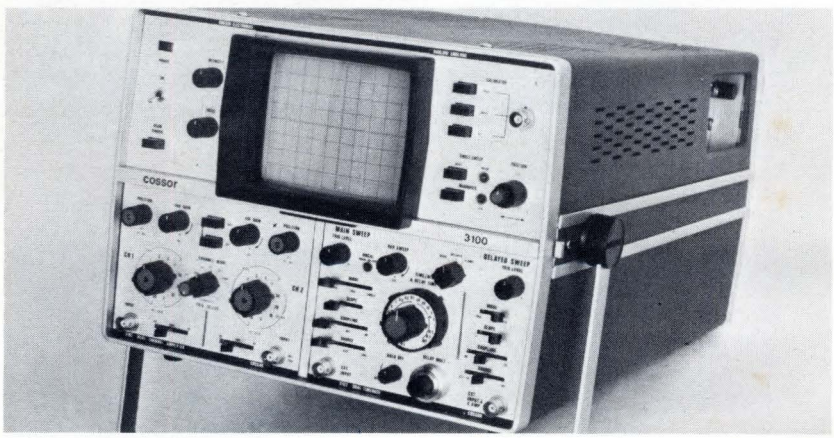
Series 82 available in 1, 2, 3, or 6 button modules. Stackable on 0.687 in. centers. pc terminals. Low profile; only 0.750 in. overall above pc board. Molded-in terminals facilitate flow soldering. Standard and special legends available. Circuitry from SPST to 4PST per button. Shorting bars can be internally connected to provide coded data input. One input can feed up to seven independent outputs. Priced from $.75 (100 pcs.). Delivery 2-10 weeks depending on quantity.

Grayhill, Inc., 561 Hillgrove, La Grange, IL 60525. Phone (312) 354-1040.

Booth 2605 **Check No. 270**



Dual trace oscilloscope designed for easy servicing



Model 3100 oscilloscope offers a basic 5 mV/cm sensitivity, a 35 MHz bandwidth and an 8 x 10 cm display. The Y input and X timebase amplifiers are connected in separate plug-in units. Additional plug-ins are being introduced with a dual-channel Y-amplifier unit and a dual-timebase unit with delayed sweep. Additional units will include a differential low-level input amplifier and a low-cost single-timebase plug-in unit. Plug-in semiconductors, and push-on printed circuit board connectors ensure easy servicing.

Raytheon Co., Instruments Operation, 175 Middlesex Turnpike, Bedford, MA 01730. Phone (617) 275-1380.

Booth 1514 **Check No. 271**

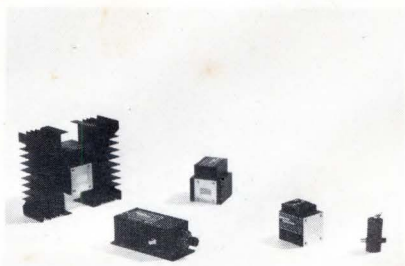
Gunn diodes provide X-band transmitter sources

LS-1414 mechanically tuned oscillator provides 1W output power from 10.7 to 11.7 GHz with single knob tuning. FM or AFC is provided by a varactor. The LS-1424 offers 0.8W min. output power in the 12.4 to 13.0 GHz band. Both of these sources have a modulation linearity of better than 1% in a 10 MHz bandwidth, with less than 0.1 db of incidental AM. The modulation sensitivity is approximately 1 MHz/V.

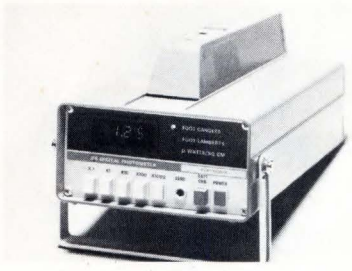
High reliability is achieved by combining four lower powered Gunn diodes operating at lower temperature than is possible with high-powered devices. The four diode circuit provides stable operation with combining efficiency, no spurious outputs and minimum noise. Additionally, Gunn diodes permit low voltage operation, and are not subject to failure due to load mismatch. Failure of any one of the four diodes will result in a power reduction of only 25%.

Litton Industries, Electron Tube Div., 960 Industrial Rd., San Carlos, CA 94070. Phone (415) 591-8411.

Booth 2904 **Check No. 272**



Digital photometer/radiometer designed for lab or field



Illuminance, irradiance, and luminance measurements can be accurately made by selecting the appropriate probe with the J16 portable photometer/radiometer. A choice of five probes is available. Each uses a silicon photodiode which has excellent long-term stability and reliability.

Easy-to-read, 2-1/2-digit LED readout reduces measurement error, particularly in low ambient light conditions.

At least two hours of continuous operation are provided by the internal rechargeable batteries. The bottom of the case and probe have a standard threaded socket (1/4 in. x 20) for tripod or optical bench use.

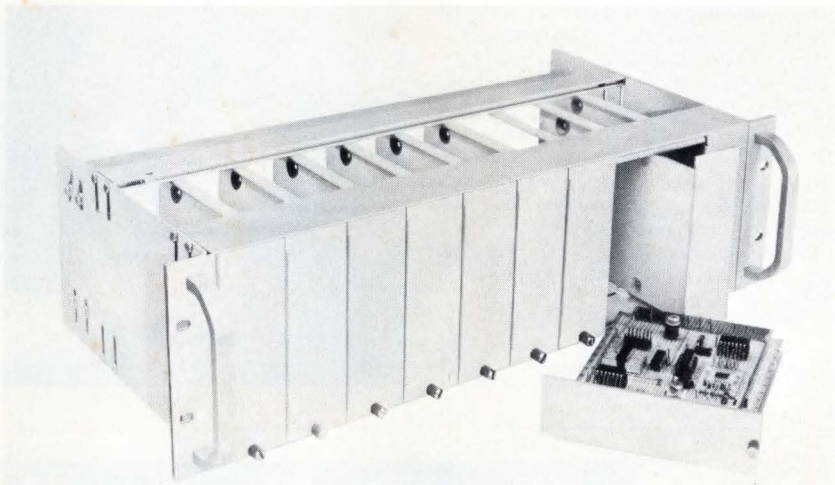
Tektronix, Inc.,
P. O. Box 500, Beaverton, OR 97005.
Phone (503) 644-0161.

Booth 1101 **Check No. 273**

Module cage is low in cost

Vector Electronic Co. has just announced a low-cost module cage assembly for 19 in. rack mounting. The CCM-13 assembly consists of a 5-1/4 in. high by 9.6 in. deep aluminum cage with ten installed "L" shaped aluminum card mounting panels. A circuit card up to 4-1/2 in. wide by 6-1/2 in. long may be mounted on each panel which has a 1.65 in. wide by 5-1/4 in. high front. Nearly any card edge connector can be mounted by the user without drilling holes in the cage assembly on the rear set of extruded cross members. Priced at $79.50 each in unit quantities.

Vector Electronic Co., 12460 Gladstone Ave., Sylmar, CA 91342. Phone (213) 365-9661.



Booth 3500 **Check No. 274**

High speed A/D converter sells for less than $100

The ADC-EH converter is an ultra-high speed 8-bit A/D converter packaged in a remarkably compact 2 in. x 2 in. x 0.375 module. The high speed and small size is achieved by utilizing a single LSI circuit which provides all the necessary successive approximation programming logic. The analog input voltage range is digitally programmable and can be either unipolar (0 to +10V FD) or bipolar (±5V). The new unit has ±0.2% accuracy and a 500 kHz throughput rate. Price is $85.

Datel Systems, Inc.,
1020 Turnpike St., Canton, MA 02021.
Phone (617) 828-6395.

Booth 4900 **Check No. 275**

Sweep generator which covers 1 to 300 MHz

Digital readout of both start frequency and stop frequency is a feature of the Model P9059A. The solid state unit provides 1.0V rms output.

An optional attenuator can be provided to reduce the signal down 41 dB in 1 dB steps. Optional crystal marker frequencies of 5 to 50 MHz are also available.

The 'CABL-SWEEP' has a triggered low repetition rate with a fast, 2 msec, sweep time. The unit is flat within plus or minus 0.2 dB.

Unit is half-rack size. Output impedance is 75Ω. Basic price of $695 plus options.

Kay Electronics Corp., Pine Brook, N J 07058. Phone (201) 227-2000.

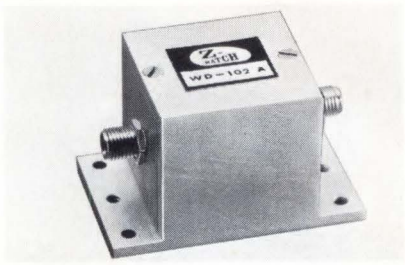
Booth 1928 **Check No. 276**

Frequency doubler accepts input frequencies from 0.02 to 4.5 GHz

The WD-102A doubler makes possible the generation of low-cost, high-frequency energy using existing signal sources. Overall input frequency range is 0.02 to 4.5 GHz. Input power +10 to +20 dBm. Fundamental and 3rd harmonic suppression is greater than 30 dB over the entire band. Input and Output impedance is 50Ω nominal. Typical input VSWR is less than 2:1 over the band. Typical output VSWR is less than 2.5:1. The circuit employs a custom designed input transformer and carefully matched Schottky barrier diodes. Circuit elements and supporting structure are encapsulated in high-temperature polyurethane foam. Operating range is −55 to 100°C.

Vari-L Co., 3883 Monaco Pkwy., Denver, CO 80207. Phone (303) 321-1511.

Booth 2203 **Check No. 268**

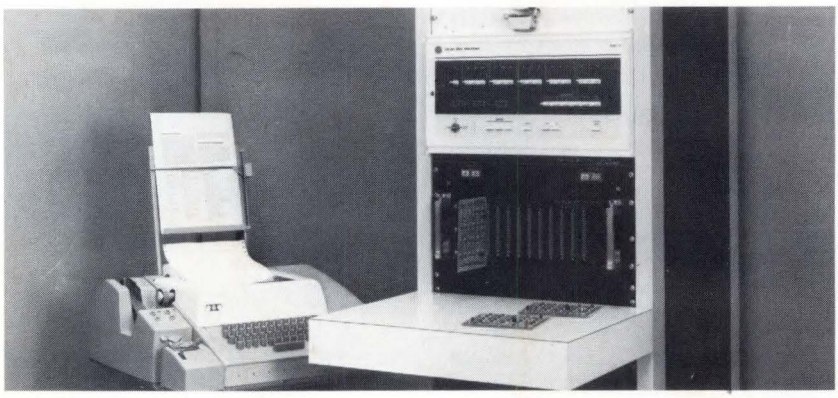


Digital assembly tester designed for 5V logic

The computer controlled ADATE II digital assembly tester can be operated, programmed and maintained by a test technician for less than 1/3 the cost of comparable systems. ADATE II dynamically test printed circuit cards, modules, subassemblies and integrated circuits. Test sequences at speeds up to 20 Mc are provided. Rates up to 300,000 tests per second reduce total test time per unit under test.

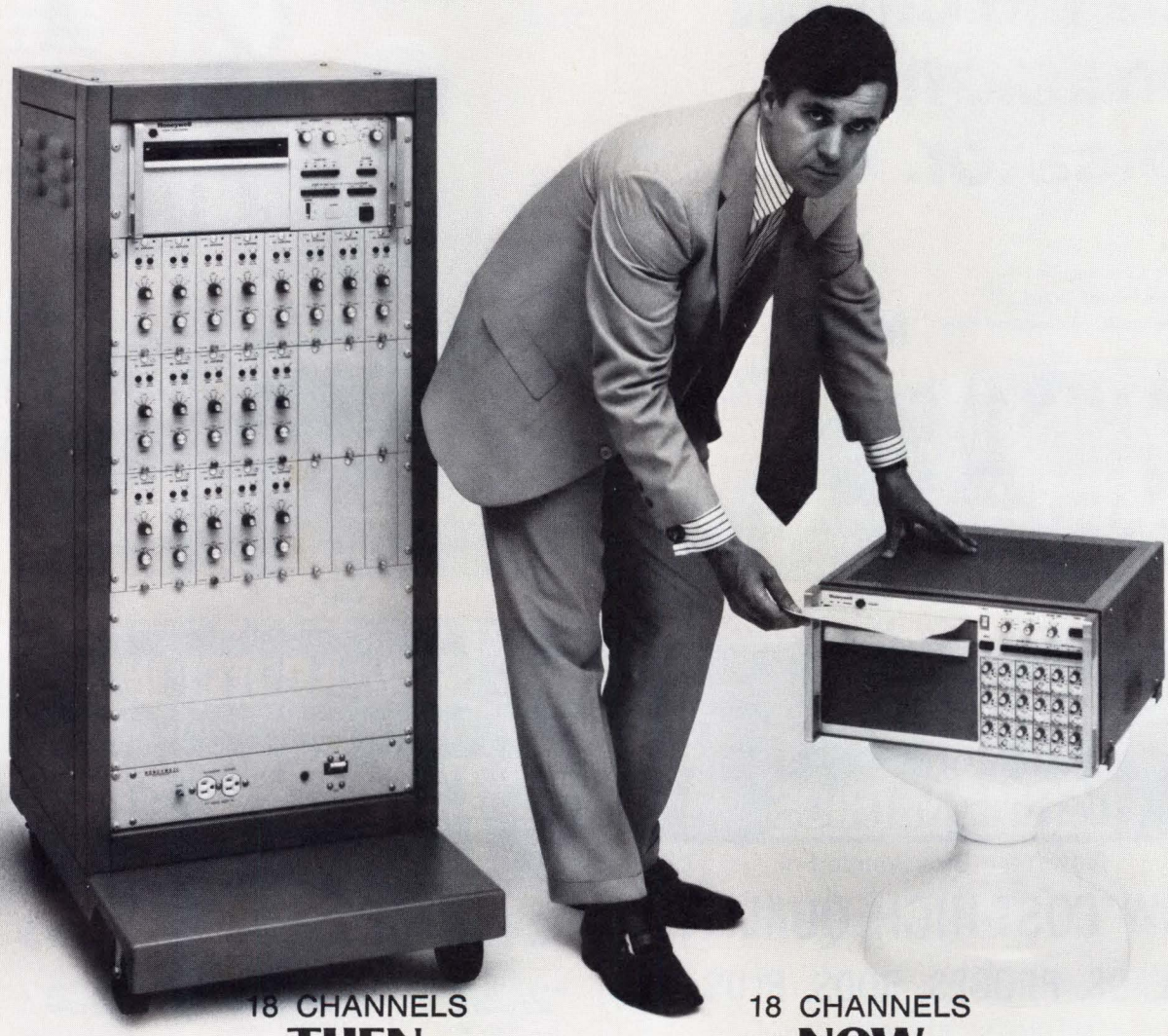
Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, CA 94304. Phone (415) 493-4141.

Booth 1511 **Check No. 267**



NEW FROM HONEYWELL

A complete graphic data acquisition system, with its own built-in signal conditioning, in a package just 8¾" high!



18 CHANNELS
THEN

18 CHANNELS
NOW

Our new one-piece data acquisition system offers benefits that other graphic systems can't, such as:

Completely self-contained. Signal conditioning circuitry is built right into the 1858! All you do is select and plug your choice of modules into the front panel.

Most readable and accurate record available. Our 1858 allows any trace to be positioned at any point on the record with full record width deflection, plus digital trace identification. In addition, it offers high-frequency response and a super-fast rise time—without trace overshoot—and without high-frequency trace wipe-out . . . for the easiest-reading record, the best resolution ever.

As easy to use as an oscilloscope. With the all-electronic, fiber-optic CRT 1858, there are no galvanometers or pens to fuss with. No mathematics or matching networks to fool with. There's simple front panel set-up for calibration, trace position and sensitivity. Just plug in your signal inputs and you're ready to record.

18-channel recording capability. This new system records up to 18 channels, each with DC to 5,000 Hz response. You also get a choice of 42 discrete paper speeds up to 120" per second!

True portability. Just because our 1858 gives you an 80% reduction in rack space and weight isn't the only reason it's called portable. It's also because *everything* you need is self-contained within that package, including signal conditioning and paper take-up! You can stick it in a rack, set it on a table, or carry it away.

A variety of signal conditioning modules. Your choice includes a high-gain differential amplifier, a low-gain differential amplifier, a medium-gain differential amplifier, an impedance interface module, a strain gage control unit and a thermocouple control unit.

And this is only part of the story. For more information, call 303-771-4700. Write Lloyd Moyer, MS 218, Honeywell, Test Instruments Division, P. O. Box 5227, Denver, Colorado 80217.

Honeywell
The Automation Company

CHECK NO. 46

MINELCO CI80 BITE* INDICATOR

*BUILT-IN TEST EQUIPMENT

A low cost, reliable circuit condition indicator.

Actual size

Features:
- Magnetic Latching
- Negligible Power Drain
- Operates on 25 Millisecond Pulse
- Sealed

Send for free brochure.

MINELCO®
DIVISION
GENERAL TIME
A Tally Industries Company

135 SOUTH MAIN STREET • THOMASTON, CONN. 06787
PHONE: 203/283-8261 • TWX: 710/475-1091

CHECK NO. 47

New PM

The people at Bodine have a new permanent magnet field D-C motor line: The 42A. Powerful and compact: Only 4.3" in diameter with continuous duty ratings of 1/8, 1/6 and 1/4 hp at 2500 rpm, 115V D-C. Plus parallel-shaft gearmotors in ratios up to 300:1. Output torques to 350 lb-in.

Delivers: exceptionally consistent output; high starting torque; low-speed operation; self-braking; surprising control capabilities; cool and quiet operation; outstanding brush life. Write for bulletin.

BODINE
ELECTRIC
COMPANY

BODINE MOTORS
GEARMOTORS
SPEED CONTROLS

Bodine Electric Co., 2512 W. Bradley Place, Chicago, Illinois 60618

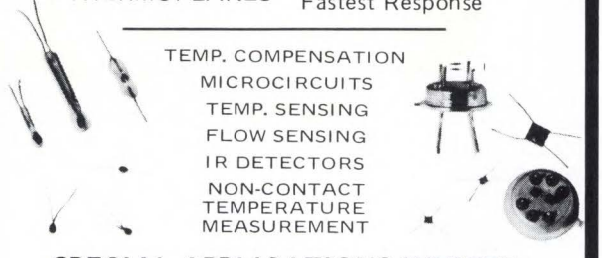
CHECK NO. 48

THERMISTORS BY THERMOMETRICS INC.

