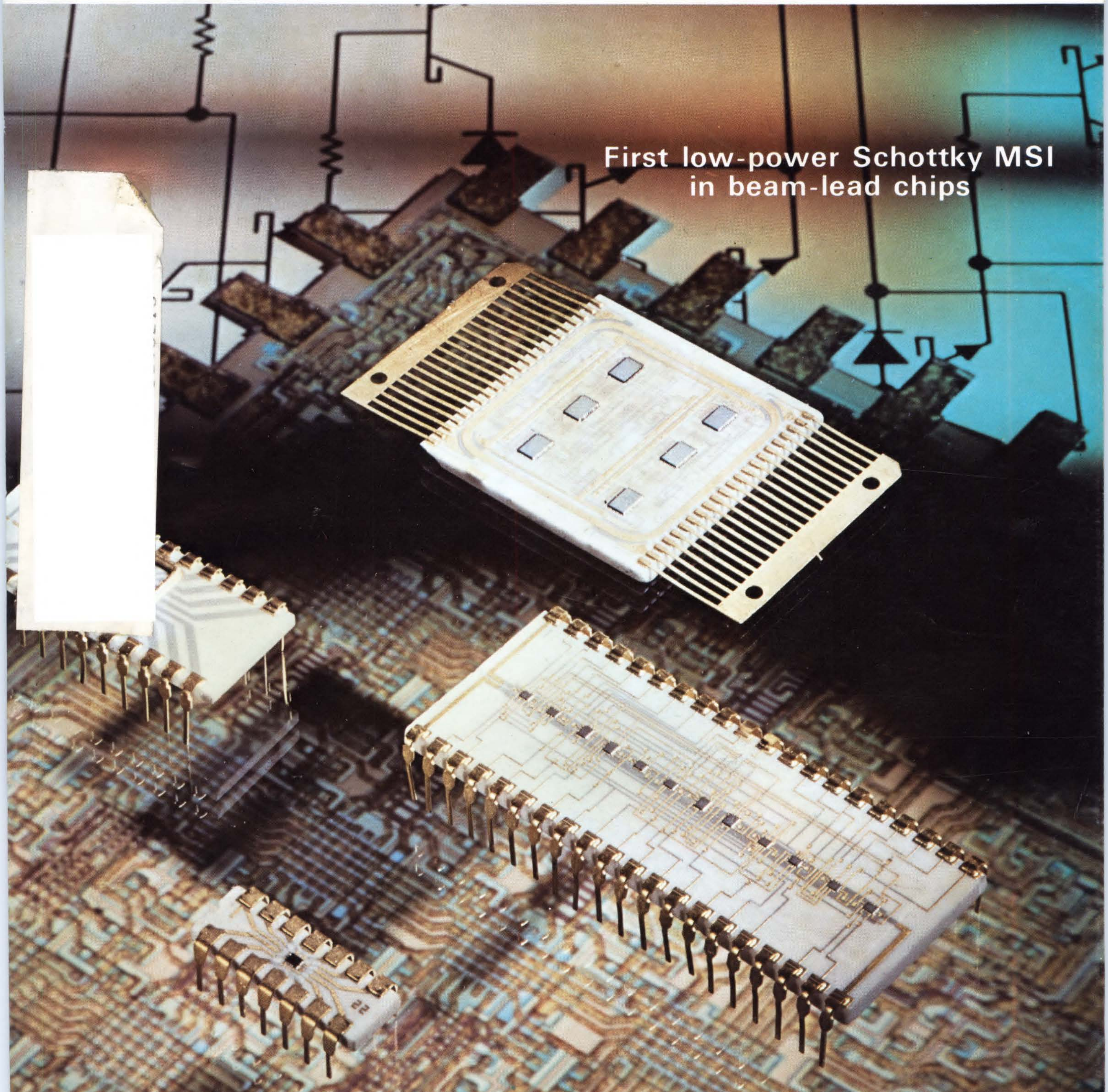
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

Logic probes vie with scopes for digital testing needs

New York engineer wins $1000 Annual Circuit Design Award



A CAHNERS PUBLICATION

MAY 15, 1972

Siemens

No one knows ferrites like a ferrite user. We produce and use more quality ferrites than anyone.

Siemens, a world leader in the design and manufacture of sophisticated telecommunications and computer systems, has also become the world's leading producer of linear, memory and microwave ferrites. Ferrites that are performance and reliability engineered to meet our demanding system requirements.

Siemens pioneered T38 with permeabilities of 10,000, T9 and T10 high-density ferrites for recording heads, SM6 and M6 filter inductors for high packing densities, 12 mil extended temperature cores, plated wire memories and CVB7 microwave material.

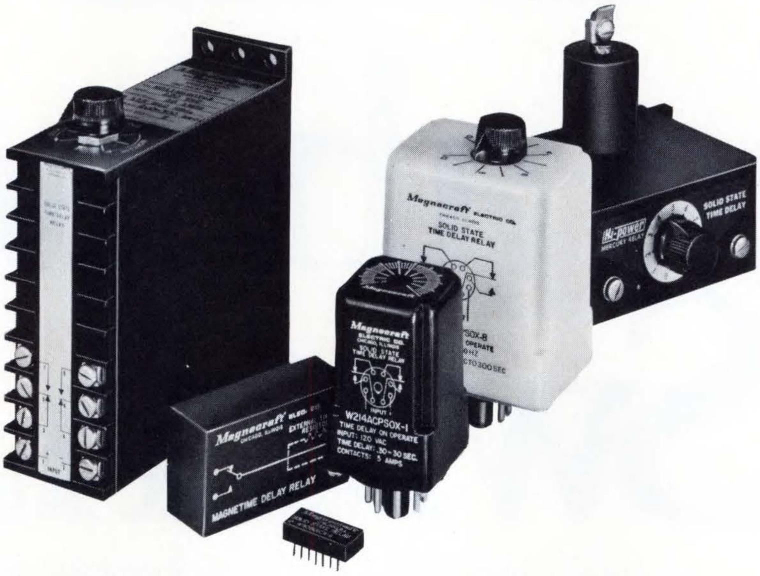
Siemens design engineers are ready to assist you in solving your ferrite problems.

Siemens Corporation, 186 Wood Avenue South, Iselin, N.J., 08830. (201) 494–1000.

Siemens. A three billion dollar name in quality products. **SIEMENS**

CIRCLE NO. 1

WE'VE GOT THE TIME



FOR YOUR APPLICATION . . . in all shapes, sizes, and timing ranges. Time Delay Relays with slow operate or slow release and time repeat accuracy to ±1%. At Magnecraft we take great pride in the broad line of Time Delay Relays available from stock for immediate delivery and even more on special order.

Solid State Hybrid, Solid State-Static Output, Air Dashpot, Copper Slug are some of the types to name just a few. Features such as plug-in, surface mount, printed circuit, screw terminals, solder terminals, quick connect terminals, panel mount, power switching, remote pot, knob adjust, screwdriver adjust, allen head adjust, open type, dust covered, hermetically sealed, economy, manually actuated, multiple contacts, auxiliary output, extended voltage, special purpose . . . the list is almost endless.

Maybe you don't need contacts rated to 100 amperes or timing repeatability to ±1% but we have them available just in case. That's where a broad line can save you money, you don't have to take more than you need. We have just the one to fit your needs . . . and if we don't, we'll make it.

Magnecraft® ELECTRIC COMPANY

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

FREE!

TIME DELAY RELAY HANDBOOK

Do you know how to properly specify a time delay relay? We have a dandy 92-page handbook that can help you. It describes applications you've never thought of. It offers suggestions on how to specify, testing procedures, comparisons of one type to another, principles of operation, and a glossary of terms. This is yours for the asking.

CIRCLE NO. 2

Go ahead. Switch.

Analog devices giving you problems? So go ahead, switch.

Take signals from analog devices like transducers and switch to digital right at the source. Philbrick analog to digital converters open up a whole new world of accurate data transmission to computers and readout devices.

Conversion time requirement fast, slow or moderate? Philbrick handles them all.

Sample and hold no more. With our Model 4110, analog signals can be continuously monitored and digitally transformed at high speed. $74.50 in 100's.

So, go ahead switch from analog to digital anytime, anywhere with Philbrick.

Evaluation samples are yours for the asking. But, first you'll want a copy of our 1972 Product Guide.

It's guaranteed to turn you on.

Ask your local Philbrick representative or write, Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026. For toll-free ready data dial (800) 225-7883. In Massachusetts (617) 329-1600.

Philbrick Data Converters. The good ones.

CIRCLE NO. 3

.. No. 855 ... York, N.Y., Mon...

Ion Implant Sparks Tidy Front-End Business

By NAT SNYDERMAN

NEW YORK — Ion implantation is gaining favor in semiconductor factories and is generating a tidy little business for a handful of equipment suppliers virtually unknown a few years ago.

Considered a laboratory maverick until recently, ion implanters have evolved into sophisticated front-end production equipment which may one day compete with diffusion in microcircuit processing, notably in MOS.

National Semiconductor, Intersil and American Micro-systems are among the major IC producers which have installed ion implanters. Fairchild, Mostek and Hewlett-Packard have units on order.

A solid endorsement of the ion bombarding art will soon be given by IBM which has placed orders for three machines — two for East Fishkill and one for Manassas, Va. — reported to be a prelude to a push in MOS circuits. Made by the Ortec division of EG&G, the units will be delivered in April.

Equipment manufacturers estimate the total cost of the three systems IBM will buy from Ortec at $250,000 to $300,000.

Ion implantation has ... technique for doping s... — generally thin-film... formly over each wafe... ty from wafer to waf... process, in this technol... ized, accelerated to h... barded onto the surfac... they penetrate and the...

Device engineers hav... permits them to dope... fine adjustments of...

Electronic News, 1/24/72

Ion-Implant Production Accelerating at Mostek

DALLAS (FNS) — Mostek Corp., here, has ion-implanted more than 100,000 wafers of MOS/LSI circuits during the past 15 months, according to Bob Palmer, vice-president of the firm's Worcester, Mass., processing operation.

All of the wafers were implanted with a single machine purchased from "Accelerators, Inc., Austin, Tex. Another machine is on order from the same firm.

The new unit will offer both higher ...d currents, and will

Electronic News, 2/21/72

Technology

The HP-35 employs MOS/LSI circuits using ion-implant processes.

Hewlett-Packard thinks they are the largest presently in volume production. Each circuit is equivalent to 6,000 transistors — a total of 30,000 devices. They are made by Mostek especially for Hewlett-Packard (Dallas) and American Microsystems (Santa Clara, Calif.).

The HP-35 may well be one of the major developments of the current decade and the harbinger of things to come.

Electronic Buyers' News, 2/7/72

Hewlett-Packard Introduces Electronic Pocket Calculator

PALO ALTO, Calif. — Hewlett-Packard Co. said it has introduced a new electronic pocket calculator called the HP-35.

William R. Hewlett, president, compared the nine-ounce battery-powered calculator to a "fast, extremely accurate electronic slide rule, with a solid-state memory similar to those used in computers." The HP-35 is approximately three inches wide, six inches long and one inch high and will sell for $395, according to Mr. Hewlett.

Major Business Publication, 1/5/72

Ion implantation as a processing tool will be used in one way or another by all manufacturers within a few years. Equipment will be refined and become less costly as more suppliers move into this market. Because of its ability to adjust thresholds, make depletion devices, make CMOS devices, etc., it is too useful a tool to ignore. Circuits made by ion implantation will be cost-competitive with most other technologies and offer some perform-

EDN/EEE, 9/15/71

Ion-Implantation Moves Ahead

Ion implantation technology continues to advance. This was borne out at the recent International Electron Devices Meeting in Washington, D. C. where, of the twelve papers presented on the subject, nine described applications other than the most commonly known ones.

EDN/EEE, 12/15/71

Today ion implantation is big news.

Look what we started!

Two years ago you probably never heard of ion implantation. Today it's big news—helping turn bright ideas into profitable products.

MOSTEK was the first to use ion implantation in the volume manufacture of MOS/LSI, beginning in 1970. Since then we have made process and product innovations that have initiated an industry-wide movement towards implantation. Today you will find our implanted MOS circuits in an ever widening range of applications including: business and scientific calculators; electronic organs; credit verification terminals; industrial timers; computer peripherals; medical electronics; avionics; portable measuring instruments and modems. Looking ahead, implanted MOS is ideal for such new and exciting areas as utility meter reading, time keeping, and automotive electronics.

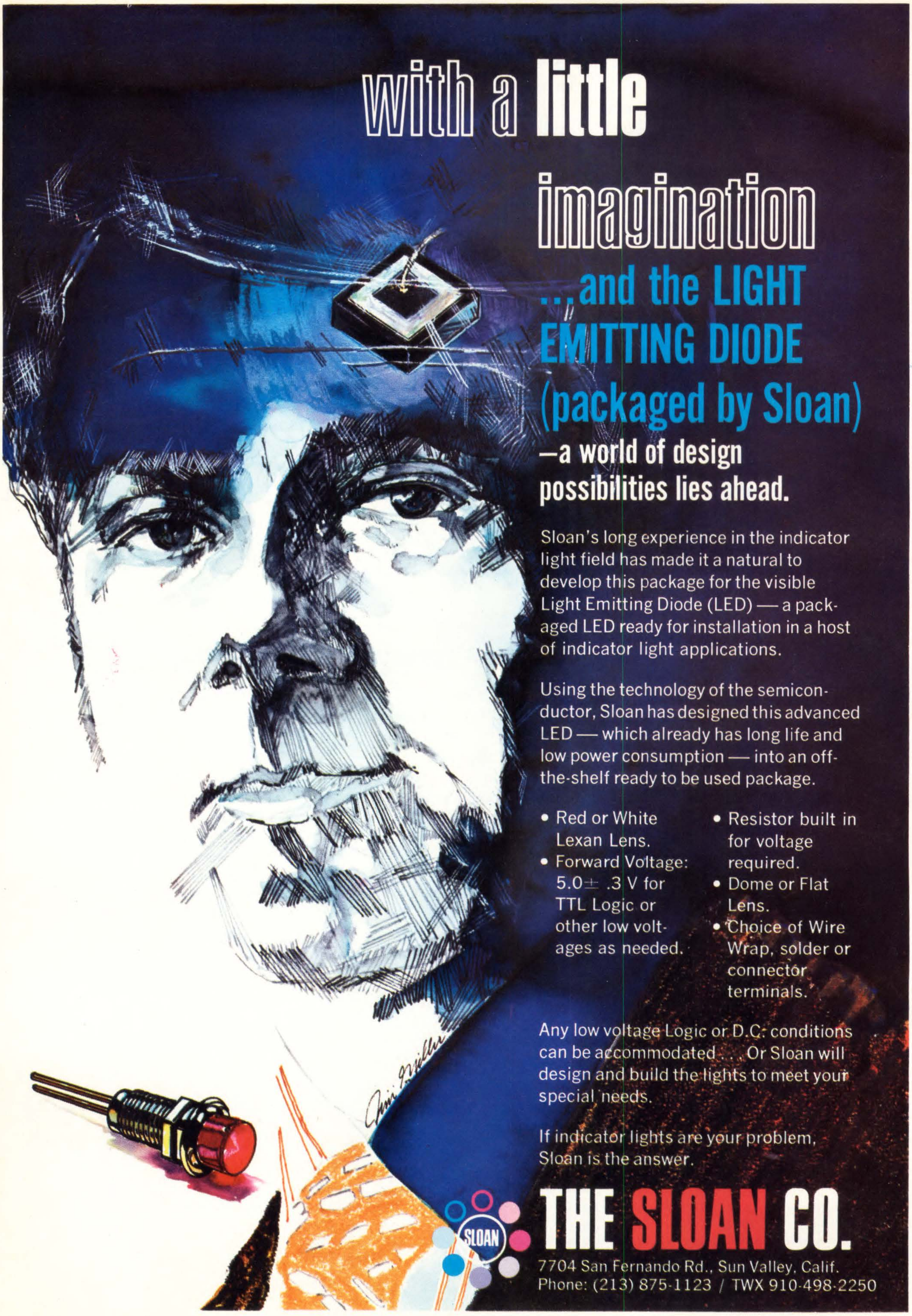
If you are considering using MOS in your products, check what implanted circuits can do for you, both technically—(lower power, higher speed, and operation over broad supply voltages)—*and* economically. Let MOSTEK recommend a custom approach or one of its standard implanted MOS circuits to meet your needs.

MOSTEK CORPORATION ®

1215 West Crosby Road
Carrollton, Texas 75006
(214) 242-0444

Regional Sales Offices: West: 11222 La Cienaga Boulevard, Inglewood, Calif. 90304 (213) 649-2600 East: 60 Turner Street, Waltham, Mass. 02154 (617) 899-9107
Midwest/Southeast: 515 S. W. Avenue, Jackson, Michigan 49203 (517) 787-0508
International: MOSTEK GmbH, 7 Stuttgart 80, Waldburgstrasse 79, West Germany 0711-731305; System Marketing Inc., Center News Bldg., 1-3-11 Sotokanda, Chiyoda-ku, Tokyo, Japan;
W. G. Booth Pty., Ltd., 39 Church Street, Hawthorn, Victoria 3122, Australia.

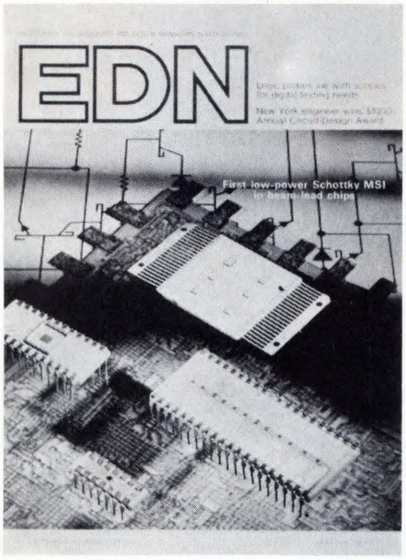
CIRCLE NO. 4


with a little
imagination
...and the LIGHT EMITTING DIODE
(packaged by Sloan)
—a world of design possibilities lies ahead.
Sloan's long experience in the indicator light field has made it a natural to develop this package for the visible Light Emitting Diode (LED) — a packaged LED ready for installation in a host of indicator light applications.
Using the technology of the semiconductor, Sloan has designed this advanced LED — which already has long life and low power consumption — into an off-the-shelf ready to be used package.
• Red or White Lexan Lens.
• Forward Voltage: 5.0± .3 V for TTL Logic or other low voltages as needed.
• Resistor built in for voltage required.
• Dome or Flat Lens.
• Choice of Wire Wrap, solder or connector terminals.
Any low voltage Logic or D.C. conditions can be accommodated . . . Or Sloan will design and build the lights to meet your special needs.
If indicator lights are your problem, Sloan is the answer.
SLOAN
THE SLOAN CO.
7704 San Fernando Rd., Sun Valley, Calif.
Phone: (213) 875-1123 / TWX 910-498-2250

CIRCLE NO. 5

MAY 15, 1972
VOLUME 17, NUMBER 10

EDN EEE
EXCLUSIVELY FOR DESIGNERS AND
DESIGN MANAGERS IN ELECTRONICS



COVER

Thirteen new MSI functions in low-power Schottky TTL from Texas Instruments are available in beam-lead chips or standard packages. Complete story on page 62.

 Norman L. Cahners; Chairman of the Board; Saul Goldweitz, President; H. V. Drumm, Executive Vice President/Magazines; Ned Johnson, Senior Vice President/Magazines. 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 We build extra reliability into all our components. Documented reliability from ER through industrial, from precision through general purpose. To let you build extra reliability into all of your systems.

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

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

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

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

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

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

CORNING
ELECTRONICS

Resistors & Capacitors

for guys who can't stand failures

CIRCLE NO. 6

BOURNS

LOW COST FAMILY

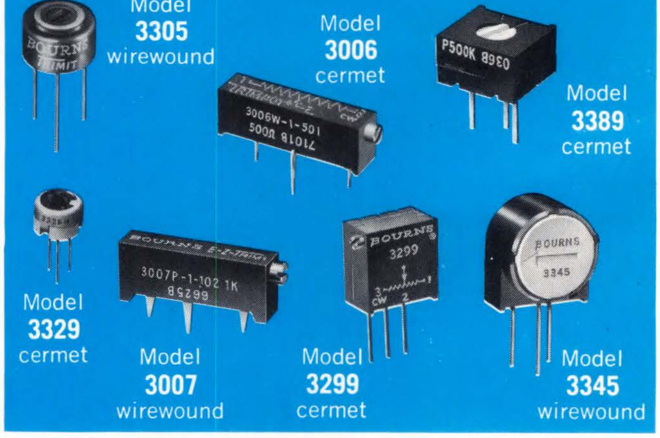
OF INDUSTRIAL TRIMPOT® POTENTIOMETERS

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. 7

Let's reward the outstanding

One of the fundamental precepts of management is that an outstanding performance should be recognized and in some way acknowledged. This is generally done in business and industry, even in companies where the management might be considered something less than enlightened.

The reason, of course, is simple: Such recognition is a great motivator, and motivation is the key to better on-the-job performance.

Motivation of this type, with its obvious rewards, shouldn't be limited, we feel, to individuals, but should be expanded to cover entire companies. In other words, companies should recognize outstanding performance by other companies they deal with.

One organization that has done just this, and with resounding success, is the Aerospace Division of Honeywell. Every year ten companies are chosen from the division's thousands of suppliers to receive the "Best Vendor" award. Criteria used to determine the winners include quality of products or services required, on-time delivery and cooperation in meeting unusual specifications or delivery dates.

Of the ten companies selected this year, five are manufacturers of electronic components or equipment. These are: General Components, Inc., Tampa, Fla.; National Semiconductor Corp., Santa Clara, Calif.; Shallcross Manufacturing Co., Selma, N.C.; Stator Products, Inc., Corona, N.Y.; and Tektronix, Inc., Beaverton, Ore.

We congratulate not only these winners, but Honeywell and other companies like it who see fit to give credit for a job well done.

Don't miss Computer Hardware section

On the 15th of each month we have been publishing Computer Hardware and sending it as a separate magazine within EDN to designers of computers and peripheral equipment. With the increasing pervasiveness of computers and digital technology throughout all areas of electronics, this limited circulation has begun to run counter to one of our basic editorial objectives—namely, to provide readers with practical design information covering all facets of technology.

Beginning with this issue, therefore, Computer Hardware is being merged into EDN and will be received by all EDN subscribers.

Frank Egan

Editor

STAFF

Publisher
E. Patrick Wiesner

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

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

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

These single-turn, 3/8", covered trimmers come in 10 different mounting styles and 19 standard resistance values from 10 ohms to 2 megohms. Covered construction helps protect against moisture, corrosive atmospheres, dust, oil and other contamination. Which means, in addition to cermet stability and better resolution, you get long-term dependable performance.

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

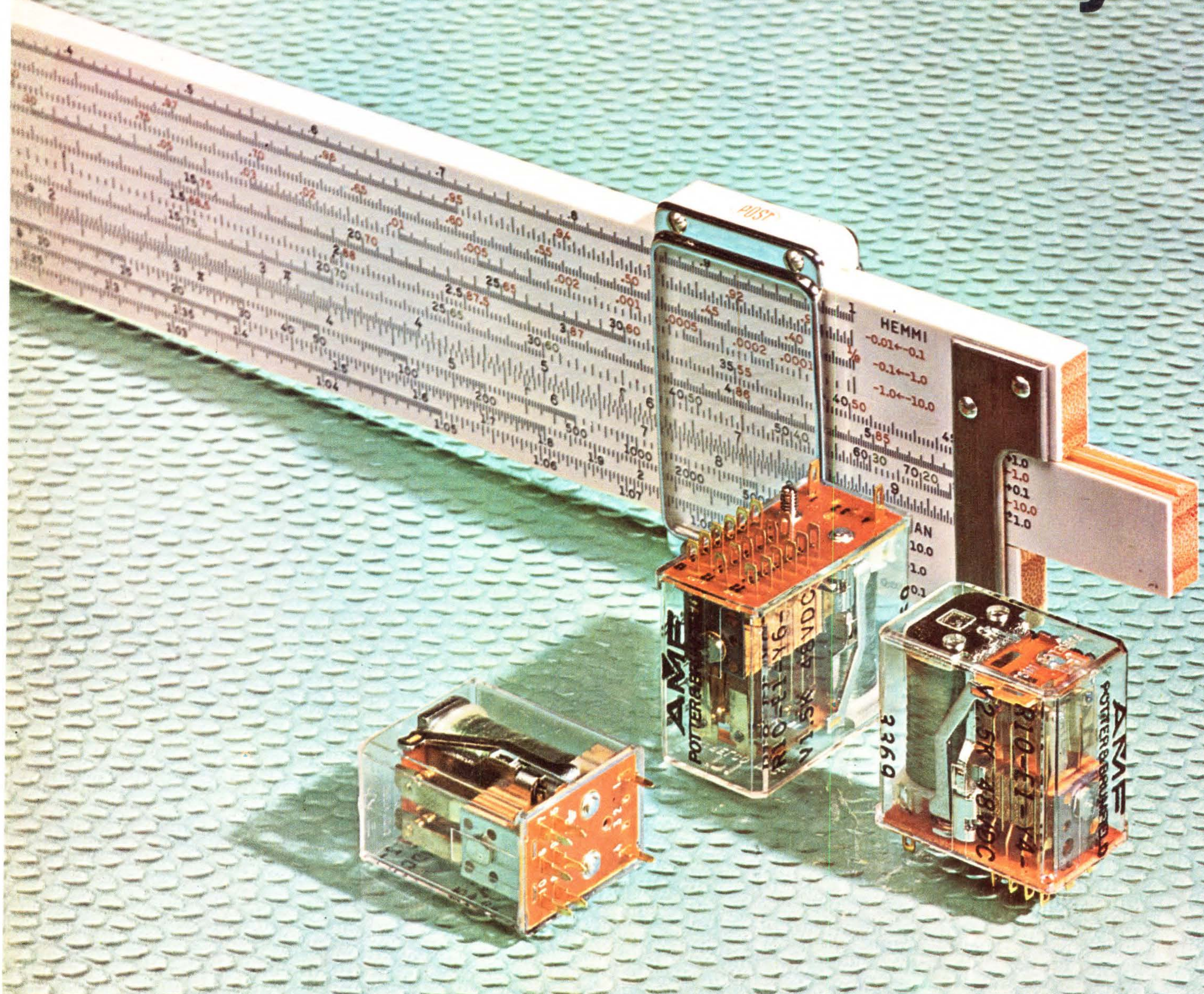
Send now for complete data on the Series 91 Trimmers . . . the finest of their class. We've made them for your projects where the budget may be tight, but you don't want to compromise performance.

Beckman®
INSTRUMENTS, INC.
HELIPOT DIVISION
Fullerton, California

HELPING SCIENCE AND INDUSTRY IMPROVE THE QUALITY OF LIFE

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

Our R-IO series offers more design options than any other single industrial relay.



The P&B R-10 Series offers designers a whole family of AC and DC industrial relays that combine extraordinary versatility in application, the reliability of telephone-type relays, and small size (less than a cubic inch). They are widely used in copiers, computer peripherals, business machines and precision instruments.

So versatile is this series that each model is literally designed by you, to meet your special needs. You use a single family of relays, with common mechanical dimensions and common mounting techniques, to cover the whole range of switching loads you may desire, from dry circuit to 10 amps, 28 V DC, 120 V AC. There are several terminal styles for solder or pc board mounting. Special octal plug mounting is available, and sockets multiply design options even more.

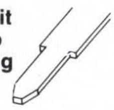
R-10's can now be ordered with Form A, B and D contacts as well as Form C, with arrangements up to 8 Form C. Underwriters' Laboratories, Component Recognition, File 42810. DC relays have a continuous power dissipation of 2.2 watts maximum. Standard sensitivity is 125 milliwatts per pole. Mechanical life is up to 100 million operations, electrical life ranges from 100,000 to 100 million operations. Special light emitting diode (LED) indicator, a convenient check when trouble shooting a circuit is available as an option on R-10 relays.

Take just four easy steps to "design" the R-10 relay that fits your requirements perfectly.

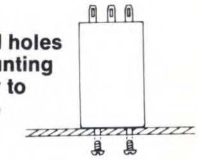
1 *Decide on the type of terminal mounting you want:*

Solder terminals. Stud or plug-in mounting

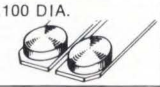
Printed circuit terminals. No stud mounting



Tapped holes for mounting directly to surface



2 *Select desired rating and contact form:*

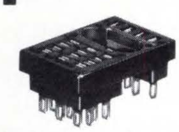
Rating	10 amp†		5 amp (Bifurcated)		5 amp		2 amp		Low Level (Bifurcated)		Dry Circuit (Cross Bar)	
	Poles	Forms	Poles	Forms	Poles	Forms	Poles	Forms	Poles	Forms	Poles	Forms
Contact form	2 4 6	A,B,C,D A,B,C,D A,B	2 4 6 8	A,B,C,D A,B,C,D A,B,C A,B,C	2 4 6 8	A,B,C,D A,B,C,D A,B,C A,B,C	2 4 6 8	A,B,C,D A,B,C,D A,B,C,D A,B,C	2 4 6 8	A,B,C,D A,B,C,D A,B,C,D A,B,C	2 4 6 8	A,B,C,D A,B,C,D A,B,C,D A,B,C
Contact data	.125 DIA. 		.100 DIA. 		.100 DIA. 		.078 DIA. 		.062 DIA. 		.017 DIA. 	
Resistive load* @ 28 VDC or 115 VAC	Typ. 7.5 Amps Max. 10 Amps Min. .200 Amps		Typ. 5 Amps Max. 7.5 Amps Min. .200 Amps		Typ. 5 Amps Max. 7.5 Amps Min. .050 Amps		Typ. 2.0 Amps Max. 3.0 Amps Min. 0.01 Amps		Typ. 0.1 Amp Max. 2.0 Amps Min. 0.001 Amp		Typ. 500 mA Max. 250 mA Min. Dry Circuit	

*Total load not to exceed 30 amperes per relay. †Use ungrounded frame for loads over 5 amperes.

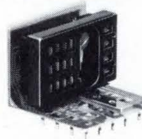
3 *Choose the proper coil resistance:*

- Standard and sensitive DC voltage coils available from 3.0 to 115 volts @ 25°C.
- AC voltage coils from 12 to 115 V @ 25°C.
- DC sensitivity as high as 20 milliwatts per pole.
- Bifilar coils to protect relay drive transistors available to 48 V nominal.

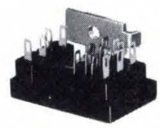
4 *Pick the socket that fits.*



R-10 Relay Socket
Retains floating terminals of either solder or P/C pin configurations.



Printed Circuit Right Angle Socket
Allows relay to mount flat on P/C board, reduces height from 1.720″ to .860″ max.



Bracket Mount Socket
Allows solder terminal relay to mount flat on a chassis.

Versatile R-10 industrial relays, with their almost limitless design options and application capabilities, are available nationwide from leading electronic parts distributors. Or call your P&B representative. For a free 214 page relay catalog, write Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385-5251.

AMF
Potter & Brumfield

CIRCLE NO. 10

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

Anybody.

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®

unable to cram all of our new computer

It doesn't hold

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

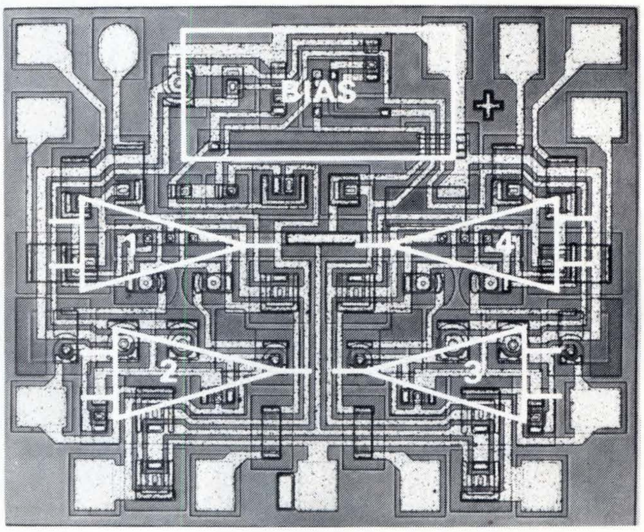
CIRCLE NO. 11

As high as 20% of all op amp applications are still using more op amp, at higher costs, than necessary. The right economy/performance alternative wasn't available. It is now!

