EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

# EDN

Winners of 1st annual creative design contest

BASIC language programs generate root locus plots

Pick the right keyboard

A CAHNERS PUBLICATION

JUNE 1, 1972

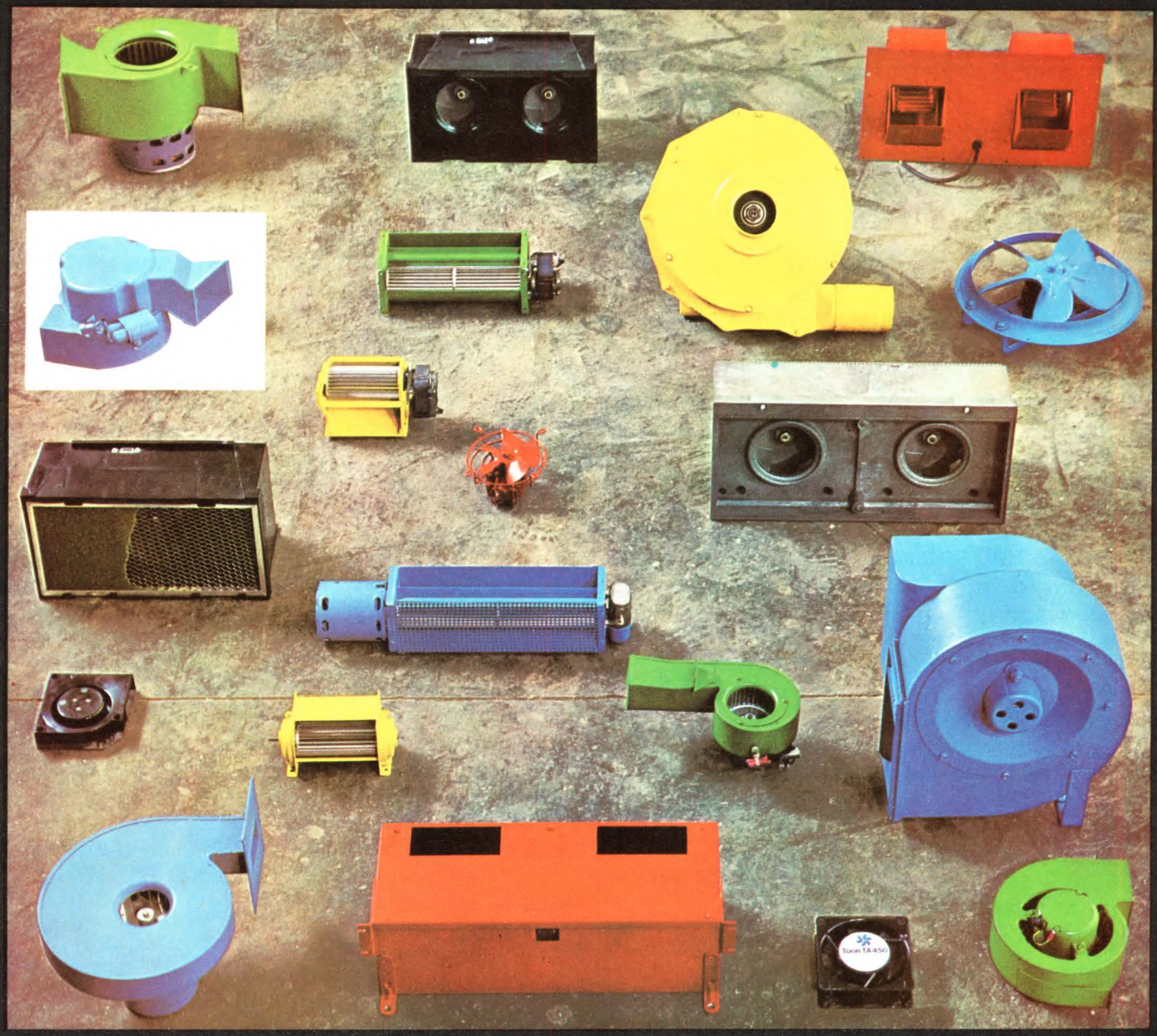

# power supplies for op-amps... $14

These 2.3 x 1.8 x 1-inch modules have tracking outputs of ±15V with regulation of ±0.1% and ripple of 1 mv. The Model D15-03 (25 ma outputs) costs $14.00 in 1000 lots and only $24.00 for one. The Model D15-05 (50 ma outputs) is $39.00. For ±12V, the model numbers are D12-03 and D12-05. Same prices. Three-day shipment guaranteed.

Acopian

Acopian Corp., Easton, Pa. 18042
Telephone: (215) 258-5441

CIRCLE NO. 1



# This one does a job for your competitor. It might not be for you.

**Torin Flexibility**

**Problem:** Late in the development stage of a new product, one of our computer customers discovered an unforeseen contamination problem that could only be corrected by an air supply. No space allowance had been made for a blower unit. Air flow and pressure requirements that required a good sized centrifugal impeller presented further difficulty. Space tolerances were tight and rigid.

**Solution:** Our engineers used a specially-designed motor with an end bell that, in order to fit, had to meet a critical limitation within 20 thousandths of an inch. To save space the motor was set into the inlet end of the centrifugal wheel. The forward-curved inlet duct was given special configuration to get around hardware already existing within the computer. Although the wheel housing was originally conceived in sheet metal, experimentation revealed that plastic would not only reduce costs considerably, but would also allow better scroll development. Design to prototype was accomplished within three weeks. 90,000 units are now in actual use, only 50 have proved less than satisfactory.

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.

**Torin Corporation**

**United States:** Torrington, Conn.
Van Nuys, Calif.
Rochester, Ind., Elgin, Ill.

**Canada:** Oakville, Ont.

**England:** Swindon, Wilts.

**Belgium:** Nivelles

**Australia:** Sydney

Torin

CIRCLE NO. 2

# What do you get when you cross a signal source with a calculator?

**Automatic testing** with HP's new 3330B AUTOMATIC SYNTHESIZER. In this one outstanding instrument, you get a flexible synthesizer, a top-performing sweep generator, and a precision level generator—all under digital control. Its built-in controller adds computer flexibility—you can forget about tying up an external computer for your automatic testing on the production line, and for the first time make this level of testing economically feasible in your lab.

For man-machine interfacing, 3330B's convenient swing-out keyboard, coupled with 9-digits of frequency and 4-digits of amplitude readout, gives you complete flexibility for setting up your test routines.

**As a frequency synthesizer** spectral purity is exceptional. Spurious is down 70 dB, and harmonics at least 40 dB below the carrier. Through its easy-to-use keyboard, you can, with 0.1 Hz resolution, set in any frequency between 0.1 Hz and 13 MHz, then automatically or manually increment (tune) that frequency by any amount. Each point has the synthesizer stability of ± 1 part in $10^8$/day.

You can repeat the same automatic or manual sweeping operation with amplitude level. Its 100 dB range, 0.01 dB resolution and flatness of ± 0.05 dB make the 3330B a **precision level generator.**

**Call on Model 3330B for your sweep generator needs,** and you'll get performance levels of accuracy, linearity, and resolution never before available. That's because the internal serial microprocessor controls digital sweeping of synthesized frequencies or precise amplitudes. Through its keyboard and front-panel controls, you enter all sweep parameters—your 3330B takes it from there.

Systems Designers will find the standard 3330B fully programmable—ready for low-cost interfacing to other ASCII instruments and controllers, like marked card programmers, calculators, and computers.

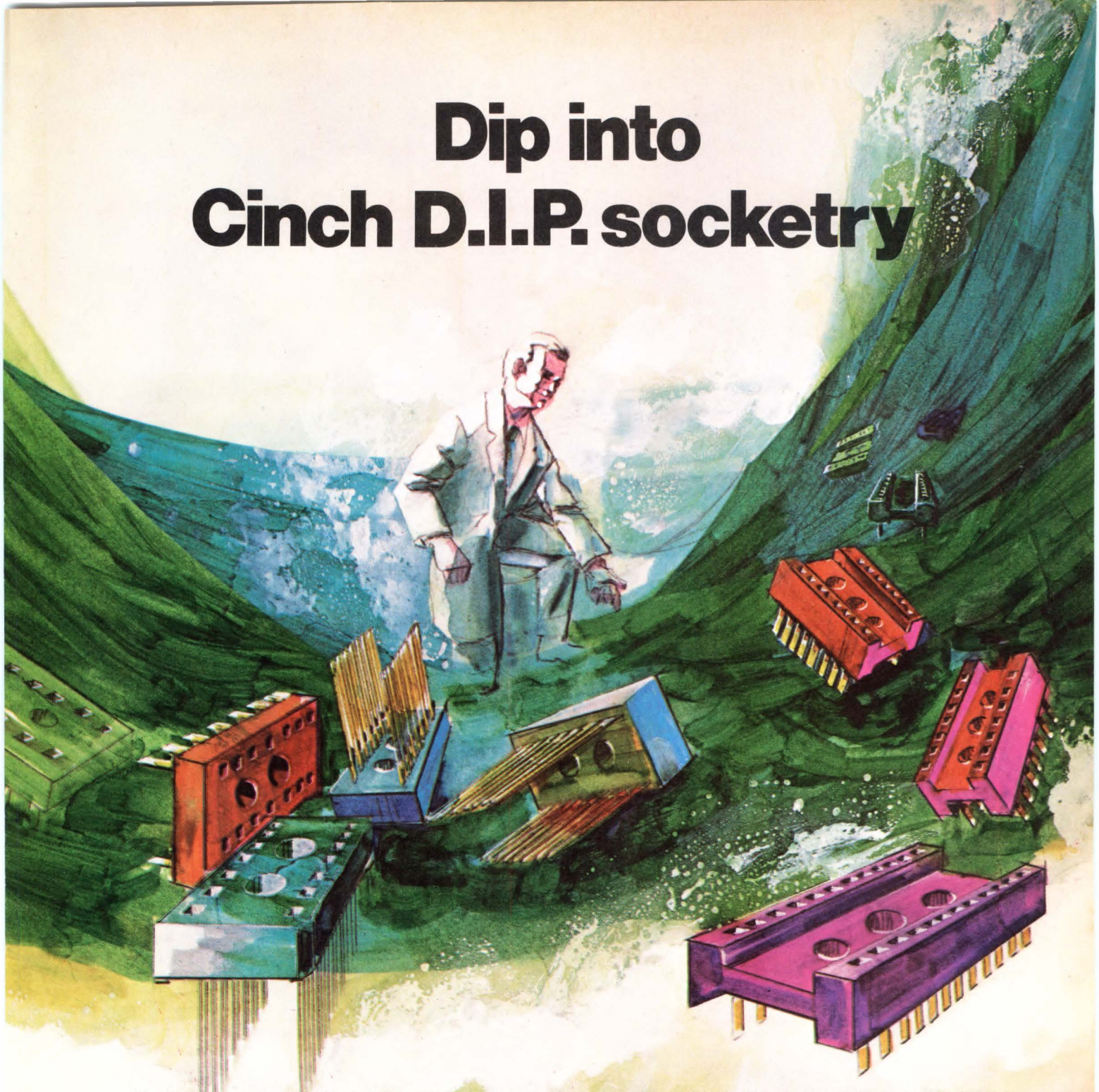
Price? If you think about it, you would have bought a synthesizer, a sweeper, a marker generator, a counter, a programmable attenuator, and some computer time to come anywhere close to solving the same problems now done by the 3330B. At $6000 for a complete frequency lab, we think you'll agree that the price-performance ratio of the 3330B is great. (Model 3330A, priced at $5100, performs identically to the 3330B but has manual amplitude control and 13 dB range.)

For further information on the 3330A/B, contact your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

CIRCLE NO. 3

A092/1

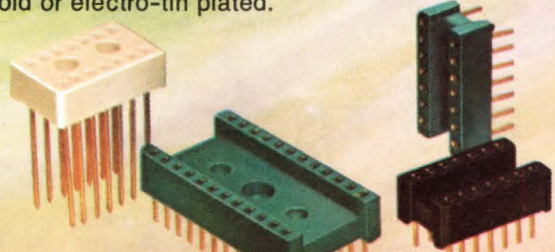
# Dip into Cinch D.I.P. socketry



You'll find the 14, 16 or 24 pin DIP socket you need in the Cinch line. Try it . . . you'll like it!

Cinch sockets have a unique bowed pin contact that provides high contact forces but permits easy insertion and removal of the DIP. Broad contact surfaces give you maximum wiping action on two sides of the DIP terminal, be it flat, round or square.

You can choose from high performance diallyl phthalate or economical GP black phenolic mono-block insulators. The contacts are of beryllium copper for the best temperature stability, either gold or electro-tin plated.



Sockets with Wire Wrap* terminals and closed entry, one-piece insulators are also available in a variety of insulations and terminal materials . . . in addition to our DIP sockets with dip solder terminals.

Many styles are available off-the-shelf from Cinch distributors nationwide.

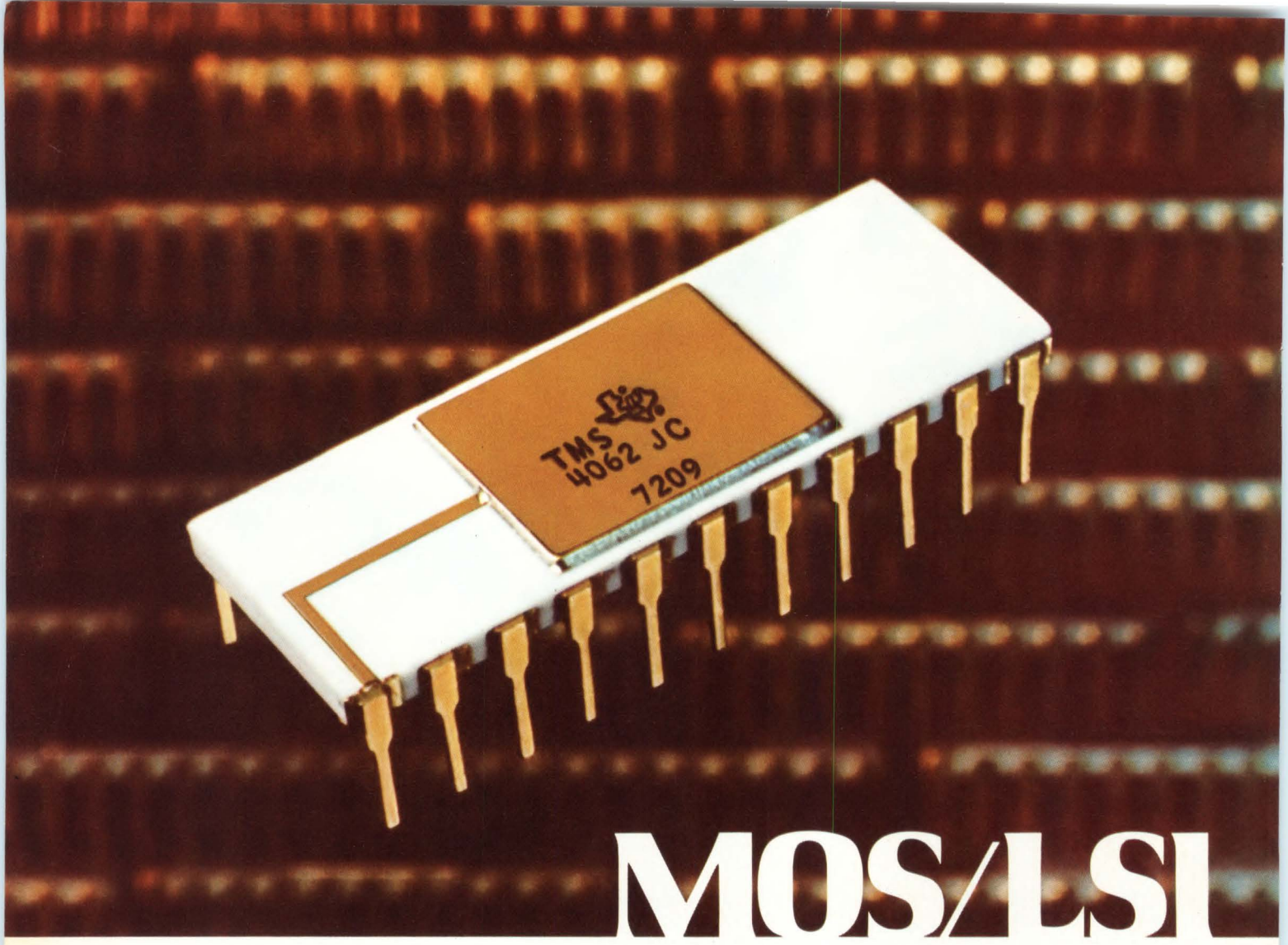
You can find out all about these sockets from your Cinch Distributor, Cinch Sales Office or by writing to Cinch Connectors, an Operation of TRW Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800.

*Trade name Gardner-Denver

C-7202

CIRCLE NO. 4

TRW®
CINCH CONNECTORS



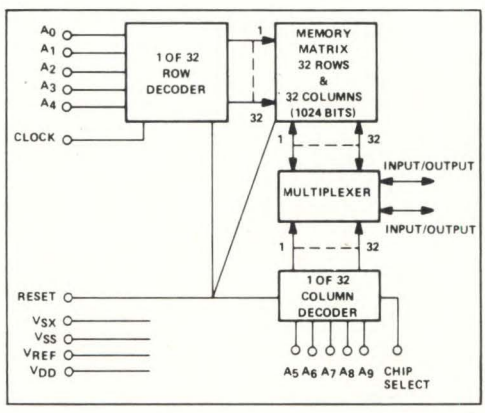

# MOS/LSI

# You can get 150-ns, 1024-bit MOS/LSI RAMs in volume from TI.

You can get fast delivery from TI in large quantities on one of the fastest 1024-bit MOS/LSI RAMs available today.

TI's new TMS4062JC has 150-ns access and 290-ns cycle times—and is a pin-for-pin equivalent to the AMS6002.

At 180 mW operating and 2 mW standby, the TMS4062JC requires less power than most other MOS devices—and it is easier to use. Used with the SN75370 sense amp/digit driver, fewer peripheral components are required and there are no critical clock overlap requirements. Differential outputs reduce noise sensitivity while low capacitance inputs ease drive requirements.




**Field-proven reliability**

Produced by the standard (111) P-channel process, this circuit has established more than *176 million device hours* of field performance in more than 90 installations. Typical users have experienced a mean-time-between-failure of 8.5 x $10^6$ hours (at 95% confidence level).

**Delivery: One week, off-the-shelf.**

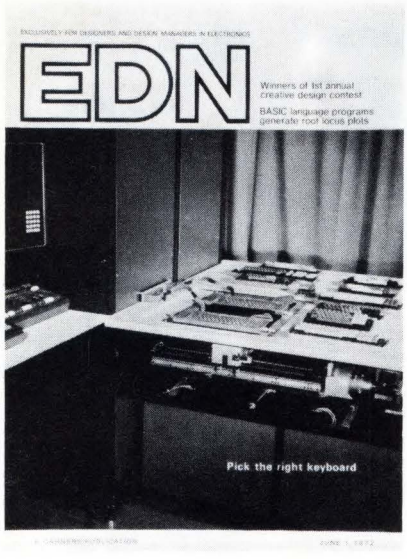
Up to 5000 units can be delivered one week after receipt of order. Larger quantity orders can be filled by TI three weeks ARO. Priced at $10.50 in 1000-piece quantities, the TMS4062JC is available either from TI stock or from authorized TI distributors.

**For data sheets** on TI's new TMS-4062JC MOS/LSI RAM, circle 92 on Service Card. Or write Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

JUNE 1, 1972
VOLUME 17, NUMBER 11

EDN WITH EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS




COVER

Micro Switch's computer controlled "Superchecker" assures quality keyboards. See Keyboards feature on page 26.

## DESIGN NEWS

**New techniques for millimeter microstrip unveiled** . . . . . 14
. . . Tiniest gas laser yet developed is a waveguide type only 2 in. long and 0.02 in. in diameter . . . Minicomputers shoulder the data communications burden for large computer systems.

## DESIGN FEATURES

**Here they are, the winners of the EDN Creative Design Contest** . . . . 19

**Keyboards—The indispensible link between man and machine** . . . . 26
This link can be frustrating and troublesome if the wrong one is chosen. Here are some of the factors to consider when selecting a keyboard for your system.

**Build a high-accuracy waveshaping circuit** . . . . . 36
Only a handful of 1% resistors and popular 1N914 diodes are used in this circuit. It can be designed to provide good accuracy using only a desktop calculator.

**BASIC language programs generate root locus plots** . . . . . 40
Analyze both positive and negative feedback circuits and systems with these two simple programs.

**Graphs yield circuit Q for gyrators and other reactive elements** . . 45
Here are two Q curves that will come in handy in the design and analysis of gyrator and Q multiplier circuits.

**CIRCUIT DESIGN AWARDS** . . . . . 47
Silicon unilateral switches detect initial event . . . Test box indicates logic levels for entire IC . . . Command detector requires zero standby power . . . Pulse technique determines series inductance of a resistor.

## PROGRESS IN PRODUCTS

**Counter/power-supply/signal-source plug-ins introduced** . . . . . 50
. . . Design your own rack-and-panel connectors with modular connector kit . . . Low-cost alphanumeric data terminal fills the price/performance gap between full-scale video displays and teletypewriters . . . Complete monolithic D/A converter provides 10-bit resolution.

## DESIGN PRODUCTS

**Circuits** . . . 56 **Equipment** . . . 60 **Components/Materials** . . . 64
**Semiconductors** . . . 68 **Computer Products** . . . 72

## DESIGN DEPARTMENTS

**The Editor's Column** . . 9 **Literature** . . 74 **Application Notes** . . 77
**Signals and Noise** . . 79
**Index to Ads, Products, Application Notes and Literature** . . . . . 80

 EDN (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 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 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 Extra reliability.** We build extra reliability into our components to let you build extra reliability into your systems.

We offer documented reliability from ER through industrial, from precision through general purpose.

**2 Pricing you'll like.** For many product styles, our quantity resistor pricing is under 5¢ and often less than 3¢. And that's for CORNING® metal film resistors that significantly outperform other metal films (including glazed), wirewounds and carbon comps.

**3 Faster delivery.** Our distributors can give you off-the-shelf delivery from an inventory of over 50,000,000 components. And our "ball parks" are firm, real and reliable. This lets you keep expediting and inventory levels to a minimum.

**4 Production savings.** Our unique product configurations greatly simplify both hand insertion and automatic insertion operations. This saves you money. And our QC is so stringent, many of our customers have totally eliminated their incoming QC testing of our parts. This saves them money.

**5 Product innovations.** Like our new CORDIP™ Component Networks. With up to 23 discrete resistors/capacitors/diodes in a miniature, pre-tested, plug-in package to save you time, money, and a whole lot of board space.

**6 Sharper support.** We've hand-picked the 30 most competent distributors in the country and built the industry's largest technically trained field force—then backed everything with a full team of specialists—to give you all the in-depth service you want and then some.

We too want your business. But we're doing 6 extra things to earn it.

Give us a chance to prove it. Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830. Or call: (607) 962-4444, Extension 8381.

CORNING
ELECTRONICS

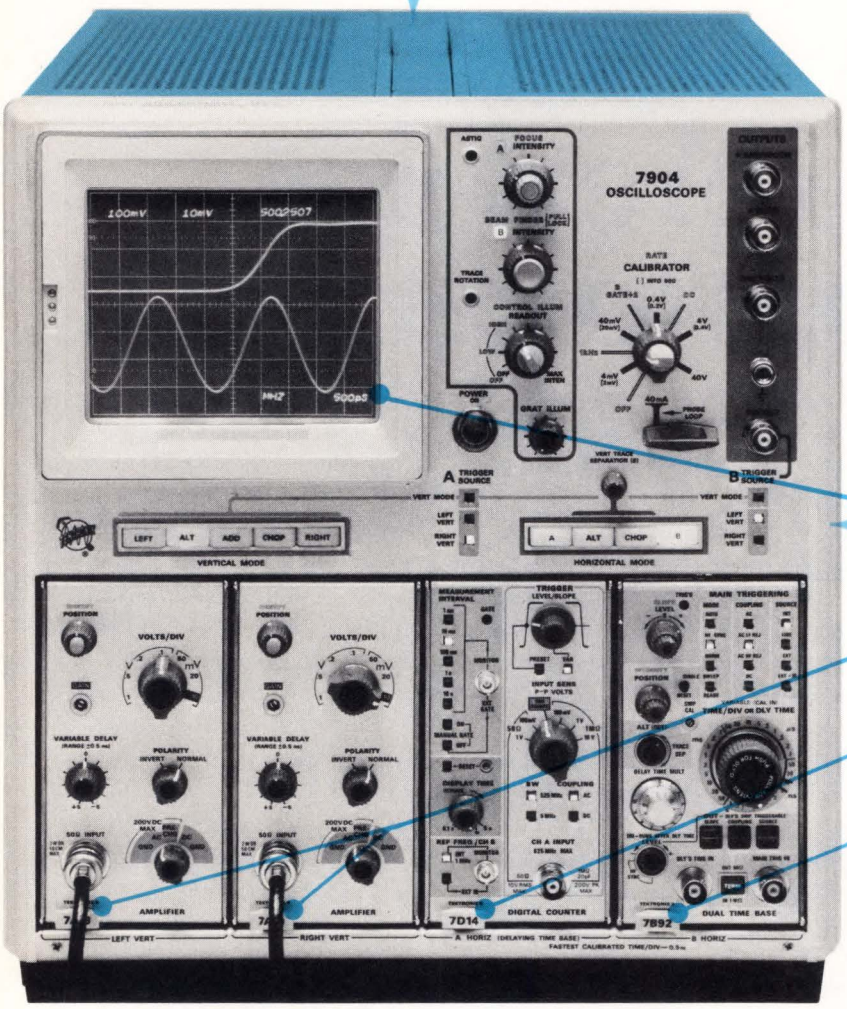
## Resistors & Capacitors

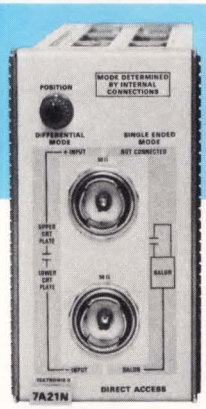
**for guys who can't stand failures**

CIRCLE NO. 6

# TEKTRONIX® 7900 FAMILY

# 1 GHz Direct-Access Oscilloscope





## TEKTRONIX 7904

featuring extended performance or general purpose use, from one mainframe and a family of plug-ins.

***Extended Performance — 20 kHz to 1 GHz***

Plug in the 7A21N and install a simple vertical amplifier bypass to directly access the CRT. The bandwidth — 1 GHz, and risetime — 350 ps. Less than 4 V/cm driving signal required — single ended or differential. Sorry — no CRT READOUT — vertical amplifier bypassed.

***General Purpose — DC to 500 MHz***

Plug in the 7A19 — 500 MHz bandwidth at 10 mV/cm, 7B92 — delaying sweep rates to 500 ps/cm, 7D14 — direct counting to 525 MHz. As your applications and measurement requirements change, choose from 21 other plug-ins for: • sampling • TDR • spectrum analysis • curve tracing • digital multimeter • etc., etc. TEKTRONIX 7904 . . . A product of technical excellence.

For further information or a demonstration call your nearby TEKTRONIX Field Engineer or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

**CIRCLE NO. 7**

**OR . . .**

## 500 MHz real-time Oscilloscope System

- 8 x 10 cm display
  CRT READOUT
  9 cm/ns writing speed
- 7A19 Amplifier
  500 MHz @ 10 mV/cm
- 7D14 Digital Counter
  525 MHz direct counting
- 7B92 Dual Time Base
  500 ps delayed sweep

**OR . . .**

choose from 21 other compatible 7000-Series plug-ins for virtually any measurement

| | |
|---|---|
| **7904 Oscilloscope** | **$2900** |
| **7A19 Amplifier** | **$500** |
| **7A19 Amplifier,** with variable delay | **$700** |
| **7D14 Digital Counter** | **$1400** |
| **7B92 Dual Time Base** | **$1400** |
| **7A21N Direct Access** | **$350** |

U.S. Sales Prices FOB Beaverton, Oregon

# Don't stop thinking on the job

Which side of your face do you shave first every morning? And which leg goes into your pants first . . . and which arm into your shirt or jacket? Odds are that you can't tell for sure without actually going through the operation. Whichever way you do it, though, it's the same every time.

There's nothing unnatural about conditioned actions such as these, of course. We all started doing these things in a particular way long, long ago, and by now they're so deeply ingrained that our minds don't bother keeping conscious track of them.

Situations like these are harmless when it comes to shaving or getting dressed. But the same type of thing can and does happen on the job. The result, all too often, is mediocre performance.

We are not talking here about doing certain things the same way every time. This in itself is not inherently wrong. What is bad is to continually do things the same way and not be aware of it. Most engineers, we're sure, would deny being victims of this type of non-thinking performance. Everybody knows that by education and training, engineers are taught to carefully and objectively evaluate all alternatives to a given course of action. But do they really? Are all alternatives always considered? Or are the possibilities frequently limited, unconsciously, to a narrow subset as a result of previous conditioning.

For example, in modern instrument design, digital techniques are being used more and more to perform functions previously considered as totally in the analog realm. Until some designers started the ball rolling, many neglected such digital approaches by default—by not even thinking about them.

To give specific numerous examples of this "non-think" syndrone would be a futile exercise, inasmuch as it is a totally subjective thing. It is as varied as it is insidious. Only the individual involved can really tell where it affects him, and then only by making a conscious appraisal of how he does his job, what he thinks about while he does it and, most importantly, what he doesn't think about.

Going through such an exercise can prove invaluable, even if you are one of these very few people who have never fallen victim to the non-think habit. To paraphrase that now famous television commercial, "Try it . . . you may like it."

Frank Egan

EDITOR

## STAFF

**Publisher**
E. Patrick Wiesner

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

**Art Staff**
Dan Kicilinski, *Director*
Roy Nelson, *Illustrator*
Beverly Lembo, *Illustrator*
Patricia Rawlins, *Illustrator*

**Production Manager**
Wayne Hulitzky

**Production Assistant**
Susan Grober

**Circulation Manager**
Ron Kinnes

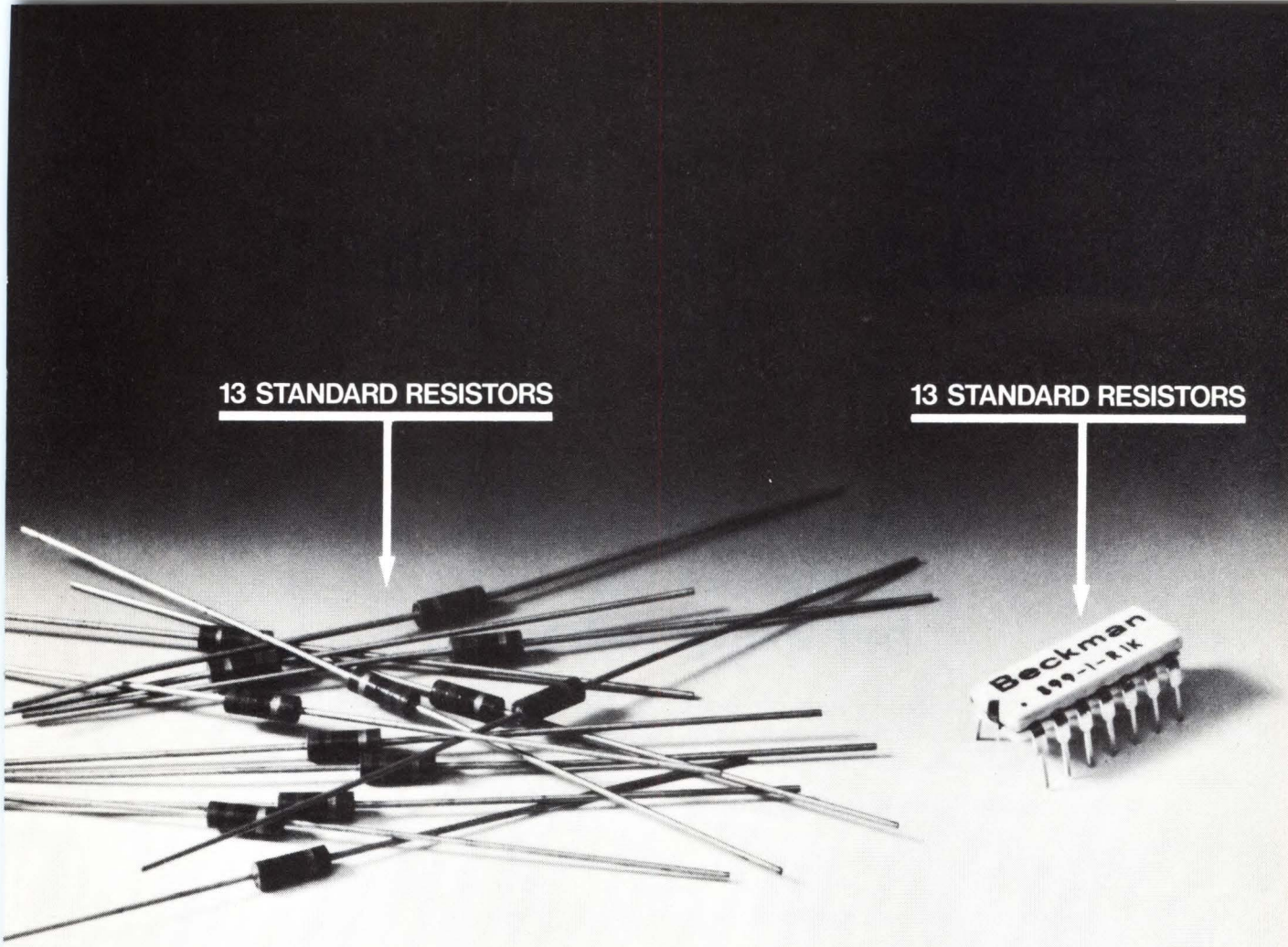
**Marketing Services Manager**
Ira Siegel

**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




# Helipot's one-piece money saver saves time and space, too.

To keep working with discrete standard resistors just isn't logical. Not when there are ceramic DIPs available that do the same jobs in less space—quicker, easier and cheaper. Whether inserted automatically or by hand.

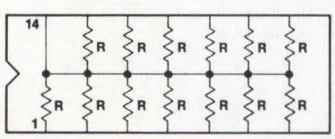
Stocked locally for immediate delivery, too. At "on the board" cost-saving prices, in small or large quantities.

(Check the specs.) No wasted time while they're "made to order," unless you want custom modifications, which we can do fast.

And remember, ceramic. Ceramic reliability at plastic prices.

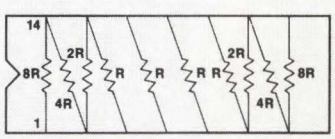
Why wait? Call your local Helipot Representative now for applications assistance or more information.

**Beckman®**
INSTRUMENTS, INC.
**HELIPOT DIVISION**
Fullerton, California



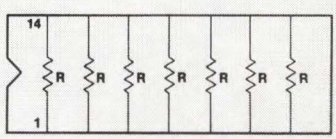

**MODEL SERIES 899-1**
*Resistance Values (ohms):* 100, 150, 220, 330, 470, 680, 1K, 1.5K, 2K, 2.2K, 3.3K, 4.7K, 6K, 6.8K, 10K, 15K, 22K.
*Common Applications:* Digital pulse squaring; MOS/ROM pull-up/ pull-down; "wired OR" pull-up; power driver pull-up; open collector pull-up; TTL input pull-down; TTL unused gate pull-up; high-speed parallel pull-up.
*Standard Tolerance:* ± 2.0%

| *Pricing:* | | |
|---|---|---|
| | 1-99 | $1.45 |
| | 100-499 | 1.12 |
| | 500-999 | 0.97 |




**MODEL SERIES 899-2**
*Resistance Value (ohms):* 10K
*Common Applications:* Inverting operational gain; potentiometric gain; differential gain; noninverting gain; gain adjustment.
*Standard Tolerance:* ± 2%

| *Pricing:* | | |
|---|---|---|
| | 1-99 | $2.75 |
| | 100-499 | 2.15 |
| | 500-999 | 1.86 |




**MODEL SERIES 899-3**
*Resistance Values (ohms):* 68, 100, 110, 150, 220, 330, 470, 680, 1K, 1.5K 2.2K, 3.3K, 4.7K, 6.8K, 10K, 15K, 22K.
*Common Applications:* Line termination; long-line impedance balancing; power gate pull-up; ECL output pull-down resistors; LED current limiting; power driver pull-up; "wired OR" pull-up; TTL input pull-down.
*Standard Tolerance:* ± 2%

| *Pricing:* | | |
|---|---|---|
| | 1-99 | $1.25 |
| | 100-499 | 0.99 |
| | 500-999 | 0.86 |

CIRCLE NO. 9

# We regretfully announce that we were system into our old calculator box.

All we could get in were 52 times as many memory registers plus 16 times as many programming steps, a lot more logic, and a magnetic card reader. The rest of the stuff we had to leave outside.

## Our box still weighs 22½ pounds, but it now holds

**Up to 522 memory registers,** in increments of 64. There's 4-rule arithmetic and special key functions into and out of all registers, and you won't destroy the contents when you turn off the machine.

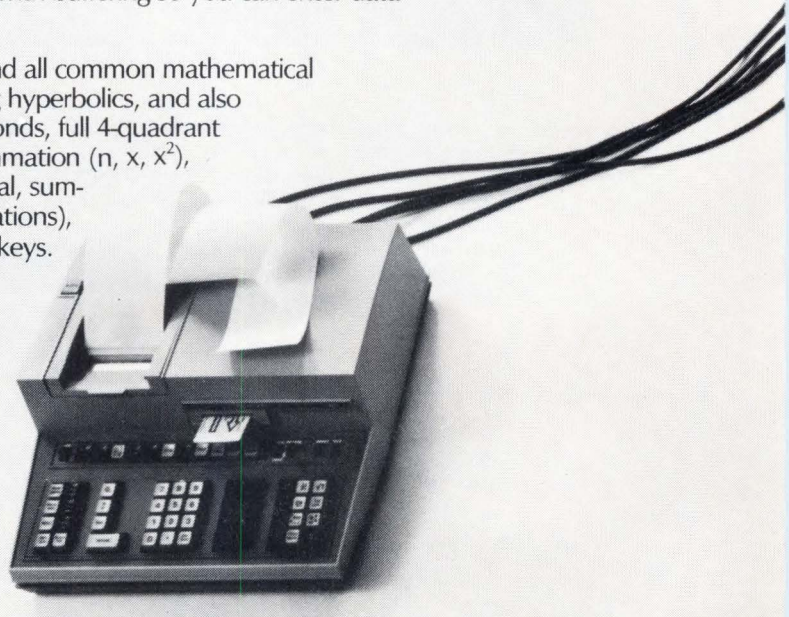
**Up to 4,096 steps of programming,** in increments of 512. You can do an entire program from the keyboard and see all your steps printed out for debugging. Symbolic addressing makes branching and jumping very simple. You can backspace, correct errors, and insert steps without having to re-enter the program. You can program the decimal-point printing format, do 16-level nesting.

**A magnetic card reader/writer** that lets you input programs, write programs, put data into memory, save programs and memory contents.

**Fully algebraic** keyboard arithmetic, with nesting of parentheses. You enter equations the way you write them, not the way the machine wants them.