Now Your Best Source For

LOW COST-HIGH QUALITY BEADS, PROBES, RODS, PLUS:

- HI-TEMP UNITS - TO 450° C continuous
- THERMOFLAKES - Lowest Noise, Fastest Response



TEMP. COMPENSATION
MICROCIRCUITS
TEMP. SENSING
FLOW SENSING
IR DETECTORS
NON-CONTACT TEMPERATURE MEASUREMENT

SPECIAL APPLICATIONS INVITED

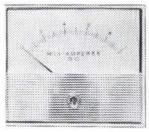
SEND FOR DETAILS ON EXPERIMENTERS FLAKE KITS

THERMOMETRICS INC.
15 JEAN PLACE EDISON, N.J. 08817
(201) 548-2299

CHECK NO. 49

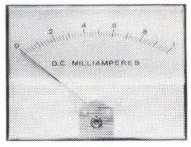
NEW ADDITIONS
to quality panel meters from
HOYT

#2430 D.C. Moving Coil
#2431 A.C. Repulsion



- Clear acrylic scratch-proof front
- Noryl case back for higher temp. applications
- Three-hole mount. Replaces older style
- 2% FS accuracy standard, 1% available

#2260 D.C. Moving Coil
#2261 A.C. Repulsion



- 6" projected front
- Clear acrylic case. Scratch resistant
- Mounts without customary bezel from behind panel

#2135 D.C. Moving Coil
#2136 A.C. Repulsion

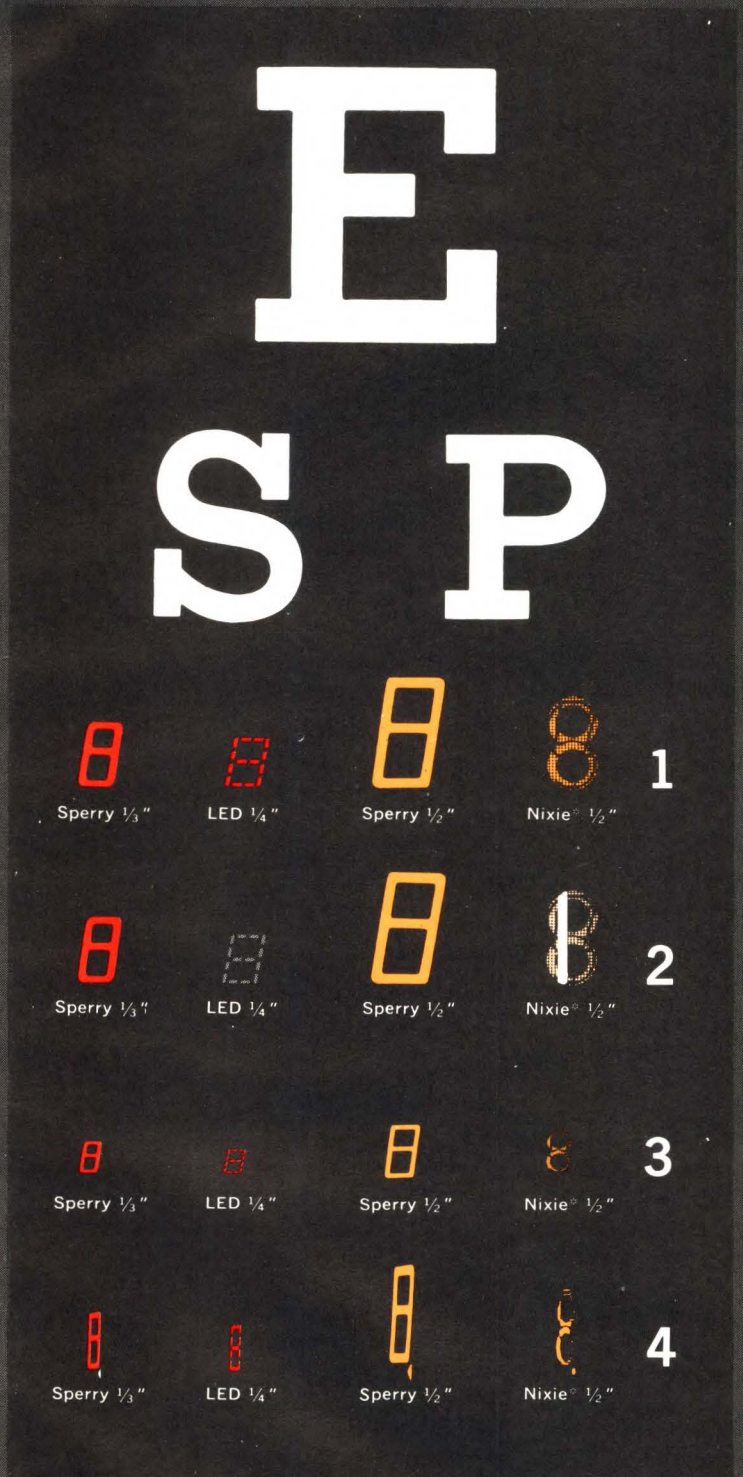
- Glass and bakelite
- Smooth satin finish
- Fast two stud mount
- Rugged case — no plastic

Send for our 1972 catalog

HOYT ELECTRICAL INSTRUMENT WORKS, INC.
BURTON-ROGERS COMPANY / Sales Division
556 TRAPELO ROAD, BELMONT, MASS. 02179 • (617) 489-1520

CHECK NO. 50

The Sperry eye test for display equipment buyers



The above is a printed interpretation of the appearance of the more popular displays. You are encouraged to make the same comparison with actual devices.

The old saying "what you see is what you get" certainly applies to the purchase of equipment incorporating displays — panel meters, DVM's, multimeters, counters, instruments, calculators and other equipment. If you can't clearly and easily read the information being displayed then you're not getting full product value. And, you're obviously not getting equipment supplied with advanced Sperry planar displays†.

How do you tell if they're Sperry displays? Simply take the Sperry eye test.

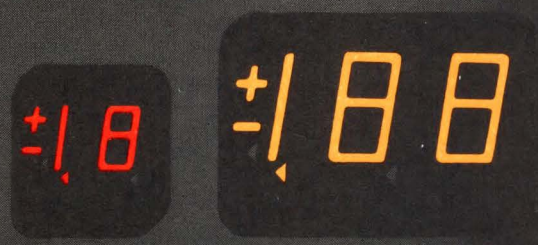
1. **Do the displays appear as uniformly bright, continuous characters with no irritating gaps or filaments and screens to reduce readability?**
   ☐ YES ☐ NO
2. **Do the displays remain bright and clearly legible with no glare or appreciable fading even under direct sunlight conditions?**
   ☐ YES ☐ NO
3. **Can you quickly, easily and accurately read the displays from 20 to 40 feet away?**
   ☐ YES ☐ NO
4. **When the unit is positioned within a 130° viewing angle, can you still clearly read the displayed characters?**
   ☐ YES ☐ NO

If you answered YES to all four questions, you already have your eyes on equipment featuring preferred Sperry displays.

If you answered NO to any of the questions, you owe it to yourself to take a comparison look at products equipped with superior Sperry displays.

FREE BUYER'S GUIDE —
To help you make the right equipment selection, Sperry offers the handy "Buyer's Guide for Equipment featuring Electronic Displays". It's your's for the asking. Order your copy today by checking the reader service card or phone or write: Sperry Information Displays Divison, P.O. Box 3579, Scottsdale, Arizona 85257, telephone (602) 947-8371.

SPERRY
INFORMATION DISPLAYS



Sperry 1/3" Sperry 1/2"
units are available for use with red filters

It's a whole new ball game in displays!

†Patents Pending
*NIXIE is the registered trademark of The Burroughs Corporation.

SPERRY RAND

CHECK NO. 51

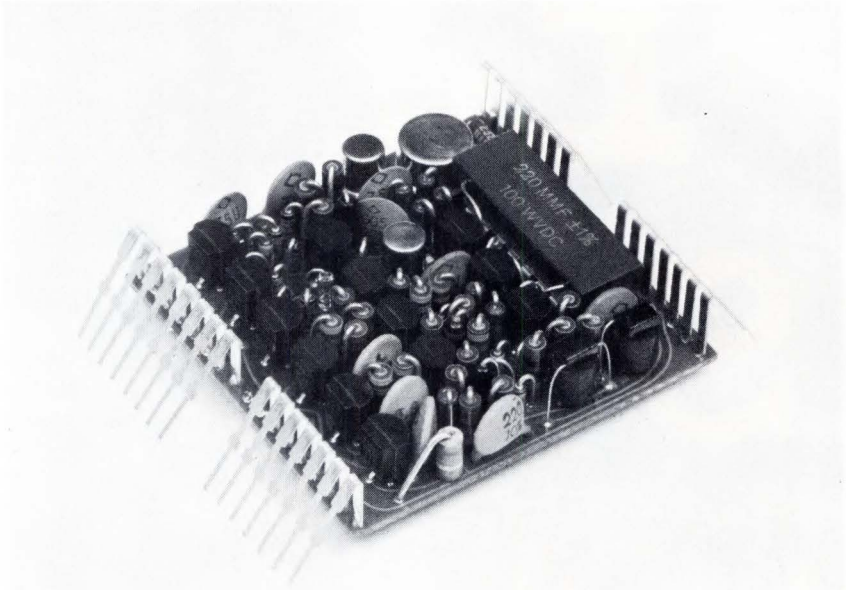
Sample- and-hold amplifier has top performance at moderate price

PROGRESS IN INSTRUMENTATION

A state-of-the-art mix of speed, accuracy and holding time has been achieved at a decidedly attractive price by Zeltex, Inc., Concord, Calif., in its latest sample-and-hold amplifier module. Zeltex's model ZD-452 sample-and-hold has fast 1-μsec settling and 5-nsec aperture times and a very respectably "slow" droop response of 0.1 μV/μsec. These specifications are to a 0.01% gain accuracy, Zeltex says.

The price for the ZD-452 is just $149 in single unit quantities and less than $100 in 100-piece quantities. Thus, the 452 represents Zeltex's contribution to lower S/H module prices at the high end of S/H performance and follows the trend towards lower prices that has already been started by some lower performance S/H modules such as Zeltex's $49 ZD-451 and Analog Devices' $47 SHA-6. These lower prices for S/Hs are logical, considering the rapid drop in analog to digital converter prices in the last few years. It was getting to the point where S/H modules were becoming more expensive than A/Ds. Such a situation proved foolish in those applications where S/Hs are used to permit economical time-sharing of one A/D among several analog input channels. Until recently, a designer could expect to pay over $200 for a S/H with the 452's specifications.

Zeltex follows the now common practice of using two JFET-input op amps. The first amplifier provides the high ($10^{11}\Omega$) input impedance desirable for the analog circuit being sampled not to be loaded. The bias currents on the two alternate inputs are each less than 50 pA over input range of $\pm$10V. The second amplifier provides the low output impedance that is vital for fast charging of the polystyrene holding capacitor (in the amplifier's feedback loop) and driving typical A/Ds. A 10k feedback resistor around both amplifiers stabilizes the gain.



Uncovered module shows how tightly Zeltex packs in the components to achieve a low dip-compatible profile. S/H circuit consists of a buffer and an integrating op amp separated by an analog switch. The user can choose either an inverting or non-inverting configuration, as both inputs are brought out. He can also externally increase the hold capacitance for longer hold times.

An analog switch between the two amplifiers controls the sample-and-hold behavior. Zeltex uses a Schottky-diode bridge circuit for this switch. When it is in its low-impedance state the module tracks the input signal up to the limit of its 4 MHz unity gain, 2 MHz full-power bandwidth ability. When it is in its high-impedance state, the module freezes the signal within the limit of its 100 μV/msec droop rate. The switch can freeze the signal within 5 nsec (aperture time) with 1 nsec uncertainty.

Obviously, the switch must be both fast and have low leakage. This represents one reason why the average electronic house should not casually undertake to design their own S/Hs.

Despite the wideband performance, the Zeltex S/H appears to pay a minimal speed-power penalty. The power consumption is only 30 mA over the 12-18V (dual) supply voltage range.

Zeltex attributes part of its ability to produce this high-performance S/H at such a low price to efficient module packaging. They mount all the components on a fine-line pc board header made by the Photocircuits Corp. NT-1 process, in a configuration that minimizes assembly labor. Zeltex is one of the relatively few module makers who has remained with open, unpotted construction. It says that both maker and customer benefit. The customer has a repairable module and the maker can dissect any failed units and learn therefrom.

Zeltex, Inc., 1000 Chalomar Rd., Concord, Ca 94520. Phone (415) 686-6660. **295**

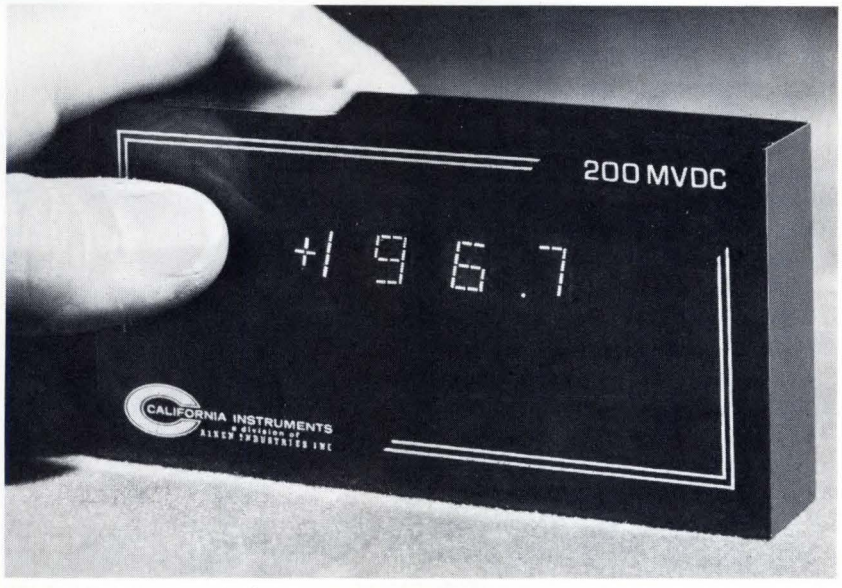
3-1/2 digit DPM mounts on front of panel instead of through it

PROGRESS IN INSTRUMENTATION

Many recent digital panel meter designs have exhibited a trend toward standardization on case size and dimensions. The aim, of course, is to simplify things for the user. Now along comes a DPM that approaches the problem of instrumentation panel design and its relationship to the DPM in an entirely different manner.

The California Instruments Series 8330 DPM mounts on the front of a cabinet, not through it. Two small mounting holes and a third hole for conductors is all that is required for installation. This can often result in a significant cost reduction in the design of instrumentation panels. Protrusion in front of the panel is minimized by the extremely narrow 0.687 in. depth of the unit, whose other dimensions are 2 in. × 4 in.

The 3-1/2 digit bipolar unit has a range of 200 mV, with optional ranges of 2, 20 and 200V dc selectable by means of an internal attenuator. Accuracy is 0.1% of reading ±1 digit and normal mode rejection is 40 dB at 60 Hz. BCD stored outputs are standard and operating power is 4.75 to 5.25V dc at 0.8A max. For over-range indication, the main readout digits go to zero and flash on and off.



Two small mounting holes and a third hole for conductors is all that is required for installing the 8330 DPM.

A single pc board has all components mounted on one side. This eliminates both circuit interconnections and the output cabling, making the 8330 the first DPM to eliminate cabling from the circuit board to the external terminal. There is not a mating connector.

The 8330 has an operating temperature range of 0 to 55°C. Since it mounts outside the front panel it is not subject to the higher ambient temperatures normally found near through-the-panel mounted DPMs.

Readout for the 8330 consists of plug-in-type seven-segmented numerical LED readouts, one for each digit. Price for the 8330 is $115.

California Instruments, 5150 Convoy St., San Diego, CA 92111. Phone (714) 279-8620. **294**

Rugged high-level logic probe characterized for industrial use

PROGRESS IN TEST EQUIPMENT

A new logic probe from Hewlett-Packard combines electrical and mechanical ruggedness to form an ideal test instrument for industrial circuit troubleshooting. The probe, Model 10525H, is designed to test the high-level HTL and HiNIL ICs commonly found in industrial control equipment. In addition, its 12 to 25V power-supply range (requiring less than 100 mA) permits probing of MOS, relay logic, and discrete switching circuits.

Mechanically, the 10525H is solidly constructed for long life. The probe body is molded of high-impact resistance plastic and is insensitive to shock. The coaxial power cable is strain relieved at both ends assuring reliable connections even with rough usage.

The probe is solidly immune to electrical damage. The power input withstands voltages to +40V, with reverse polarity protection to −400V. The probe tip is protected against inadvertent probing of voltages up to ±70V continuous and ±200V intermittent. The instrument is not damaged by probing 120V ac for 30 sec, although it would get somewhat warm under such abuse.

The probe's input impedance is at least 20 kΩ for both logical ONEs and logical ZEROs. To the circuit under test, the probe tip looks like a 20 kΩ resistor to a 6.25V battery (referenced to the probe's negative power supply input).

Removing the probe tip and separating the body halves quickly reveals the probe electronics (**Fig 1**). The custom IC makes possible a full function, fully protected logic probe with only 14 components, including the internal

voltage regulator for 12 to 25V operation.

The probe circuit is designed to permit redefinition of logic-level thresholds by an exchange of 2 or 3 discrete components on the pc board. The standard probe has the following thresholds: logical one = 9.5 ± 1V, logical zero = 2.5 ± 1V.

The high-level logic probe is operationally similar to its TTL/DTL counterpart, the 10525T. Input voltages between the logic thresholds, or open circuits, are indicated with the lamp at half brilliance. Logical ONEs and ZEROs produce full brilliance and full off-lamp indications respectively. Pulses of either polarity, even as short as 100 nsec, are captured by the high-level probe. The pulses are "stretched" to provide a clearly visible lamp-flash indication. The lamp display is never ambiguous. Pulse trains to better than 5 MHz are displayed with the lamp blinking on and off. The diffusion cone makes the lamp visible from all angles. Price is $95. Hewlett-Packard Co., 5301 Stevens Creek Blvd., Santa Clara, CA 95050. Phone (408) 246-4300.

293

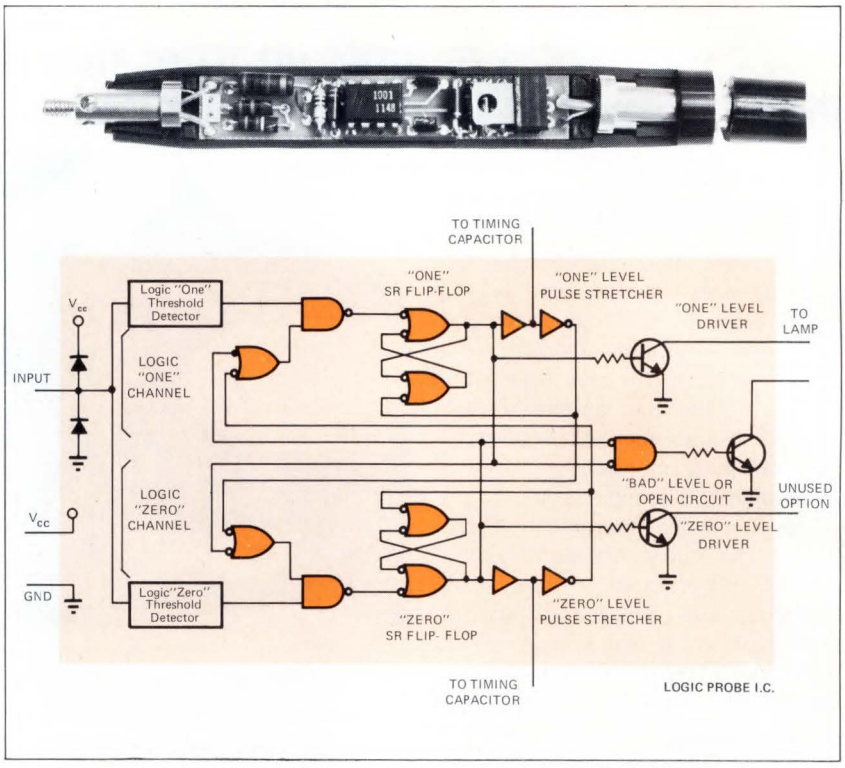


Fig. 1—The heart of the probe's electronics is the 8-pin mini-DIP integrated circuit designed and produced at HP. The IC contains high-impedance threshold detectors, the probe operation logic, and lamp drivers.

To *isolate*
power switching devices, SCR's, Triacs and the like, from low level IC control circuits —

—Optical couplers (a) and reed relays are among the most attractive alternatives. One form of optical coupler is made by Sigma and doesn't cost three or four bucks (50¢ is more like it); unlike those using phototransistors or diodes, its output is totally passive.

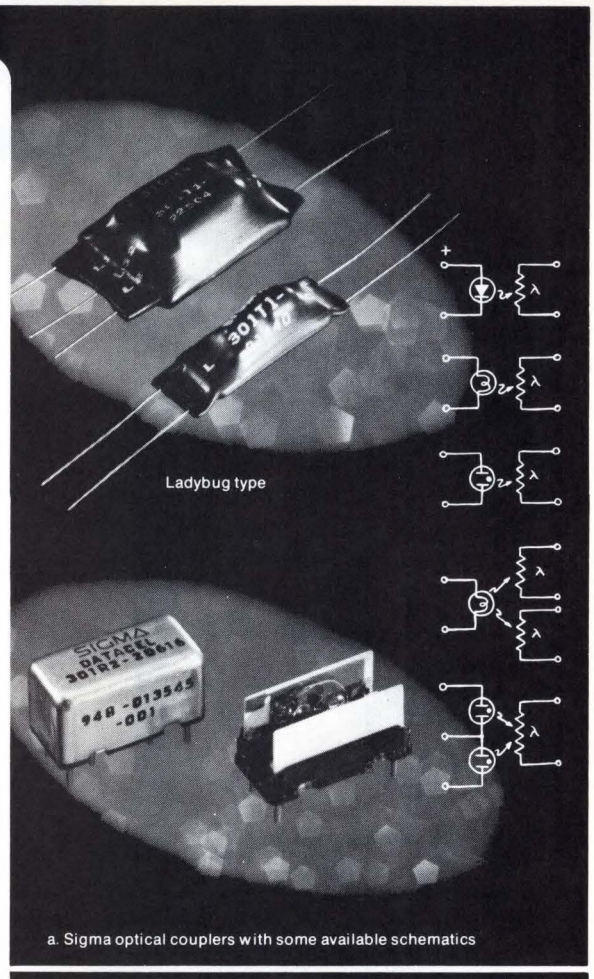
Reed relays (b) are the classical electromagnetically operated mechanical switch, but with the switch totally enclosed in a minute glass envelope *inside* the actuating coil. They are available either separately or combined with a triac (at c); operate fast (200 usec.), have life expectancies of many millions, and may have elaborate configuration, both multipole and transfer switching contacts (Form C). Their cost is moderate, ranging as low as 75¢ or less, and they have close to zero output circuit resistance. Because our reed capsules are made *in-house*, quality control is a particular Sigma reed relay advantage.