The Quad Op Amp–MC3401P...

The Saver.

A monolithic quad, single-supply op amp.



The MC3401P is four internally compensated op amps and the biasing circuitry common to all, on the same chip, assembled into a plastic dual in-line package. It's new. It's available. And it sells for only $1.75 in 100-999 quantities, making it the most economical op amp on the market. MC3401P is the alternative to using more device than necessary, and spending more in the process, in that pesky 20%.

Single-supply operation over a +5.0 V to +18.0 V range, means that digitally oriented systems offer excellent opportuinty for the MC3401 to lower costs further by eliminating the additional power supply previously required for linear functions. Perfect for industrial control systems. Single-supply operation also qualifies the MC3401 as ideal in battery operated systems. Or use it for such ac applications as active filters, multi-channel amplifiers, and oscillators, or as a simple gain block.

It's versatile.

Don't consider it for applications demanding extremely tight gain tolerance or highest gain. It wasn't designed for that, although if you need more gain than a single stage provides, connect two, three, or even all four stages in series for eye-popping increases.

The MC3401P is designed to provide all the performance ever needed at reduced costs in that awkward 20% of the total op amp applications.

That's what it does. That's why we call it the Saver. That's why it's great.

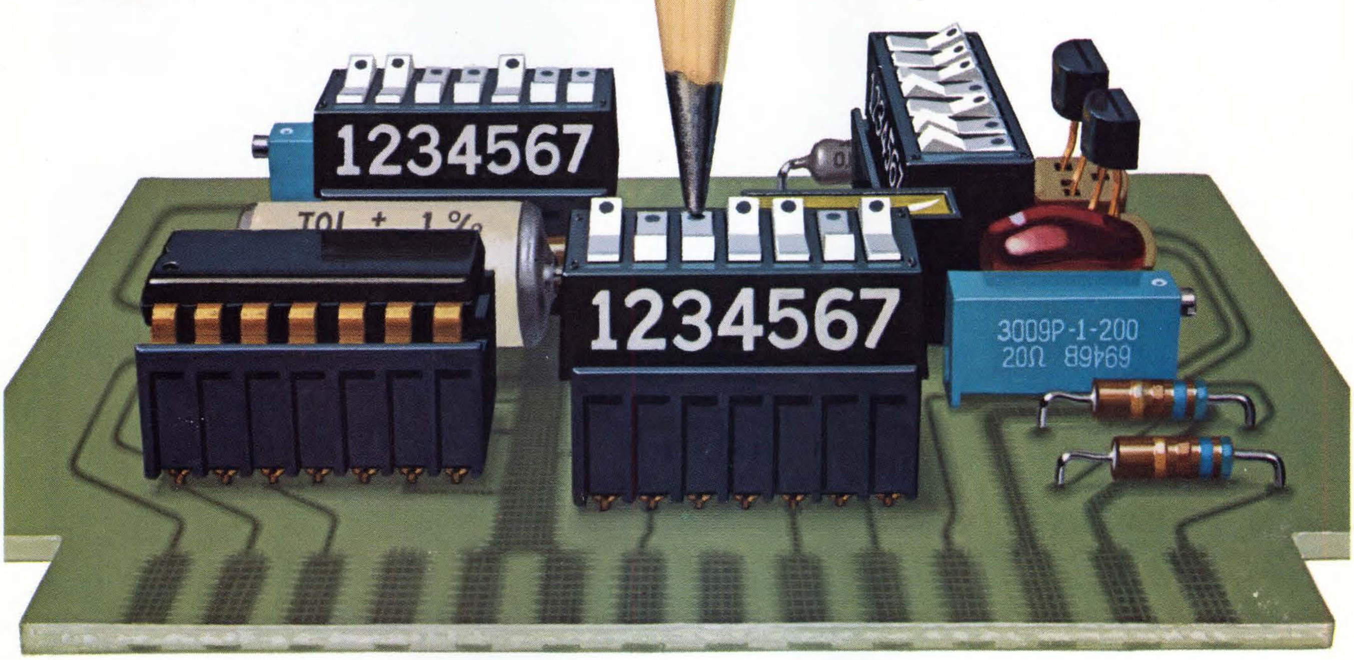
More information is available from Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036, and your Motorola distributor has them in stock now.

MOTOROLA LINEAR

— Serving a greater range of analog designs

CIRCLE NO. 12

Economical on-board programming. Quite a switch.



Our DIP switch, in fact. A brand-new device that lets you program your IC's right on their boards. Without the labor costs, nuisance and excessive space required by jumper wires or bracket-mounted toggle switches.

Now all you need for fast, reliable programming is a pencil and a logic diagram. Rocker buttons operate positively but easily with the touch of a pencil. And they're legibly marked to show "on" and "off" positions.

New, low-profile DIP switches take up no more room on the board than a standard DIP. And can be reflowed into plated through-holes or plugged into our DIP headers. Gold-over-nickel plating on phosphor-bronze contacts assures reliable operation in the milliamp "dry-circuit" range.

These DIP switches are available with any number of poles you want, from 4 to 10. Most popular to date are the 7-pole and 8-pole versions which correspond, respectively, to 14-lead and 16-lead standard DIP's.

For more information on really economical on-board programming with DIP switches, write to: **AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105.**

AMP
INCORPORATED

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

CIRCLE NO. 13

For the communication system of the future: low-loss optical fibers

A low-loss optical fiber that may find applications in future communication systems has been developed at Bell Laboratories. The liquid-filled fused-quartz capillary fiber tube can transmit light signals with a loss as small as 13.5 dB/km, measured in a 450-meter length of fiber using incoherent light at a wavelength of 1.08 microns. Such fibers are expected to be useful in long-distance optical transmission systems, because of their high-capacity transmission characteristics, small size and low cost.

Loss measurements were made using two light sources—a He-Ne laser at 6328Å (TEM_{00} mode) and a high-pressure xenon arc lamp with 100Å-wide filters every 200Å between 6000Å and 11,000Å.

Losses measured were about 20 dB/km maximum between 8400Å and 8600Å and between 10,400Å and 11,000Å. The minimum loss recorded was 13.5 dB/km at 1.08 microns. In the intervals between 7000Å and 7600Å, and 8200Å and 11,000Å, the fiber exhibited transmission losses as low as or lower than any that have been previously reported.

The regions between 8400Å and 8600Å and between 10,400Å and 11,000Å are of particular interest. Within these regions operate highly promising oscillators such as the GaAs diode and the Nd:Yag laser.

The new fiber consists of a hollow fused-quartz capillary tube filled with tetrachloroethylene. Core diameter of the fiber is about 65 microns and the fiber's quartz wall is about 15-microns thick.

The hollow-fiber optical waveguides were made from quartz tubing 6-mm in outside diameter with a 1-mm-thick wall pulled in an air atmosphere on a fiber-pulling machine. The fibers have an outside diameter of 95 microns and an inside diameter of 65 microns.

The index of refraction of the fused quartz is about 1.457. Tetrachloroethylene whose index of refraction is 1.50 was used to fill the fiber. These index-of-refraction values are given for 6328Å.

The liquids were purified by distillation to eliminate dust particles, while hollow fibers were filled under hydrostatic pressure which made it possible to fill the fibers without introducing any bubbles. □

Communication medium of the future? Quite probably. This 200m-long liquid-filled optical fiber is being demonstrated by a Bell Laboratories' scientist. The fiber was reported to have the lowest recorded loss yet—a maximum of 20 dB/km between 8400Å and 8600Å and between 10,400Å and 11,000Å. The bright spot below the scientist's finger is light emerging from the fiber.

Holography may bring world's art treasures to millions

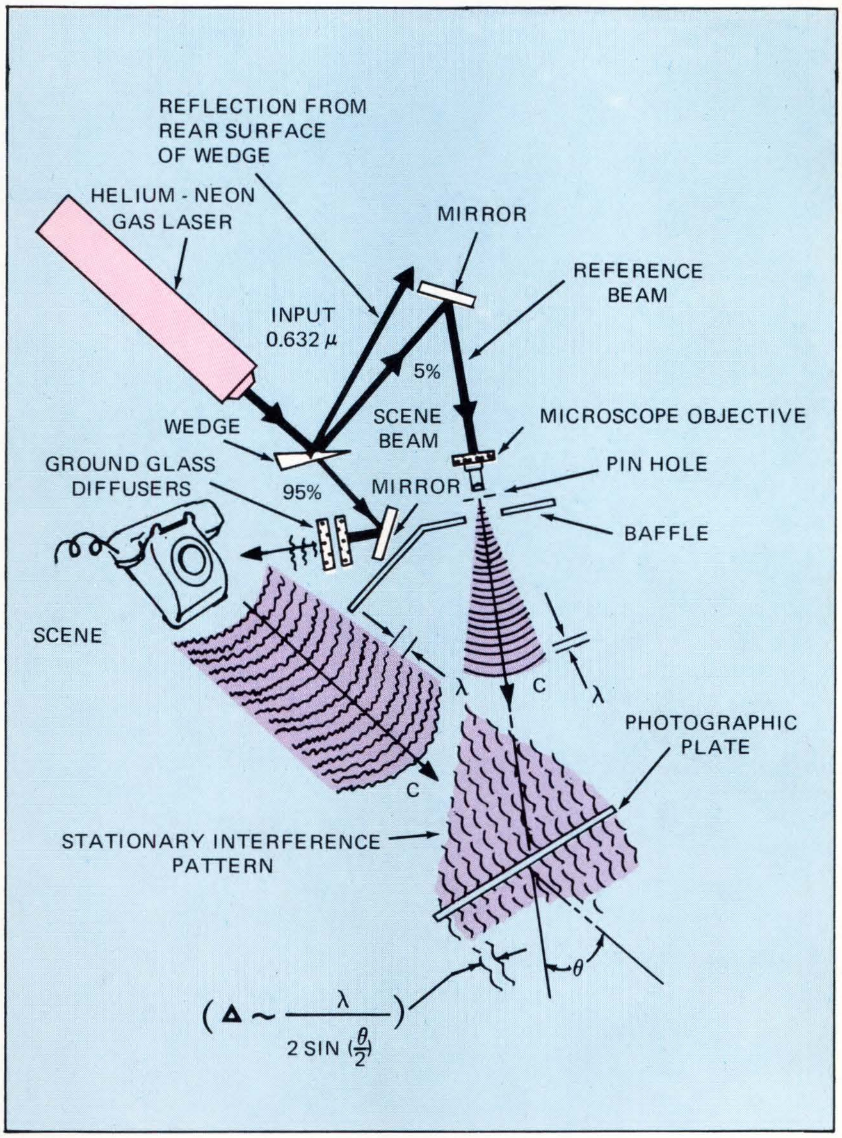
Preservation and sharing of the world's art treasures through the use of laser holography was advanced in a three-week test among the historic statues of Venice, Italy.

The test, according to Dr. Ralph Wuerker, of the Advanced Technology Div. of TRW Systems Group, Redondo Beach, California, and a pioneer in the development and application of holography, achieved the first creation in the field of holographs of statuary, including many world-famous works.

The project, jointly sponsored by ENI (the Italian Petroleum Institute), TRW and Science Applications, Inc., also demonstrated the use of holography for non-destructive testing of statuary to reveal existing internal or concealed surface flaws. It showed patches made hundreds of years ago on centuries-old sculptures. Using refinements of TRW laser developments for NASA, the project was requested by Dr. Giovanni Urbani of Rome's Institute Centrale del Restauro, to create new techniques for recording Italy's treasure trove of art.

It was also hoped that future tests would provide a continuing means of determining the rate of erosion. Further studies of the holographic pictures at Dr. Wuerker's California laboratories will clarify this aspect of the project.

During the course of the project, Dr. Wuerker's team set up laser photography recordings of the Donatello masterpiece at Venice's Church of Santa Maria Gloriosa dei Frari; of Nino Pisano's 14th-century marble Madonna and Child, at the Church of Saints Giovanni e Paolo; and of other smaller marble pieces.



Holographic setup such as this is used for recording a reflected-light hologram.

"Art treasures can in the future be shared beyond the bounds of individual museum or church displays when technology develops an acceptable reproduction presentation," Dr. Wuerker said. "In the present state of the art, a three-dimensional full-size hologram of a sculpture is so true to life that visitors will not realize it is not an original unless they attempt to touch it."

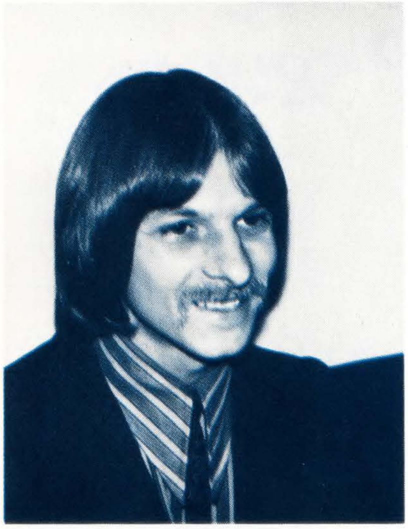
For the American museum of tomorrow, he sees the laser as a standard item of equipment which will permit display of the world's art treasures in a form which does not seriously compromise from a viewing of the original.

Dr. Wuerker believes that the results of his project will lead to support from the government of Italy for a broad-scale program of holographic recording of the nation's most valued art objects. Many of these are in serious and imminent danger of erosion, with the ravages of age hastened by modern pollutants in the air of major cities.

In holography, patterns of the complex wave fronts of light reflected from a laser-illuminated object are recorded on a special high-resolution photographic emulsion, usually on a glass plate.

When the hologram is developed—much as a film is developed—there is no image of the visible object. Instead, the hologram presents a smoky, gray appearance, with perhaps a few swirls or wavy lines detectable to the naked eye. However, when the hologram is illuminated by laser light—or "reconstructed"—a precise, realistic three-dimensional image of the object is visible. Through proper projection techniques, life-size measurements can be made. □

Self-adjusting zener circuit wins EDN's '71 contest



Leonard Accardi was rather pleased to win the $1000 savings bond. He modestly indicated that this was the sort of tangible reward he thought a dedicated circuit designer like himself has every right to expect.

A "super-stable" zener reference circuit was voted winner of the 1971 Circuit Award Contest. It was chosen from 19 circuits that won for the issues during 1971 on the basis of reader votes.

The winning circuit (reprinted below, and in it's entirety on page 50) cleverly uses a zener's own voltage to set up the zener's current. Thus, the zener can be kept operating at a desired fixed current despite wide temperature variations. If a temperature-compensated zener is used (one with a built-in forward-biased diode), the fixed current will enable the circuit to hold a desired reference voltage within a few parts per million over the full military temperature range. It is practical for production circuits because no trim pots are needed to obtain useful stability.

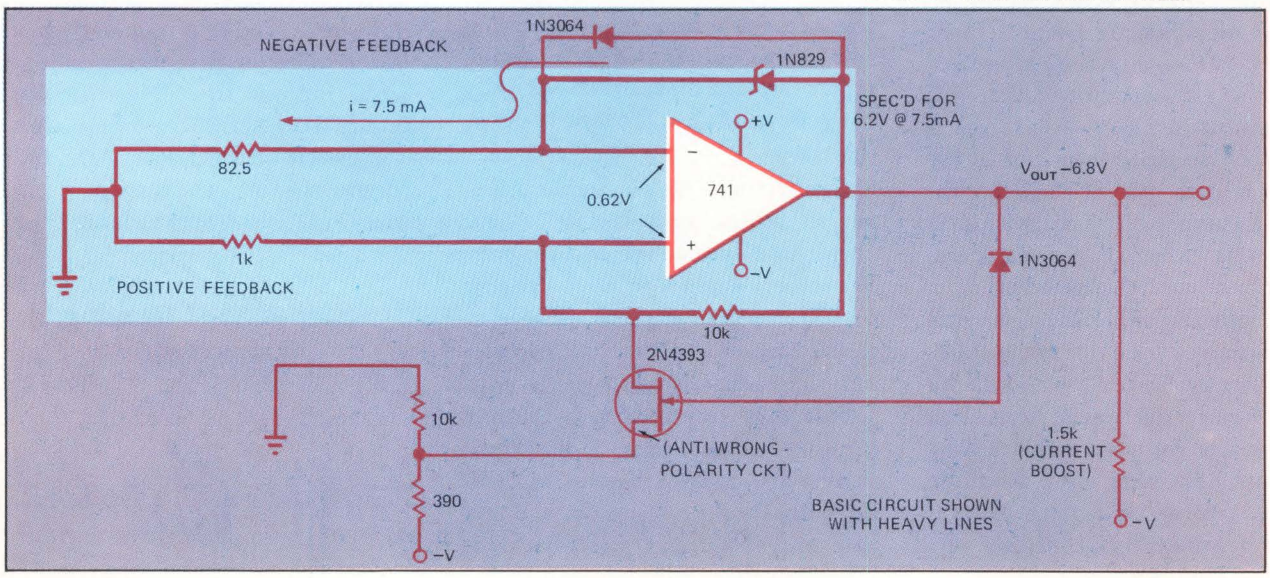
The zener is put in the negative feedback loop of an inexpensive op amp. Then the positive feedback side of the op amp is used as a voltage divider to pull the op amp input slightly away from its usual virtual ground voltage, with the negative feedback input following this shift. This is where this circuit gets a bit tricky, because both inputs of the op amp end up having the same small common-mode offset from ground. This offset then sets up the desired zener current in the negative feedback side via the input resistor. Meanwhile the zener has driven the output of the op amp negative. Everything has to be working at once for this "ring-around-the-rosey" to happen, so you have to assume the circuit is found in the desired state with the op amp output negative to understand it. The additional circuitry shown in lighter lines was added to insure that the circuit won't get hung up in the reverse state where the zener would be forward biased. The output resistor decreases the amount of zener current the op amp has to supply.

Inventor Leonard Accardi of Maspeth, Queens, N.Y., said he was lead to this circuit by asking himself, "How can I make the zener's nice, well-defined voltage stabilize the zener's current?" He was working at Kollsman Instrument Corp. at the time.

In talking with Accardi, EDN learned that it was no accident that he came up with a winner. Accardi has taken circuit design very seriously. "I wanted to be the best circuit designer there was," he said.

There were times, he recalls, when he had gone home after work and poured over EDN and other technical magazines, trying to keep up with the latest devices and applications. "I used to circle those numbers on your reader-service cards like mad," he recalls. "I've built up a formidable array of notebooks, each containing manufacturer's literature and circuit ideas in areas I was interested in."

Accardi recently resigned from Kollsman to complete his MBA in management at Baruch College of the City University of New York. He is now looking for work on the management side of electronics. His special interest is personnel selection, development and appraisal. Despite his success in creative circuit design—another one of his circuits won an issue contest back in 1970—he's convinced the real need in high-technology electronics companies is for people in management who know how to select, develop and reward creative, dedicated engineers. He is also taking some courses towards an MEE.



₵-LINE PLASTIC PUTs
24¢

more of the best for less for more types of timing circuits

The Programmable Unijunction Transistor (PUT) has superseded conventional Unijunctions. It has become the preferred device for low-cost timing circuits, oscillators, sensing circuits, and many other variable voltage level threshold applications. Now with the addition of 4 new plastic PUTs, Unitrode has the broadest line available—15 standard types including hermetically sealed. And we will select to meet your specific needs. Unitrode also offers the highest voltage PUTs and the first with better than 1% oscillator timing accuracy guaranteed from −55° C to +125°C. ₵-Line plastic PUTs are available off-the-shelf for as low as 24¢ ea. in quantity, and they come complete with the services of a strong applications engineering staff. For fast action and the name of your nearest Unitrode distributor, call Sales Engineering collect at (617) 926-0404.
Unitrode Corporation, Dept. 5Z
580 Pleasant Street, Watertown, Mass. 02172

UNITRODE quality takes the worry out of paying less.

Unitrode Corporation
Dept. 5 Z, 580 Pleasant St., Watertown, Mass. 02172

Please send free samples of ₵-Line plastic PUTs

☐ P13T1 / 2N6027 for general purpose, ☐ P13T2 / 2N6028 for long interval timing

☐ Please send PUT information folder, complete with data sheets and application notes.

NAME ______________________ TITLE ______________________

COMPANY ____

ADDRESS ____

CITY ______________________ STATE ____________ ZIP ____________

CIRCLE NO. 15

If you're blowing power transistors in switching regulators, our 20 nsec commutating diodes should blow your mind.

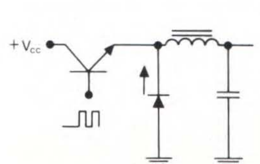
Think of the possibilities. For new 20 KHz designs. For present designs, now scraping by with the standard 200 nsec 1N3800-3900 series. Our SVD series includes a full line of ultra-fast commutating diodes, from 1 to 30 Amps, with a turn-off time of 20 nsec. Diodes that can protect your series transistors. That won't overstress them. That won't blow them.

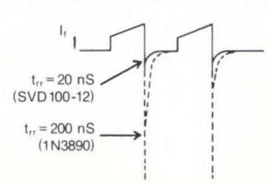
If your application is in an area where enough blown transistors can make you blow your acceptance tests — and maybe your contract — our SVD diodes are the answer. Especially since speed is only part of what they give you.

They feature a low V_F — only 1V, compared to the 1.4V you're used to. Plus the packaging flexibility of isolated studs and axial double slug diodes up to 5 Amps.

They work. They really do the job in your 20 KHz designs. And if that isn't a mind-blower, what is?

For full application notes, "Choosing the Best Commutating Diode for Switching Regulators," call us collect, (213) 679-4561. Or write to TRW Semiconductors, an Operation of TRW Electronic Components, 14520 Aviation Boulevard, Lawndale, California 90260. TWX 910-325-6206.





TRW® SEMICONDUCTORS

CIRCLE NO. 16

Don't let avoidable reed-relay pitfalls cripple your equipment designs

Avoid unseen traps buried in the data sheets and you can more than double the reliability, performance and life expectancy of relay circuits

J. A. Jodice, Teradyne, Inc.

Most designers feel that the reed relay is an inherently reliable device. Reeds exhibit most of the properties that you look for in a relay. Isolation and life are excellent, contact resistance is stable and the cost is low. Why do engineers run into problems with reeds, then? Usually because they specify and purchase reed relays according to the manufacturers data sheet and if they test their relays at all, they test to the static conditions listed on that same data sheet.

In a typical evaluation recently completed at Teradyne, a sample lot of reed relays from a major manufacturer was first tested to the static conditions listed on the spec sheet. All of the relays passed these tests, just as the manufacturer had certified. Yet, the results of further dynamic testing and a brief life test were appalling. None of these devices closed and settled within the "typical" time listed on the data sheet. Before they had completed 10,000 operations, half of the relays exhibited static contact resistance in excess of the specified maximum. Of those remaining, 30 percent recorded static failures and 50 percent dynamic failures between 10,000 and 20,000 cycles.

Ignoring the initial failure of these relays (close and settle time), which could have made them all useless in certain applications, only one in ten of these relays was operating reliably at the end of 20,000 cycles. This isn't the sort of behavior you expect from a device commonly designed into equipment intended to fulfill up to a million trouble-free operations.

Do results like this mean that reed relay manufacturers are printing fraudulent spec sheets? Nothing could be farther from the truth. What really happens is that the manufacturer and the user of reed relays aren't always speaking the same language. Specifications which are important to the manufacturer may have little or no meaning to the user. Many of these specs are simply carry-overs from the tests used to check armature-type relays.

A good example of this is the "pull-in" voltage specification, originally designed to verify coil fabrication and spring tensions. The general-purpose relay will have a minimum and maximum pull-in voltage specification. There is no time relationship involved; that is, the pull-in voltage is simply that which results in movement of the armature and closure of the contact. This is often a visual observation. Usually no consideration is given to the actual value of contact resistance which occurs when "closure" occurs at these levels. An engineer who is depending upon the minimum pull-in voltage as an acceptable minimum when wide variations in power source are present will find that he has a problem, since contact resistance can vary directly with applied voltage due to variations in contact pressure. In fact, most relays are operated at a nominal coil voltage level of 150 to 200% of the minimum pull-in level in order to achieve satisfactory performance. This factor, is not considered in the specification of pull-in voltage.

Coil resistance is another example

Coil resistance is specified in ohms, dc. However, the current level at which the resistance measurement is made is very rarely specified; thus, resultant heating and its effect on the coil resistance are not considered. Further, there is no consideration given to the time required to make the measurement. It may be in the millisecond region if performed by an automatic test instrument, or it could take as long as 15 or 20 seconds if done manually.

Interestingly enough, these kinds of specifications have been carried over to the manufacture of reeds, where most of them do not apply. The mechanical assembly (the actual reed switch) is made on a relatively automatic basis and has no adjustments, except during the manufacturing process. At that time, the reed is inserted in the coil and the assembly completed. Once this happens, there are no adjust-

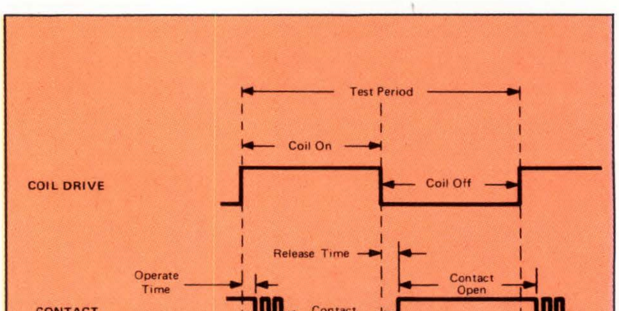


Fig. 1—Timing diagram for a normally open reed relay provides time based definitions for specifying and testing relays. Operate time, bounce time, active time, and release time should be specified when purchasing relays, and not accepted to be those published as "typical."

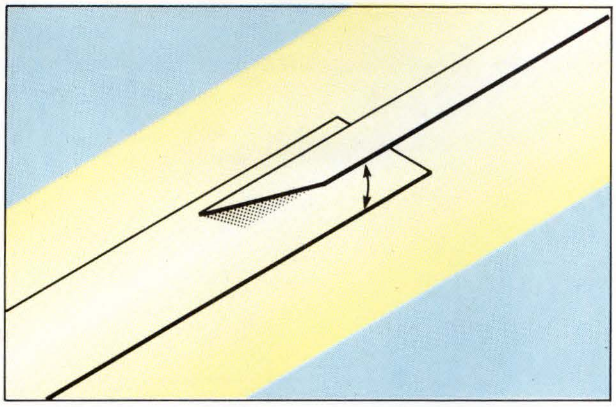


Fig. 2—Rotational misalignment of reeds can cause catastrophic failure of the device since contact area is greatly reduced. Fortunately this flaw can be detected in testing since such misalignment will alter the dynamic operating characteristics of the device.

ments, so pull-in and coil resistance specifications are much less meaningful for the manufacturer and just as limited to the user.

In a reed relay there are typically no additional mechanical elements in the assembly, such as the contact stops and back-tensioning springs commonly found in armature type relays. As a result, the transfer function is simply that shown in **Fig. 1**. When the field is applied, the blades begin to move; and when the blades touch, the transfer function is complete. Nevertheless, there are some physical characteristics involved which complicate the picture.

Proper mechanical alignment is essential

If the contact surfaces of a reed relay are misaligned, as would be the case in a parallel contact arrangement if the amount of overlap varies from the design norm, or if the blades are in rotational misalignment as in **Fig. 2**, then the amount of mating contact surface will not be within design limits. Consider the possible effects of localized heating that would result should two contacts have only a fraction of the surface area intended. Sticking under load is the most probable result; that is, the contacts may fail to open when required to do so. Additionally, the operate and release time of the relay is markedly affected by variations in mechanical alignment of the contact.

One of the most interesting effects, and one that is useful in testing, is the relationship of mechanical alignment to bounce. If the contact blades are rotationally misaligned, the friction from the mating surfaces of the blades will be far less than normal. This condition will be exhibited in a greater bounce time, since mechanical damping of the contact blades by the contact surface area has been reduced. This is also possible if the contact overlap depicted in **Fig. 3** is not correct. Should the contact overlap be excessive, bounce will probably be reduced; however, the probability of contact sticking is markedly increased, since much greater surface areas are in contact.

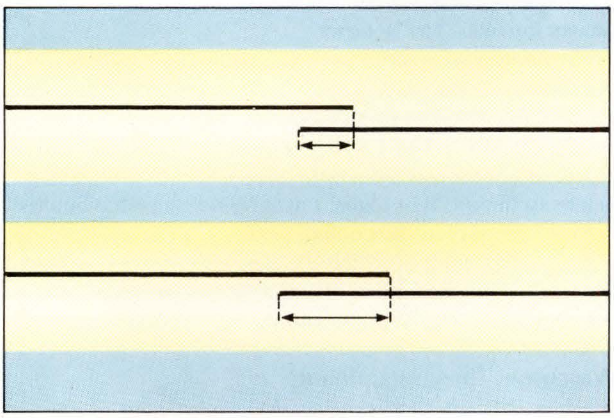


Fig. 3—Overlap, or contact area, of a reed relay must be within specified limits. If the contact area is too small, current capabilities will decrease and noise will increase. If too large, operate times will be degraded. Again, dynamic testing will expose such defects.

Misalignment is the cause of one of the most complicated failure mechanisms of relays—namely, transient performance. If the mechanical dynamics of the device are not fully under control, the probability is great that the relay may, in fact, open during the period when the coil is energized—long after the initial closing and bounce time. Further, should the operate frequency be relatively high with respect to the device's maximum operating frequency, mechanical misalignment can be exhibited as a transient closing, after the coil has been deenergized, again at a point in time long after the normal contact-open period.

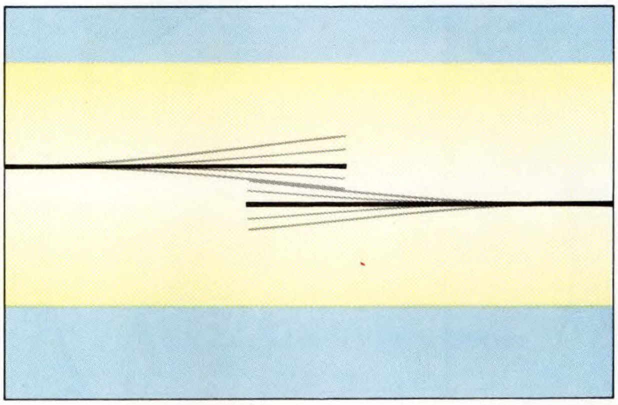


Fig. 4—Cantilevered arms of a reed relay are undamped, except by contact friction, and must be tightly controlled in manufacturing if dynamic performance is to be within specifications. Small changes in alignment, friction or length can change resonant frequencies drastically.

After the blades touch, even if they are perfectly aligned, they continue to vibrate. Their motion continues because the reeds are cantilevered, as shown in **Fig. 4**, and damped only by contact friction. This produces the phenomenon of contact noise, which continues for long periods of time after the contacts have closed. Typically, it is still present for a period 10 times longer than the closure time of the relay. This, combined with the thermal EMFs generated by dissimilar metals (i.e. the base material and the plating material), make it absolutely necessary to specify contact resistance in relation to time after closure.