**Multiple key interlock** and rollover, with buffering so you can enter data while the machine is calculating.

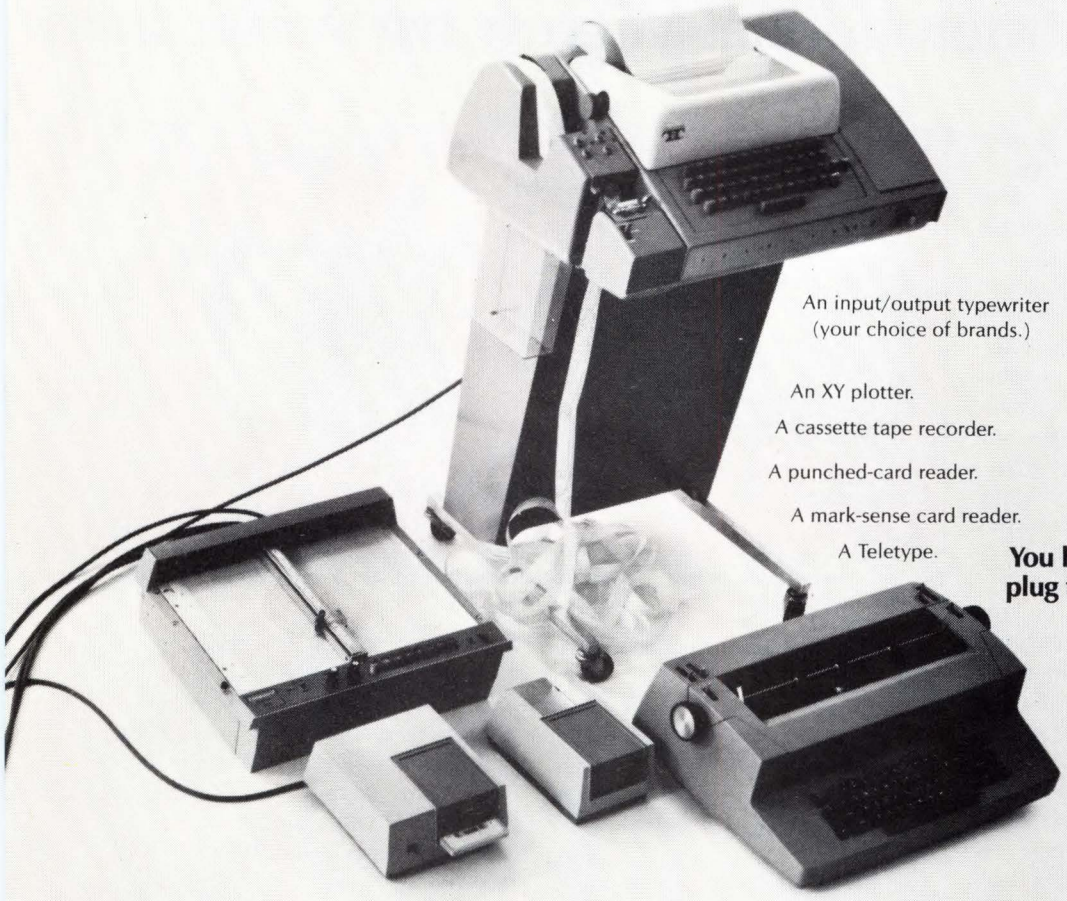
**Labeled keys** for logs, antilogs, $a^x$, and all common mathematical and trigonometric functions including hyperbolics, and also input/output in degrees-minutes-seconds, full 4-quadrant coordinate conversion, statistical summation (n, x, $x^2$), standard deviation and mean, factorial, sum-square backout (correction of summations), plus optional user-definable function keys.



Compucorp®

# ınable to cram all of our new computer

## It doesn't hold



An input/output typewriter
(your choice of brands.)

An XY plotter.

A cassette tape recorder.

A punched-card reader.

A mark-sense card reader.

A Teletype.

**You have to plug those in.**

We're talking about the new 400 Series of desktop computers that complements and extends our Compucorp calculator line. The Model 425 is for engineers, scientists and surveyors, the 445 is for statistical folks.

We've made more than 30,000 of our other models in the last couple of years. They come in little boxes that sit on a corner of your desk. Each one has an array of powerful one-punch keys that solve the problems of a particular kind of user. They have up to 20 storage registers and 256 steps of programming.

There's a wide range of prices so you can buy enough power to do your job without having to pay for more than you need.

But many customers have said, "That's not enough machine for me." Hence the 400's.

The 400's are as easy to operate as our other models (easier, in fact.) They're enormously powerful and versatile, they interface with an array of peripherals, and they come in the same little box.

The 400's start at $3,750, our other models a lot lower.

Write down what you need on your letterhead. We'll show you a calculator or a desktop computer that fits your problems and your pocketbook.

**Computer Design Corporation** 12401 West Olympic Boulevard, Los Angeles, California 90064 Telephone (213) 478-9761

CIRCLE NO. 10

# New techniques for millimeter microstrip unveiled at International Microwave Symposium

Two new integrated-circuit techniques that may prove superior to conventional microstrip at millimeter wavelengths were described at the recent International Microwave Symposium.

The techniques are being developed to overcome the problems, inherent in millimeter microstrip, of critical tolerances, fragile substrates, thin conductor strips which are not completely compatible with hybrid devices and difficulty in obtaining a simple transition to conventional waveguide. Status of the techniques was described by Paul J. Meier of AIL, Deer Park, N. Y., where the work is being conducted.

The two new techniques, or construction media, are called integrated fin-line and oversize microstrip. **Fig. 1** shows the essential features of the first of these. Here, metal fins are printed on a dielectric substrate, which bridges the broad walls of a rectangular waveguide. This adaptation of ridge-loaded waveguide permits circuit elements to be fabricated by low-cost printing, and is compatible with thin-film hybrid techniques. The degree of miniaturization can be limited, which is an advantage at millimeter wavelengths.

The fins increase the separation between the first two modes of propagation, thereby providing a wider useful bandwidth than conventional waveguide.

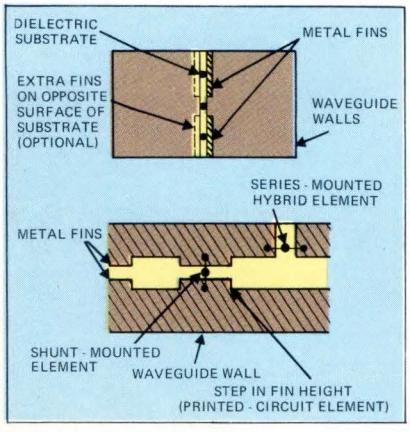



**Fig. 1—Integrated fin-line** uses metal fins printed on a dielectric substrate, which bridges the walls of a rectangular waveguide.

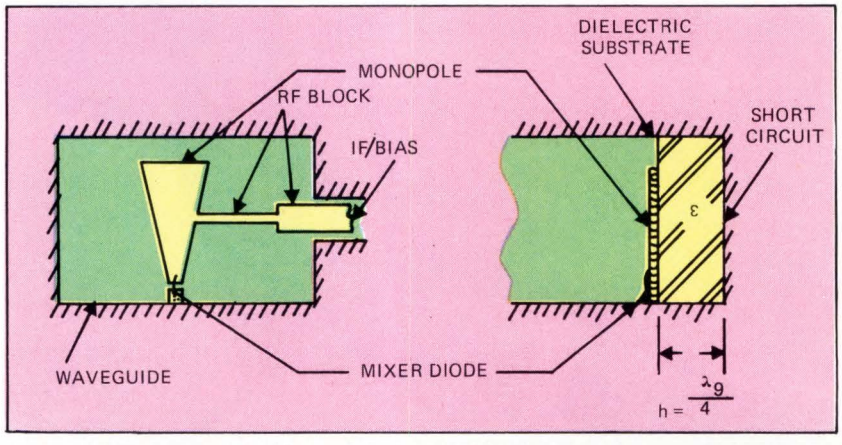



**Fig. 2—A mixer constructed in oversized microstrip** illustrates the general construction details of the technique.

In passive circuits, such as filters, the fins may be directly grounded to the waveguide, and lumped elements, such as beam-lead capacitors, may be added. **Fig. 1** also suggests how the gap between the fins can be varied along the longitudinal axis, to provide low-cost circuit elements. When semiconductor devices are to be added, at least one of the fins must be insulated from ground at dc, to permit the application of bias.

For thin, moderate-$\epsilon$ substrates, the dielectric will have a minor effect and the single-mode bandwidth and attenuation of integrated fin-line may be estimated from existing data. Such estimates lead to the conclusion that integrated fin-line can provide bandwidths in excess of an octave, with less attenuation than microstrip. In addition to eliminating spurious modes and radiation, this media is compatible with hybrid IC devices and amenable to low-cost printed-circuit techniques. The performance advantages will be experimentally investigated with a cavity test-fixture, which is under construction at AIL.

The second new IC medium is oversized microstrip. Normally, the thickness of a microstrip substrate (H) is held to a small fraction of a guided quarter-wavelength to restrict the radiation loss. If, however, the substrate thickness is intentionally set at a quarter-wavelength, an efficient radiator may be printed on the ungrounded surface of the substrate. When mounted in a waveguide, as shown in **Fig. 2**, this radiator will couple to the TE-10 waveguide mode and all the power may be delivered to an impedance-matched load (such as a mixed diode), provided that no energy is reradiated in some other mode such as the crossed TE-01 mode.

For this reason, the air-filled portion of the waveguide should not support the TE-01 mode, which is automatically accomplished when a standard waveguide is operated within its normal frequency range. Moreover, the dielectric-filled portion of the waveguide should not support the TE-01 mode, in order to prevent resonances within the substrate. This may be accomplished by reducing the waveguide size within the dielectric region, or by printing the radiator on a thin substrate which is suspended above the ground plane.

**Fig. 2** illustrates the essential features of a mixer constructed in oversized microstrip. Both the local oscillator and the signal are coupled from the waveguide by a monopole, whose length and shape are selected to provide a wideband impedance match to the diode. □

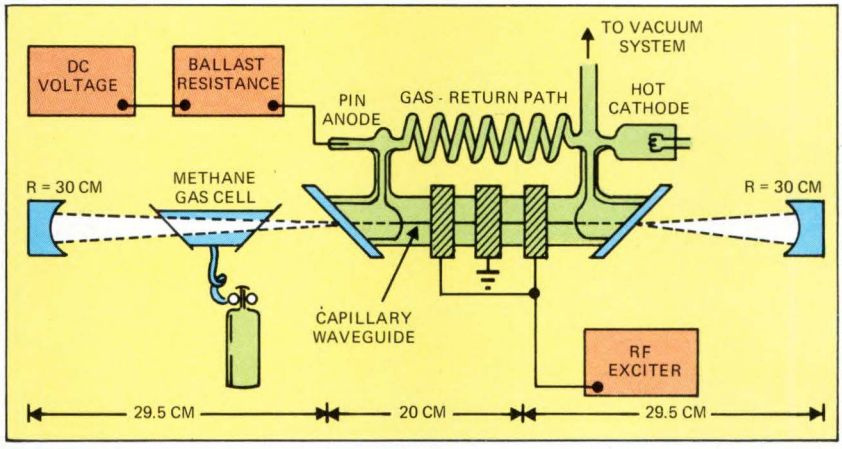
# Tiniest gas laser yet developed is a waveguide type only 2 in. long and 0.02 in. in diameter

Gas lasers may prove to be great tools for communications purposes. They provide very high gains and can carry large amounts of data. Large physical size, however, has been their main drawback. The average gas laser has a diameter roughly equivalent to that of a neon bulb. As scientists have tried to make gas lasers smaller in diameter, problems have arisen in the form of greater light loss due to blockage.

Bell Telephone Laboratories has now succeeded in making a waveguide He-Ne laser about 2 in. long and only 0.02 in. in diameter—approximately one-half the thickness of the lead in a mechanical pencil. The 5-cm-long laser tube uses a cold cathode, has no ground return path and requires only dc excitation. The tube has a gain in excess of 2.5% at 6328Å and 10 dB at a wavelength of 3.39 $\mu$m. Such a waveguide configuration for gas lasers should allow miniaturization to the point where these sources will be convenient for use with integrated optics elements.

The new waveguide gas laser tube is fabricated with inner walls that are very straight and highly polished. By focusing light into this special tube in such a way that the light experiences multiple reflections at the walls when passing down the tube, a beam can be efficiently transmitted with low losses.

Light is actually "guided" down the axis of the tube where it can be amplified by a gas discharge. In this way, much higher amplification can be obtained for a given length of tube than in conventional lasers. ▭




**First successful waveguide gas laser** used a 20-cm length of glass capillary tubing having a bore of 430$\mu$. With a He-Ne discharge at 6328Å in the visible spectrum, the laser produced gains of 2.7 dB/m. As can be seen, rf excitation was needed. Subsequently, a gas laser only 5-cm long (2 in.) and only 0.051 cm in diameter (0.02 in.) was developed. This cold-cathode laser tube has a gain of 2.5% at 6328Å.

# Minicomputers shoulder the data communications burden for large computer systems

With the announcement of a family of eight functional minicomputer systems, Honeywell, Inc. has furthered the trend toward having minicomputer systems relieve large computers of their data communications chore. System 700 is meant to solve communications and control problems in data processing, especially in computer-to-computer communications. Honeywell's response to this trend is due, in part, to the results of a user survey it conducted. This survey said that, more than anything else, user's data communications requirements have become a prime concern. The survey results were reinforced by the fact that more than half of the minicomputers shipped in 1971 were bound for communications applications.

Honeywell's integration of minicomputer products into large computer product lines is aimed at solving these needs. "As part of this integration, the minicomputer central processor becomes a part of System 700, and System 700 becomes a very important element in the hierarchy of an information processing network that includes a large host computer, a communications processor and several minicomputer systems that perform specific functions" according to Edward C. Lund, vice president and general manager of Honeywell's North American computer operations.

The System 700 family is designed to reduce the workload of the host computer by performing tasks such as data collecting and processing, remote message concentrating, sensor-based data monitoring and controlling, or stand-alone processing with communications. Host computers can include other System 700 systems, Honeywell Series 200, 2000, 600, or 6000 medium and large computers, or any computer that uses a binary synchronous mode for data transmission, such as IBM 360 and 370 systems. ▭

**A System 700 minicomputer** is checked out prior to shipment.

# Think Twice:

# Extra contribution is one way to the top. Specifying HP scopes will help you, too.

# Here's why.

You're an engineer on the way up. Your ideas, your designs, your work all reflect the extra contribution you're making. (You might even slip back to "the shop" after dinner and on weekends.) Rewards won't be long in coming.

There's one more thing you can do for yourself and your management. Show them a way to cut operating expenses and boost profits. How? By being critical and downright hardnosed in making your cost/performance comparisons on instrument purchases.

## Scopes Have Changed.

Take laboratory oscilloscopes for instance. In the past several years, scope design and performance have changed—for the better. Many companies, maybe yours, are in the process of replacing older scopes, to take advantage of the extra capability these new models offer. To get the best buy now, you're going to have to do more than look at the name tag and spec sheet. Plug-ins are not compatible. Calibration is completely different. Controls and operations have changed radically. It's a whole new ball game. *Little* that you learned or used on older scopes —*whether theirs or ours*—can be transferred to the new models. You need new techniques, new training materials, new parts. Here are three specific reasons why you should investigate the HP 180 Series...why you should think twice.

## HP Scopes Cost Less To Buy

Analyze your total measurement needs, then ask both manufacturers to submit prices. On latest model plug-in lab scopes, you'll find that HP can consistently save you money — lots of it. For example on a 75 MHz non-delayed sweep, plug-in system, ours is 24% less (with delayed sweep, 18% less); at 100 MHz, ours is 16% less; for 1 GHz sampling, you'll pay 54% less if you buy ours.

## HP Scopes Cost Significantly Less To Operate

Because scopes have changed, training, operation, calibration, and repair are expenses that you'll have to contend with—no matter which make you buy. HP's new scopes are supported by simplified operation and live or videotaped training and repair sessions that can substantially cut your start-up and overall operating costs.

Calibration? We've cut the number of adjustments by 50%—and eliminated interactive adjustments. Therefore, when you're comparing oscilloscopes be sure to include in that comparison the cost of calibrating each manufacturer's unit.

Our users are reporting shorter training periods, faster, surer measurements, and savings up to 50% on calibration time and costs. Some companies buying Hewlett-Packard, cite this as the main reason.

## HP Technological Leadership. More Performance. Fewer Problems.

HP innovations in general purpose lab scopes include: the first scope with a real time bandwidth of >250 MHz; the first 18 GHz sampling scope; the first 100 MHz variable persistence and storage scope; and the first and only 100 MHz scope with a "big-picture" CRT (8x10 div, 1.3 cm/div). These are meaningful, functional innovations that boost your performance, not your costs.

Think twice! Once you make the comparison, we're certain you'll choose HP. Many engineers like yourself—engineers on the way up —have already made the switch. For more information on how you can help your company boost profits and how you can help yourself make faster, more positive measurements, write for our free "No Nonsense Guide To Oscilloscope Selection."

Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

**Scopes Are Changing; Think Twice!**

HEWLETT hp PACKARD

OSCILLOSCOPES

CIRCLE NO. 11

082/6

# BOURNS

# LOW COST FAMILY

## OF INDUSTRIAL *TRIMPOT*® POTENTIOMETERS

## OFF THE SHELF AS LOW AS 49¢*

**POWER:** ½ WATT (or better) AT 70°C.

**TEMPCO:** AS LOW AS 100PPM/°C OVER TEMPERATURE RANGE OF —55° TO +125°C AND —55° TO +150°C.

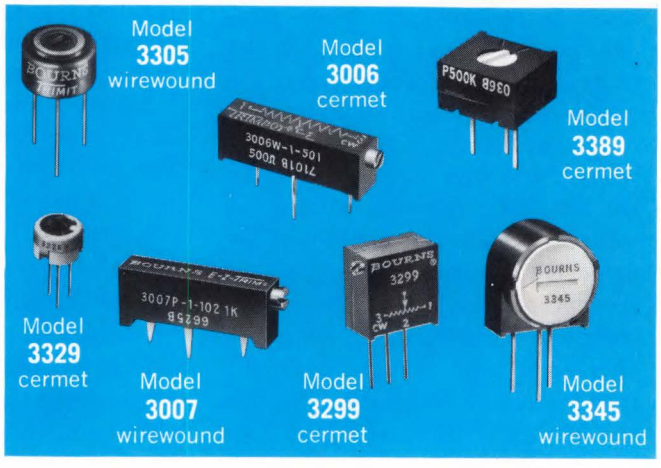
**Bourns LOW-COST FAMILY was designed specifically to fill the requirements of cost-conscious industrial users — *so were the prices!* Imagine how they reduce on large production-run quantities. As a bonus, you get Bourns TRIMPOT potentiometer quality, reliability and performance.**

### AVAILABILITY

**All models shown are stocked in depth RIGHT NOW, so delivery is off-the-shelf from the factory or your local Bourns distributor.**

**Complete data on all models of the LOW-COST FAMILY is available upon request. Just write, or call, your local Bourns Sales office, representative, or distributor.**

*1000-piece price Model 3389, U.S. dollars, F.O.B., U.S.A.




BOURNS

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

CIRCLE NO. 12

# HERE THEY ARE . . . THE WINNERS OF THE EDN CREATIVE DESIGN CONTEST

In the January 1 issue, EDN kicked off the new year with its first Creative Design Contest. The rules, you'll remember, were simple. Design something creative using the products advertised in that issue.

Well, if the rules were simple, the judging most certainly was not. The earliest entry arrived on January 4, which says something positive about rapid engineering turn-around time. They then kept coming and coming, even, unfortunately, after the cutoff date.

Volume wasn't the only problem. The vast majority of entries were A-1 design efforts, which put us somewhat in the position of judging a beauty contest where all the girls were gorgeous. But judge them we did. And on the basis of (1) technical competence and utility, (2) creativity and (3) number of different products used, the grand prize winner is Waller M. Scott, a project engineer for Nutone Company, Cincinnati, Ohio. Mr. Scott's winning entry, "An Electronic Casino," is described on the following pages.

The 10 runners-up in the contest, each the winner of a hand-held electronic calculator, are listed in the box at the top of the following page. These runner-up entries ran the gamut from a bidirectional amplifier, capable of simultaneous power gain of complex signals in both directions, to a device called a "touch talker." This is a keyboard-actuated voice-response unit having a vocabulary of 1000 words.

There was even a remote-reading weather station that measures and transmits data on temperature, wind direction and velocity, and rainfall.

One thing that struck us about the entries, and this applies to all of them, not just the winners, was that they came in bunches as far as categories were concerned. For example, there was a raft of designs related to music and musical instruments. These included a mini-amplifier for a string bass, an electronic guitar tuner and a harmonic tone synthesizer for organs.

Probably the most unusual was a device called a "loony music box." When turned on, the box plays musical melodies consisting of a random sequence of rates and rhythms. As stated by its designer, "this continues until the listener goes loony."

Another category into which many entries fell was that of electronic games or pastimes. These included not only the grand-prize-winning electronic casino, but an electronic tic-tac-toe game and a game called race-to-space, just to name a few.

Still another category, and a rather narrow one at that, into which numerous entries fell was electronic locks. Some were actuated by pressing the correct combination and sequence of pushbuttons, some by rotary switches and one was even light actuated. They ranged in possible input combinations from a low of 1000 to a high of 99,999.

One we especially liked uses ten input switches, four of which must be actuated in the right sequence to open the lock. Should anyone depress any combination of the keys more than 16 times, a loud, audible alarm is activated. As the designer of the device says, "this not only prevents tampering, but gives my wife four tries before she has to call the Fire Department to open the door for her."

One unusual variation on the lock theme was an electronic interlock for electronic garage door openers. This device prevents stray rf fields from activating the door opener. Essentially, it keeps the door's receiver deenergized until it itself is activated, for example, by the car's headlights.

We wish we could describe all of the entries received in the contest, but, unfortunately, space does not permit. We take this opportunity, though, to congratulate the winners and to sincerely thank all those who entered the contest. □

## PARTS FROM JANUARY 1 ISSUE USED IN WINNING DESIGN

Corning, resistors
Erie Technological, capacitors
Electrotube, capacitors
Allan-Bradley, potentiometers
Spectrol, trimming potentiometers
Centralab, line filter
Dynamic Instrument, transformer
Ledex, solenoid
Amp, plug and jack
Reed Devices, terminal strip
Heinemann Electric, circuit breaker
North Electric, modular power supply
MIL Electronics, dc-to-dc converter
Chicago Dynamic Industries, thumbwheel switch
Alco Electronic Products, lighted pushbutton switch
C & K Components, toggle switches
Lamps, Inc., lamp
Kurz-Kasch, knob
Electronic Instrument & Specialty Corp., reed relay
IMC Magnetics, blower motor
Rectifier Components, bridge rectifier
American Power Devices, signal diode
Schauer, zener diode
Opcoa, LEDs and 7-segment display
TI, IR emitter and quad transistor
Monsanto, LEDs
Sperry, 3-digit display
Europeon Electronic Products, IC audio amplifier
Fairchild Semiconductor, shift register and op amps
RCA, decade counter and quad counter
Motorola, transistors
Unitrode, Darlington pairs
Templock, shrinkable tubing
Zierck, ground lug
Keystone Electronics, hinged standoffs
Vector Electronic Co., CKT. bd.
HP/multimeter and frequency counter
Tektronix, oscilloscope
Heath, function generator

## CONTEST WINNERS

### *GRAND PRIZE WINNER*

Waller M. Scott
Project Engineer
Nutone Company
Cincinnati, Ohio

### *RUNNERS-UP*

David Cousins
Sr. Technician
Simpson Electric
Chicago, Ill.

Fred G. Geil
Senior Engineer
Westinghouse Electric Corp.
Pittsburgh, Pa.

Lawrence Grover
Chief Engineer, General Engineering Dept.
Heath Co.
Benton Harbor, Mich.

Marshall K. Kessie
Senior Control Systems Engineer
Bechtel Corp.
Los Angeles, Calif.

A. H. Marsh
Senior Engineer
Raytheon
Sudbury, Mass.

Bob Ravenstein
Design Engineer
Computer Systems Engineering
N. Billerica, Mass.

John R. Rawley
Electronic Engineer
Naval Air Development Center
Warminster, Pa.

Richard Reardon
Senior Design Engineer
Burroughs Corp.
Goleta, Calif.

G. K. Shubert
Design Engineer
Hisonic, Inc.
Olathe, Kansas

M. C. Waltz
President
Waltz Enterprises
Basking Ridge, N. J.

# CREATIVE DESIGN CONTEST GRAND PRIZE WINNER AN ELECTRONIC CASINO

The $100 grand prize is awarded to W. M. Scott for his Electronic Casino.

As described by Mr. Scott, "the circuit contains five games of chance implemented in an electronic manner. These are: dice roll, roulette, coin flip, high card, and a one-armed bandit. While intended as an adult party game, undoubtedly some people might put it to use on a more regular basis. Use of LEDs and lamps is combined with sounds to make a more interesting game."

The complete schematic diagram of the electronic casino is shown on the opposite page. Unfortunately, due to space considerations it has had to be reduced in size considerably. The five major sections, though, are easily distinguished. As an example of how the casino works, the following is a description of the operation of the one-armed bandit section.

The bandit is awakened by game code 55555. By pulling the lever down, three COS/MOS oscillators are started, which clock three separate decade counters. The three oscillators run at three different unrelated frequencies. Each CD4026A contains its own 7-segment decoder, which drives a Sperry readout through high-voltage buffers.

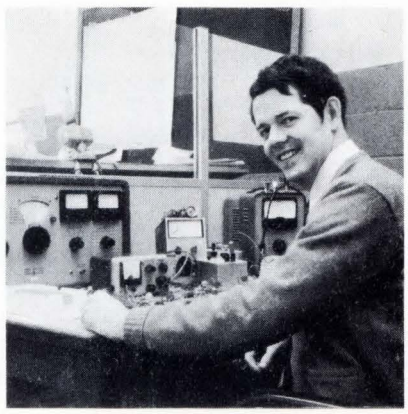
After the lever is released, each of the three oscillators continues to run for some time, as determined by C502, C505, and C508 and their associated 1-megohm resistors. The "L" oscillator will stop first followed by the "C" and then the "R". The position of each counter at the time its respective oscillator stops determines the displayed number, 0 through 9. At the instant each oscillator stops, the op amp oscillator will be momentarily connected to the audio amplifier through relay $K_1$, giving a burst of 1 kHz tone. □

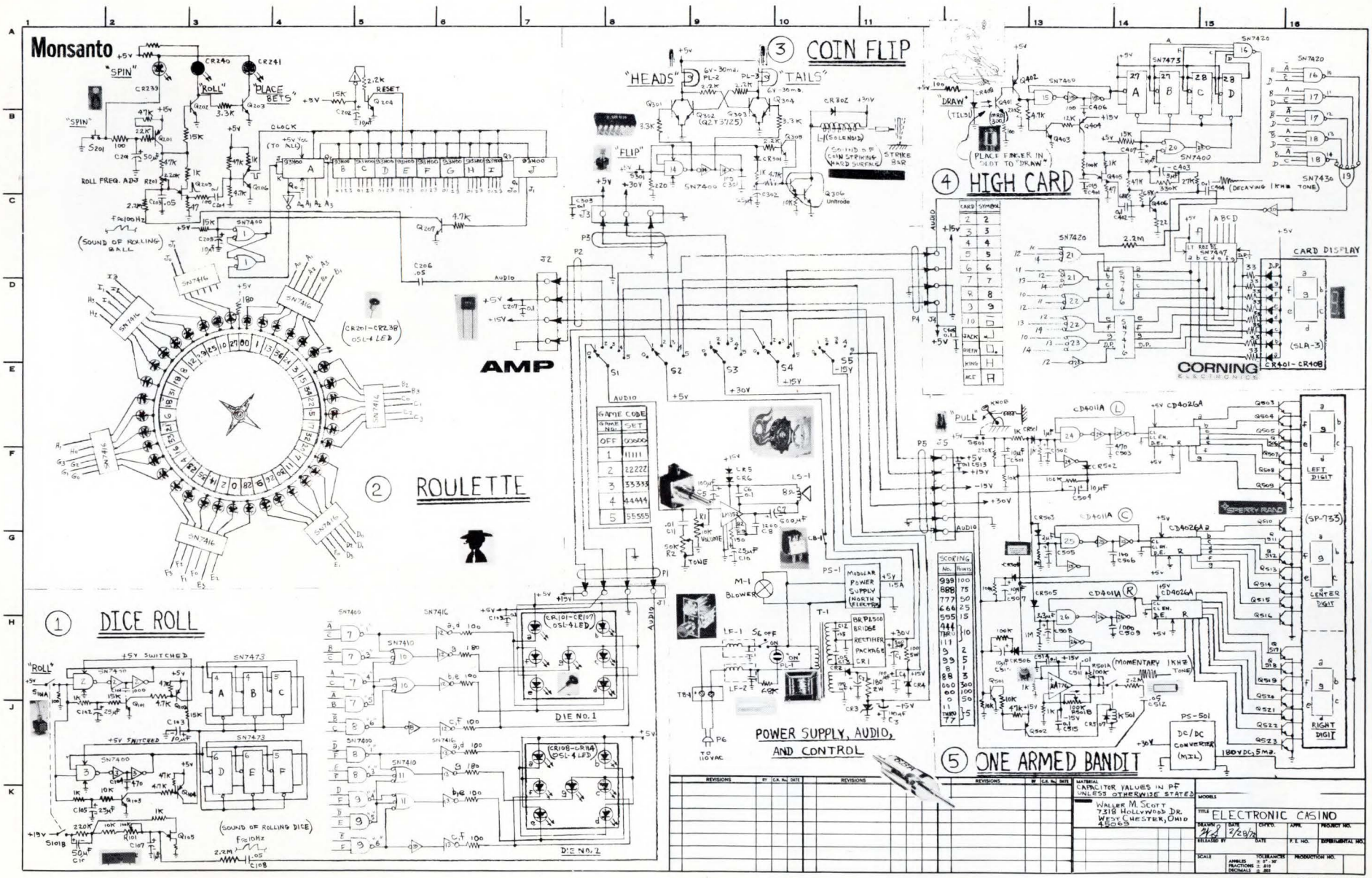
# *BIOGRAPHY OF A WINNER*

Waller M. Scott is a project engineer for the Nutone Company, a Division of Scovill Industries. He is involved in the rf, audio and digital design of built-in electronic equipment for residential use, such as AM/FM radio-intercons and security systems. Prior to moving into the consumer electronics field in 1970, he was in the aerospace business working on the rf and digital design or aircraft radio transceivers.

Mr. Scott received his BSEE from the University of Kentucky in 1966, and now lives with his wife, Dianne, in West Chester, Ohio.

His main off-the-job pursuit for the last two years has been building, together with his wife, their new home, which is now almost complete. In spite of this, he still finds time for a wide variety of other interests. As he puts it, "When not running around with hammer, saw and paintbrush in hand, I am involved in one of several hobbies. These include HAM radio under the call letters K8DIZ in Ohio and K4QPJ in Kentucky, experimental electronics, woodworking, swimming, target shooting and photography."




Monsanto
1 DICE ROLL
2 ROULETTE
3 COIN FLIP
4 HIGH CARD
5 ONE ARMED BANDIT
AMP
CORNING
POWER SUPPLY, AUDIO, AND CONTROL
ELECTRONIC CASINO
WALLER M. SCOTT
7318 HOLLYWOOD DR.
WEST CHESTER, OHIO
45069

# Complete Trimmer Satisfaction

## One design...9 pin styles

### Still the industry's best trimmer value
### ... Less than 50¢ each in production quantities

Settability of ±.03% and environmental performance requirements of characteristic C of Mil-R-22097

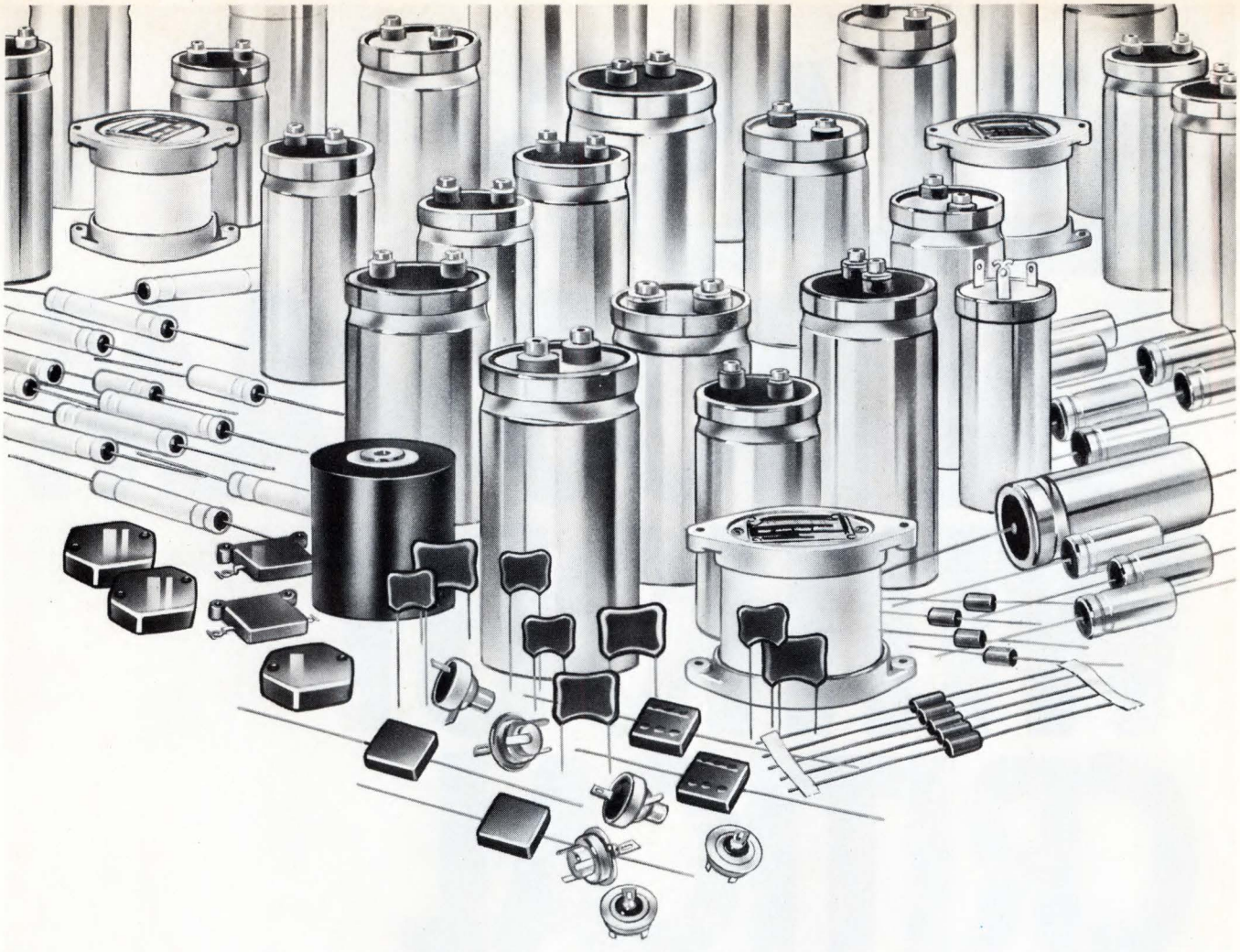
- 1.5% average ENR noise resistance
- 0.5% average CRV
- 1/2 watt @ 70°C

You can choose from an expanded line of compact trimmers. .150″— .125″—.100″ in-line terminal spacing and TO-5 pin spacing all available in top and side adjust. Plus .200″ delta (.100 grid) in top adjust. All available from your CTS Distributor. **Still the best value in the industry.** CTS of Berne, Inc., Berne, Indiana 46711. Phone: (219) 589-3111.

**CTS CORPORATION**
*Elkhart, Indiana*

*A world leader in cermet and variable resistor technology*

CIRCLE NO. 13



# Sangamo Capacitors deliver exactly what you want, whether you want a million...

There's one thing you can't afford and we can't afford: Below-standard capacitors. Not even one.

That's why at Sangamo our production and inspection systems are designed to deliver aluminum electrolytic and mica capacitors as close to zero defects as modern technology can take them. Order a million or order one. The Sangamo systems hold the standards we expect you to demand from us.

We're also ready to give you engineering, design and production assistance.

Fast. Right from our factory.

That's our program on all standard capacitors. If you need extra current carrying capabilities in a smaller package, you'll want to hear about our new Type 100 Power Pack computer-grade capacitors. Whatever your needs are, we'll deliver exactly what you want. Whether you want a million... (or one).

CAPACITOR DIVISION

**SANGAMO**
**ELECTRIC COMPANY**

Box 128/Pickens, South Carolina 29671
(803) 878-6311

## or one.

EC721

CIRCLE NO. 14

# AT LAST: AN 1103 RAM WITHOUT CRITICAL TIMING

## Our 3534 1024 x 1 Dynamic Silicon Gate MOS RAM: Plug-in replacement for the 1103. But without its timing margin problems and with 97% lower stand-by power dissipation.

Our new 3534 1024-bit RAM is a vastly simplified *pin-for-pin replacement* for the 1103. We've optimized the design in five important areas. Important to those who would use our 3534 as a plug-in replacement for the 1103 in an existing system. Equally important to those who would design our device into new systems. Important to both because these innovations solve the major problems of the existing 1103.

**No Precharge and Chip Enable overlap requirement.** Result: Better and less critical timing margin on control of Chip Enable-Precharge overlap. Less drift problem. Less adjusting. Less maintenance. No critical window to stew about. Greater design margins (other 1103's have no margin, worst case).

**Data Out referenced to the leading edge of the Chip Enable.** Unlike other 1103's, which have as many as 5 critical times affecting access time, ours has only 2; the 3534 array access time is dependent on the timing of only one critical edge relative to Precharge and only one delay relative to Chip Enable. No timing margin problems to create system malfunctions, board rework, acceptance tests, downtime, and other virulent forms of field aggravation.

**Maximum standby power dissipation reduced 97%.** From 70mW for the other 1103's to 2mW for our 3534. Result: significantly lower power supply costs.

**Equal Read and Write cycle time (480ns).** The system can now operate at a higher data rate. You don't need to Read before Writing. By a simple pre-selection the 3534 can go either way. The system can operate at a higher data rate without additional timing and control circuitry.

**Read/Write specified as a voltage level rather than a pulse.** Since the Read/Write input may remain low indefinitely (assuming continuous Write cycles), Read/Write timing is no longer critical. And system Read and Write cycle times are sharply reduced.

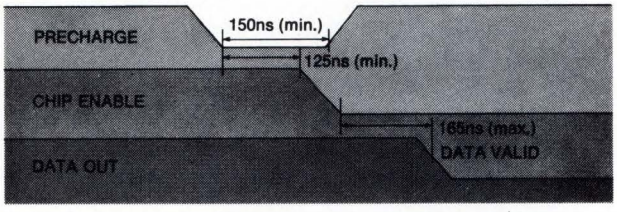
The 3534 is another example of Fairchild OPTI-MOS: *practical* MOS devices that optimize your system. Easy to use. Simple to produce. At less cost / function.

The 3534/1103 is available now – in ceramic DIP – from your friendly Fairchild distributor.

| 1-24 | 25-99 | 100-999 |
|---|---|---|
| $21.70 | $18.40 | $14.00 |

A data sheet and detailed application note are available on demand. Demand.

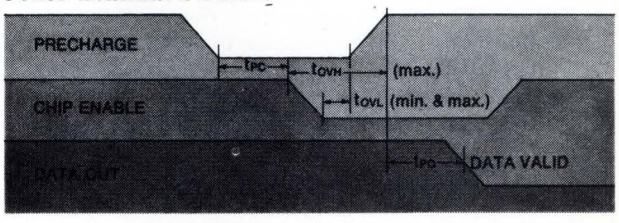
**Fairchild 3534/1103**




**No Precharge and Chip Enable overlap requirements.** The 3534 requires only that the Precharge pulse stays low for a minimum of 150ns and that at least 125ns delay occur from the start of Precharge to the start of Chip Enable. The Data Out is valid 165ns after the Chip Enable goes low but is independent of Precharge.

There are no other restrictions on the Precharge pulse. It can go high immediately or it can stay low throughout the entire cycle. Or it can remain low for successive cycles.

**Other Standard 1103's**




With other 1103's, the Precharge pulse not only must stay low for a precise Precharge interval but its transition from low to high must occur within a time interval which has a *minimum* as well as a *maximum* limit. As a result, the designer must stay within very tight boundaries of these maximum and minimum values. All control circuitry must be extraordinarily precise, and system costs rise sharply.

MADE IN FAIRCHILD

FAIRCHILD SEMICONDUCTOR, A Division of Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Ca. 94040. (415) 962-5011. TWX: 910-379-6435

CIRCLE NO. 15

# Keyboards-The indispensible link between man and machine

*This link can be frustrating and troublesome if the wrong one is chosen. Here are some of the factors to consider when selecting a keyboard for your system.*

**Richard Brisk,** Arthur D. Little, Inc.

Many forecasts predict that the market for keyboards will almost double by 1975, reaching a volume of approximately 1.2 million per year. Such observations make it apparent that increasing numbers of electronic engineers are becoming involved in the selection of keyboards and keyswitches. Selection of the best component or subsystem for a product is never easy to make and many questions must be answered before a final decision is made.

Considerations, difficult to evaluate in their own right, are made more difficult in this case by the fact that some of the thinking is different from that in which an electronic engineer normally gets involved. The decision usually requires a mixture of concerns for such things as: human factors, cosmetics, size, mechanical failure and lifetime, as well as the more familiar considerations of cost and electrical specifications. This article discusses the variety of choices offered by keyboard manufacturers with the intent of developing sufficient background to enable the reader to ask the right questions. The article does not, however, attempt to give any cookbook recipe for selecting the right keyboard, because there is no such recipe. The best guide is a good understanding of the field.

The keyboard and interface electronics are the middle links in a four-link chain that is analogous to many systems in which keyboards are used:

operator/ keyswitch or keyboard / interface/ equipment

As the middle link, the keyboard and interface electronics do not define the other parts of the system, but should themselves be defined both by the type of operator, and the type of operation that the keyboard will see. Choosing the right keyboard is clearly a case of the means justifying the extremes. Hence, when making this choice, the designer needs to innumerate all constraints that will be imposed on the keyboard.