Light substitutes for magnetism as the connecting link for the other class of isolating couplers offered by Sigma. In-house manufacture of photosensitive resistors led us to develop Sigma's optical couplers which contained a photoresistor and an internal light source. Control current to the internal light causes a rapid (stepless) decay of output resistance from circa 10meg to a few hundred ohms. There is no electrical feedback, either conductive or inductive; there is total isolation, at kilovoltages when required; and there is no noise generation in the output (a good deal for audio control also). Best of all, output is passive, can be either AC or DC.

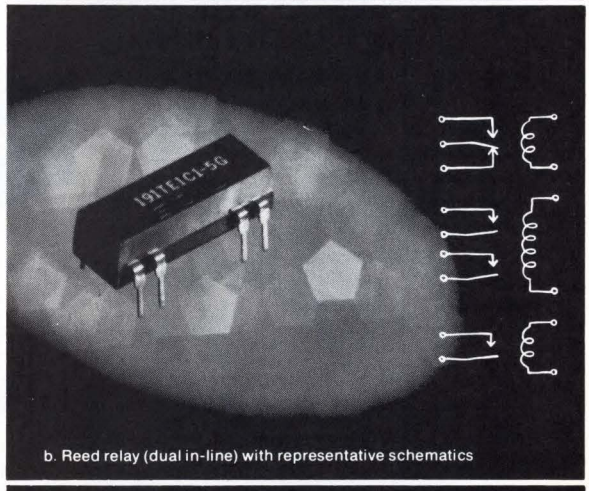
The Ladybug featured above is the latest and lowest cost Sigma optical coupler. (It was developed by a lady—our senior physicist!) For 50¢ in production quantities, you can get them as pictured (at a) with one input and one output. The light can be incandescent or neon (attractive for lock-on potential plus absence of circuit loading til energized). You can also, for more money, have an LED light source. Also one may specify two or more lights, either capable of controlling the photoresistor (and isolated from each other). Or there can be several photoresistors controlled by one light . . . passive input, passive output, infinite isolation . . . all for 50¢.

You will need details, and to give our best, we will need yours. If you outline your project and purpose in a personal letter or phone call to Jim Seppala, Applications Manager, you'll be well pleased with the promptness and thoroughness of our reply. Write or call Sigma Instruments, Inc., 170 Pearl St., Braintree, Mass. 02185. Telephone 617-843-5000.

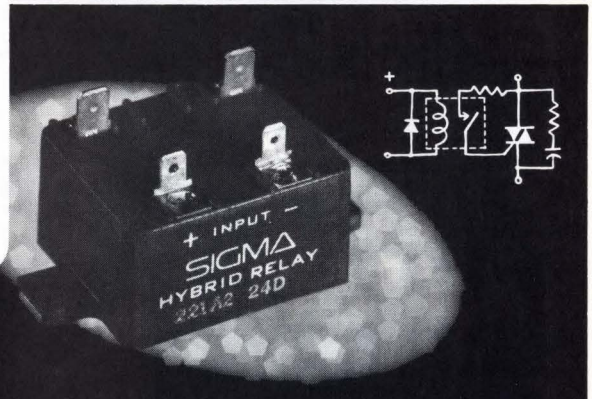
SIGMA
INSTRUMENTS INC



a. Sigma optical couplers with some available schematics



b. Reed relay (dual in-line) with representative schematics



c. Reed relay gated triac

CHECK NO. 77

Cable-Scan™ System

Model G4D — with 400 circuit adapter chassis.

Model CS-200SR — 200 input encoder with remote readout head.

Cable-Scan users have eliminated costly rework and production delays by verifying the correctness of the work at the point of fabrication. This system combines instant identification and testing in 1/5th the time of present methods.

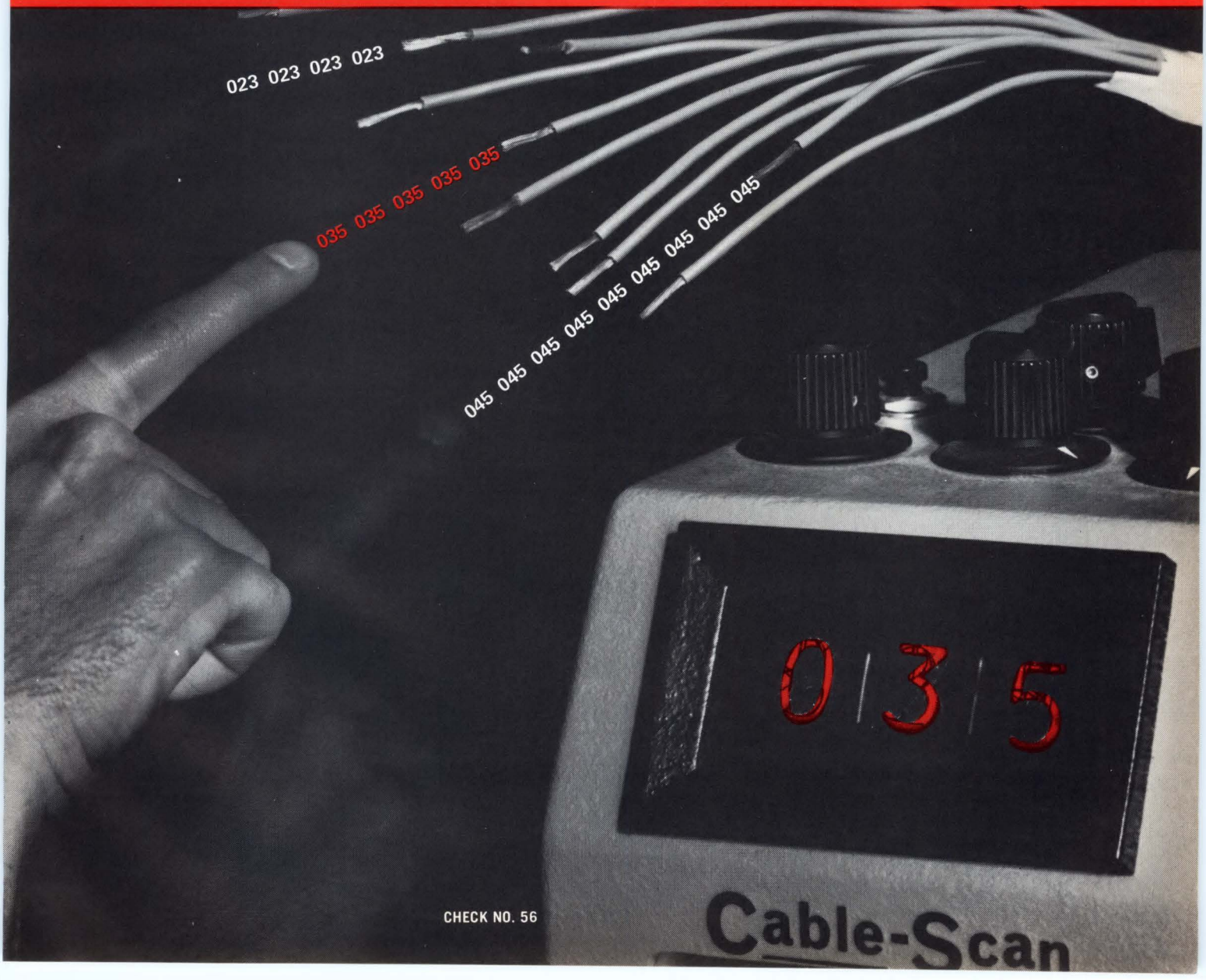
By touching the end of any wire the operator introduces a low level signal through the finger tips to each circuit. This causes the readout to identify the wire by number.

Write for bulletin on how you save with Cable-Scan—identify, test for continuity, shorts and many other production functions. Cable-Scan Inc., 145 E. Emerson Ave., Orange, California 92665 (714) 998-1961

Cable-Scan Inc.
Division of Thomas & Betts Corporation

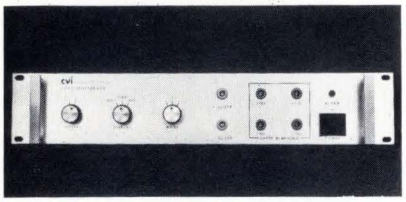
508

identifies and tests wires and cable assemblies by touch while you are fabricating



CHECK NO. 56

SIGNAL ANALYSIS SYSTEM SPANS 500 MHz to 1.25 GHz. The model 760 is an advanced solid-state signal analysis system with CRT display and 8-digit frequency indication. The unit provides scan widths for 300 MHz to 10 kHz and resolution from 300 Hz to 1 MHz. Sensitivity is −117 dBm. Price is $10,500. Systron-Donner, Microwave Div., 14844 Oxnard St., Van Nuys, CA 91409. Phone (213) 786-1760. **248**

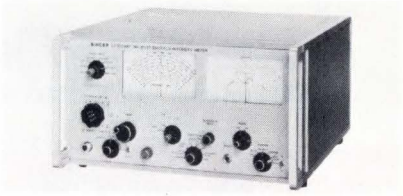


VIDEO DETECTOR PERFORMS INDUSTRIAL MONITORING. The model 630 is primarily intended for industrial control processes. The unit accepts signals from any standard television camera and produces an alarm indication when video levels in a selectively gated area exceed a predetermined amplitude. Price is $1500, and delivery is 60 days ARO. Colorado Video, P.O. Box 928, Boulder, CO 80302. Phone (303) 444-3972. **249**

4-1/2 DIGIT MULTIMETER PRICED AT $595. The Model 8100B is a 0.02% multimeter that measures ac and dc volts in four ranges to 1200V and ohms in five ranges to 12 MΩ. Readout is four full digits plus "1" for 20% overranging. Features include an active 2-pole switchable filter and automatic polarity indicator. All functions are push-button selectable. John Fluke Co., P.O. Box 7428, Seattle, WA 98133. Phone (206) 774-2211. **250**

8-CHANNEL GENERAL-PURPOSE RECORDER HAS BUILT-IN PREAMPS. The Brush 481 has a measurement range from 1 mV/division to 500V full scale (there are 50 divisions across each 40mm-wide channel). The preamplifiers have differential, floating, balanced-to-guard inputs that are isolated from each other, from chassis, and from the output. Gould, Inc., Instrument Systems Div., 3631 Perkins Ave., Cleveland, OH 44114. Phone (216) 361-3315. **251**

LOGIC TEST PROBE SERVES AS OSCILLOSCOPE ACCESSORY. As an accessory to the Tektronix 453, 454, and 7000 series scopes, the LOGIC PEN-T is used as a digital signal tracer when testing TTL/DTL logic circuits. The probe provides handheld indications of high or low logic levels and the occurrence of pulses and pulse trains. Power is obtained from the oscilloscope. Unit quantity price is $130.00. Advanced Digital Research Corp., 1901 Old Middlefield Way., Mt. View, CA 94040. Phone (415) 965-1303. **252**

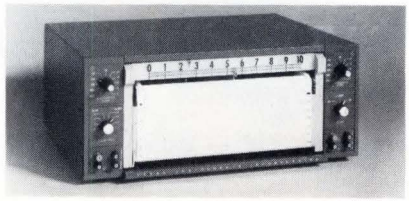


PROGRAMMABLE RFI METER PERFORMS AUTOMATIC TESTING. The Model NM-37/57 EMI/RFI test receiver covers the frequency range of 30 to 1000 MHz. With suitable programming, it will perform all automatic and semiautomatic testing required by MIL-STD-461A and MIL-STD-826A. It can operate off regular ac power or for eight hours on internal rechargeable batteries. The Singer Co., 3211 S. La Cienega Blvd., Los Angeles, CA 90016. Phone (213) 870-2761. **253**

TRANSMISSION/REFLECTION ANALYZER IS PERMANENTLY CALIBRATED. The Model TRA-1001 is a two-channel comparison power meter which has greater than 60 dB of differential dynamic range. It combines capability in one instrument for measurements of transmission and reflection properties (referenced to a 50Ω system) of networks and systems. The Vari-L Co., Inc., 3883 Monaco Parkway, Denver, CO 80207. Phone (303) 321-1511. **254**

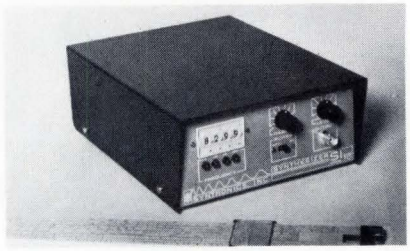
FUNCTION GENERATORS HAVE COMPLEMENTARY VARIABLE PULSE OUTPUTS. The three units in the Series 500 line are Model 501 (5 MHz trigger/variable start-stop), priced at $395; Model 510 (10 MHz VCF generator), $495; and the Model 511 (10 MHz trigger/variable start-stop), $695. Output wave forms are sine, triangle, pulse, ramp, squarewave, and dc. The 10 MHz generators feature a super-fast 2500V/sec bipolar linear output amplifier. Ailtech, 19535 E. Walnut Dr., City of Industry, CA 91478. Phone (213) 965-4911. **255**

3-1/2 DIGIT MULTIMETER IS COMPLETELY AUTOMATIC. The Model 8310 has 100% coverage, auto zero, autoranging, auto polarity and dual slope integration for max. accuracy and noise rejection. Specifications include 0.1% on dc volts and 0.5% on ac volts to 20 kHz. Resistance measurements are to 200 MΩ and dc and ac current options are availabe to 2A. Price is $345. California Instruments Co., 5150 Convoy St., San Diego, CA 92111. Phone (714) 279-8620. **256**



GRAPHIC RECORDER IS ONLY 7 IN. HIGH. The "Servo/Riter" has a wide variety of chart speeds, selectable both by gear selection and by transmissions. Users can select one or two overlapping pens or two pens side by side, and a broad range of inputs, both voltage and thermocouples. Front and rear input terminals, disposable felt tip pens, and many other options are available. Texas Instruments, Inc., Digital Systems Div., P.O. Box 1444, Houston, TX 77001. Phone (713) 494-5115. **257**

AM SIGNAL GENERATOR HAS 3-DIGIT FREQUENCY DISPLAY. The Model 921A covers 50 kHz to 80 MHz, has 0.1 to 1% accuracy and provides built-in overrange capability. Price is $1730. Logimetrics, Inc., 100 Forest Dr., Greenvale, NY 11548. Phone (516) 481-2222. **258**



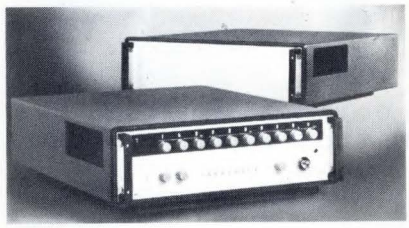
HIGH-RESOLUTION AUDIO SYNTHESIZER COST $495. The Model SI-70 has an output range of 0.1000 Hz to 9.999 MHz. It puts out a TTL-compatible squarewave signal having a frequency accuracy and stability of ±10 ppm from 0 to 50°C (with 1 ppm for 0-55°C available as an option). Syntronics, Inc., 169 Millham St., Marlboro, MA 01752. Phone (617) 481-7827. **259**

MINIATURIZED FREQUENCY STANDARD IS BATTERY POWERED. The Type F100 generates 9 precision, crystal controlled frequencies from 20 Hz to 10 kHz, which are switch selectable on the front panel. Each frequency signal has an accuracy of ±0.01%. The square wave output pulses have 4V peak-to-peak amplitude. Accuracy is ±0.01% and weight is 2 lbs. Dynalco Corp., 4107 N.E. 6th Ave., Ft. Lauderdale, FL 33308. Phone (305) 563-8461. **260**

DIGITAL MULTIMETER HAS 3-1/2 DIGIT DISPLAY. The LDM-850 AC/DC Multimeter measures voltage, current and resistance in 25 ranges. Max. input voltages are 1000V dc and 350V ac with 10 MΩ input impedance. Sensitivity ranges from 100 μV to IV and current from 0.2mA to 1A, ac or dc. Resistance range 200Ω to 2 MΩ. Price is $299.50. Leader Instruments Corp., 37-27 Twenty-Seventh St., Long Island City, NY 11101. Phone (212) 729-7410. **261**

CONTROLLERS MONITOR MIXTURE INTERFACES. The TC1 ParaLLevel units are solid-state controllers for monitoring material levels and the interface of components of mixtures. Used in conjunction with fixed-position conductivity probes, they are also suitable for an extensive variety of other in-plant and OEM applications. They are sensitive to a conductivity differential as small as 2 to 3%. Heinemann Electric Co., 127 Magnetic Dr., Trenton, N J 08602. Phone (608) 882-4800. **262**

SWEEP/SIGNAL GENERATOR COVERS 1 TO 500 MHZ, with an optional high band from 450 to 950 MHz. Model 1801 has a built-in 75Ω detector, matching its output impedance. PIN diode leveling and attenuation provide a calibrated output of from +57 dBmV to −33 dBmV (90 dB total). Flatness is +0.35 dB over both bands. The 1801 will sweep at line rate or from 0.01 to 100 sec per sweep. Price is $1245 and availability is 30 days. Wavetek, 9045 Balboa Ave., San Diego, CA 92112. Phone (714) 279-2200. **263**

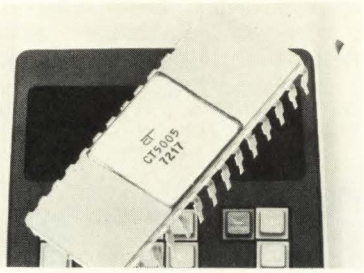


FREQUENCY SYNTHESIZER COVERS 400 kHz to 160 MHz. The 1061 Frequency Synthesizer is characterized by an 80-dB signal-to-spurious ratio, 100-μsec switching speed, and exceptional phase-noise performance. The basic unit provides a leveled output of 0 dBm to +20 dBm into 50Ω. Both frequency and output level can be remotely programmed and a search-sweep mode provides additional resolution to 100 Hz. Price is $4700. General Radio, 300 Baker Ave., Concord, MA 01742. Phone (617) 369-4400. **264**

SOUND MONITORS COMPUTE DAILY NOISE EXPOSURE. The SPL-101 and SPL-101 W Series Sound Monitors are simply mounted on a bench or wall and plugged into the nearest 110V outlet. The cumulative daily noise exposure is then automatically summed to determine if the noise level is within the legal tolerance of the law. A four digit readout indicates when the permissable limit is reached. Price is $395. Columbia Research Labs., Inc., MacDade Blvd. & Bullens Lane, Woodlyn, PA 19094. Phone (215) 532-9464. **265**

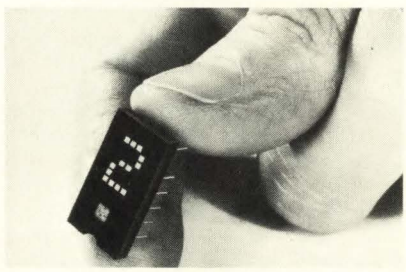
AC CALIBRATION SYSTEM SERVES BOTH LAB AND PRODUCTION TESTING. This precision system consists of the Model 5200A AC Calibrator and the Model 5205A Precision Power Amplifier. Range of the 5200 is 10 Hz to 1.2 MHz and of the 5205A Power Amplifier dc to kHz. Seven ranges of amplitude, from 1 mV to 1000V with six-digit resolution, are featured. Price of the Model 5200A is $3395 and the Model 5205A is $2495. Delivery is 120 days ARO. John Fluke Co., P.O. Box 7428, Seattle, WA 98133. Phone (206) 774-2211. **266**