Transient response

Mechanical misalignment is not the only thing that affects the transient performance of a reed relay. The fact that the blades remain in motion for long periods of time after they are closed, combined with the high probability of mechanical resonances which occur at frequencies far below the actual resonant frequency of the device, result in transient openings and closures. Dry reed relays exhibit both while mercury wetted types are frequently troubled with reclosures due to mercury transfer. These transients

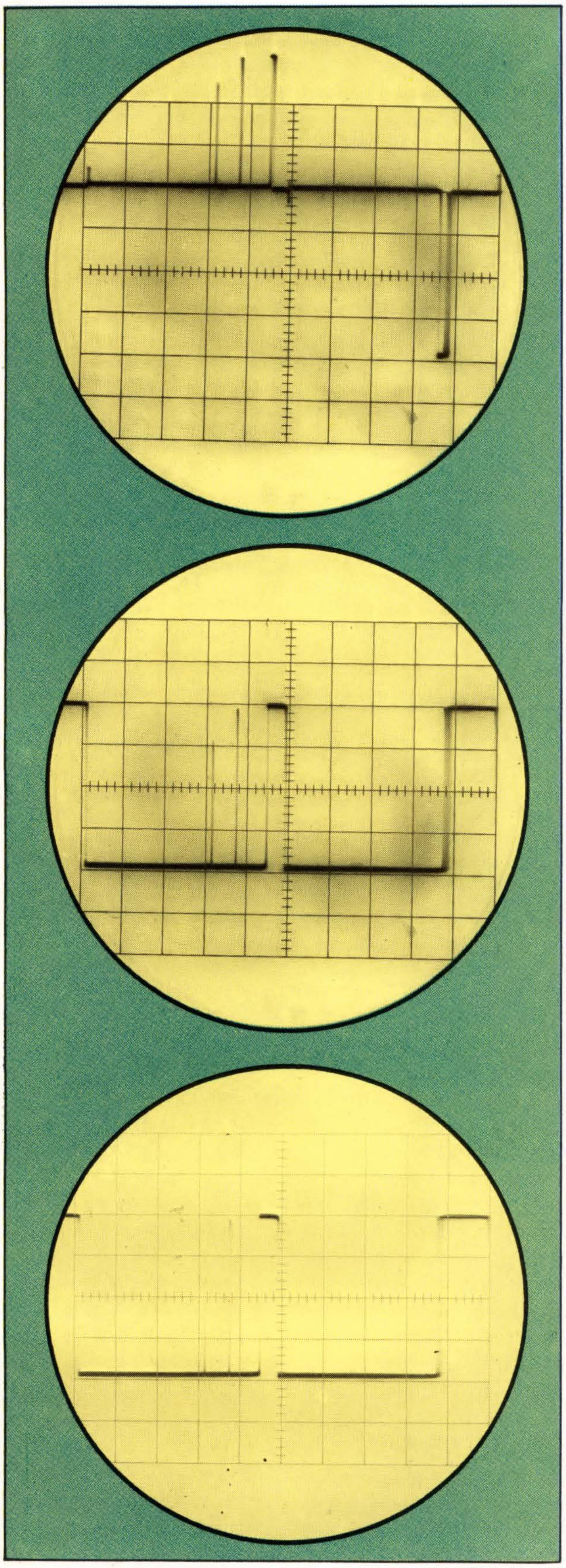


Fig. 5—Scope traces from a relay evaluation instrument show normal operation of a reed relay closing and opening (top). The same relay, at a different operating frequency exhibits transient closing spikes (center photo) that could be catastrophic in certain applications. Output of relay evaluation test strobe circuit (bottom photo) shows these reclosures are recorded as dynamic failures.

PROPOSED SPECIFICATION SHEET FOR REED RELAYS

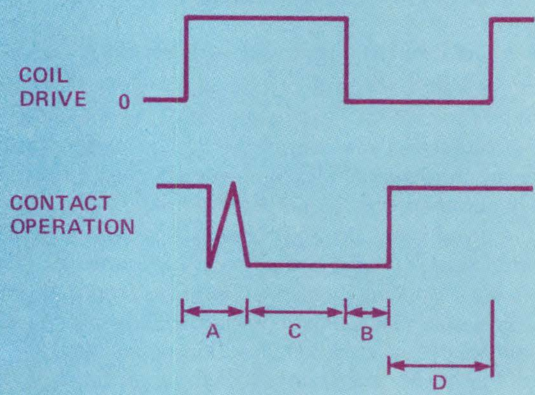
Coil drive		____nominal ____ min
Coil open ckt voltage		____
Coil drive on		____mS max; ____ mS min
Coil drive off		____mS max; ____ mS min
Pull-in and bounce time	(A)	____mS max
Release time	(B)	____mS max
Closed time	(C)	____mS min
Open time	(D)	____mS min

Contact Resistance measured at: ____m Ω max

(A) Gated current __10 mA
Compliance voltage __30 mV

(B) Contact current ____ mA
Compliance voltage ____ V
(dependent upon the application)

(C) This performance to be verified over____operating cycles.



frequently occur at points which extend the normal release time of the relay 3 to 10 times.

The photographs shown in **Fig. 5** were taken from a Teradyne relay evaluation instrument. The first (5a) is an oscilloscope trace showing normal contact operation and can be related directly to **Fig. 1**. Here you can see the first closure, at which time the actual contact resistance is on the order of tens to hundreds of ohms; this is followed by the bounce period, after which the contact settles to some value of resistance. The point at which the desired contact resistance (R_c) is defined determines the usable characteristic of the relay for the particular application.

Watch out for contaminants

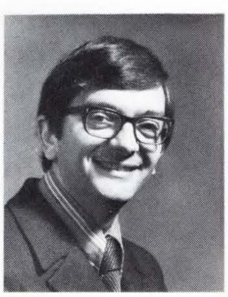
Another common failure mechanism in reed relays, or any sealed contact relay, is contact surface contamination. There are many sources of contact films, the most common being organic solvents used to clean the blades and glass envelope. There are also particulate contaminants, which are frequently observed in the form of bits of dirt, eyelashes, and pieces of plating material that have flaked off the contact surfaces. The films exhibit very high resistance, frequently hundreds of ohms at voltages below 50 to 100 mV. As a result, when reed relays are used to carry or switch low-level loads such as thermocouples or transistor base-drive currents, the film may not break down. In this case the apparent R_c value is high. However, should the contact be exposed to a voltage level higher than this value, the film will break down and R_c will appear low, although frequently unstable if it is subsequently used for low-value loads. The film will reform with time, until R_c is in the 10's to low 100's of ohms region, once again.

The display in **Fig. 5b** shows the same contact pictured in **Fig. 5a** but operating at a slightly different frequency. You'll notice that the transient reclosures do not necessarily occur at the same points or at predictable points during the coil-off cycle. As a result, contact performance must be constantly monitored for the complete coil-on periods as well as the complete inactive contact period during coil-off. The photograph in **Fig. 5c** shows the response of the relay evaluation instrument to these transients. The detectors are driven hard negative at the time of contact failure. This information is processed by the evaluation instrument, and recorded as a dynamic stick. During the active contact-closed period the value of R_c must be monitored as shown in the two lower waveforms in **Fig. 1**. However, if the contact is exposed to levels which will break down the surface films the existence of that failure mechanism will be masked. Therefore, the contact current must be gated-on during the period noted "B" and the voltage drop across the contact must be limited so as not to exceed 30 mV—a safe level, where film breakdown will not occur.

Accompanying this article is a proposed specification check list which will insure the delivery of reed relays that meet your design requirements. One point which has not been mentioned, but which should be included in the specifications is the length of testing. Over what number of operations should performance be verified? In most cases 2 to 10 thousand cycles is sufficient. Remember that one failure can be catastrophic in certain applications, and yet you cannot use any significant portion of the design life of the relays for testing, except on a sample basis.

This review has covered the most common reed-relay failure mechanisms and, more importantly, how to detect them before they degrade the performance of your system. The sample specs provide a method for communicating your needs to your suppliers. Don't let it be your only communication, though. If you don't communicate with your supplier, he can't put his experience to work for you. □

Author's biography



Jerry Jodice is a product manager in the relay test instrument group of Teradyne, Inc. He graduated from Lowell Tech., in Lowell, Mass., with a BSEE degree and has worked toward a graduate degree in management at Boston University. He is a member of IEEE.

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

series 1400

illuminated push button controls

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

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

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

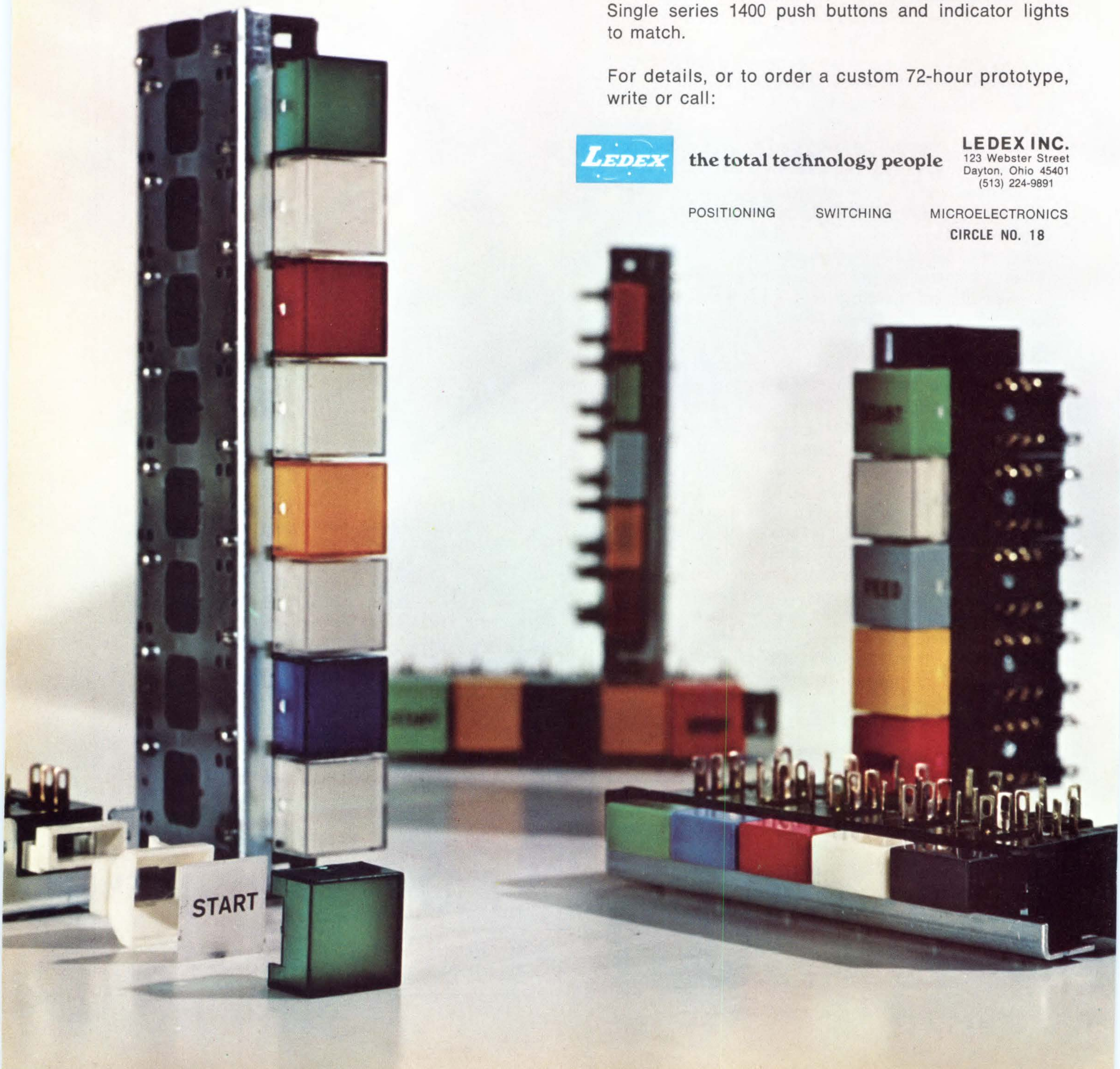
For details, or to order a custom 72-hour prototype, write or call:

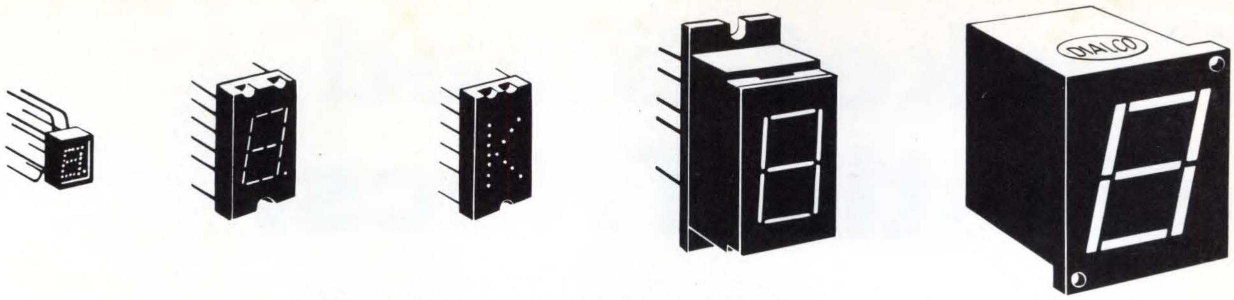
LEDEX **the total technology people**

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

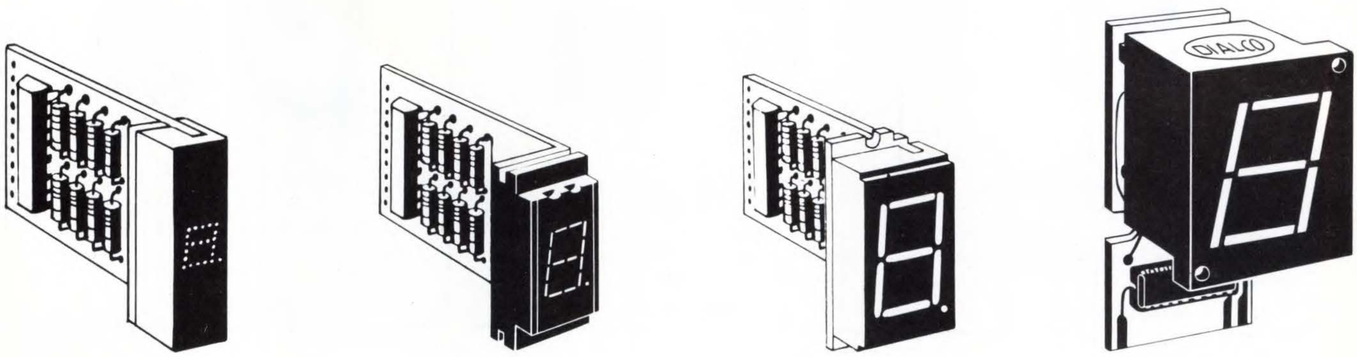
POSITIONING SWITCHING MICROELECTRONICS

CIRCLE NO. 18

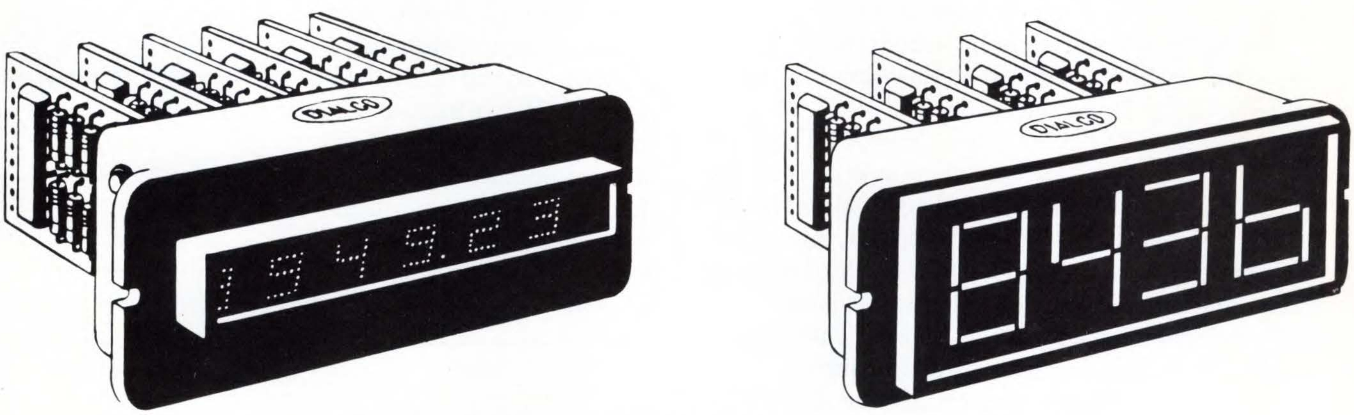




Readout modules in character heights from .125″ to 1″



Readout packages (modules with decoder/drivers)



Complete readout assemblies (1-10 packages in bezel for instant mounting)

Readouts?
Talk to the specialists at Dialight first. You won't have to talk to anyone else.

For one thing, Dialight offers you a wider range of sizes than anyone else—character heights from .125″ to 1″. Only Dialight can give you LED, incandescent or neon light sources. Important, too, Dialight gives you complete design flexibility—you can buy a digital module or that module packaged with a decoder/driver or a complete assembly of packages ready to mount. And the cost per digit may well be less than you'd pay for the decoder/driver alone. Finally, you get Dialight's expertise in visual indicators. That doesn't cost you anything. Neither does the readout data we'll send you upon request. Write for it today!

DIALIGHT DIALCO

DIALIGHT CORPORATION, A NORTH AMERICAN PHILIPS COMPANY • 60 STEWART AVENUE, BROOKLYN, N.Y. 11237 • (212) 497-7600

CIRCLE NO. 19

Socket-Sized Plastic Triacs:

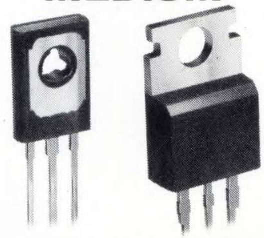
SMALL

0.45, 0.65 & 0.8 A RMS Triacs
MAC92, 93, 94

– For 2 or 4 mode use in solid-state relays, T²L logic and light industrial applications

CIRCLE NO. 74

MEDIUM

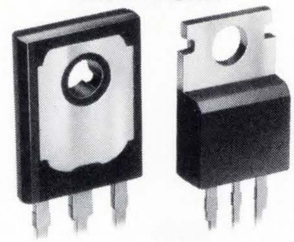


2N6068-72, 2N6342-49
4 & 8 A RMS Triacs

– For full-wave ac control in light dimmers, motor and heating controls and power supplies

CIRCLE NO. 75

LARGE



2N6151-56, 2N6342A-49A
10 & 12 A RMS Triacs

– For demanding, higher voltage designs where up to 800 V, 9600 W full-wave control is required.

CIRCLE NO. 76

A line of low-cost plastic Triacs job-rated to fit virtually any full-wave control socket has been hard to find . . . up till now.

Now you can design in the exact Triac you need to do the job you want to do in your stepless ac control system without upgrading, downgrading, over- or under-buying. From one source.

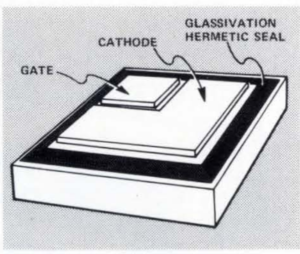
The new MAC92/93/94 series Unibloc* Triacs are unique — in package, performance and price. They offer less-than-1 A current capability in 30 to 400 volt blocking voltage ranges. The compact, one-piece, injection-molded case — pioneered by Motorola for volume production of small signal transistors — is ideal for automatic insertion techniques. They furnish low, 100 μA leakage currents for minimum power drain, 4 quadrant firing (ideal for driving directly off T²L) and cost as little as 50¢, 100-up.

Two styles of medium-sized packaging are yours to choose from in the 4 to 8 A range: the new Thermowatt* TO-220AB for direct replacement of existing types in 8 A sockets and the 4 A Thermopad* units providing 25 to 600 V muscle in the 1,000 W control area.

And Thermowatts now handle 12 A! That's unique. And Motorola did it first. The 2N6342A-49A series 220AB types provide top power handling in this broadest plastic Triac family . . . up to 9,600 W. Still small and rugged, these new types offer low thermal resistance and high heat dissipation and durability for rugged control applications.

Extra reliability on all . . .

Now you get the built-in reliability and long-term stability of glassivation on all Motorola plastic Triacs from 4 to 12 A and thermally-grown, oxide-passivation on the Unibloc types. Whichever you choose, you'll have sealed, uncontaminated junctions, higher blocking voltages and increased savings.



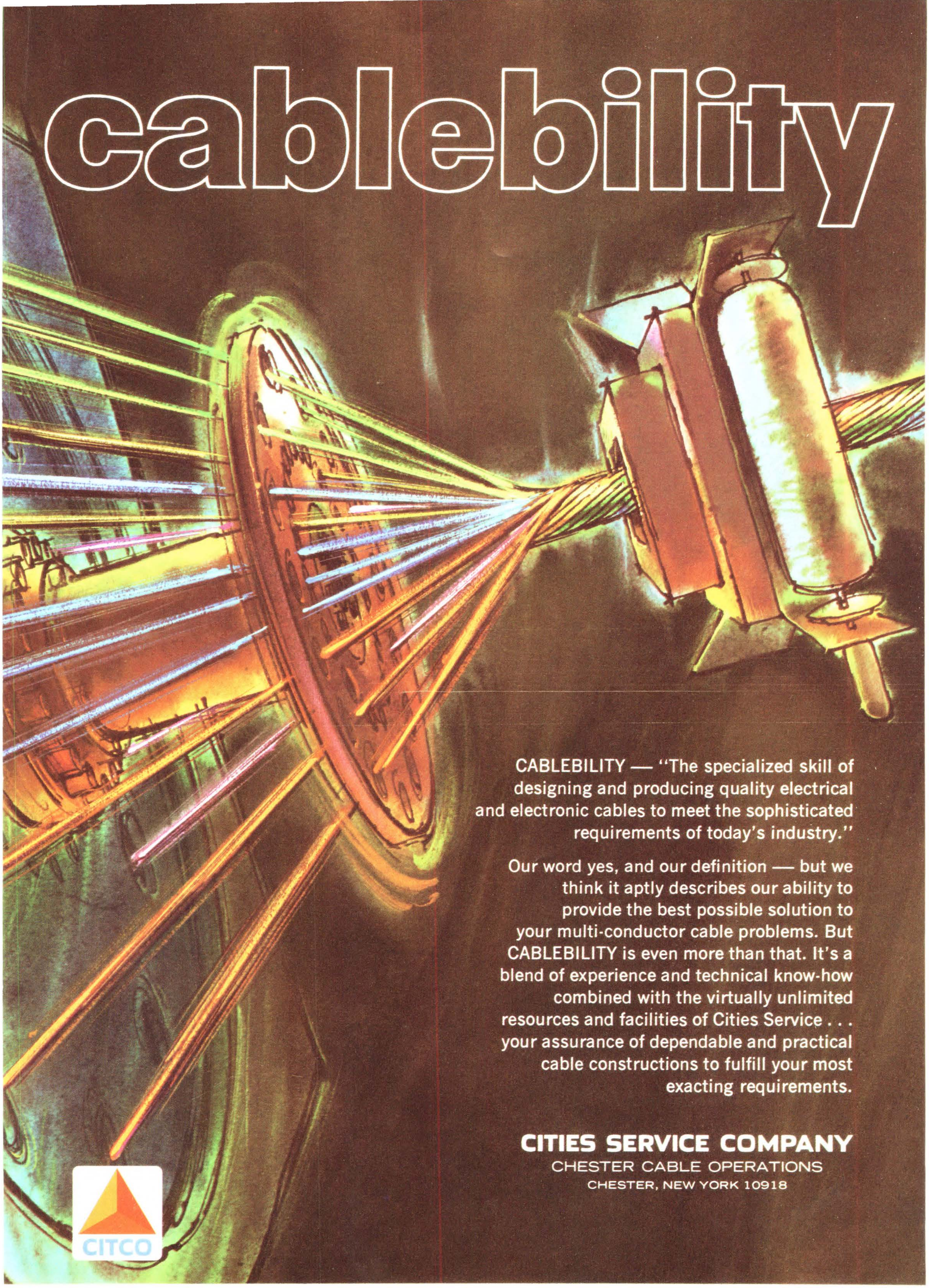
Triac Series	Plastic Package	I_T (RMS) A	V_{DRM} Range V	I_{TSM} (SURGE) A	Price Range 100-Up
MAC92	Unibloc	0.45	30-400	6	50¢-95¢
MAC93	Unibloc	0.65	30-200	6	61¢-98¢
MAC94	Unibloc	0.8	30-200	6	67¢-$1.05
2N6068	Thermopad Case 77	4	25-600	30	56¢- 2.10
2N6342	Thermowatt Case 220AB	8	200-800	100	95¢- 3.05
2N6151	Thermopad Case 90	10	200-600	100	1.15- 1.75
2N6342A	Thermowatt Case 220AB	12	200-800	120	1.10- 3.40

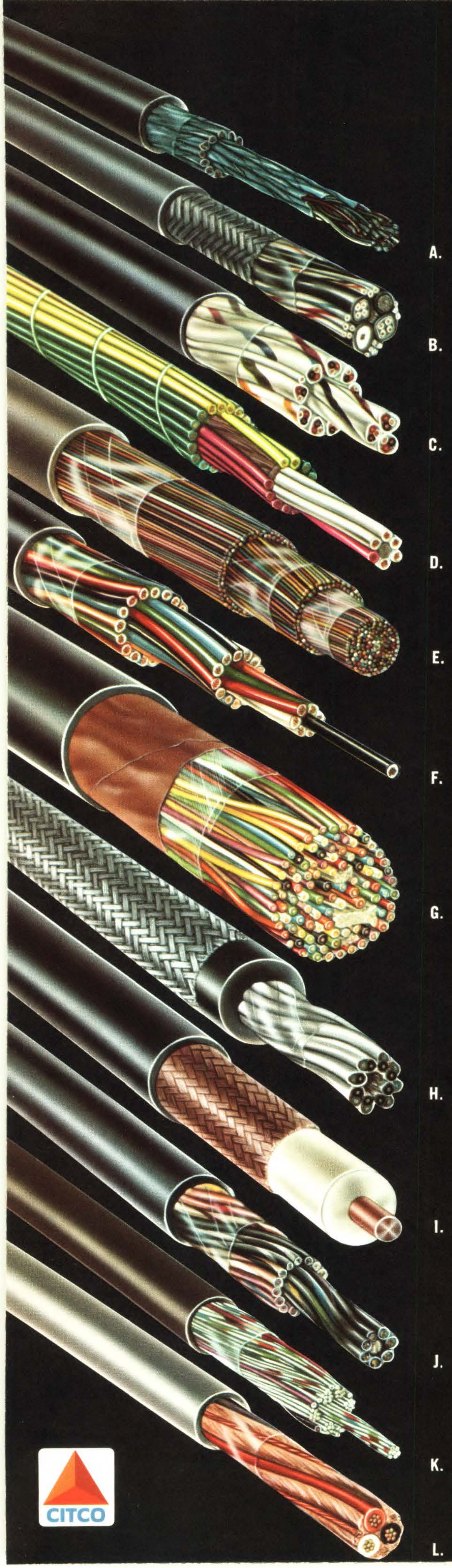
Write Box 20912, Phoenix, AZ 85036 for complete data. See your Motorola distributor or factory representative for prototype or production quantities. Size up our control capability today.

*TRADEMARK OF MOTOROLA INC.

MOTOROLA THYRISTORS
—300 ways to get control

CIRCLE NO. 21


cablebility
CABLEBILITY — "The specialized skill of designing and producing quality electrical and electronic cables to meet the sophisticated requirements of today's industry."
Our word yes, and our definition — but we think it aptly describes our ability to provide the best possible solution to your multi-conductor cable problems. But CABLEBILITY is even more than that. It's a blend of experience and technical know-how combined with the virtually unlimited resources and facilities of Cities Service . . . your assurance of dependable and practical cable constructions to fulfill your most exacting requirements.
CITIES SERVICE COMPANY
CHESTER CABLE OPERATIONS
CHESTER, NEW YORK 10918
CITCO



cablebility

proven by performance

Leading manufacturers in such fields as electronics, automation, nucleonics, communications and electronic data processing have learned to depend on Cities Service quality cables. This industry-wide acceptance has resulted in four expansion programs since 1945 to keep pace with increasing customer demands. Thanks to enlarged research and development facilities, exceptional technical manpower and the latest production equipment, we furnished more than 1,000,000 miles of insulated cables and wires to our customers last year.

Today, our CABLEBILITY is your assurance that Cities Service CITCO brand cables will meet your specifications . . . be competitively priced and will be delivered to you on time. No matter what your requirements . . . check first with Cities Service . . . we know you'll be glad you did.

A. **CITCO AUDIO SOUND CABLE:** 25 shielded pairs. stranded copper conductors, low loss insulation, twisted with uninsulated drain wire, isolated aluminum tape shields, cabled PVC jacket.

B. **CITCO TV CAMERA CONTROL CABLE:** Camera control cable for Audio and Video signals: a composite of PVC and polyethylene insulated conductors, cabled, overall braid shield, PVC jacket.

C. **CITCO AIRCRAFT CONTROL CABLE:** 12 triples shielded jacketed, stranded copper conductors, PVC insulated, individual shield jacket color coded, cabled overall PVC jacket.

D. **CITCO ELEVATOR CONTROL CABLE:** 35 conductors, stranded copper, PVC insulated, conductors coded by colors and printed numbers, cabled with open binder; individual conductors U/L listed.

E. **CITCO INTEROFFICE COMMUNICATION CABLE:** 250 conductor interoffice communication and signaling cable: solid bare copper, PVC insulation, paired, cabled, PVC jacket; U/L listed.

F. **CITCO STATION CONTROL CABLE:** 37 conductors, stranded polyethylene and PVC insulated, color coded, cabled, overall tough PVC jacket; per NEMA/IPCEA Specifications.

G. **CITCO MUNICIPAL COMMUNICATION CABLE:** 50 pairs, polyethylene insulated, cabled, continuous layer of copper shielding tape, PVC jacket; per spec. IMSA-19-2, 600 volts.

H. **CITCO SHIPBOARD CABLE:** Stranded conductors, nylon-jacketed PVC insulation, pairs shielded and jacketed, cabled, PVC jacket, and aluminum braid armor overall; per spec. MIL-C-915.

I. **CITCO COAXIAL CABLE:** Type RG-218/U, solid copper conductor, polyethylene insulated, copper braid shield, PVC jacket; per spec. MIL-C-17/79.

J. **CITCO REMOTE CONTROL BROADCASTING CABLE:** Stranded conductors, polyethylene insulation, pairs and triples shielded and jacketed, cabled, PVC jacket overall.

K. **CITCO COMPUTER CONTROL CABLE:** 55 conductors, stranded copper conductors, PVC insulated, formed into 7 groups of 7 conductors, cabled, PVC jacket; U/L listed.