## What equipment is being controlled?

The equipment that the keyboard controls will impose limits or constraints on many of the variables of the keyboard design. An understanding of these constraints will enable you to eliminate all but a few keyboards from among the many hundreds that are available. This interface is a good place to start defining the keyboard. The specifications of this interface involves definitions such as:

- the type of signals required
- the power and loading
- the number of keys required and their arrangement
- the mechanical size and construction

Resolution of the third issue is basic to defining the keyboard. Knowing the general type of system will, by definition, identify the basic keys required, while the system particulars will often add another 10-20% to that number. For instance, if the design is for a telephone-oriented product, the keyboard will almost certainly consist of 12 keys physically arranged in a 3 by 4 matrix. In addition to those 12 keys, the system may require a few others for control functions. The same sort of me-too ism will govern the selection of the number and arrangement of keys for a calculator, a typewriter or a computer I/O product.

This look-alike process for determining the number of keys on the keyboard is useful as a first approximation, but in actuality, the problem is much more subtle. There is always a trade-off between the elimination of or doubling up on some of the keys, and making the keyboard appear to be more or less intelligible to the user. Furthermore, while the former takes some costs out of the keyboard, it can add cost to the interface electronics. There are no specific techniques developed for minimizing the number of keys or the cost. You must ponder this problem yourself, listing the trade-offs involved with each key.

If mechanical restrictions on the size of the keyboard are severe, then the choice is narrowed to a few keyboard types. Some are not much thicker than the outside skin of the product itself without the keyboard. In general, the trend is toward keyswitches which take up minimum vertical height. The horizontal area is defined by the center-to-center spacing required for easy operator use and by the total number of keys.

Next, the format of information generated by the keyboard must be defined. In addition, the question of whether you have the interface at the keyswitch or after some logic must be answered. Many keyboard users consider it

**Standard ASCII Tri-Mode mechanical keyboard. (Cherry)**

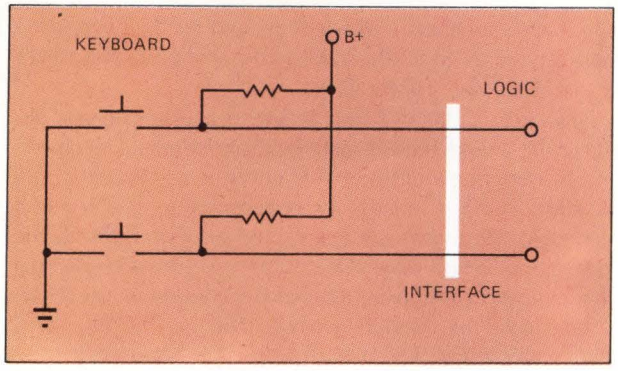



**Fig. 1—Direct-wired keyswitches** are commonly used in small keyboards.

cost effective to use the raw contact closures from the keyswitches, and do the decoding in the system logic. However, the smaller your system's production quantity is, relative to the keyboard manufacturer's total production quantity of that type of keyboard, and also, the larger the size of the keyboard, the cheaper it will be to consider the keyswitches and decoding logic as a whole subsystem.

Certain rules of thumb about the format of information coming from the keyboard are evolving as keyboards are being used in more systems. For keyboards of only a few switches, most systems wire the output of each switch directly into the logic, as shown in **Fig. 1**. At six contacts per keyboard, you begin to save connections between the keyboard and the logic at the expense of intra-key wiring by using a crossbar or matrix arrangement as shown in **Fig. 2**.

A method for calculating connections between keyboard and logic is as follows: If N is the number of key switches, the scheme in **Fig. 1** requires N interconnections between the keyboard and the logic. However, in **Fig. 2**, if N is factored into two almost equal parts such that $X \times Y = N$, where $X \approx Y$, then $X + Y$ equals the number of connections between the logic and the switches. For example, if $N = 6$, then $X + Y = 2 + 3 = 5$. Thus, it requires five contacts for the crossbar arrangement, but six otherwise. A more dramatic example is seen where $N = 12$. Then, $X + Y = 4 + 3 = 7$, a savings of 5

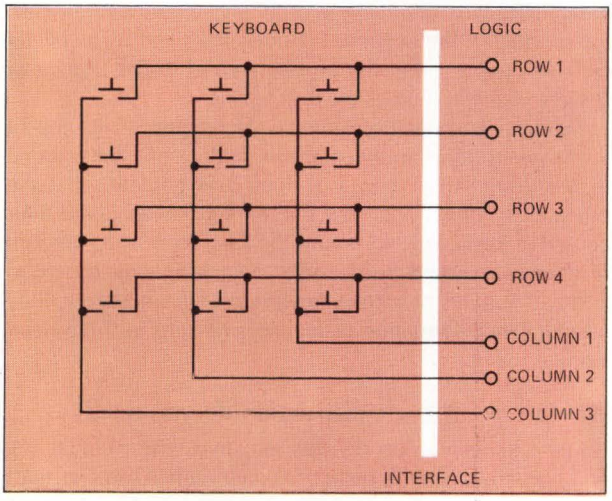



**Fig. 2—Crossbar or matrix keyswitch arrangement** is most economical in large keyboards. It minimizes the number of keyswitch-logic connections.

connections, which can be useful if you are going into an MOS chip and are concerned about the limitation of pins into the logic.

In the crossbar arrangement, you would probably choose to sequentially strobe the column lines and look for the presence of any logic level on a row output line. Notice the savings in pull-up resistors resulting from the logic strobing of the column lines. The crossbar arrangement has the added advantage of being bounce insensitive, provided that the strobe circuitry is well designed.

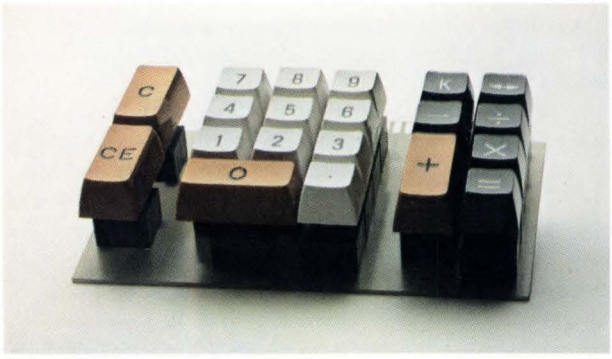
Typewriter size keyboards don't get involved in the crossbar wiring configuration because roll-over protection (when more than one key is actuated at the same time) becomes a dominant concern in the logic design. The easiest way to get this protection is to look at the output of each switch directly in order to judge which key was activated first.

A few keyboard manufacturers have developed keyswitches that give a pulse output (1 msec or less) for each depression of a key. This type of keyswitch is useful in achieving N-key roll-over. It is not needed to achieve two-key roll-over. (N-key roll-over allows the system to accept multiple key closures and identify their sequence of closure, while two-key roll-over only identifies the first two keys of an almost simultaneous actuation.)

**Photo electric keyboard** used with Model 30 printer. (**Litton ABS**)

Most people agree that two-key roll-over is required in typewriter keyboard decoding logic, but not everyone agrees about N-key roll-over. The issue is most often resolved by considering the cost. N-key roll-over costs 10-12% more than two-key roll-over. Most designers would like to have it, but cannot afford it at today's price. The decision for two-key rather than N-key rollover has been made enough times so that equipment manufacturers have established a trend of using two-key, but not N-key roll-over. This trend will continue for awhile since the end user is often not technically sophisticated enough to know whether he needs the N-key roll-over feature, and he feels he can't afford to find out.

In large keyboard systems, the equipment designer must face the question of where he will draw the line defining the keyboard interface. Should the system logic include the debouncing, roll-over, and decoding logic? Or should this be purchased on an OEM basis as part of the keyboard subsystem? It is purely a cost trade-off. If you feel you can design and build this logic cheaper than you can purchase




**Elastomeric-pc contact system** in Model EB keyswitch. (**Chomerics**)

it, then you should do so. To date, about 75% of typewriter-type keyboards are purchased with the keyboard manufacturer's logic.

## Who will use the keyboard?

Who is the operator of the machine? Is it any John or Jane Doe, or is it a trained operator trying to achieve high-speed keyboard operation? Is the operator typically male, female or both? These questions are easy enough to answer, but how to use this information is less straightforward. The type of operator will affect things such as key spacing, arrangement of the keys, pitch and size of the key tops and dynamic feel of the keys. Christopher Clare in his article in **Computer Hardware Magazine** (Dec 15, 1970) synthesized the keyboard/human interface design into four considerations, choosing the keyboard to:

- enable the finger to locate the key easily without hitting other keys or obstructions,
- allow the resisting force to give feedback information about the key travel,
- give the best visual perception of the key label or function,
- allow the distribution of pressure on the finger to give feedback about it's position on the key, and to place the force on the desired portion of the finger.

The first consideration has different answers for different products. For instance, if the keyboard is for a telephone product which will be used by both men and women, you should pay attention to a Bell Lab study which concludes that the best key feel results from 1/2 inch key tops spaced on 3/4 inch centers. In addition, the key numbering will start with 1 in the upper left corner of the 3 × 4 matrix of keys. An entirely different set of dimensions would be optimum for a typewriter keyboard, where high performance for hours at a time is the prime consideration.

The last three considerations cover a subjective area high debated by keyboard manufacturers.

One such highly debated issue is that of tactile feedback. A lot of research has been expended trying to prove that it is not needed for high-speed keyboard operation by experienced operators. Honeywell, who does not offer tactile feedback with their typewriter keyboards, conducted a study a few years ago which concludes that it is not necessary. Honeywell, not withstanding, I believe that most users would like to have it, and that it is purely a cost trade-off. Some types of keyswitch mechanisms inherently give tactile feedback of one sort or another, while others require extra components and therefore, extra cost. As a general rule, tactile feedback costs money, and product engineers have tended to go for the lowest-cost keyboards regardless of the exact feel of the switch.

However, if the decision is left to a user-oriented designer, he would choose some measure of tactile feedback, and in fact, he would probably go on to say that it would be good, but not mandatory to accompany it with audio feedback. The most widely accepted solution to the tactile feedback question (IBM selectric) is a sudden well-defined change in pressure accompanied by an audible signal that is related to the pressure change. This can be described graphically in **Fig. 3**.

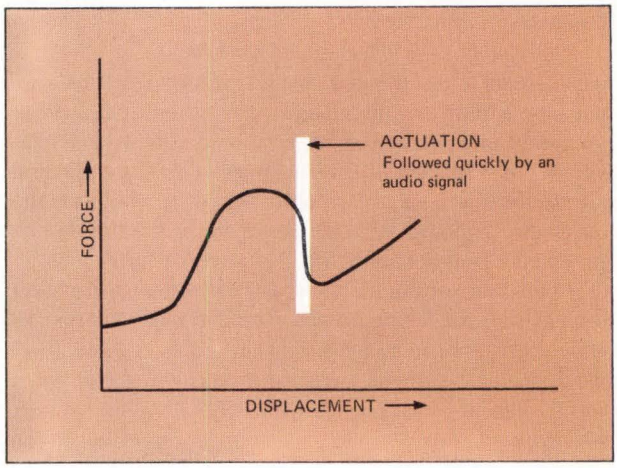



**Fig. 3—Optimum tactile feedback** shows a rapid drop in pressure at the moment of switch closure.

In general, there are three solutions to the problem of tactile feedback among keyswitch manufacturers. Some try very hard to emulate the feel of an electric typewriter. Others ignore this approach altogether claiming that it is really unimportant as long as the key pressure is light. While still others tread the middle ground by requiring increasing force vs. distance travelled, but with no abrupt change of pressure at the point of actuation.

Tactile feedback is one of the many subjective features of keyboards about which there is little agreement. If your product is to be used in highspeed keyboard operations, you should definitely consider the user and run some meaningful tests involving people who would actually use the product. If the keyboard is not to be used by a special class of people, then it is probably valid to use your own subjective evaluation as the touchstone.

The last consideration involves the shape of the top of the keys and their arrangement. If you are not the first one in a product area, then look long and hard at what the others have done, and how the market has accepted their choice of keyboard. If you are the first, then a fair amount of attention should be devoted to investigating the good and bad features of various keyboards. Unfortunately, little quantitative information is available to help in these decisions.

## Which type of key construction do you need?

Keyswitches can be divided into two types; contacting and non-contacting. Contacting keyswitches have at least one set of physical contacts that make or break when the key is actuated. Contact keyswitches include reed, mechanical, mercury tube and elastrometric, to name a few.

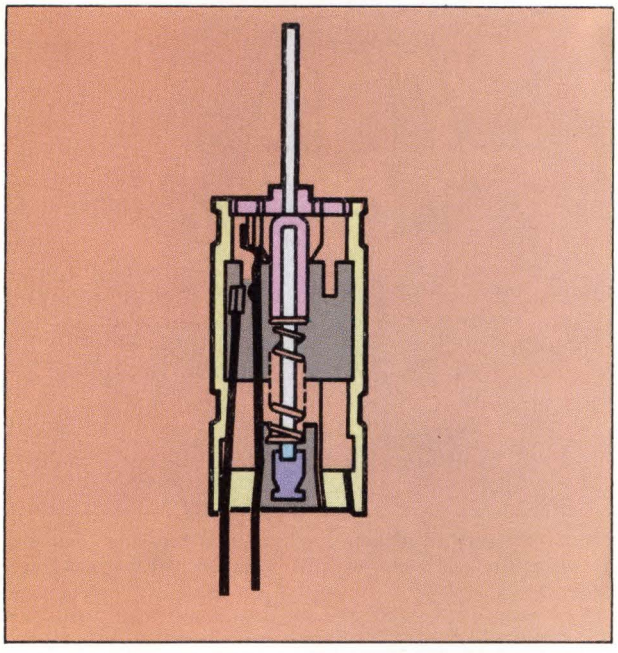


**Fig. 4 – Mechanical switches** remain the lowest-cost keyswitches available. (Oak Mfg. Co)

Non-contacting switches give an electronic output without making use of contacts. These include photoelectric, Hall effect, saturating magnetic core, and capacitive. The advantage claimed for the non-contacting switches are: no bounce, no variation in contact resistance, no degradation with time, easy interfacing with standard logic, long life, high reliability, and low RFI. The two major disadvantages are: high standby current, and the need for associated electronics which adds complexity and cost. These disadvantages can be substantial; for instance, the Micro Switch Hall effect keyboard requires about 5 watts of operating power.

Most companies that make keyboards use only one type of keyswitch throughout their entire product line. In most cases, only those manufacturers making reed or mechanical type keyswitches are willing to sell individual switches, and not even 100% of them will do it. The reason for this, I feel, is the relatively small size of many companies in the business (Micro Switch aside), and where those manufacturers perceive their largest market to be. For instance, many of the companies making non-contacting switches are less than five years old. Their product is somewhat proprietary and sensitive to the customer interfacing. They are also intent on pushing the "we'll do the whole thing" concept for OEM sales purposes.

The mechanical switch is one of the oldest and most popular switches on the market today. The mechanical motion of the key is used to put one springy metal piece into contact with another stationary piece of the same metal. **Fig. 4** shows Oak's mechanical switch. This type of switch is most often seen as a Form A contact but can be made as a Form B or C. It can also be made to give a momentary contact output. The contacts, springs, supports, etc., are often enclosed, and the enclosure is usually a dust cover, rather than a hermetically sealed housing.

Magsat Corporation has a unique version of the mechanical switch which makes use of repelling magnets to close and strobe the several contacts (**Fig. 5**). The principle gives both tactile feedback and an audible click at the trip point.

For many years the mechanical switch was the most popular one among keyboard manufacturers, then reed switches took over. About five years ago, mechanical switches were in danger of becoming extinct. Today however, there is a definite resurgence of interest in mechanical switches. Many manufacturers are even expanding or thinking of expanding their line to include mechanical keyswitches. The motivation here is *cost*. The mechanical switch is the cheapest switch manufacturable and has sufficient reliability for many applications. The difference between five years ago and today is several-fold: (1) improved manufacturing techniques have led to improved mechanical switches; (2) today's logic circuits are more sophisticated and can tolerate high-impedance closures; (3) the price competition of keyboard products using a small number of keys (i.e., 20 and under) tends to be very fierce, requiring the lowest cost keyswitch available.

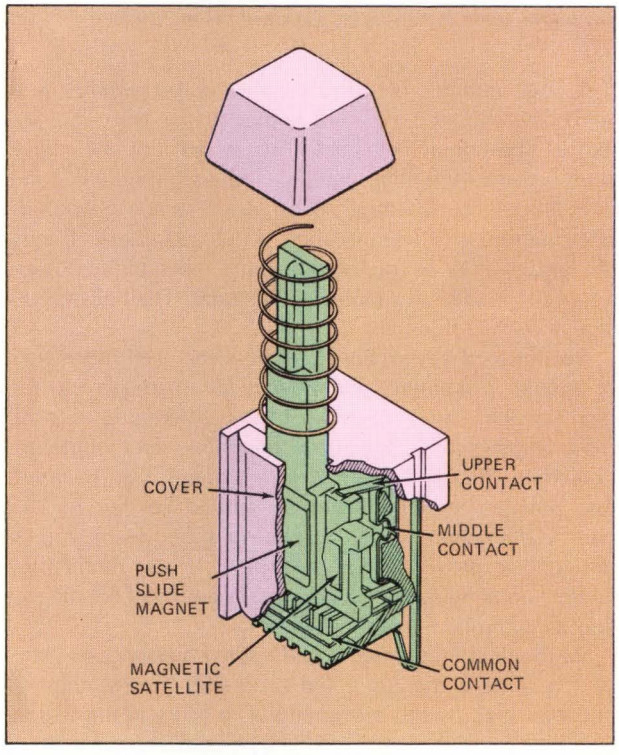
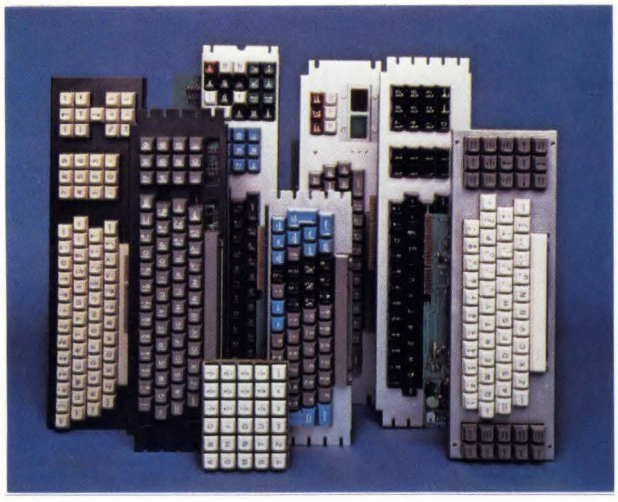



**Fig. 5 – A "flying magnet" in the keyswitch** provides both tactile feedback and an audible click when contact is made. (Magsat Corp)

**Contactless capacitive keyboard** has illuminated keycaps (**Raytheon**)



**Keyboards come in all shapes, sizes and colors.** (Licon)

A large number of manufacturers of keyswitches and keyboards use reed switches (either dry or mercury wetted) as the contact element. This is because they have been around for a long time, are inherently reliable, and have excellent switching specs. Reed switch keyboards offer many useful features such as: sealed contacts, long life, long history of use, high stability, no standby power, and easy readily available replacement. Their disadvantage is contact bounce.

Not all reed keyswitches are the same. The mechanics of magnet placement, and how it moves relative to the reed switch varies considerably. Furthermore, not all reed switches have the same reliability since some are limited by their mechanical arrangement. **Fig. 6** shows one possible implementation of a reed keyswitch. This particular implementation is interesting because it can be designed to provide either a Form A, B or a momentary contact, depending on the quiescent position of the magnet and its controlled length of travel.

Mechanical Enterprises has designed a bounceless keyswitch using a mercury-filled tube (**Fig. 7**). Switching is accomplished by the movement of mercury in the sealed, flexible tube. When the key is depressed, the mercury in the tube flows together making continuity between terminals. When the key is released, the mercury tube is pinched off so that continuity is broken. A version of this switch with up to eleven diodes in it provides an encoded output.

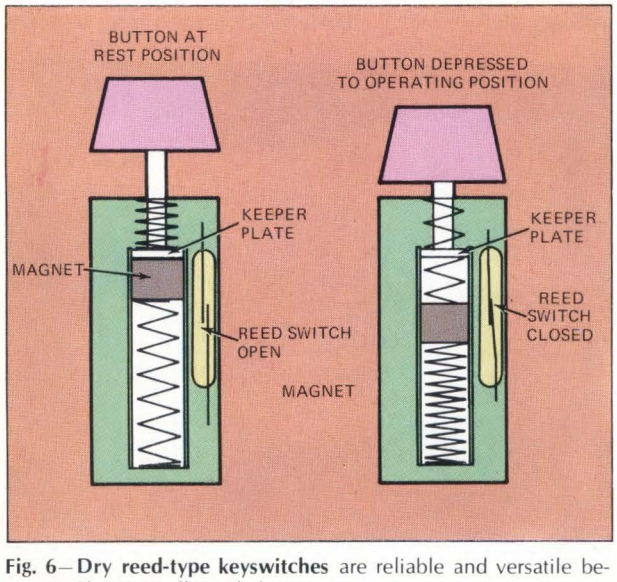



**Fig. 6—Dry reed-type keyswitches** are reliable and versatile because of hermetically sealed contacts.

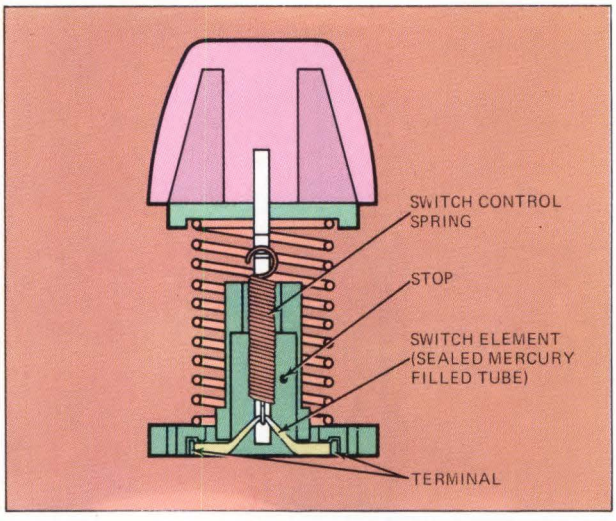



**Fig. 7—Mercury filled tube** is pinched off breaking continuity between terminals when switch is released. (Mechanical Enterprises)

Three manufacturers offer elastomeric keyswitches. **Fig. 8**, and **9** show the Datanetics and Chomerics versions of this type of keyswitch. The basic ingredients of these versions of the switch are a conductive/elastic membrane, an insulating membrance and an etched printed circuit board. The most striking feature of these switches is their low profile. The manufacturers claim many advantages such as: bounceless operation, long life, low price and completely sealed (waterproof) construction. The chief disadvantages are the high contact resistance and the spongy feel of the switch. The Chomerics switch has a relatively low contact resistance because Chomerics uses a silver-filled elastomer vs. carbon-filled, and they offer an encoded output.

The Hall effect keyswitch is one of the biggest sellers of non-contacting types. Micro Switch, with their Hall effect keyswitch, was one of the first companies in the non-contacting keyswitch business, and they are still the largest. In 1968, their keyboard was one of the only fully decoded, two-key roll-over electronic keyboards on the market. As with all of the non-contacting keyswitches, the principle is straightforward, but the implementation is difficult, and Micro Switch had its problems. It works by moving a magnet near a Hall effect device when the key is depressed, and amplifying the output of the device (**Fig. 10**). Micro Switch has both a dc output version of the switch and a pulse output (less than 1 msec) version. The latter is useful for N-key roll-over capability.

Licon uses a saturating magnetic core for its switching element (**Fig. 11**). When the key is up, the magnetic field causes the core to saturate. As the key is depressed, the magnetic field is removed from the core, which then unsaturates and acts as a transformer to couple an ac signal from one line to the other.

An E-field or capacitively coupled keyswitch is manufactured by Control Devices (**Fig. 12**). When the key is depressed, an ac signal is capacitively coupled into an amplifier/detector, the output of which is a dc level.

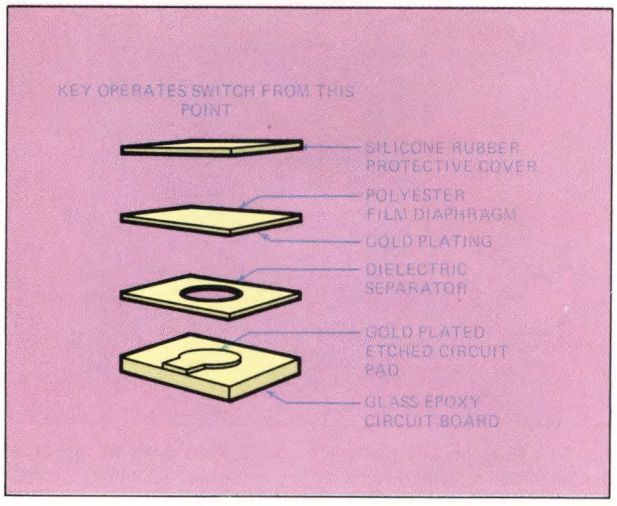



**Fig. 8 – Conductive plating on film diaphram** becomes one switch contact when depressed into contact with conductor pad on pc board. (Datanetics)

Another capacitively coupled keyswitch (**Fig. 13**), made by Colorado Instruments Corp., also provides tactile feedback. The monostable capacitor element within each keyswitch consists of a dime-size spring-metal disc. The disc has been formed to rest in a dome shape, arching slightly above a circular "target" disc which is etched in the underlying printed circuit board. A special thin insulating film is deposited over the target disc to prevent metal-to-metal contact when the dome spring snaps down against the target. These elements form a simple capacitor which is charged to a static voltage while the key is at rest.

Pressure applied to the key cap is transferred through a precision coil spring to the center of the arched dome. When the avalanche point is reached, the dome collapses with a crisp snap, causing a sudden increase in its capacitance to the target and also providing a gentle tactile feedback. This is accompanied by an impulsive change in voltage which provides a sufficient electrical signal to drive the encoding logic. When released, the dome quickly snaps back to its arched position in readiness for the next actuation. Through bifurcation of the target, two independent voltage impulses are generated at each key position, thus providing the coordinate information necessary to identify and appropriately encode each key as it is pressed.

TEC and Digitronics use a photoelectric device as the basis for their keyboard switches. The photoelectric sensor senses whether the key is depressed or not by observing changes in the state of the light source. Its output state will also change as a result.

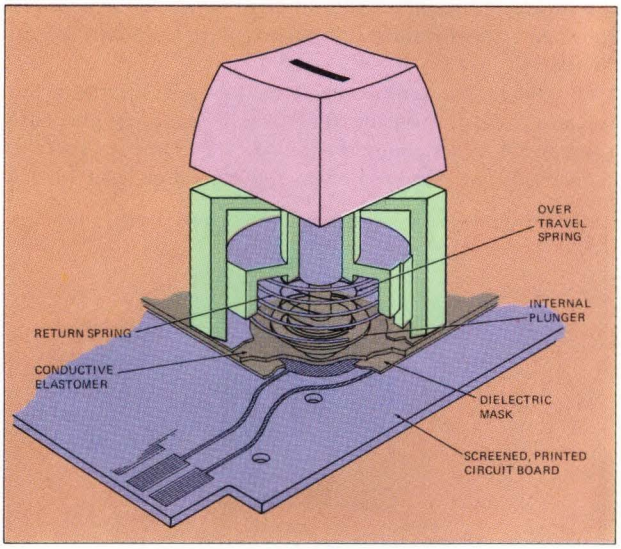



**Fig. 9 – Conductive elastomer becomes a shorting bus** between two screened contacts on pc board when internal plunger presses it through opening in dielectric mask. (Chomerics)

## Other things to consider

Up to this point we have only discussed how the keyboard looks from a physical and electrical point of view. We have not mentioned the electrical and mechanical parameters of the switch itself. Keyswitches vary greatly in their mechanics, electronics and theory of operation, and there a few crucial specifications that will help you select a keyswitch. The type of switch you choose may have already fallen out of some of the earlier considerations, such as the maximum available height, the power restrictions, size, etc., but it may not have. If the latter is the case, the decision is apparently a difficult one to make. It is unlikely that the decision will get much easier from here on, but I will mention a few other considerations that should influence your choice, namely:

- cost
- the required mean-time-to-failure
- non-acceptable failure modes
- serviceability and replacement requirements
- anticipated production quantity

The importance of keyswitch reliability depends greatly on the system's use. For instance, a touch-tone* telephone system may consider some level of intermittancy acceptable because of the slow operation and the simultaneous acoustic feedback telling the user that the digit is properly dialed. In a typewriter or a computer I/O system, on the other hand, any level of intermittancy is considered unacceptable.

The selection of almost every keyboard used today was dominated by the considerations of cost and reliability. Keyboards can cost anywhere from a rock bottom 25¢ to about $2.00 per key. The pricing structure is soft, however. Keyboard manufacturers, more so than most other elec-

*A registered trademark of the American Telephone & Telegraph Co.

**Hall effect solid state keyboards** feature MOS encoding. (**Micro Switch**)

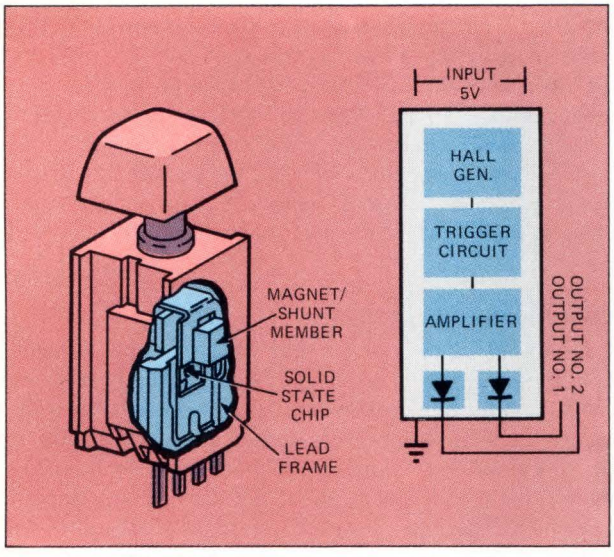



**Fig. 10—Hall effect device generates a voltage** when magnet on keyswitch plunger passes near it. (Micro Switch)

tronic component manufacturers, put quantity order customers in a very special category. If you will be using a large number of keyboards a year (e.g., 1000-5000) you don't have to worry whether a manufacturer's standard product is exactly what you want. Most will be glad to remodel a standard design to suit your needs at no extra cost to you. This sort of specialization can save you money in interfacing and mechanical assembly. You should get the keyboard manufacturer involved early enough to work out more easily the exact nature and cost of the product. This is especially true if you are projecting large volume production. Keyboard companies are capable of getting very excited over potential 1000 and 10,000 piece orders, since a large part of their business is in 100 piece orders. If your large quantity projections still look reasonable after the design phase is completed, it is to your advantage to continue assessing alternate source bidding through the first year of production.

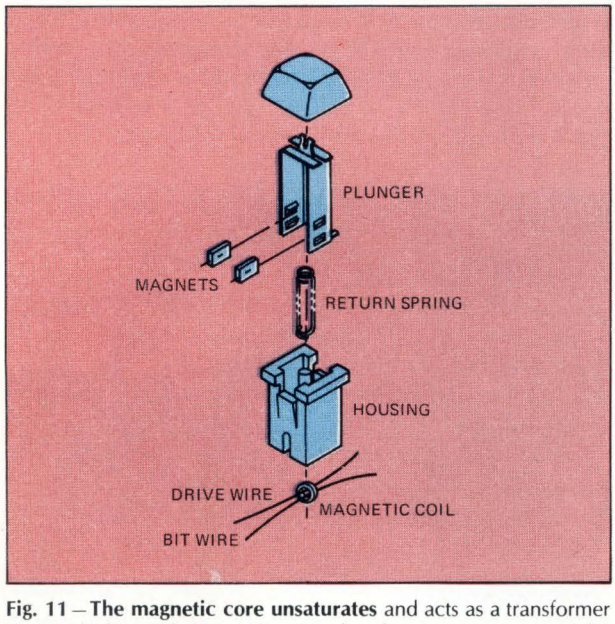



**Fig. 11—The magnetic core unsaturates** and acts as a transformer to couple bit and drive wire signals whenever magnets on the plunger are moved from near the core (Licon)

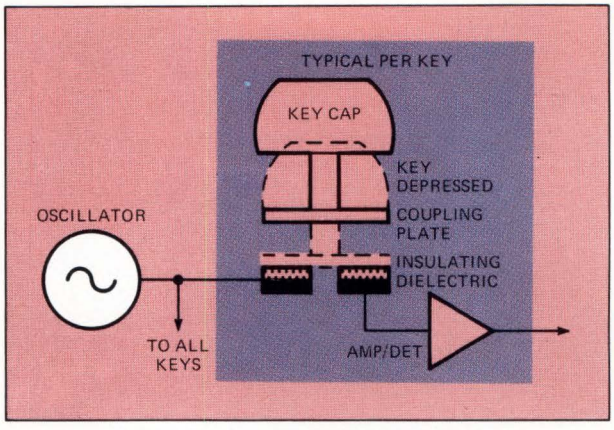



**Fig. 12—Plate on key plunger capacitively couples ac** signal to the amplifier detector whenever key is pushed. (Control Devices)

Reliability is a tougher thing to pin down. Most vendors feel that few keyboards experience more than a million operations in their lifetime. However, many keys and some entire keyboards will experience this sort of use. The real question is not the time to catastrophic failure of a keyswitch, but the mean time between high-impedance contact, as defined by your system. This keyswitch reliability is different from the lifetime that manufacturers normally talk about. The difference is the loading of the contact, since most life data is taken under no-load conditions.

Most manufacturers have data on the mean-time-to-failure, the failure impedance and the existence of any peculiar failure modes of their keyswitches. But, they usually present interpretations of the data rather than the data itself. You should be cautious when reviewing whatever data the keyboard manufacturers give you lest you be fooled by data that is good but is, for any number of reasons, irrelevant to your system. You may want to make more than an off-hand judgement about the reliability of some of the keyswitches in contention. This may mean viewing the manufacturers test set-up as well as analyzing his results. It may mean doing your own reliability tests on keyboards as they actually perform in your system. Whichever way you choose to resolve this question, you should be aware of the inherently different construction and performance specifications for each type of keyboard in contention.

If your service philosophy does not affect your selection of a keyboard, then the reverse will surely be the case, perhaps at a cost you had not expected. Some keyswitches can easily be removed upon failure, others can be less

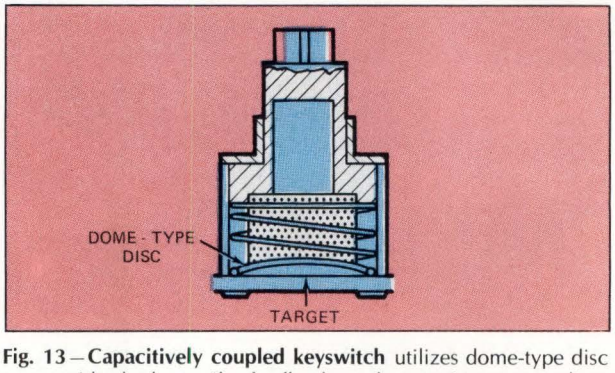



**Fig. 13—Capacitively coupled keyswitch** utilizes dome-type disc to provide both tactile feedback and capacitance coupling.. (Colorado Instruments Corp)

easily removed, and still others require the replacement of the entire keyboard. There are many legitimate ways to go, but you should think through your choice carefully.

So there you have it! While you still don't have a cookbook recipe for selection of a keyboard, you do have all the ingredients. How you mix them together and use them depends on the exact nature of your application. You should now be able to approach your selection task with a lot more assurance that you will get what you really want and need.

## Who makes keyboards?

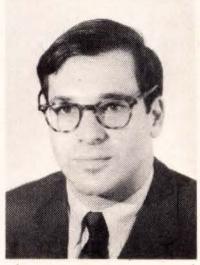
The following is a list of the companies in the keyboard business. The list is alphabetical and includes the names and a partial address of the various companies along with an indication of the type of keyboards they sell. There are several companies that sell individual key switches not specifically directed at keyboard products. This list does not include such companies. □

| Company | Type Keyswitch | Type Keyboard | For more info circle: |
|---|---|---|---|
| Alco Electronics Products, Inc.<br>North Andover, Mass. 01845 | reed<br>mechanical | 1, 2<br>1, 2 | |
| Cherry Electrical Products Corp.<br>Waukegan, Ill. 60085 | mechanical | 1, 2, 3, 4 | |
| Chomerics, Inc.<br>Woburn, Mass. 01801 | elastomeric | 1, 2 | |
| Clare-Pender Co., Div. of<br>General Instrument Corp.<br>Post Falls, Idaho 83854 | reed<br>mechanical | 1, 2, 3, 4<br>1, 2, 3, 4 | |
| Computronics Engineering<br>Los Angeles, Calif. 90027 | mechanical | 1, 2 | |
| Coloroado Instruments, Inc.<br>Broomfield, Colo. 80020 | capacitive<br>mechanical<br>(4 on request)<br>mechanical<br>(pancake) | 1, 2, 3, 4<br>1, 2, 3<br><br>1, 2, 3 | |
| Control Devices<br>Woburn, Mass. 01801 | capacitive<br>mechanical | 3, 4<br>1, 2 | |
| Control Research Corp.<br>Santa Ana, Calif. 92704 | reed<br>mechanical | 1, 2, 3, 4<br>1, 2, 3, 4 | |
| Datanetics Corp.<br>Redondo Beach, Calif. 90278 | elastomeric | 1, 2, 3, 4 | |
| Dialight Corp.<br>Brooklyn, NY 11237 | reed<br>elastomeric | 1, 2, 3, 4<br>1, 2, 3, 4 | |
| Elect-trol, Inc.<br>Saugus, Calif. 91350 | reed<br>mechanical | 1, 2, 3<br>1, 2, 3, 4 | |
| IDM Corp.<br>Hanover, N. H. 03755 | mechanical | 2 | |
| ITT Telecommunications<br>Corinth, Miss. 38834 | mechanical | 2 | |
| Licon, Div. Illinois Tool Works<br>Inc.,<br>Chicago, Ill. 60634 | magnetic core<br>mechanical | 1, 2, 3, 4<br>1 | |
| Litton ABS, OEM Products Div.<br>Carlstadt, N. J. 07072 | photo electric | 1, 2, 3 | |
| Magsat Corp.<br>Hartford, Conn. 06106 | mechanical | 1, 2, 3, 4 | |
| Mechanical Enterprises, Inc.<br>Alexandria, Va. 22304 | mercury tube | 1, 2, 3, 4 | |
| Micro Switch,<br>Div. Honeywell Corp.<br>Freeport, Ill. 60132 | Hall effect<br>reed | 1, 2, 3, 4<br>1, 2, 3 | |
| Milli-Switch Corp.<br>Gladwyne, Pa. 19035 | reed | | |
| Oak Mfg. Co.<br>Crystal Lake, Ill. 60014 | mechanical | 1, 2 | |
| Raven Electronics Corp.<br>Sparks, Nev. | capacitive | 2 | |
| Raytheon Co. Industrial<br>Components Operation<br>Quincy, Mass. 02169 | reed<br>mechanical<br>capacitive | 3<br>3<br>4 | |
| George Risk Industries, Inc.<br>Kimbal, Neb. 69145 | reed | 1, 2, 3, 4 | |
| TEC, Inc.<br>Tuscon, Ariz. | reed | 1, 2, 3 | |
| Wild Rover Corp.<br>Norwood, N. J. 07468 | mechanical | 1, 2, 3 | |

**Legend**
1 = very small keyboard under ten keys
2 = larger than 10 keys but not typewriter size
3 = typewriters, I/Os up to 100 keys
4 = same as 3 plus N-key roll over feature


The Micro Switch keyboard "Superchecker" shown on the cover, is capable of making over 100 functional tests *per key* for *every* Hall effect solid state keyboard manufactured. It can also test any other type keyboard. The tester is made up of several keyboard test stations such as the one shown, all controlled by a Honeywell DDP-516 computer located nearby. Testing for each type of keyboard is controlled by a computer program and test measurement results are gathered and interpreted by the computer. The "Superchecker" eliminates human judgment factors from inspection testing as it electronically measures all keyboard functions, as well as output voltages and rise/fall times, at various loading conditions for all modes of keyboard operations. Average testing and measurement time for an entire keyboard is about 2 minutes.