SEMICONDUCTORS



CALCULATOR CHIP FEATURES FOUR FUNCTIONS AND MEMORY. The CT5005 contains over 400 gates and 230 shift-register bits. It has automatic keyboard debounce, leading-zero suppression, and automatic lockout on a P-channel MOS chip with two operation registers as well as the memory. Price is $23 in single units or $15 each in large quantities. Cal-Tex, 3090 Alfred St., Santa Clara, CA 95006. Phone (408) 247-7660. **196**

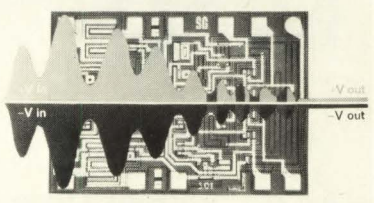
710A RMS INVERTER SCR FEATURES 10 μsec TURN-OFF. The 450PF series (ceramic) and 451PF series (plastic), are available with forward and reverse voltage ratings from 50 to 600V. The SCRs also have a high non-repetitive surge current rating: 9000A max. Price in 10-99 quantities for 600V version is $105.30 each for the 451PF60. International Rectifier Corp., 233 Kansas, El Segundo, CA 90245. Phone (213) 678-6281. **197**



LED HEXADECIMAL DISPLAY HAS INTEGRAL TTL DECODER. The display with character height of 0.270 in. and the TTL MSI chip are mounted on a lead-frame assembly that is then cast within a red, nonconductive plastic. Multiple displays may be mounted on 0.450 in centers. In quantities of 1000 units, cost is $10.00 each. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 497-7600. **198**

MONOLITHIC RADIATION RESISTANT TRANSISTORS ARE RATED AT 300W. Intended for high reliability applications, they are the largest radiation resistant single chip transistors available. They feature a high V_{CEO}(sus) of 150V, useful gain at 60A and a low V_{CE}(sat) of 1V at I_c = 50A. Prices range from $130 to $1300. Silicon Transistor Corp., Katrina Rd. (KSC Way), Chelmsford, MA 01824. Phone (617) 256-3321. **199**

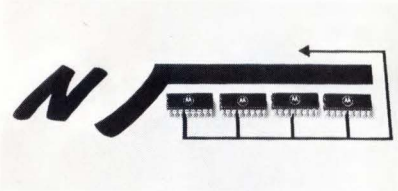
TTL/MSI STORAGE REGISTER WITH THREE-STATE OUTPUTS ANNOUNCED. The SN54/74173 MSI circuit will accept typical input clock rates of 35 MHz and consists of four D-type flip-flops. To prevent overlap and simplify designs, the disable time is considerably shorter than the output enable. The 173 is priced from $3.22 to $14.50. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, TX 75222. Phone (214) 238-2011. **200**



±15V DUAL TRACKING REGULATOR REDUCES DESIGN COMPLEXITY. The unit is capable of powering up to 25 op amps, but can be extended to load currents in excess of 2A with the aid of external transistors. Output voltage tracking at ±15V within ±5%. Output voltage balance to within 2% and regulation of 0.1%. Input range is ±30V. Silicon General Inc., 7382 Bolsa Ave., Westminster, CA 92683. Phone (714) 892-5531. **201**

P-CHANNEL MOSFETS OFFER HIGH IMPEDANCE AND LOW LEAKAGE. The 3N207 and 3N208 feature unput impedances of 10^{15} and $10^{12}\Omega$ and gate leakage currents of four pA and one nA. Production quantities are available 6 weeks ARO. Price in 100-piece quantities is $4.40 for the 3N207 and $4.60 for the 3N208. Texas Instruments Inc., 13500 N. Central Expressway, Dallas TX 75222. Phone (214) 238-2011. **202**

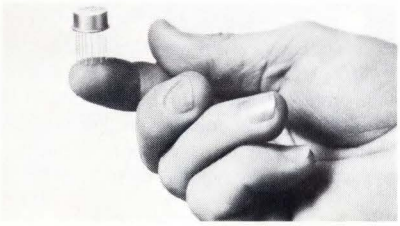
1024-BIT ISOPLANAR TTL MEMORY AVAILABLE IN EVALUATION QUANTITIES. The new TTL fully decoded memory, designated the 93415, features a 60 nsec access time. It is organized 1024 words × 1-bit, and can be used to construct large memories which operate at the same speed as their associated logic circuit. The price is $87.50 in 1 to 24 quantities. Fairchild Semiconductor Components Group, 464 Ellis St., Mt. View, CA 94040. Phone (415) 962-3816. **203**



PROGRAMMABLE CMOS COUNTERS PROVIDE LOW POWER ÷ N FUNCTIONS. The MC14522 programmable, divide-by-"N" decade counter, and the MC14526, binary counter provide cascadable down counting functions using only μW of power. Prices for these devices in plastic DIPS, in 100 up quantity is $6.60. Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. Phone (602) 273-6900. **204**

PRINTHEADS AND PRINTERS. The EPN2200 thermal printhead comprises 35 heating elements in a 5 × 7 matrix, a heat sink, and a cable. The EPN2201 thermal printer includes the 2200 and five drivers. The 2300 comprises 20 heating elements in a 4 × 5 matrix, and the 2301 includes the 2300, one row driver and one column driver. Texas Instruments Inc., 13500 N. Central Expwy., Dallas, TX 75222. Phone (214) 238-2011. **205**

1.5V BATTERY CAN DRIVE LOW-POWER TRIPLE OP AMP. Low power requirements of the L 144 op amp also permit high-voltage operation across rated temperature ranges. It is unity-gain stable and has ±30V differential input range. The L 144A is rated for military operation at −55° C to +125° C, and price is $19.50 in 1-29 quantities. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 246-8000. **206**

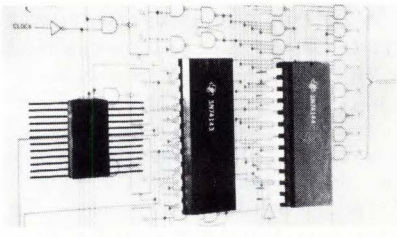


HYBRID VIDEO FREQUENCY AMPLIFIER FEATURES FAST SETTLING. This inverting amplifier operates well up into the video frequency ranges up to 50 MHz. It settles to 0.1% of full scale amplification in 200 nsec. Slew rate, as an inverter, is 400 V/μsec min. Input offset is adustable to zero mV and 150 nA. Designation is Model HFS-23. Price is $125. ILC Data Device Corp., 100 Tec St., Hicksville, NY 11801. Phone (516) 433-5330. **207**

SEMICONDUCTORS

NPN SILICON PLANAR POWER TRANSISTORS are constructed with the largest single planar chip in the industry. Indentified as the SDT 5845, SDT 5855 and SDT 5865 Series, these transistors are rated at f_t = 15 MHz (typical); power dissipation each 100°C = 300W; and thermal resistance, O_{J-C} = 0.33° C/W. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. Phone (305) 848-4311. **208**

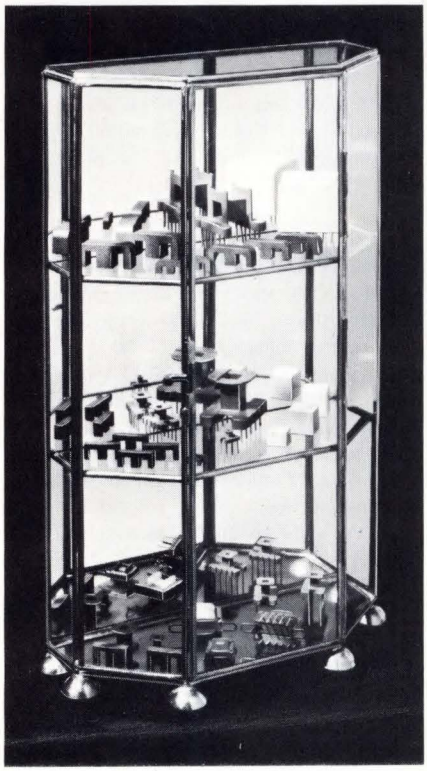
EXPANDABLE 8-INPUT MULTIFUCTION GATE USES CMOS DEVICES. Three binary control inputs select 1-of-8 output functions of eight input variables. The eight output functions are OR, NOR, AND, NAND, OR/AND, OR/NAND, AND/OR, and AND/NOR. Price: CD4048AD (Preliminary) $10.00 in 1-99 quantity. RCA/ Solid State Div., Route 202, Somerville, N J 08876. Phone (201) 722-3200. **209**



TWO MONOLITHIC TTL/MSI EACH CONTAIN a four-bit synchronous counter, a four-bit latch, and a seven-segment decoder/LED or lamp driver. Designated the SN54/74143 and SN54/74144, these complex circuits each contain the equivalent of 86 gates. Each can be used to replace the SN54/74160 decade counter, an SN54/7475 four-bit latch, and an SN54/7477 seven-segment decoder/driver. Texas Instruments Inc., 13500 N. Central Expwy., Dallas, TX 75222. Phone (214) 238-3741. **211**

2048-BIT MOS RAM INTRODUCED. Originally developed for Honeywell Information Systems, the Model 2548 is completely TTL-compatible and fully decoded. Read acess time is less than 300 nsec. Built-in amplifiers refresh the memory automatically during the "read" period. Priced at $19.53 each in lots of 100. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **210**

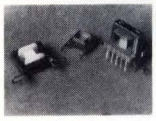
The Elegant Transformer Kits



Select from 157 kits. To find the exact match for your needs. Plus ready-made economies. With ferrite cores. Steel frames. Cases. And bobbin/coil forms that pin precisely into standard printed-circuit grid patterns.

Six materials: fluorocarbon, nylon, glass-reinforced nylon, DAP, polyester and epoxy. For stability at temperature ranges from 105 to 200 C.

The complete collection expresses the craftsmanship you expect from EPC as an EAI component company. Look to EPC also for custom-molded parts. Or



to EAI for thick-film audio amps. Capacitors. Custom coils. Solenoids. Active filters. Analog/digital converters and other special function modules. Plus a growing list of other elegantly crafted etceteras.

EPC

Electrical Plastics Corporation
500 Long Branch Avenue
Long Branch, New Jersey 07740
Tel. (201) 870-9500
A Subsidiary of Electronic Associates, Inc.

CHECK NO. 62

This solid-state Digital Panel-Meter has everything you've ever seen in other meters... plus...

- Solid State LED Readout
- Up to 200 Readings Per Second
- Will Operate From 5VDC or 115VAC
- 11 Cubic Inches
- Floating,Bipolar Differential Inputs
- Optically Isolated Outputs
- Self Check Display Test
- 100 μvolt Resolution

Priced from **$119.00**

World's smallest Line-operated Digital Panel Meter...

DATEL SYSTEMS, INC.

1020 TURNPIKE STREET, CANTON, MASS. 02021 • TEL. (617) 828-6395 • TWX 710-348-0135

CHECK NO. 63

If you depend on temperature measurements, rely on one of our 29 models.

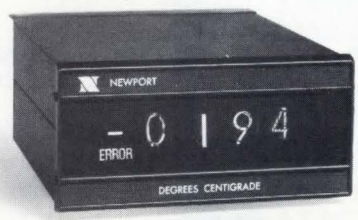
Out-of-calibration DPM's make critical measurements all guesswork — and your engineering schedule wishful thinking.

But being right-on **is** tricky. That's why Newport's new Series 260 Digital Thermocouple Indicator guarantees accuracy from the start. Reference junction compensation counteracts ambient temperature changes with 0.05°/degree error.

Over the entire sensor range, a 31-segment digital linearizer guarantees drift-free measurements. Fail-safe burn-out indication signals a thermocouple break or an off-scale reading. And Series 260 gives you extra protection with features like BIGS-BCD output, internal filtering and shielding.

Make sure your system works right from the start. Depend on our Series 260 or any of Newport's 150 matching meters. The panel instruments you install and forget.

Newport Laboratories Inc., 630 East Young Street, Santa Ana, California 92705 (714) 540-4914.

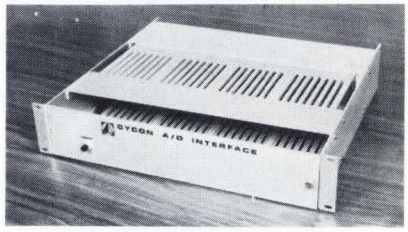


SERIES 260 DIGITAL THERMOCOUPLE INDICATOR: For TC types J,K,T,S,R,E and RTD's 1° resolution • °F or °C • —310° to +3100°F • BIGS-BCD outputs • 2½"H x 5"W x 6½"D.

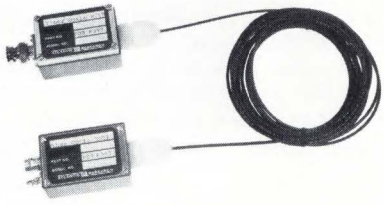
Newport Digital Panel Instruments

CHECK NO. 64

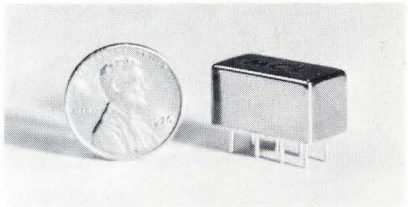
CIRCUITS



POWERED CARD NEST PROVIDES INSTANT INTERFACE SYSTEMS. The CY700 Powered Card Nest has connectors for up to 32 standard pc cards, a regulated power supply, and all the hardware necessary for a self-contained interface system. It is intended primarily for short run multi-channel interface requirements. Cards are spaced on 0.5 in. centers, and wire-wrap connectors are provided. Price is $299. Cycon, Inc., 1080 E. Duane Ave., Sunnyvale, CA 94086. **221**



OPTICAL LINK FORMS COMPLETE SYSTEM. The Model FOL 6387 Fiber Optics Link consists of a transmitter and a receiver interconnected with up to 20 ft. of a fiber-optic light guide. The system converts 300 to 20,000 Hz electrical signals for transmission over the optical link. At the receiver, the optical signal is reconverted to an electrical one. Price, complete with 20 ft. of fiber optics, is $295. Atlantic Research Corp., Shirley Hwy. at Edsall Rd., Alexandria, VA 22314. Phone (703) 354-3400. **222**

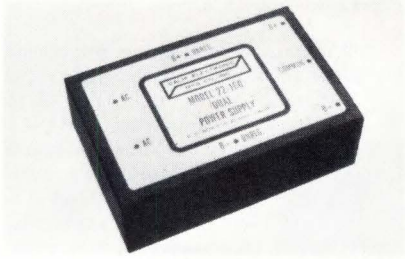


DOUBLE-BALANCED MIXER OPERATES OVER 3kHz TO 100 MHz. The model SRA-6 exhibits a 6-dB conversion loss and isolation of 60 dB. The SRA-6 operates with a 50Ω impedance at its ports and a local oscillator power level of +7 dBm. Absolute ratings include total input power of 50 mW, total peak input current of 40 mA and a pin temperature rated for 10 sec at 510F. Price is $19.95 in 5-24 quantities. Mini-Circuits Lab., 2913 Quentin Rd., Brooklyn, NY 11229. Phone (212) 252-5252. **223**

HIGH-SPEED SAMPLE/HOLD MODULE SETTLES TO 0.005% IN 5 μSEC. The Model SHM41 is for use with 12-bit medium speed A/D converters. It features a maximum dynamic transfer non-linearity of +0.005% (equal to +1/4 LSB), and has a maximum acquisition and settling time of 4 μsec for a 10V input step and 5 μsec for a 20V input step. A companion model the SHM40, is designed to use with 8- and 10-bit A/D converters. The SHM41 is priced at $135 (1 to 9 units) and the SHM40 is $85. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone (602) 294-1431. **224**

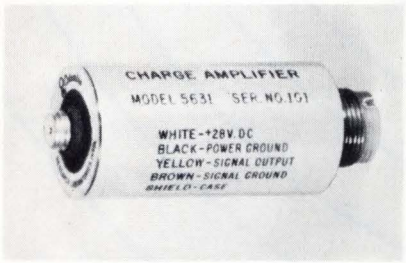
400 HZ-TO-DC CONVERTERS MEET MIL-STD-461. The W5 Series power modules convert 115V ac, 400 Hz power to any desired output voltage between 30 and 50V dc at a full-load output current of 5A. Line regulation is +0.05% or 10 mV (whichever is greater) for input changes of 105 to 125V RMS at constant load. Load regulation is +0.05% or 20 mV from no load to full load at constant line. Abbott Transistor Lab., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. Phone (213) 936-8185. **225**

VOLTAGE MONITOR PROTECTS COMPUTERS. Designed at the request of computer engineers, Model 852-5V HI-LO LINESENSOR is a logic compatiable ac voltage comparator/monitor with two setpoint circuits that can monitor line voltages (110 or 220) with better than 1V RMS accuracy and repeatability. The two setpoints are completely independent. Power for the LINESENSOR comes directly from the line it is monitoring. Price is $58 each. Calex, P.O. Box 555, Alamo, CA 94507. Phone (415) 932-3911. **226**



POWER SUPPLY DESIGNED FOR MOS CIRCUITS. The encapsulated Model 22-100-512 provides 100 mA at +5V dc and 50 mA at −12V dc. It is only 2 in. × 3 in. × 1 in., weighs 11 oz., and offers 0.05% line and load regulation and less than 1 mV RMS of ripple and noise. Also, each of the regulator circuits (plus and minus) has a separate internal precision reference. Price is $48 each. Calex, P.O. Box 555, Alamo, CA 94507. Phone (415) 932-3911. **227**

PLUG IN PHOTOELECTRIC CONTROLS MEET VARIED OEM NEEDS. Model PI consists of a complete photoelectric control: regulated power supply, lamp transformer, amplifier, relay and sensitivity adjustment. Model DR eliminates the relay, Model EPI eliminates the lamp transformer, and Model MPS-PI eliminates the power supply. Other versions are also available, as are a variety of time delays. Scanning Devices, 245 Sixth St., Cambridge, MA 02142. Phone (617) 354-7226. **228**



CHARGE AMPLIFIERS MATE WITH PIEZOELECTRIC TRANSDUCERS. The 5630 Series of miniature in-line ac charge amplifiers provide complete signal conditioning for all piezoelectric transducers. The ac charge mode of operation permits use of varying lengths of transducer cable without change in system sensitivity or signal distortion. The line consists of four models, with prices starting at $195. Columbia Research Labs., MacDade Blvd., Bullens Lane, Woodlyn, PA 19094. Phone (215) 532-9464. **229**

HIGH-SPEED OP AMP FEATURES DIFFERENTIAL OPERATION. The Model 1030 provides true high-speed differential performance coupled with low current drain. It performs at top speed either as an inverter or in the non-inverting mode. Guaranteed specifications are 500V/μsec slew rate, 500 nsec settling time to 0.01%, and a gain bandwidth product of 100 MHz. Price is $62 in 100 quantities. Teledyne Philbrick, Allied Dr., at Rt. 128, Dedham, MA 02026. Phone (617) 329-1600. **230**

8-BIT A/D CONVERTER HAS 500 kHz THROUGHPUT RATE. The ADC-EH is an ultra-high-speed converter packaged in a compact 2 in. × 2 in. × 0.375 in. module. The analog input voltage range is digitally programmable and can be either unipolar (0 to +10V FS) or bipolar (±5V). The unit has ±0.2% accuracy and differential linearity. Parallel and serial outputs are a standard feature. Price is $85. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **231**

3M BLOCKS EMI RADIATION.

New tapes deliver long-term shielding protection

New Scotch Brand tapes with embossed metal foil backings provide an easy, low-cost way to apply lasting EMI shielding in applications up to 12 GHz. Insertion loss levels remain constant in year-long tests. (Applied to a copper substrate, over a ½″ x 2¾″ open slot radiating at 143 MHz, Scotch X-1245 tape held the insertion loss level at a steady 65 db.) Insertion losses are equally consistent on steel, aluminum and cadmium; ranging from 35 db to 55 db.

Easy to apply, Scotch Brand Shielding Tapes end the need for plating, painting or other expensive shielding methods. Can be applied in the factory or in the field and permit easy on-the-spot shielding repairs.