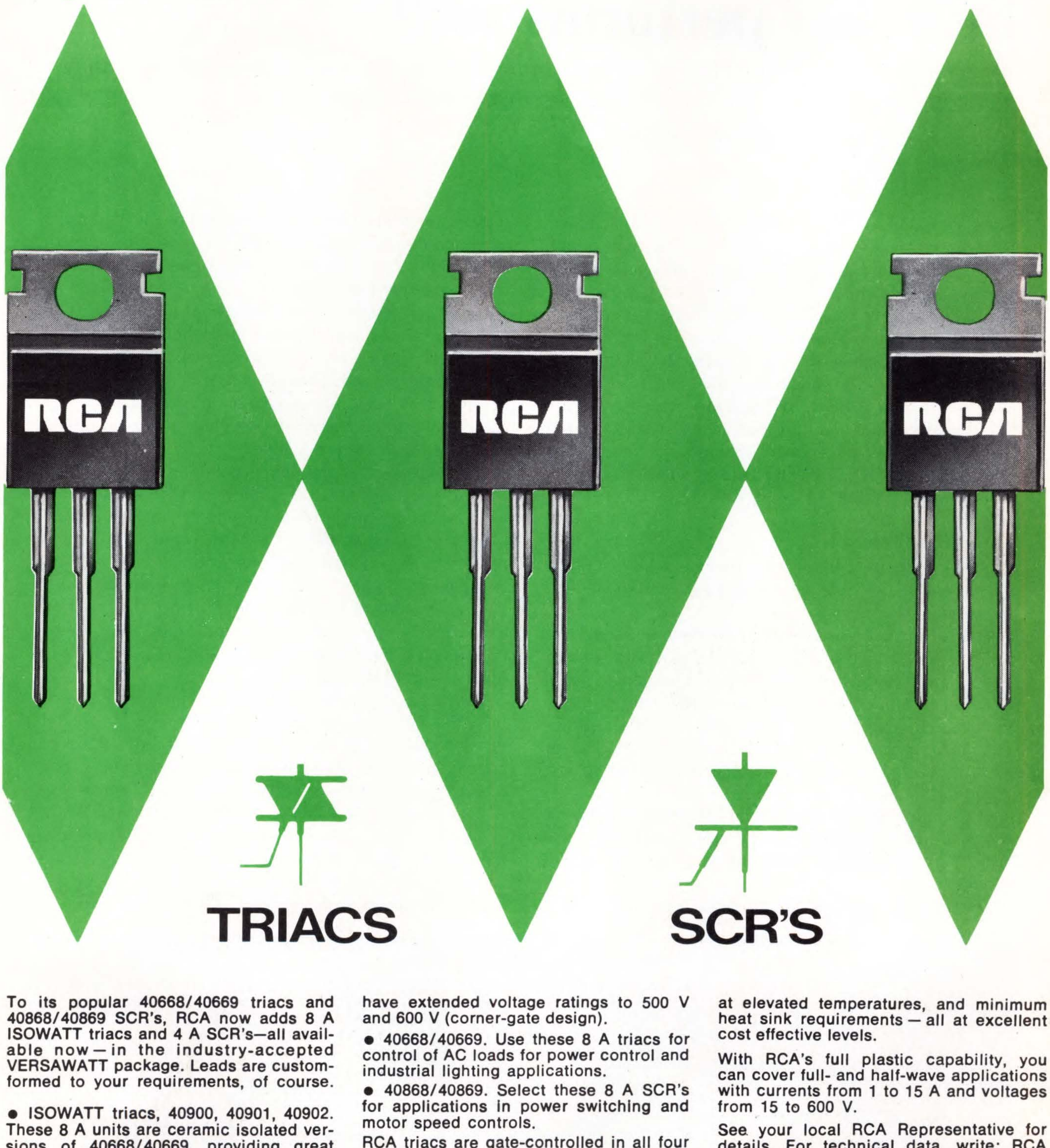
L. **CITCO BUS DROP CABLE:** 3 PVC insulated stranded conductors, with split uninsulated grounding conductor, cabled, overall PVC jacket; U/L listed; per NEC.

OTHER CITIES SERVICE WIRE & CABLE PRODUCTS

APPLIANCE WIRE • BUILDING WIRE • FLEXIBLE CORDS • FIXTURE WIRE
GAS TUBE SIGN CABLE • HIGH VOLTAGE CABLE • HOOK-UP WIRE
LEAD-IN CABLE • MACHINE TOOL WIRE & CABLE • SHIELDED WIRES
WEATHER-PROOF WIRE • DEEP-WELL SUBMERSIBLE WATER PUMP CABLE
LOW ENERGY CIRCUIT CONTROL CABLE • GASOLINE & OIL RESISTANT WIRE

CITIES SERVICE COMPANY
CHESTER CABLE OPERATIONS
CHESTER, NEW YORK 10918
Phone: (914) 469-2141 TWX (914) 469-9801

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



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 50E15 /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

CIRCLE NO. 24

Printed in U.S.A.

Stepping-motor controller costs little but performs well

For a component cost of under $200, this controller provides performance and versatility that compare favorably with larger, more costly commercial controllers.

Lee A. Erb, P. K. Govind and C. D. Zafiratos
Univ. of Colorado

Extensive use of silicon TTL and DTL ICs helps hold down both the cost and the size of this controller, which was designed for use with a bidirectional, solenoid-actuated stepping motor that has 10 discrete angular steps per rotation and a maximum stepping rate of 25 steps per second.

A block diagram of the system is shown in **Fig. 1**, and a flow chart of its operation is given in **Fig. 2**. The stepping-motor controller is a single-axis unit that is manually switched to one of three bidirectional stepping motors. The operator initiates control operations by selecting the desired motor, its direction of rotation and the desired number of steps. The stepping sequence begins when he presses the START button.

Controller circuit

Functionally, the controller circuit can be broken down into a control logic section, a step scaling section and the output circuits.

Control logic. Here the major element is the control flip/flop (**Fig. 1**). This, along with its associated set and reset circuitry is shown in **Fig. 3**. In its reset state the control flip-flop blocks operation of all counting stages. It also inhibits clock pulses from being gated into the test flip-flop. In its set state the control flip-flop allows clock pulses to be processed, activates all counter stages, and lights a "stepping" indicator lamp.

The control flip-flop is set when the front panel START button is pushed. Contact bounce effects, inherent in this switch, are eliminated by buffering its action with an R-S flip-flop.

The control flip-flop can be reset from one of two sources. Normally, the reset is generated by the "test gate" when the desired number of steps have been completed. In addition, a manual reset lets the operator "abort" a count sequence if necessary.

The clock oscillator and selection circuit has two sources of clock pulses (**Fig. 3**). One is the internal oscillator, which provides a variable motor stepping rate of 4 to 20 steps per second, controlled by a front-panel potentiometer (step rate). The second is an external input that can be used to normalize the stepping rate to an outside parameter when this is desirable.

Rate adjustment of the unijunction-transistor-type internal oscillator is through a variable current source. Both input selection and control flip-flop gating are accomplished by clamping the UJT emitter to ground to inhibit operation. The external clock input is buffered by an emitter follower and presented to one input of an AND gate. The other input to the AND gate provides the selection and enabling of the external clock input. An ORed connection of the internal oscillator and the external clock input gate feeds the test flip-flop.

The purpose of the test flip-flop is to eliminate the possibility that false comparator signals might reset the control flip-flop. Such false signals could result from transient counter states that were caused by a "carry" propagating through the decade counter flip-flops (**Fig. 1**). The test flip-flop generates a step and a decade counter ADVANCE every other clock pulse. The alternate clock pulses cause the test flip-flop to enable the test gate to check for the completion of a preset number of motor steps.

When all inputs of the test gate are HIGH, the gate gen-

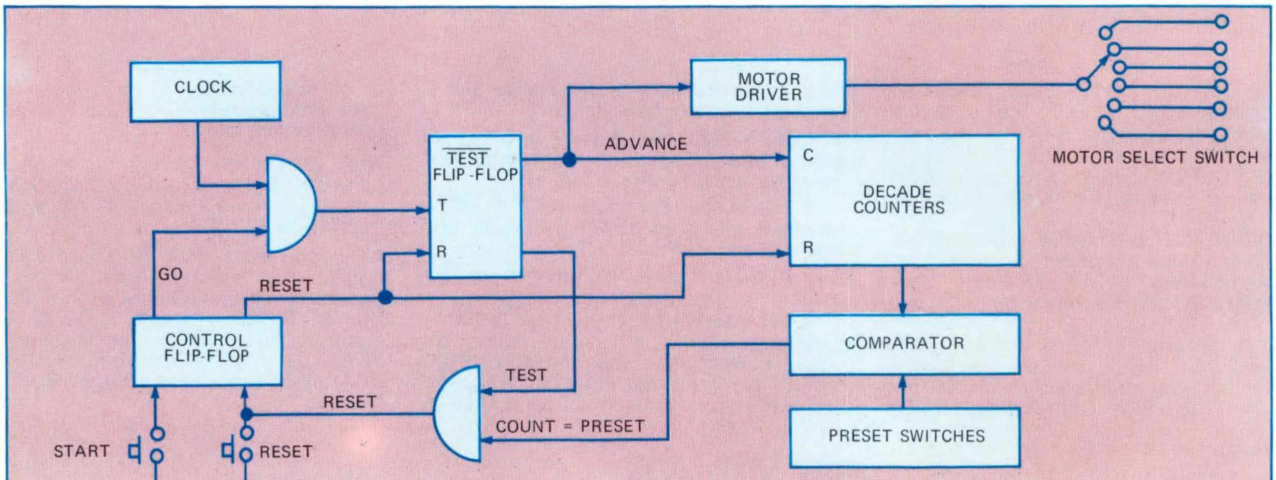


Fig. 1—Functional block diagram of the stepping-motor controller shows that when a manual start is initiated, the stepping motor that was selected advances the number of steps indicated on the preset switches.

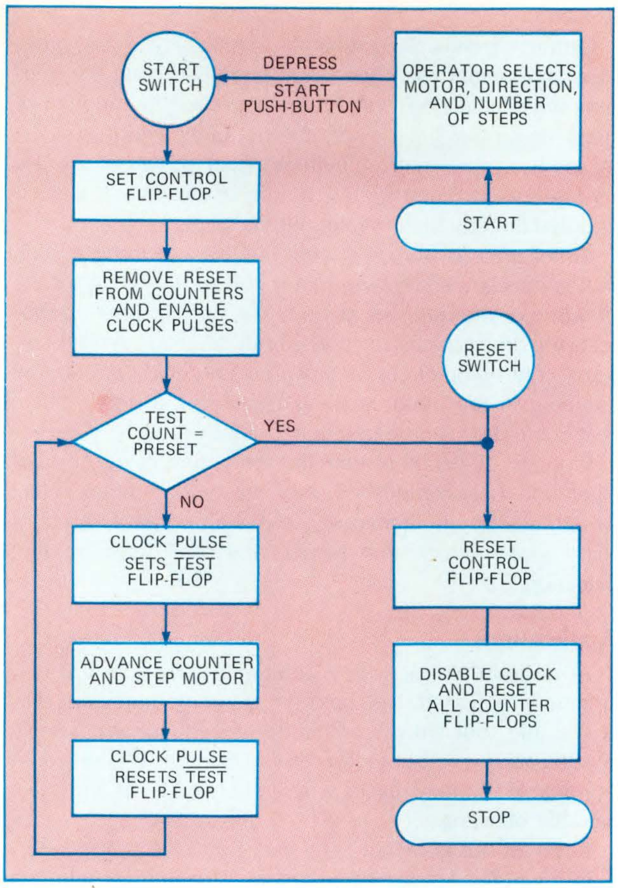


Fig. 2—Operational flow chart. The operator selects the motor, the rotation direction and the number of steps. He then presses the START button and the preset number of steps is automatically performed.

erates a reset to the control flip-flop. Five of the test gate inputs are from the decade comparator circuits. Each of these signals will be HIGH if the decade counter associated with it contains the proper number of counts. When the test flip-flop is in the reset state the gate is enabled for the count check. The control flip-flop in its reset state inhibits the test gate operation.

Step scaling. Each motor step is counted by five decade scalers, one of which is shown in **Fig. 4**. This permits a maximum of 99,999 steps in one sequence. As shown in **Fig. 4**, each decade stage contains a BCD decade counter, four EXCLUSIVE OR circuits for comparators and a four-pole 10-position rotary switch for a count preset.

A TTL 7490 decade counter IC is used in each decade scaler. This device has a clock input that advances the counter on a negative transition. It also has a parallel reset, which resets its four BCD outputs to zero when the reset line is raised to a positive logic level. Each decade scaler is capable of acquiring pulses much faster than the stepping motor can advance.

The four-pole 10-position preset switches are wired to generate negative BCD signals compatible with the type of integrated circuits used. Each switch sets the preset count for its associated scaler.

The outputs of each decade counter are checked against the preset switch settings by a comparator, which is constructed of four DTL EXCLUSIVE OR circuits with their outputs connected together in a wired AND configuration. If each decade counter flip-flop output is the opposite of its associated switch section, then the output of that EXCLUSIVE OR goes HIGH. Any one EXCLUSIVE OR output LOW will keep the comparator output LOW. All must be HIGH to allow the comparator output to be HIGH. Each decade comparator output goes to the test gate for further

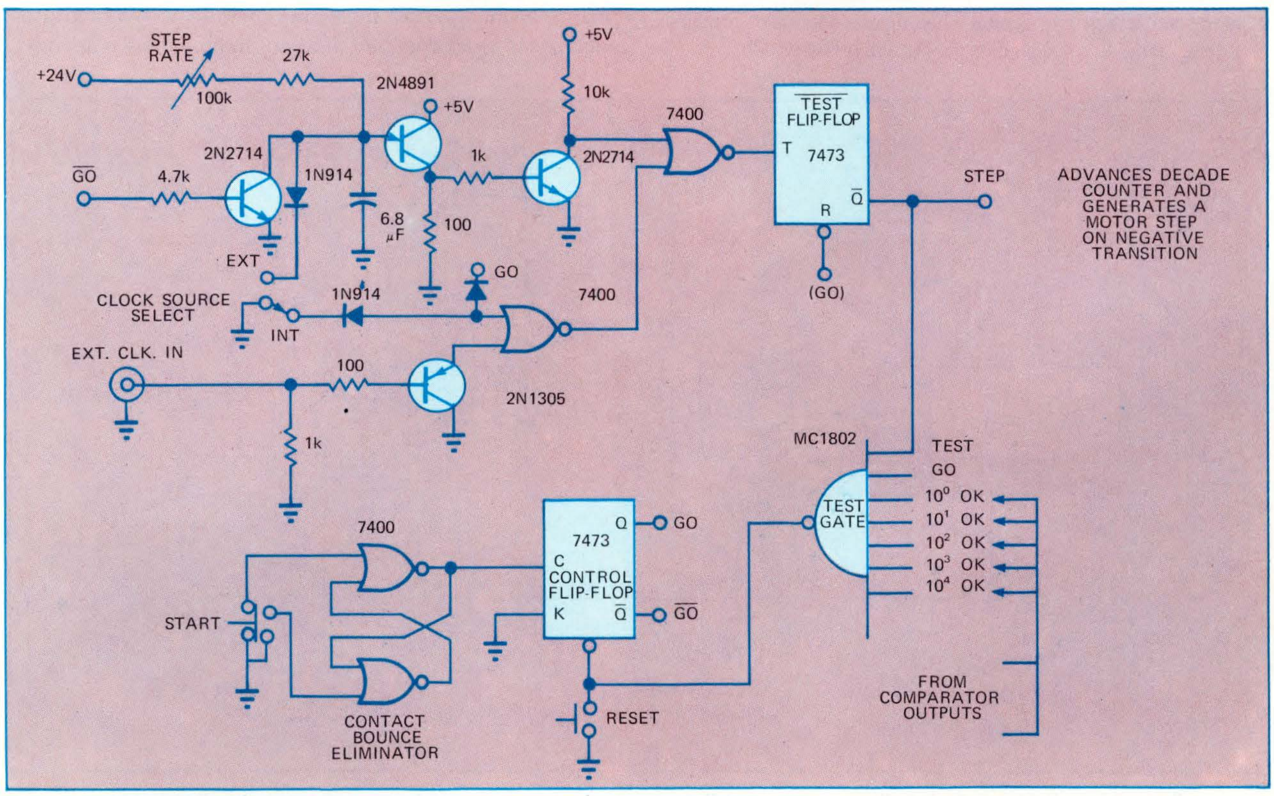


Fig. 3—Control logic section contains the control flip-flop, the clock signal gating and the count sequence complete test logic.

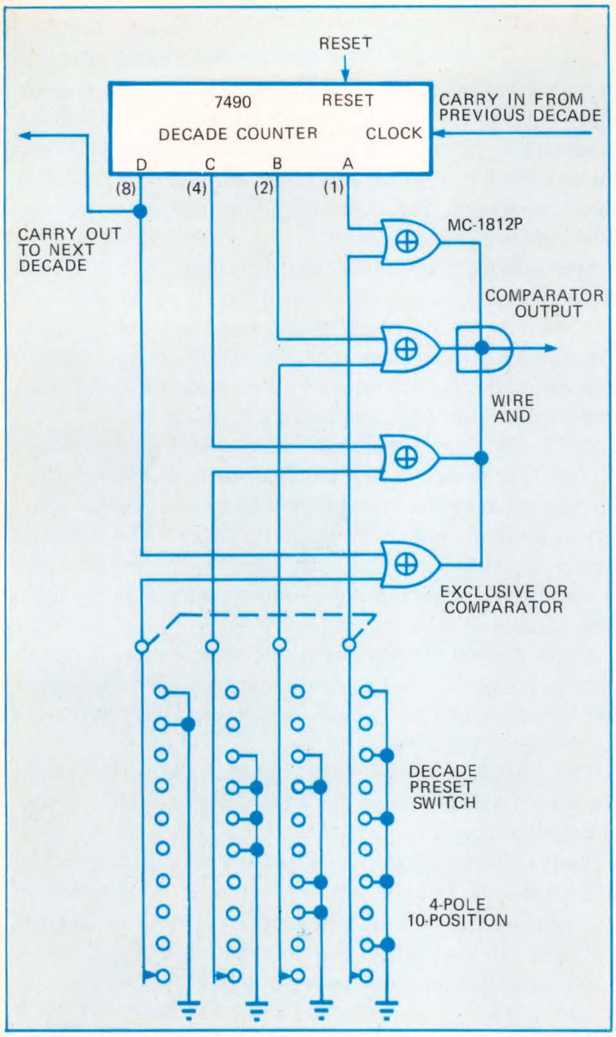


Fig. 4 – Step scaler is one of five identical decade scalers used to count motor steps to 99,999. The EXCLUSIVE OR comparator responds with a logic "1" output when the decade scaler contains the same number that is dialed on the decade preset switch.

ANDing.

Output Circuits. Two separate outputs (**Fig. 5**) are provided for external use. One is for actually driving the stepping motor, the other for externally scaling the number of steps the motors have taken. Output pulse width is determined by a one-shot multivibrator that produces a pulse 15 msec wide. The negative output of the one-shot is ac-coupled directly to the scaler output.

Motor drive is from a current-limiting electronic switch that connects the stepping motor coil to +24V dc for the duration of the one-shot period. The current limiting protects the driver in case a short circuit develops. A field collapse controlling circuit is provided to quickly release the solenoid in the motor without generating a high voltage that could damage the output transistor.

Operator selection of both the motor and its direction of operation is accomplished with the output motor select switch, which simultaneously selects an output to a counter (counter select) that records the total steps for that selection.

Applications

Aside from its use with a goniometer, for which it was originally designed, (see **box**) the stepping motor driver is a versatile tool with a multitude of applications. Simple modification of the motor driver section will make it applicable in many places where the need is for a discrete number of events.

Many of the potential uses are of an electrical or electronic nature. Among these are as a device for general-purpose pulse count generation, for simulating dial pulses or for testing electronic and electromechanical counters.

Several other applications for this controller are more mechanical than electronic, such as for exact parts count dispensing in a stock room or for exact pill dispensing of pharmaceuticals. And there are chemically oriented uses such as for rapid digitized titrations in quantitative analysis. □

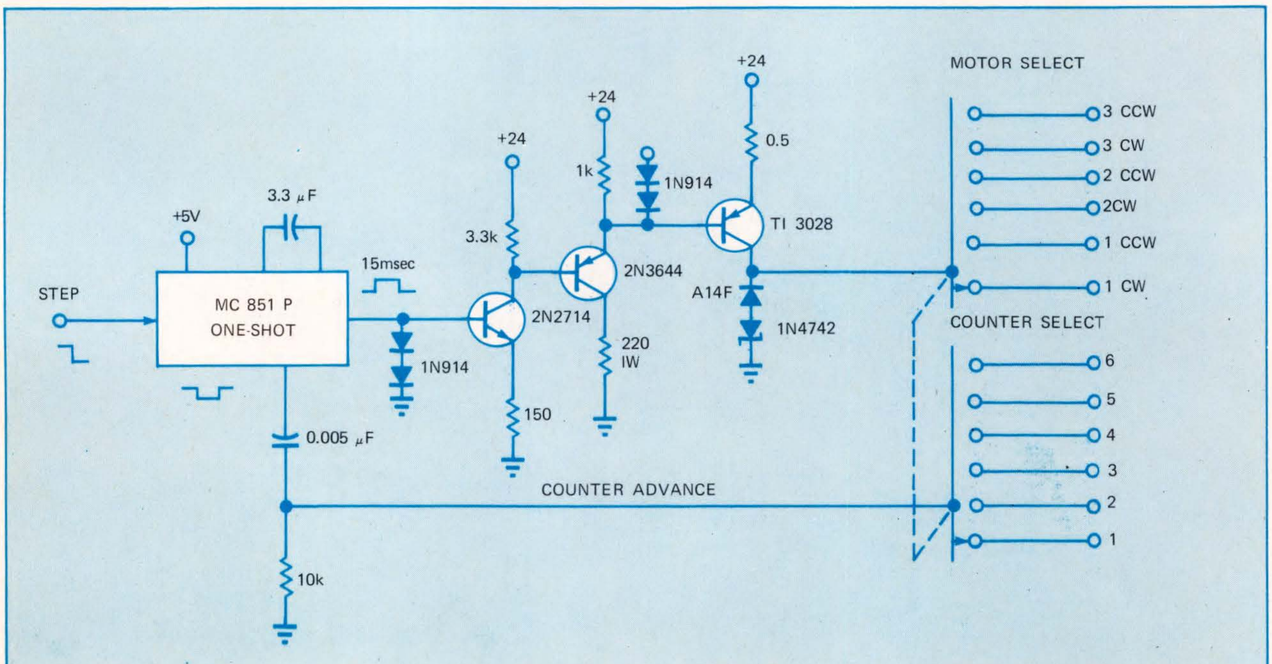


Fig. 5 – Stepping motor drive, when triggered by the negative transition of the step signal, causes the one-shot multivibrator/transistor combination to generate a 15-msec pulse through the stepping motor. It also provides a COUNTER ADVANCE pulse.

Application with a goniometer

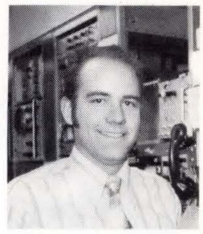
Goniometers capable of providing three independent angular operations have widespread application for crystal studies where accurate alignment is essential. Stepping-motor control of such goniometers provides flexible operation, in air or vacuum, and permits digital techniques to be used in the control system. In the inexpensive system described here, extensive use of silicon TTL and DTL integrated circuitry offers a performance-to-size-to-price ratio generally unavailable in commercial stepping-motor controllers.

The particular crystal goniometer assembly with which the stepping-motor controller was first used had been constructed for studying the lattice location of ion-implanted impurities in semiconductors that employed the ion-channeling effect.

In this instance the goniometer design was similar to that of K. C. Knox, which was described in Nucl. Instr. and Meth. 8 (1970) 202. Stepping motor drives coupled to gear trains provided rotations about horizontal and vertical axes in the plane of the target in increments of 0.005 and 0.0067° per step, respectively. Rotation about the beam axis was in increments of 0.0067° per step.

Part of the support for work described in this article was provided by the U.S. Atomic Energy Commission and part by the KDI Corporation.

Authors' biographies



Lee A. Erb is an electrical engineer with 6 years experience at the Univ. of Colorado's nuclear physics laboratory. He is responsible for the design, construction and maintenance of the electrical and electronic systems used for the particle accelerator and its data processing facilities. Mr. Erb acquired his BSEE at the University of Colorado.

P. K. Govind, who was with the University of Colorado's EE Department when this article was written, is now a scientist employed by the National Center for Atmospheric Research (NCAR) at Boulder, Colo. Mr. Govind holds both an MS and a PhD (physics major) from the University of Colorado and is a member of the American Physical Society.

Chris D. Zafiratos is an associate professor of physics at the University of Colorado, where he divides his time about equally between teaching and research in nuclear physics. A prolific writer on nuclear physics, he has recently been doing research on using sub-nanosecond timing techniques for fast neutron time-of-flight spectroscopy. Mr. Zafiratos received his PhD at the University of Washington.

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

SRL Power Supplies... Performance. Versatility.

Check the specs.

Model	Output Power: Voltage Range (Vdc)	Current (Adc) 55°C	Current (Adc) 60°C	Current (Adc) 71°C	Ripple (PARD) Volts RMS (4V)	Ripple (PARD) Volts P-P (mV)	Ripple (PARD) Amps RMS	Regulation Line & Load (Comb.) Voltage	Regulation Line & Load (Comb.) Current	Full Load Change Transient Response Time (μS)	Programming* Voltage Mode Ohms/Volt (±.5%)	Programming* Voltage Mode Volts/Volt	Programming* Current Mode Ohms/Amp (±10%)	Programming* Current Mode mV/Amp	U.S.A. List Price
SRL10-25	0-10	25	22	16.7	350	20	10mA	0.01% or 2mV	0.02% +4mA	150	200	1	40	20	$450
-50	0-10	50	44	33.5	300	10	20mA		0.02% +4mA	150	200	1	20	8	$650
-100	0-10	100	88	67	300	20	30mA		0.02% +6mA	150	200	1	10	2.5	$825
SRL20-12	0-20	12	10.5	8	200	20	3mA		0.02% +4mA	70	200	1	80	80	$435
-25	0-20	25	22	16.7	300	20	10mA		0.02% +4mA	150	200	1	40	20	$525
-50	0-20	50	44	33.5	500	40	10mA		0.02% +4mA	150	200	1	20	8	$775
SRL40-6	0-40	6	5.3	4	200	20	0.5mA		0.02% +1mA	70	200	1	150	150	$435
-12	0-40	12	10.5	8	300	20	1mA		0.02% +4mA	150	200	1	80	80	$525
-25	0-40	25	22	16.7	500	10	10mA		0.02% +4mA	150	200	1	40	20	$630
-50	0-40	50	44	33.5	700	40	10mA		0.02% +4mA	150	200	1	20	8	$850
SRL60-4	0-60	4	3.5	2.68	300	20	0.5mA		0.02% +1mA	70	200	1	250	250	$450
-8	0-60	8	7	5.36	300	20	1mA		0.02% +1mA	70	200	1	125	125	$580
-17	0-60	17	14.9	11.4	500	10	3mA		0.02% +4mA	150	200	1	50	40	$690
-35	0-60	35	31	23.4	700	40	10mA		0.02% +4mA	150	200	1	25	15	$970

*Selectable: write for Sorensen performance note, PAN-1.

Sorensen's SRL line. A family of high performance, general-purpose power supplies designed for laboratory and systems applications. Outstanding features include built-in overvoltage protection that is quickly set and checked even under full load. Selectable programming coefficient and voltage gain. Great ripple and transient response performance. But, check the specs. Evaluate SRL total performance and value for yourself.

Get information on our other power supplies too. Write for your free complete line catalog. Sorensen Company, a unit of Raytheon Company, 676 Island Pond Road, Manchester, New Hampshire 03103. Tel. (603) 668-1600.

Sorensen POWER SUPPLIES

CIRCLE NO. 26

NEW! A/D ENCODER CIRCUIT.

Contains all the digital circuitry necessary to build an 8-bit successive approximation A/D converter.

HI-0180
This new device replaces three conventional TTL MSI packages, resulting in significant space and cost savings.

Features:
Both serial and parallel output data compatible with DTL/TTL.

"Data Ready" output pin indicates when conversion is complete and can be used for serial word synchronization, gating of parallel data, or actuating an analog sampling circuit.

"Reset" and "Enable" inputs which allow the device to convert continously or stop on completion of a conversion until externally restarted.

Applications:
The HI-0180 can be used with the HI-1080, 8-bit D/A converter, the HA-2111 comparator, and a reference voltage source to implement a complete 8-bit A/D system capable of converting unipolar or bipolar signals with 1/2 L.S.B. accuracy at up to 40,000 conversions per second.

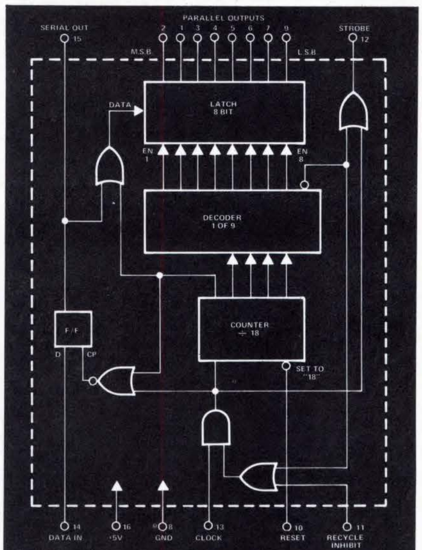
Other applications include:
Point of measure A/D converters in data acquisition systems.

Encoders and decoders for digitally multiplexed audio, instrumentation, or control transmission systems.

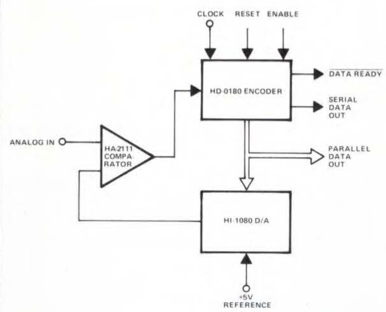
Supplied:

16-pin ceramic DIP	100-999 units
HI-1-0180-2 (−55°C to +125°C)	**$17.70**
HI-1-0185-5 (0°C to +75°C)	**$ 8.85**
CFO-0185-6 (Chips)	**$ 5.35**

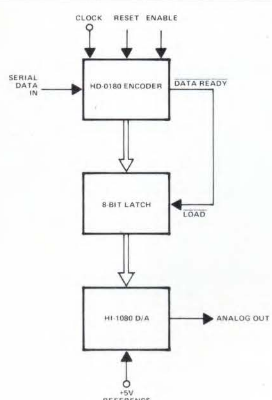
For details see your Harris distributor, representative or write direct.



FUNCTIONAL DIAGRAM
HI-0180



SUCCESSIVE APPROXIMATION
A TO D CONVERTER



SERIAL INPUT
D TO A CONVERTER

Special Introductory Offer!
Complete 8-bit A/D Converter System Kit
For a limited time we are making available a complete 8-bit A/D converter system in kit form for both commercial and military applications. Kits also contain a prewired PC card and information package. Both versions may be ordered only through your Harris distributor, but be sure to to place your order early because quantities are limited.

The military version consists of our new HI-0180 encoder, the HI-1080 D/A converter, the HA-2111 voltage comparator. **$65.00** in 1-99 quantities.

The commercial kit contains our HI-0185 A/D encoder, the HI-1085 D/A converter, and the HA-2311 voltage comparator.
$36.80 in 1-99 quantities.

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS-INTERTYPE CORPORATION
P.O. Box 883, Melbourne, Florida 32901
(305) 727-5430

DISTRIBUTORS: Schweber Electronics: Westbury, New York (516) 334-7474; Rockville, Maryland (301) 881-2970; Hollywood, Florida (305) 927-0511 / **Harvey/R & D Electronics:** Lexington, Massachusetts (617) 861-9200 / **Semiconductor Specialists, Inc.:** Chicago (312) 279-1000; Detroit (313) 255-0300; Minneapolis (612) 884-8132; Kansas City (816) 452-3900; St. Louis (314) 428-6100; Dallas (214) 358-5211; Indianapolis (317) 243-8271; Pittsburgh (412) 781-8120; Dayton (513) 278-9455 / **R.V. Weatherford Co.:** Albuquerque (505) 265-5671; Anaheim (714) 547-0891; Austin (512) Enterprise 1443; Dallas (214) 231-6051; Denver (303) 427-3736; Glendale (213) 849-3451; Houston (713) Enterprise 1443; Palo Alto (415) 321-5373; Phoenix (602) 272-7144; Pomona (714) 623-1261; San Diego (714) 278-7400; Seattle (206) 762-4200. **HARRIS SALES OFFICES:** Wellesley, Massachusetts (617) 237-5430; Wayne, Pennsylvania (215) 687-6680; Palos Heights, Illinois (312) 597-7510; Melbourne, Florida (305) 727-5430; Palo Alto, California (415) 321-2280; Melville, New York (516) 249-4500; Syracuse, New York (315) 463-3373; Washington, D.C. (202) 337-4914; Dallas, Texas (214) 231-9031; Scottsdale, Arizona (602) 946-3556; Long Beach, California (213) 426-7687.

CIRCLE NO. 27

Test IC voltage regulators with one general-purpose circuit

Here's a test circuit that will evaluate all present and future IC voltage regulators. It also allows you to simulate the automatic tests made by manufacturers.

E. R. Hnatek and L. Goldstein, National Semiconductor Corp.

One of the things a user of ICs needs is a good basic test set up for each class of devices he uses. Ideally, the user should have one single-test "jig" that will cover all the ICs of that class or function, despite the fact that there are so many different designs and so many different manufacturers.