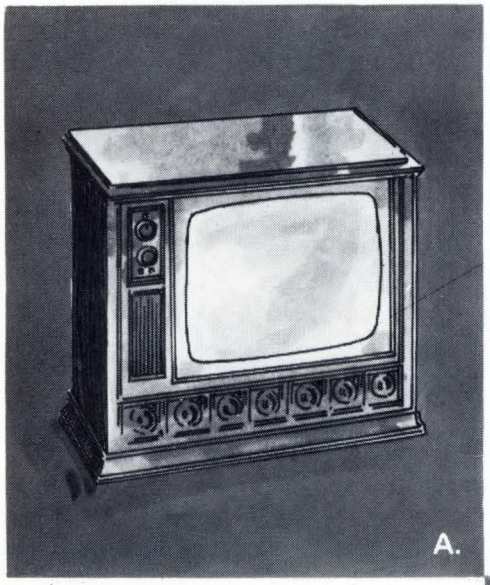
## Author's biography



As a member of the Electronics System Section of Arthur D. Little, Inc., for the past four years, **Mr. Brisk** has been involved in a variety of new product designs and evaluations. He did his undergraduate work at M.I.T. and has an M.S. in Electrical Engineering from Northeastern University.

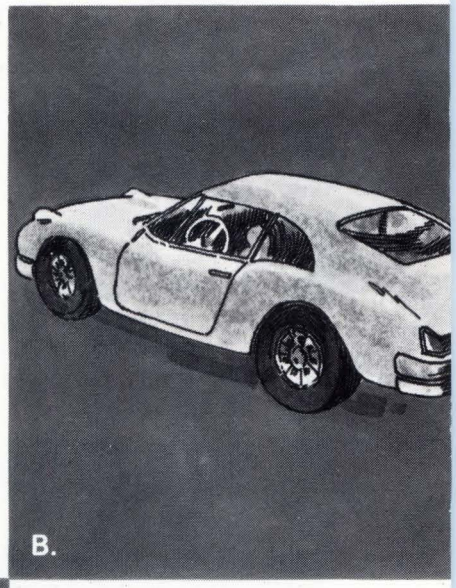
FOR A FREE COPY OF THIS ARTICLE, **CIRCLE 161**

# Come to where




**A**

RCA 2N3440, 2N5804, 2N5838, and 2N6175 offer a high-voltage line-up for every high-voltage socket in color TV — video output, picture-tube driver, high-voltage regulator, class-A audio, horizontal driver, and vertical and horizontal deflection.

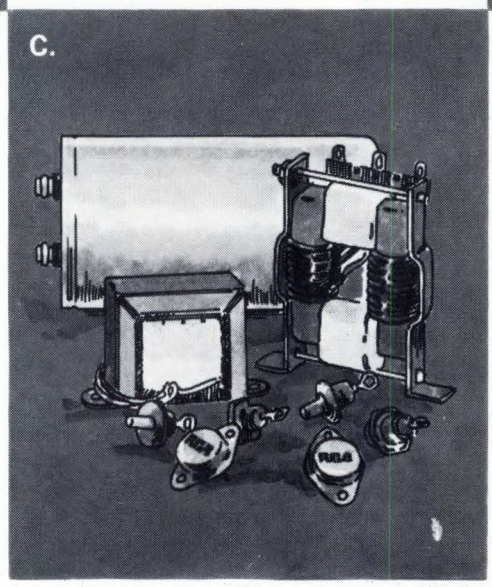



**B.**

RCA 2N5804, 2N5838, 2N6077, and 2N6249 are employed in inductive or capacitive discharge ignition systems or electronic carburetors. Device ruggedness is documented in RCA's second-breakdown data and the industry's only thermal fatigue ratings. If your specs don't require thermal fatigue ratings, you can't be sure you're protected.

**C.**

RCA types 40850, 40851, 40852, 40853, and 40854 perform in off-line switching mode power supplies. Why not improve your system costs two ways: first, through RCA's exclusive thermal fatigue ratings to assure longer service life and, second, through competitive prices.




**Ratings within the basic families listed below vary from 200 to 400 volts. Custom selections with ratings above 400 volts are available.**

| Basic Family | Max. Ratings $P_T$ (W) | $I_C$ (A) | Pkg. | 100-Unit Price (Each) |
|---|---|---|---|---|
| 2N3440 | 10 | 1 | TO-5 | $0.65 |
| 2N5415* | 10 | –1 | TO-5 | 0.90 |
| 2N6175 | 20 | 1 | TO-5 (P) | 0.59 |
| 2N3583 | 35 | 5 | TO-66 | 0.96 |
| 2N6211* | 35 | –5 | TO-66 | 2.70 |
| 2N6077 | 45 | 10 | TO-66 | 1.80 |
| 2N5838 | 100 | 10 | TO-3 | 1.98 |
| 2N5239 | 100 | 10 | TO-3 | 2.16 |
| 2N5804 | 110 | 15 | TO-3 | 3.30 |
| 2N6249 | 175 | 30 | TO-3 | 6.00 |

*p-n-p types

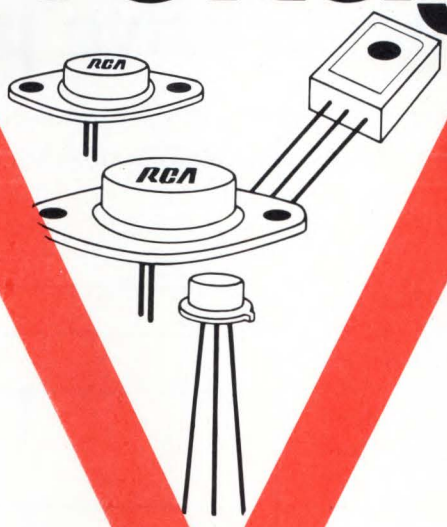
For more information on these and other RCA silicon power transistors, see your local RCA Representative or RCA Distributor. Or call Gene Van Wagner, Power Transistor Marketing Manager, at (201) 722-3200, ext. 3381. For technical data on specific types write: RCA Solid State Division, Section 50F-1 /UTL-28, Box 3200, Somerville, N.J. 08876. International: RCA, Sunbury-on-Thames, U.K., or P.O. Box 112, Hong Kong. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Quebec.

**RCA Solid State**

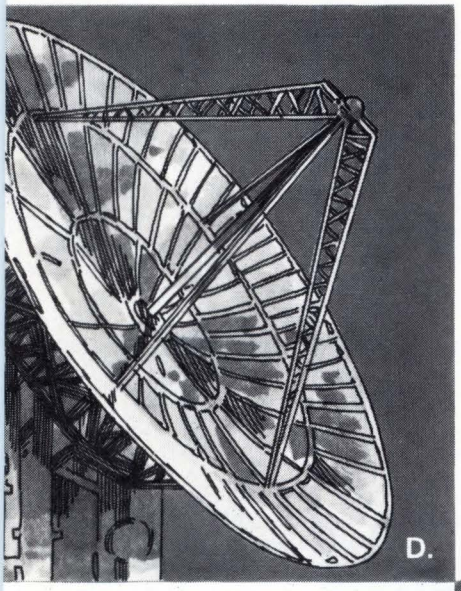
**products that make products pay off**

**CIRCLE NO. 16**

# high voltage is...



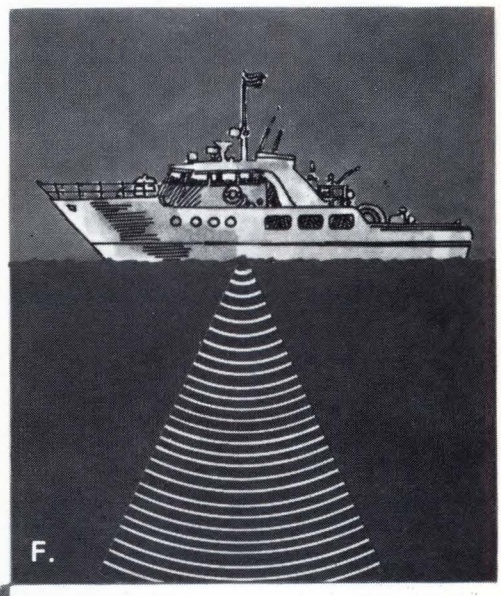

# RCA



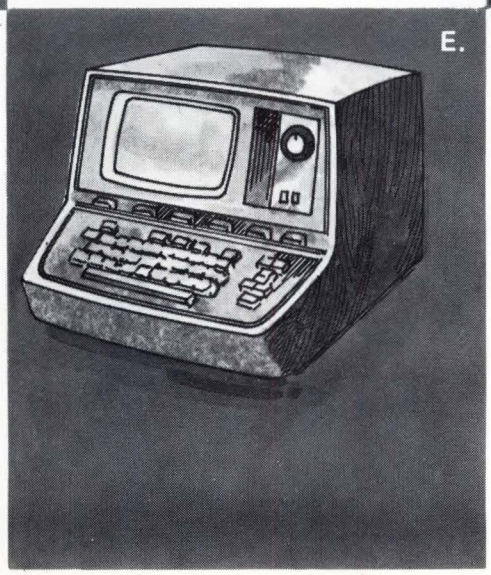
D.

**D.**
RCA 2N5415, 2N5838, and 2N6077 are utilized for high-reliability service in antenna PIN diode phase-shift drivers. For this — and other high-voltage military applications — check RCA's high-voltage devices from one of the lines of combined JAN, JAN TX and equivalent types.

**F.**
RCA 2N5804, 2N5838, and 2N6249 are engaged in ultra-sonic transducer/driver and output applications where reliability is essential, based on forward-bias, second-breakdown-free operations and thermal-fatigue ratings.



F.



E.

**E.**
RCA's high-voltage p-n-p devices contribute to the broadest high-voltage line in the industry. From it, select 2N3440, 2N3583, 2N5415, and 2N6211 for electrostatic and magnetic deflection applications requiring high-voltage complementary device performance.

# Build a high-accuracy waveshaping circuit using inexpensive parts

*Only a handful of 1% resistors and popular 1N914 diodes are used in this circuit. It can be designed to provide good accuracy using only a desktop calculator.*

**H. G. Riekers,** Westinghouse Electric Corp.

Waveshaping circuits, often used to provide non-linear outputs, run the gamut from low-cost ones with relatively few components to circuits containing sophisticated and expensive devices. One commonly used waveshaping circuit is shown in **Fig. 1**. It has however four distinct disadvantages: (**a**) A change in a single resistor's value necessitates recomputing the entire resistor ladder value. (**b**) The slope and breakpoints of each curve segment is dependent on all resistor values. (**c**) High accuracy is not easily achievable, even with the aid of a carefully written computer program. (**d**) The necessary trial-and-error methods of mechanization are often too time consuming.

An improved and relatively inexpensive diode wave-

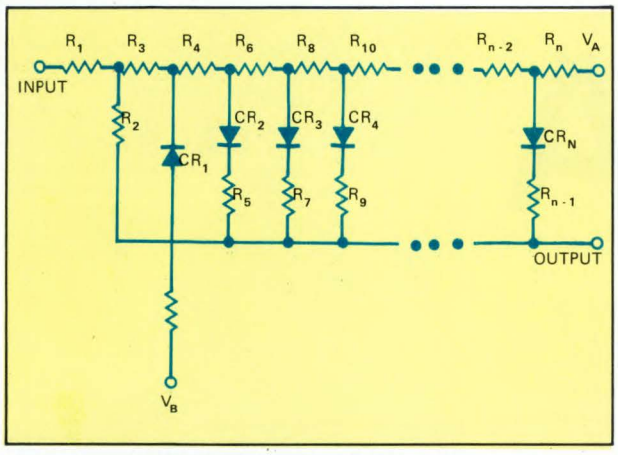



**Fig. 1 – A conventional waveshaping circuit** used to provide a non-linear output from a given linear input signal. Such a circuit, however, requires a time-consuming, well-written computer program to provide even relatively moderate-level accuracies. The output function is also very dependent on the value of each resistor.

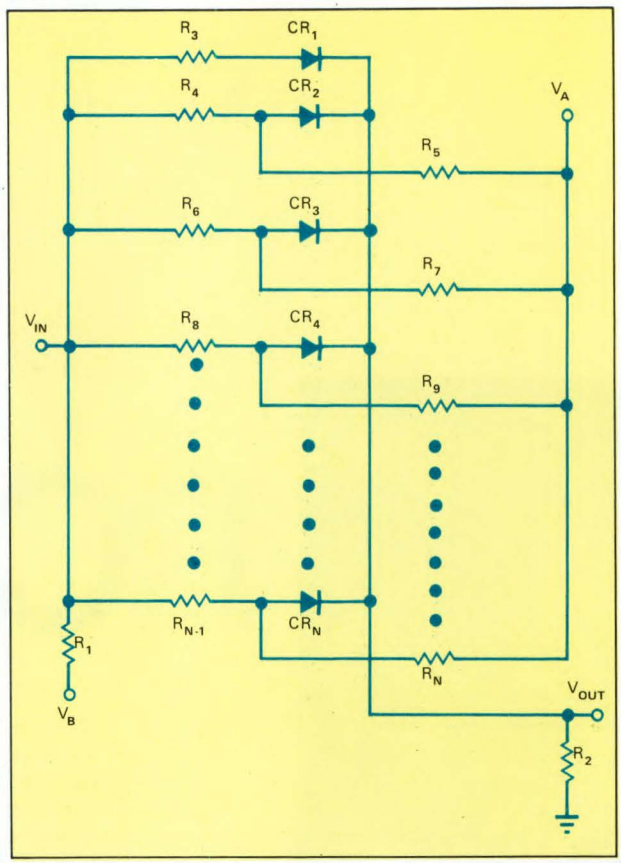



**Fig. 2 – This improved waveshaping circuit** (Compared to the conventional one in **Fig. 1**) uses 1%-tolerance resistors and popular 1N914 diodes. It provides a high-degree of accuracy using only a conventional desktop calculator for resistor-value calculations.

**Table 1 – Slope computation**

| CR1 | CR2 | CR3 | CR4 . . . CRN | Line Segment | Slope |
|---|---|---|---|---|---|
| ON | OFF | OFF | OFF OFF | BC | $\frac{R2}{R3 + R2}$ |
| ON | ON | OFF | OFF OFF | CD | $\frac{R2}{RX + R2}$ where $RX = \frac{R3\ R4}{R3 + R4}$ |
| ON | ON | ON | OFF OFF | DE | $\frac{R2}{RY + R2}$ where $RY = \frac{RX\ R6}{RX + R6}$ |
| ON | ON | ON | ON OFF | EF | $\frac{R2}{RZ + R2}$ where $RZ = \frac{RY\ R8}{RY + R8}$ |
| ON | ON | ON | ON ON | FN | $\frac{R2}{RZ \ldots RN - 1 + R2}$ |

shaping circuit that does not have the drawbacks of the commonly used circuit in **Fig. 1** is shown in **Fig. 2**. Popular and inexpensive 1N914 diodes and 1%-tolerance resistors are used, making this circuit not only low in cost but also suitable for monolithic techniques.

Advantages of this circuit include: (**a**) A single breakpoint may be changed by adjusting only two resistors of the network: either R4 and R5, or R6 and R7, or R8 and R9, or RN − 1 and RN. (**b**) In most cases, the slope of a line segment may be changed by adjusting only one resistor value: R3, or R4, or R6, or R8, or RN − 1. (**c**) Good accuracy may be achieved with the use of a desk-top calculator. (**d**) Trial and error mechanizations are seldom necessary.

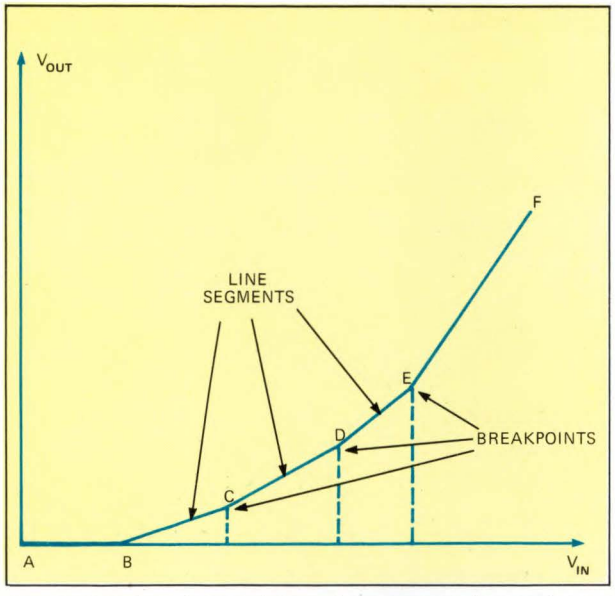



**Fig. 3 — Transfer characteristics** of the improved waveshaping circuit shown in **Fig. 2**. The slope of each of the line segments from A to F can be easily computed as shown in **Table I**.

**Fig. 3** shows a typical transfer characteristic of this improved diode circuit together with line segments and breakpoints appropriately labelled. The slope of each of the line segments shown may be computed with the aid of **Table 1**. The voltage of each breakpoint can be computed using **Table II**.

The unique properties of the network shown in **Fig. 2** depend on three factors:

1. Selecting R2 such that R3‖R4‖R6‖R8‖ . . . RN − 1 > > R2
2. A diode must be placed in series with R3 for the calculations of **Table II** to be valid.
3. Resistor R1 must be selected such that $V_{in}$ is zero when $V_A$ and $V_B$ are ON, and no input signal is applied.

The circuit in **Fig. 2** was used as a squaring circuit whose output is the square of the input voltage. **Fig. 4** shows the actual application using X and Y inputs of the deflection sweeps of a scan converter. To accurately correct the dynamic focus of the scan converter, it is necessary to square and sum both the X and Y sweeps. The circuit's output is a parabolic function derived from a ramp input. It should be noted that summing resistors RA and RB are the same as R2 in **Fig. 2**. This is allowable since the summing point of the op amp is a virtual ground. □

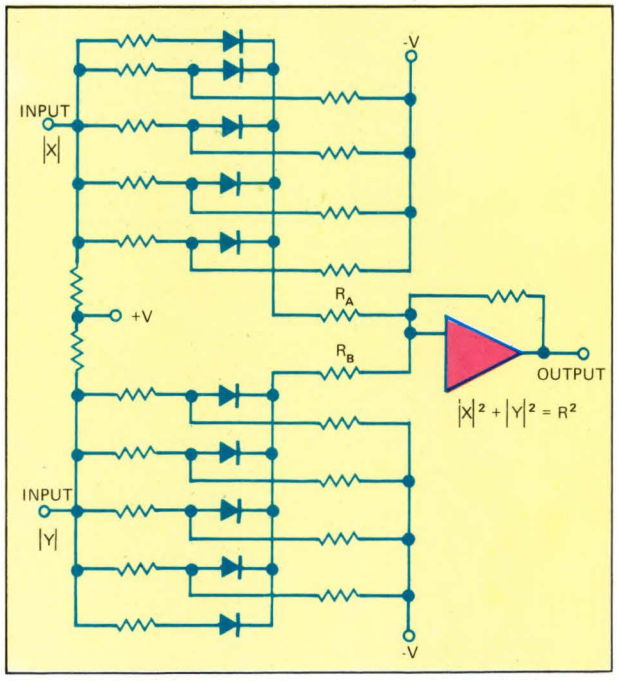



**Fig. 4 — Applying the improved waveshaping circuit of Fig. 2** converts the ramp output of the deflection sweeps of a scan converter to a parabolic output. This circuit corrects the scan converter's dynamic focus.

**Table II — Breakpoint computation**

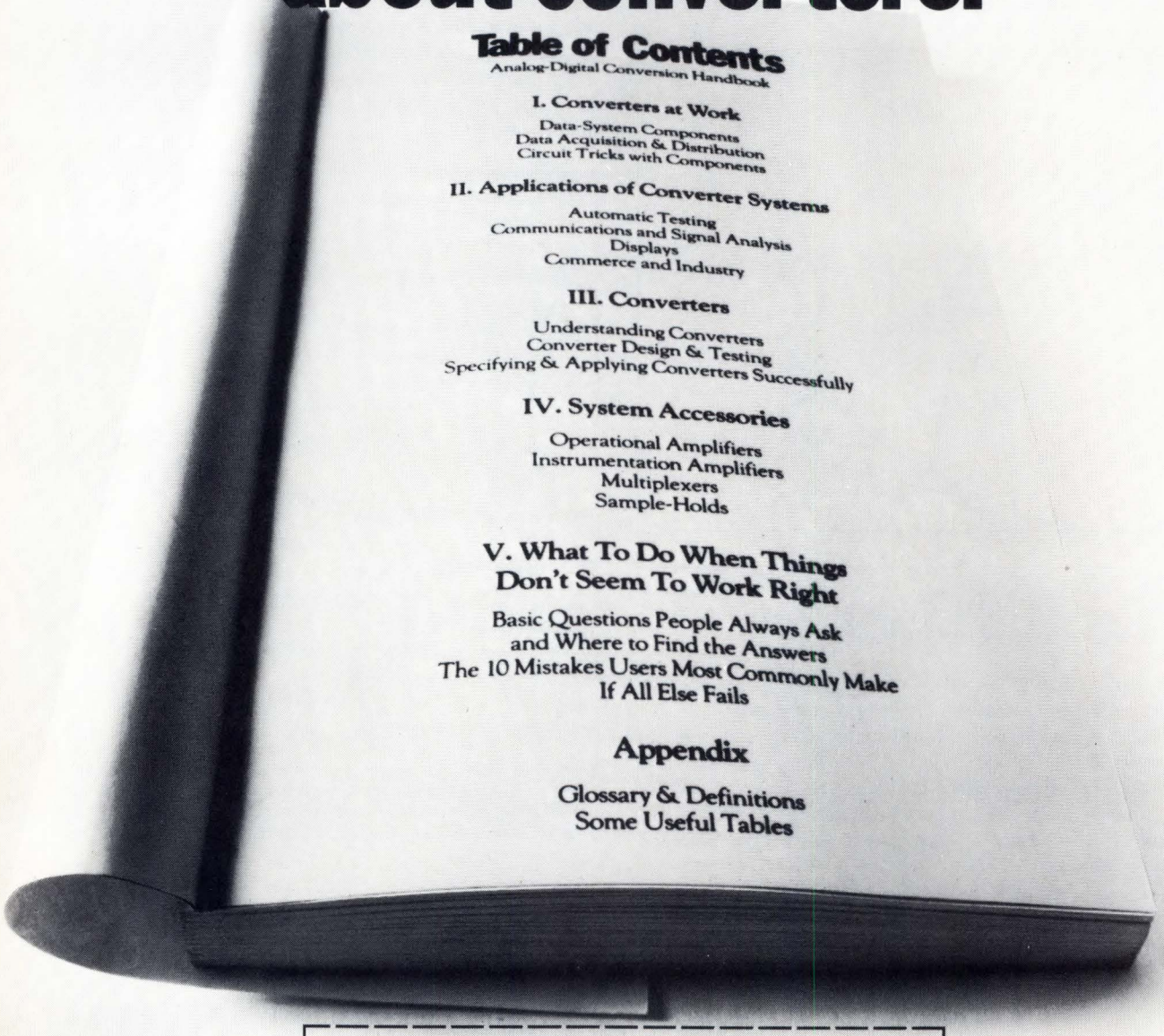
| Diode | Breakpoint Voltage | Breakpoint in Fig. 3 |
|---|---|---|
| CR1 | Diode Threshold Voltage ($V_T$) | B |
| CR2 | $\lvert V_A\rvert\left(\frac{R4}{R4 + R5}\right) + V_T$ | C |
| CR3 | $\lvert V_A\rvert\left(\frac{R6}{R6 + R7}\right) + V_T$ | D |
| CR4 | $\lvert V_A\rvert\left(\frac{R8}{R8 + R9}\right) + V_T$ | E |
| CRN | $\lvert V_A\rvert\left(\frac{RN - 1}{RN - 1 + RN}\right) + V_T$ | F |

**Author's bibliography**

H. G. Riekers is a systems development engineer at Westinghouse Electric Corp.'s Baltimore, Md., Div. where he has been employed for seven years. His duties include the design, fabrication and interfacing of analog and digital subsystems. Previously he was employed as a member of the faculty of the NSF-AEC Reactor Physics Institute and Electrical Engineering Dept. of Manhattan College in New York City. He received his BEE from Manhattan College and has done graduate work at New York University and George Washington University.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE 162**

# This is what you have to know to know everything about converters.



## Table of Contents

Analog-Digital Conversion Handbook

**I. Converters at Work**

Data-System Components
Data Acquisition & Distribution
Circuit Tricks with Components

**II. Applications of Converter Systems**

Automatic Testing
Communications and Signal Analysis
Displays
Commerce and Industry

**III. Converters**

Understanding Converters
Converter Design & Testing
Specifying & Applying Converters Successfully

**IV. System Accessories**

Operational Amplifiers
Instrumentation Amplifiers
Multiplexers
Sample-Holds

**V. What To Do When Things Don't Seem To Work Right**

Basic Questions People Always Ask and Where to Find the Answers
The 10 Mistakes Users Most Commonly Make
If All Else Fails

**Appendix**

Glossary & Definitions
Some Useful Tables

## Analog-Digital Conversion Handbook 312 pages. $3.95

Since you make more kinds of A-D and D-A converters than anyone else, I wouldn't pass up your handbook for anything. Enclosed is my check for $_____ for _____ copies.

Name_____ Title_____

Company_____ Street_____

City_____ State_____ Zip_____

Please allow 4-6 weeks for delivery.

Mail to: Analog Devices, Inc., Box 796, Norwood, Mass. 02062

ANALOG DEVICES EDN/EEE

CIRCLE NO. 17

Now, there's a digital voltmeter that offers a combination of capabilities never before available. The new Hewlett-Packard 3403A.

Outstanding features of the 3403A are its eight-decade bandwidth, its six-decade ac voltage range (10 mV to 1000 V full-scale), its ability to measure both simple and complex signals with great accuracy (±0.2% reading ±0.2% range), and its advanced, solid-state 3-digit display.

With the 3403A, you can measure ac, dc, or ac + dc, with **true-RMS accuracy**—and get your readout in either volts or dB. Its wide voltage range, and **extraordinarily wide frequency range** give it unprecedented versatility. Its **direct readout in dB** makes it a "natural" for all kinds of communications work. And its ability to measure complex signals with crest factors as high as 10:1 makes it especially useful for noise measurement.

The 3403A is available with a wide variety of options and accessories, including dB display, autoranging, isolated or nonisolated digital output, isolated remote control, printer cables, active probes, and a rack adapter frame... making it ideal for systems applications, as well as lab and production work.

The 3403A's price ranges from $1400 to $2100, depending on options. An ac-only version, the 3403B, is also available, starting at $1150. For further information on the versatile new 3403A, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

091/19

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

# HP's new 3403A voltmeter puts it all together... at an amazingly low price

☐ **True-RMS accuracy**

☐ **AC from 2 Hz to 100 MHz, plus DC**

☐ **Digital readout, in volts or dB**


CIRCLE NO. 18

# BASIC language programs generate root locus plots

*Analyze both positive and negative feedback circuits and systems with these two simple programs.*

**Philip Forman,** Consultant

Root locus analysis of feedback amplifiers, oscillators, regulators and other closed-loop circuits enables a straightforward modeling and design procedure in the s-plane. It permits the design engineer to observe the transient and steady-state effects of specific designs and parameters on the behavior of complicated circuits and systems.

The analytical tool used by the designer in this procedure is the root locus plot. This plot or graph is usually obtained by graphical means, a tedious and time-consuming procedure. Now, the readily-available time-shared computer can be programmed to calculate root loci in a few minutes, saving days and weeks of the design engineer's time.

LOCUS − and LOCUS + are simple BASIC language programs that generate root locus plots for negative and positive feedback circuits. They have proven to be very helpful in the design of

- voltage regulators
- servo-mechanisms
- power control systems
- feedback amplifiers (DC to 60 MHz)
- oscillators (30 kHz to 3 GHz).

The programs are first introduced and discussed briefly, and a design application is then presented to illustrate the value of the programs.

## Reduce the system to a simple loop

The root locus is based on the single-loop feedback circuit shown in **Fig. 1**. The closed-loop circuit performance is given by

$$\frac{\theta(s)}{R(s)} = \frac{G(s)}{1 + G(s)\,H(s)} \qquad (1)$$

G(s) represents the forward transfer function and H(s) represents the feedback transfer function. G(s) and H(s) are rational algebraic functions of the Laplace-transform variable s.

$$G(s) = \frac{k\,p(s)}{q(s)} \qquad (2)$$

$$H(s) = \frac{k\,n(s)}{d(s)} \qquad (3)$$

The closed-loop performance of the circuit is characterized by the denominator of eq. (1)

$$1 + G(s)\,H(s) \qquad (4)$$

The root loci are the roots of the equation

$$1 + G(s)\,H(s) = 0 \qquad (5)$$

or,

$$K\,\frac{p(s)}{q(s)}\,\frac{n(s)}{d(s)} = -1 \qquad (6)$$

where K represents the loop gain.
In general terms,

$$\frac{K\,C(s)}{E(s)} = -1 \qquad (7)$$

or,

$$K\,C(s) + E(s) = 0 \qquad (8)$$

The roots of this equation represent the poles of the root loci for a closed-loop circuit with negative feedback. (Line 490 of the LOCUS − program presents this equation to the computer for solution.)

LOCUS − is shown in **Table 1**. This program computes the closed-loop poles of an open-loop transfer function KC (s) / E(s) with negative feedback. C(s) represents the numerator polynomial; E(s) represents the denominator polynomial. C(s) and E(s) are entered as shown in lines 150 to 230.

The poles are calculated for increasing values of loop gain K, at K = .1 increments. However, the design engineer will want to monitor the computer printout so that the increments and range of K provide an optimum set of locus points. Range and increment step may be changed by retyping lines 420 and 430. The output may be terminated at any time by typing STOP. Outputs with new ranges and increments may be started by typing RUN.

Input data is read in lines 350 to 410.

Root locus eq. (8) is solved in lines 480 to 500. The coefficients of A(I) represent intermediate results of the program. They may be used to check the computer or de-bug a run and are obtained upon request. LOCUS − asks the user for instructions on the intermediate coef-

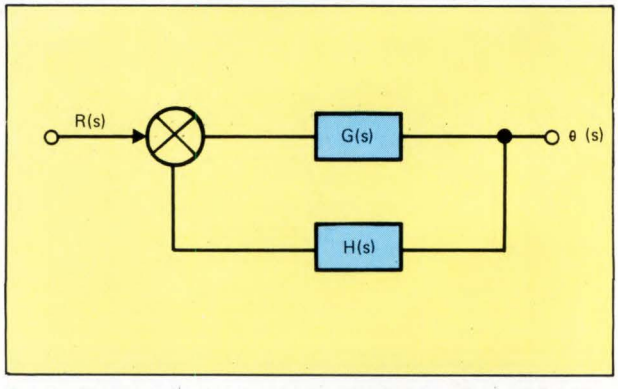



**Fig. 1 − The circuit or system to be analyzed** with the LOCUS− or LOCUS+ programs must first be reduced to an equivalent single-loop system.

**TABLE 1**
**LOCUS—**

```
100 REM THIS PROGRAM COMPUTES THE CLOSED-LOOP
105 REM POLES OF AN OPEN-LOOP TRANSFER FUNCTION
110 REM KC(S)/E(S) WITH NEGATIVE FEEDBACK. THE LOOP
115 REM GAIN K IS PROGRAMMED TO STEP IN INCREMENTS
120 REM OF 0.1 FROM K = 0 TO COMPUTER MAX LIM. C(S)
130 REM AND E(S) ARE ENTERED AS FOLLOWS:
140 REM
150 REM              10 DATA N
160 REM              20 DATA A(N),A(N - 1), . . .,A(0)
170 REM              30 DATA B(N), B(N - 1), . . .,B(0)
180 REM              RUN
181 REM
190 REM        HERE, N = THE LARGER ORDER OF C(S),E(S).
200 REM      A(N), . . . = THE COEFFICIENTS OF C(S) IN
205 REM                    DESCENDING ORDER WITH 0'S IN
210 REM                    DEFICIENT ORDERS.
215 REM      B(N), . . . = THE COEFFICIENTS OF E(S) IN
220 REM                    DESCENDING ORDER WITH 0'S IN
230 REM                    DEFICIENT ORDERS.
240 REM
250 REM THE RANGE AND STEP INCREMENT MAY BE CHANGED
260 REM BY RETYPING LINES 420 AND 430
270 REM
280 REM
290 REM
300 REM
310 PRINT "IF YOU WISH A PRINTOUT OF THE INTERMEDIATE
315 PRINT COEFFICIENTS AND" "ROOTS TYPE '1'. IF YOU
320 PRINT DESIRE ROOTS ONLY TYPE '0'.
330 PRINT WHAT IS" "YOUR WISH";
340 INPUT H
350 READ G
360 FOR I = 0 TO G
370 READ C(I)
380 NEXT I
390 FOR I = 0 TO G
400 READ E(I)
410 NEXT I
420 LET K = 0
430 LET K = K + .1
440 LET N = G
450 PRINT
460 PRINT
470 PRINT " ", "K = " K
480 FOR I = 0 TO N
490 LET A(I) = K*C(I) + E(I)
500 NEXT I
510 LET G8 = 0
520 LET G8 = G8 + 1
530 IF H = 0 THEN 1550
540 PRINT "COEFFICIENTS (IN DESCENDING ORDER) ARE:"
550 PRINT
560 FOR I = 0 TO N
570 PRINT "    ";
580 PRINT A(I)
590 LET B(I) = A(I)
600 NEXT I
610 PRINT
620 PRINT "THE POLES ARE:"
630 PRINT
640 IF N < = 2 THEN 1140
650 IF A(N) = 0 THEN 1220
660 IF (N/2 - INT(N/2)) = 0 THEN 690
670 GOSUB 1300
580 GOTO 640
690 IF ABS(A(N - 2)) < 1·E - 25 THEN 730
700 LET P = A(N - 1)/A(N - 2)
710 LET Q = A(N)/A(N - 2)
720 GOTO 750
730 LET P = A(N - 1)
740 LET Q = A(N)
750 FOR I = 0 TO N
760 LET X(I) = A(I)
770 NEXT I
780 GOSUB 1250
790 FOR I = 0 TO N - 2
800 LET B(I) = X(I)
810 NEXT I
820 LET R = X(N - 1)
830 LET S = A(N) -P*X(N - 1) -Q*X(N - 2)
840 GOSUB 1250
850 LET X(N - 1) = -P*X(N - 2) -Q*X(N - 3)
860 LET D = X(N - 2)↑2 - X(N - 1)*X(N - 3)
870 IF ABS(D ) > 1·E - 25 THEN 900
880 PRINT "    UNOBTAINABLE WITH THIS PROGRAM."
890 GOTO 1600
900 LET P1 = P + (R*X(N - 2)-S*X(N - 3))/D
910 LET Q1 = Q + (S*X(N - 2)-R*X(N - 1))/D
920 IF ABS(P ) > 1·E - 25 THEN 960
930 IF ABS(P1) > 1·E - 25 THEN 960
940 IF ABS( Q) > 1·E - 25 THEN 970
950 GOTO 980
960 IF ABS(P1/P - 1) > .000001 THEN 980
970 IF ABS(Q1/Q - 1) > .000001 THEN 1010
980 LET P = P1
990 LET Q = Q1
1000 GOTO 750
1010 FOR I = 1 TO N - 2
1020 LET A(I) = B(I)
1030 NEXT I
1040 LET N = N - 2
1050 LET D = P*P - 4*Q
1060 IF D < 0 THEN 1110
1070 LET D = SQR(D)
1080 PRINT "        ";(-P + D)/2;" AND  ";(-P - D)/2
1090 IF N - 2 > 0 THEN 650
1100 GOTO 1140
1110 LET D = SQR(-D)
1120 PRINT "        ";-P/2;" + J *";D/2," and ";-P/2;"-
1125 PRINT J *";D/2
1130 IF N - 2 > 0 THEN 650
1140 IF N = 1 THEN 1200
1150 IF N - 0 THEN 1600
1160 LET P = B(1)/B(0)
1170 LET Q = B(2)/B(0)
1180 LET N = 0
1190 GOTO 1050
1200 PRINT "        ";-B(1)/B(0)
1210 GOTO 1600
1220 PRINT "        0.00000"
1230 LET N = N - 1
1240 GOTO 640
1250 LET X(1) = X(1)-P*X(0)
1260 FOR I = 2 TO N - 1
1270 LET X(I) = X(I)-P*X(I - 1)-Q*X(1 - 2)
1280 NEXT I
1290 RETURN
1300 IF B(1) = 0 THEN 1330
1310 LET X = -B(1)/B(0)
1320 GOTO 1340
1330 LET X = B(N)/B(0)
1340 LET F = 0
1350 LET F1 = 0
1360 FOR I = 0 TO N
1370 LET J = N - I
1380 IF B(J) = 0 THEN 1420
1390 LET F = B(J)*X↑I + F
1400 IF I = 0 THEN 1420
1410 LET F1 = I*B(J)*X↑(I - F) + F1
1420 NEXT I
1430 LET X1 = X-F/F1
1440 IF ABS(X/X1 - 1) < .000001 THEN 1470
1450 LET X = X1
1460 GOTO 1340
1470 PRINT "        ";X1
1480 LET N = N - 1
1490 FOR I = 1 TO N
1500 LET A(I) = B(I) + X1*A(I - 1)
1510 LET B(I) = A(I)
1520 NEXT I
1530 RETURN
1540 GOTO 1590
1550 FOR I = 0 TO N
1560 LET B(I) = A(I)
1570 NEXT I
1580 GOTO 610
1590 PRINT
1600 GOTO 430
1610 PRINT "WHEW."
1620 END
```

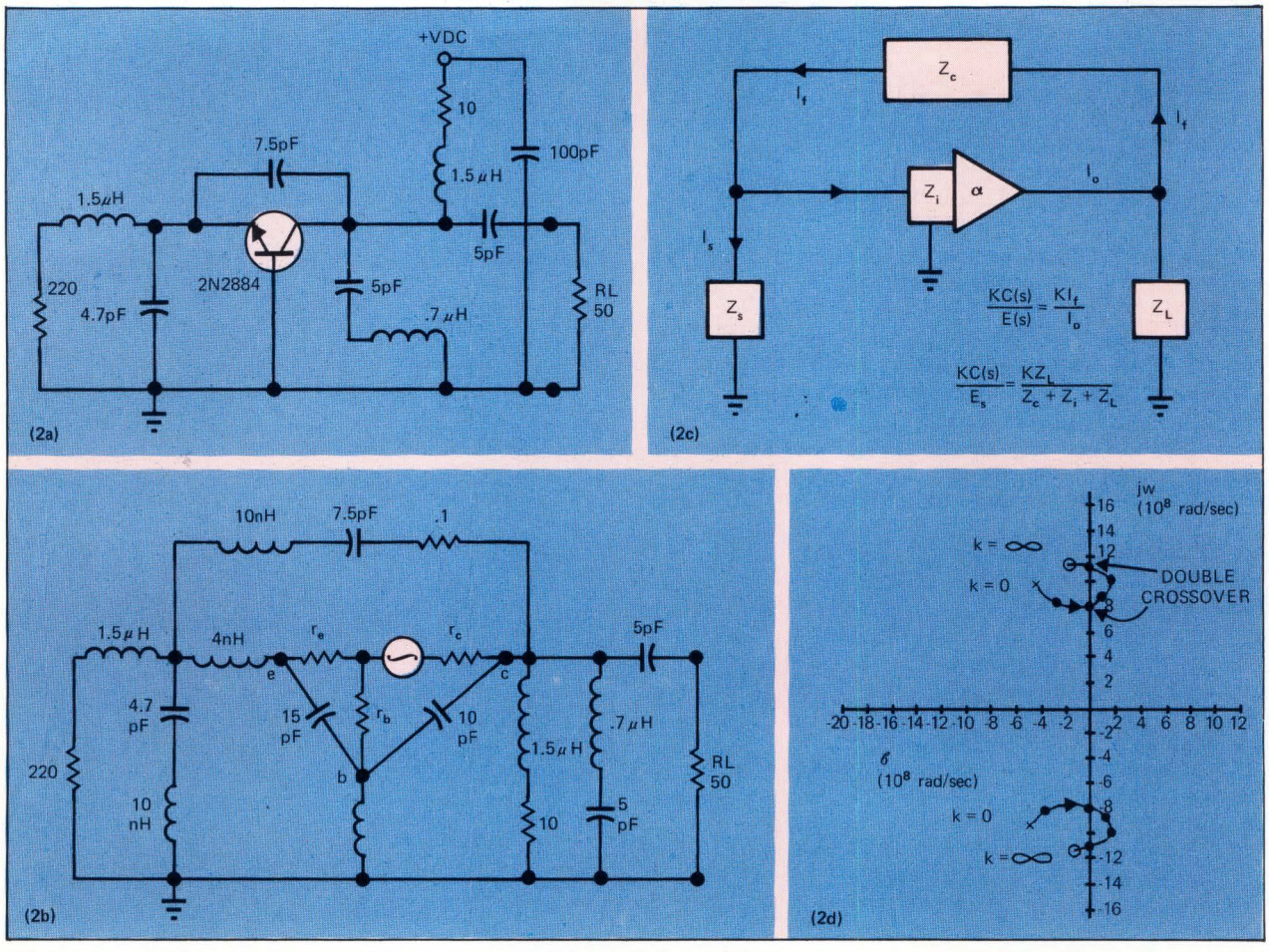



**Fig. 2—The common-base oscillator circuit** (**a**) could not produce the desired single-mode oscillation. After reducing the schematic to the equivalent circuit (**b**) and then to a functional block diagram (**c**), the open loop transfer function was determined. Using this transfer function, LOCUS+ calculated the root locus shown (**d**). The multi-moding effect shown circumvented fruitless laboratory investigation.

ficient request in lines 310 to 340.