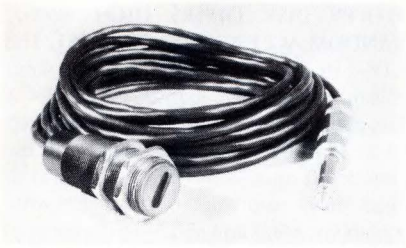
Scotch Brand X-1245 has an embossed copper foil backing which permits solder connections. Scotch Brand X-1267 has an embossed aluminum foil backing. These tapes are ideal for shielding enclosures, cables and electronic test equipment and for static charge draining and trouble shooting.

For complete facts write: DM&S Div., 3M Company, St. Paul, Minn. 55101.

See our complete catalog in eem.

Dielectric Materials & Systems Division 3M COMPANY

CHECK NO. 13



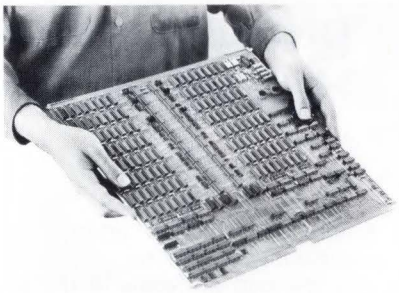
PHOTOELECTRIC PICKOFF MATES WITH ELECTRONIC STROBOSCOPES. The GR 1536-0 includes a photocell and a light source built into a 0.75-in. threaded housing with an attached 15-ft. cable. The cable connects the output of the pickoff to the strobe and also supplies the necessary power to the light source. The required power is 20 to 28V. Price is $45. General Radio Corp., 300 Baker Ave., Concord, MA 01742. Phone (617) 369-4400. **232**

VARIABLE SPEED DRIVES OPERATE OR TEST STEPPER MOTORS. Series K35503 and K35502 are available for 4-phase and 8-phase motors, respectively. The units have frequency ranges of 1-100 Hz; 10-1000 Hz; and 100-10,000 Hz, with a pulse train output level from 0 to 5V dc. North American Philips Controls Corp., Cheshire Industrial Pk., Cheshire, CT 06410. Phone (203) 272-0301. **233**

FET OP AMPS FEATURE FAST SETTLING, LOW DRIFT. The FA540 and FA541 are differential FET op amps which combine a settling time of 1.5 μsec with common mode rejection of 100,000. In addition, Model FA541 offers a low drift of 2 μV/°C minimum. Other specifications include a gain bandwidth of 5 MHz, 10 PA input current, and $10^{11}\Omega$ input impedence. Prices are $55 for the FA540 and $68 for the FA541. Intronics, 57 Chapel St., Newton, MA 02158. Phone (617) 332-7350. **234**

MULTIPLIER HAS ACCURACY OF ±0.5% WITHOUT EXTERNAL TRIMMING. The Model 550 has ±0.5% accuracy without external trimming and a maximum drift of ±0.04%/°C. Maximum nonlinearity over all four quadrants (any X, Y value between ±10V) is a maximum of ±0.2% of full-scale. The Model 550 has provision for optional low-pass filtering of the output signal. The inputs and outputs are scaled for ±10V full-scale. Price is $37 in 100 quantity. Function Modules, Inc., 2441 Campus Dr., Irvine, CA 92664. Phone (714) 833-8314. **235**

COMPUTER PRODUCTS



SC ADD-ONS REDUCE COSTS OF NOVA MEMORIES. Intel in-1200 SC memory boards cost 30 to 50% less, and replace core memory boards in Data General's 1200, 1210, and 1220 minis without any modification to the computer. Boards storing 2k or 4k words are also available. Each board can hold an additional 1k 16-bit words of ROM, which may eliminate need for a separate ROM board. Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501. **184**

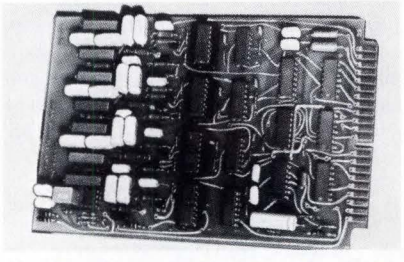
DRUM PRINTER CONTROLLER FITS ON ONE PC BOARD. This controller for a Seiko drum printer accepts BCD inputs, decimal point select, print command, red ribbon shift command and external paper feed command. Fifteen column printout, with spaces, is standard (21 columns optional). Power supply regulators are mounted on the same board. $175 T & T Technology, Inc., 4820 Dale Rd., McFarland, WI 53558. Phone (608) 838-3171. **185**

PROGRAMMABLE CALCULATOR INTERFACES WITH MEASURING SYSTEMS and performs programmed data calculations directly upon receiving data from "digital" measuring devices. It produces a printout of 150 lpm in two colors (red for negative values), and has up to 23 digit capacity. Six to 12 independent data storage registers are available. The most highly-complex data calculations can be handled easily by the S-301M, which has storage function for programs up to 153 steps. Seiko, 437 Madison Ave., New York, NY 10022. Phone (212) 758-5780. **186**

ECONOMICAL ADD-ON MEMORY FOR H-P MINIS EXTENDS CAPACITY. The add-on or replacement core memory systems for HP Model 2100A or 2114A, or 2114B minicomputers are plug-compatible with the HP equipment. They can expand HP core capacity to 32k words. The memory can save the user over $2000 per 8k word increments of expansion over the H-P available units. Fabri-Tek Inc., 5901 South County Rd. 18, Minneapolis, MN 55436. Phone (612) 926-2721. **187**

FLOPPY DISK OFFERS HIGH SPEED, RANDOM ACCESS AND LOW COST. The CDS-110 utilizes a removable, 7.5 in., 4 mil mylar, jacketed disk that stores over 1.4M bits of data on 64 tracks. Data is transferred at 33.3k bits/sec. and track-to-track access time is 40 msec. Units are available with read only, read/write or read-after-write capability. $500/unit and $4/disk cartridge. Century Data Systems, Inc., 1270 N. Kraemer Blvd., Anaheim, CA 92806. **188**

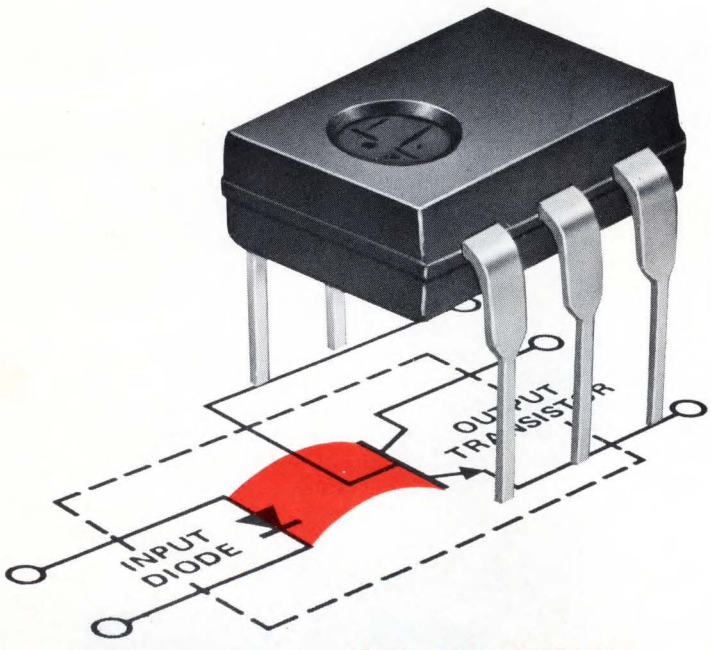
KEYBOARD OFFERS LOW COST AND REDUNDANT CONTACT SWITCHES. A new 53 position ANSI keyboard, features gold contact BI-PAC switches, full ASCII coding (shifted, unshifted, control & control/shift), standard 2-key rollover interlock, low power consumption (less than 300 mA) and standard typewriter array. $49 in qtys. of 5000. Controls Research Corp., 2100 South Fairview, Santa Ana, CA 92704. Phone (714) 557-7161. **189**



TOUCH TONE RECEIVER FOR DATA TERMINALS. Model TD-113 converts standard two-tone signals into one of twelve TTL compatible signals and provides a TTL logic zero and strobe for a valid input signal. It will accept all valid touch tone signals over the commercial telephone range or may be used with a touch pad directly, in private systems. Applications also include security, private key, mobile communications and credit checking systems. Teletron Co., 40 Elliott St., Melrose, MA 02176. Phone (617) 665-5837. **190**

MODEM PROVIDES 2400 BPS ON 2 OR 4-WIRE UNCONDITIONED LINES. An integral modem Model 2010, which provides fully Bell 201B compatible operation features automatic fast sync, new sync, clear to send delay, carrier detect, external/internal transmitter timing, and MARK hold on receive data when carrier is lost. Error rate is $<$ one bit in 10^6 at a signal-to-noise ratio of 15 dB with 20° peak-to-peak phase jitter at a rate from 0 to 180 Hz. $1040. Intertel Inc., 6 Vine Brook Pk., Burlington, MA 01803. Phone (617) 273-0950. **191**

THE MAGIC COUPLER



Of more than 20,000,000 phototransistors produced by Fairchild MOD, four million have been used in optical couplers.

Take a light emitting diode chip. Mount it facing a light sensitive semiconductor detector. Package these two chips in a case with input and output leads. The result is probably the most versatile solid state device available, literally a subsystem that:

- Switches on and off with a speed in the low microsecond range and faster.
- Isolates input and output with 10^{11} ohms resistance and a coupling capacitance of approximately one pF.
- Relays information from DC to hundreds of KHz.
- Serves as the drive element to control equipment.
- Operates with an efficiency of up to 50% and more, producing a linear output.
- Provides unidirectional operation, with no feedback to the input.
- Interfaces such circuit devices as transistors and integrated circuits.
- Interfaces memory – CPU – I/O Logic.

WHAT IT DOESN'T DO IS ALSO INTERESTING.
For example, it:

- Has no moving parts, no contacts to bounce or arc or erode.
- Is unaffected by magnetic fields.
- Doesn't take up much space, being about 1/3" X 1/4" X 1/3".
- Has no known failure modes to make it fail in our lifetime.
- Doesn't require much current for operation, only a few mA.
- Doesn't cost much. Economical. In fact, downright practical.

The World Beaters	Current Transfer Ratio – % (Typ)	Breakdown Voltage – V Input to Output	Description
FCD 810	25	750	Lowest cost
FCD 811	50	2500	Highest Voltage Plastic DIP
FCD 820	50	1500	The Standard

This device has been called a solid state relay, coupler, isolator and transformer. But think of it simply as the answer to many problems, whether you are in the electronics, control or processing industries; whether you are designing medical instrumentation, processing equipment, transportation systems, etc.

Data sheets describing the characteristics of these remarkable devices and how they operate are yours for the asking from your local Fairchild semiconductor sales engineer. Your stocking Fairchild semiconductor distributor can provide immediate product delivery.

MADE IN FAIRCHILD

FAIRCHILD MICROWAVE & OPTOELECTRONICS DIVISION 4001 MIRANDA AVENUE, PALO ALTO, CALIFORNIA 94304

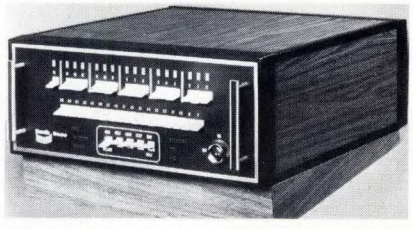
CHECK NO. 72

COMPUTER HARDWARE

LINE SAVER PERMITS SIX TERMINALS TO SHARE ONE MODEM. The LSD-6 time-shares one modem on a "first come, first serve" basis. By operating several LSD-6 units in tandem, one modem can be extended to accommodate 11, 16, 21, etc. collocated terminals. The self contained unit conforms to EIA Standard RS-232C and requires no operator attention. Rixon Electronics, Inc., 2120 Industrial Pkwy., Silver Spring, MD 20904. Phone (301) 622-210. **192**

300 BPS ANSWER-ONLY DATA STATION HAS 20 CHANNELS. The T113B is compatible with Bell or Sangamo 101C, 103A2, 103E, and 113A data sets and is interchangeable with the Bell 113B. The 113B includes 9 interface status lamps on each channel modem, abort timer, loss-of-carrier disconnect, restrainer signal transmission and make-busy features and a remote monitor capability. Each channel modem functions independently from the others. $6800. Sangamo Electric Co., P.O. Box 3347, Springfield, IL 62708. Phone (217) 544-6411. **193**

INTERFACE REDUCES COST OF PDP-8 MULTI-TELETYPE CONTROL. The DL8-E can be interfaced to either RS232C modems or directly to teletypes, uses the same microcodes as DEC's KL8-E, and KL8-EA through EG, and plugs directly into an Omnibus connector. Any number of serial channels up to 32 may be interfaced to the PDP-8 by using one DL8-E per channel. It may be used in place of individual KL8 modules or DEC's DCO2 8-channel multi-teletype control. $175. Digital Lab., 377 Putnam Ave., Cambridge, MA 02139. Phone (617) 876-6220.



MICROPROGRAMMABLE MINI PROVIDES 2 μSEC ADD TIME. The BDX-9000 16-bit, parallel-processing computer has the unusual feature of being functionally interchangeable with a previously developed aerospace computer, the BDX-900 and is completely compatible with regard to software and interface. The basic chassis can hold up to 24k words of core memory and 12 peripheral device controllers. Bendix Corp., Teterboro, N J 07608. Phone (201) 288-2000. **195**

free its.

BORDEN® MYSTIK BRAND

Insulation Tape Selector

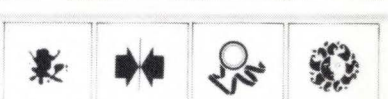
6407 VINYL • 6408 VINYL • 6410 VINYL • 7000 FIBERGLASS • 7001 FIBERGLASS • 7010 FIBERGLASS • 7020 FIBERGLASS • 7021 FIBERGLASS • 7100 FIBERGLASS • 7223 PAPER • 7233 PAPER • 7252 NOMEX • 7300 POLYESTER • 7321 POLYESTER • 7322 POLYESTER • 7323 PRINTABLE POLYESTER • 7324 ACETATE • 7325 ACETATE • 7326 POLYESTER MAT • 7331 POLYESTER • 7351 POLYESTER • 7352 POLYESTER • 7355 POLYESTER • 7361 KAPTON • 7362 KAPTON • 7366 KAPTON • 7367 KAPTON • 7375 TEDLAR • 7502 TEFLON • 7503 TEFLON • 7505 TEFLON • 7510 TEFLON • 7600 COTTON CLOTH • 7700 ACETATE CLOTH • 7701 ACETATE CLOTH • 7800 POLYESTER/ROPE PAPER LAMINATION • 7801 POLYESTER/ROPE PAPER LAMINATION • 7850 ACETATE FILM/ RAYON FILAMENT LAMINATION

FIBERGLASS
7000 7001 7010 7020 7021 7100
INSULATION CLASSES 130°C 180°C

PAPER • CLOTH • LAMINATIONS
7223 7233 7252 7600 7700 7701 7800 7801 7850
INSULATION CLASSES 105°C 130°C 155°C

FILM/KAPTON/TEDLAR/TEFLON
7361 7362 7366 7367 7375 7502 7503 7505 7510
INSULATION CLASSES 155°C 180°C

FILM/ACETATE/POLYESTER
6407 6408 6410 7300 7321 7322 7323 7324 7325 7326 7331 7351 7352 7355
INSULATION CLASSES 105°C 130°C 155°C



MYSTIK TAPE... MEETING THE CHALLENGE OF CHANGE!

ITS is our new Insulation Tape Selector. And it's yours, free. Just for the asking.

ITS is handy. Fits neatly into any loose leaf binder. ITS is easy to use. One little flip gives you all the information you need about our Mystik® Tapes. ITS gives you a full breakdown by insulation class and dielectric strength. Including military and government specifications.

The most important information we can pass on to you is that Mystik makes a pressure sensitive tape for almost every application—from harness wrapping to electroplating of printed circuit boards. For temperatures of −110 degrees F. to 550 degrees F.

For more information about Mystik insulation tapes and, for your free ITS, mail in this coupon.

Mystik Tape
Borden Chemical
Division of Borden Inc
P.O. Box 189
Winnetka, Illinois 60093

BORDEN®

Gentlemen:
Please send me my free ITS. ☐ Plus more information on Mystik insulation tapes:
☐ 180° C ☐ 155° C ☐ 130° C ☐ 105° C.

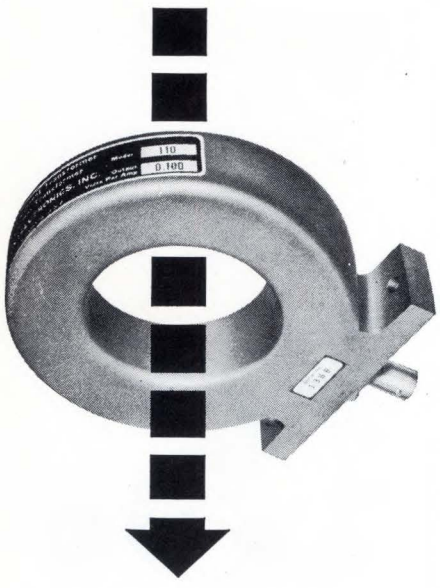
Name_____

Company_____

Street_____

City_____ State_____ Zip_____

CHECK NO. 74



Wide Band, Precision

CURRENT MONITOR

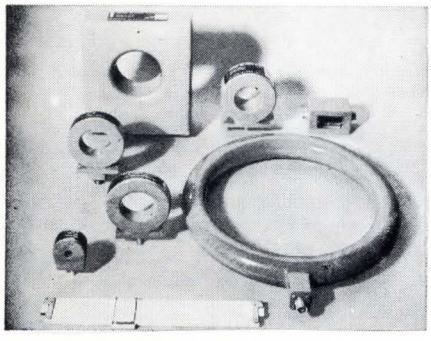
With a Pearson current monitor and an oscilloscope, you can measure pulse or ac currents from milliamperes to kiloamperes, in any conductor or beam of charged particles, at any voltage level up to a million volts, at frequencies up to 35 MHz or down to 1 Hz.

The monitor is physically isolated from the circuit. It is a current transformer capable of highly precise measurement of pulse amplitude and waveshape. The one shown above, for example, offers pulse-amplitude accuracy of +1%, −0% (typical of all Pearson current monitors), 20 nanosecond rise time, and droop of only 0.5% per millisecond. Three db bandwidth is 1 Hz to 35 MHz.

Whether you wish to measure current in a conductor, a klystron, or a particle accelerator, it's likely that one of our off-the-shelf models (ranging from ½" to 10¾" ID) will do the job. Contact us and we will send you engineering data.

PEARSON ELECTRONICS INC

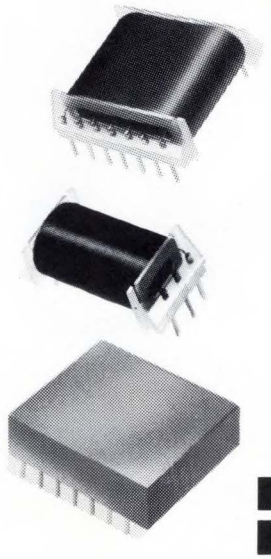
4007 Transport St., Palo Alto, California 94303
Telephone (415) 326-7285



CHECK NO. 75

FREE

A NEW BABCOCK REED RELAY FOR YOUR EVALUATION



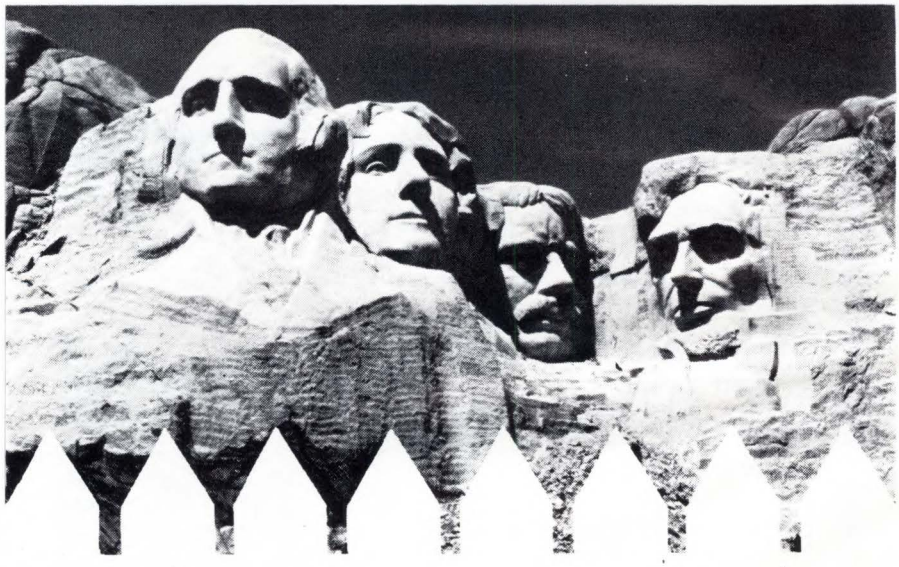
Check for yourself these relay features . . . gold-plated terminals—reed welded to terminals—glass reinforced bobbin—stand-off pads to facilitate board cleaning . . . THEN check its performance. The new 10-watt dry-reed and 50-watt mercury-wetted series is offered in 0.100″ and 0.150″ terminal spacings, in Forms A, B, and C and combinations, and in open frame and covered versions.