Here, in **Fig. 1**, is such a universal test set-up for IC regulators. It is an adaptation of the basic universal test set-up we showed for IC op amps (EDN/EEE, March 1, 1972, p. 28). The user can plug in almost any existing IC regulator—a Fairchild 723, a National LM105, a Motorola 1566, etc.—into this general-purpose circuit and by cycling the set-up switches S1 to S4 through the seven modes shown in **Table 1**, check the specifications that are important to a user. However, this circuit cannot be used for regulators where the feedback loop is kept inside. For example, the fixed output LM109 which has just three terminals—input, output and ground—could not be connected into this tester.

The **Fig. 1** universal test circuit has an op amp buffer in the regulator's feedback loop. This buffer permits the output of the regulator under test to be adjusted independently of the regulator's V_{ref} eliminating the need for different dividers for different output voltages. The adjustment is through an external-signal $V_{out(set)}$ applied to the summing input into the buffer amplifier. This arrangement makes the regulator's V_{out} the complement of $V_{out(set)}$.

Take the case of a 723 regulator being tested in mode-4 of **Table 1**. For this mode the raw dc input, V_{in}, to the regulator is 40V and the V_{out} should be +37V. The +37V is commanded by making $V_{out(set)}$ −37V. **Fig. 2** shows how the voltages adjust around the loop. This can be understood by considering that the differential inputs of the two amplifiers in the loop—the error amplifier and the buffer amplifier—must respectively be within millivolts of each other. Then the inputs to the error amplifier must be at the 7.15V level of the regulator reference and the inputs to the buffer amplifier must be at the ground level of the invert-

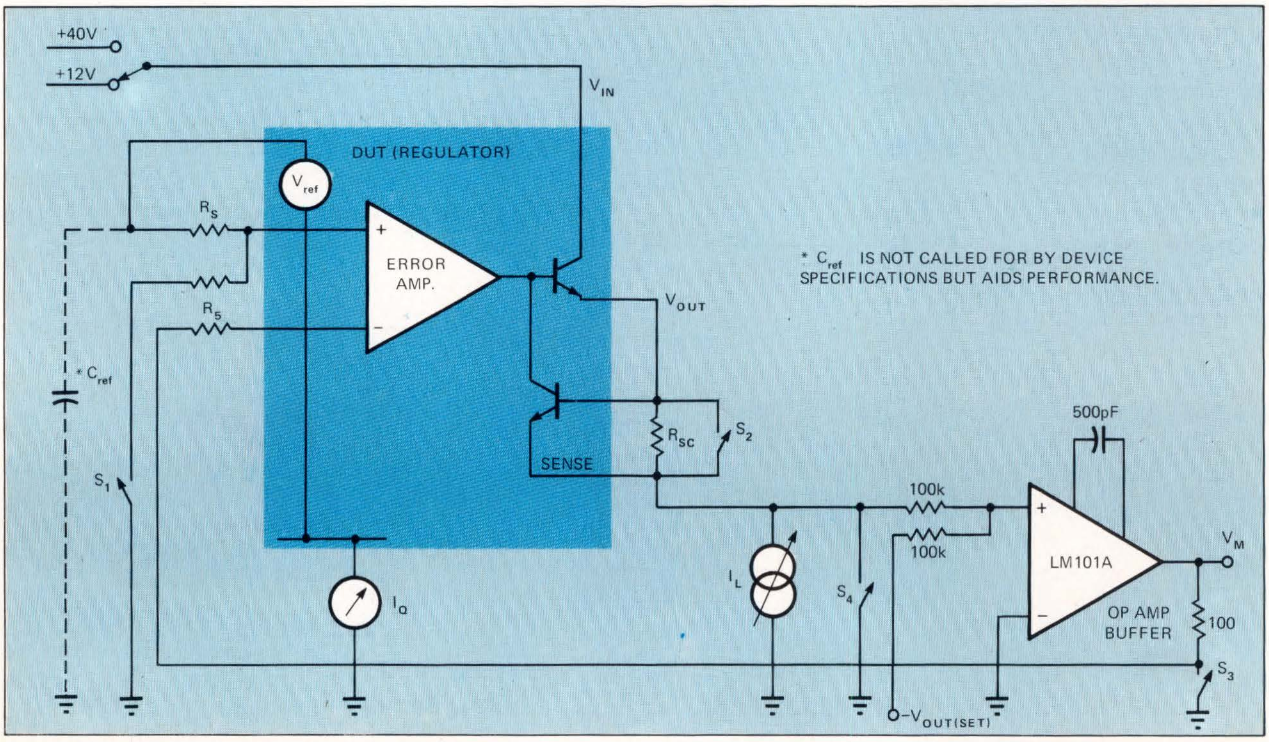


Fig. 1—Basic general-purpose IC voltage regulator test circuit is shown with manual switches for setting up the test modes. Table 1 lists how these switches should be operated for the seven basic tests. The values for the tests relate to the popular 723 IC regulator, but obviously they could be adjusted to suit other low-power linear regulators. The purpose of the buffer amplifier (LM101A) is explained in the text.

Test Mode	Parameter	APPLY (IN VOLTS) V_{IN}	V_{out}	SWITCH POSITIONS S_1	S_2	S_3	S_4	I_L	MEASURE Value	MEASURED PARAMETER Equation	Units
1.	Load Regulation (mid range)	12 12	−7.15 −7.15	open open	closed closed	open open	open open	MIN MAX	V_{M1} V_{M2}	$\text{Ld.R.} = \frac{V_{M2} - V_{M1}}{V_{M1}} \times 100$	%
2.	Line Regulation	40	−7.15	open	closed	open	open	MIN	V_{M3}	$\text{Ln.R.} = \frac{V_{M3} - V_{M1}}{V_{M1}} \times 100$	$\%/V_{IN}$
3.	Load Regulation (low end)	12 12	−2.0 −2.0	closed closed	closed closed	open open	open open	MIN MAX	V_{M4} V_{M5}	$\text{Ld.R.} = \frac{V_{M4} - V_{M5}}{V_{M4}} \times 100$	%
4.	Load Regulation (high end)	40 40	−37 −37	open open	closed closed	open open	open open	MIN MAX	V_{M6} V_{M7}	$\text{Ld.R.} = \frac{V_{M6} - V_{M7}}{V_{M6}} \times 100$	%
5.	Quiescent Current	30	−7.15	open	closed	open	open	MIN	I_Q	Direct	mA
6.	Ripple Rejection	12Vdc + ±IV @ 10KHz	−7.15	open	closed	open	open	MIN	V_{M8} (ac.)	$\text{Rp.R.} = 20 \log V_{M8}$	dB
7.	I_{SC} (short ckt.)	12	−7.15	open	open	closed	closed	—	V_{SC} (V_{out})	$I_{SC} = \frac{V_{SC(mV)}}{R_{SC}}$	mA

TABLE 1:—*VOLTAGE REGULATOR TEST SEQUENCE*

ing input. The loop takes care of the rest.

The voltage measurements, V_M, for the tests are made at the output of the buffer amplifier. This voltage is essentially the same voltage as at the inverting input of the error amplifier, for the currents flowing into the error amplifier will be small. The output of the buffer amplifier makes a convenient, low-impedance point to make these measurements.

The measurement V_M then reflects the change in the error amplifier voltage (relative to V_{ref}, which will not change much) with the various V_{in} and I_L changes imposed by the tests. It might be thought of as showing how "hard" the internal gain stages of the regulator have to work to counteract the imposed disturbances. The less the change in V_M, the higher the internal gain and the better the regulation ability.

Using the test circuit

To explain how the universal test circuit of **Fig. 1** is used we will run down the seven modes of **Table 1** one-by-one. We will be talking in terms of testing the 723, and the values in **Table 1** pertain to this device. Different values would be used for other devices.

1—**Load regulation (mid-range).** This is the basic test of the DUT's (device-under-test's) regulating ability for a mid-range input of 12V. The switches set up the conditions. Switch S2 is closed to short out the regulator's short-circuit sensing resistor, R_{sc}, as the 723 specifications call for this. Obviously, this helps the 723 look better, especially at higher load currents, because the short-circuit cutout transistor is not robbing the DUT's pass transistor of base drive. But this may not be the most realistic test so far as the user is concerned, for the application may call for operation with the short-circuit protection. If so, it is a simple matter to also test with S2 open.

As has been explained, the $V_{out(set)}$ commands the regulator output voltage, V_{out}, to be its complement. For this basic mid-range test, the 723 is to be putting out its zener reference voltage or 7.15V. Therefore, $V_{out(set)}$ is −7.15V. This means that even if the DUT's zener happens to stray from the 7.15V, as it can within the leeway allowed by the 723 specifications, the test circuit will still hold all DUTs at 7.15V, which makes for more uniform results.

The constant-current sink loading then "commands" the two specified output currents, which set the range over which the Ld.R. (Load Regulation) equation in the table will be computed. The 723 specifications call for an I_{min} of 1 mA and an I_{max} of 50 mA. Actually, because the test circuit holds V_{out} at a known level, fixed-value resistors could be used for the loading rather than the current sink shown.

2—**Line regulation.** Because the "V_{M1}" measurement from the first mode can be retained and used for this computation, only one measurement has to be made in this mode. The V_{in} is raised to 40V, its high end for the 723, and the change in V_M read. The computation for Ln.R. (Line Regulation) then represents how much the DUT's error amplifier input had to change to hold the V_{out} called for by $V_{out(set)}$. This is an indication of the DUT's gain which in turn reflects on the DUT's ability to regulate. Specifications for this test call for load current of I_{min}.

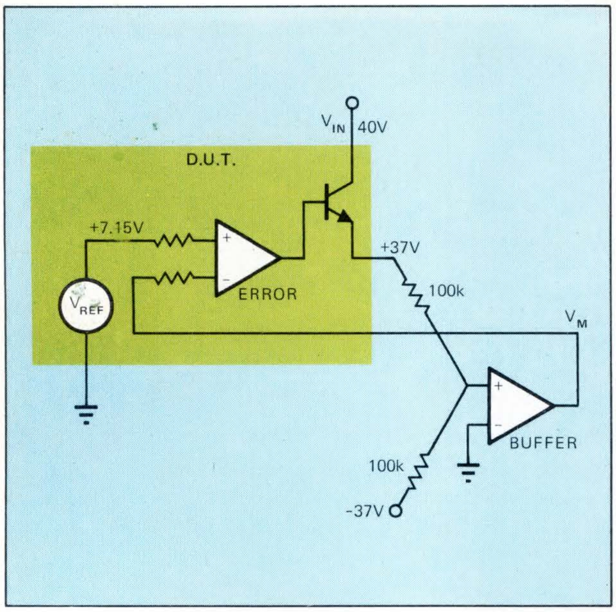


Fig. 2—Independent adjustment of regulator-under-test's output is accomplished by applying an external signal to the buffer amplifier. The closed-loop test set-up forces the regulator-under-test's output to be the complement of this signal.

3—**Load regulation (low end).** The $V_{out(set)}$ is put at −2V to set V_{out} at +2V and the change in V_M is read for the I_{min} and I_{max} load currents. Note that S1 is closed in this mode to properly simulate the fact that the positive or non-inverting side of the DUT's error amplifier would be seeing a divided-down or degraded portion of the DUT's Vref. The purpose of closing S1 is not to command the lower output voltage, because that is done independently by $V_{out(set)}$.

4—**Load regulation (high end).** The $V_{out(set)}$ is lowered to −37V to raise V_{out} to +37V and again the change in V_M is read for the I_{min} and I_{max} load currents. Again, the less V_M has to change, the better the DUT's regulating ability.

5—**Quiescent current.** This test checks the current that the DUT itself is drawing. For the 723, the specified conditions for this test are that the input voltage, V_{in}, be raised to 30V, and the output voltage, V_{out}, be held at its nominal 7.15V mid-range value. The quiescent current is sensed in the ground leg as shown in **Fig. 1**.

6—**Ripple rejection.** The degree to which the DUT will regulate against ac variations in the input line is measured by superimposing a 10 kHz, ±1V signal on the mid-range 12V V_{in} and measuring the resulting ac signal on V_M. Again, the better the regulating capability of the DUT, the smaller the correction signal fed back to the inverting input of the DUT's error amplifier, or the smaller V_M. Incidentally, the user may want to add a capacitor across the DUT's zener as shown by C_{ref} in **Fig. 1**. The 723 test specifications don't allow this but users often put it in as it significantly improves performance.

7—**Short circuit.** In this final mode, the two switches that haven't been closed up till now, S3 and S4, are closed and the one switch that has been closed up till this point, S2, is opened. Switch S4 applies the short circuit at the DUT's output. Switch S3 is closed to simulate the fact that under this short circuit condition the feedback to the DUT's error amplifier would be at ground. The 100-ohm resistor before S3 protects the output of the buffer amplifier.

Switch S2 is opened to activate the DUT's short circuit (overcurrent) protection circuit. The value of the short-circuit current—the remaining current after the DUT overcurrent protection has shut the DUT down—is measured by looking at V_{out}, which is now the voltage across the short-circuit sensing resistor, R_{sc}. This is the one instance where the voltage measurement isn't made at the output of the buffer amplifier.

A semi-automatic version

Fig. 3 shows how the circuit of **Fig. 1** can also be upgraded for more complete line and load regulation testing and also more closely approximate the high-speed automatic test systems used by IC manufacturers. This should interest the engineer whose company uses a fair number of IC regulators, but not enough to warrant the investment in fully-automatic checkout equipment and who wants line and load regulation at other than standard conditions. Here some of the switches are transistorized for higher-speed bounceless operation from electronic commands. Transistor Q_4 shorts the output to ground for the current limit test, and transistor Q_5 has been added to switch in the high current load for the load regulation test. Switch S_2 of **Fig. 1** which divided the reference voltage has been omitted for simplicity.

With this arrangement, the first four modes of **Table 1** can be compressed into less than a minute. A triangular wave is fed into V_{in}. This carries V_{in} from the minimum voltage, to the peak voltage, and back to minimum in less than 5 msec. Transistor Q_5 switches the full load current in for the rising portion of the ramp, and then out for the falling portion. Thus, this cycle subjects the DUT for the full range combination of V_{in} and I_L for a given V_{out} during one 50 msec cycle.

The results are displayed V_M vs V_{in} on an XY scope readout as shown in **Fig. 3**. The slope of the curve indicates how much V_M varies with V_{in}. The change in I_L halfway through the triangular wave will cause the return trace to be higher than the rising-V_{in} trace. This vertical difference indicates the degree of change in V_M with the change in loading at any input voltage. Therefore the display gives an at-a-glance visual indication of the DUT's regulating ability.

This cycle can be repeated for all prescribed V_{out} levels, the $V_{out(set)}$ input being used to set the V_{out} levels as in **Fig. 1**. As far as the equipment is concerned, one cycle per each $V_{out(set)}$ is all that is needed. However, a human observer will need enough cycles so that he can read the scope. Therefore, it might take a minute to step through the three V_{out} levels indicated for the 723 in **Table 1**. By using marks on the CRT screen to indicate acceptable performance, this test could be given to a girl to perform on a production basis.

The quiescent current can be measured at the peak V_{in} point when V_{out} is at its mid-range value. The short-circuit current can be measured by putting the three-pole, double-throw switch S6 at its No. 2 position and measuring V_{sc} across the current limiting resistor.

The user will have to add his own ripple test signal and measurement to this circuit. Typically ac measurements are not part of high-speed automatic tests, because the speed of the line regulation test is such that its dynamics are fast enough to correlate to the ripple rejection test. If the DUT hasn't the bandwidth to keep up with the 200 Hz test cycling rate, this deficiency will show up in the test results.

One testing problem that the **Fig. 3** circuit will help the user appreciate is the way the manufacturer's high-speed tests must necessarily slight the DUT's temperature-rise characteristics. Though the test sweeps the DUT over a full range of loadings, the actual time under load is so brief that the tests are performed at essentially constant chip temperature.

The I_Q measurement does indicate how much the regulator will heat itself in operation, above and beyond what it dissipates in dropping voltage through its pass transistor. But there is no indication of how the performance parameters will vary with heating. The user must put these circuits in temperature chambers to find this out. □

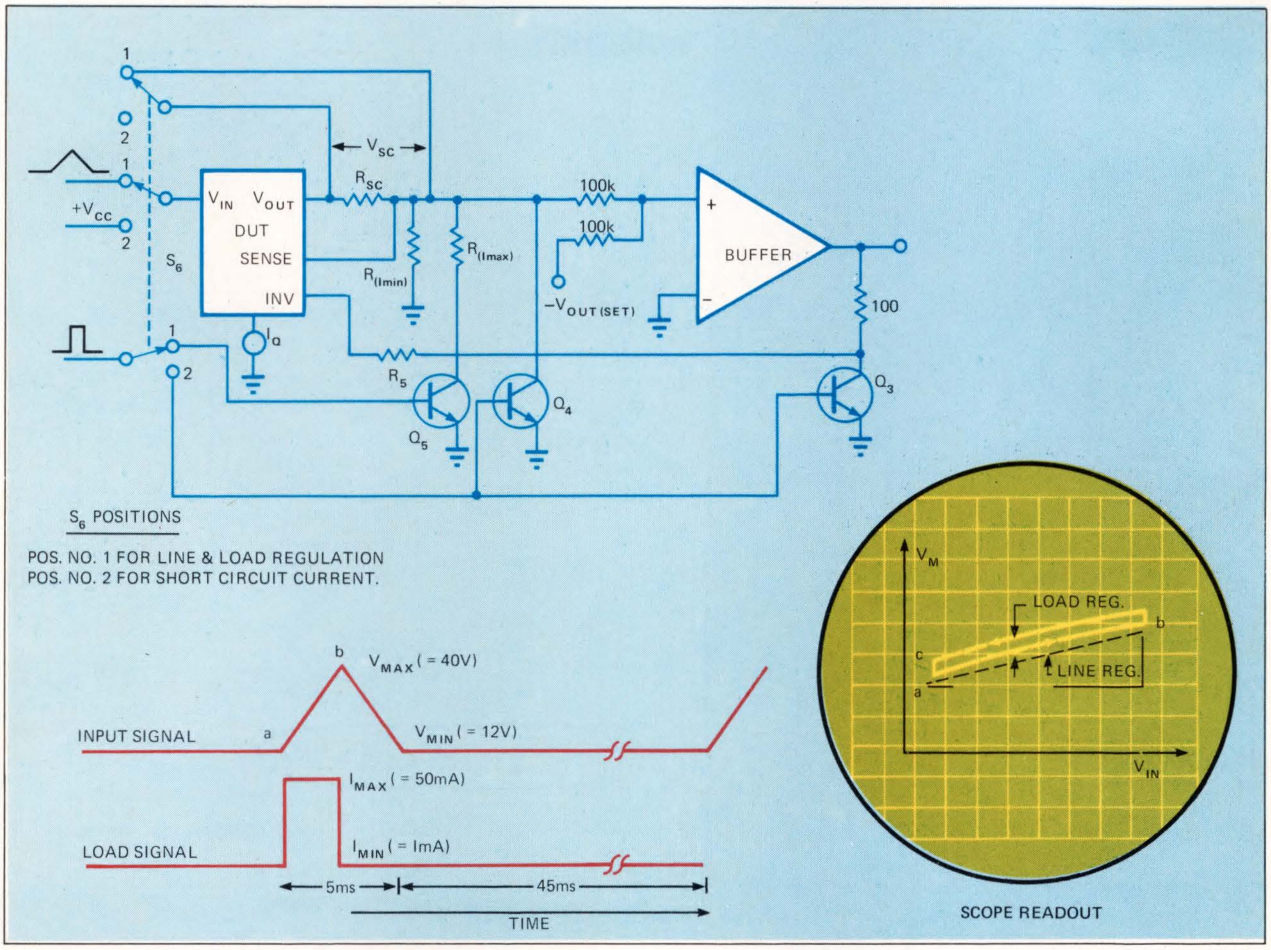


Fig. 3—Automated bench tester version of Fig. 1 simulates the type of testing done at high speed by automatic test equipment at the IC supplier's factory. The triangular ramp on the input voltage sweeps the DUT (device under test) across its line-regulation specifications while the load is switched to check the load regulation specifications. This displays the V_{out}-vs-V_{in} transfer function on a scope. The input excitations are then switched to position 2 to check the DUT's short-circuit behavior.

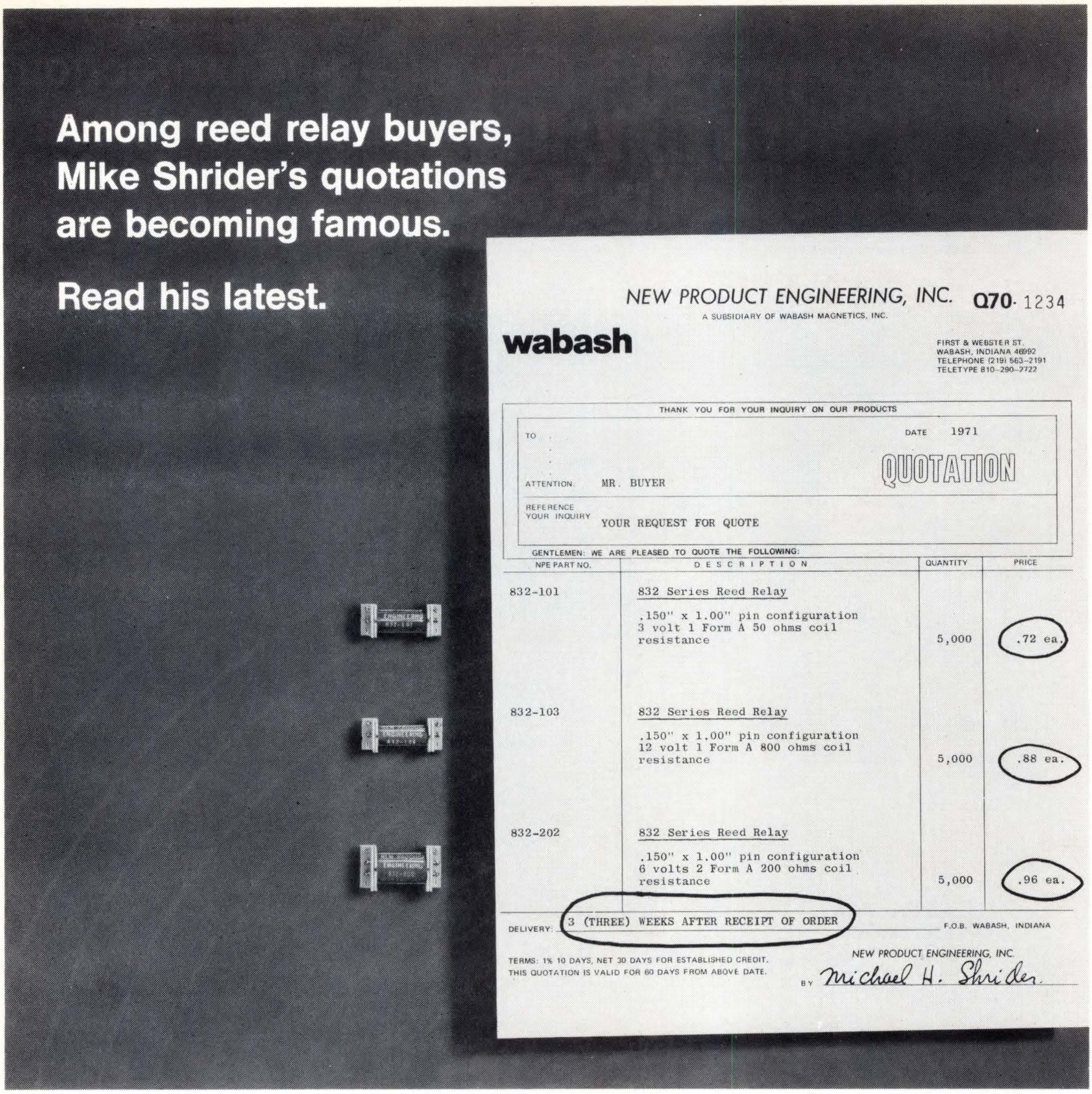
Author's biographies

Larry Goldstein (L) is manager of linear test systems at National Semiconductor, where he has been for 2-1/2 years. Before joining National, he was with Autonetics. Larry earned a BS in physics from New Mexico State.

Eugene Hnatek (R) is military/aerospace product marketing manager, and is responsible for all Hi-Rel products at National. He was formerly with Lockheed Missiles and Space Co., where he was power systems project manager. Gene has a BSEE and MSEE from Bradley University, and a PhD from MIT.

Among reed relay buyers, Mike Shrider's quotations are becoming famous.

Read his latest.


NEW PRODUCT ENGINEERING, INC. Q70-1234

A SUBSIDIARY OF WABASH MAGNETICS, INC.

wabash

FIRST & WEBSTER ST.
WABASH, INDIANA 46992
TELEPHONE (219) 563-2191
TELETYPE 810-290-2722

THANK YOU FOR YOUR INQUIRY ON OUR PRODUCTS

TO

DATE 1971

QUOTATION

ATTENTION: MR. BUYER

REFERENCE YOUR INQUIRY: YOUR REQUEST FOR QUOTE

GENTLEMEN: WE ARE PLEASED TO QUOTE THE FOLLOWING:

NPE PART NO.	DESCRIPTION	QUANTITY	PRICE
832-101	832 Series Reed Relay .150" x 1.00" pin configuration 3 volt 1 Form A 50 ohms coil resistance	5,000	.72 ea.
832-103	832 Series Reed Relay .150" x 1.00" pin configuration 12 volt 1 Form A 800 ohms coil resistance	5,000	.88 ea.
832-202	832 Series Reed Relay .150" x 1.00" pin configuration 6 volts 2 Form A 200 ohms coil resistance	5,000	.96 ea.

DELIVERY: 3 (THREE) WEEKS AFTER RECEIPT OF ORDER

F.O.B. WABASH, INDIANA

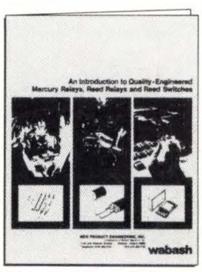
TERMS: 1% 10 DAYS, NET 30 DAYS FOR ESTABLISHED CREDIT.
THIS QUOTATION IS VALID FOR 60 DAYS FROM ABOVE DATE.

NEW PRODUCT ENGINEERING, INC.

BY Michael H. Shrider

Also ask about our:
Dry Reed Switches
Proximity Detectors
Dip Reed Relays
Mercury Reed Relays
Solid State Relays
Electronic Module Boards

If you don't have our condensed catalog — TWX or write for one.



Mike gets the message straight to the buyer's interests: **quality** reed relays, delivered **fast** and at **prices** that don't choke your budget. Mike can deliver because NPE is tooled for nearly all reed relay types, including more than 6000 variations. All types can be delivered very quickly — typically within three (3) weeks. We can perform within your production cycle. **Let us prove it to you.**

And Mike has a message for component engineers, too. NPE completely manufactures its relays in one location — including switches and **coils** — and quality tests each one a **dozen** ways before shipping.

Mike Shrider can come up with a quotation to meet all occasions. Try him. Ask Mike to answer your next RFQ with an original quotation from NPE.

wabash

NEW PRODUCT ENGINEERING, INC. Wabash, Indiana 46992 (219) 563-2191 TWX 810-290-2722

A Subsidiary of Wabash Magnetics, Inc.

CIRCLE NO. 28

Donald K. Wilkin of Hewlett-Packard speaks out

on the scope versus the logic probe for digital testing

Service aids such as logic probes are handy for go/no-go indication of pulse activity—but only a scope can help you diagnose the tough ones.

Logic probes, clips, comparators and other tools are taking dead aim at the scope as the computer serviceman's sidekick. Some manufacturers even tout the logic probe as a replacement for an oscilloscope in most field service applications.

Before we write the scope's obituary, however, let's look at both the basic field service requirements and the capabilities of scopes and logic test equipment. Then we can select the best combination for the job at hand.

There is little disagreement on the computer serviceman's basic task: to get the system back in use in as short a time as possible, with as little cost to the manufacturer as possible—and to do so every time there is a malfunction. It is also commonly accepted that scopes, logic probes, and other testing devices are useful tools for troubleshooting, problem isolation and the adjustment of digital systems. Each of them has its specific capabilities, though, and it can prove very unsatisfactory to blindly follow the maxim "digital instrumentation for digital problems".

You need to look critically at your total measurement needs, selecting instrumentation that will do the job at the lowest possible cost.

Most field service measurements fall into one of two broad categories: (a) go/no-go indications of pulse activity; or (b) detailed quantitative measurements of timing relationships, pulse shapes and pulse parameters.

A logic probe really shines where the need is to detect the presence or absence of pulse activity. It will tell you whether an IC is working or not, and is useful largely because many IC failures are catastrophic, and consist of open or short circuits (either mechanically or electrically caused). Logic probes let you "touch and read" to see if an IC is working. They are also handy for observing single-shot events if they contain a pulse-stretcher provision.

You should make sure, of course, that the probe has the same threshold levels as the ICs under test. Logic probes are typically logic-family oriented (for example, bipolar T^2L). Normally they can't be used to test ECL or MOS circuits, but there still are many digital systems for which compatible logic probes are available. A wise precaution is to make sure that the probe causes negligible circuit loading of *both* high and low states (many manufacturers don't specify probe input impedance for a logic low).

To a large extent, logic probes are static test or low-rep rate devices. Most have pulse-stretcher circuits that will capture a very short pulse, say 10 nsec in width, and "stretch" the lighted display to 100 msec or more. The advantage is that you're able to see events that happen only occasionally or that are of short duration. The limitation is that you don't know what's happening any more often than every 100 msec or so.

Like a logic probe, the oscilloscope certainly can detect the presence or absence of pulses. Once you set the scope's trigger level, you can "touch and read" just as you can with a probe. Consider, though, the additional benefits. With a scope you are not restricted to working with one logic family. Also, the input impedance remains high regardless of state, and the dynamic measurement range encompasses all pulse widths, rep rates, and rise times within the bandwidth and brightness constraints of the scope. For instance, if a circuit's gate operates properly only in the presence of a double pulse, the CRT will show you if this is happening, but a logic probe won't.

The major disadvantages of using a scope for detecting simple pulse activity (besides cost) are that it is cumbersome as compared to a pencil-like probe; that the readout is not right at your fingertips; and that it needs external line power. (Many field service scopes can be powered by their own internal battery, thus overcoming this last objection).

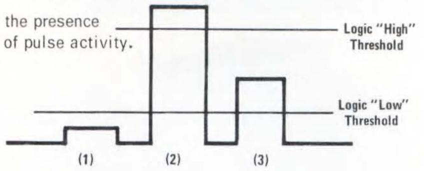
Scopes are well qualified for making such detailed quantitative measurements as those involving pulse timing.

Today's computer speeds require pulse timing capability from a few seconds to subnanosecond resolution. There are numerous measurements that require determination of the time intervals between clocks and bit pulses, between one gate and another, between clocks, and the like.

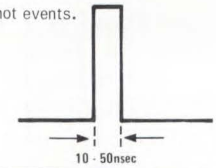
It can scarcely be denied that this is the scope's forté—facilitating visual observation of the two pulses of interest, and permitting measurement of the time interval between them, at any given point on their transition time, to the accuracy required. Some measurements involve time intervals of several microseconds between two pulses a few nanoseconds wide; or adjusting one narrow pulse to occur within a wider pulse; or pulse bursts occurring at a given time relationship to another pulse—and the list could go on and on.

A Logic Probe Lets You....

(a) Detect the presence or absence of pulse activity.

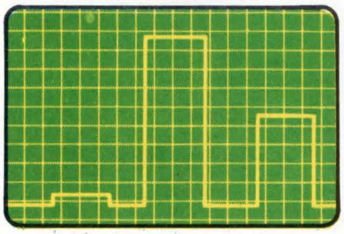


(b) Capture single-shot events.

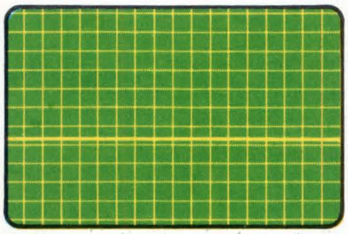


An Oscilloscope Will Show You....