The remainder of the program (lines 500 to END) calculates the roots of the root locus eq. (8) for each value of loop gain K. These roots are determined by an algorithm that is based on the Bairstow-Hitchcock Method[1] for numerical solution of polynomial equations. These roots or poles change as the loop gain K is incremented. The graphical path described by the moving poles represents the root locus and the design engineer can rapidly plot these points in the s-plane.

## LOCUS + for positive feedback

The LOCUS + program for closed-loop circuits with positive feedback is derived from the LOCUS − program by rewriting line 490 as follows:

490 LET A(I) = K*C(I) −E(I)

LOCUS + calculated the root locus shown in **Fig. 2.** The open loop transfer function that was inputed to the computer was

$$\frac{KC(s)}{E(s)} = 1.51 \times 10^{-13}\, s^3 + 10^{-4}\, s^2 + 2.02 \times 10^5\, s + 10^{14}/$$

$$3.77 \times 10^{-13}\, s^3 + 17.6 \times 10^{-4}\, s^2 + 12.78 \times 10^5\, s + 15.09 \times 10^{14}$$

describing the s-plane model of a multi-moding oscillator. This transfer function of the common-base transistor oscillator was derived by analysis of the equivalent circuits shown in **Fig. 2**.

The root locus plot of **Fig. 2** indicated that the common base configuration could not produce the desired single-mode oscillation. The multimoding predicted by the double cross-over of the jω axis was confirmed by laboratory measurements. The frequencies of oscillation were determined to be within 5% of the jω cross-over frequencies.

C(s) and E(s) were entered as follows:

```
10 DATA 3
20 DATA 1.51 E −13, 1 E−4, 2.02 E5, 1E 14
30 DATA 3.77 E −13, 17.6 E−4, 12.78 E5, 15.09
   E14
```

□

## REFERENCE

1. Ralston, A. and Wilf, H. S., "Mathematical Methods for Digital Computers," Vol. 2, John Wiley and Sons, Inc., New York, pg. 192.

## Author's biography

**Philip Forman** is an engineering consultant specializing in new product development and production design. He received a BEE from the City College of New York and was chief engineer of Mid-Century Instrumatic, Inc. Mr. Forman has been granted three patents. He lives in Jericho, N.Y.

In '71 we gave you an SE-1 grade nylon, Ultramid® A3XG5.

In '72 we're giving you an SE-0 grade nylon, Ultramid® A3XG7.

And also two nylon resins with an arc resistance of 125 seconds on ASTM 495.

Ultramid A3XG5—Black—00100 and A3XG5—Brown—27885 give you SE-1 and arc resistance.

Ultramid A3XG7—Black—00100 offers both SE-0 and arc resistance.

So what have you got.

Two Thermoplastic high performers with unique electrical's.

Two Halogen free, glass fiber reinforced 6/6 nylons.

Two SE grades—an SE-0 and an SE-1 Group I UL Subject 746 and non-dripping ASTM Standard D635-63. Two with UL use rating of 105°C. Two heat stabilized, hydrolysis resistant, 23,000 psi tensile, 392° deflection temperature, 1.6 ft. lbs. impact nylons.

Two arc resistant resins rated at 125 seconds on ASTM 495.

**NOW!**
**SE-0**
**ULTRAMID®**
**A3XG7**
**NYLON RESIN**

**BASF**

**BASF Wyandotte Corporation**

Advertising Dept.
100 Cherry Hill Rd., P.O. Box 181
Parsippany, New Jersey 07054

OK BASF, I need what you got. Send data on—

- ☐ SE-1 grade, Ultramid® A3XG5
- ☐ SE-0 grade, Ultramid® A3XG7
- ☐ Arc resistant nyions to improve performance at low cost.

Name _____

Company _____

Address _____

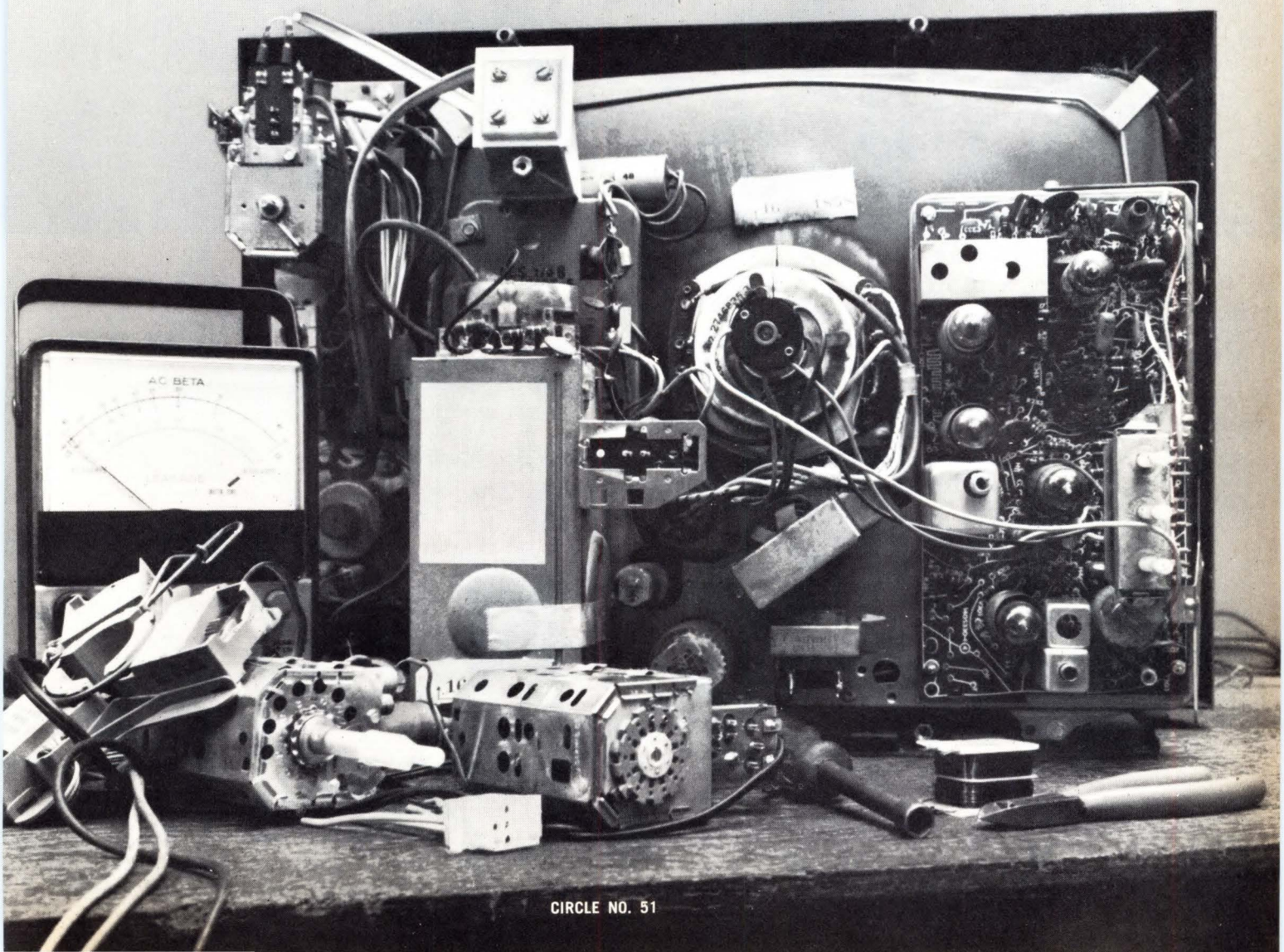
City _____

State _____ Zip _____

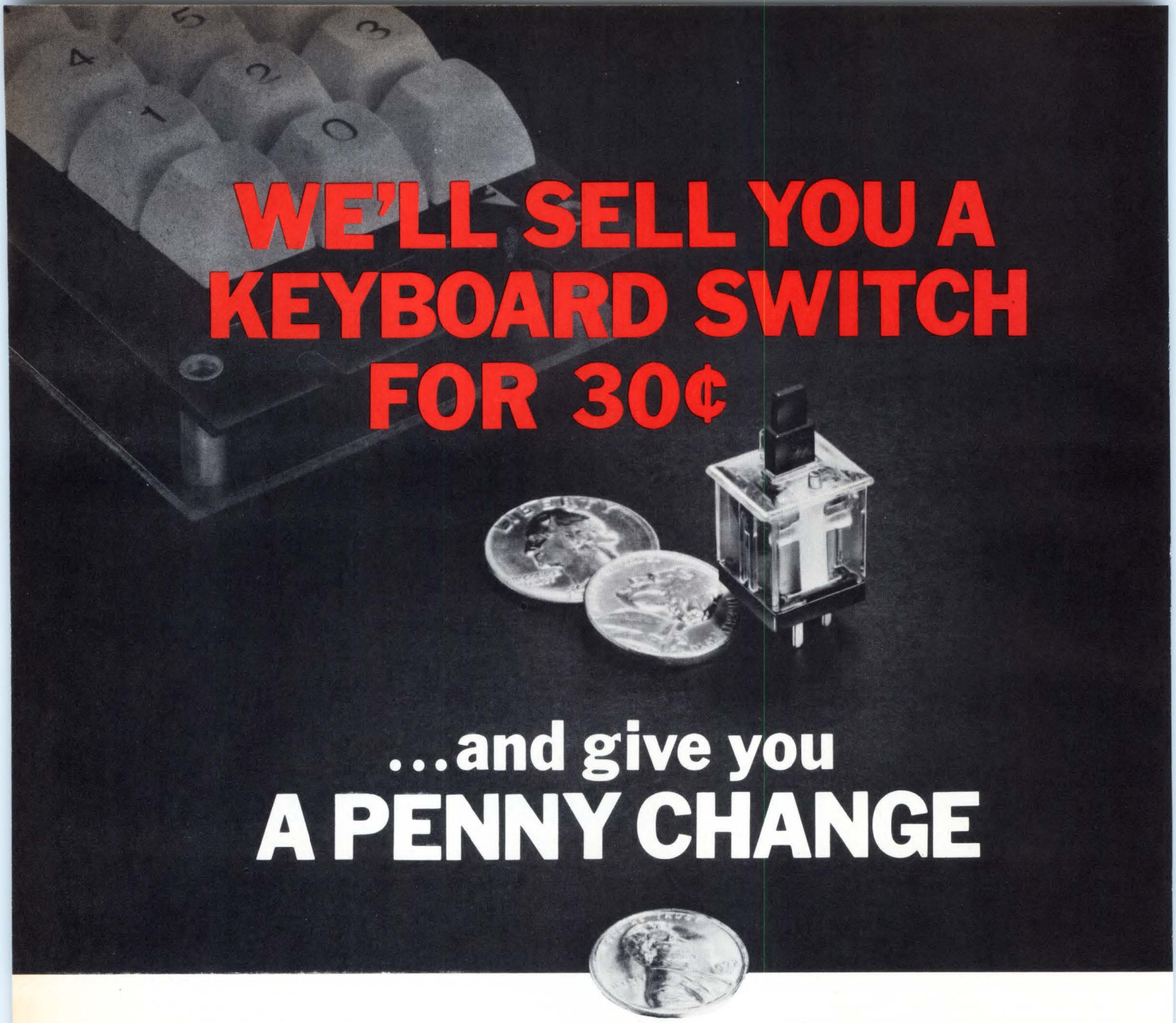
Phone (___) _____ Ext. _____

**Ultramid® A3XG5**
**Ultramid® A3XG7**

# No Burn, No Drip




CIRCLE NO. 51



# WE'LL SELL YOU A KEYBOARD SWITCH FOR 30¢

## ...and give you A PENNY CHANGE



**How to save silver when buying gold:** Spec Cherry Gold "Crosspoint" Contact keyboard switches. With a momentary Form A (SPST/NO) price tag of just 29¢ in 250,000 quantity . . . lower prices in higher quantities.

What do you get besides low price? Unique, proven Cherry Gold "Crosspoint" contact configuration that enhances reliability. Tested beyond 50,000,000 operations. (Test Report No. TK 10071 available on request.) You get Cherry's low profile Keyboard switch featuring rugged construction, 2½ ounce operating force and stable contact resistance (typically 25 milliohms over life). Made by the people who pioneered the Gold "Crosspoint" Contact in snap-action switches.

The result? Cherry keyboard switches are your ideal choice for computer terminals, electronic calculators and credit card validators.

**TEST A FREE SAMPLE.** Choose the 29¢ Form A switch . . . or any of Cherry's complete line of keyboard switch modules. Just TWX 910-235-1572 . . . or PHONE 312/689-7703 and ask Walt to give you facts on Keyboard Switches . . . or circle appropriate reader service number.

ACTUAL SIZE

**FORM A, MOMENTARY (SPST/NO)**
Circle No. 93 for Free Sample

**ALTERNATE ACTION (SPST)**
Circle No. 94 for Free Sample

**DUAL FORM A, MOMENTARY (DPST/NO)**
Circle No. 95 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.***

# Graphs yield circuit Q for gyrators and other synthetic reactive elements

*Here are two Q curves that will come in handy in the design and analysis of gyrator and Q multiplier circuits*

**H. A. Wittlinger,** RCA, Solid State Division

With the increased emphasis today on synthetic reactive circuit elements, like the gyrator and various forms of Q multipliers, rapid determination of in-circuit Q when using these elements is becoming more and more important.

In such situations, the two Q curves shown in **Figs. 1** and **2** can provide extremely useful data quickly and easily. **Fig. 1** shows the result on the circuit Q of a phase shift that differs from that of an ideal inductor. **Fig. 2** is used to find the circuit Q by observing the damping of shocked excitation.

When synthesizing inductors with the gyrator, the inherent phase shift within the amplifiers, as well as the desired phase shift, become increasingly important. For example, from **Fig. 1**, which shows phase angle versus Q, a phase shift of only ±5.7° from the ideal −90° shift of current with respect to voltage will result in a Q of only 10. A phase shift of ±0.57° will result in a Q of 100, indicating that excessive phase shifts are not tolerable in high-Q circuits.

**Fig. 2** becomes useful in determining total effective circuit Q once an LC network is established with either real or synthetic components. To use it, you shock the circuit into oscillation and then count the number of oscillations between some initial point and a point at which the amplitude drops to either 0.043, 0.1, 0.2, etc. of the initial am-

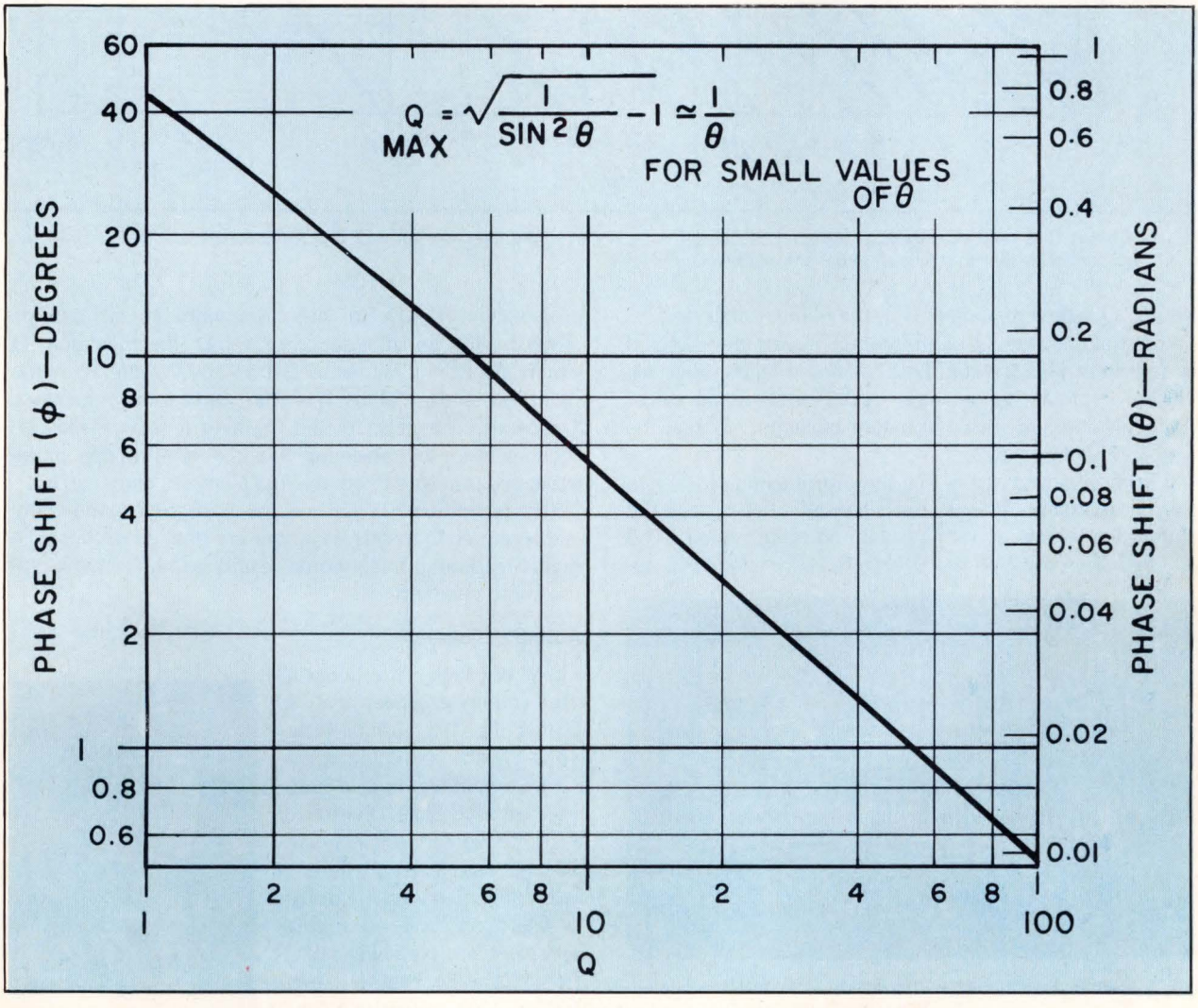



**Fig. 1—Phase shift** from that of an ideal inductor significantly affects circuit Q.

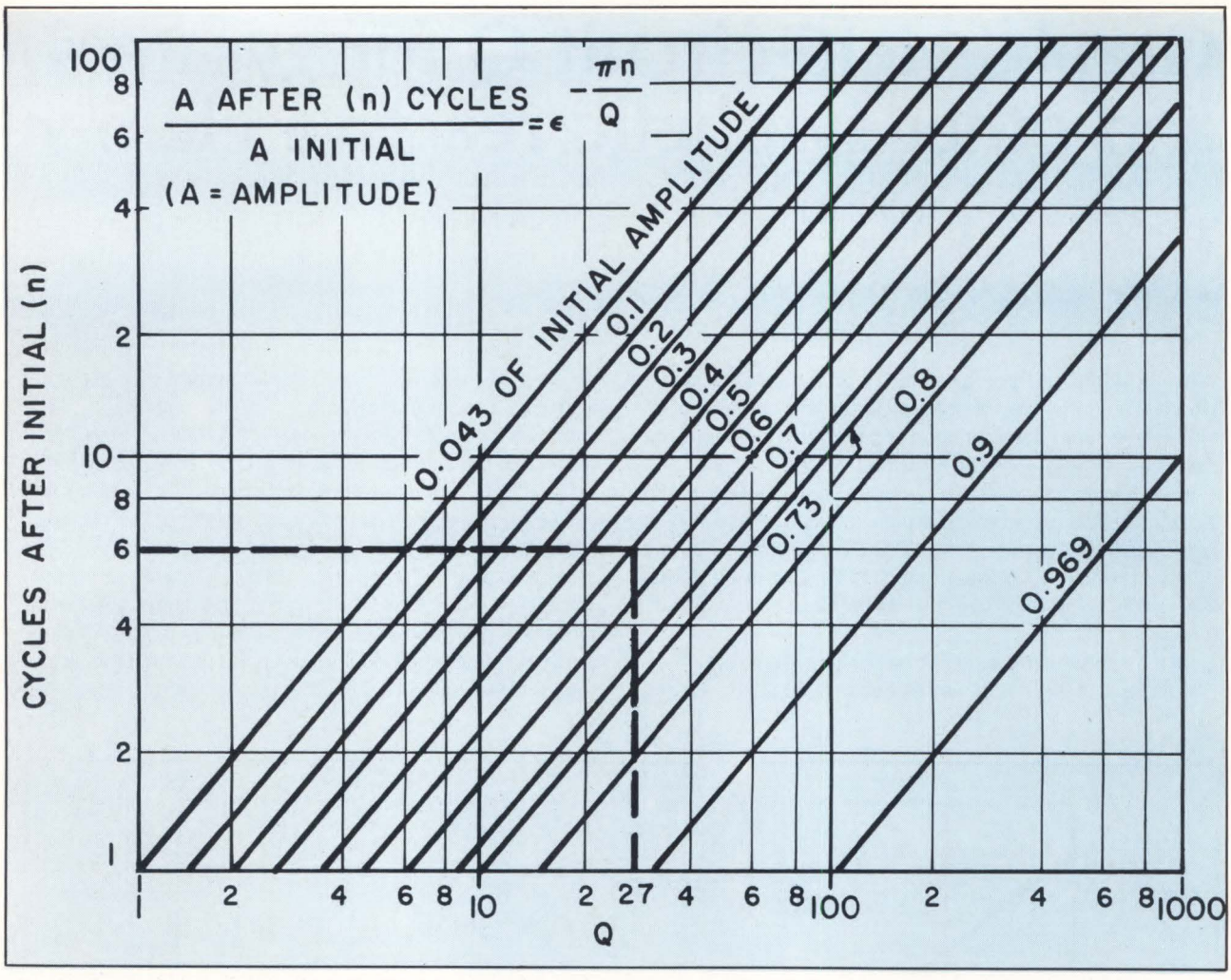



**Fig. 2—Circuit Q is read directly** from damped oscillation data. For example, the waveform of **Fig. 3** represents a Q of 27, since the waveform amplitude falls to 0.5 of an initial amplitude after 6 cycles.

plitude. Q is then read directly as the number of cycles.

For example, the Q of the circuit having the damped waveform of **Fig. 3** would be 27, since it takes six cycles for the amplitude to decrease to 0.5 of an initial value. With the addition of a resonating capacitor, Q may be read at other frequencies.

It is important to assure that the instrumentation used to observe the damping does not adversely alter or load the circuit. For example, a circuit with an inductance of 160 millihenries resonating at 10 kHz has a reactance of approximately 10 kΩ. In this case, with an oscilloscope probe having an impedance of 1 mΩ, the maximum Q would be $Q = R_s/\omega L = 10^6/10^4 = 100$, where $R_s$ is the shunt resistance in ohms, $\omega = 2\pi f$, and L is the inductance in henries. The effect of the shunting resistance may be accounted for by assuming that the oscilloscope probe resistance is in shunt with the loss elements of the circuit.

This technique has formed the basis of commercially manufactured Q meters. With present digital techniques, a digital-readout Q meter could readily be built using a fast-rise pulse generator. □

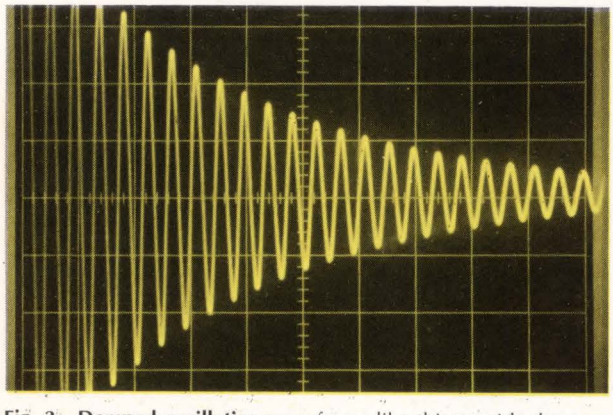


**Fig. 3—Damped oscillation** waveforms like this provide the necessary data for determining circuit Q.

### Author's biography

**H. A. Wittlinger** is a linear IC applications engineer at RCA, Somerville, N.J., primarily involved with monolithic operational amplifiers. Prior to joining the Solid State Division of RCA, he worked at RCA's Astro Electronics Division, where he was concerned with the design of television cameras for weather satellites. He holds a BSEE from Case Institute of Technology.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE 164**

# CIRCUIT DESIGN AWARDS

## Silicon unilateral switches detect initial event

**Neal E. Pritchard,**
ACDC Electronics, Oceanside, Calif.

This initial event indicator circuit is capable of monitoring several separate events simultaneously, detecting the first and storing this information. The number of separate events that can be monitored is determined by the number of stages used, which can be virtually unlimited. The circuit is especially useful in applications where the events are momentary, but greater than one microsecond.

The operating characteristics of the initial event indicator circuit is a result of the series–parallel configuration of the bistable SUS devices ($D_1$-$D_4$) in the two stages as shown below. More stages may be added. The necessary conditions for proper operation of the circuit are:

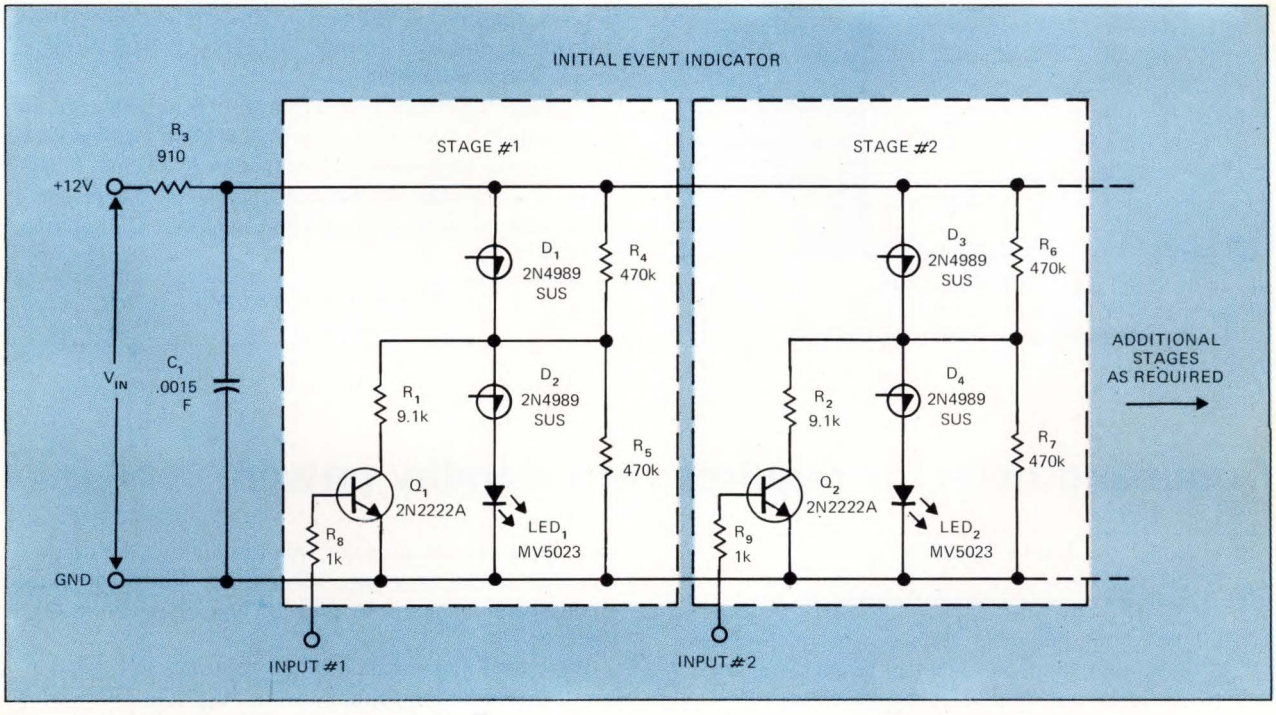
1. The applied voltage ($V_{IN}$) must be less than twice the switching voltage ($V_S$) of the bistable device (SUS) but still greater than $V_S$;
2. The switching voltage ($V_S$) must be greater than twice the forward voltage ($V_F$) of the SUS plus the forward voltage of the LED;
3. The IR product, namely holding current ($I_H$) times either resistor $R_1$ or $R_2$, must be greater than the switching voltage ($V_S$).

With the application of $V_{IN}$, assuming inputs 1 and 2 are zero volts, resistors $R_3$ through $R_7$ form a voltage divider network that determines the initial stable state of the circuit. In this state the voltage across the bistable devices is approximately $V_{IN}/2$, which is less than the required switching voltage; therefore, no current will flow in either LED.

In order to change the state of the circuit, a positive voltage (the initial event to be detected) must be applied to an input. Assuming event #1 occurs first, transistor $Q_1$ will saturate, increasing the voltage across $D_1$ until it switches to the ON state. The current through $R_1$ switches $D_2$ to the value $V_F$ turning $D_2$ ON. The voltage across the input to the stages is now $2V_F + V_{LED}$, and the current through the LED is $[V_{IN} - (2V_F + V_{LED})] \div RI$. When input #1 returns to zero, the circuit still remains in this second stable state. With stage #1 ON, stage #2 cannot be switched ON. The circuit can be reset by momentarily removing $V_{IN}$ or shorting $C_1$.

This circuit is especially useful in systems where a fault initiates a system shutdown, which in turn removes the fault condition. $C_1$ is used for noise filtering. □

**To Vote For This Circuit**
**Circle 150**




**Silicon unilateral switches** arranged in a series-parallel circuit will react to only the first input pulse.

# Test box indicates logic levels for entire IC

**Richard G. Sullivan,**
Control Data Corp., Rochester, Mich.

This circuit performs the function of a logic-level indicator, and works as follows:

There are 16 identical circuits, each having one connection to a pin of the IC under test. The circuits independently determine which pin is +5V and connects this to the voltage bus, and which pin is ground and connects this to the ground bus. The two diodes can be considered a decision gate network directing the +5V pin and the ground pin to the proper bus. The diodes are Germanium to allow a greater voltage on the voltage bus, about +4.5V in this case. It doesn't matter where +5V and ground are, the circuits automatically connect the proper voltage to the proper bus.

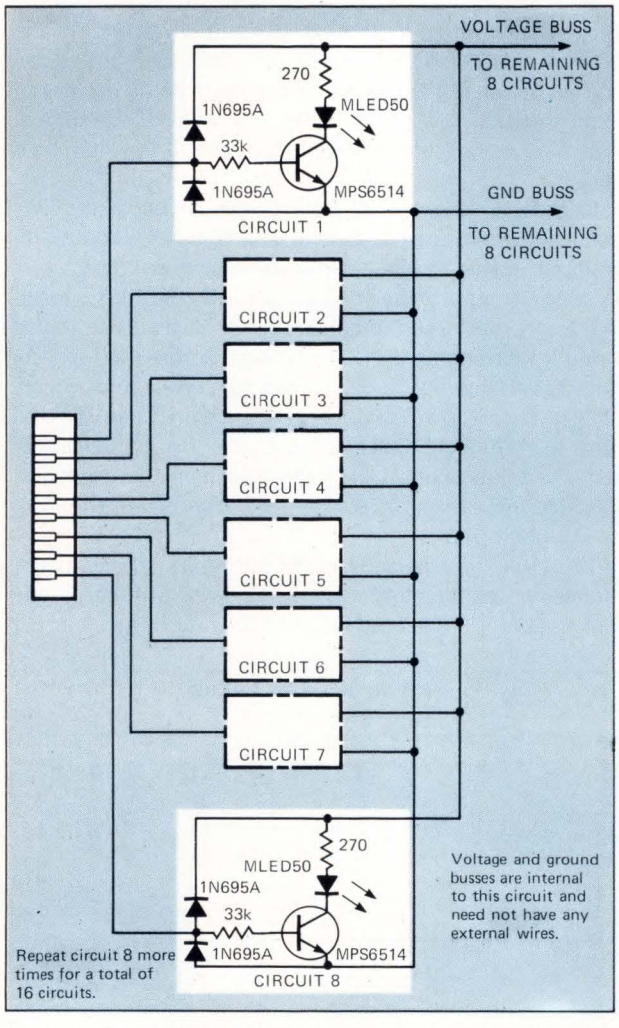



**Fig. 1—16 identical LED circuits** housed in a small test box will indicate logic state of each pin in a DIP package. Diodes automatically switch input to the proper ground or +5V bus.

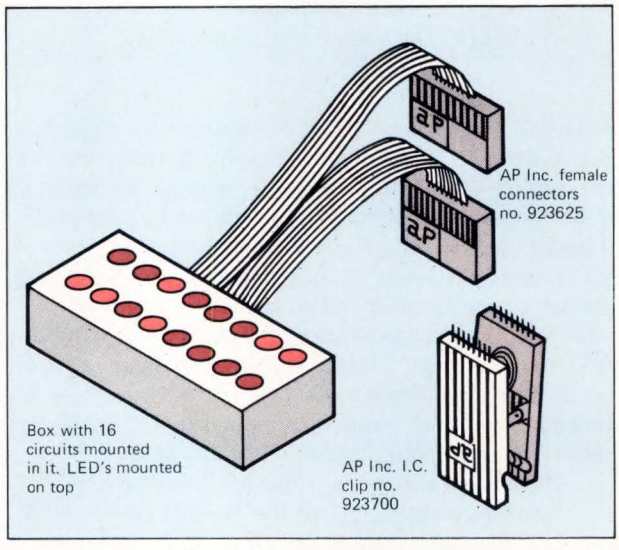



**Fig. 2—Commercially available test clips** are used for simultaneous probing of all pins in the DIP. No internal supply is required since power is drawn from the supply circuit for the IC under test.

Any pin at a logic "ONE" level will provide enough current through the 33Ω resister to turn on the MPS6514 transistor, and hence the LED will glow red. If the pin under check is at a logic "ZERO" the MPS6514 will not turn on and the LED will be off. This circuit draws power from the IC and uses 10 mA per LED for a typical brightness of 200 foot lamberts.

To make the circuit useful as a trouble shooter, put the 16 circuits in a small box, with the LEDS on top. Two harnesses come from the box terminating in AP Inc. female connectors number 923625 or equivalent. These are 8 socket connectors that mate with their Logic Clip number 923700. □

**To Vote For This Circuit**
**Circle 151**

# Command detector requires zero standby power

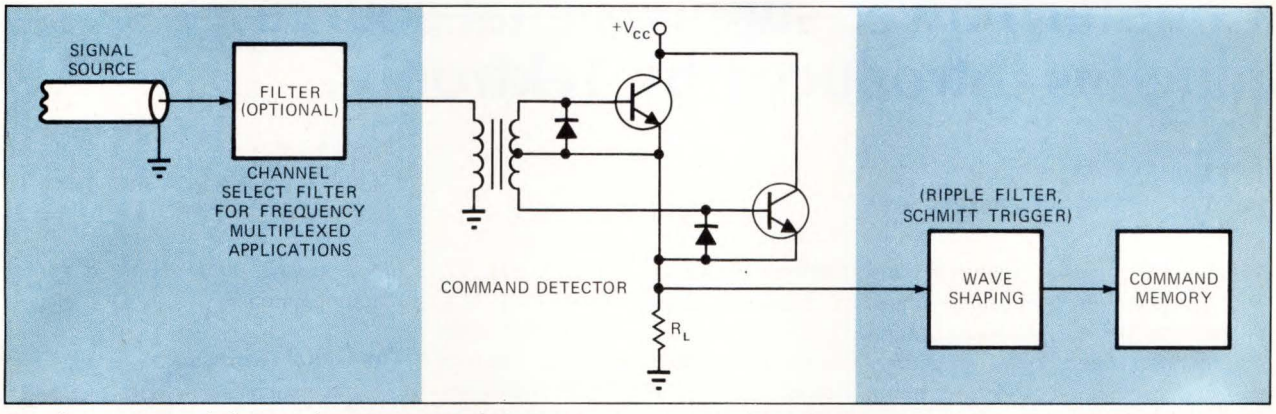
**John J. Murphey, Jr.**
Naval Weapons Center, China Lake, Calif.

The simple circuit shown here provides an excellent method for detecting command signals in remotely controlled, battery operated equipment. This circuit requires essentially zero standby current ($I_{CBO}$) and provides a full-wave rectified output when energized by an ac signal. The circuit is basically a class-B amplifier with the output taken from a common-emitter impedance. Diodes are added across the emitter-base junctions to prevent breakdown from high signal levels.

The circuit has provided excellent results in a remotely controllled oceanographic system which has a low command duty cycle. After appropriate filtering and shaping of the detector output, digital data (from coded tone bursts) is

entered into an MOS shift register memory. This results in a command decoder with extremely low power consumption, which is necessary in situations where the commands to remote equipment are changed at infrequent intervals. Power to the remaining circuits in the command decoder can be controlled by this detector, resulting in a system which requires zero standby power while still active and capable of receiving commands. □

**To Vote For This Circuit**
**Circle 152**




**Tone-burst command detector** for remote-control devices is a simple emitter-follower amplifier that is biased "OFF" when command inputs are absent. Power consumption is essentially zero in standby mode.

# Pulse technique determines series inductance of a resistor

**Carlo Venditti,**
Charles S. Draper Laboratory, Cambridge, Mass.

This simple time-measurement technique allows the inductive properties of resistors to be measured without a bridge using only a pulse generator and an oscilloscope. **Fig. 1** shows the circuit required to determine the inductance of an 85Ω resistor.

Voltages $e_i$ and $e_o$ are displayed on the oscilloscope with $R_1$, $R_2$ and $R_t$ equal to an effective 50Ω (suggested termination for the pulse generator). $R_1$ and $R_2$ are carbon (non-inductive). The display system is calibrated and verified by using a carbon resistor for $R_t$. The displayed $e_i$ and $e_o$ waveforms under this condition should have identical time characteristics.

The inductance of a resistor is determined by examining the $e_o$ waveform. The amount of amplitude overshoot and decaying characteristics of the waveform indicate, qualitatively, the effective series inductance of the resistor. L can be calculated for an R-L system by determining, from the $e_o$ displayed waveform, the time for the overshoot to decay to 67 percent of its amplitude. Since 67 percent corresponds to one time constant, the expression $\frac{R}{L}t = 1$ applies. With the measured t and the known circuit equivalent R, the L is calculated using $L = R_t$. □

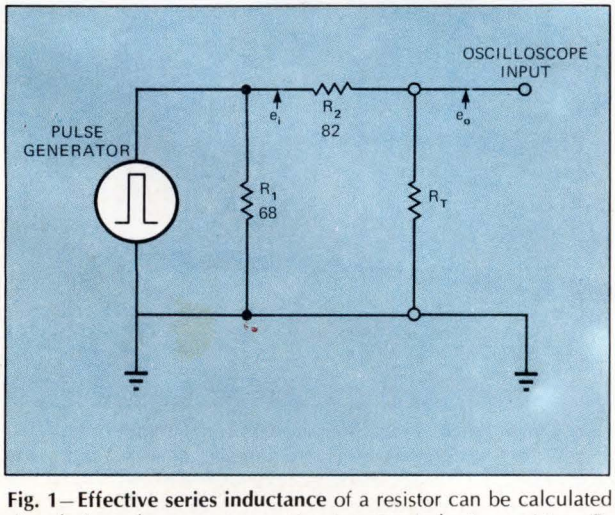



**Fig. 1—Effective series inductance** of a resistor can be calculated directly from the scope trace using two non-inductive resistors ($R_1$ and $R_2$) in this impedance-matching network.

**To Vote For This Circuit**
**Circle 153**

## Rules & Announcements

Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by circling the appropriate number on the reader inquiry card.

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

Readers have voted: Ury Priel winner of the February 15 Savings Bond Award. His winning circuit was called, "One Shot Triggers on Both Edges." Mr. Priel is with National Semiconductor Corp., Santa Clara, Cal.

# Counter/power-supply/signal-source plug-ins introduced by Tektronix

*PROGRESS IN INSTRUMENTATION*

Mention the name Tektronix and you'll probably think of oscilloscopes. Would you believe electronic counters, function, ramp and pulse generators and oscillators? And how about power supplies?

Expanding its measurement horizons, Tektronix has introduced 12 new instrument plug-ins (with more on the way) that interchangeably fit into one-wide plug-in or three-wide plug-in mainframes. These plug-ins include two function generators, a ramp generator, a pulse generator, an oscillator, three electronic counters and four power supplies.

Designated as the TM500 Series, these readily serviceable instruments are designed to give the user a low-cost and versatile measurement package within a minimum of bench or rack space.