Send for your FREE sample and complete technical data; contact Babcock Electronics Corp., Subs. of Esterline Corp., 3501 No. Harbor Blvd., Costa Mesa, Calif. 92626.

BABCOCK

A UNIT OF ESTERLINE CORPORATION

CHECK NO. 76



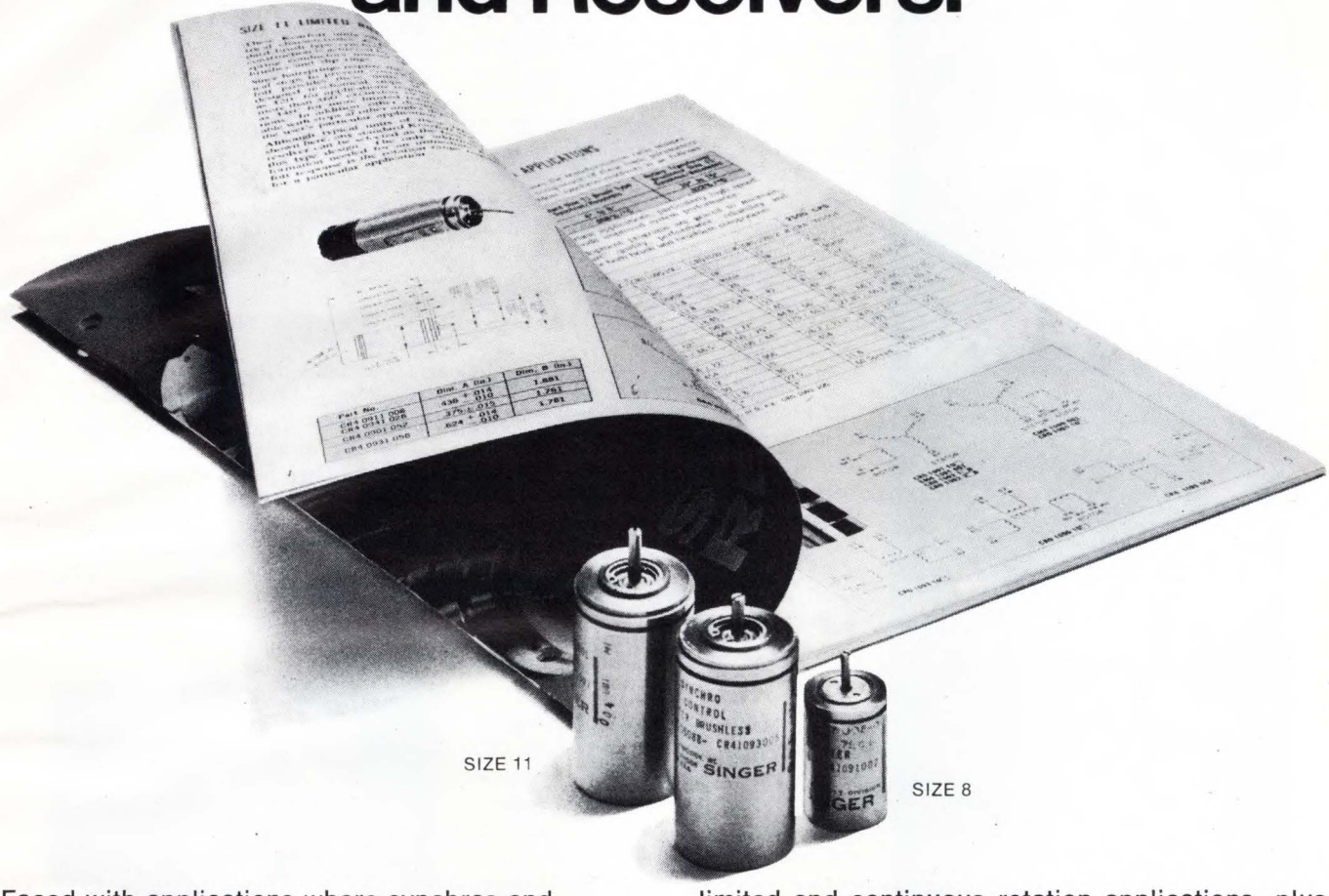
Say hello to the boys next door.

People come from all over the world to discover the man-made and natural wonders of America. And you have a heck of a head start—it's all in your own backyard.

This year, discover America. Carve out a great vacation.

DISCOVER AMERICA IT'S SOME BACKYARD

Send for our brushup course on Brushless Synchros and Resolvers.



Faced with applications where synchros and resolvers have to be driven at extremely high speeds? Or where brush wiping contact can't be permitted?

Kearfott Brushless Components provide system performance advantages. (Instead of standard brushes and slip rings, rotary transformers couple power into the synchro motor.) And extra-wide bearings give you increased reliability and load-carrying capacity.

Our Brushless Synchros offer you a number of other benefits, too. Longer life, since there's nothing to wear but the bearings. No spurious signals from high-speed brush bounce which Digital Computers can interpret as a command input. Elimination of brush friction for Indicators that require the ultimate in minimum loading. And an end to RFI noise.

Kearfott Brushless Synchros and Resolvers also serve as excellent low cost Brushless Encoders when used in combination with Kearfott TRIGAC I S/D converter cards.

Like to know more? Write for our 36-page brochure on Synchros and Resolvers. It's packed with facts and figures on Brushless Synchros for limited and continuous rotation applications—plus our full line of Synchros and Resolvers. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, New Jersey 07424.

SINGER

AEROSPACE & MARINE SYSTEMS

The Singer Company, Kearfott Division
1150 McBride Avenue
Little Falls, New Jersey 07424

Gentlemen:

☐ I want to know more about Brushless Synchros. Rush me your 36-page booklet on Synchros and Resolvers.

☐ I have an application for Brushless Synchros. Have a company representative call.

Name_____

Title_____

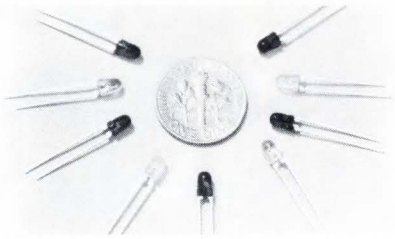
Company_____

Address_____

City_____ State_____ Zip_____

CHECK NO. 78

COMPONENTS/MATERIALS



SOLID STATE LAMPS CONFORM TO CLASS T-1 BULB OUTLINE. These new mini-LEDs can be flush mounted in 0.045-in. diameter holes on 0.1 in. centers on printed circuit boards. Three lens configurations are available—red diffused, white diffused and white clear. Price of the Model 5082-4480 Solid State Lamp is 45¢ in quantities of 1000. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **170**

MAT PROTECTS MOS DEVICES FROM ELECTROSTATIC DAMAGE. Velostat electrically conductive bench tops and floor mats for work stations are designed to eliminate static. Bench tops and floor mats are available in 4 ft. × 8 ft. or 4 ft. × 16 ft. sheets and in thicknesses of 0.025 in., 1/16 in., 1/8 in., 3/16 in., and 1/4 in. Custom Materials, Inc., Alpha Industrial Park, Chelmsford, MA 01824. Phone (617) 256-3911. **171**

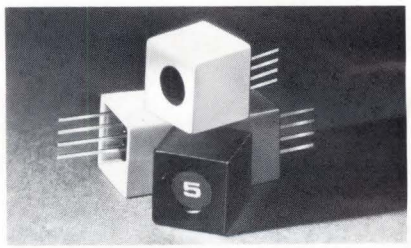
SINGLE-IN-LINE NETWORKS PUT MORE CIRCUITRY ON LESS BOARD SPACE. The networks are available with up to 15 leads in epoxy conformal coatings. Tolerances are as required, up to 0.1%, power dissipation up to 5W. Resistors are thick film on an alumina substrate. Non-resistor components may also be added. Quantity deliveries in four weeks. Mepco Electra, Inc., Columbia Rd., Morristown, N J 07960. Phone (201) 539-2000. **172**

"ROLLING WAVE" SWITCHES CAN HANDLE 3 and 5A LOADS. A max. of 25 grams of force on the end plunger will operate the 3SV power switch. The 5SV operates at less than 40 grams. The 3SV and 5SV switches are a quarter of an in. thick. Basic list price for both the 3SV and 5SV is $1.45. Micro Switch, A Division of Honeywell Inc., 11 W. Spring Street, Freeport, IL 61032. Phone (815) 232-1122. **173**

OPTO-ISOLATOR PROVIDES LOGIC ISOLATION. Among the typical specifications are these: LED power dissipation @ 25°C = 50 mW; LED continuous forward current = 30 mA; detector power dissipation @ 25°C = 200 mW; and detector collector-emitter breakdown voltage = 30V. In 1000 lot quantities units are $3.01 each. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 497-7600. **174**

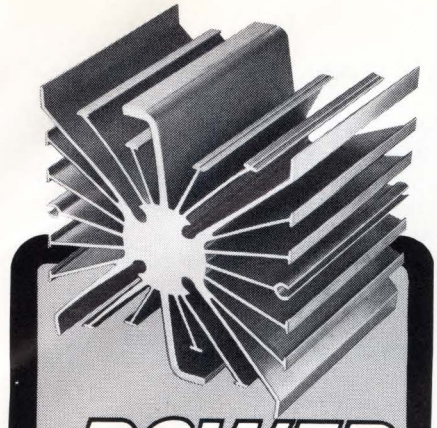
THICK FILM PASTE ALLOWS SCREEN PRINTING OF CAPACITORS. Thick film capacitor pastes can be fired at less than 1000°C in the same furnace used for firing resistors and conductors. The multi-layer capacitor paste consists of three screens with a dielectric layer between two conductors. Cost is $15.00 per ounce in large quantities. Electro-Materials Corp. of America, 605 Center Ave., Mamaroneck, NY 10543. Phone (914) 698-8434. **175**

LOW PROFILE CERMET TRIMMER MEASURES 0.15 in. HIGH. The Model 82, a single-turn, general-purpose trimmer, is substantially below the max. allowable height of a TO-116 dual inline package. The rate of resistance change in the unit is typically less than 0.5% during the first 1000 hours of operation. Beckman Instruments, Inc., Helipot Div., P.O. Box 11866, Santa Ana, CA 92711. Phone (714) 871-4848. **176**



SOLID-STATE SWITCHES FEATURE A TOTAL ABSENCE OF MOVING PARTS. The operate with a capacitive sensor, and are available in momentary, latching and touch-on, touch-off (toggle) configuration. Operating voltage for the F200 Series is from 5 to 30V dc. Models are available with LEDs as visual indicators. Magic Dot, Inc., 40 Washington Ave. S., Minneapolis, MN 55401. Phone (612) 333-8161. **177**

CONNECTOR FEATURES SELF-MOUNTING AND QUICK DISCONNECT. The receptacle half of the connector snaps into a pre-punched rectangular chassis hole and is held in place with molded-in wings and stops. The plug mates with quick disconnect type latches. The QIKMATE connector is designed for use with the Burndy Trim Trio system of contacts. Burndy Corp., Richards Ave., Norwalk, CT 06852. Phone (203) 838-4444 **178**



POWER HEAT SINKS

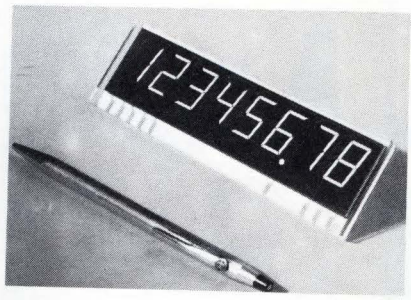
A COMPLETE RANGE
10 TO 1000
WATT DISSIPATION

Thermalloy manufactures a variety of natural-convection, fan-cooled and liquid-cooled heat sinks to give you optimum performance in the kilowatt and near kilowatt heat-range.

FREE
Catalog #72-HS-8 on request

Thermalloy Company
8717 DIPLOMACY ROW
DALLAS, TEXAS 75247
PHONE: 214-ME 7-3333
TWX: 910-861-4410

CHECK NO. 80



PANEL DISPLAY WITH 0.7 IN. CHARACTERS CAN BE VIEWED FROM 35 FT. This unit, the BR08751 PANAPLEX II panel, contains eight digits of display interconnected within a common envelope. Only 24 connections are required to address the eight character positions and decimal point. Prices in OEM quantities will be $2 per digit. Burroughs Electronic Components Div., Box 1226, Plainfield, N J 08861. Phone (201) 757-5000. **179**

25¢ to buy
24 hours to ship

Low price for open transformers-bifilar wound with two color, solder pot strippable wire. Try them for your balun, floating switch, inhibit drive and coupling applications. Order 500 and they are only $.25 each.

Quick delivery means shipped within 24 hours of your order, any part shown below. Delivery is in lots of 50. Ask for a quote when you want thousands. Eliminate core search and winding time.

ELECTRICAL SPECIFICATIONS

Catalog Number	Turns Ratio ±5%	Primary OCL μH min	ET Volt-μsec Min	Cww pf max	L_L μH max	DCR ohms max
PE 52104	1:1	10	1.0	1.5	0.18	.14
PE 52106	1:1	20	1.3	2.0	0.20	.17
PE 52108	1:1	35	1.6	2.5	0.20	.23
PE 52110	1:1	60	1.8	3.5	0.22	.25
PE 52112	1:1	85	2.1	4.0	0.22	.28
PE 52114	1:1	125	2.7	5.0	0.22	.30
PE 52116	1:1	160	2.8	6.5	0.22	.35
PE 52118	1:1	215	2.8	8.5	0.22	.35
PE 52120	1:1	240	3.2	10.0	0.22	.37
PE 52122	1:1	290	3.6	12.0	0.22	.41
PE 52124	1:1	360	3.9	12.5	0.24	.42
PE 52126	1:1	385	4.2	12.5	0.28	.48
PE 52128	1:1	445	4.4	14.0	0.28	.50
PE 52130	1:1	515	4.9	14.5	0.32	.54

PHYSICAL DIMENSIONS

Lead Length:
Start 1.5 in. min.
Finish .75 in. min.
O.D.—0.220 max.
Height—0.100 max.
Inspection per MIL STD 105 1% AQL Level 2

Rating Range	
Average Power Rating (40°C Rise)	250 mw
Dissipation Rating	75 mw
Peak Pulse Voltage	50 volts
High Potential Test	200v rms
Insulation Resistance	10,000M ohms

Pulse Engineering Inc.

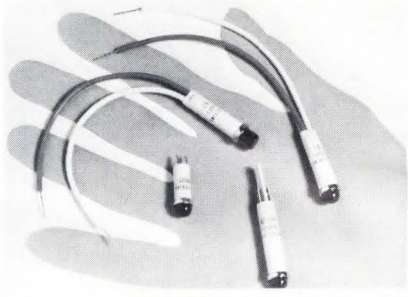
A Varian Subsidiary

Pulse Engineering, Inc.
P. O. Box 12235 • San Diego, Calif. 92112
Phone 714-279-5900 • TWX 910-335-1527

CHECK NO. 81

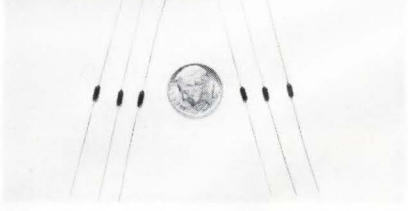
COMPONENTS/MATERIALS

LIGHTED PUSHBUTTON SWITCHES AND INDICATORS, the Series C1, offers 2PDT contact in momentary and alternate actions. Contact ratings are 2A resistive at 28V dc/115V ac. Life expectancy is in excess of 100,000 operations. Wiping, leaf-spring contacts clean the contact surface with each operation. Stacoswitch, 1139 Baker St., Costa Mesa, CA 92626. Phone (714) 549-3041. **180**



FREE SAMPLES OF LED PILOT LIGHT. The pilot light comes as a complete package ready to interface with the user's circuit. For dc applications the package includes a current-limiting resistor. For ac a diode is built in. Please specify lens shape, operating voltage, whether ac or dc, and leads (how long) or terminals. Industrial Devices, Inc., Edgewater, N J 07020. Phone (201)224-4700. **181**

LOW-PROFILE KEYBOARD SWITCH IS AIMED AT CALCULATOR APPLICATIONS. Designated Series 415, the switch stands 0.415 in. high. It has bounce characteristics of less than three msec. and an operating force of 70 grams. Key caps are available in a 5/8 in. square cap for hand-held calculators and 3/4 in. cap for desk top models. OAK Industries Inc., Switch Div., Crystal Lake, IL 60014. Phone (815) 459-5000. **182**



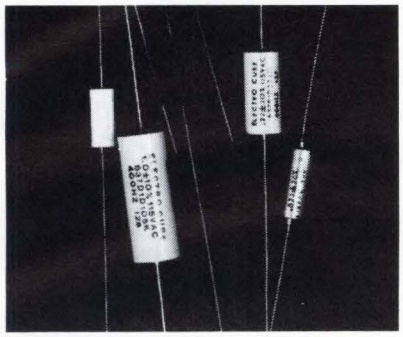
MINIATURE CERAMIC CAPACITORS ARE GLASS ENCASED. "Gla-Pac" caramic capacitors are available in both NPO and W5R characteristic dielectrics. They feature monolithically constructed ceramic capacitive elements hermetically sealed in epoxy coated glass and are rated at 50V. Capacity values are from 10 pf to 0.012 μf. Circuit Functions, Inc., 20908 Itasca St., Chatsworth, CA 91311. Phone (213) 882-0960. **183**

100% testing proves every Electrocube AC rated polycarbonate capacitor is a sure thing.

Even with derating, a DC unit can pop if its DF isn't right for the frequency. So we build these metallized units just for AC, and screen them 100% so you know they'll go 115 VAC at 400 Hz. These aren't derated DC units. Choose from 241 different units. Values are from .0010 to 2.0 mfd, in six case styles.

We'll send you data sheets and a bulletin on problems in using DC capacitors for AC applications.

Call (213) 283-0511, TWX 910-589-1609, or write to 1710 South Del Mar Avenue, San Gabriel, California 91776.



electrocube

Capacitors, EMI filters, RC networks, transformers, ballasts

CHECK NO. 46

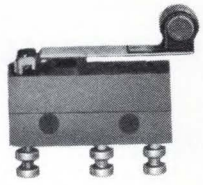
NEW

smallest precision snap action switch yet!