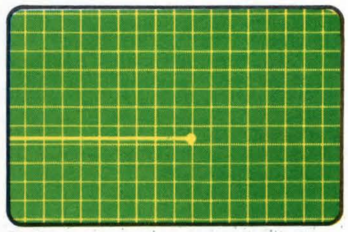
(a) Presence or absence of pulse activity.



(b) Single-shot events

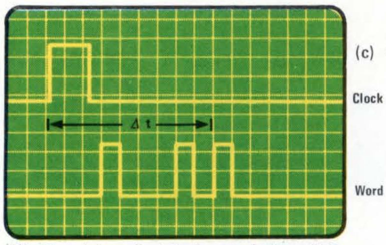


1) Storage scope in single-sweep mode captures event. Stored sweep indicates that pulse has occurred.

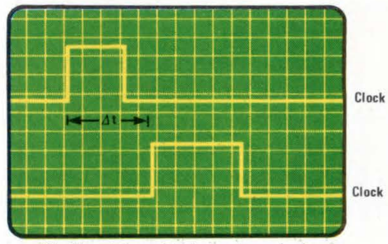


2) Conventional scope in single-sweep mode may be swept very slowly once triggered by pulse.

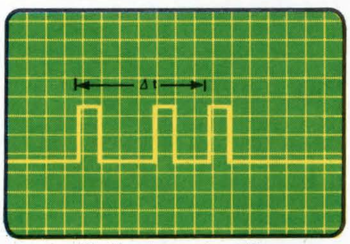
(c) Complex timing relationships.



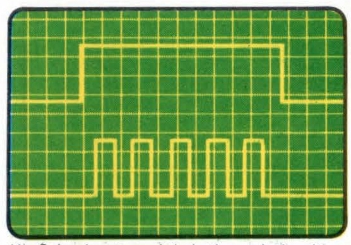
(1) Time interval, Δt, between clock and bit.



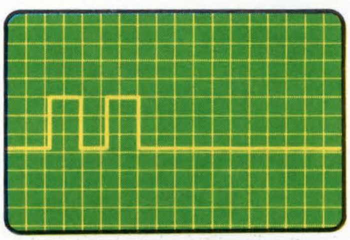
(2) Time interval between two clocks.



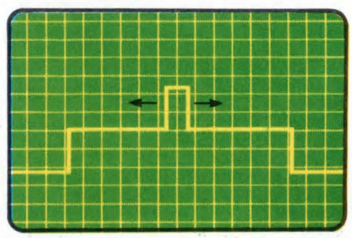
(3) Time between two bits.



(4) Pulse bursts and their time relationships to another pulse.

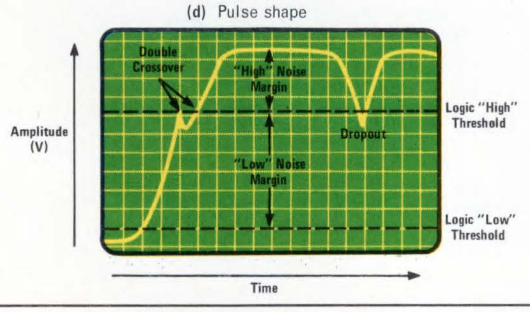


(5) Double pulse needed to fire gate.

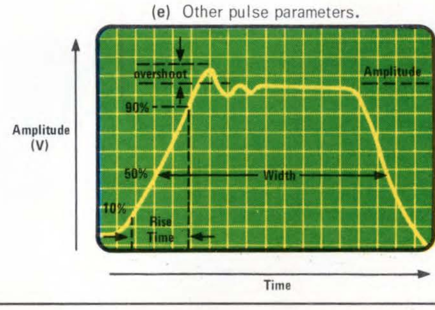


(6) Alignment of one pulse within another.

(d) Pulse shape



(e) Other pulse parameters.



Whether you're troubleshooting or adjusting, you need a scope if the timing relationships require more than a few tenths of a second resolution.

When you want to know pulse shapes, you will again fall back on the scope. With it you can observe pulse parameters, such as ringing, leading- and trailing-edge transition times, and the like. Related to pulse shape are amplitude measurements such as those of crossover voltage, noise margin, and dc offset of the pulse. The actual percentage of time that such measurements are needed may be small, but cannot be predicted.

If the capabilities of scopes and probes are that clearly defined, where, then, is the controversy? Proponents of logic probes claim that since timing measurements or pulse shape observations are needed in only a small percentage of service calls, logic probes can replace scopes the majority of the time.

This argument—that you can troubleshoot faster with a logic probe than you can with a scope—may be true where the failure is catastrophic, but what about the other situations?

Of course you don't know ahead of time which sort of trouble you'll encounter. Much more field investigation will be needed before we can determine the overall usefulness and cost effectiveness of the logic probe.

It is true that there is a considerable amount of overlap between scope capability and probe capability, but it seems clear that the scope is still the essential multipurpose tool, with the logic probe serving as a supplement.

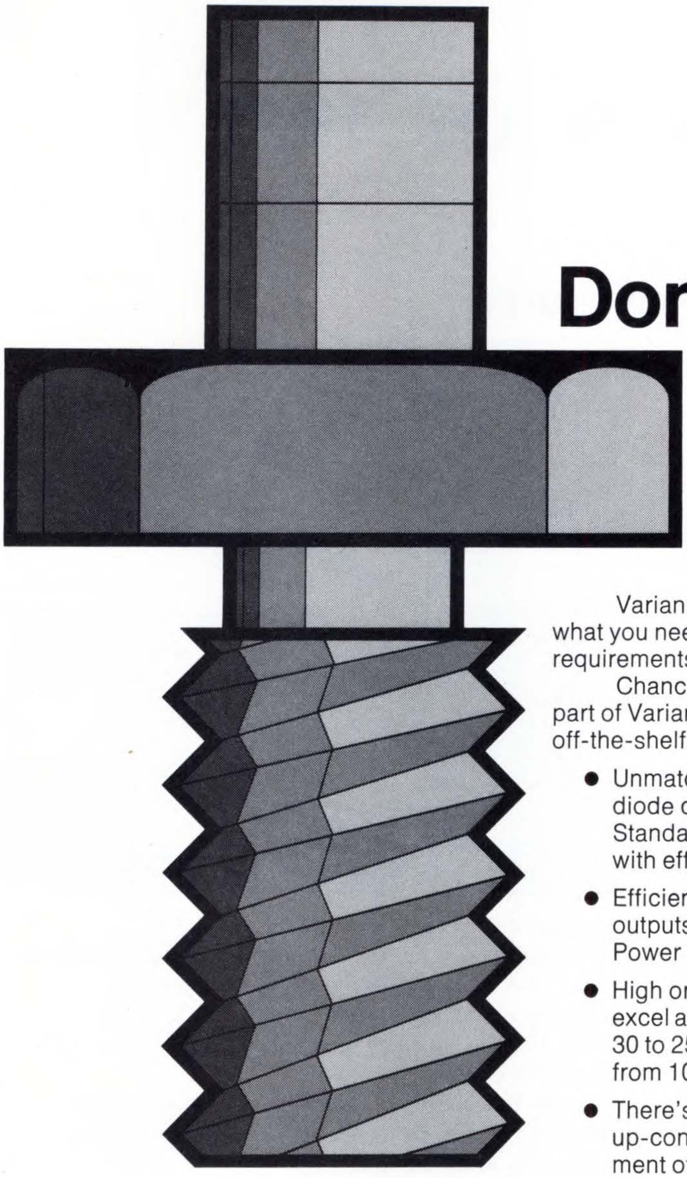
Perhaps an illustration will help explain this viewpoint. A rural doctor might be said to face a situation similar to that confronting a man doing field service on digital equipment. Suppose that for many years the doctor carries in his black bag medicines, instruments, bandages and other items which he feels will be adequate for handling nearly any situation he might encounter. One day he suddenly realizes that for roughly 50% of the time, all he will need to combat an illness or accident is a bottle of aspirin and a can of "Bandaids". Even though the likelihood is high that on the next call he will only need those two simple items, he probably still will take his bag along, just in case he runs into one of the more unusual troubles.

Before becoming too much enthused over the concept of "digital testers for digital equipment", and completely revamping your array of test equipment, you'll be wise to carefully consider (1) the likelihood that a given piece of equipment will do the job, (2) the penalty for not having the equipment at hand should you need it, and (3) the long-run time/money savings involved in troubleshooting with various instrumentation packages.

Author's biography

Donald K. Wilkin, who has been with Hewlett-Packard for 5 years, is product manager of portable oscilloscopes at the company's Colorado Springs operation. Mr. Wilkin holds a BSEE from the Univ. of Colorado and an MBA from Santa Clara Univ.

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



Don't settle for nearly perfect multiplier diodes.

Varian Solid State makes a point of building exactly what you need in multiplier diodes. No matter how unique your requirements.

Chances are, though, that what you need is already part of Varian's standard product line. Here's what you can get off-the-shelf from Varian.

- Unmatched high power. Stackpack™ diodes are 2 or 3 diode chips in single, series-stacked configurations. Standard products deliver 2 to 60 watts from 0.5 to 13.0 GHz with efficiencies up to 65%.
- Efficiencies up to 70%. Bimode® diodes are available with outputs up to 24 watts between 0.3 and 25.0 GHz. Super Power Bimode multipliers deliver as much as 40 watts.
- High order multiplication. Varian Step-Recovery diodes excel at factors up to X6. Typical transition times range from 30 to 250 picoseconds with reverse breakdown voltages from 10 to 60 volts.
- There's even a series of diodes ideal for wide tuning and up-conversion applications and well suited to the development of super-special high-order multiplication diodes.
- In the near future, many Varian Multiplier diodes will feature Plesa® passivation, a planar-like method using thermal oxide passivation and post diffusion with a mesa structure. This will enable Varian to supply chips as well as packaged diodes. And all Varian multiplier diodes have the optimum combination of transition time and breakdown voltage.
- To get standards, specials, or just some application assistance, contact Varian, Solid State Division, Salem Road, Beverly, Massachusetts 01915. Or any of the more than 30 Varian Electron Tube and Device Group sales offices throughout the world.

varian

CIRCLE NO. 22

CIRCUIT DESIGN AWARDS

BEST DESIGN OF 1971

Super-stable reference-voltage source

Leonard Accardi Kollsman Instrument Corp.
Elmhurst, N.Y.

With conventional reference-voltage circuits, the problem is not so much the stability of the temperature-compensated zener used, but the bothersome trimming or trial-and-error selection of the components that supply the zener current, and the often nebulous stability of the current-determining circuitry.

With the circuit described here, however, the current through the zener diode is truly independent of the power-supply voltage—which may be as low as 10V. The current is determined by the zener itself, thus one avoids the trimming and component selection needed for other circuits.

To understand how the circuit works, temporarily ignore components CR_3, CR_2, Q_1, R_4, R_5 and R_6. Let's assume also that zener CR_1 is in the breakdown region. Assume a voltage, $-V_1$, at the junction of R_1 and R_2. Then the output of A_1 is $-(V_1 + V_z)$. But resistors R_1 and R_2 form a voltage divider, therefore,

$$-(V_1 + V_Z)\frac{R_2}{R_1 + R_2} = -V_1$$

If we select R_1 equal to $10R_2$, then,

$$V_1 = \frac{V_Z}{10}$$

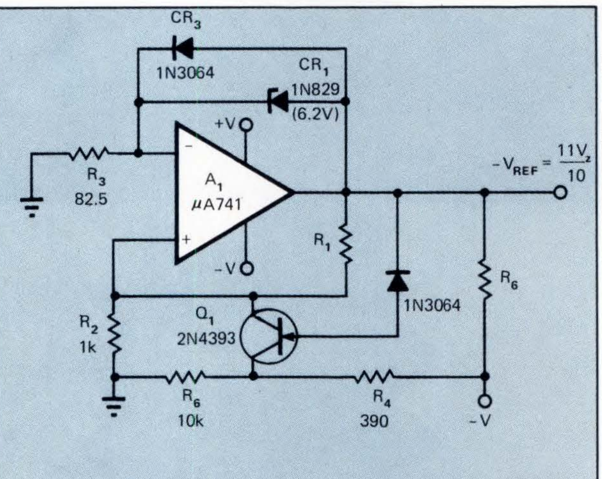
Therefore the zener current is given by the following equation:

$$\frac{V_1}{R_3} = \frac{V_Z}{10R_3}$$

We can then calculate the value of R_3 needed to supply the specified zener current of 7.5 mA.

Now let's examine the functions of the remaining components. Resistor R_6 is included to sink a current of around 7.5 mA because most low-cost op amps can provide only 5 mA without exceeding their output rating. The remainder of the auxiliary components insure that the circuit assumes the current stable state when power is turned on.

Temperature-compensated zeners have internal forward-biased diodes, so CR_3 is included in this circuit to clamp the output voltage of the undesired positive-output stable state to about 1V. In this state, Q_1 is ON, and a negative potential, determined by R_1, R_2, R_4, R_5, $-V$ and the ON resistance of Q_1 (100Ω), appears at the noninverting input of A_1. This causes the circuit to revert to the desired negative-output stable state, turning off Q_1 and effectively removing the auxiliary components from the circuit in normal operation.



In this reference-voltage circuit, the current through the zener diode is stabilized by the diode itself.

With the specified components, output stability approaches that of the zener itself. A μA741 amplifier typically introduces less than 1 mV of output-voltage variation over a temperature range of 100°C. Using premium versions of the 741, such as the Sprague 2151D or Precision Monolithics SSS741, output variations due to the op amp can be reduced to 150 μV over the same 100°C temperature range. The op amp used in this circuit should be frequency compensated for unity-gain operation since the impedance of the zener diode is low and thus provides almost 100% ac feedback.

Output-current capability can be increased, with no sacrifice in stability, by inserting a booster transistor inside the feedback loop of A_1. Also, the circuit can be built as a positive reference supply by using a p-channel FET, reversing the diodes, and changing the current-sinking voltage to +V. □

The Contest for 1972 has already begun! Each design published in EDN wins a $25 bond. Best design of every issue wins a $50 bond. The best design of the year wins a $1000 savings bond.

One transistor improves IC voltage regulator

Carlo Venditti, The Charles Stark Draper Laboratory, Cambridge, Mass.

A parameter to consider in using IC voltage regulators is the minimum input-to-output voltage differential. Typical values range from 2 to 3V for regulators like the National LM105 and Fairchild μA723. This sets the minimum amplitude that can be regulated at a value of 2 to 3V above the desired regulated output. You can decrease this differential to only 0.5V above the output by using a voltage divider and a transistor. **Fig. 1** shows how a μA723 regulator and a single NPN transistor can be used to provide this reduced differential.

The values of R_1 and R_2 are selected, with current I flowing into node a, so that the voltage at node a is 3V (minimum) less than the desired E_0. The composite regulator will give a regulated E_0 for $V = E_0 + 0.5$. The input-output voltage differential for the μA723 is held greater than 3V, assuring its proper operation.

This circuit technique allows dc voltage sources that did not meet the previous minimum input-output voltage differential to be regulated directly. Further, the input working voltage can be decreased, for a given E_0, minimizing power dissipation and increasing overall efficiency. ☐

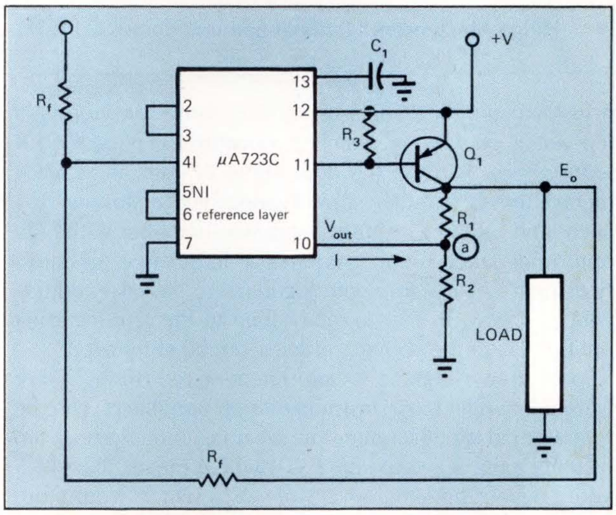


Fig. 1—IC voltage regulators can be operated with as little as 0.5V input-to-output differential with the addition of a single NPN transistor. 2 to 3V differential is normally required for proper functioning of this type of regulator.

To Vote For This Circuit
Circle 150

Bias supply circuit provides constant current

Glen Coers, Texas Instruments, Inc. Dallas, Texas

When testing transistors on an RX meter, G.R. bridge, or "S" parameter set up, two power supplies are usually required and collector current for each device tested must be adjusted individually. With the aid of the constant-current supply in **Fig. 1**, devices with a wide beta range can be biased automatically to within one percent of the desired collector current.

Operation is very simple: just select the proper range with S_2 and adjust that potentiometer for the desired current. A reference voltage is established by the IN914 diodes and Q_1, the 2N3819 FET. The error is sensed across the potentiometer and R_7. The 47Ω resistor, R_7, is for current limiting when the potentiometer is at minimum resistance. The 2N4058's and 2N3702's form a differential amplifier and, due to the 150Ω resistors R_5 and R_6 in series with the collectors, the amplifier does not saturate when there is no device under test. Each collector resistor carries about 4 mA, and the small amount of base current required to drive the U.U.T. is subtracted from that 4 mA. Therefore, the amplifier operates in it's most active region. The 9V battery can be replaced by an ungrounded power supply.

V_{CC} range is 3 to 25V
I_C range is 12 μA to 20 mA.

It is also possible to measure beta by placing a current meter in series with the base of the U.U.T., and to measure V_{be} (active) by placing a voltmeter across the emitter-base terminals. ☐

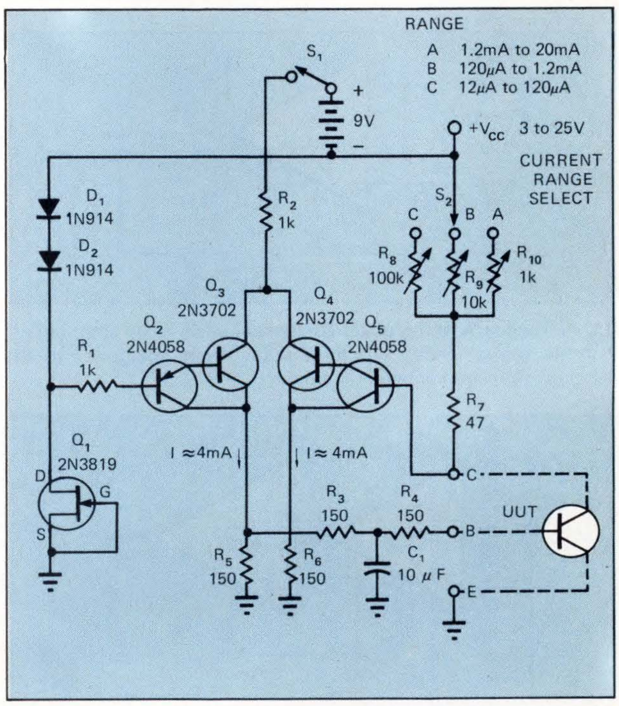


Fig. 1—Constant current supply consists of a differential amplifier, Q_2 through Q_5, and a voltage reference, Q_1, D_1 and D_2. Base drive to the transistor under test, through R_3 and R_4 maintains the desired collector current even when testing devices with a wide beta variation.

To Vote For This Circuit
Circle 151

IC op amps make inexpensive instrumentation amplifiers

Helge Mortensen, National Semiconductor Corp.
Santa Clara, Calif.

Instrumentation amplifiers using IC op amps are normally dependent on closely matched resistors for good CMRR performance. Further, the adjustment of gain and CMRR interact unless a rather sophisticated design approach is taken, and building an instrumentation amplifier with high input impedance usually requires at least three op amps. By using a 741 op amp with feedback to the offset adjustment as shown in **Fig. 1**, rather than to the non-inverting input, many of the above problems can be eliminated.

Some new limitations are encountered though. For example, while most instrumentation amplifiers can be programmed for unity gain, this set-up cannot. To program for unity gain, R_2 would be 2 kΩ, which means that pin 5 would have a potential of 2/3 of $-V_{cc}$, which would turn off the internal transistor Q_6. Unity gain will also overdrive the input stage. From experimental results, this configuration works best when gain is kept >50. The basic instrumentation amplifier using a 741, as shown in **Fig. 1**, provides 5V output for 100 mV input. The 100 kΩ resistor (R_2) connected from the output terminal to the offset null provides a feed-back path to the internal 1 kΩ resistor. In order to balance the set up, another 100 kΩ resistor (R_1) is added from ground to pin 1.

The gain is given by: R_2/2X 1k, and the output offset can be varied over the full output range by referencing R_1 to voltages other than zero. In addition, an output sense point is provided so that a unity gain power booster may be added in the feed back loop, as depicted in **Fig. 2**.

The gain stability for the amplifier is dependent on the temperature coefficient of the diffused resistors (≈ 0.25%/°C). By shunting the 1 k's with smaller resistors this effect is minimized with increased gain. □

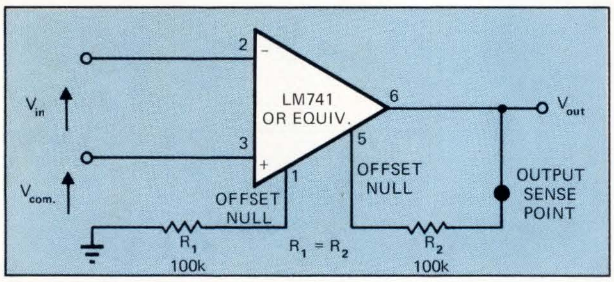


Fig. 1—Feedback to the offset adjustment of an IC op amp, rather than the normal feedback to the input, converts the device to an inexpensive instrumentation amplifier.

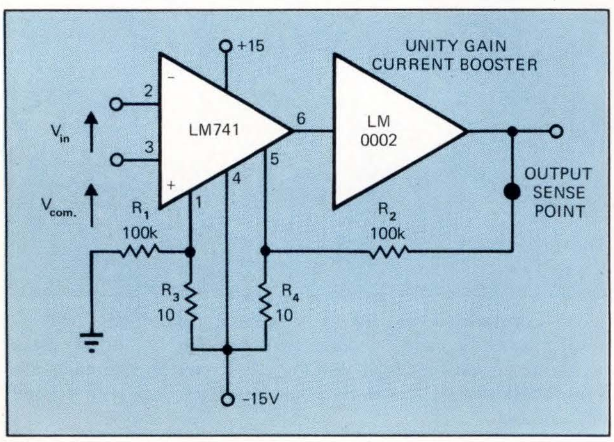


Fig. 2—Unity gain power booster added to the basic circuit of **Fig. 1** provides more flexible operation at only a modest increase in cost, and is still less expensive than more complex designs.

To Vote For This Circuit
Circle 152

Circuit Design Entry Blank

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

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

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

Name________
Title________
Company________
Division (if any)________
Street________
City________ State________
Circuit Title________

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

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

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

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

Signed________

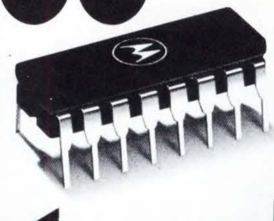
Date________

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. Saving 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, EDN/EEE, 221 Columbus Ave., Boston, MA 02116.

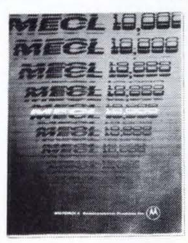
The Motorola MECL* 10,000 family.



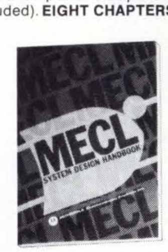
The next standard-of-the-industry.

SCHWEBER has the complete inventory of ALL Motorola MECL circuits.

*Motorola Emitter Coupled Logic



MECL 10,000 LOGIC— High Speed, Low Power. This new MECL family successfully avoids the significant disadvantages of other forms of high speed logic. In addition to retaining its high speed (2 ns) it maintains a low power dissipation per gate (25 mW—load not included). **EIGHT CHAPTERS 112 PAGES**



MECL SYSTEM DESIGN HANDBOOK
This book completely defines MECL operation, giving the designer the information to establish design rules for his own high performance systems. MECL circuits not only have the characteristics to meet the performance requirements of present systems, but also of future systems.
EIGHT CHAPTERS 213 PAGES

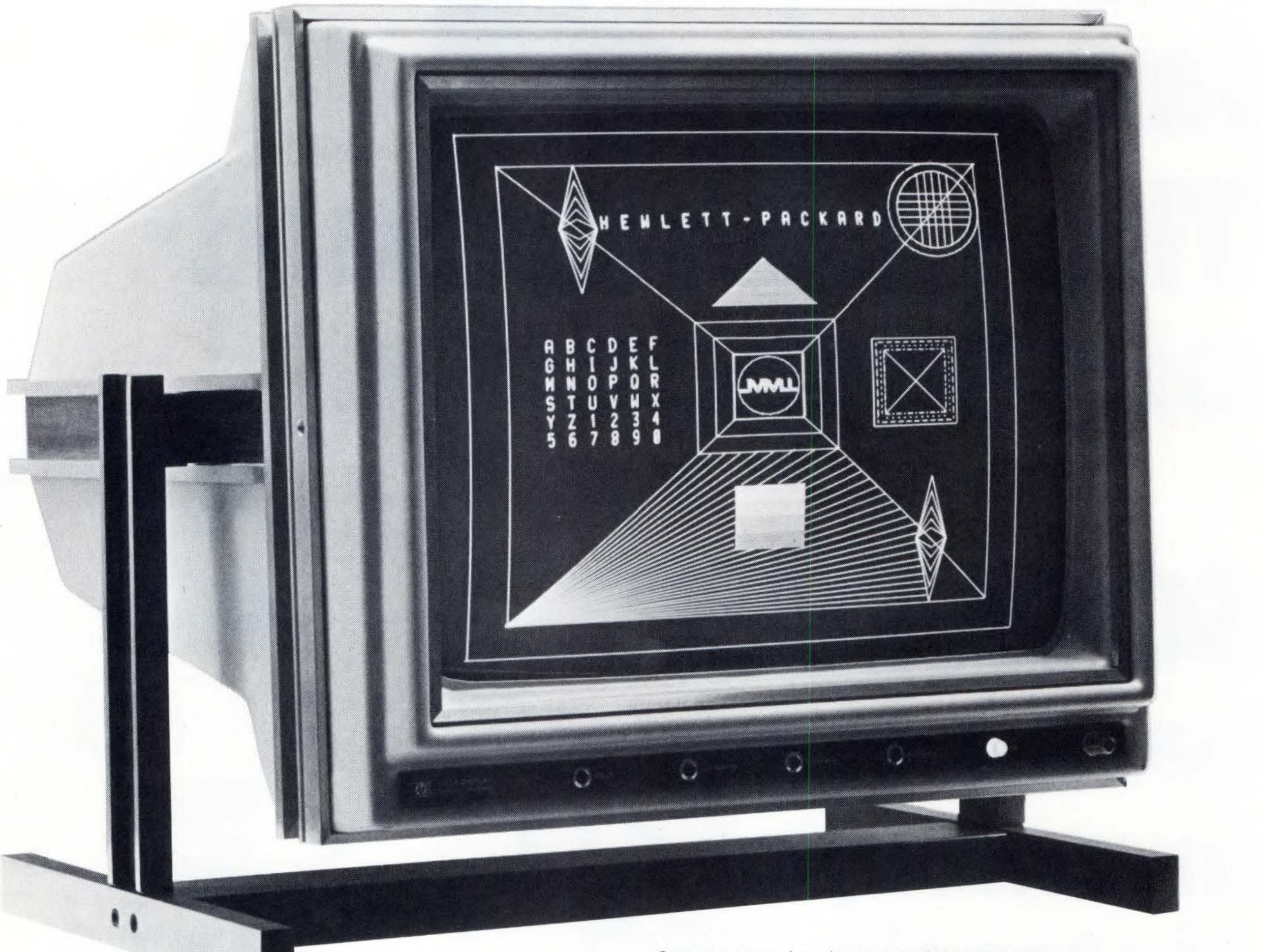
Phone any of these offices listed for your Free MECL books.

Westbury, New York: 516/334-7474
Waltham, Mass: 617/890-8484
Rockville, Md: 301/881-2970
Beachwood, Ohio: 216/464-2970
Hollywood, Fla: 305/927-0511
Chicago, Ill: 312/593-2740
Rochester, New York: 716/328-4180
New Jersey: 800/645-7377
Eastern Penna: 800/645-7377

Be a MECL Expert... phone for our new FREE Motorola MECL books.

SCHWEBER ELECTRONICS

This display writes as fast as your computer can talk.



Computer-generated graphics courtesy of The Boeing Company.

HP's new 1310A 19-inch-diagonal X-Y display is the answer to many an OEM's prayer... because it's the **first display ever that can keep up with the graphic information output of today's high-speed computers.**

The 1310A has a **writing speed of 10 inches per microsecond** – 10 times faster than any other display's. Its slew rate is 100 inches per microsecond. And its large-step jump and settle time is 1 microsecond. Thus, the 1310A gives you the ability to display information as fast as your computer puts it out – in any desired sequence of locations, without "smearing." No longer must you program outputs in a manner imposed by display limitations.

The key to the 1310A's outstanding performance is its **unique, advanced cathode ray tube** which uses electrostatic deflection to control its electron beam.

Also as a result of using electrostatic deflection, the 1310A is smaller, lighter, and **requires less power** than any competitive graphic display – only 100 watts. Because it uses the latest, highly rectangular CRT face glass, its display area is equal to that of many 21-inch units. And its **0.020-inch spot size** gives you a crisp, clear image over that entire area.

And performance is only the beginning! With the 1310A, you also get plug-in-board construction for fast, easy servicing. Replacement boards are available from any of HP's service centers around the world, on an exchange basis, within 48 hours. And it takes only minutes to remove or insert any board.

Yet, despite all these advantages, the **1310A costs only $3000**—far less than competitive displays (covers and stand, $100 extra). Or, for $2875, you can get all the features of the 1310A, in the new 14-inch-diagonal 1311A. **OEM price schedules are available on both the 1310A and 1311A.**

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

CIRCLE NO. 35

081/14A

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

One circuit performs both binary-to-BCD and BCD-to-binary conversions

Modification of a conventional serial counting converter scheme yields an all-purpose bi-directional converter.

Robert D. Solomon, Massachusetts Institute of Technology

There is often a need to economically convert between the BCD code of numeric readouts and keyboards and the binary language of computers and digital processors. Many different schemes are used successfully; however most of them perform a one-way conversion: that is, either from binary to BCD or BCD to binary. A conventional converter as modified in **Fig. 1** is able to do twice the job. This circuit can translate both BCD to binary and binary to BCD, with the conversion mode being determined by a single logic level. The circuit performs its bilateral feat by using two chains of cascaded presettable up/down counters, one binary and the other BCD.

How to control a 2-way converter

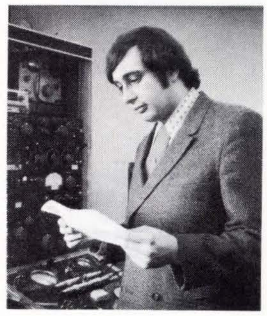
When in the BCD-to-binary mode, the start pulse resets the binary counter, and also loads the BCD counter with the BCD number to be converted. The clock signal is steered to the "up" clock of the binary counter and the "down" clock of the BCD counter. After the BCD counter has counted down to zero, all of the borrow outputs are low, which signals that the conversion is done and the converted binary number is available at the binary counter outputs. The "done" signal also disables the clock.

If the mode control is set for binary-to-BCD conversion, the up and down clocks, as well as the clear, load and borrow-done pulses are routed to the opposite counter from the one just described. Since the circuit is symmetrical, operation is the same in both modes, with the binary and BCD counters exchanging roles as the input "down" counter or the output "up" counter.

With this scheme, each mode has its own independent set of input and output word terminals, thus eliminating the costly job of steering input and output bits. Additional BCD and binary counter stages may be cascaded, as indicated in the schematic, but since there are 3.3 binary bits per decade compared to 4 BCD bits, fewer binary counters are needed for large number conversions. For six decades, only five binary counters are needed.