Basic to the system are one and three-plug-in mainframes designated as TM501 ($115) and TM503 ($150), respectively. Two TM503 units can be bolted together for standard rack-mounting to accept up to six instrument plug-ins. They may also be stacked atop one another vertically. The mainframes provide the unregulated dc power to the plug-ins (regulation is achieved in each plug-in).

## The counters

Three digital counter plug-ins are available: The $550 DC501 100-MHz counter, the $895 DC502 550-MHz counter and the $695 DC503 100-MHz universal counter. All feature a 7-digit stored LED display with leading zeros (those to the left of the decimal point) blanked. The standard internal clock is 1 MHz with an accuracy of 10 ppm and aging rate of 10 ppm/month. A $95 optional clock with 0.5 ppm (0° to 50°C) and an aging rate of 0.1 ppm/month is available as an option.

Four counting times of 0.01, 0.1, 1.0, and 10 sec are provided with automatic switching of the decimal point and kHz and MHz indicators. Automatic ranging is available on the 100-MHz unit as an option in an instrument costing $615. All three units offer totalizing from 0 to $10^7$ at any rate up to 100 MHz.

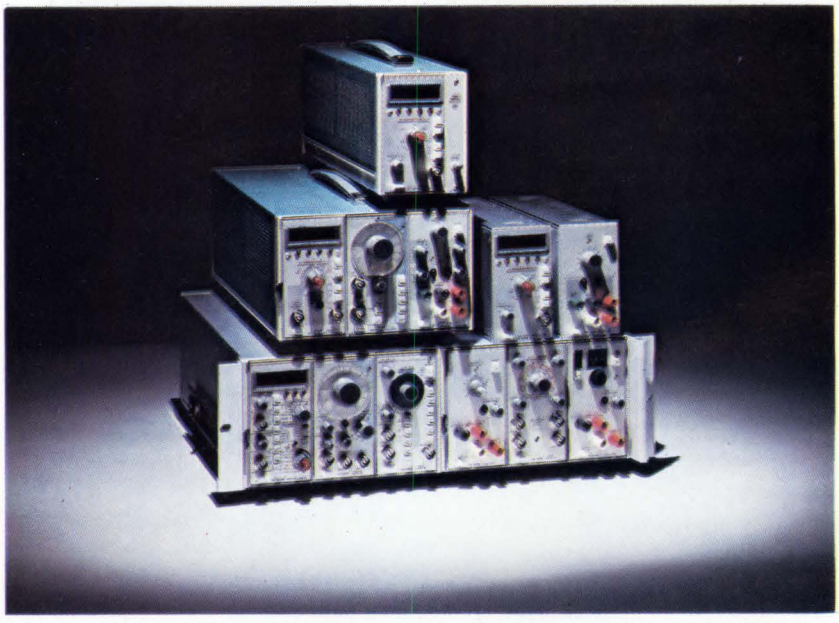
The 550-MHz counter has both 1-MΩ and 50Ω inputs. In the 1-MΩ position, the unit counts directly from 10 Hz to 100 MHz. In the 50Ω position, the input is divided by 10 before counting, with a range of 50 to 550 MHz.

The dual-channel DC503 100-MHz universal counter offers six measurement functions: a frequency-counting mode, a frequency ratio mode, three time-counting modes and an event-counting mode.

## The signal sources

Signal sources include the $325 FG501 function unit which is a general-purpose module with a frequency range of 0.001 Hz to 1 MHz. Output waveforms include sine, square, triangle and ramps of either polarity. An offset control with a ±10V range is provided to allow generation of $\sin^2$ pulse and zero-volt baseline pulses.

An external input allows control of frequency by means of a dc voltage. Applying a ramp waveform to this input provides sweep-frequency operation. A gate input is provided to allow "burst" operation or single cycles. Another convenient control, the "hold" switch, can interrupt the oper-



**Instrument plug-ins covering a wide range of measurements** are being introduced by Tektronix, Inc. These include a pair of function generators spanning the range of 0.001 Hz to 10 MHz, a 50-MHz pulse generator, a ramp generator, a 10-Hz-to 1-MHz oscillator, three electronic counters covering 550 MHz, and four power-supply plug-ins. These modules have been designed to give the user maximum flexibility at low costs. Soon to be introduced is a 4-1/2-digit multimeter plug-in and a possible tiny oscilloscope plug-in.

ation of the generator in midcycle, allowing precise setup of mechanical or other low-frequency systems. Maximum output voltage of the FG501 is 20V pk-pk.

The FG502 function generator is essentially identical to the FG501 with the exception of its frequency range of 0.1 Hz to 10 MHz. No price is available for this instrument at present.

Ramp generator plug-in RG501 ($175) is capable of providing variable-amplitude outputs of either polarity. The RG501 produces a TTL gate waveform coincident with the ramp, which can be used to gate a function generator to produce "burst" operation or single cycles.

The fourth signal source is the PG501, 50-MHz general-purpose pulse generator with simultaneous 5V positive and negative output pulses. Pulse rise and fall times are under 5 nsec with output amplitudes separately adjustable from approximately 0.25 to 5V into 50Ω.

The $295 SG502 low-frequency sine wave oscillator covers the range from 10 Hz to 1 MHz. Five decade ranges and a 1 to 10 log dial permit frequency selection within 3% for all but the top range. Output amplitude is 2.5V rms into 600Ω or 5V rms (TTL compatible) open circuit.

An auxiliary square wave is also available at the front panel. The square wave switches on the 0 to 180° points of the sine-wave output with rise and fall times of less than 50 nsec.

### The power-supply plug-ins

There are four members in the power-supply plug-in family at present. The $95 PS501 has two supply voltages available: a 0-to-20V dc adjustable supply at up to 400 mA and a +5V dc supply at up to 1A.

The 20V supply may be floated up to 350V and either output terminal may be grounded. Current limiting is adjustable to 400 mA by a front-panel control. A panel-mounted LED signals the user when current limiting occurs. The +5V supply is an auxiliary unit intended for non-critical applications.

The $130 PS501-1 module is identical to the PS501 except that the output voltage is set and read by a ten-turn potentiometer with a 3-digit in-line dial, plus a range switch. The output is adjustable from 0 to 10V or 10 to 20V depending on the range-switch setting.

The $130 PS502 floating dual-tracking supply module consists of positive and negative supplies with a common terminal. Any one terminal may be grounded or floated up to 350V dc and peak ac.

The last supply is the $180 PS503 which is a floating dual supply with many of the features in the PS502. Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone (503) 644-0161.

**314**

# Low-cost alphanumeric data terminal fills price—performance gap between full-scale video displays and teletypewriters

*PROGRESS IN DATA COMMUNICATIONS*

Digital Equipment Corp. has announced a small terminal to both enter and receive data from a computer. The RTO² has a simple 16-pad keyboard that contributes to easier operation by eliminating the need for the interpretation of complex codes, numbers and symbols. In addition, it is simple to operate because it interacts with the user in a conversational mode. It is capable of displaying 32, 0.2 in. high bright red characters on a single-line readout. Because of its single line readout, the unit maximizes security. The RTO² has a 64 character modified ASCII set.

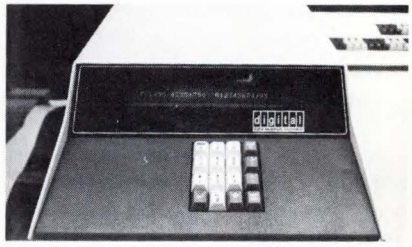
The terminal connects to a computer using a full-duplex, 4-wire data communications teletypewriter interface and also has modem interface capability corresponding to EIA RS-232-C specifications. Transmit/receive rates from 110 to 1200 baud are available. The new unit is extremely reliable because it is all solid state. In addition, its keyboards are tested for 200 million operations and features N-key rollover.

The RTO² can be used with a computer for data entry and receiving in many applications including those for inventory control, production monitoring, security systems, and credit verification.

The keyboard can enter up to 30 characters using a shift key, and the readout can display a 64 character modified ASCII set entered by the computer.

The new terminal is priced at $1300 for single quantities with deliveries scheduled to begin in August. Digital Equipment Corp., 146 Main St., Maynard, MA 01754. Phone (617) 897-5111.

**312**



**New alphanumeric terminal** interacts with the user in a conversational mode.

# Design your own rack-and-panel connectors with modular connector kit

*PROGRESS IN PACKAGING*

A new concept in miniature rack-and-panel connectors allows designers to custom assemble their own prototype connectors and drastically cut the turnaround time usually associated with custom connectors.

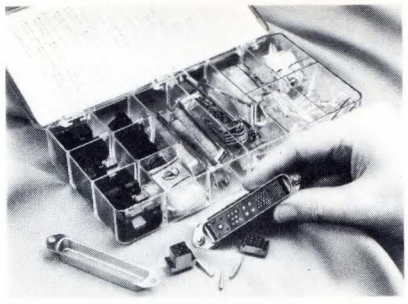
The miniature modular connector concept involves a kit of parts from which a design engineer can assemble his own connectors. Included in the kit, from which three complete mated pairs of connectors can be made, are: front shells, back plates, contacts, necessary screws and rivets and, most important, a wide variety of insert modules. These insert modules range from blanks with no provision for contacts, to ones that will accept up to 21 num-

ber-24 power contacts. Another module, for example, will accept a number-1 shielded (coax) contact. The designer's kit comes with full assembly instructions and diagrams.

Designated Amphenol 137 Series MIC-KIT (Modular Integral Connector Kit), the complete kit sells for $25.

In addition to cost and time savings, the kit provides designers with a far wider choice of insert arrangements than previously available in miniature rack and panel connectors. With the five different insert modules, it is possible to produce approximately 7500 different insert configurations.

Another advantage to the user is that he may be able to reduce the number of connectors required in a given system, since the wide range of inserts possible may preclude the need for special connectors for each contact size or for shielded (coax) contacts, for example.



**Custom connector designs** can be made with the new modular connector kit.

The 137 Series is not intended for high production runs, according to Amphenol engineers. Its main use should be in prototype connector development or possibly limited production runs. When needed in large quantities, Amphenol will tool a one piece insert to the exact arrangement designed from the kit by the user.

For small production runs and to replenish the kit parts, Amphenol will supply all components, modules, shells, and contacts in pre-packaged quantities of five and ten units from distributor stock.

The components which make up the 137 Series kit are tried-and-tested parts. The shells and back plates are similar to those in Amphenol's 57 Series connectors; the contacts are similar to those used in the 17 Series rack-and-panel connectors; and the insert modules are Amphenol's standard glass filled nylon Zytel 101, which has an operating temperature of −55 to +125°C.

Amphenol Industrial Division, 1830 S. 54th Ave., Chicago, Il 60650. **311**

# Complete monolithic D/A converter provides 10-bit resolution

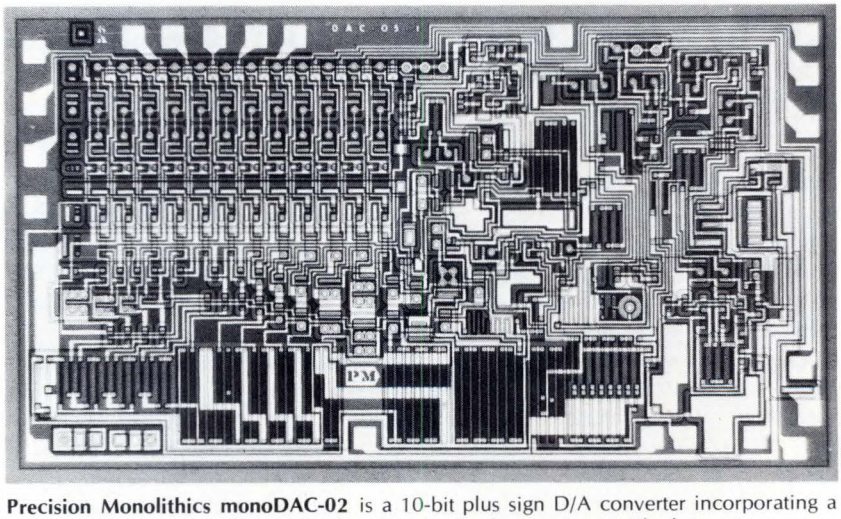
*PROGRESS IN SEMICONDUCTORS*

With the introduction of a 10-bit plus sign D/A converter, Precision Monolithics, Inc., continues to produce the most complex single-chip converters. The new converter, the monoDAC-02ACU1, achieves 0.05% linearity and 1 μsec settling time (to 0.1%) over the entire 0 to 70°C temperature range.

Packed in an 18-pin dual-in-line package is a single 82 × 148 mil chip that incorporates all the elements required for a complete 10-bit-plus sign converter, including a high stability voltage reference, internally-compensated high-speed output op amp, Schottky-clamped current switches, matched current sources and a diffused R-2R resistor ladder.

In 100-piece quantities, the monoDAC-02ACU1 is priced at $45 each. Another version, the monoDAC-02CCU1, with 0.2% linearity is priced at $35 each in the same 100-piece quantities.

Two significant features of the monoDAC-02 are the sign magnitude, previously unavailable in a monolithic D/A converter, and the diffused, untrimmed R-2R ladder network resistors, matched to better than 0.05%. According to Precision Monolithics, this accuracy represents an improvement of better than two orders of magnitude over conventionally diffused resistors and will open up new areas for linear ICs. Precision Monolithics declined to elaborate on the special design and processing techniques used to achieve this accuracy.



**Precision Monolithics monoDAC-02** is a 10-bit plus sign D/A converter incorporating a reference zener, internally-compensated high-speed op amp, matched current sources, current switches and a diffused ladder network on a single 82 × 148 mil chip packaged in an 18-pin DIP.

The approach taken by Precision Monolithics was to build as complete a converter as possible on a single chip. This approach differs from other IC manufacturers, notably Harris Semiconductor and Motorola, who take a "building-block" approach. With the building-block concept only portions of the converter, such as the ladder network and current switches, are built on a single chip. Most often the output op amp is not included, the belief being that there are so many to choose from, why limit the user. And it's easier to achieve high yields.

Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, CA 95050. Phone (408) 246-9222. **313**

# *New 42R motors/gearmotors*

**From the people at Bodine: More power. Smaller package.** The 42R! A new line of totally enclosed fan cooled AC motors and gearmotors. With new cool. New quiet. Power capabilities you'll find hard to believe in a NEMA 42 frame configuration. Ratings of higher hp Bodine 42R motors are comparable to many NEMA 48 frame motors.

The Bodine 42R runs cool to the touch, even after hours of continuous use. Because die cast aluminum frame, rotor fan and extruded aluminum center ring dissipate heat fast. Ball bearings are used throughout. And the 42R delivers Bodine's traditional long-life service and dependability. Another plus: Bodine application engineers are ready to help you apply the 42R. We'd like to be of service. Bodine Electric Company, 2500 W. Bradley Place, Chicago, Illinois 60618.

*. . . the people with the drive to solve your fhp problems*

**BODINE ELECTRIC COMPANY**

BODINE MOTORS
GEARMOTORS
SPEED CONTROLS

**42R Motor line:** Standard continuous ratings from 1/20 through 1/4 hp. Available in all AC winding types including special arrangements. Options include capacitor mountings, overload protectors, etc.

**42R-E Parallel-Shaft Gearmotor line:** Gear ratios up to 300:1 available. Helical steel gearing. High output-to-size loading ratio. Output shaft rotates in large needle bearings providing high overhung load capabilities.

CIRCLE NO. 21

# Refreshing. Books to keep you up-to-date in your profession.

**BASICS OF CIRCUIT ANALYSIS FOR PRACTICING ENGINEERS**
*by Gordon E. Johnson, Department of Electrical Engineering, Indiana Institute of Technology*

Treating circuit analysis in a volume of this size (260 pages) is made possible by a unique approach. Direct current, alternating current and complex frequency drive are considered as special cases of exponentially varying sinusoidal drive. A single analysis of exponentially varying sinusoidal drive replaces the conventional treatment of each type of drive in turn. This results in greatly reduced volumes of text, provides the background that gives meaning to Laplace transform methods and unifies the subject matter of circuit analysis. Although the level of mathematics used does not go beyond that of elementary integral calculus, circuit theory is developed to the level necessary for the reader to continue study in related fields such as electronics, pulse techniques and feedback control theory. Analogue methods are presented that make it possible to utilize the electronic circuit theory developed to the solution of mechanical vibration problems.

*Table of Contents:* Electronic Quantities – The Three Circuit Elements – Electrical and Mechanical Analogues – Mathematics to Simplify Circuit Analysis – The Exponentially Varying Sinusoid – Steady State Response – The Step Function – The LaPlace Transform – Power – Frequency Response – Two Port Network Parameters 258 pages cloth $7.95 paper $4.95

**APPLIED ENGINEERING STATISTICS FOR PRACTICING ENGINEERS**
*by Lawrence Mann, Jr., Mechanical, Aerospace & Industrial Engineering Department, Louisiana State University*

*Contents:* Probability – Statistical Parameters – Distributions – Chi-Square Tests – Analysis of Variance – Regression by least Squares Method. 175 pages cloth $7.95 paper $4.95

**PROBABILITY FOR PRACTICING ENGINEERS**
*by Henry L. Gray, B.S., M.S., Ph.D., Professor of Mathematics, Texas Technological College and Patrick Odell, B.S., M.S., Ph.D.; Professor and Chairman of Mathematics, Texas Technological College*

*Contents:* Basic Concepts – Probability, Distribution and Density Functions – Moments and Limit Theorems – Important Probability Density Functions – Statistical Estimation – Stochastic Processes – Linear Estimation of Stochastic Processes. 217 pages cloth $7.95 paper $4.95

**MATERIALS IN ELECTRONICS**
*by Charles E. Jowett*

A survey of the problems involved in the use of materials in electronics. The essential concepts of the nature and behavior of the materials used are covered together with a comparison of those used in electronics and micro-electronics. Describes the practices in the application of materials to the major types of components and examines the purpose of testing materials. Useful for design and production engineers. Illustrated. 220 pages $24.00

**MEASUREMENTS AND CONTROL APPLICATIONS FOR PRACTICING ENGINEERS**
*by Joel O. Hougen, Department of Chemical Engineering, The University of Texas*

Emphasizes the empirical approach to problem solution. Because the approach applies to existing facilities, the extent to which the optimum possible solution approaches the ideal is dictated by the performance characteristics of the processing apparatus which must be used, the processing technology employed and the economic factors associated with the solution and current operation. Available June, 1972 330 pages cloth $10.95 paper $7.95

**INVENTION PROTECTION FOR PRACTICING ENGINEERS**
*by Tom Arnold, B.S., E.E., Ll.B. and Frank S. Vaden, III, B.S., E.E., Ll.B.*

*Contents:* Fundamentals of the Patent System – What the Patent Is and Is Not – The Obtaining of a Patent – Elements of Patent Exploitation – Patent Enforcement and Litigation – Avoiding Patents of Others – Evaluating a Patent for Purchase or Sale – Organization of a Corporate Patent Program – Patent Licensing – How to Use Your Patent Lawyer – Trends in the Patent Law. 190 pages cloth $7.95 paper $4.95

**DECISION AND RISK ANALYSIS FOR PRACTICING ENGINEERS**
*by Melvin W. Lifson, President, Valvementrics, Sherman Oaks, California*

The need for visibility and quantification of judgemental factors arises not only from a desire for logical consistency in the treatment of decision elements but also from the need for people to communicate, review and discuss such factors as part of the total decision process. This book develops a decision methodology, including explicit quantitative evaluation models by adapting decision theory, utility theory and Bayesian concepts to the needs and requirements of systems decision making.

**SEMICONDUCTORS**
*Edited by D. F. Dunster*

The first volume in a series of International Dictionaries of Science and Technology, this dictionary was compiled by a team of experts from seven European countries and contains 4,572 entries with definitions and over 5,500 terms in French, German, Italian, Portuguese, Russian and Spanish. There is an abundance of detailed technical data with illustrations and tables and particular attention has been paid to the complex problems presented by signs, symbols, measurements and parameters. 37 pages of tables. 200 illustrations. Indices. 1,383 pages $49.50

**QUANTITATIVE MANAGEMENT METHODS FOR PRACTICING ENGINEERS**
*by Scott Page, Department of Industrial and Systems Engineering, University of Houston*

*Contents:* Quantification – The Scientific Process – Decision Theory – Models - Simple but Useful – Replacement – Congestion Models – Queuing Theory – Networks - CPM – Inventory Methods – Programming – Simulation – Forecasting – Production Systems – Organizational Models – Systems. 186 pages cloth $7.95 paper $4.95

**THEORY AND TECHNIQUES OF OPTIMIZATION FOR PRACTICING ENGINEERS**
*by Raymond L. Zahradnik, Ph.D., Associate Professor of Chemical Engineering, Carnegie-Mellon University*

*Contents:* Parameter Optimization – Linear and Quadratic Programming – Geometric Programming – Gradient Techniques – Non-Linear Programming – Discrete Dynamic Programming – Trajectory Optimization – Continuous Dynamic Programming – Maximum Principle – Approximate Techniques and Trajectory Approximization. 260 pages cloth $7.95 paper $4.95

Available in June

**APPLIED NUCLEAR POWER FOR PRACTICING ENGINEERS**
*by Knud Petersen, Department of Nuclear Engineering, U. of Puerto Rico with Donald S. Sasscer, Heriberto Plaza, Aviva E. Gileadi, Richard Brown Campos and Robert H. Holyoak*

May be used as a quick reference to a particular problem in applied nuclear power or may be used as a whole to give the reader a well-rounded introduction to the topic. Almost every chapter treats a subject without depending on the context of the other chapters yet continuity has been provided by treating the same example throughout. 250 pages cloth $9.95 paper $6.95

(Please cut along this line)

**Cahners Books** Dept. EDN
89 Franklin Street, Boston, Massachusetts 02110

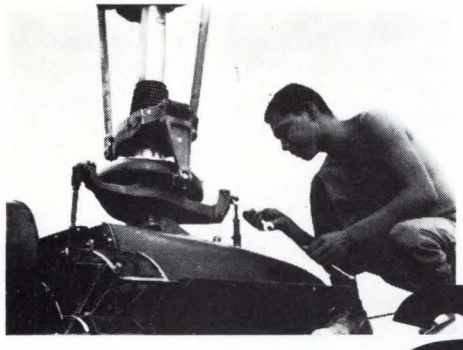
Please send me the books I have checked off below. I understand that I may examine them FREE for 15 days. If they meet my requirements, I will send you my check. Otherwise, I may return them to you in an undamaged condition.

☐ Bill Me
☐ Bill Company
☐ Check Enclosed (We Pay Postage)

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

____ Basics of Circuit Analysis for Practicing Engineers @ $4.95
____ Measurements and Control Applications for Practicing Engineers ☐ cloth @ $10.95 ☐ paper @ $7.95
____ Decision and Risk Analysis for Practicing Engineers ☐ cloth @ $9.95 ☐ paper @ $6.95
____ Applied Nuclear Power for Practicing Engineers ☐ cloth @ $9.95 ☐ paper @ $6.95
____ Theory and Techniques of Optimization for Practicing Engineers ☐ cloth @ $7.95 ☐ paper @ $4.95
____ Invention Protection for Practicing Engineers @ $4.95
____ Probability for Practicing Engineers @ $4.95
____ Applied Engineering Statistics for Practicing Engineers @ $4.95
____ Quantitative Management Methods for Practicing Engineers @ $4.95
____ Materials in Electronics @ $24.00
____ Semiconductors @ $49.50

# Hire the veteran.



# Hire ability.

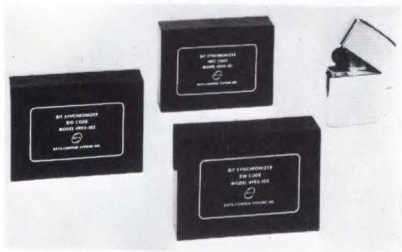
The ability to do a job well. To learn. To take orders. And to give them. ■ The Armed Forces spend over $3 billion yearly on training servicemen. That means many veterans have skills *you* can use from the moment they're hired. And if they need further training, monthly allowances under the GI Bill can supplement their wages while they are in approved training programs. ■ Hire veterans. Put their ability to work. ■ For help in hiring veterans, contact your local office of the State Employment Service; for on-the-job training information, see your local Veterans Administration office.

**Don't forget. Hire the vet.**

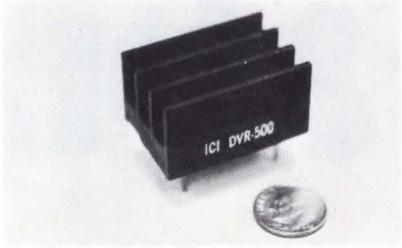
JOBS FOR VETERANS

ADVERTISING COUNCIL®

## CIRCUITS



**PCM BIT SYNCHRONIZERS AND CODE CONVERTERS** Series 4903 are designed for optimizing the bit-packing density of analog tape recorders in excess of 30 kbits/in./track. The Series is offered in encapsulated form for mounting on PC cards. Three bit synchronizers and six code converters are available. Prices range from $660 to less than $300 depending on quantity purchased and delivery is 60 days. Data-Control Systems, Commerce Dr., Danbury, CT 06810. Phone (203) 743-9241. **271**



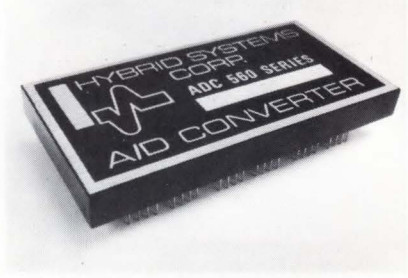

**DUAL-TRACKING VOLTAGE REGULATOR** Model DVR-500, is a thick-film, hybrid circuit designed to provide balanced ±15V ±0.2V dc outputs at 500 mA from each output. It is short-circuit proof and has built-in current limiting. The DVR-500 comes complete with its own heat sink and requires no external components. Price is $39. Integrated Circuits Inc., 13256 Northrup Way, Bellevue, WA 98005. Phone (206) 747-8556. **272**

**A NEW DC POWER SUPPLY MODULE** makes it possible to power "glow-type" information displays. Series 700 power supply units include regulated and unregulated models requiring dc voltages of 5, 9, 12 or 15V. The regulated units are 1.5 × 1.43 × 0.97 in. and provide 200V outputs regulated to ±15V. The unregulated units measure 1.2 × 1.1 × 0.85 in. and provide nominal 200V outputs. OEM prices start at $5.65. Endicott Coil Co., 24 Charlotte St., Binghamton, NY 13905. Phone (607) 797-1263. **273**

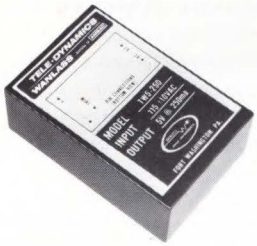
**NEW A/D CONVERTER** Model ADC-P10B has a quantizing error of ±0.01%. This 10-bit unit has a bit rate of 200 nsec/bit, ±0.01% accuracy and a TC of ±0.003%/°C. It measures 2 × 4 × 0.4 in. Full-scale input can be 0 to −5V, 0 to −10V, ±5V or ±10V at an input impedance of 2 kΩ. Price is $695. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **274**

**DC-TO-DC SIGNAL ISOLATOR** Model DCI-177 provides input/output transformer-isolation for −10 to +10V dc or 20V pk-pk input signals. The unit operates from −55 to +85°C and provides 180° phase inversion. It features floating signals, isolates potential-difference circuits up to 500V and meets the requirements of MIL-E-5275. Price in 100 piece quantities is $97 each. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. Phone (213) 785-4473. **275**

**DUAL POWER SUPPLIES FOR OP AMPS** are encapsulated and mount on PC cards. They include levels of ±15V dc at 25, 65, 100 and 200 mA. Line/load regulation is ±0.05% and ripple and noise is 1 mV rms. Input is 115V, 50 to 400 Hz. The units are priced from $28 to $65. Computer Products, Inc., 1400 Gateway Dr., Box 23849, Fort Lauderdale, FL 33307. Phone (305) 974-5500. **276**



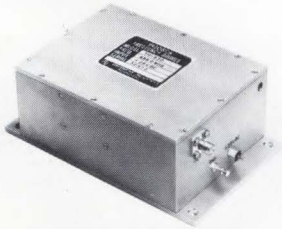

**THE ADC560 12-BIT A/D CONVERTERS** contain 4 relative accuracies from 0.05% through 0.0125%, all with 20-μsec conversion times. These successive-approximation units can take ratio as well as standard measurements. The 2-X-2-X-0.4-in. modules feature input ranges of 0 to +10V or ±5V, depending on pin interconnection, and a TC of 5 ppm/°C. They are available in a price range of $150 to $180 depending on model. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, MA 01803. Phone (617) 272-1522. **277**



**MINIATURE MODULAR POWER SUPPLIES** in 23 versions provide regulated dc voltages from 5 to 180V dc with current ratings from 10 mA to 1A. Both single (TW Series) and dual (TWD Series) output models are available. All supplies accept 115 ±10V ac, 50 to 400 Hz inputs. Line and load regulation is 2 or 5%. Prices start at $25. TeleDynamics/Wanlass, Div. of AMBAC Industries Inc., 525 Virginia Dr., Fort Washington, PA 19034. Phone (215) 643-3900. **278**

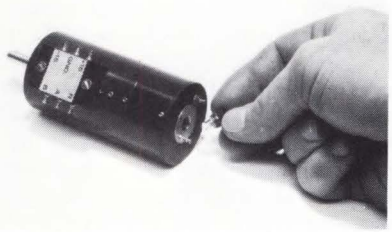
**CRYSTAL OSCILLATOR MODULE** Model BQ provides sine-wave outputs as low as 25 Hz. Frequency stability and accuracy is up to 0.001% over 0 to 50°C. Standard output levels into a 10-kΩ resistive load are 2V rms minimum at 25 to 200 Hz and 3V rms minimum at 200 Hz to 10 MHz with a 12V supply. Prices start at $59. Fork Standards, Inc., 205 Main St., W. Chicago, IL 60185. Phone (312) 231-3511. **279**

**DC/DC CONVERTER** for utility instrumentation displays. Model PM 1854-125-28 utilizes a switching regulator that delivers 28V and 280W of dc power from a 105 to 140V dc source. Convection cooled, it weighs less than 9 lbs and has typical efficiencies of 75%. The converter has 1% ripple and −5% line and load regulation. It operates over +15 to +50°C. Pioneer Magnetics, Inc., 1745 Berkeley St., Santa Monica, CA 90404. Phone (213) 829-3305. **280**



**HIGH-POWER OSCILLATOR** Model YH-830 produces a 1W output over 150 through 300 MHz or 300 through 450 MHz, depending on version. Its frequency stability is $\pm 1 \times 10^{-6}$/day and over the temperature range of 0 to +50°C. Harmonics are 26-dB down and spurious signals are 60-dB down. Price is $895 and $997 for low- and high-frequency units, respectively. Delivery is 6 to 7 weeks. Greenray Industries, Inc., 840 W. Church Rd., Mechanicsburg, PA 17055. Phone (717) 766-0223. **281**

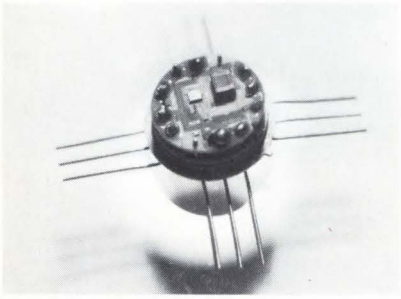
**A BACKWARD-WAVE OSCILLATOR** with an electronic tuning range of 75 to 110 GHz at a minimum power output of 1 mW is now being marketed in the U.S. by Siemens Corp. Covering the entire R band, the RW0110B is designed for operation at ambient temperatures ranging from +55 to −20°C. Its warranty is 2000 hours, with tubes having been in service up to 10,000 hours. Price is under $10,000. Siemens Corp., 186 Wood Ave., South, Iselin, N J 08830. Phone (201) 494-1000. **282**



**THE IMCODER INCREMENTAL OPTICAL ENCODER** is a shaft-angle unit that offers a number of advantages over conventional encoders. The 1.6-in.-OD encoder utilizes a lamp source and parabolic reflector. It offers accuracy of 20° or ±2 minutes of arc and 600 lines/channel count in single and dual-channel versions. Frequency range is dc to 75 kHz (7500 rpm). IMC Magnetics Corp., 570 Main St., Westbury, NY 11591. Phone (516) 334-7195. **283**

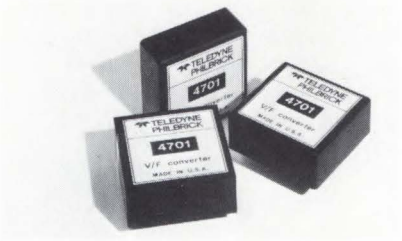
**GUNN-EFFECT SIGNAL SOURCE VSQ-9035** delivers 75 mW at 42 GHz. The new frequency trimmable device features power stability of 0.01 dB/°C and frequency stability of 1 MHz/°C in any 10°C range from 0 to 65°C. It operates into a maximum-load VSWR of 1.3. Nominal input voltage is 12 to 28V dc ±10% at 1.2A maximum. Varian, Solid State West, 611 Hansen Way, Palo Alto, CA 94303. Phone (415) 493-4000. **284**

**NEW ULTRASONIC DELAY-LINE** Series features 63-μsec units, for TV applications, measuring only 0.18 in. in thickness. One Series operates at 3.58 MHz with a bandwidth of 2.7 to 4.4 MHz. Another Series operates at 4.43 MHz, with a bandwidth of 3.43 to 5.2 MHz. Both have insertion losses of 8 dB and operate over +10 to 50°C. Cost is $5 each in production quantities. Andersen Laboratories, 1280 Blue Hills Ave., Bloomfield, CT 06002. Phone (203) 242-0761. **285**



**A NEW HYBRID ACTIVE FILTER** is available in a TO-8 package. The thick-film filter features a four-pole, low-pass, Butterworth design and a cutoff frequency of 5 kHz. Other filter custom designs are also available in one and two-layer hermetically sealed TO-81 and 16 or 20-pin plastic DIP packages. Prices range from $4 to $12 and delivery is 3 to 4 weeks. Airpax Electronics, Controls Div., 6801 W. Sunrise Blvd., Fort Lauderdale, FL 33313. Phone (305) 587-1100. **286**

**DOUBLE BALANCED MIXER** Model Z-Match DBM-166 comes in a DIP configuration and spans 0.2 to 500 MHz. The mixer has a conversion loss of 6 dB and interport isolations of 40 dB up to 100 MHz. Operating temperature range is −55 to +100°C. Price is $15 for single quantities and $6.95 for 100 quantities. Vari-L Co., 3883 Monaco Pkwy, Denver, CO 80207. Phone (303) 321-1511. **287**




**VOLTAGE-TO-FREQUENCY CONVERTER** Model 4701 permits 2-wire digital data transmission at 12-bit accuracy and costs only $590. The 4701 features 0.01% linearity and 27-ppm stability from 0 to +70°C in converting 0 to +10V input to a corresponding 0 Hz to 10-kHz output. Output waveform is a train of DTL/TTL-compatible 30-$\mu$sec pulses with a repetition rate proportional to the analog input value. Teledyne Philbrick, Allied Dr. at Rte 128, Dedham, MA 02026. Phone (617) 329-1600. **288**

**PROGRAMMABLE TIMER/COUNTER** Series 67 includes four basic models: two timers for measuring elapsed time and time remaining, and two counters for counting up and counting down. The series is designed for multiple-timing applications in which several different preset values are involved. The units use a 115V, 50 or 60-Hz line voltage as the time base. Tenor Co., 17020 W. Rogers Dr., New Berlin, WI 53151. Phone (414) 782-3800. **289**

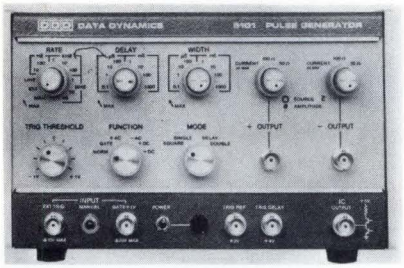

**FET OP AMP SLEWS AT 60 V/$\mu$SEC** and settles to 0.01% in 150 nsec (inverting). Unity gain bandwidth is 18 MHz, differential input impedance is $10^{12}\Omega$ and output is ±10V at ±20 mA. Versions A/B/C offer offset voltages of 50, 25 and 10 $\mu$V/°C and bias currents of 100, 50 and 20 pA at costs of $40, $45 and $52, respectively. Operating temperature range is −25 to +85°C. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **290**

**NUMERICAL-CONTROL DC MOTOR CONTROLLER** Model 203 features full-regenerative, four-quadrant operation for driving all types of dc motors with ratings of 5 hp in electric servo-drive applications. Units are available as complete packages to operate directly from 208/220/440V ac, three phase, with integral isolation transformers. Prices start from $1600. Control Systems Research, Inc., 1811 Main St., Pittsburgh, PA 15215. Phone (412) 782-4460. **291**

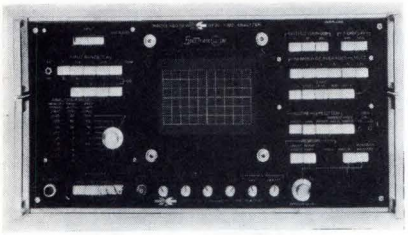
**DATA-ACQUISITION SYSTEM** Series N is a stripped-down version of Datel's DAS-16 and sells for $449. This includes a 16-channel multiplexer with sample/hold module, 10-bit a/d converter, dc-to-dc power supply, system programmer and housing and connectors. The Series also includes 8 and 12-bit versions. Overall accuracy is ±0.05%. Throughput rates are 100, 60 and 50 kHz, for 8, 10 and 12 bits, respectively. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **292**

**TWO NEW SERIES OF MODULAR DC POWER SUPPLIES** are the MMS and MMD Series. Outputs of the MMD Series range from ±15V at 25 mA to ±15V at 200 mA, and ±12V at either 120 to 240 mA. The MMS Series ranges from 5V at 250 mA to 180V at 10 mA. All units have internal current limiting. Four package sizes are offered, depending upon power rating. They range from 1 × 1.75 × 2.25 to 0.875 × 2.5 × 3.5 in. Prices range from $24 to $65. Raytheon Sorensen Co., 676 Island Pond Rd., Manchester N H 03103. Phone (603) 668-1600. **293**

**LQ SERIES POWER SUPPLY BUILT WITH A FERRO-RESONANT TRANSFORMER** in an open-construction configuration. Available in 19 models at up to 48V and 40A, the Series is priced between $100 and $160. The line comes in a new DA package size—5 × 7-1/2 × 10 in.—in both the Series 6000 and 5000 models. Supplies are inherently overvoltage protected. Line regulation is 2% and load regulation is 5%. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, NY 11746. Phone (516) 694-4200. **294**



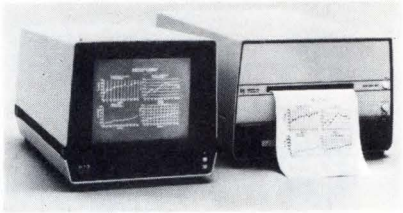

**RACK-MOUNTED 50-MHZ PULSE GENERATOR** Model 5101 offers pulse repetition rates from 1 Hz to 50 MHz and three separate and simultaneous outputs: positive pulses, negative pulses and IC-compatible pulses specifically designed for TTL, RTL and DTL ICs. Single and double pulses may be selected, with the output pulse width adjustable from 10 nsec to 1 sec. The 5101 costs $550. Data Dynamics Div., Electronic Counters, Inc., 240 Humphrey St., Englewood, N J 07631. Phone (201) 567-5300. **190**



**REAL-TIME ANALYZER SCOPE,** the SD330 Spectrascope, is actually an analyzer, spectrum averager and display scope in a single package. Suited for field work, it allows the operator to trace sources of noise and vibration in a wide variety of structures. Frequencies as high as 20 kHz can be processed and presented in four separate operational modes. Spectral Dynamics Corp., Box 671, San Diego, CA 92112. Phone (714) 278-2501. **191**


**SERIES 2400 DIGITAL CLOCKS** from Electronic Research feature LED displays. They come equipped with the remote-control features necessary for systems use. Standard models are available with three methods of time reference: 60-Hz power line, internal crystal oscillator or external input. Standard features include simplified front-panel presetting, power-failure indication and BCD outputs. Electronic Research Co., 10,000 W. 75th St., Overland Park, KS 66204. Phone (913) 631-6700. **192**

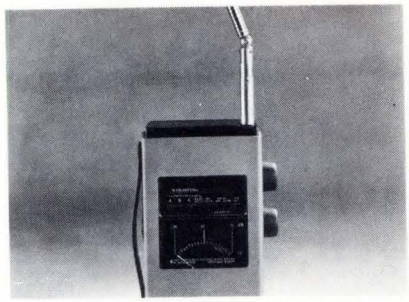
**MODULAR FERRO-RESONANT REGULATED DC POWER SUPPLIES,** the CVDC Series, are available in two basic sizes: 120 and 180W, and in two standard chassis sizes. Overall line and load regulation is ±10%, nominal. The units will hold output voltages to ±1% for line input variations as great as ±15%. There are 20 different units available with a wide variety of current/voltage ratings. Sola Electric Div., 1717 Busse Rd., Elk Grove Village, IL 60007. Phone (312) 439-2800. **193**



**STORAGE DISPLAY** Model 613 with an 11-in. flat-faced CRT provides high information density with good resolution without flicker or drift. The 613 is hard-copy compatible with the Tektronix 4610 hard-copy unit. Catalog price of the 613 is $2200. Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **194**

**DC POWER SUPPLIES** are available in 10 modular models. STM units offer computer-optimized input/output filtering that controls noise to less than 50 mV pk-to-pk and rf interference to within most portions of MIL-STD 461A. Combined line and load regulation is 0.05% and TC is less than 0.01%/°C. Efficiencies range up to 75% Outputs range from 3 to 56V and prices from $229 to $269. Sorensen Co., 676 Island Pond Rd., Manchester, NH 03103. Phone (603) 668-1600. **195**

**L/C/R METER** Model 4332A measures inductance from 3 μH to 1H, capacitance from 3 pF to 1 μF and resistance from 3Ω to 1 MΩ full scale, each in 12 ranges. The measuring frequency is 1 kHz for resistance and 1 kHz or 100 kHz for inductance and capacitance. Accuracy of inductance and capacitance measurements is ±[1% of reading +(1.5 + 3/Q)% + 0.03 μH or pF]. Resistance measurements are accurate to within ±1% of reading +2% of full scale. Price is $720. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **196**



**PRECISION SOUND-LEVEL METER AND ANALYZER** Model 1933 combines three instruments in a single unit: a sound-level meter, an impulse/impact analyzer and an octave-band analyzer. It complies with the precision standards of ANSI S1.4-1971 Type 1 and IEC 179. A, B or C-weighted sound-level measurements can be made from 10 to 150 dB. Frequency is 5 Hz to 100 kHz. Price is $1350. General Radio, 300 Baker Ave., Concord, MA 01742. Phone (617) 369-4400. **197**

**TWO NEW 11-X-17-IN. X-Y RECORDERS** are Models 7044A and 7045A. The 7044A has a slewing speed of 20 in./sec while the 7045A slews at 30 in./sec. Acceleration of the Model 7045A on the Y axis is 3000 in./sec², and on its X axis it is 2000 in./sec². Input ranges of both instruments are from 0.5 mV/in. to 10V/in. Prices are $1350 and $1675, respectively. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **198**

**HIGH-SPEED ANALOG X-Y RECORDERS** Series 1000 feature 50-in./sec. slew rates backed by 5000-in./sec ² accelerations at full slew reverses. The 11-X-17-in. plotters feature disposable fiber-tip pens, silent differential-pressure paper hold-down, sealed maintenance-free follow-up potentiometers and electronic over-drive protection. Multi-range capability is available from 1 mV/in. to 10V/in. Prices start at $1195. MFE Corp., 340 Fordham Rd., Wilmington, MA 01887. Phone (617) 658-5500. **199**

**A NEW LOW-PROFILE TWO-CHANNEL CHART RECORDER** is only 3-1/2-in. high and weighs less than 8 lbs. The recorder was designed for OEM bench-top use. Its linearity is 1% for the full 50-mm channel width. A high-torque stiff-movement mechanism assures reproduction of signals at frequencies up to 125 Hz. Chart speeds are 25 and 50 mm/sec. Astro-Med, Div. of Atlan-Tol Industries, Inc., Atlan-Tol Industrial Park, W. Warwick, RI 02893. Phone (401) 828-7010. **208**

# Introducing the working man's signal generator.

It works in Production.
It works in the Lab.
It works in the Field.
It works in the Service Shop.
In fact it works just about everywhere.