Case dimensions of our new 4900 Series MINI-MITE switches are less than .250″ by .300″ by .100″. Ratings are 2 amp. 125-250V AC; 2 amp. (Res.) and 1 amp. (Ind.), 30V DC. Meet MIL-S-8805 specs. Available with 4 types of terminals, pin plunger and various lever type actuators.

new sub-miniature switches

Our new 4800 Series sub-miniature switches are rated 5 amp. 125-250V AC with 5 amp. resistive and 2½ amp. inductive ratings at 30V DC. Case dimensions are approximately .400″ by .800″ by .250″. Available with 6 terminal types, a variety of lever actuators and optional bifurcated or dual gold contacts. Meet MIL-S-8805 specs. McGill Manufacturing Co., Inc., Electrical Division, Valparaiso, Indiana 46383



Available from Authorized McGill Electrical and Electronic Distributors

McGILL®
ENGINEERED SWITCHES

CHECK NO. 27

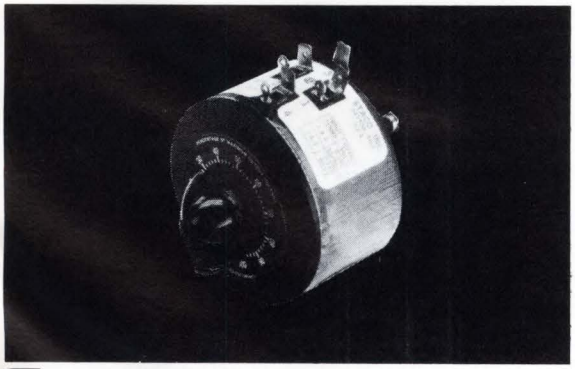
---

smallest

3 AMP UNIT AVAILABLE

Staco's new miniature AC voltage control is the smallest and most economical unit on the market. Staco's 291 Series (3.0 amp) and 201 Series (2.0 amp) are open construction models designed for back of panel mounting. Models offer the user a unit closer to exact application needs, saving space and reducing cost, yet provide peak rating and performance characteristics. Save 75¢ per unit, save even more in quantities. Staco Variables are available for immediate "off the shelf" delivery from leading electronic distributors. Save money and space with STACO, INCORPORATED, 2240 E. Third Street, Dayton, Ohio 45403.

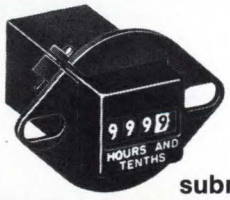
STACO variable autotransformers



Other STACO products: custom transformers, STACO, INCORPORATED, Richmond, Indiana; panels & switches, STACOSWITCH, Costa Mesa, California.

CHECK NO. 45

Where life counts... count on General Time



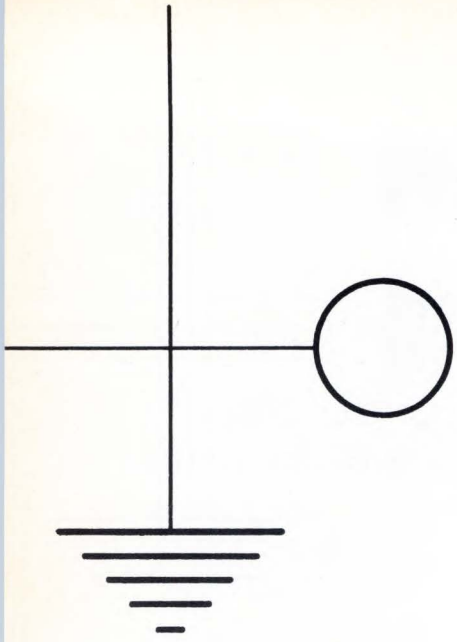
subminiature elapsed time indicators and events counters meet Military Standards.

General Time subminiature Elapsed Time Indicators and Events Counters provide a built-in record of how-long/how-many data for aerospace and military applications. Precise. Dependable. Proven reliability/30 million test hours. Digital or dial readouts. 400 Hz or 28v DC Systems. Anticipate breakdowns, record service life, count revolutions, monitor starts, vibrations, any critical function. We'll design or modify to your specifications.

Write for Catalog 136 today.

GENERAL TIME
A TALLEY INDUSTRIES COMPANY
SPACE AND SYSTEMS DIVISION
1200 Hicks Road • Rolling Meadows, Ill. 60008

CHECK NO. 28



Do You Have Enough The Way No One Could

- GROUP TELEPHONE CONFERENCES
- SMALL NATIONWIDE GROUPS
- YOU'RE ON THE LINE WITH OTHER DESIGNERS, AND INDUSTRY EXPERTS
- TRADE KNOW-HOW AND GET HIGH PAY-OFF SOLUTIONS
- SKILLED MODERATORS
- ASK QUESTIONS, EXPLORE IDEAS, OR JUST LISTEN
- DIAL IN FROM WHEREVER YOU ARE
- NO LOST TIME, TRAVEL, LODGING
- COST: PHONE CHARGES PLUS $30 FOR FULL HOUR
- OVER 700 TELESESSIONS SO FAR. **IT WORKS!**

Imagination to Spend An Hour Ever Spend An Hour Before?

For whichever topic you choose, you will be discussing problems such as:

- Which technology is best?
- What the specs don't say . . .
- Hidden costs.
- Alternate suppliers . . .
- When is making cheaper than buying?
- Applications pitfalls.
- Hidden effects on your system.
- How to get a particular vendor to work harder for you.
- Cost effectiveness subtleties.

TOPICS AVAILABLE

	Reader Service #
• High Speed Logic Families	200
• A/D & D/A Converters	201
• Semiconductor Memories	202
• Plated Wire Memories	203
• Keyboards	204
• Terminals & Displays	205

CIRCLE THE READER SERVICE CARD NUMBER AND YOU WILL GET BY RETURN MAIL:

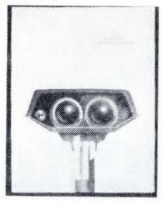
- Date & Time of Your TeleSession
- Your Group's Specific Agenda
- List of Other Participants
- Details on How to Dial Into Discussion
- Tips on How to Get the Most Out of It

EDN/TeleSession®

THE DISCUSSIONS YOU DIAL INTO

LITERATURE

LSI TEST SYSTEM. A 6-page brochure describes the MD-104 LSI test system and the new microprogrammable multiprocessor designed for testing both MOS and bipolar LSI devices, such as ROMs, RAMs, shift registers, UAR/T, and random logic. Complete with photos and block diagram, the brochure discusses the significance of "Pattern Sensitivity" in device characterization and it lists more than 20 standard test programs available. Macrodata Co., 20440 Corisco St., Chatsworth, CA 91311. **236**



INFRARED DATA LINKS, together with their economic and performance benefits for direct transmission of data over short distances, without wires, are discussed in a new brochure. The 4-page brochure describes how two devices, called Optrans, provide an entire, self contained communications link, via an easily aligned infrared beam that accommodates data terminals of any speed up to 1 Mb or higher. Computer Transmission Corp., 1508 Cotner Ave., Los Angeles, CA 90025. **240**

SENSITIVE RESEARCH INSTRUMENTS are detailed in a 30-page catalog which provides price and specification information on a broad line of analog instruments. Included is information on laboratory standards; ac-dc and dc polyrangers and reference standards; ac-dc wattmeters; power factor meters; electrostatic voltmeters, thermocouple (true RMS) instruments; magnetic testing equipment; differential instruments; and panel mounted instruments. Electrical Instrument Service, Inc., 25 Dock St., Mount Vernon, NY 10550. **244**

PHASE-ANGLE VOLTMETER. A 4-page brochure describes the PAV-4 series of phase-angle voltmeters and frequency plug-in modules. It presents five different types of applications with typical set-up diagrams. Included are full specifications and comprehensive selection charts for specifying standard and non-standard frequency plug-in modules. The Singer Co., Los Angeles Operation, 3211 S. La Cienega Blvd., Los Angeles, CA 90016. **237**

FOUR-HANDBOOK PACK DESCRIBES DIGITAL AND LINEAR ICs. The fee is $3.00 for a complete package containing all four handbooks. Individual books can be obtained for $1.00 each. These are: 54/74 TTL; "8000" Series TTL/MSI and Memory; M.O.S. Silicon Gate 2500 Series and Linear ICs. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. **241**

CIRCUIT TEST SYSTEM, called the Flexible Automatic Circuit Tester (FACT) system, is described in a 16-page brochure. The brochure illustrates how the FACT wiring analyzer and various functional interconnection methods may be adapted to provide efficient and economical solutions to large volume, exacting test procedures for a wide variety of electronic systems and equipment. Hughes FACT Systems, P. O. Box 92904, Los Angeles, CA 90009. **245**

TEMPERATURE CONTROLLERS are described in a new bulletin. Design and application features of the TB1 line of solid-state temperature controllers are described in this 2-page bulletin. The new controllers are the first in the low- to medium-price range with sufficient sensitivity to accommodate 100Ω RTD sensors. Basic specifications and a list of representative applications are provided in the bulletin. Heinemann Electric Co., 127 Magnetic Dr., Trenton, N J 08602. **238**

ENGINEERING DRAWING PREPARATION SYSTEM. EDITS, a computer-based system for preparing schematics, logic diagrams and other types of technical diagrams, is fully described in a new 12-page brochure. It shows how EDITS can cut the number of man-hours spent on each drawing by 80% or more. Capabilities for transferring stored drawings to microfilm are also set forth. Systems Engineering Lab., Communications Dept., 6901 W. Sunrise Blvd., Ft. Lauderdale, FL 33313. **242**

SILICON RECTIFIER CATALOG covers standard and fast recovery rectifiers for industrial, commercial and military applications. The catalog devotes individual pgs. to ratings and electrical characteristics as well as dimensional drawings of case styles for bridges, high-voltage axial-lead rectifier cartridges, high-voltage rectifier assemblies and miniature axial lead rectifiers. Electronic Devices, Inc., 21 Gray Oaks Ave., Yonkers, NY 10710. **246**

PLOTTING IN APL TIME-SHARING. A new manual describes how to produce graphic plots using a Selectric terminal in the APL PLUS® time sharing service. A special typesphere permits resolution of 900 points/sq. in. on the same typewriter terminal used for other conversational applications. Options within the software package permit histogram outputs, automatic scaling of axes, interchanging the axes, logarithmic scaling, and the choice of any set of plot symbols. Scientific Time Sharing Corp., 7316 Wisconsin Ave., Bethesda, MD 20014. **239**

BELL 201B-COMPATIBLE MODEM. A free four-page brochure describes the Model 2010 modem capable of synchronous operation at 2400 bps. Included are descriptions of important features, detailed theory of operation, and complete technical specifications. An outline drawing of the pc card is included, as well as a Model 2010 block diagram, a data mode timing diagram, and an illustration showing the transmitted signal frequency spectrum. Intertel Inc., 6 Vine Brook Pk., Burlington, MA 01803. **243**

REMOTE ACCESS PROGRAMS BULLETIN. RAP, a monthly current-awareness reporting service, surveys new programs available for in-house use or on time-sharing services. RAP is the news component of the TIME-SHARING APPLICATIONS DIRECTORY. Specialty editions surveying particular industries, such as manufacturing and engineering comprise the second section of the volume. A one-year subscription to RAP is $42.50. Time-Sharing Information Services, Inc., 3401 Science Center, Philadelphia, PA 19104. **247**

Most likely to succeed.

Being smallest and lowest-priced is an eye-catching way to enter the OEM meter market. On the other hand, what good is a small cheap DPM that takes its time to warm up to rated accuracy, faithfully displays variations in line voltage, or cooks to death in its own power dissipation?

Our new logic-powered AN2535 occupies only 6.8 cubic inches, costs only $85 in 100's, but does none of the bad things mentioned above. Because it was engineered for reliability and tested within an inch of its life before graduation. Tests like vibration, long burn-in, and baking. We will even provide a calibration sheet of all specifications tested under computer control. We are determined to give you a meter that will make good.

Sample specifications of the AN2535 logic-powered meter
Accuracy 0.05%
Automatic zero – no offset
Stability 50ppm/°C
Power requirement 2.5 watts (5v from logic or battery)
Operating temperature −10° to +60°C
Floating, bipolar differential inputs
BCD output included
Separate analog and digital grounds
Input impedance 1000 megohms min.
Dimensions: 1.25″h x 3.2″w x 1.8″d (mounting surfaces)

This is the first of a series of DPM's designed for the special requirements of you, the OEM, manufactured by the largest supplier of DPM's in the world – us. We've also prepared a 28-page booklet on the theory of meter operation in general – a surprisingly useful and impartial guide for getting through the claims and counter-claims of meter makers. Just ask. Analogic Corp., Wakefield, Mass. 01880, (617) 246-0300.

ANALOGIC®

Northeast	Mid Atlantic	Midwest		South		West		Canada
617-235-2330	201-652-7055	314-837-0597	312-283-0713	713-785-0581	205-539-1771	303-744-3301	714-540-7160	613-836-4411
203-966-2580	212-947-0379	216-267-0445	913-362-0919	817-268-3505	919-834-6591	505-523-0601	408-374-5220	604-688-2619
315-446-0220	215-272-1444	513-434-7500	412-892-2953	305-423-7615		602-946-4215	206-762-7664	416-444-9111
	301-587-3910	313-892-2500				505-296-8303	503-646-6064	514-861-1375

CHECK NO. 83

signals and noise

A reader sheds some light

Dear Sir:
You published in the January 1, 1972 issue of EDN/EEE an article by Mr. Otto J. Forsberg entitled "Incandescent Lamps Mate Well With Silicon Photosensors."

Mr. Forsberg presents a narrow view of the subject, and I feel that it is only fair to your readers that they be given a little broader perspective. The Miniature Lamp Products Department of my company makes neon-glow, incandescent and solid-state lamps, so my reply is unbiased.

Mr. Forsberg does a fine job in restating long known facts regarding incandescent lamps and their applicability for use with silicon detectors. He fails to mention however or treats lightly a few other important points, such as:

1. Most of the energy emitted by an incandescent lamp does *not* excite the silicon detector because of the relatively narrow spectral response curve of the detector.

2. Consequently, *most* of the energy that is produced by the incandescent lamp is absorbed by its surroundings in the form of heat, which causes many design problems. Solid state lamps (SSL) or light-emitting diodes (LED) generate a negligible amount of heat.

3. The lowest LED voltages Mr. Forsberg used for continuous operation were 1.65V and 3.5V. These electrical characteristics suggest that he used visible light-emitting gallium arsenide-phosphide and gallium phosphide lamps having peak light emitting outputs at about 640 nm and 700 nm, respectively. These are mismatched with the spectral response of a silicon detector which peaks at 900 nm. Gallium arsenide infrared emitters peak at 900-940 nm, have a voltage of 1.25 to 1.35 V at 100 mA, are 10-20 times more efficient (per input watt) than gallium arsenide-phosphide emitters and are the type of solid-state lamp that should be considered and compared against an incandescent lamp when using a silicon detector. This would substantially modify the relative efficiency information which the article supplied.

4. By virtue of the fast switching speed (100 nsec to 0.1 msec) of gallium-arsenide infrared-emitting solid-state lamps (which allows them to be pulsed, or modulated at frequencies to 50 MHz), they are useful in many applications which cannot be satisfied by any other light source. Commercially available gallium-arsenide lamps can be pulsed to produce up to 0.4W peak radiated power and operated continuously at 6.0 mW radiated power.

5. Neon glow lamps (cold-cathode, negative-glow-discharge lamps) having their radiant output in the red-orange region of 570-750 nm, are generally unsuited for use with silicon detectors, but are a close match for photo-resistors (CdS or CdSe) and other receivers having a matching peak sensitivity. They are particularly suitable for applications which have high voltage (over 70V dc) available.

It should be pointed out that new light sources such as SSLs (LEDs) complement rather than compete with existing light sources such as incandescent lamps and neon-glow lamps and allow the design engineer a much greater choice in design options.

Sincerely,
J. W. Hall II
Solid State Lamps
General Electric Co.

" Am I speaking in a monotone ? "

We try to oblige—

One of the prime goals of EDN is to respond to readers' desires. The First Annual Creative Design Contest was so well received that requests for additional winning circuits has been overwhelming. Therefore, future issues of EDN will carry more of these winning circuit designs.

Editor

Someone up there likes me!

Gentlemen:
As an electronics circuit designer, I consider the TO-5, TO-18 and their plastic equivalents, TO-92, TO-105 and TO-106 packages to be devices designed for the producer, not the user. While they are not particularly difficult to handle, they are difficult to heat sink. Now, RCA has developed a simple variation of a competitors package which seems close to the ideal. I refer to the so-called "plastic TO-5" that RCA has developed for low frequency, small signal and medium power applications. Free standing, it is good for a watt (25°C), and when screwed into a heat sink, it is good for up to 20W. What can be more ideal? RCA should be commended.
Very truly yours,
Howard H. Smith
Electronics Design Engineer

The Singer Company
Palo Alto Operation

Oops—our slip is showing!

Our programmer failed to go to the edit mode when transposing the computer program on page 41, June 1, 1972 in the article "BASIC language programs generate root locus plots." As a result, there are several errors to which your computer might take exception. We will supply copies of the original correct program printout to any reader requesting it. Meanwhile, our man is brushing up on the BASICS of programming.
Editor

Did you hear about the optician-trainee who fell into the lens-grinding machine and made a spectacle of himself???

COUNTER REVOLUTION!

If you're on the verge of open insurrection over frequency counters that deliver too much price and not enough performance...

JOIN THE HEATH/SCHLUMBERGER COUNTER REVOLUTION!

We've got counters that will get you to over 80 MHz for only $350... or to 600 MHz for just $795. And check out some of our other revolutionary ideas: long-lived, highly visible LED readout... very high input sensitivity... BCD output... complete programmability for all functions... computer compatibility... handy gimbal mounts... combination carrying handle/tilt stand... lab-grade time base stability. Circle the reader service number below to get complete information... and join the Heath/Schlumberger Counter Revolution.

Ⓐ SM-110A: 1 Hz to 200 MHz range... input sensitivity: 10 mV @ 35 MHz, 15 mV @ 200 MHz... 1 megohm/15 pf and 50 ohm inputs... 7-digit LED readout plus overrange... four switch-selected time bases... 1 MHz crystal time base... 7.5 ppm/yr stability **$495.00**

Ⓑ SM-110B: features same range, input sensitivity and readout as SM-110A above, plus 1 MHz TCXO time base stable to 1 ppm/yr... complete programmability for Range, Reset, Input Select, Count Inhibit, all standard TTL-level. Outputs: 7 digits of BCD, Overrange flag, Decimal Points, Print Command, 5 V reference and ground **$625.00**

Ⓒ SM-110C: includes all the features of the A and B models as detailed above. Also provides a 600 MHz prescaler for the high frequency input for measurements into the UHF region. Prescaler can be switched in and out from the front panel..... **$795.00**

Ⓓ SM-114A 600 MHz Prescaler. Extends the useful range of any counter with more than 100 kHz capability. Three pushbutton selected ranges allow division of input frequency by 1, 10 or 100. 50 ohm input... less than 2:1 VSWR to 600 MHz... 50 mV rms input sensitivity. 50 ohm output, 1 V P-P..... **$365.00**

Ⓔ SM-105A... the world's most remarkable value. 10 Hz to well over 80 MHz range... 5-digit LED readout plus overrange... 8-digit measurement capability with kHz/MHz front panel switch... 100 mV input sensitivity ... 1 MHz crystal time base with 1 ppm/mo stability... gimbal mount **$350.00**

Ⓕ SM-104A... same as SM-105A described above but with high stability TCXO time base (1 ppm/yr)... 5-digits of BCD output plus overrange and print command **$450.00**

For additional information, use reader service number below or write:

Heath/Schlumberger Scientific Instruments
Dept. 531-233
Benton Harbor, Michigan 49022