Maximum conversion time is equal to the largest number to be converted times the clock period. Therefore, an operator console interface with six decades of numeric information and a 10 MHz clock would have a 100 msec maximum conversion time, which enables real-time inputting of data to and from the operator.

Author's biography



Mr. Solomon is presently a doctoral candidate working on color perception and digital image processing and transmission at MIT, where he received his MSEE degree in the area of solid state devices. His undergraduate work was done at Polytechnic Institute of Brooklyn where he graduated summa cum laude.

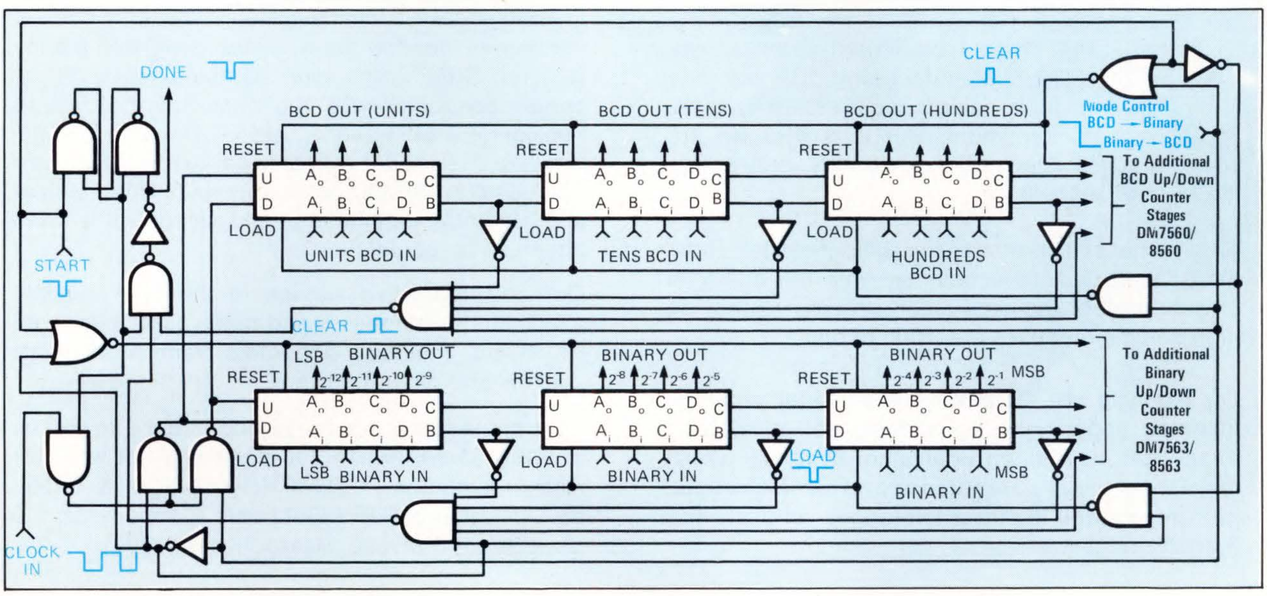


Fig. 1—Control of a bi-directional BCD/binary converter requires the addition of some steering gates. Both counters must be presettable and capable of up/down clocking.

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

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

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

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

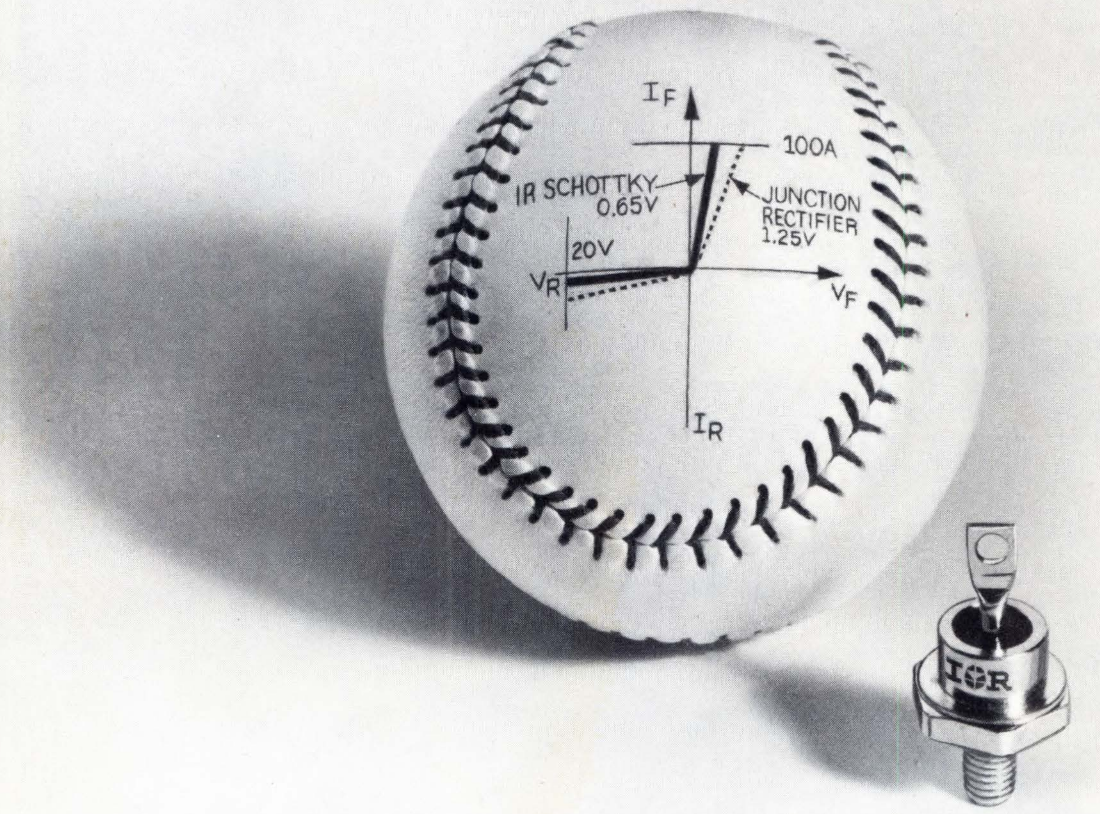
In another case, a minimum diameter 90 ohm coaxial cable was needed by a major computer manufacturer. Other cable sources stated that a 30 ga. center conductor was the minimum they would consider, resulting in a .125″ OD cable. TRW/Holyoke designed it with a 32 ga. center conductor producing a .086″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

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

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

TRW®
HOLYOKE WIRE & CABLE

CIRCLE NO. 37



The IR/Schottky Power Curve. A new twist that cuts power loss 50%.

Schottky had a good idea. His hot-carrier principle brought unique advantages to users of signal level diodes. So we teamed up to bring the same advantages to the high power league: designers of I/C power supplies and switching regulators in the 50 Amp/20 Volt range. Now it's a whole new ball game.

Check our curve. The dotted line shows the voltage-current characteristics of junction rectifiers. The solid line is the basis for our new pitch. There's quite a difference.

Half The Forward Voltage Drop. Note the forward voltage drop of 0.65 Volt vs. 1.25 Volts for typical rectifiers. At low voltage-low frequency, it means 50% less power loss, for a marked increase in efficiency. Like 10% at 5 Volts/100 Amps. Now you can use fewer rectifiers, smaller transformers, and cut heat-sinks in half. If you design high-frequency circuits, you'll do even better.

More Efficient at High Frequencies. The higher the operating frequency, the more efficient the IR/Schottky rectifier becomes. At 20 KHz, system efficiency can increase by an additional 25%. And, it can operate at even higher frequencies.

No Reverse Recovery Losses. Unlike junction rectifiers, the IR/Schottky barrier doesn't store minority carrier charges. There are none to be swept out as it is switched to the reverse mode. So time-lag and electrical loss are virtually zero, which accounts for its increased efficiency in high and ultra-high frequency systems.

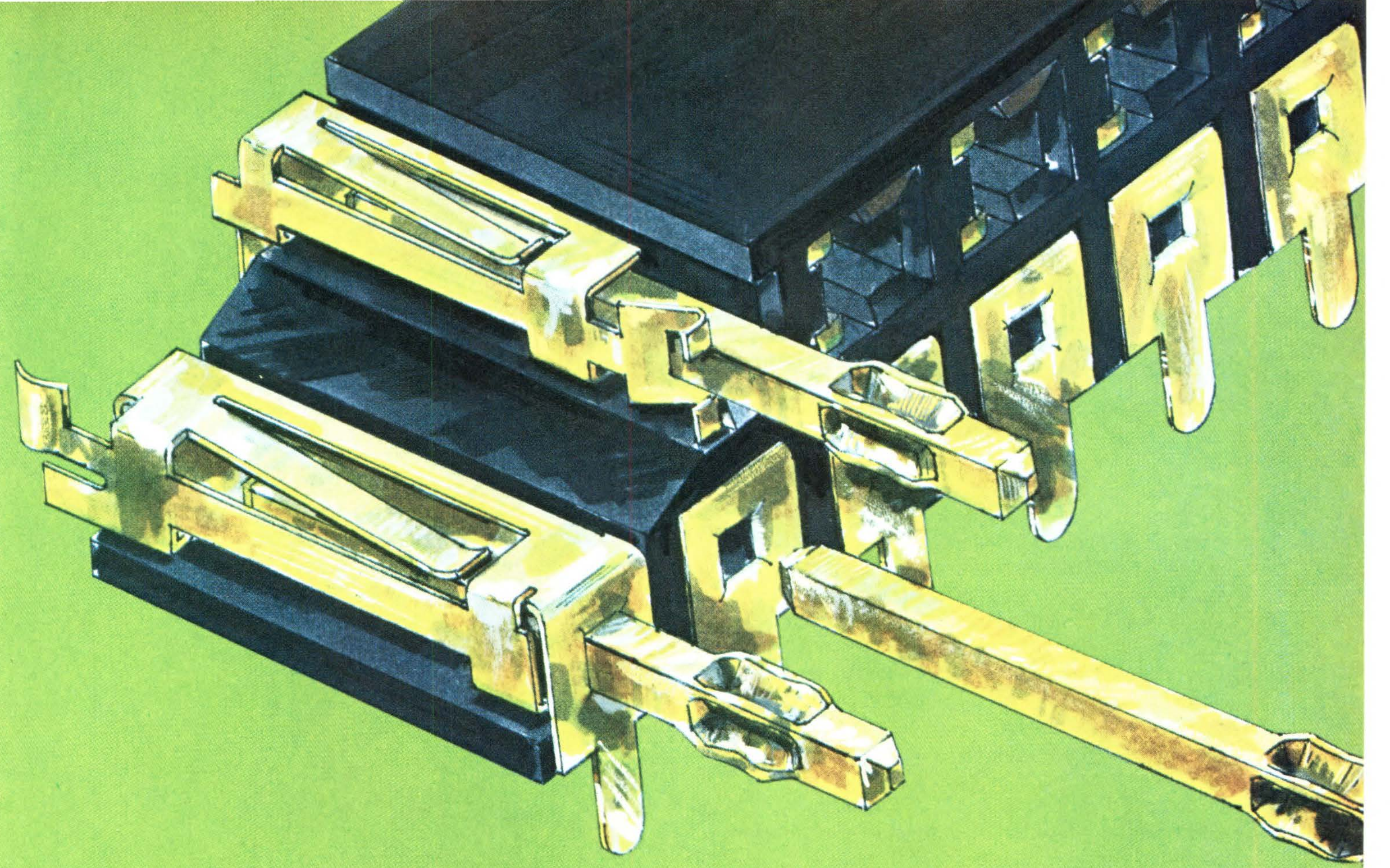
Reliability/Stability. You can forget about conservative derating. IR proprietary passivation and metallization technology assure long-term stability, extremely low leakage and low sensitivity to temperature. You can count on reliability and optimum life at full ratings.

Try our new curve. Call your IR sales office or distributor today and ask for details on IR/Schottky Power Rectifiers — in either forward or reverse polarities. You'll get everything you need for a whole new ball game.

New from IR...
the innovative power people

IOR INTERNATIONAL RECTIFIER
SEMICONDUCTOR DIVISION • 233 KANSAS STREET, EL SEGUNDO, CALIFORNIA 90245 • (213) 678-6281

CIRCLE NO. 38



THE PERFECT MATING

Any .025″ square post, yours or ours. And Elco's Varipost Box™ connector. For true togetherness in board-to-board and cable-to-board connections. Our new single row (Series 8243) and dual row (Series 8242), connectors will mate with any .025″ square posts on the market, even if they're wire-wrapped one level. Which means you can hold with your existing design and still make the connections you need.

Let's peek inside one of our Varipost Box™ connectors and see why they're so receptive.

First, the contact surfaces of the spring members are parallel to the surface of the p.c. board, and thus can span post-to-post tolerance deviations in your board. This compensates for misalignment between posts and contacts, so you get a perfect mating every time. Competitive box connectors — on the other hand — have perpendicular contact surfaces that demand tighter post-to-post tolerances to insure the mating of every contact with its corresponding post.

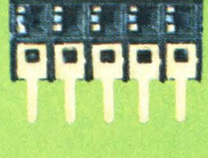
The spring contacts in our Varipost Box™ connector are longer, deflect farther and provide a longer wiping action than competitive connectors. Our contacts extend all the way to the entrance of the connector, so they'll mate with shorter-than-standard posts. And if your posts are longer than standard, a built-in stop prevents the posts from extending out the rear of the connector and shorting out with the upper row of contacts in the dual row version.

There's more. Our contacts can be removed from the housing and replaced without deformation. And sequential mating in dual row connectors—first one row, then the other —reduces insertion forces by half.

A wide range of models is now available . . . right off the shelf. Cable-to-board units with contact spacing on .100″ and .125″ centers in single row (with up to 25 contacts) and dual row with up to 50. Board-to-board (.100″ centers) versions with up to 50 contacts, and dual row (.100″ by .100″) with up to 100 contacts.

As companion pieces, we offer our new .025″ square posts, Elco Variposts™. And we've the insertion equipment to stake these posts into the board. So we can supply your p.c. board with posts already inserted, ready for mating.

Leave it to Elco, the Matchmaker. Another service in keeping with CONNECTRONICS, Elco's Total Connector Capability.



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

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

ELCO™

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

CIRCLE NO. 39

How to tailor your memory needs with a minimum of external parts

It is a relatively easy matter to use standard chips and a few external components in order to build a larger RAM that meets your specific requirements.

Dan Pearson, Solitron Devices, Inc.

The internal organization of a Random Access Memory (RAM) determines the number of decoders necessary, and ultimately determines access time. Since each decoder contributes to access time and total power consumption, it is desirable to minimize the number of decoders, as well as their size. If memory cells are arranged in a rectangular array, two decoders are necessary—one to decode the columns and one for the rows. The advantage of this arrangement is that fewer package leads are required for the input and output functions. Many examples of this type of organization exist; such as the 256 × 1 RAMs commonly available.

In contrast, when the memory cells are arranged in a single column, only one decoder is necessary. The disadvantage of the single decoder-single column approach is that for an equivalent memory capacity, larger translators to drive the decoder will be required. However, it is possible to compromise if one is willing to accept a word of more than one bit.

The UC6550/UC7550 offers such a solution with an organization of 64 words × 4 bits to provide a total memory capacity of 256 bits. Since only one decoder is necessary, the user can typically access his memory 200 nsec sooner than he could with a 256 × 1 organization requiring two decoders and consuming the same power. In addition, the 4-bit word is a very convenient size for building up larger memory systems, and the four chip enable inputs allow the user to build up his own memory.

A 256 × 4 memory need six external parts

Fig. 1a shows a system containing 256 words of 4 bits. By using the additional external output decoding in **Fig. 1b**, a 1024 word × 1 bit organization can be built. For the 256 × 4 organization the only external components required are four pullup resistors for the outputs and two TTL inverters. The power supplies are not shown as they are common to all four RAMs. Address inputs and the read/write select input, which are compatible to worst case TTL levels, are also common to all four RAMs. The clock-frequency range is the same as for an individual RAM and is defined by a maximum period of 20 μsec and a minimum period of 900 nsec. (This includes a minimum clock inactive time of 300 nsec plus an access time of 600 nsec).

Only two of the four chip enable inputs per RAM are needed for individual RAM selection. The remaining two are tied to ground. To select one RAM all four chip enable inputs must be low. This feature simplifies the external decoding required.

In this application, the pullup resistors are connected to V_{GG}, therefore they should be 6.2 KΩ. If they are connected to V_{DD} they should be 3 KΩ. Since tying the four outputs for each bit together typically increases the output capacitance of the memory less than 5 pF, the memory will still meet the guaranteed access time as long as the total capacitance on the output line does not exceed 50 pF.

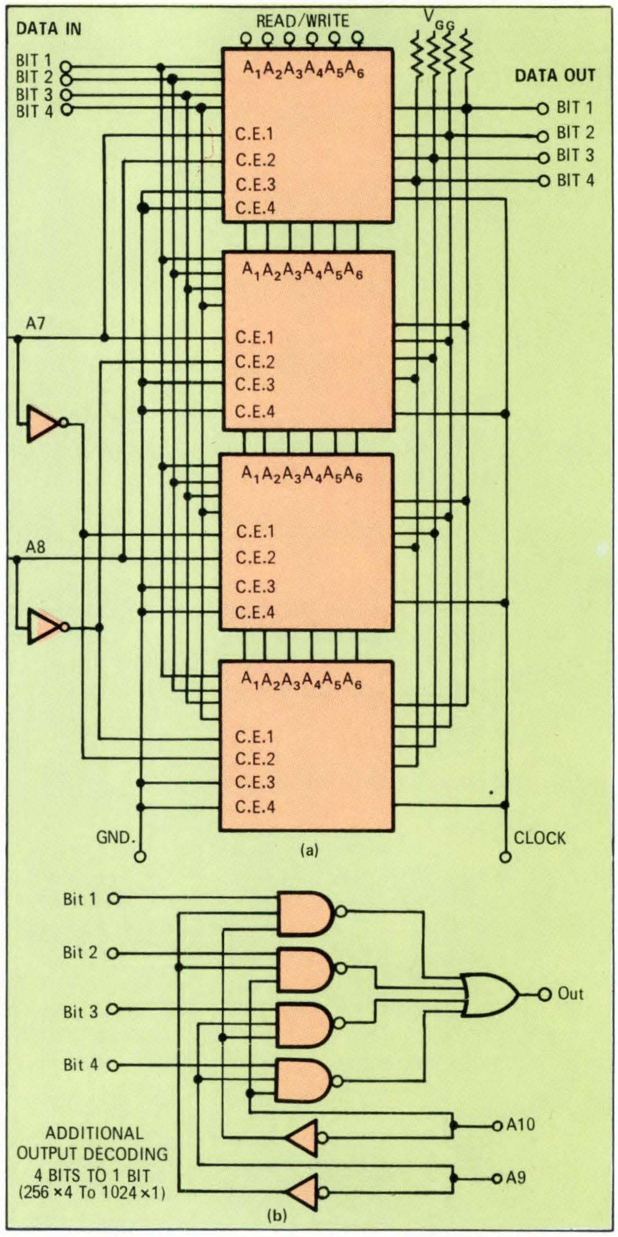


Fig. 1—**Only ten individual components** are needed to build a 256 + 4-bit random access memory (**a**). Add some additional external circuitry for decoding and you get a 1K + 1-bit RAM.

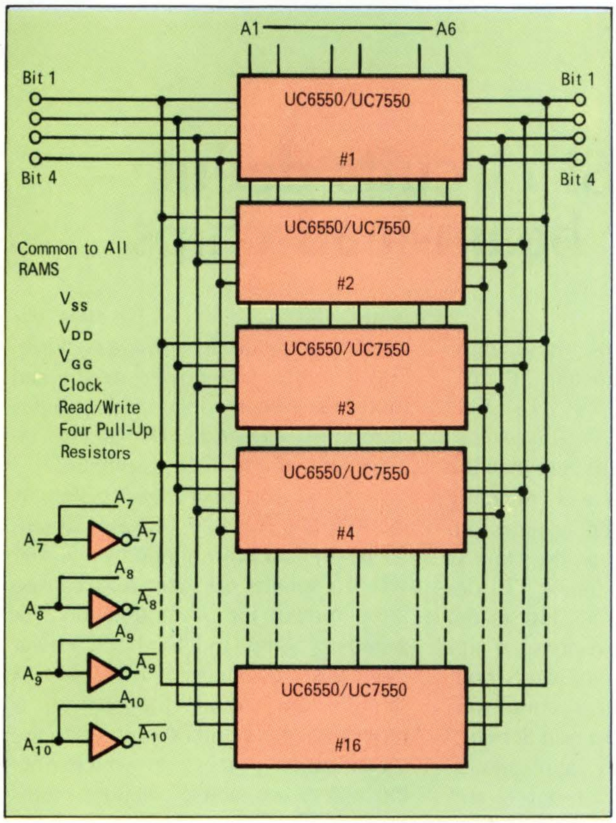


Fig. 2 — 1K × 4-bit RAM requires only the additional twelve 64 × 4 RAM's plus two more inverters for decoding.

In addition, TTL compatibility is preserved since both inputs and outputs meet worst case TTL logic levels.

Two additional inverters make a 1K × 4 RAM

A larger system of 1024 words of 4 bits is shown in **Fig. 2**. Once again, the additional external output decoding shown in **Fig. 1** can be used to organize 4096 words × 1 bit. For the 1024 × 4-bit case, the only external components required are four pullup resistors for the outputs and four TTL inverters. In this case, all four chip enable inputs per RAM are needed for decoding as indicated in the table in **Fig. 2**. Other details are as shown in **Fig. 1**.

CHIP ENABLE RAM SELECT TABLE

RAM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CE1	A7	A7	A7	A7	A7	A7	A7	A7	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$	$\overline{A7}$
CE2	A8	A8	A8	A8	$\overline{A8}$	$\overline{A8}$	$\overline{A8}$	$\overline{A8}$	A8	A8	A8	A8	$\overline{A8}$	$\overline{A8}$	$\overline{A8}$	$\overline{A8}$
CE3	A9	A9	$\overline{A9}$	$\overline{A9}$	A9	A9	$\overline{A9}$	$\overline{A9}$	A9	A9	$\overline{A9}$	$\overline{A9}$	A9	A9	$\overline{A9}$	$\overline{A9}$
CE4	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$	A10	$\overline{A10}$

The systems previously described have all had a 4-bit word base. Word length can also be expanded in increments of 4 bits.

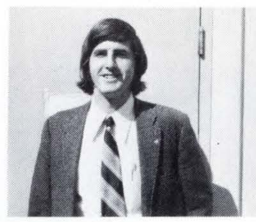
Eight-bit memories can also be built

Fig. 3 shows a memory containing 256 words of 8 bits. The external components required are very few in number; eight resistors and two TTL inverters. In this system the six address lines are common to all eight RAMs. Two additional lines provide decoding using only two enable inputs per RAM. The remaining two may be tied to ground as shown, or to V_{DD}, to V_{GG}, to the two inputs being used, or they may be used as a master control gate for the memory. When chip enable is high, all RAMs are disabled; and when low, all RAMs, except for the one selected by A7 and A8, are disabled. This TTL compatible system provides 900 nsec maximum access time over the full temperature range of the part used; UC6550 for −55°C to 125°C, UC7550 for −25°C to 70°C.

The three systems described are not by any means all inclusive and are only meant to suggest the range of applications possible. The possibilities for expansion are limited only by the system designer's imagination. ☐

Author's biography

Dan Pearson is a MOS circuit design engineer at Solitron Devices Inc., Semiconductor Division, San Diego, CA. Dan has been in this capacity with Solitron for the past 2 years. He received his BSEE from the University of California, Berkeley.



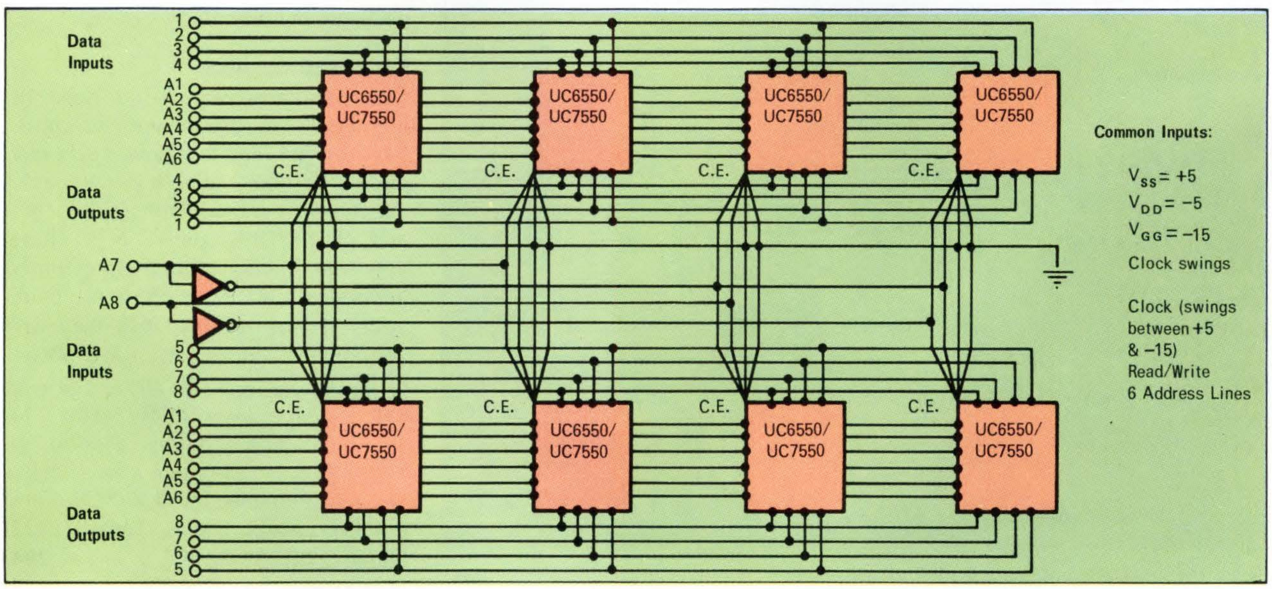


Fig. 3 — Larger word sized RAMs can also be built. The 256 × 8-bit organization need only two inverters for decoding.

Low-power Schottky MSI circuits debut in standard packages or beam-lead chips

PROGRESS IN MICROELECTRONICS

Two parallel but separate design efforts in low-power Schottky TTL circuits have come to fruition and together they bring, for the first time, low-power Schottky MSI capabilities to engineers over a wide spectrum of design efforts.

Of the thirteen new MSI functions introduced by Texas Instruments, Inc., twelve are available in standard IC packages and all in beam-lead chips. Both types are identical in operation but differ in chip design, since the packaged versions and the beam-lead chips are pin compatible with their low-power counterpart 54L/74L ICs. The beam lead devices have all interface pads located at the periphery of the chip, while this is not necessarily so for chips used in standard DIPs and flatpacks, because wire bond techniques allow much more freedom in locating bonding pads.

Power dissipation of these new TTL/MSI devices is typically 50 mW each (except the 54LS/74LS/181 ALU which requires 100 mW). This is nearly an order of magnitude less than the equivalent standard-power Schottky versions. Propagation delay times are typically 10 nsec per gate, the same as specified for standard 54/74 TTL devices, and three times as fast as the low-power 54L/74L versions. It appears that the new low-power Schottky circuits will be competing with low-power and standard non-Schottky 54/74 logic in many applications, especially where the fan-out (2 mA per gate) is all that is required.

Hi-rel assemblies

The new beam-lead chips are intended for use in custom beam-lead assemblies (a term TI prefers to "hybrid"). They offer the user very high packaging density and low power drain and provide complexities exceeding 300 gates in a single package. Seven other low-power beam-lead (but non Schottky-clamped) circuits introduced earlier by TI can also be incorporated into these assemblies.

Heart of the beam-lead system is the RLB-60. This is a 140-by-130 mil, 50 beam-lead chip, random logic bar which contains 60 gates and can be programmed for MSI functions or groups of gates and flip-flops. Power dissipation averages 1 mW/gate. A semi-custom circuit, the RLB-60 is processed as a standard unit, up to the metallization process, at which time the wafers are stored awaiting customer specifications.

Upon receipt of a customers block diagram or logic equations, the 60 gates (all 3-input NANDS) are interconnected by metallization. TI claims that this procedure provides custom designed units in half the time normally required. Elimination of wire bonds and the use of silicon-nitride sealed junctions is said to improve reliability more than ten-fold over conventional hybrid or PC board assemblies. The silicon-nitride sealed junctions provide hermetic chips, and allow a designer to use low-cost, non-hermetic packages in non-military designs.

Packaged devices

For designers who do not need, or are unable to use beam-lead chips, 14, 16-or 24-lead low-power Schottky circuits will be available in two package types: ceramic DIPs (suffix "J") and plastic DIPs (suffix "N"). These new MSI functions join the previously announced 54LS/74LS83, a 4-bit full adder. TI has revealed that they will announce packaged, low-power Schottky versions of all low-power TTL gates from 54L/74L00 to 54L/74L55 and flip-flops 54L/74L74, 112, 113 and 114 within a few weeks. Texas Instruments, Inc. 13500 N. Central Expressway Dallas, Texas 75222 Phone (214) 238-2011 **294**

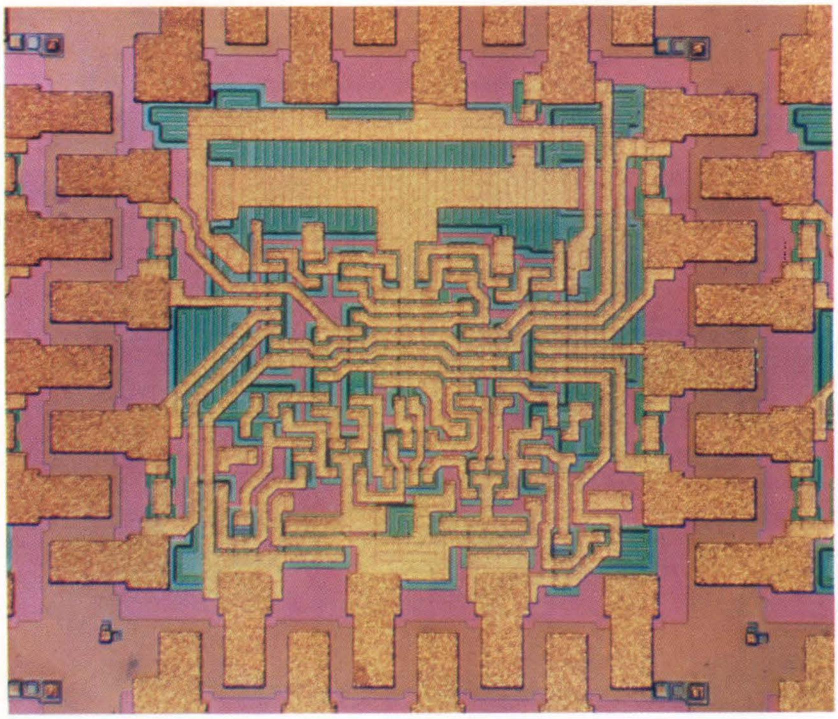


Fig 1—The integration of beam-leads and low-power technology now offers MSI complexity devices with a speed-power product significantly improved over that of previous beam-lead technologies.

Device Number and Function	Beam Lead 54LS	Plastic DIP 74LS
95A 4-bit, right-left shift register	$14.10	$ 4.35
295 same as 95A, with 3-state outputs	16.90	5.22
138 3-to-8-line decoder	12.00	4.35
139 Dual 2-to-4-line decoder	12.00	4.35
153 Dual 4-to-1-line multiplexer	9.00	4.35
253 same as 153, with 3-state outputs	10.80	5.22
155 Dual 2 to 4 line decoder	14.10	4.35
181 Arithmetic Logic Unit	33.70	23.50
193 Synch. 4-bit U/D binary counter	22.20	NA
194 4-bit Bidirectional Shift Register	14.15	4.35
195 4-bit Parallel access S/R	14.15	4.35
196 50 MHz Mod. 5 Presettable Decade & Binary counter/Latch	19.30	4.35
197 50 MHz Mod. 2 presettable Decade & binary counter/latch	19.30	4.35

Fig. 2—Thirteen new low-power Schottky TTL/MSI devices announced by TI are listed above with their unit prices, when ordered in quantities of 1000 or more. A "54 LS" prefix denotes the full military temperature range of −55 to 125°C. The "74 LS" versions are intended for standard industrial operation from 0 to 70°C.