That's because our new 8654A Signal Generator delivers big performance but is small in size – and price. It weighs just 16 pounds and costs only $1135. Yet you get all the functions you'd expect from higher priced instruments.

The 8654A is a 10 to 512 MHz VHF solid-state signal generator with leveled, calibrated output adjustable from +3 to −130 dBm. CW stability is 20 ppm/5 minutes, and you can AM or FM, internally or externally. A look at the front panel will give you an idea of just how easy it is to use.

For more information about this high-value RF signal generator, call your HP field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SIGNAL GENERATORS


Domestic USA prices

CIRCLE NO. 25

# EQUIPMENT

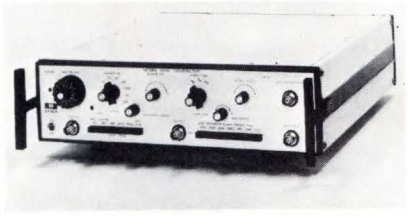
**DC VOLT-AMMETER** Model 4304B indicates polarity as well as magnitude of voltage and current on an analog front-panel meter. This $410 instrument measures voltages from ±1 mV to ±300V full scale in 12 ranges, and currents from ±1 nA to ±300 μA full scale. Accuracy for both voltage and current is ±1.5% of full scale. Drift is 0.2% of full scale and internal noise is 1% of full scale. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **200**

**FARATRON'S** new 2-1/2-digit DPM Series 2500 sports a $65 price tag (including BCD) and two display options. Also available in the 2-3/4-digit 2700 Series, the meter includes a 7-segment standard incandescent display and optional LED display. Over-and-under-range indicator lights are standard on unipolar models. Input power is from +5V dc or 117V ac. Faratron Corp., 290 Lodi St., Hackensack, N J 07601. Phone (201) 488-1440. **201**

**A NEW TEST CLIP FOR DIP ICs** named "DIP CLIP" is designed to facilitate the testing of 14 or 16-lead DIPs. The Model 3916 clip provides elevated test points to which test probes can be easily attached for hands-free testing. It works like a spring-loaded clothes pin: squeeze the top together to open contact jaws; then position the clip over the DIP leads and release. Pomona Electronics Co., Inc., 1500 E. Ninth St., Pomona, CA 91766. Phone (714) 623-3463. **202**

**A NEW 20-mW He-Cd LASER** features less than 1% rms ripple and noise output over 10 Hz to 5 MHz. The ML-442 laser which sells for $780 emits a coherent deep blue light at 442 nm. It operates in the $TEM_{oo}$ mode and is randomly polarized. Power output is 15 mW minimum and 30 mW maximum. Beam diameter at the output is 1.0 mm and beam divergence is 0.6 mrad. Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, N J 08030. Phone (609) 933-0100. **203**

**A NEW NANOSECOND KILOVOLT PULSE GENERATOR** with a characteristic impedance of 50Ω provides a variable output of 1 to 9 kV with a rise and fall time of 1 nsec and a delay of 20 nsec. The unit is capable of pulse repetition rates up to 100 Hz and can be triggered manually by pushbutton, or electrically with repetitive 3V pulses. The new generator is manufactured by Instrument Technology Ltd., of England. EG&G, Inc., Electro-Optics Div., 35 Congress St., Salem, MA 01970. Phone (617) 745-3200. **204**



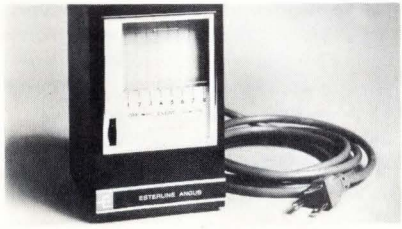
**FUNCTION GENERATOR** Model 7056 offers AM and phase-lock capabilities, trigger and gate functions for single-shot and burst waveforms and a frequency range of 0.0001 Hz to 11 MHz. Sine, square, triangle, ramp, pulse and sync waveforms are available in continuous, single-shot or burst modes. Several choices of dc offset are available: variable ±15V, symmetry about ground and voltage-controlled offset. Price is $995. Exact Electronics, Inc., Box 160, Hillsboro, OR 97123. Phone (503) 648-6661. **205**

**PORTABLE RFI ANALYZER** NM-12AT can make measurements over the range of 10 to 250 kHz with a sensitivity of 0.014 μV. Formerly manufactured under the Stoddart brand name, the NM-12AT is line or battery-operated and can be used 40 hours without re-charging. The instrument provides average, quasi-peak and peak field-intensity measurements. Singer Instrumentation, Los Angeles Operation, 3211 S. La Cienega Blvd., Los Angeles, CA 90016. Phone (213) 870-2761. **206**

**EXTENDED-RANGE MICROWAVE SWEEPER** Model 404A covers the complete Spectrum of 1 to 18 GHz in 50 msec. It sequentially sweeps this range with 5 mW ±1 dB of internally leveled rf power. The utilization of four discrete oscillators covering 1 to 2 GHz, 2 to 4 GHz, 4 to 8 GHz and 8 to 18 GHz allows the user to operate the instrument in single-octave, straddle-band or multi-band configurations in any part or all of the instrument's range. Servo Corp. of America, 111 New South Rd., Hicksville, NY 11802. Phone (516) 938-9700. **207**

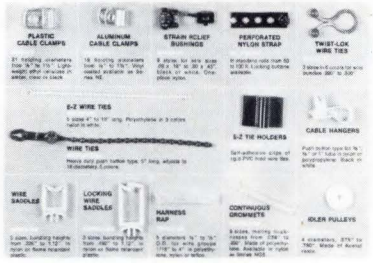

**TOTALIZER-EVENTS COUNTER** Model 6200 features automatic contact-bounce rejection, yet costs only $250. The panel-mounted unit counts pulses with amplitudes from 5 mV to 400V. The 6200 tolerates steady-state variations of +10% or −25%. To prevent spurious counts from contact bounce or complex waveforms, a minimum interval between countable events may be preset anywhere from 1 μsec to 100 msec. Newport Laboratories, Inc., 630 E. Young St., Santa Ana, CA 92705. Phone (714) 540-4914. **209**

**VARIABLE ELECTRONIC FILTERS** Series 4210 come in five models that cover the frequency range of 0.01 Hz to 1 MHz (each model covers six decades). Four-pole Butterworth filters are used in the normal mode and four-pole Bessel filters in the pulse mode. The series features frequency accuracy of ±1%, phase shift of ±2° and amplitude response of ±0.2 dB. Ithaco, Inc., 735 W. Clinton St., Ithaca, NY 14850. Phone (607) 272-7640. **210**



**MINIATURE EVENT RECORDERS** are offered in 4 and 8-channel models for operation on a wide range of dc or ac sources. They are suited for industrial and laboratory applications in which yes/no or on/off records are needed. The inkless recorders record in 1/10 sec with a special stylus or pressure-sensitive paper, drawing a continuous record for each channel. Prices begin at $119. Esterline Angus, Box 24000, Indianapolis, IN 46224. Phone (317) 244-7611. **211**

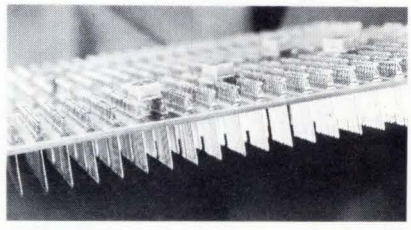
## COMPONENTS/MATERIALS




**FREE SAMPLE BOARD** contains physical samples of 24 of the most popular fastener and holding components. The board includes such devices as PCB supports and guides, spacers, clamps, clips, bushings, perforated straps, wire ties, hangers, wire saddles, harness wrapping, grommets and idler pulleys. The sample board is available through any Richco representative or directly from the company. Richco Plastic Co., 5825 N. Tripp Ave., Chicago, IL 60646. Phone (312) 539-4060. **170**

**EVALUATION SAMPLES** of the first miniature latching reed switch, designated the MSLS-2, are available. The MSLS-2 is activated and latched by a one msec or longer pulse. Samples for evaluation will be mailed upon letterhead or telephone request. Quantity pricing starts at $2 in 1000 switch quantities. Hamlin, Inc., Lake Mills, WI 53551. Phone (414) 648-2361. **171**

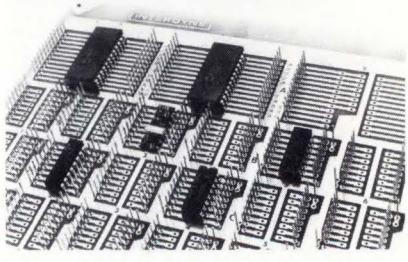
**NATURAL CONVECTION HEAT SINK,** P/N 435, is an economy unit designed for vertical mounting. Standard units are available either blank or with hole configurations for mounting TO-3 transistors. Thermal resistance at higher power levels ranges from 0.8°C/W to 0.65°C/W. Price in 500 piece quantities–approximately $2 each. Wakefield Engineering, Inc., Audobon Rd., Wakefield, MA 01880. Phone (617) 245-5900. **172**



**FREE SAMPLES** to qualified inquirers. 352 Series Free-Standing IC Terminals enable installed connections to be made for as little as 2¢ per IC terminal. Terminals will accept the rectangular leads of DIP type IC packages in addition to the round leads of popular discrete components. The square post accepts up to three levels of solderless wrap. Amphenol Industrial Div., 1830 S. 54th Ave., Chicago, IL 60650. Phone (312) 652-1220. **173**

**SUB-MINIATURE REED SWITCH** for keyboard systems is available. The DR302 is 0.675-in. long (excluding leads), 0.108-in. in diameter, with leads 0.022-in. in diameter. Maximum contact rating (dc resistive) is 5W (up to 0.5A; up to 50V). Imaging and Display Devices (ID²), General Electric Co., 316 E. Ninth St., Owensboro, KY 42301. Phone (502) 683-2401. **174**

**11 NEW LEDS ANNOUNCED.** The FLV107, measures only 0.80 × 0.50 × 0.100-in. The FLV108 is a large area light source with a clear diffused lens; the FLV111 and 112 emit wide angle red light. The FLV115 and 116 are plastic encapsulated lamps. The FLV117, 118 and 119 are wide-angle light sources. Prices range from $0.58 to $1.95 in quantities over 100. Semiconductor Components Group, 464 Ellis St., Mountain View, CA 94040. Phone (415) 962-3816. **175**



**LOW PROFILE INTEGRATED CIRCUIT CARD** can be wire wrapped and then converted to all printed circuit connections for high production. Because the ICs and wire wrap interconnections are on the same side, SLIM-WRAP cards may be placed closer together than other wire wrapped IC cards. The cards accommodate 44 ICs (14, 16, and 24 pin devices), based on an average allocation of one square inch per IC. Interdyne, 14761 Califa St., Van Nuys, CA 91401. Phone (213) 873-6510. **176**

**ADHESIVE/INSULATING BARRIER** for multi-layer printed circuits is a pressure-sensitive thermo-setting acrylic adhesive, coated on both sides of Nomex paper. Nomex provides the insulating barrier between circuit board layers. Two thicknesses are available: XP6 with a thickness of 0.0045 ± 0.0010, and XP7 with a thickness of 0.020 ± 0.001. Hexcel Corp., Trevarno Div., 11711 Blvd., Dublin, CA 94566. Phone (415) 828-4200. **177**

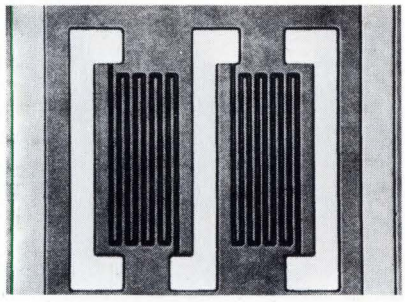

**FREE PRINTED STRIPS** help designers visualize appearance of displays. Sperry Information Displays Div., is now supplying printed, self-adhesive strips containing reproductions of displays digits and characters. The strips were developed to aid designers in visualizing the appearance of displays on prototype equipment and mockups. Copies are available from Sperry Information Displays Div., P.O. Box 3579, Scottsdale, AZ 85257. Phone (602) 947-8371. **178**

**HIGH BRIGHTNESS LED DISPLAY, THE MAN10,** uses a Gallium Arsenide Phosphide material of improved efficiency. The 0.27-in. high display has typical brightness of 500 ft. Lamberts at 10 mA. Packaged in a standard 14-pin DIP, the MAN10 is capable of displaying all digits from 0 to 9 plus nine distinct alpha characters. Pricing is $13 each (1-9), $10.75 (10-99), and $9 (100-999). Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, CA 95014. Phone (408) 257-2140. **179**

**CURRENT CONTROLLED RESISTORS** offer 5% tracking, 1000: 1 range. Model 500-104 and 500-105 current controlled resistor pair and quad modules consist of an LED control element and CdSe photo-resistors, selected and matched to track within ±5% from 1 kΩ to 1 MΩ. Maximum control current required is 20 mA at 1 kΩ. Price for the 500-104 is $18 and for the 500-105 $24. Radiation Devices Co., P.O. Box 8450, Baltimore, MD 21234. Phone (301) 665-2764. **180**

**PLASTIC-ENCASED SOLID TANTALUM** capacitors for mass production use on printed wiring boards come in single-ended cylindrical design which look like a large plastic transistor. Among the design features of the ECONOLINE" capacitors are a large flatted surface on the epoxy cases to permit clear and easy-to-read marking and a small top detent to provide easy identification of the positive leads. Standard capacitance ratings range from 100 μF to 0.1 μF. Sprague Electric Co., North Adams, MA 01247. Phone (413) 664-4411. **181**

## COMPONENTS/MATERIALS

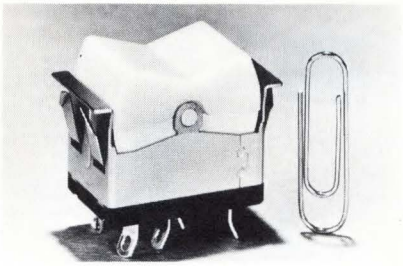


**TANTALUM NITRIDE CHIP RESISTORS** for hybrid applications offer up to 4 times the resistance previously possible on a standard 30-mil chip. These resistors feature a dissipation rating of 250 mW in the 30-mil size. All standard resistance values from 4.7 Ω to 2 MΩ are included in this line. Standard resistance tolerance is ±10%. On special order, resistances to ±12% can be provided. Semi-Films Technology Corp., Box 188, West Hurley, NY 12491. **182**

**PIEZOELECTRIC ACCELEROMETER** can operate to 900°F. Designated the Model 2276, it has an absolute charge sensitivity of 10.0 pC/g at 100 Hz. Charge sensitivity deviation due to temperature change is 7 to 15% from room temperature to 900° F. It is one in.-high, 0.625 in.-in diameter and has a 5/8 in.-hexagonal base. It weighs 25 grams and its mounted resonant frequency is 28 kHz. Endevco Dynamic Instrument Div., 801 S. Arroyo Pwy, Pasadena, CA 91109. Phone (213) 618-2401. **183**

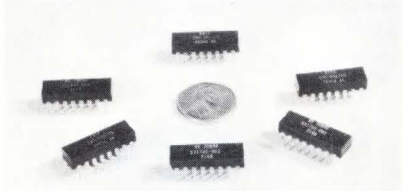
**TRANSISTOR SOCKET** accepts NPN/PNP plastic silicon power transistors. The molded nylon top portion of the socket allows direct panel or heat sink mounting and the spring brass contacts permit the use of transistors having either flat or round leads of 0.020 to 0.030 thickness. The contacts are available for either hand wiring or printed circuit board termination. All metal parts are plated for easy solderability. Keystone Electronics Corp., 49 Bleecker St., NY 10012. Phone (212) 475-4600. **184**

**PRINTED CIRCUIT BOARD** functions as heat sink and chassis. A chassis-like printed circuit board that combines the functions of circuit board, heat sink, and structural element in one component with the capability of dissipating an unprecedented amount of circuit power has been introduced by IERC. International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, CA 91502. Phone (213) 849-2481. **185**



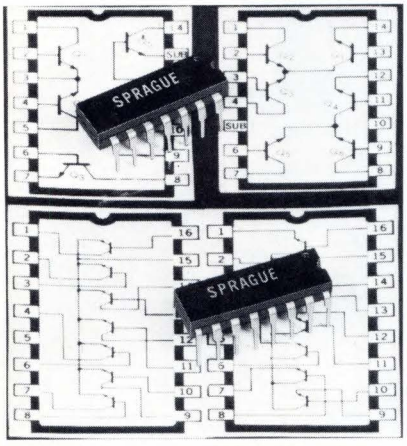
**ILLUMINATED SNAP-IN ROCKER SWITCHES** provide wide application flexibility, simplified mounting and easy bulb replacement. A twin lamp design permits illumination of either half of the entire rocker face. A three-terminal lamp circuit is electrically independent of the switch circuit. Bulbs are available in 6, 14, 18 and 28 volts. Cutler-Hammer, Inc., 4201 N. 27th St., Milwaukee, WI 53216. Phone (414) 442-7800. **186**

**SEVEN-SEGMENT LED DISPLAY** with a 0.6-in. character height is offered in two distinct fonts, the MAN6 and MAN66. The MAN6 font is similar to the MAN1, while the MAN66 is designed to conserve material and reduce costs. In orders of 100 or more pieces the MAN6 is priced at $17.50 and the MAN66 at $11.10 each. Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, CA 95014. Phone (408) 257-2140. **187**



**DUAL INLINE DELAY LINES,** the 'DipLine', offer impedances of 50, 100 and 200 ohms standard, with delay times of 50 to 150 nsec. Standard rise times range from 12 to 35 nsec. Up to 10 taps, and configurations of 14 or 16 pins are standard. Price is approximately $5 per unit in production quantities, with estimated delivery of four to six weeks after receipt of order. Vanguard Electronics, 930 W. Hyde Park, Inglewood, CA 90302. Phone (213) 678-7161. **188**

**LOW PROFILE DIP SOCKETS** are only 0.125 in. high. Incorporating 0.145 in. long pins for solder tail connection, these new sockets were designed for low-profile, high-density logic panels. Base material of the pins is Miller phosphor bronze with 0.000010 in. or 0.000050 in. gold plate over nickel. Insulators are black, glass-filled nylon. Circuit Assembly Corp., 3025 S. Kilson Drive. Santa Ana, CA 92707. Phone (714) 540-5490. **189**



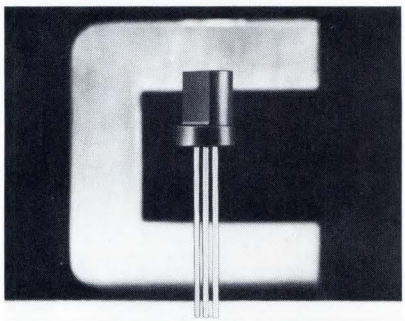

**MONOLITHIC TRANSISTOR ARRAYS** combine the attributes of silicon ICs with the flexibility of discrete devices. Types ULS2045H and ULN2046A consist of five NPN transistors, two connected as a differential pair; type ULN2054A has six NPN transistors connnected to form two independent differential amplifiers; and types ULN2081A and ULN2082A have seven NPN transistors connected in common-emitter and common-collector configurations, respectively. Pricing in quantities of 100-999 are: Type ULS2045H-$1.75 ea; type ULN2046A-$1.05 ea; type ULN2054A-$1.25 ea; and types ULN2081A and ULN2082A-$2.25 ea. Sprague Electric Co., Marshall St., North Adams, MA 01247. Phone (413) 664-4411. **221**

**ECL 10,000 HIGH-SPEED LOGIC FAMILY** now available from Signetics. The first ten integrated circuits in the high-speed "ECL 10,000" series of emitter-coupled logic elements includes many second-source equivalents for Motorola's MECL 10,000 series and a number of Signetics-originated 10,000 series designs. The 10161 and 10162 1-of-8 decoder/demultiplexers and the 10171 and 10172 dual 1-of-4 demultiplexer/decoders are Signetics originated. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **222**

**HIGH PERFORMANCE OP AMPS** are free of latch up. Two high slew rate op amps, the RM4531 and RC4531, provide the dc performance of the 741 op amp plus 30 V/$\mu$sec slew rates. The 4531 input stage retains small signal characteristics even when subjected to large differential input signals. The units feature offset null capacity and exhibit typical 1% settling times of less than 1.5 $\mu$sec, power dissipation of 165 mW and input impedance of 20 M$\Omega$. Raytheon Co., Semiconductor Div., 350 Ellis St., Mountain View, CA 94040. Phone (415) 968-9211. **223**

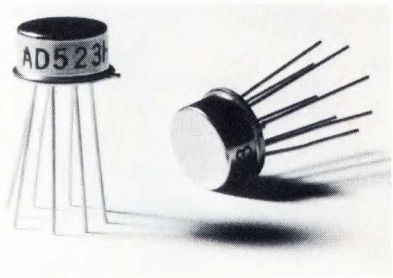
**DIELECTRICALLY ISOLATED DUAL TRANSISTOR** has 2$\mu$V/°C offset voltage drift. The monolithic dual transistor, designated the 114A/115A, offers $V_{OS}$ = 0.5 mV max. The dual 114A is for use with 45V power supplies, the 115A for 60V supplies. The 114A has a minimum $h_{FE}$ of 500 @ $I_C$ = 10$\mu$A) and the 115A has 250. Price for the 114A is $5.50 and the 115A is $4.50 each in 100-up quantities. Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. Phone (408) 257-5450. **224**

**CMOS TRIPLE AND-OR BI-PHASE PAIRS** introduced. CD4037A is intended for use in digital equipment where low-power dissipation or high noise immunity are primary design requirements. The CD4037A is currently available on a limited sampling basis in a 14-lead DIP ceramic package (CD4037AD). Price: $11.07 (1-24 unit level). RCA Solid State Div., Box 3200, Somerville, NJ 08876. Phone (201) 722-3200. **225**



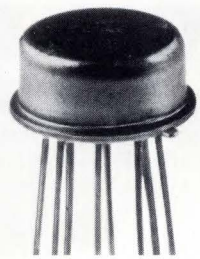
**PLASTIC PUT**s provide expanded range of programmability. The 2N6027 is a general-purpose device while the 2N6028 is specially designed for long interval timing circuits. Applications include: timing, pulse, and sensing circuits, SCR triggers and relaxation oscillators. Both models are available off-the-shelf. Prices are as low as 54¢ in 100-999 quantity. Unitrode Corp., 580 Pleasant St., Watertown, MA 02172. Phone (617) 926-0404. **226**

**7-STAGE FREQUENCY DIVIDER IC,** the DM8410N, is a monolithic integrated circuit created by means of standard bipolar techniques and especially developed for use as a frequency divider for electronic organs. Seven flip-flops connected in 5 groups are housed on one silicon chip: The input and the output of each flip-flop are externally accessible. Price: 1-24, $4.50 each. European Electronic Products Corp., 10180 W. Jefferson Blvd., Culver City, CA 90230. Phone (213) 838-1912. **227**



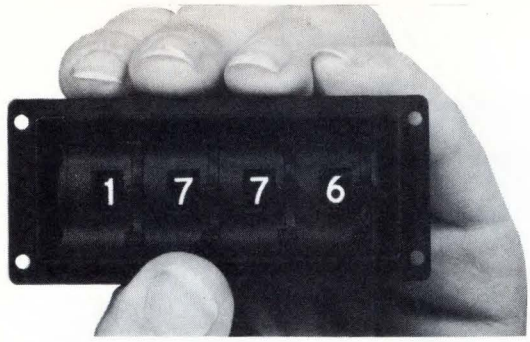

**SUB-PICOAMP FET IC OP AMP,** the AD523, achieves a maximum bias current of 0.25 pA in the "L" version under warmed-up conditions and slews at the rate of 3V/$\mu$sec. The unit achieves its low bias current by combining matched, small-geometry J-FET chips with a specially designed monolithic thin film chip in a low leakage TO-99 package. The 100 piece price of the AD523 is $18.75 (L version). Analog Devices, Inc., Route 1, Industrial Park, P.O. Box 280, Norwood, MA 02062. Phone (617) 329-4700. **228**

**MOS SHIFT REGISTER** has 10 MHz rate. The new 1024-bit multiplexed dynamic shift register, designated HDSR 1024, utilizes ion implantation to minimize gate overlap capacity and thereby achieves its high shifting rate. Power dissipation is typically 150 mW at 25°C for 5 MHz operation with 25% duty cycle clocks. The HDSR 1024 is priced at $20 in quantities of 100. Hughes Microelectronic Products Div., 500 Superior Ave., Newport Beach, CA 92663. Phone (213) 670-1515. **229**



**MICROPOWER OP AMP** has more than double the voltage and operating temperature range of its prototype. This device, designated the CA3078AT, and having a supply voltage range from ±0.75V to ±15V is the premium version of the previously announced CA3078. The CA3078AT features a reduction in maximum input-offset voltage (5 to 3.5 mV), input-offset current (32 to 2.5 nA) and input bias current (170 to 12 nA) as well as a 4-dB increase in minimum open-loop voltage gain (from 88 to 92 dB).

The CA3078AT is hermetically sealed in 8-lead TO-5 style package and priced at $4.95 (1000-unit level). RCA Solid State Div., Box 3200, Somerville, N J 08876. Phone (201) 722-3200. **230**




# The infinity switch

Series-1776 EECoSWITCHES are rotary thumbwheel switches available in a near-infinite variety of configurations.

Features include:

- 38 standard codes
- 8, 10, and 12 positions
- component mounting provisions
- double-width message switches
- lighting
- black, grey or white colors
- field-adjustable stops
- mother-board compatible terminals
- four standard mother boards
- up to 4 poles per switch
- EECo's exclusive 2-year warranty

And — with prices as low as $3.00 for single units — the application possibilities are infinite too!

**Free** Want full data on the widest line of thumbwheel switches in the industry? Request our 12-page brochure.

**Electronic Products Division**
**Electronic Engineering Company of California**
1441 East Chestnut Avenue, Santa Ana, California 92701
Telephone: (714) 547-5651
Dist. by: G.S. Marshall — Hall-Mark — Schweber

CIRCLE NO. 31


# Profit Through Quality

*By Sidney Weinberg*

A practical guide to help production and general managers analyze quality and reliability policies for their companies. The author discusses the basic requirements for a Q and R policy and shows how and where to use them to increase profits.

CONTENTS: Profit in Quality and Reliability; Basic Requirements of Q and R Policy; Human Contribution to Quality; Increasing the Proportion of Good Quality; Standardization and Specification; Role of Inspection; Development I: Innovation and Improvement; Development II: Increase in Reliability; Purchase of Quality.

Order now. If you are not convinced that this book will help improve your company's profits, return within 15 days for full refund or credit.

Illus. 192 pp. $10.95

**Cahners BOOK DIVISION**
**89 Franklin St., Boston, Mass. 02110**

## looking for a....

# LOW COST HIGH QUALITY POPULAR SIZE

## ....ceramic capacitor?

Well, look toward USCC/Centralab.

Our Mono-Kap™, a radial lead, epoxy coated monolithic ceramic capacitor could be the answer. They're available in six sizes from .100 x .100 to .500 x .500 in NPO, W5R, Z5U and Y5V dielectrics. Capacitance values range from 4.7pF to 10Mfd in 50, 100 and 200 VDC ratings.

USCC/Centralab has developed highly automated assembly techniques for Mono-Kap and our other ceramic capacitor products—from raw materials to chip capacitors to leaded capacitors with no sacrifice to quality. All this makes possible the fastest delivery in the industry on the wide variety of USCC components. Ask us, we'll give you our best.

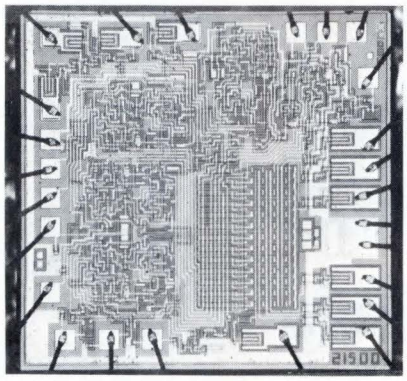

For FREE Mono-Kap evaluation samples, write on company letterhead to USCC/Centralab, 2151 N. Lincoln Street, Burbank, California 91504. For complete technical data on Mono-Kap, and a FREE copy of our Ceramic Capacitor Catalog, circle the information retrieval number below.

USCC
U.S. CAPACITOR CORPORATION

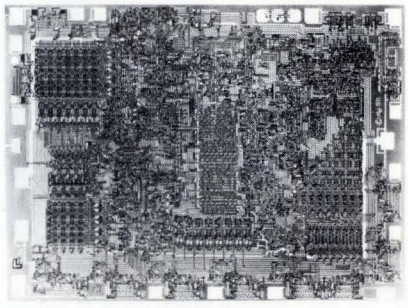
CENTRALAB
Electronics Division • GLOBE-UNION INC.

CIRCLE NO. 45


**VIDEO AMPLIFIER IC** tolerates high Q circuits on input. A new wideband video amplifier IC with two stages, a differential input, and a differential output is now available for use as a tape head amplifier in video recorder systems and as a video or pulse amplifier. The price for the "SE592K" (−55°C to +125°C) is $3.80 each when ordered in a quantity between 100 and 999. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **231**



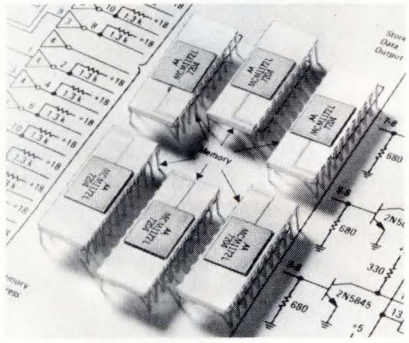
**BIPOLAR 7-SEGMENT DISPLAY DRIVER** has BCD data output. The HD-0140 monolithic 4-bit latch/decoder/display driver provides a high-speed, high-current data handling capability for LED and other types of numerical displays. Typical data rate is 10 MHz. A single +5V power supply is required for the entire circuit. In 24-pin ceramic DIPs, it is priced in 100-to-999 quantities at $7.55 for the commercial version and $11.25 for the military version. Harris Semiconductor, Melbourne, FL 32901. Phone (305) 727-5430. **232**



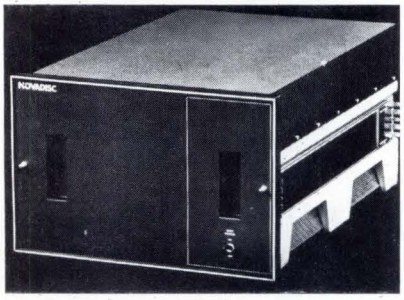
**COMPUTER ON A CHIP** handles large volumes of data. Type 8008 CPU combines with Intel RAMs, ROMs and shift registers to create MCS™ −8 computer systems. The CPU is a P-channel silicon-gate MOS circuit containing an 8-bit parallel adder, six 8-bit data registers, an 8-bit accumulator, two 8-bit temporary registers, four flag bits and eight 14-bit address registers. Price: $90 in 100-piece quantities. Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501. **233**

**GENERAL-PURPOSE OP AMPS,** the CA3458T, CA3558T, and CA3747 Series (dual types) and CA3741 and CA3748 Series (single types), feature output short-circuit protection, latch-free operation, wide common-mode and differential-mode signal ranges, and have offset voltage nulling capability. Each type incorporates a differential-input amplifier to effectively drive a gain- and level-shifting stage having a complementary emitter-follower output. RCA/Solid State Div., Rte. 202, Somerville, N J 08876. Phone (201) 722-3200, Ext. 2561. **234**

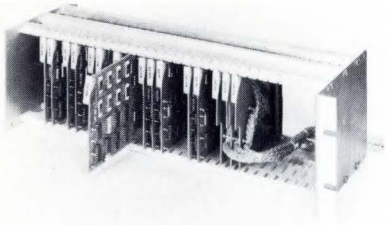




**TWO DYNAMIC RAMS.** The MCM1172L and the MCM1175L MOS RAMs are 1024-bit memories with a wired-or capability for memory system expansion. Power dissipation of the 1172 is 75 μW/bit, with access time of 350 nsec. Access time for the 1175 is 150 nsec. Price in quantities of more than 100 is $11 ea. for the 1172, and $12.10 ea. for the 1175. Motorola Inc., Semiconductor Products Div., P.O. Box 20924, Phoenix, AZ 85036. Phone (602) 273-6900. **235**



**FIXED-HEAD DISCS FOR MINIS.** The Novadisc has storage capacities of 128K, 256K, 512K and 768K 16-bit words. It incorporates reliability innovations like an air bearing which prevents damage or data loss from typical head bumps or vibrations, and read-write heads that are retracted when the unit is not operating. Cost is $5200 for a 128K words up to and $12,560 for 768K. Data General Corp., Southboro, MA 01772. Phone (617) 485-9100. **236**

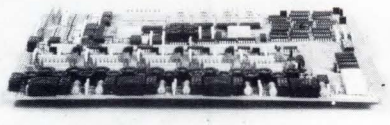


**BIPOLAR RAM SYSTEMS SPORT 150 NSEC CYCLE TIMES.** Offered in very high speed configurations-MONOSTORE II bipolar RAM systems have capacities of 256 words to 16K words with bit lengths from 1 to 96. Multiple units are combined for larger capacities. I/O is TTL compatable and is available through paddle cards. Units operate from a +5VDC power supply only. Price for a 4K × 24 is 9¢/bit in single quantity. Monolithic Systems Corp., 2700 So. Shoshone, Englewood, CO 80110. Phone (303) 761-2275. **237**

**LOW-COST INSTRUMENT-COMPUTER INTERFACE.** The DATASPAN 410 coupler converts instrument decimal or BCD output directly into computer, terminal or teletypewriter language. Programmable line formatting is standard, up to 10 digits per word and 10 words per line. Input level is DTL/TTL compatable. It can accommodate either high or low true logic. Price: $995. Ambient Systems, Inc., 3020 Scott Blvd., Santa Clara, CA 95050. Phone (408) 247-4400. **238**

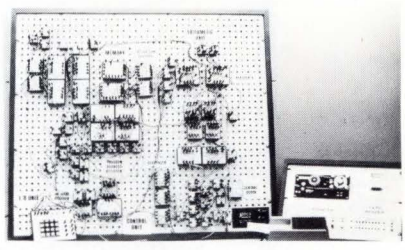
**MICRO-MINICOMPUTER SELLS FOR UNDER $1000.** The Star System 4 features up to 32K bits of programmable ROM which can be erased and reprogrammed in the field and a maximum of 5K bits of RAM. The basic controller's (C.P.U.) 45 instructions with a 10.8 μsec instruction cycle time includes 15 I/O and memory access instructions, 16 machine instructions and 14 accumulator group instructions. It can handle both analog and digital I/O in increments of 16 lines. Comstar Corp., Edina, MN 55435. Phone (612) 941-4454. **239**

**"MOS" ENCODED KEYBOARDS FEATURE "N" KEY ROLLOVER AND LOW COST.** The keyboard assembly is offered with standard reed switch contacts or the new low cost BI-PAC switches. 9-channel capability permits 64 distinct coded positions or less. Also featured is automatic repeat capability, externally selectable odd of even parity, error signal output, built-in electronic shift lock and positive or negative logic and level or pulse strobe. Price is $100 in 1000 qtys. Controls Research Corp., 2100 So. Fairview, Santa Ana, CA 92704. Phone (714) 557-7161. **240**



**COMPLETE 8K × 20 MEMORY SYSTEM ON ONE BOARD.** DR-101 memory system includes data and address registers and all timing and control. Cycle and access times are 650 and 290 nsec respectively. Two voltages (+5 and −18) are required. The single board is also available as a 4K system. 8K modules can be bussed in parallel to expand to 64K × 20. In 100 quantity, the 8K module is less than 1.0¢/bit. Dataram Corp., Princeton-Highstown Rd., Cranbury, NJ 08512. Phone (609) 799-0071. **241**

**COLOR IMAGING SYSTEM FOR COMPUTER DISPLAYS.** Spectrovision produces full color, gray scale and color-coded images from common digital sources giving a flicker-free display using color hue, saturation and luminescence for improved visual discrimination of 3-D subject matter. It provides massive data reduction in real time and enables the operator to quickly assign and re-assign color values; and to correct, compensate or re-scale displayed values on all 3 axes (X, Y, Z). Aerojet-General Data Systems, 9200 E. Flair Dr., El Monte, CA 91734. Phone (213) 572-6285. **242**



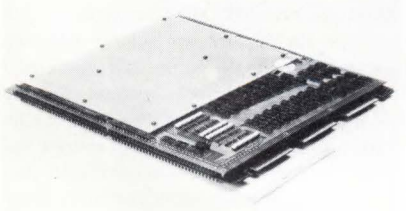
**VISIBLE COMPUTER IS USEFUL FOR COMPUTER DESIGN AND TEACHING.** Model 40 is ideal for teaching computer fundamentals, digital techniques, computer design, and machine language programming on all levels as well as design projects. All functions are performed by patented plug-in Logicubes. Typical Logi-cubes are registers, adders, memory, flip-flops, gates, etc. Standard TTL circuits permit direct connection to most computer peripherals. Price: $3995. Adtech Inc., P.O. Box 10415, Honolulu, HI 96816. Phone (808) 941-0708. **243**