HEATH

Schlumberger

CHECK NO. 84

ADVERTISER'S INDEX

AMF/Potter & Brumfield 60-61
AMP, Inc. 28-29
Acopian Corp. 118
Adar Assoc. 27-1
Allen-Bradley Co., Electronics Div. 59
Allied Electronics 78
American Lava Corp., sub. of 3M Co. 13
American Zettler, Inc. 99
Amperite Co. 90
Analogic Corp. 115
Astro-Med, Atlan-Tol Industries, Inc. 110
Babcock Electronics Corp. 106
Beckman Instruments 11
Bodine Electric Co. 84
Borden Inc., Chemical Div. 105
Bourns, Inc., Trimpot Products Div. 41
California Instruments 82
Cherry Electrical Products Corp. 12
Control Data Corp. 45
Corning Glass Works, Electronics Products Div. 4, 6-7
Cutler Hammer, Inc. 65
Dale Electronics . . . . . Cover IV
Datel Systems, Inc. 97
Delco Electronics Div., General Motors Corp. 46-47
Deltrol Controls 98
EPC, sub. of Electronic Assoc., Inc. 97
Elco Corp. 3
Electrocube, Inc. 111
Electronic Navigation Industries 102
Fabri-Tek, Inc. 14
Fairchild M.O.D. 103
John Fluke 19
General Electric Co., Miniature Lamps Div. 104
General Time Corp., Space & Systems Div. 111
Genisco Technology Corp. 10
Heath/Schlumberger Scientific Instruments 117
Hewlett-Packard 20-21, 48
Honeywell, Test Instruments Div. 83
Hoyt Electrical Instrument Works, Inc. 84
International Rectifier Corp., Crydom Controls 96
Kulka Electric Corp. 94
Ledex 73
3M Co., DM&S Div. 100
3M Display Film Products 90
McGill Mfg. Co., Inc., Electrical Div. 111
Magnecraft Electric Co. 1
Marco-Oak, Sub of Oak Industries Inc. 90
Metex Corp. 95
Minelco, Div. of General Time 84
Monsanto, USC Div. 2
Motorola Semiconductor Products, Inc. 40
NJE Corp. 64
Newport Laboratories Inc. 93, 95, 97
North American Phillips Controls, A. W. Haydon Products . . 101
Pearson Electronics 106
Pulse Engineering, Inc. 109
RCA 54
Raytheon Co., Sorenson Co. Unit 36-37
Shigoto Industries, Ltd. 118
Siemens . . . . . Cover II
Sigma Instruments 89
Siliconix, Inc. 72
Singer Co., Kearfott Div. 107
Spectrol Electronics Corp. 71
Sperry Information Displays Div., Sperry Rand 85
Staco, Inc. 111
TRW/Holyoke Wire & Cable 55
Techni Power 108
Teradyne, Inc. 8
Thermalloy Co. 109
Thermometrics 84
Thinsheet Metals Co. 64
Thomas & Betts Co. 91
Torin Corp. . . . . Cover III
Unitrode Corp. 15

Application Notes

32 PAGE APPLICATION NOTE ON PHOTON COUPLERS. This publication discusses the pros and cons of different opto-electronic coupler systems, coupler terminology, key parameters, their inter-relationships, and a wide variety of applications. General Electric Co., Semiconductor Products Dept., Electronics Park, Bldg. #7, Mail Drop 49, Syracuse, NY 13201. **212**

SIMPLE, INEXPENSIVE DIGITAL TEST INSTRUMENTS is a 4-pg. reprint of an article in EDN which describes the concept of using simple instrumentation to maintain digital systems in the field. The use of the logic probe and the need for timing information is covered. Advanced Digital Research Corp., 1901 Old Middlefield Way, Mt. View, CA 94940. **213**

BULLETIN FOR ULTRA LOW BIAS OP AMPS, the Intersil ICH8500 and ICH8500A, which have input bias currents of 0.1 and 0.01 pA respectively, contains a discussion of basic characteristics of the amplifiers, which are pin identical to the 741 op amp. Also included are applications and diagrams for pico-ammeter circuits, sample-and-hold circuits, and a gated integrator. Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. **214**

SPECTRUM ANALYZERS and their use in CATV systems are covered in a 24-page booklet. The 3-part booklet (1) discusses in detail how a spectrum analyzer can verify good engineering standards and make measurements; (2) presents a concise pictorial summary of the FCC requirements that can be verified with a portable battery operated spectrum analyzer and (3) for those who may not be too familiar with them, gives a brief tutorial rundown on spectrum analyzers. Tektronix, Inc., P. O. Box 500-A, Beaverton, OR 97005. **215**

THERMISTOR APPLICATIONS DATA REQUIREMENTS GUIDE is designed to reduce the time necessary to select the proper thermistor for applications which most often present the design engineer problems such as: time delay, transistor compensation, coil compensation, surge suppression, temperature measurement. Fenwal Electronics, 63 Fountain St., Framingham, MA 01701. **216**

UHF TRANSISTORS FOR BROADBAND APPLICATIONS covers the basic performance characteristics and specific circuit design details related to the application of the 2N6104 and 2N6105 uhf power transistors in broadband (225-to-400-MHz) uhf power amplifiers. RCA/Solid State Div., Route 202, Somerville, N J 08876. **217**

EVERYTHING YOU ALWAYS WANTED TO KNOW ABOUT TELEDYNE JFETs. Included in the new 160-pg. manual are the following sections: Complete tabular data, specifications, parameters and operating curves; App. notes covering basic theory, circuit design, performance analysis and critical measurements; selection guides; definitions, equations and glossary of terms. Write on company letterhead. Teledyne Semiconductor, 1300 Terra Bella Ave., Mt. View, CA 94940. **218**

DIGITAL MULTIMETER EVALUATION is easy with a new, 25-page evaluation kit designed to help provide an objective and comprehensive analysis of digital multimeters. Called "Evaluating Digital Multimeters," the kit allows the user to match requirements and criteria against various manufacturer specifications, design, supporting data and instructions in seven different areas. These criteria provide a total analysis of instrument quality for any DMM regardless of design or manufacturer. Data Precision Corp., Audubon Rd., Wakefield, MA 01880. **219**

SALES OFFICES

E. Patrick Wiesner
Publisher
221 Columbus Ave.
Boston, Mass. 02116
(617) 536-7780

Hugh R. Roome
National Sales Director
205 E. 42nd St.
New York City, New York 10017
(212) 689-3250

NEW YORK CITY 10017
Gerry Hoberman, District Manager
Richard Millar, District Manager
205 E. 42nd St.
(212) 689-3250

BOSTON 02116
Richard Parker, District Manager
Hal Short, District Manager
221 Columbus Ave.
(617) 536-7780

PHILADELPHIA 19103
Steve Farkas, District Manager
Penn Towers
1819 John F. Kennedy Blvd.
(215) 569-2424

SOUTHEAST
Newman Ladabouche,
Southeast Regional Manager
6065 Roswell Rd.,
Northside Tower
Atlanta, Georgia 30328
(404) 252-7753

CHICAGO
Terry McDermott, District Manager
Frank Sibley, District Manager
15 Spinning Wheel Rd.
Hinsdale, Illinois 60521
(312) 654-2390

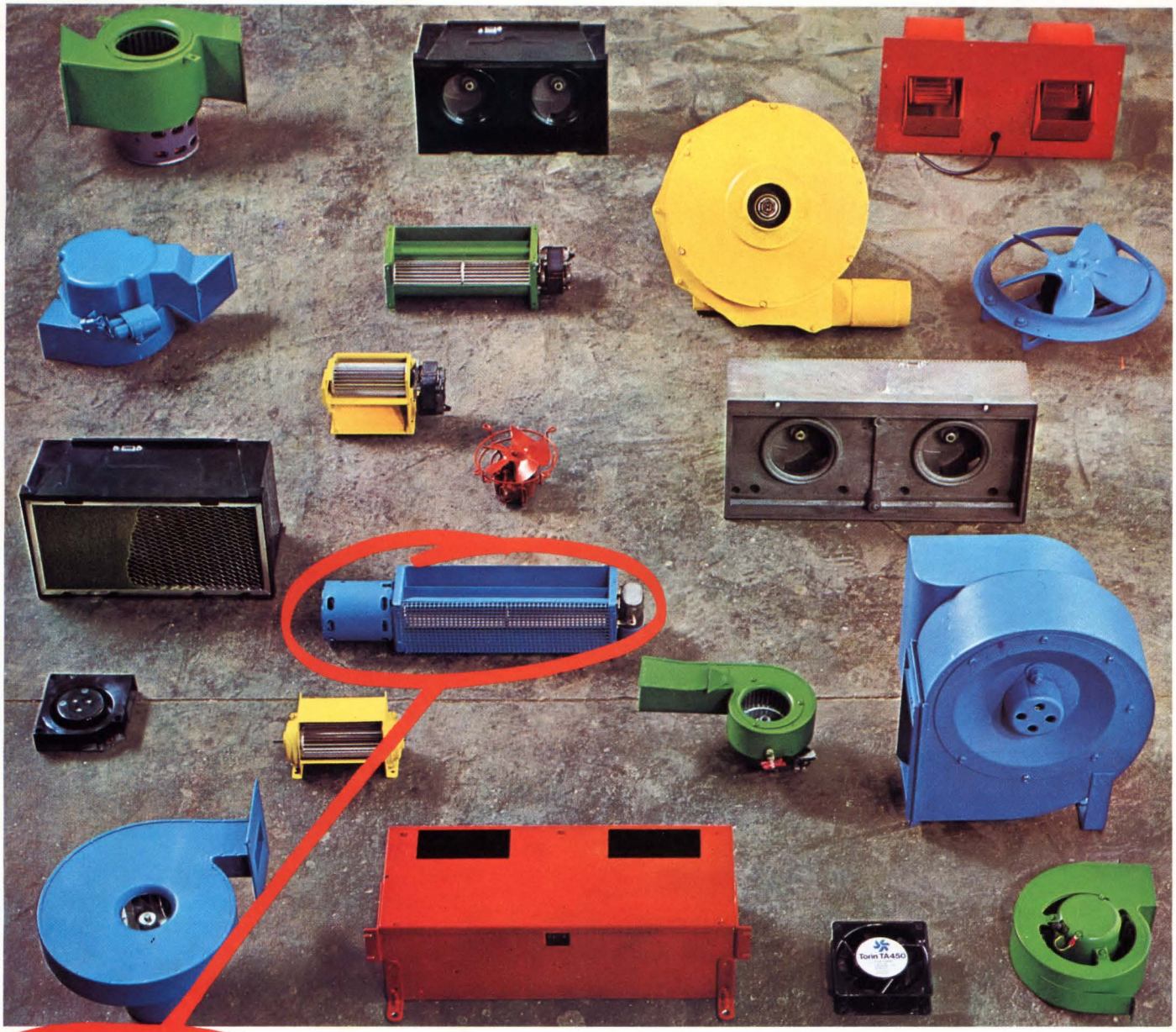
DENVER 80206
John Huff, Regional Manager
270 St. Paul St.
(303) 388-4511

SAN FRANCISCO 94103
William J. Healey, District Manager
1111 Hearst Building
(415) 362-8547

LOS ANGELES 90036
Ed Schrader, Regional Manager
Eli Warsaw, District Manager
5670 Wilshire Blvd.
(213) 933-9525

INDEX TO ADS, PRODUCTS AND LITERATURE Use card for free product information

	I. R. NO.	PG. NO.
CIRCUIT MODULES/CARDS		
A/D Converters	231	99
Charge Amplifiers	229	99
Core Memory Systems	15	14
FET Op Amps	234	101
400 Hz-to-dc Converters	225	98
High Speed Op Amps	230	99
Keyboards	189	102
Line Voltage Monitors	226	98
Memories	184	102
Modem Interfaces	194	105
Multipliers	235	101
Printer Controllers	185	102
Sample/Hold Modules	224	98
Touch-Tone Receivers	190	102
COMMUNICATIONS EQUIPMENT		
Infrared Data Links	240	114
Modem Interfaces	194	105
Modem Terminals	192	105
Modems	191	102
Modems	193	105
Modems	243	114
Optical Links	222	98
Touch-Tone Receivers	190	102
DATA HANDLING EQUIPMENT		
Core Memory Systems	15	14
Disk Drives	188	102
Graphic Data Acquisition Systems	46	83
Infrared Data Links	240	114
Keyboards	189	102
Memories	184	102
Memories	187	102
Minicomputers	195	105
Modem Interfaces	194	105
Modem Terminals	192	105
Modems	191	102
Modems	193	105
Modems	243	114
Printer Controllers	185	102
Programmable Calculators	186	102
Thermal Printheads	205	95
Touch-Tone Receivers	190	102
DISCRETE SEMICONDUCTORS		
Darlington Pairs	25	46-47
FETs	218	119
High Current SCRs	197	94
LED Indicators	10	10
P-Channel MOSFETs	202	94
Opto Isolators	174	108
Power Transistors	208	96
Radiation Resistant Transistors	199	94
Rectifiers	16	15
Relays	66	99
Semiconductors	43	78
Silicon Rectifiers	246	
VHF Transistors	217	119
ELECTROMECHANICAL COMPONENTS		
Connectors	178	108
Connectors	24	45
Dc Motors	48	84
Digital Displays	51	85
Disk Drives	188	102
Elapsed Time Indictors	28	111
Electric Motors	70	101
Keyboards	189	102
Keyboards	182	108
Lighted Pushbutton Switches	55	90
Lighted Switches	180	108
Miniature Switches	67-69	12
Miniature Switches	33	65
Optical Couplers and Reed Switches	52	89
Panel Meters	50	84
Photo-Isolated Relays	61	96
Power Switches	173	108
Pushbuttons	14	73
Relays	20	28-29
Relays	76	106
Relays	7-8	4, 6-7
Relays	65	98
Relays	4	1
Slide Switches	27	111
Stepper Motor Drives	233	101
Synchros and Resolvers	78	107
Thermal Printheads	205	95
Thermostatic Delay Relays	53	90
Trimmer Potentiometers	176	108
ENGINEERING AIDS		
Computer Drafting Equipments	242	114
Computer Program Bulletins	247	114
INSTRUMENTATION		
Ac Calibration Systems	266	93
AM Signal Generators	258	92
Audio Synthesizers	259	92
Circuit Condition Indicators	47	84
Digital Logic Probes	213	119
Digital Multimeters	44	82
Digital Panel Instruments	64	97
Digital Panel Instruments	57	93
Digital Panel Instruments	60	95
Digital Panel Meters	63	97
Digital Voltmeters	17	19
Frequency Synthesizers	264	93
Function Generators	255	92
General-Purpose Recorders	251	92
Graphic Recorders	257	92
Research Instruments	244	114
Signal Analysis System	248	92
Strip-Chart Recorders	82	110
Sweep/Signal Generators	263	93
Transmission/Reflection Analyzers	254	92
MATERIALS/HARDWARE		
Cooling Fans	2	Cov. III
Connectors	24	45
Electrostatic Eliminators	171	108
Electronic Materials	43	78
EMI Gaskets	59	95
Heat Sinks	80	109
Indicator Lamps	73	104
Insulation Tapes	74	105
Metal Plate Backplanes	6	3
Metal Sheets	35	64
Readouts	179	109
Shielding Tapes	13	100
Substrate Materials	40-42	13
Terminal Blocks	58	94
Thick Film Pastes	175	108
Transformer Components	62	97
Wire and Cables	30	55
MICROWAVES		
Double-Balanced Mixers	223	98
MONOLITHIC/HYBRID ICs		
Calculator Chips	196	94
CMOS Counters	204	95
CMOS Multiplexer Gates	209	96
CMOS Multiplexers	19	72
Digital and Linear ICs	241	114
±15V Regulators	22	40
±15V Regulators	201	94
LED Hexadecimal Displays	198	94
Low Power Triple Op Amps	206	95
MSI Counter/Drivers	211	96
1024-Bit TTL Memories	203	94
Op Amps	214	119
Optical Couplers and Reed Switches	77	89
Photo Couplers	212	119
Semiconductors	43	78
Storage Registers	200	94
Thermal Printheads	205	95
2048-Bit RAMs	210	96
Video Frequency Amplifiers	207	95
PASSIVE COMPONENTS/NETWORKS		
Capacitors	46	111
Ceramic Capacitors	183	108
Chip Capacitors	37-39	13
Component Networks	8	4
Open Transformers	81	109
Potentiometers	52	41
Resistor Networks	172	108
Resistor Networks	31	59
Resistors	3	Cov. IV
RFI/EMI Filters	11	11
Thermistors	216	119
Thermistors	49	84
Trimmer Potentiometers	23	71
Variable Autotransformers	45	111
POWER SUPPLIES		
Modular Power Supplies	21	36-37
MOS Power Supplies	227	98
Op Amp Power Supplies	85	118
Power Supplies	79	108
PRODUCTION EQUIPMENT		
Laser Trimming Systems	9	8
SPECIAL PRODUCTS		
Frequency Standards	260	93
Interface Controllers	262	93
Interfacing Hardware	221	98
Sound Monitors	265	93
Video Detectors	249	92
SPECTRAL DEVICES		
Digital Displays	51	85
Display Films	54	90
Indicator Lamps	73	104
LED Indicators	10	10
LEDs	170	108
LEDs	181	108
Photoelectric Components	86	118
Photoelectric Controls	228	99
Photoelectric Pickoffs	232	10
SYSTEMS/SUBSYSTEMS		
Disk Drives	188	102
Keyboards	189	102
Memories	187	102
Memories	184	102
Minicomputers	195	105
Modem Interfaces	194	105
Modems	191	102
Modems	193	105
Photo-Isolated Delays	61	96
Power Amplifiers	71	102
Printer Controllers	185	102
Programmable Calculators	186	102
Printer Controllers	185	102
Temperature Controllers	238	114
Touch-Tone Receivers	190	102
TEST EQUIPMENT		
Cable Test Sets	56	91
Circuit Test Systems	245	114
Current Monitors	75	106
Digital Displays	51	85
Digital Logic Probes	213	119
Digital Multimeters	219	119
Digital Multimeters	250	92
Digital Multimeters	256	92
Digital Multimeters	261	92
Digital Multimeters	44	82
Digital Panel Instruments	57	93
Digital Panel Instruments	64	97
Digital Panel Instruments	60	95
Digital Panel Meters	63	97
Digital Panel Meters	83	115
Digital Voltmeters	17	17
Laser Trimming System	9	8
Logic Probes	252	92
LSI Test Systems	236	114
Phase-Angle Voltmeters	237	114
Pulse Generators	26	48
Research Instruments	244	114
RFI Meters	253	92
Spectrum Analyzers	215	119



This one does a job for your competitor. But it might not be for you.

Torin Flexibility

Problem: A computer manufacturer handed us a knotty air-supply problem. Their new model had a memory and a logic system with gates of 18 cards each. Both systems required an equal air flow for each card, and the rate of flow was different for each system.

Installations would be at a wide range of altitudes, and since their market was foreign as well as domestic, both 50 and 60-cycle motors were called for.

Because of the proximity of the motors to the gates, a high degree of EMI containment was vital. And, finally, guards were required for maintenance protection.

Solution: Our engineers considered the horizontal configuration of the gates and utilized transverse blowers. Impeller length was matched to the width of the gates to provide an equal air flow to each card.

We used shaded-pole motors for altitudes up to 3,000 feet. Both 50 and 60-cycle versions. For altitudes above 3,000 feet we selected a permanent split-capacitor motor.

That makes three motor capacities, each with left and right-hand mounts. Six in all, and all adaptations of one basic blower. Each met the high EMI containment, and the maintenance guards were designed so as not to hinder flow requirements.

See? There's a lot to it, even when you know how.

Your competitor's air-moving problems are his. Yours are yours. And both are firmly dictated by optimum product performance. Often we can produce exactly what you require through modifications of existing units. But if custom design is called for we can turn that out too. More than 500,000 square feet of modern production space results in competitive pricing and realistic deliveries.

You see here just one example of our flexible problem-solving experience. There's so much more to the Torin story. Get it first hand from one of our twenty Technical Sales Representatives. Or, write or phone for our tells-it-all booklet.

CHECK NO. 2

Torin Corporation

United States: Torrington, Conn.
Van Nuys, Calif.
Rochester, Ind., Elgin, Ill.

Canada: Oakville, Ont.
England: Swindon, Wilts.
Belgium: Nivelles
Australia: Sydney

Torin

Everything you've always wanted to know about film resistors...but didn't know who to ask

You can do a lot more with Dale Film Resistors—and we're ready to send you a chart that proves it. Adding the Welwyn Group to our film resistor lines lets you rely on Dale for practically every resistance function in the book—and opens up new possibilities for saving time and cash.

Dale's expanded film resistor line now includes everything from the most exotic, to the least expensive. For example:

HIGHER VALUES—glass enclosed metal oxide film resistors to 1 billion ohms at 1% tolerance.

LOWER VALUES—down to .27 ohms at 1% tolerance.

HIGHER VOLTAGES—to 50KV pulse, 14KV continuous, with values to 150KM.

LOW-COST POWER—3 through 10 watt styles, 2%, 5% with flameproof coating.

CARBON COMP. COMPETITION—Beyschlag (W. Germany) carbon film resistors. Up to 2 watts in 2%, 5% tolerance.

Circle 3 for
FREE Film Resistor Reference Guide
or call 402-564-3131 for immediate information.

DALE ELECTRONICS, INC.
1300 28th Avenue, Columbus, Nebraska 68601
A subsidiary of The Lionel Corporation • In Canada: Dale Electronics Canada, Ltd.