**COMPACT CORE MEMORY HAS 250 NSEC ACCESS TIME.** The memory stores more than 1000 bits of data/cu. in. The modular 1860 priced at less than $.015 per bit in quantity offers a full cycle time of 600 nsec. 1860 systems can be expanded from 8192 to 65,526 words of 18 bits or up to 32,768 words of 36 bits. The compact Ampex memory uses 18-mil cores in 3-wire, 3-D configurations. Ampex Corp., 13031 W. Jefferson Blvd., Marina del Rey, CA 90291. Phone (213) 821-8933. **244**

**NEW MINIS CUT PRICE, IMPROVE PERFORMANCE.** The 620/f-100 with 32K words of core drops from $33 to $27 thousand and includes memory protection, extended arithmetic unit, real time clock and power failure/restart. The new 620/L-100 is 90% faster (950 nsec cycle time vs 1.8 msec), and includes as standard equipment, hardware multiply/divide, real time clock, power failure/restart and priority interrupts-8 levels standard, expandable optionally up to a maximum of 64 levels. Varian Data Machines, 2722 Michelson Dr., Irvine, CA 92664. Phone (714) 833-2400. **245**

**NEW PRODUCTS CUT PDP-11 MINICOMPUTER SYSTEM PRICES.** The lower prices were made possible by the introduction of two new DEC-manufactured memory systems. RK05 DECpack cartridge disk drive is priced at $5100 compared to $8000 for the previous similar unit it replaces. The redesigned ME11-L 8K core memory system is priced at $5200 with add-on incremental 8K memory units at $4400 each, up to the 24K capacity of the system. Previous DEC 8K core cost $7500. Digital Equipment Corp., Maynard, MA 01754. Phone (617) 897-5111. **246**

**INTERACTIVE GRAPHICS SYSTEM OPERATES WITH IBM SYSTEM/360 OR 370.** Adage Graphics System/370 can be used with the IBM System/360 or 370 in several ways: as an IBM 2250 Model 1 emulator; as a display unit; or as a remote job entry graphics terminal. The system can transfer 50K cps, has the built-in ability to rotate and otherwise move the displayed information, has msec cycle time, stores 30-bit words in core and 40.5 million bits in disk. Adage, Inc., 1079 Commonwealth Ave., Boston, MA 02215. Phone (617) 783-1100. **247**



**CORE MEMORY CONSUMES LOW POWER.** This 3W, 3D core memory offers a cycle time of 1.2 μsec and accesses at 550 nsec. Worst case power consumption is 0.11 mW/bit in a 65K × 40 system configuration. The MICROMEMORY 6000 is available from 16K to 65K words by 40 bits and from 32K to 131K words by 20 bits. Field expansion of the memory capacity can be made available by the addition of pluggable stacks and pc boards. Electronic Memories, 12621 Chadron Ave., Hawthorne, CA 90250. Phone (213) 644-9881. **248**

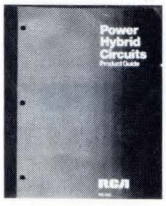

**MAGNETIC TAPE SYSTEM ADDS POWER AND FLEXIBILITY TO MINICOMPUTERS.** The CartriFile 40 can read or write up to 18K bps on any of its four tapes—and can simultaneously loadpoint-search the others. It comes complete with read, write, and controller electronics and uses endless-loop, single-tape cartridges. Four 150-foot cartridges can store nearly 13 million bits of data. Typical prices are $4950 with interface, $3015 in small OEM quantities (without interface). Tri-Data Corp., 800 Maude Ave., Mountain View, CA 94040. Phone (415) 969-3700. **249**

**NEW INTERFACE LINKS PRINTER/KEYBOARD WITH MOST MINICOMPUTERS.** The interface control unit enables the Tycom 35/37 typewriter unit to operate on the external I/O bus of such minicomputers as the PDP-8, Nova, and almost all other standard series. Programmed data transfers in 92-character modified ASCII code occur at 15.5 cps. The TYCOM 35/37 terminal including ASCII interface control is priced at $1070 Terminal Equipment Corp., 750 Hamburg Tpke., Pompton Lakes, N J 07442. Phone (201) 839-3000. **250**

**TV-COMPATIBLE INTERACTIVE GRAPHICS TERMINAL.** CONOGRAPH-12 uses a video monitor for image display and is fully compatible with standard signals for closed circuit TV. It is fully interactive and provides the user with the ability to selectively erase and update a line, curve segment or character at any place on the screen. It is built around a CONOGRAPHIC generator which provides capability for vectors and points, and also provides capability for general (conic) curves, ellipses and circles. Price is $10,900. Conographic Corp., 6 Gill St., Woburn, MA 01801. Phone (617) 935-7300. **251**

# LITERATURE


**HIGH PERFORMANCE LUBRICANTS** are described in a new folder. The four-page brochure describes many specialty lubricants, ranging from aerososl sprays and liquid suspensions to exotic powders. These lubricants are fortified with a variety of heavy metal sulfides and selenides, notably those of molybdenum and tungsten, and characterized by their very low coefficients of friction. Bemol Corp., P.O. Box 126, Willimantaic, CT 06226. **252**




**POWER HYBRID CIRCUITS** are described in a new product guide. The "RCA Power Hybrid Circuits Product Guide," PHC-600, contains abbreviated data on linear amplifiers with current capabilities up to 7A, series voltage regulators for 5, 12 and 15V with 1 and 3% regulation, Darlington circuits with current gains of 650 minimum at 2A, high-current output arrays, and "building blocks." RCA Solid State Div., Box 3200, Somerville, N J 08876. Phone (201) 722-3200. **257**


**"7900 FAMILY" OSCILLOSCOPES** providing 1 GHz via direct CRT access and 500 MHz real-time system are described in "TEKTRONIX" 7900 Family" brochure. Versatility of the family is afforded with 24 plug-in's, including the 525 MHz 7D14 Digital Counter. Also discussed in this 8 page brochure are a scope camera and a Writing Speed Enhancer that permit a writing speed of 25 cm/nsec. Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **262**

**TIME-SHARING INDUSTRY DIRECTORY.** A comprehensive buyers guide for the users of remote-access computing details services offered by 142 companies. It includes a 440-page update which tells who has what, where, how you can use it, and costs. A one-year subscription is $185, including updates and the monthly TIME-SHARING TODAY newsletter. Time-Sharing Information Services, Inc., 3401 Science Center, Philadelphia, PA 19104. **253**

**NEW GLOSSARY OF COMPUTER TERMS.** A new revised and updated pocket size Glossary of Computer Terms is now available free from General Automation, Inc. The Glossary also includes definitions of computer acronyms frequently encountered in the computer industry. Copies may be obtained by writing on your letterhead to Dept. A./S.P., General Automation Inc., 1055 South East St., Anaheim, CA 92805. **258**

**ANALOG DEVICES' 1972 PRODUCT GUIDE.** This 180-page book is prepared for the designer of instrumentation and systems which accept, analyze, process, convert and react to analog signals. It has complete descriptions and prices of Analog Devices' lines of converters, amplifiers, linear ICs, digital panel meters, function modules and accessories. Analog Devices, Inc., Box 280, Norwood, MA 02062. **263**

**HIGH-VOLTAGE TEST EQUIPMENT** is illustrated and described in a 30-page catalog. Included are 1-to-300-kV ac and dc power packs, power supplies and test sets for dielectric strength, breakdown, leakage, corona and continuity tests. Peschel Instruments, Inc., 1412 Viscaya Pkwy, Cape Coral, FL 33904. **254**

**SWITCHCRAFT'S 1972 SHORT-FORM CATALOG** lists over 6000 mechanical electro-mechanical components. The catalog lists phone jacks and plugs, lever, slide and pushbutton switches, connectors and audio accessories. Switchcraft, Inc., 5555 N. Elston Ave., Chicago, IL 60630. **259**

**TEKTRONIX'S LATEST PRODUCTS,** all introduced since March 1971, are described in a 76-page catalog. In addition to scopes, other products listed include automated test systems, computer display terminals, machine-control products and TV test instruments and monitors. Tektronix, Inc., Box 500, Beaverton, OR 97005. **264**

**MODEL 600 CARD READER** from Tru Data Corp. is described in a brochure. The card reader is said to provide virtually error-free read rates of up to 600 cards/minute, at a fraction of the cost of other OEM readers with comparable speeds. The brochure discusses the card reader's operation, performance and specifications. True Data Corp., 2172 Dupont Dr., Irvine, CA 92664. **255**

**DIGITAL CASSETTE RECORDER** Model 240 from Bell & Howell is described in a 12-page brochure. Included in the brochure are graphic descriptions, photos and diagrams illustrating the 240's precision and reliability, advantages over upgraded audio systems, applications examples and specifications. Bell & Howell's Electronics & Instruments Group, 360 Sierra Madre Villa Ave., Pasadena, CA 91109. **260**

**ELECTRONIC CABINETS** for cooling a wide variety of instruments are listed in a 28-page catalog and design guide. The guide contains cooling enclosures housing electrical or electronic equipment. Included are design tips on air intake and exit design, baffles, vibration, location recommendations and a helpful blower selection nomograph. Kooltronic, Inc., Box 504, Princeton, N J 08540. **265**

**BATTERY POWERED TWO-CHANNEL RECORDER,** Brush Model 222, is described in a bulletin. The general-purpose recorder with an internal battery supply and charger can be used independent of external power sources as well as from them. Described in the four-page, illustrated bulletin are features, detailed specifications, ordering information, accessories and supplies. Gould Inc., Instrument Systems Div., 3631 Perkins Avenue, Cleveland, OH 44114. **256**

**SERVO RECORDERS** from the Esterline Angus line of Speed Servo II single and two-channel crossover 10-in. recorders are shown in a six-page bulletin. Strip chart units described offer response speeds faster then 0.3 sec full scale with 0.5-mV spans, wireless linear feedback potentiometers and throw-away writing systems. Esterline Angus, Div. of Esterline Corp., Box 24000, Indianapolis, IN 46224. **261**

**AUDIO SPECTRUM ANALYZER MODEL 99A600** from DuKane Corp. is described in a brochure. The brochure discusses the two principal areas of application for the device: in sound-equalizing procedures and as a permanently installed test instrument. It includes complete equipment specifications and installation photographs. Communications Systems Div., DuKane Corp., 2900 DuKane Dr., St. Charles, IL 60174. **266**


**MINIATURE PC SOCKET** which provides repeated pluggability for ICs, LSIs, lamps, transistors, LEDs and other components is described in a new bulletin. According to the bulletin, one size of this low-profile socket (which is known as the MINISERT) will accept round leads ranging from 0.012 in. to 0.022 in. diameter, or flat leads 0.008 in. to 0.015 in. thick by 0.015 in. to 0.023 in. wide. Berg Electronics, Inc. New Cumberland, PA 17070. Phone (717) 938-6711. **267**

**MODEL 2248 CAMAC MULTI-ADC,** a newly introduced instrument from LeCroy Research that combines eight complete gated 8-bit a/d converters in a single-width CAMAC module is described in a data sheet. Specifically designed to digitize photomultiplier pulses and similar fast-transient signals, the bilinear Multi-ADC accepts and digitizes nano-second pulses directly without need for prior stretching or pre-shaping of any kind. LeCroy Research Systems Corp., 126 N. Rte 303, W. Nyack, NY 10994. **268**

**PHYSICAL TEST EQUIPMENT** is illustrated in a new brochure entitled "Environmental Simulation for Physical Testing." Described are temperature chambers incorporating special accessory features and designed for use in conjunction with tensile test equipment to simulate the environments needed. Adapted to various models of physical test equipment, low temperatures can be accomplished with mechanical refrigeration, $CO_2$ or liquid nitrogen. Cincinnati Sub-Zero Products, Inc., 2612 Gilbert Ave., Cincinnati, OH 45206. **269**

**MULTI-FILM FILTERS** for light control in the UV, visible and infrared regions of the spectrum are featured in a new catalog. Described are optical coatings used to generate color, eliminate reflections, control heat in optical systems, isolate spectral lines and provide visible blocking in covert imaging systems. Also described are color-correction coatings, neutral-density filters and laser mirrors. Vacuum Coating Div., Bausch & Lomb, 10 Champeney Terrace, Rochester, NY 14605. Phone (716) 232-6000. **270**

## LITERATURE


**THE 1972 INSTRUMENT RENTAL CATALOG** from Rental Electronics is available. The 60-page booklet contains the specifications and rental prices for more than 25 different kinds and hundreds of different models of electronic test and production equipment, available from nine "instant inventory" centers throughout the United States and Canada. Rental Electronics, Inc., 16600 Oakmont Ave., Gaithersburg, MD 20760. **306**

**P-I-N DIODE SWITCH** literature describes the latest additions to General Micro-wave's expanding line of ultra-broadband p-i-n diode control devices—a sp2t and a sp4t switch. Both units feature continuous coverage from 200 MHz to 18 GHz with minimum isolations as high as 60 dB. A switching speed as fast as 200 nsec is also featured. General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. **307**

**FIVE SERIES OF D/A CONVERTERS** are described in a four-page brochure. All electrical and mechanical specifications and performance and application data are listed. The low-cost and moderate-performance units are designed for use in low-cost single-channel A/D converters, CRT display and servo drivers, data transmission via modems, programmed/feedback control systems and digital frequency synthesizers. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **308**

**A BLOWERS AND FANS** catalog details complete information on a line of standard assemblies within a 4-to-140-CFM output range. Technical information includes photos, engineering drawings, performance curves (CFM vs static pressure) and engineering data. Ripley Co., Inc., Middletown, CT 06457. **309**

**POWER-SUPPLY MODULES** from Power/Mate are shown in a new 60-page catalog. Included in the catalog are many recently introduced power-supply modules, high-performance laboratory models, as well as various standard off-the-shelf supplies. The product line consists of over 32,600 models. Power/Mate Corp., 514 S. River St., Hackensack, N J 07601. **310**

## SALES OFFICE


**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 02110**
Richard Parker, District Manager
Hal Short, District Manager
89 Franklin St.
(617) 482-6786.

**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 Towers—Suite 815
Atlanta, Georgia
(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
Harry Fisher, District Manager
5670 Wilshire Blvd.
(213) 933-9525

# Application Notes

**NEGATIVE THERMISTOR LINE** is described in a new brochure. The thermistors are designed for industrial and consumer applications ranging from temperature measurement to electrical circuit temperature compensation. Easy to follow charts offer thermistor dimensions as well as characteristics at values from 4Ω to 500 kΩ. Brochures are available from HB Dept., Siemens Corp., 186 Wood Ave. S., Iselin, N J 08830. Phone (201) 494-1000. **296**

**MOS/LSI CATALOG** provides complete specification data for all National MOS RAMs, ROMs, shift registers, clock drivers, analog switches, character generators, code converters and logic elements. The catalog also contains application notes and briefs for a variety of MOS functions. National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051. Phone (408) 732-5000. Ext. 6106. **299**

**THE LATEST CALIBRATION TABLES FOR THERMOCOUPLES** just released by the National Bureau of Standards are available from Omega Engineering. Its new CT-3 thermo-couple calibration tables and alloy data reference book contains calibration tables for all thermocouples in use in industry. These new tables supersede all tables listed in NBS circular #561. Omega Engineering, Inc., Box 4047, Stamford, CT 06907. **302**

**APPLICATION REPORT ON MOSFET FM TUNER** design, bulletin CA-164, is eight pages, and provides test data and helpful hints on designing with the 3N201 dual-gate MOSFET at 100 MHz. Technical guidelines including dc considerations are given for a 100-MHz radio-frequency (RF) amplifier and for a mixer. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, TX 75231. Phone (214) 238-2011. **297**

**NEW TIME CODE FORMAT REFERENCE BOOK** from Datum, Inc., contains a complete reference of time code formats. The book gives drawings and characteristics of about two dozen of the most commonly-used codes, including the IRIG standards, NASA, various range codes and special serial codes. A glossary of terms, abbreviations and references are included. Datum, Inc., Timing Div., 170 E. Liberty Ave., Anaheim, CA 92801. **300**

**S/D AND D/S CONVERTERS** are described in an eight-page brochure. Termed TRIGAC (for trigonometric analog converters), these units are presented in three basic models, with diagrams and characteristics tabulations for each. The brochure concludes with a section on typical converter applications. Kearfott Div. of the Singer Co., 1150 McBride Ave., Little Falls, N J 07424. **303**

**HIGH-PERFORMANCE TRACKING A/D CONVERTERS.** An 8-page application note provides complete details on the design, construction and performance of a compact, high-performance 8-bit tracking A/D converter costing less than $30. Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, CA 95050. Phone (408) 246-9222. **298**

**SILICON READOUT CELLS** are described in technical information bulletin RC-72, which offers the designer practical information on electrical and mechanical design. The Bulletin lists a wide range of "standards," including scribed and etched cells with from 2 to 12 segments in both P-on-N and N-on-P configurations. M7 Inc., Optoelectronics Group, 210 Campus Dr., Arlington Heights, IL 60004. Phone (312) 255-7796. **301**

**SOLID-STATE PUSHBUTTONS** are described in a new brochure. The full line of solid-state pushbuttons derived from work with Hall-effect keyboard switches is included in product brochure "SN" which lists features, applications, switching concept, operating characteristics, and general calculations for interfacing. It describes lighted and unlighted direct printed-circuit board mounting modules. Micro Switch, 11 W. Spring St., Freeport, IL 61032. Phone (815) 232-1122. **304**

# REFERENCE COPIES AVAILABLE

**Reference copies of the following articles are available without charge:**


| R.S. NO. | TITLE | PAGE NO. |
|---|---|---|
| **161** | Keyboards—The indispensible link between man and machine | 26 |
| **162** | Build a high-accuracy waveshaping circuit | 36 |
| **163** | BASIC language programs generate root locus plots | 40 |
| **164** | Graphs yield circuit Q for gyrators and other reactive elements | 45 |

## ADVERTISERS INDEX


Acopian Corp. ..... Cov. II
Adams & Westlake Co. ..... 65
Alco Electronic Products, Inc. ..... 78
Allen-Bradley Co. ..... Cov. III
Alpha Industries, Inc. ..... 71
Analog Devices, Inc. ..... 38
BASF Wyandotte Corp. ..... 43
Barber-Colman Co. ..... 59
Beckman Instruments, Helipot Div. ..... 11
Bendix Corp., Electro-Optics Div. ..... 75
Bird Electronic Corp. ..... 70
Bodine Electric Co. ..... 53
Bourns, Inc. ..... 18
CTS Corp. ..... 22
Cambridge Thermionic Corp. ..... 78
Centralab Distributer Products ..... 71
Cherry Electrical Products, Inc. ..... 44
Columbia Research Laboratories, Inc. ..... 59
Computer Design Corp. ..... 12-13
Corning Glass Works, Electronic Products Div. ..... 6-7
Circuit Technology, Inc. ..... 63
EECO ..... 69
Fairchild Semiconductor ..... 24-25
Harrington & King Perforating Co. ..... 73
Heinemann Electric Co. ..... 67
Hewlett-Packard ..... 2, 39, 15-16, 61
Hope Electronics ..... 71
Janco Corp. ..... 58
Kulka ..... 56-57
Printact ..... 64
RCA Solid State Div. ..... 34-35, Cov IV
Sangamo Electric Co. ..... 23
Sprague Electric Co. ..... 10
T-Bar, Inc. ..... 62
TRW, Cinch Connectors ..... 3
Tektronix, Inc. ..... 8
Therm-O-Disc, Inc. ..... 66
Texas Instruments Incorporated ..... 4
Torin Corp. ..... 1
USCC/Centralab ..... 69
West Coast Manufacturing Corp. ..... 76

# signals and noise

## It's the principle involved

Dear Sir:
I really don't think you have perceived the point in your editorial "Mirror, mirror on the wall" (EDN, April 15). In it you objected to those who criticized an AMA publication for running a photo of a person wanted by the FBI.

While it is true that acne is not perhaps a deadly affliction, and perhaps on that basis alone this advertisement could be justified, still the principle to which I shall advert exists.

I do not think that you would question the right of anyone to medical service for a disease, especially a deadly one. Even criminals who have been convicted are entitled to medical service as a right. Suppose, now, that a person wanted for questioning suffered from a heart ailment, and that person avoided medical care because he might be prosecuted or feared prosecution for nonpayment of alimony (which would be a contempt-of-court action usually sanctioned by a short term of imprisonment). The penalty for fleeing alimony thus could be death.

What difference in principle is there between requiring a doctor to report and requiring a lawyer to report if a fugitive comes seeking legal advice? At least with the situation in its present state, a fugitive may come to a doctor or lawyer and may have some good advice proffered, whereas in the "complete reporting" situation, the person who is wanted or who thinks he may be wanted has to do the best he can without medical or legal aid.

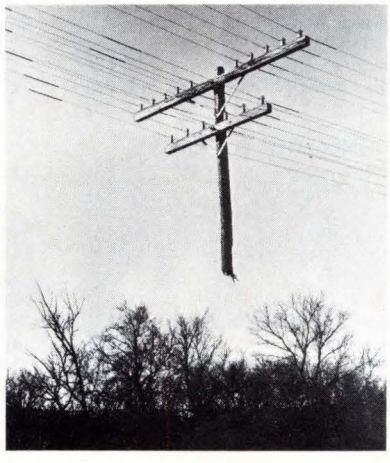
I would rather be able to make a complete disclosure to my doctor or lawyer so that I may have the best service he can give. And as I understand the legal underpinnings of this nation, that is my right.
*William A. Weise*
*Southampton, Pa.*

## The refrigerator paradox

Eddie engineer, BSEE '72, has just been confronted with his first practical problem. Dashing to the refrigerator for a beer during the midnight break of the Tonite Show, he painfully discovers that when he places one hand on the refrigerator handle and the other on the grounded sink, he receives quite an unpleasant shock. A quick check with a VOM shows that full line voltage is indeed present. Eddie realizes that there must be a short in the refrigerator and being aware of the fact that one side of the power line is ground, he pulls the plug and turns it around. However, much to Eddie's chagrin, the meter still reads full line voltage! Can you offer any help to Eddie?
*Sincerely,*
*Dennis R. Morgan*
*Electronics Laboratory*
*General Electric Company*
*Syracuse, N.Y. 13201*

## OK! Who's the wise guy?

Northwestern Bell people in Galchutt, N.D., are still wondering what happened to the bottom of this telephone pole. The case was unsolved after a three-week investigation that produced only one solid answer: Telephone wires are stronger than they look.



## Reader protests oversimplification

Dear Sir:
During the past few months I have read several articles in EDN on active RC networks, the most recent of which appeared in the March 15th issue (pg. 53). The title "Design Complete Active Filters with these Few Equations" is typical of the kind of article to which I am referring.

Nothing presented is new or novel; the reader is only falsely led to believe that active RC network synthesis is a snap, just follow the cookbook directions. Nowhere is active or passive element sensitivity even mentioned or the effect of the active element roll-off (which all active elements exhibit) on network response. How about element value spread? It turns out to be pretty wide for the unity-gain configurations shown in Tables 1 and 2.

These networks have been around for 15 years, and others have assembled them into the obvious cascaded configurations to realize the common multi-pole filter functions long ago.

I feel that any time an engineer writes an article on any active filter, he had better give complete sensitivity analysis as well. Active RC filter theory is a whole new ball game, and poles are no longer limited to left half plane positions. The root locus in Table 2 of the heretofore mentioned article not only indicates this but also indicates that the poles approach the $j\omega$ axis perpendicular to that axis, the worst possible situation for high-Q poles.

Chebyshev filters have high-Q poles and fall into this class of networks having high active element sensitivity.

I will not labor the point any longer as I feel I have by now become wearisome. My comments were not intended to reflect directly upon the author of the article to which I specifically referred. It is the general haphazard casual approach to active RC filter design that has become the rule rather than the exception to which I object.

Active RC circuits are here to stay, but an engineer should understand their limitations before applying cookbook equations simply because they make the solution to a complex problem look simple.

Thank you for your consideration.
*Sincerely,*
*Richard S. Aikens*
*Assistant Engineer*
*Kitt Peak National Observatory*
*Tucson, Arizona*

# INDEX TO ADS, PRODUCTS AND LITERATURE Use card for free product information

( ) DENOTES INFORMATION RETRIEVAL NUMBER


**CIRCUIT MODULES/CARDS**

| | | |
|---|---|---|
| Active Filters | (286) | 56 |
| A/D Converters | (274) | 56 |
| A/D Converters | (277) | 56 |
| Bipolar Memories | (237) | 72 |
| Core Memories | (244) | 72 |
| Core Memories | (248) | 73 |
| Crystal Oscillators | (279) | 57 |
| D/A Converters | (308) | 76 |
| Data Aquisition Systems | (292) | 59 |
| DC/DC Converters | (280) | 57 |
| DC/DC Isolators | (275) | 56 |
| Delay Lines | (285) | 57 |
| Double Balanced Mixers | (287) | 58 |
| FET Op Amps | (290) | 58 |
| Function Modules | (263) | 74 |
| Memories | (241) | 72 |
| Modular Power Supplies | (278) | 57 |
| Op Amp Power Supplies | (276) | 56 |
| PCM Modules | (271) | 56 |
| Power Supplies | (293) | 59 |
| Power Supply Modules | (273) | 56 |
| S/D & D/S Converters | (303) | 77 |
| Transfer Timers | (28) | 65 |
| Voltage Regulators | (272) | 56 |
| Voltage-To-Frequency Converters | (288) | 58 |
| Wide Band Amplifiers | (34) | 71 |

**COMMUNICATIONS EQUIPMENT**

| | | |
|---|---|---|
| Backward-Wave Oscillators | (282) | 57 |
| Microwave Oscillators | (281) | 57 |
| PCM Modules | (271) | 56 |

**DATA HANDLING EQUIPMENT**

| | | |
|---|---|---|
| Bipolar Memories | (237) | 72 |
| Card Readers | (255) | 74 |
| Cassette Recorders | (260) | 74 |
| Computer Interfaces | (238) | 72 |
| Computer Interfaces | (250) | 73 |
| Computer Systems | (10) | 12-13 |
| Computers | (243) | 72 |
| Core Memories | (244) | 72 |
| Core Memories | (248) | 73 |
| D/A Converters | (308) | 76 |
| Data Aquisition Systems | (292) | 59 |
| Disc Memories | (236) | 72 |
| Graphic Systems | (247) | 73 |
| Graphic Terminals | (251) | 73 |
| Keyboards | (48) | 78 |
| Keyboards | (240) | 72 |
| Magnetic Tape Systems | (249) | 73 |
| Memories | (241) | 72 |
| Micro-Minicomputers | (239) | 72 |
| Minicomputer Systems | (246) | 73 |
| Minicomputers | (245) | 72 |
| Storage Displays | (194) | 60 |
| Time Code Formats | (300) | 77 |

**DISCRETE SEMICONDUCTORS**

| | | |
|---|---|---|
| Analog Plotters | (199) | 4 |
| Analog Recorders | (198) | 60 |
| Darlington Transistors | (9) | 11 |
| Dual Transistors | (224) | 68 |
| LEDs | (175) | 4 |
| Plastic Put's | (226) | 68 |
| Power Transistors | (16) | 34-35 |
| Sound-Level Meters | (197) | 60 |

**ELECTROMECHANICAL COMPONENTS**

| | | |
|---|---|---|
| AC Motors & Gearmotors | (21) | 53 |
| Blowers | (2) | 1 |
| DC Motors | (23) | 59 |
| Illuminated Rocker Switches | (186) | 67 |
| Keyboard Switches | (19) | 44 |
| Keyboards | (240) | 72 |
| Miniature Switches | (93-95) | 78 |
| Pushbutton Rotary Switches | (22) | 58 |
| Reed Switches | (171) | 64 |
| Reed Switches | (174) | 64 |
| Relays | (26) | 62 |
| Relays | (27) | 64 |
| Shift Encoders | (282) | 57 |
| Solenoids | (47) | 76 |
| Solid State Switches | (304) | 77 |
| Switches | (259) | 74 |
| Temperature Controllers | (29) | 66 |
| Thermocouples | (302) | 77 |
| Thumbwheel Switches | (31) | 69 |
| Time-Delay Relays | (30) | 67 |

**ENGINEERING AIDS**

| | | |
|---|---|---|
| Computers | (243) | 72 |
| Display Modules | (178) | 65 |

**INSTRUMENTATION**

| | | |
|---|---|---|
| Analog Plotters | (199) | 60 |
| Analog Recorders | (198) | 60 |
| Audio Analyzers | (266) | 74 |
| Audio Analyzers | (266) | 75 |
| Chart Recorders | (208) | 60 |
| DPMs | (201) | 62 |
| Electronic Filters | (210) | 63 |
| 4-C & R Meters | (196) | 60 |
| Function Generators | (205) | 62 |
| High Voltage Test Equipment | (254) | 74 |
| Instruments | (306) | 76 |
| Kilovolt Pulse Generators | (204) | 62 |
| Microwave Sweepers | (207) | 62 |
| Oscilloscopes | (7) | 8 |
| Pulse Generators | (190) | 60 |
| Real-Time Analyzers | (191) | 60 |
| Recorders | (256) | 74 |
| Recorders | (261) | 74 |
| Rfi Analyzers | (206) | 62 |
| Segment Drives | (232) | 68 |
| Scopes | (264) | 74 |
| Voltage Ammeters | (200) | 62 |

**MATERIALS/HARDWARE**

| | | |
|---|---|---|
| Connectors | (4) | 3 |
| DIP Sockets | (189) | 67 |
| Electronic Cabinets | (265) | 74 |
| Heat Sinks | (172) | 64 |
| IC Circuit Cards | (176) | 64 |
| IC Terminals | (173) | 64 |
| Jacks | (50) | 78 |
| Lubricants | (252) | 74 |
| Nylon Resins | (51) | 43 |
| PC Sockets | (267) | 75 |
| PC Insulators | (177) | 64 |
| Perforated Blocks | (36) | 73 |
| Printed Circuit Chassis | (185) | 66 |
| Terminal Blocks | (40-43) | 56-67 |
| Transistor Sockets | (184) | 66 |

**MICROWAVES**

| | | |
|---|---|---|
| Backward-Wave Oscillators | (284) | 57 |
| Capacitors | (6) | 6-7 |
| Double Balanced Mixers | (287) | 58 |
| Gunn-Effect Oscillators | (284) | 57 |
| He-Cd Lasers | (203) | 62 |
| Microwave Diode Handbooks | (35) | 71 |
| Microwave Oscillators | (284) | 57 |
| Microwave Sweepers | (207) | 62 |
| P-I-N Diodes | (306) | 76 |

**MONOLITHIC/HYBRID ICs**

| | | |
|---|---|---|
| Active Filters | (286) | 58 |
| A/D Converters | (298) | 77 |
| CMOS Bi-Phase Pairs | (225) | 68 |
| Computer ICs | (233) | 68 |
| Custom Hybrids | (44) | 63 |
| ECL ICs | (222) | 68 |
| FET Op Amps | (228) | 68 |
| General Purpose Op Amps | (234) | 68 |
| LED Displays | (179) | 65 |
| Micropower Op Amps | (230) | 68 |
| Monolithic Power Drivers | (8) | 10 |
| MOS/LSIs | (299) | 77 |
| MOS/LSI RAMs | (92) | 4 |
| MOS RAMs | (15) | 24-25 |
| MOS Shift Registers | (229) | 68 |
| Power Hybrid Circuits | (257) | 74 |
| Segment Drives | (232) | 68 |
| 7-Stage Dividers | (227) | 68 |
| Thyristors | (39) | Cov. IV |
| Transistor Arrays | (221) | 68 |
| Video Amplifiers | (231) | 68 |

**PASSIVE COMPONENTS/NETWORKS**

| | | |
|---|---|---|
| Blower Fans | (309) | 76 |
| Capacitors | (14) | 23 |
| Capacitors | (46) | 71 |
| Ceramic Capacitor | (45) | 69 |
| Current Controlled Resistors | (180) | 65 |
| High Slew Rate Op Amps | (223) | 68 |
| Plastic Tantalum Capacitors | (181) | 65 |
| Potentiometers | (12) | 18 |
| Resistors | (38) | Cov. III |
| Thermistors | (296) | 77 |
| Trimmer Potentiometers | (13) | 22 |

**POWER SUPPLIES**

| | | |
|---|---|---|
| Ferroresonant Power Supplies | (294) | 59 |
| Power Supplies | (193) | 60 |
| Power Supplies | (195) | 60 |
| Power Supplies | (295) | 59 |
| Power Supplies | (310) | 76 |

**SPECIAL PRODUCTS**

| | | |
|---|---|---|
| Computer Displays | (242) | 72 |
| Digital Clocks | (192) | 60 |
| Fiber Optic Faceplates | (37) | 75 |
| Sound-Level Meters | (197) | 60 |

**SPECTRAL DEVICES**

| | | |
|---|---|---|
| He-Cd Lasers | (203) | 62 |
| LED Displays | (187) | 67 |

**SYSTEMS/SUBSYSTEMS**

| | | |
|---|---|---|
| Bipolar Memories | (237) | 72 |
| Computer Displays | (242) | 72 |
| Data Aquisition Systems | (292) | 59 |
| Digital Meters | (18) | 39 |
| Digital Timers | (299) | 58 |
| Disc Memories | (236) | 72 |
| Graphic Systems | (247) | 73 |
| Graphic Terminals | (251) | 73 |
| Magnetic Tape Systems | (249) | 73 |
| Memories | (241) | 72 |
| Micro-Minicomputers | (239) | 72 |
| Minicomputer Systems | (246) | 73 |
| Minicomputers | (245) | 72 |
| Motor Controllers | (291) | 59 |
| Multi-A/D Converters | (268) | 75 |
| Totalizer-Events Counters | (209) | 63 |

**TEST EQUIPMENT**

| | | |
|---|---|---|
| Analog Plotters | (199) | 60 |
| Analog Recorders | (198) | 60 |
| Analyzers | (206) | 62 |
| Automatic Synthesizers | (3) | 2 |
| Chart Recorders | (208) | 60 |
| DPMs | (201) | 62 |
| Electronic Filters | (210) | 63 |
| 4 C/R Meters | (196) | 60 |
| Function Generators | (205) | 62 |
| High Voltage Test Equipment | (254) | 74 |
| IC Test Chips | (202) | 62 |
| Instruments | (306) | 76 |
| Microwave Sweepers | (207) | 62 |
| Oscilloscopes | (262) | 74 |
| Oscilloscopes | (11) | 16-17 |
| Physical Test Equipment | (269) | 75 |
| Pulse Generators | (190) | 60 |
| Real-Time Analyzers | (191) | 60 |
| Resistor Chips | (182) | 66 |
| Scopes | (264) | 74 |
| Signal Generators | (25) | 61 |
| Sound-Pressure-Level Meters | (24) | 59 |
| Volt Ammeters | (200) | 62 |
| Wattmeters | (33) | 70 |


Paying the lowest price doesn't mean you're getting the lowest cost. Many fixed resistor brands lose their identification in the PC board cleaning process. Some don't have true colors to begin with. Or the color bands darken and become illegible from the heat produced in normal usage. The result is costly identification errors. Contrast this with the bright, crisp identification of Allen-Bradley's specially formulated paints. Baked on to resist aging, rough handling and solvents. Why gamble with questionable quality that can lead to unforseen costs?

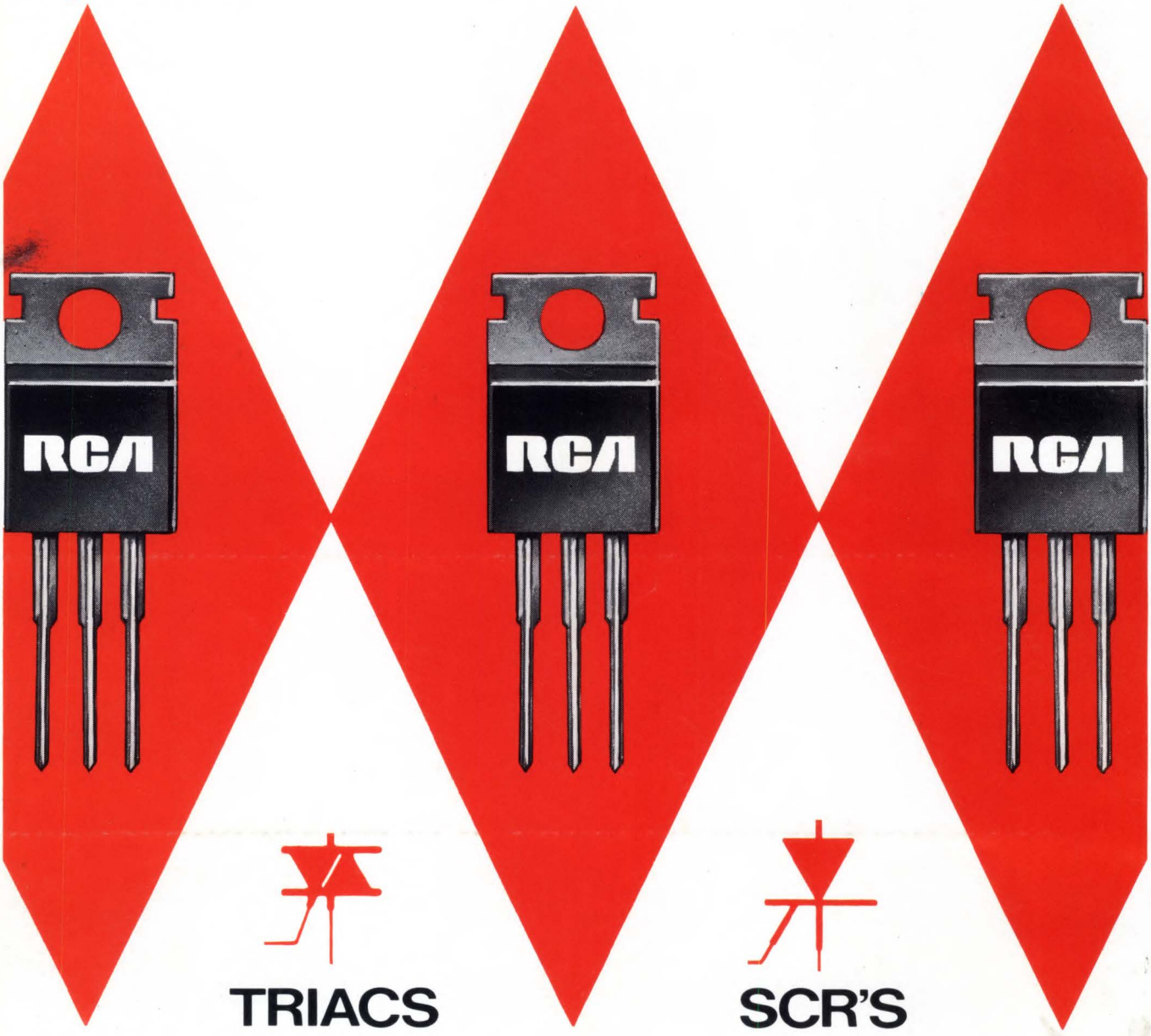
Learn the facts. Ask your nearest A-B distributor for our free booklet, "7 ways to tell the difference in fixed resistors." Or write Allen-Bradley Electronics Division, 1201 S. Second St., Milwaukee, WI 53204. Export: Bloomfield, N. J. 07003. Canada: Galt, Ont. U.K.: Bletchley, Bucks.

**ALLEN-BRADLEY**
QUALITY ELECTRONIC COMPONENTS

A-B QUALITY

CIRCLE NO. 38

# RCA's glass-passivated /center-gate thyristor line continues to expand– in plastic.




TRIACS

SCR'S

To its popular 40668/40669 triacs and 40868/40869 SCR's, RCA now adds 8 A ISOWATT triacs and 4 A SCR's—all available now—in the industry-accepted VERSAWATT package. Leads are custom-formed to your requirements, of course.

- ISOWATT triacs, 40900, 40901, 40902. These 8 A units are ceramic isolated versions of 40668/40669, providing great flexibility in chassis mounting.
- RCA-106 and 107. Here are 4 A SCR's that fill your needs for low-cost circuit areas that require triggering at 200 and 500 μA. These RCA microamp gate SCR's have extended voltage ratings to 500 V and 600 V (corner-gate design).
- 40668/40669. Use these 8 A triacs for control of AC loads for power control and industrial lighting applications.
- 40868/40869. Select these 8 A SCR's for applications in power switching and motor speed controls.

RCA triacs are gate-controlled in all four modes.

RCA VERSAWATT thyristors employ glass-passivated center-gate chips for quality performance. With the RCA VERSAWATT thyristor, you get ease of mounting, low thermal impedance for operation at elevated temperatures, and minimum heat sink requirements—all at excellent cost effective levels.

With RCA's full plastic capability, you can cover full- and half-wave applications with currents from 1 to 15 A and voltages from 15 to 600 V.

See your local RCA Representative for details. For technical data, write: RCA Solid State Division, Section 50F-1/UR14, Box 3200, Somerville, N.J. 08876. International: RCA, Sunbury-on-Thames, U.K. or P.O. Box 112, Hong Kong. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Quebec.

**RCA Solid State**

**products that make products pay off**

Printed in U.S.A.

CIRCLE NO. 39