FM/AM and pulse modes featured in 9.5-to-520-MHz signal generator

PROGRESS IN TEST EQUIPMENT

Covering 9.5 to 520 MHz, Logimetrics' Model 750 signal generator features independent as well as simultaneous FM, AM and pulse modes. The $2575 instrument offers a direct five-digit LED readout and calibrated FM.

A low-cost signal generator (only $2575) spanning a frequency range of 9.5 to 520 MHz has been introduced by Logimetrics, Inc., of Greenvale, N.Y.

The Model 750 is an AM-FM generator that has five-digit LED readout with variable resolutions of 1 MHz, 100 kHz or 10 kHz. It offers calibrated FM with calibrated deviations of 10, 30, 100 and 300 kHz read directly on a front-panel meter. FM accuracy is ±5% of full scale (20 Hz to 100 kHz) with a low distortion level of less than 1/2% at 75-kHz deviation.

The real versatility of this instrument is provided by its incorporation of not only AM and FM, but also pulse modulation. The 750 offers independent AM, FM and pulse modulation as well as simultaneous AM/FM and FM/pulse capabilities.

Singer Instruments also offers a signal generator, the Model SG-1000, with independent AM, FM, pulse and video modulation, as well as simultaneous AM/FM, FM/pulse, AM/pulse and FM/video modulation over 7.75

to 512 MHz. This instrument however costs $4250. Hewlett-Packard has its recent Model 8654A (10 to 500 MHz) offering only independent AM and FM at a cost of $1135. Logimetric's 750 fills the performance/price gap between these two.

The Model 750 has accuracy from ±0.001% to ±0.05% and harmonics that are 30 dB below the carrier. AM noise is 70 dB down and spurious signals are 60 dB below cw.

The instrument's rf output is 1V into 50Ω, leveled to within ±1/2 dB and continuously adjustable from 1 μV full-scale to 1V full scale with a 120-dB attenuator.

AM distortion is less than 1% for 30% AM and 3% for 70% AM. Internal 400 and 1000-Hz as well as external dc-to-20-kHz modulation is available. For the FM mode, external modulation is to 100 kHz.

The minimum pulse width that can be obtained with the 750 is 0.1 μsec.

Delivery is being quoted from 90 to 120 days.

Logimetrics, Inc., 100 Forest Dr., Greenvale, N.Y. 11548. Phone (516) 484-2222.
Greenvale, N.Y. 11548. Phone (516) 484-2222. **295**

Singer Co., 915 Pembroke St., Bridgeport, Conn. 06608. Phone (203) 366-3201.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. Phone (415) 493-1501. **296**

1-μsec sample/hold module allows 12-bit, 140-kHz throughput

PROGRESS IN PACKAGED CIRCUITS

A typical high-speed, data-acquisition system consists of an input multiplexer followed by a sample-and-hold unit and an output A/D converter. In the past, the limiting factor of such a system's speed, or throughput rate, has been the A/D converter. With the recent introduction by Analogic of a 12-bit A/D converter with 4-μsec speed and the availability of 2-μsec multiplexers, speed emphasis has now been centered on sample-and-hold amplifiers.

Analogic Corp. has just introduced a $175 sample-and-hold module, the Model MP270, with an acquisition time of 1 μsec maximum to within 0.01% of full scale. Equally important is the amplifier's high input impedance of 10^8Ω shunted by 10 pF.

Specifically, the MP270 settles to within 0.01% of full scale for every 20V step or to within 0.05% of full scale for every 10V step. Combined with Analogic's $100 2-μsec multiplexer (Model MP4716) and its $595 MP2912A 4-μsec 12-bit A/D converter, a true-12-bit data-acquisition system can be put together with a throughput rate of about 140 kHz for $870. Previously, the best throughput rate available in a plug-in modular system for full 12-bit conversion has been approximately 33 kHz.

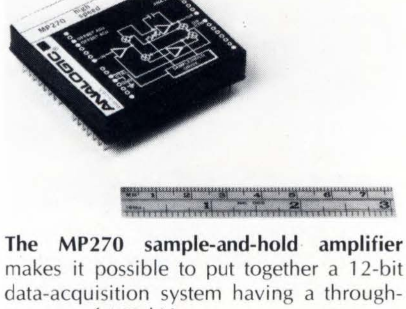
A less expensive system ($624), with a 100-kHz throughput rate, can be configured using the new MP270 sample-and-hold unit together with the MP4716 multiplexer and the $349 MP2112 12-bit a/d converter that has a 7-μsec speed.

The MP270 sample-and-hold amplifier has unity gain ±0.01% and a droop rate of 2 μV/μsec. Acquisition uncertainty time is 0.5 nsec, aperture time is under 2 nsec and aperture-time uncertainty is less than 0.5 nsec.

Additional specifications include 2-μV/μsec hold decay, sampling-offset TC of 50 μV/°C, linearity of 0.005%, bandwidth of 10 MHz and full-power bandwidth of 500 kHz minimum.

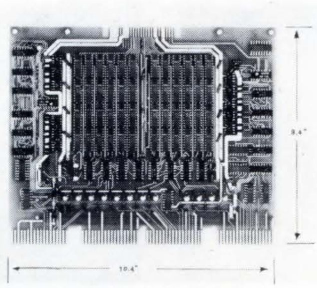
The MP270 has an offset-voltage TC of 50 μV/°C and only 300 μV pk-pk of noise. Input voltage is ±10V and maximum bias current is 100 pA. Output is ± 10V at ± mA.

Analogic Corp., Audubon Rd., Wakefield, MA 01880. Phone (617) 246-0300. **297**



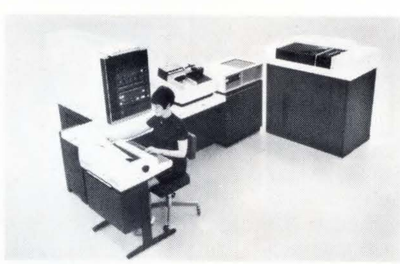
The MP270 sample-and-hold amplifier makes it possible to put together a 12-bit data-acquisition system having a throughput rate of 140 kHz.

COMPUTER PRODUCTS



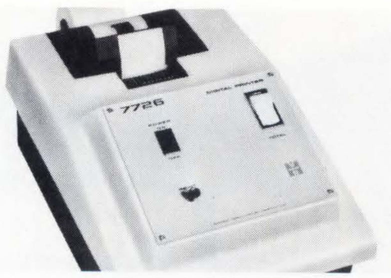
FIRST MOS PLUG-COMPATIBLE MEMORY FOR PDP-8/E COMPUTER can be used either as a complete substitute memory or as an add-on for existing systems. Capacity is from 4K to 32K in 4K increments. The PDP-8/E memory is comprised of one timing and control card plus up to eight 4K × 12 memory cards. 4K of memory, including control and timing, is $1630. All cards plug directly into the OMNIBUS chassis of the PDP-8/E computer. Signal Galaxies, Inc., 6955 Hayvenhurst Ave., Van Nuys, CA 91406. Phone: (213) 998-1570. **177**

SINGLE CAPSTAN TAPE TRANSPORT family fills all speed needs. The 1600 Series units operate at standard speeds of 25, 18.75, or 12.5, ips. Optional speeds of 37.5 or 6.25 ips are available. Featured are densities of 200, 556, 800, or 1600 bpi; 8-1/2" reels (1200 ft.); and IBM compatible. Configurations include read only, write only, and read/write with single or dual gap heads. Prices start at $1927. Digi-Data Corp., 4315 Baltimore Ave., Bladensburg, MD 20710. Phone: (301) 277-9378. **176**



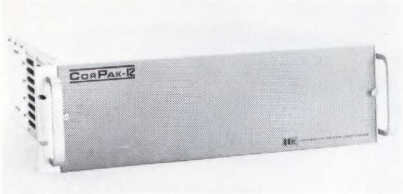
TWO COMPUTER SYSTEMS feature multiprocessor states. MRX/40 and 50 computer systems offer 16K to 128K bytes of MOS memory, up to 15 communications lines and 29 to 232 million bytes of disc storage. The eight processor states share the system's alterable control memory, main memory and the arithmetic logic unit. Rental prices range from $2500 to 12,000 a month. Memorex Corp., San Tomas at Central Xway, Santa Clara, CA 95052. Phone: (408) 987-2200. **175**

POCKET-SIZE CALCULATOR weighes less than one pound. The Monroe 20, a 6-in. by 3.6-in. minicalculator is designed for in-the-field use and features an eight digit light emitting diode display. The Monroe 20 adds, subtracts, multiplies and divides, has automatic constants in all operations, and has automatic underflow. Price is $269, including batteries, a battery charger and case. Monroe, 550 Central Ave., Orange, N J 07051. Phone: (201) 673-6600. **178**



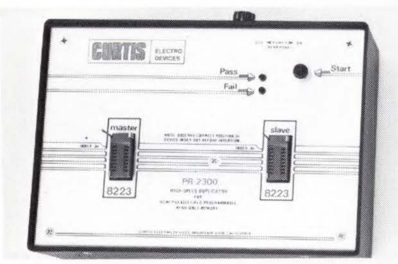
ACCUMULATING DIGITAL PRINTER accepts BCD inputs. Series 7726 printer records production for processing, inventory, and production control. This low cost printer/totalizer uses a conventional adding machine printing mechanism and standard tape. It operates at up to 3 sec/line from parallel BCD data input. Series 7726 has a full 7 column print capacity and 8 columns for totalizing. Totals print in red. Veeder-Root, 70 Sargeant St., Hartford, CT 06102. Phone: (203) 527-7201. **179**

LINE PRINTER works with naked mini and alpha computers. The line printer package includes a Centronics 101 table-top printer, cable, computer interface and software, with diagnostics and print routine. The 132-column printer operates at 100 lines/min. with ASCII character set and pin feed up to 14-in. paper. Price is $5500. Computer Automation Inc., 895 West Sixteenth St., Newport Beach, CA 92660. Phone: (714) 642-9630. **180**



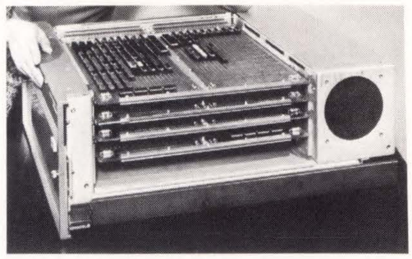
ADD-ON MEMORY expands PDP-12 core memory to 32k. CorPak-12 allows PDP-12 users to increase their core memory at a cost 30 to 40% less than DEC's published list price. Price for 28K in a typical installation is $20,900. The new memory package, including power supply, fits into a 10-1/2" rack space, and is plug-to-plug compatible with the DEC PDP-12. Information Control Corp., 9610 Bellanca Ave., Los Angeles, CA 90045. **290**

HIGH SPEED STRIP PRINTER IS POWERED BY BATTERIES. The non-impact printer prints two lines of data at speeds to 120 characters/sec on dry paper. The paper has indefinite shelf life, is insensitive to pressure, temperature, and humidity, and does not require any processing either before or after use. The printer has only one moving part, used to transport the paper strip. Input is parallel ASCII code; all interface signals are TTL compatible. Adtrol, Inc., 700 Abbott Dr., Broomall, PA 19008. **291**

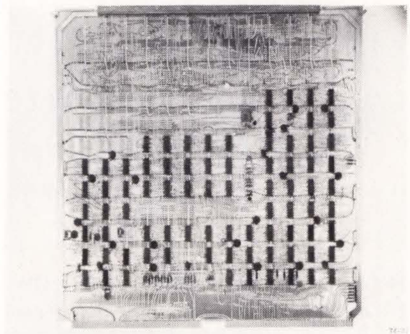


PROGRAMMABLE ROM DUPLICATOR programs 8223 in one second. PR-2300, program timing, optimized for the Signetics 8223, results in a 1 sec "PASS" cycle and a 1-1/2 sec "FAIL" cycle. Light emitting diode lamps indicate "PASS" or "FAIL". No adjustment or calibration is required. Zero force DIP sockets and a glass sealed reed start switch assure long service life. PR-2300 is priced at $429.50. Curtis Electro Devices, Box 4090, Mountain View, CA 94040. Phone: (415) 964-3136. **174**

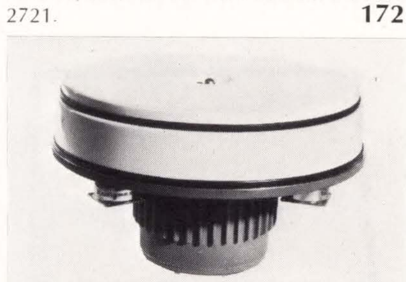
COMPUTER PRODUCTS



ARRAY PROCESSORS are plug-compatible with pdp-11 and nova minicomputers. The Model 030 series used in signal analysis systems include an FFT processor, array coordinate converter, array multiplier/adder unit, and array logarithmic processor. The Model 030 series is designed to process data in the memory of the host computer on command. UniComp Inc., 19749 Bahama St., Northridge, CA 91324. Phone: (213) 882-6313. **173**



INTERFACE CONTROLLER drives printec-100 line printer. Series 160 controller is designed to interface Data General and Digital Computer Controls systems with the 100 CPS Printec-100 printer. Price is $575, including supporting software. Interfaces for other minicomputers will also be available. Mini-Systems Inc., 4935 Boone Ave. North, Minneapolis, MN 55428. Phone: (612) 926-2721. **172**

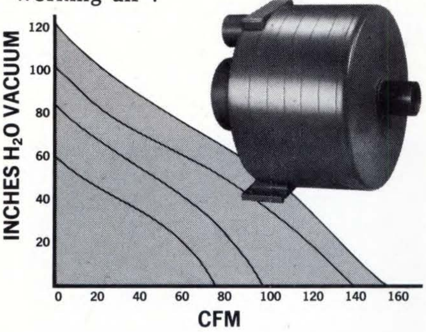


MINICOMPUTER DISC MEMORY HAS 128 TRACKS. The expanded memory unit offers 70,000 bits/track and a 2.1 million bit/sec transfer rate. Storage capacity ranges from .56 to 8.96 megabits. Access time is 17 msec. Cost/bit starts at .08c/bit per single unit, less than .06c in quantity. The compact unit, designed for minicomputer and terminal input/output applications, features a flying head per track design, an integral drive system and lifetime lubricated bearings. Tally Corp., 8301 180th St., Kent, WA 98031. Phone: (206) 251-5500. **171**

LAMB ELECTRIC OFFERS COMPUTER-ORIENTED PRECISION

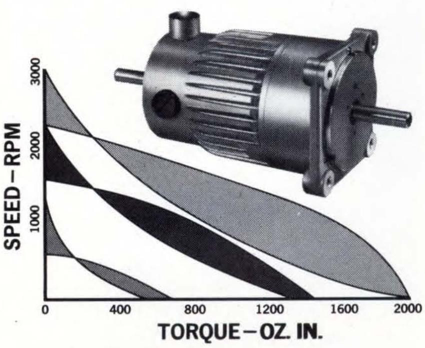
Windjammer® blowers for quiet, "working air"...

Motorized centrifugal blower systems provide pressure or vacuum, or both—economically. Wide range of operating characteristics can be obtained by modular "stages" of fan system. Units function in any position, are easy to install. APPLICATIONS: tape decks, office copiers, data terminals, and virtually any type of equipment utilizing "working air".



... DC SERVO MOTORS for thoroughly reliable control.

Lightweight and compact, Lamb servos respond quickly, smoothly. Design assures cool motor operation despite heavy cycling over prolonged periods. Armature diameters are small in relation to field, minimizing inertia and allowing for greater extremes in cycling of rotation, torque and speed. Available in wide range to suit your torque requirements. APPLICATIONS: magnetic tape drives, paper tape handlers, closed-loop servo systems, variable speed drives, etc.



For additional information, contact AMETEK/Lamb Electric, Kent, Ohio 44240
Telephone: (216) 673-3451

AMETEK / Lamb Electric

AMETEK

CIRCLE NO. 85

A.W. Haydon Company motors... problem-solvers for Hewlett-Packard

Minimum magnetic interference, reversibility, accurate positioning and low cost are some of the features offered by two A. W. Haydon motors used in the Hewlett-Packard Model 10 programmable calculator.

Amazingly versatile, the calculator combines plug-in modules with a wide number of options which allow it to be adapted to a host of disciplines using mathematics, statistics and other functions.

One option, for instance, permits often-used programs to be stored on magnetic cards. The cards can then be fed through a built-in magnetic card reader for speedy data and program entry.

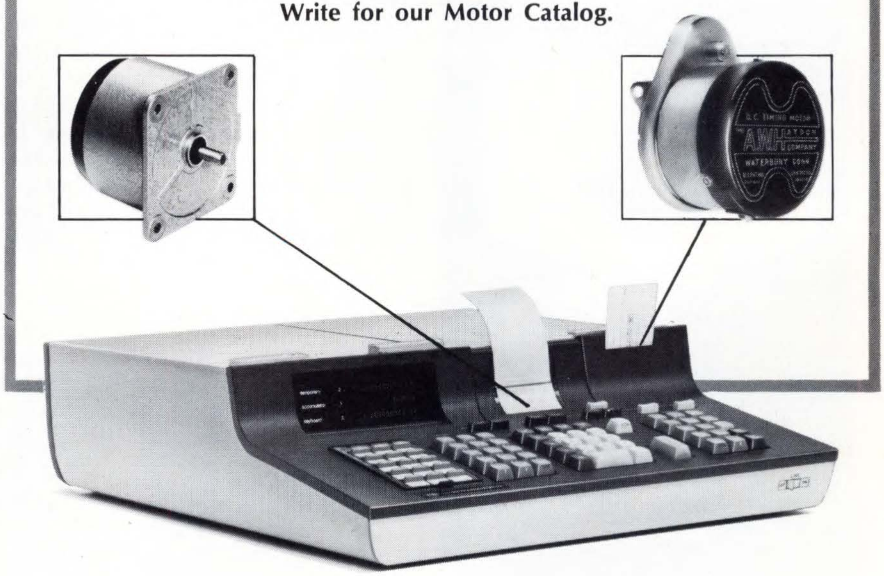
But herein lay design problem No. 1. Find a motor capable of feeding the cards in and out at a smooth, constant speed. Also, one which would keep electromagnetic interference to a minimum to prevent the input data from being adversely affected.

The answer? An A. W. Haydon 43100 reversible dc motor. Widely used for timing and control applications, the 43100 series features permanent magnet construction encased in a steel shell to minimize stray electromagnetic fields. Another design advantage: a hollow cage ironless rotor which eliminates cogging. Result: the magnetic card is fed through the reader at a smooth constant rate of speed.

Problem No. 2 was to find a motor capable of driving the Model 10's alphanumeric printer. Accurate positioning and economy were essentials. The answer was "on the shelf" . . . a standard A. W. Haydon 12 vdc ID05 stepper motor which offers accuracy and dependability at an attractive low cost.

If your own design problems encompass timed motion or control, our broad range of synchronous, dc timing and stepper motors — plus our extensive engineering experience — can help solve these problems and lower your costs. Try us and see.

Write for our Motor Catalog.



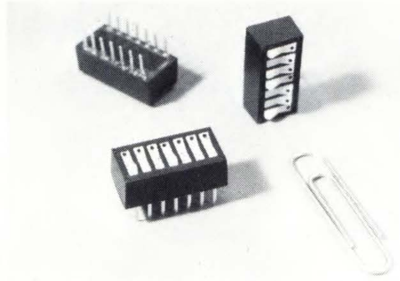
A.W. HAYDON CO. PRODUCTS

NORTH AMERICAN PHILIPS CONTROLS CORP.

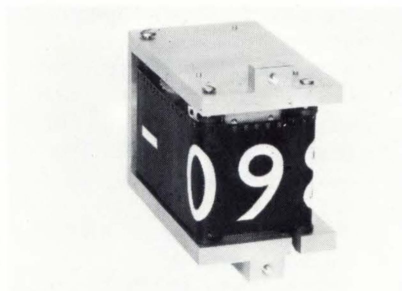
A NORTH AMERICAN PHILIPS COMPANY
232 North Elm St. · Waterbury, Conn. 06720 · (203) 756-4481

CIRCLE NO. 47

COMPONENTS/MATERIALS



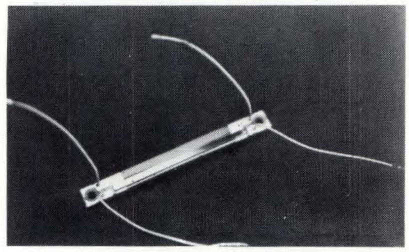
DIP SWITCHES house seven individual manually operated, SPST rocker switches in a standard 14-lead configuration. Other sizes containing four-to-ten switches are available in 8-to-20 lead dual-in-line packages. Lead arrangement for all sizes is two rows on 0.300 in. spacing with 0.100 in. centers within each row enabling the switches to mate with any standard DIP receptacle. Amp Inc., Harrisburg, PA 17105. Phone (717) 564-0101. **292**



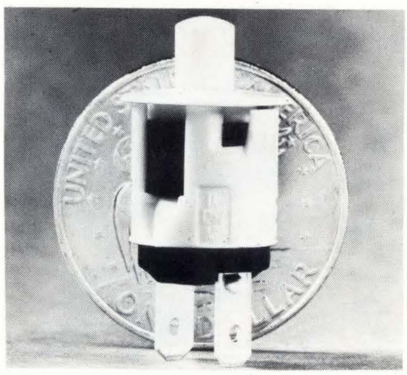
LOW-COST DISPLAY provides large numeral character format for extended range visibility. Each digit is internally illuminated from electroluminescent light source. Visidrive is a tape driven readout accepting BCD inputs from any DTL/TTL compatible source. The rear of the tape is coded with a BCD format and monitored by an optical reader. Theta Instrument Corp., Fairfield, N J 07006. Phone (201) 227-1700. **293**

INDICATOR LIGHTS with 0.187 in. and 0.060 in. terminals facilitate wire wrap connections. MINI-SLIDE 3000 Series available in round or rectangular styles, the lights mount in either a 1/2 in. round hole or a standard "D" shaped hole. These high-intensity lamps are available in voltages up to 120V. Industrial Devices, Inc., 982 River Rd., Edgewater, N J 07020. Phone (201) 943-4884. **185**

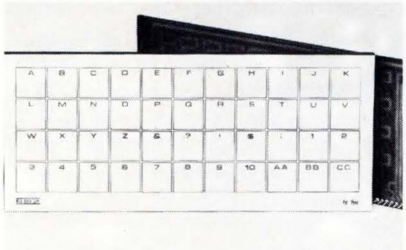
MINIATURE TANTALUM CAPACITORS are designed for use in bypass, blocking, filtering and decoupling applications. Over 50 types are offered to satisfy a wide range of voltage/capacitance requirements. Miniature size and radial leads make these devices ideal for use on compact PC board assemblies. European Electronic Products Corp., 10180 W. Jefferson Blvd., Culver City, CA 90230. Phone (213) 838-1912. **186**



POSITION SENSITIVE PHOTODETECTOR is capable of measuring displacements as small as 50 microinches. Utilizing diffused junction technology, this line of highly stable linear photodetectors is designed to provide very precise position and energy information, even under high illumination levels. Active area of the PS-100 is 2 in. by 0.1 in. and spectral response is 300 to 1100 nm. Solid State Radiations Inc., 2261 S. Carmelina Ave., Los Angeles, CA 90064. Phone (213) 478-0557. **187**



COMMERCIAL PUSHBUTTON SWITCHES feature U.L. listed 3A, 125V ac ratings. SPST devices are available with momentary action, nc or no contacts, 1/4 inches and 15/32-inch bushings, and snap-in or flush mounting. Contacts are silver plated. Prices range from 75¢ to $1.55 in large quantities. Specialty Products Div., Cutler-Hammer, Inc., 4201 N. 27th St., Milwaukee, WI 53216. Phone (414) 442-7800. **188**

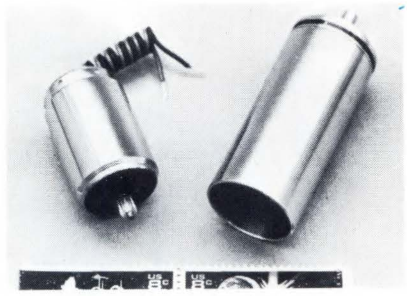


ONE PIECE, FLAT-SURFACED KEYBOARDS utilize patented multi-element electric grating switch concept. Available in almost any size or any shape with units as thin as 1/8 in., "Mono-lithic" keyboards are totally sealed. Keyboards are constructed on a printed circuit substrate, and other electronic components may be mounted along with the keys. Wild Rover Corp., 97 Oak St., Norwood, N J 07648. Phone (201) 768-8393. **189**

MINIATURE SHAFT ENCODER uses LED source. Measuring only 1 in. by 1 in. cased in a size 11 servo housing, the new encoder has been designated Subminiature Series 820. It is a photoelectric type device and the small size allows application in virtually any high density packaging application. Solid state light emitting diodes are used as illuminating sources. Sensors are phototransistors. Disc Instruments, Inc., 2701 S. Halladay St., Santa Ana, CA 92705. Phone (714) 549-0343. **190**

PLASTIC CARD GUIDES available. The guides are offered for 1/16-inch thick circuit cards in various lengths and may be mounted independently with screws or rivets where only a few cards need support. Alternately, the guides may be attached to special extruded aluminum struts which have captive nut grooves for infinitely variable card spacing. The guides are made from ABS plastic which is non-nutrient and may be used in temperatures up to 250F without distortion. Guides are priced as low as 0.11¢ each in quantities of 200 pieces. Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342. Phone (213) 265-9661. **191**

COMPONENTS/MATERIALS



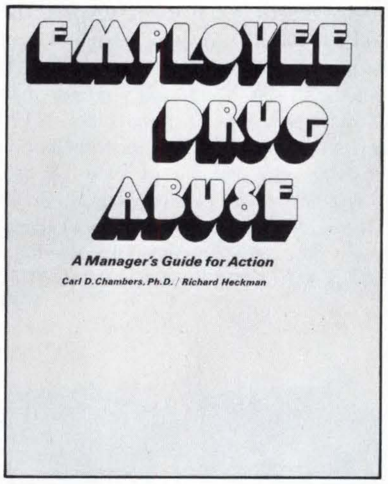
MINIATURE DC MOTORS and slip-on gearbeads, Series 03/2, deliver peak torque ratings of 80 in oz. for continuous service. The 03/2 Series has 23 ratios available, ranging from 3 to 1 up to 903,447 to 1. All gearbeads are "slip-on" type which also are adaptable to other motors. The slip-on gearbeads are 0.935 inches in diameter with lengths ranging from 1.5 to 3.5 inches. Motors feature an ironless rotor. Micro Mo Electronics, 3691 Lee Rd., Cleveland, OH. 44120. **192**

Why you should read

Employee Drug Abuse

A Manager's Guide to Action

by Carl D. Chambers and Richard D. Heckman.



This book has two objectives: (1) To document employee drug abuse and its potential proportions and (2) to provide management with help in formulating and implementing policies and programs to minimize the problem. The data base was drawn from studies conducted by the Division of Research of the New York State Narcotic Addiction Control Commission.

Research was not limited to a specific industry, specific workers or specific drugs.

For the first time, drug survey specialists measured the incidence of on-the-job drug use. Projections for the use of various drugs, both legal and illegal, are made for seven occupational groups: (1) Professionals, technical workers, managers and owners; (2) Clerical and other white collar workers; (3) Skilled and semi-skilled workers; (4) Unskilled workers; (5) Service and protective workers; (6) Sales workers; (7) Farmers. The most workable aspects of existing policies and programs have been analyzed and evaluated, along with the pitfalls of implementation. Additionally, the views of both employees and potential employees for whom these policies and programs were designed were obtained and measured against program goals. No policy or program expressed in this book is offered as a panacea for any company. The book offers the actual experiences of companies and employees— a base on which to create your own policy and programs.

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

Dr. Chambers received his Ph.D. in Medical Sociology from the University of Colorado. He is currently Director of Research, New York State Narcotic Control Commission; Co-Director, Division of Addiction Sciences, Department of Psychiatry, University of Miami (Florida) School of Medicine; and Senior Associate, Resource Planning Corporation, Washington, D.C. Dr. Chambers has been a consultant on drug abuse to many private, business and governmental organizations, a teacher and counselor at schools and penal institutions, and a contributor to many major professional publications on the problem of drug abuse. Mr. Heckman is a freelance writer who, since his graduation from Boston University, has written almost exclusively about business and industry. He has devoted the past two years to investigating and reporting on drug abuse in industry.

256 pp. **$12.50**

RELATED BOOKS

DESIGN OF PROJECT MANAGEMENT SYSTEMS AND RECORDS by Alan F. Peart. Although formalized project management is a recognized cost effecting industrial tool, there has been a gap in information on the implementation of project management. This book describes and illustrates the systems approach and documentation needed to define project objectives, analyze materials and finance, plan the tinescale, coordinate parallel activities, control expenditure and report results. It is a working guide for any industrial manager.
206 pp. $12.95

MANAGING CREATIVELY: A Very Practical Guide (Two Volumes) by Ted Pollock. As author of more than 700 articles on personnel guidance, sales promotion, sales training and personnel psychology, and as a consultant to industry on personnel problems, Mr. Pollock emphasizes the practical solution to problems. These two volumes are the outgrowth of experience with the top management of many companies.
2 volume set $16.50

Volume 1: Managing Yourself Creatively presents guidelines for the executive in dealing with himself and improving himself both professionally and personally.
180 pp. $9.95

Volume 2: Managing Others Creatively illustrates how the executive can evaluate his own performance with subordinateds, peers and superiors and work totally with his employees.
160 pp. $9.95

MANAGE OR BE MANAGED by Don Fuller. This book is a handbook for managers and supervisors and has particular relevance for the new manager promoted from technical specialist. Full of practical ideas and specific techniques of effective management, the book pinpoints common management mistakes; explains how to be your own "problem consultant;" presents new ideas on job enrichment, work simplification and the application of human relations and human engineering methodology; and gives guidelines for evaluating decisions, decreasing a manager's work load and reporting effectively to superiors.
336 pp. $15.00

Any of these books will make a useful addition to your library. Examine one or all FREE for 15 days.

Cahners Books 89 Franklin Street, Boston, Mass. 02110

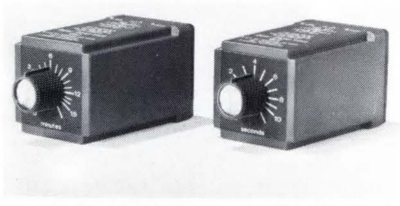
Please send me the indicated books. If not completely satisfied after a 15-day free examination, I may return the book (s) and owe nothing. Otherwise I will send my check. ☐Bill me ☐Bill company ☐ Payment enclosed (Cahners pays shipping). (Please add any applicable sales tax)

Quantity	Title	Price

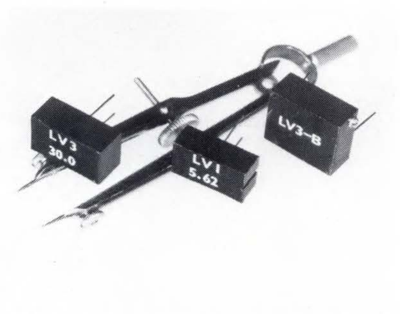
Company ______________________
Address ______________________
Name ______________________
City ______________________
State ______________ Zip __________

CIRCUITS

MINIATURE COAXIAL BAND PASS FILTER Model 4300FDE16 gives an insertion loss of less than 0.6 dB over a 50-MHz bandwidth centered at 4300 MHz, with greater than 30-dB attenuation at frequencies ±100 MHz from midband. This performance is achieved in a volume of only 1.2 in³. (2 × 0.85 × 0.7 in.) with a weight of under 1-1/2 oz. Microwave Development Laboratories, Inc., 87 Crescent Rd., Needham Heights, MA 02194. Phone (617) 449-0700. **193**



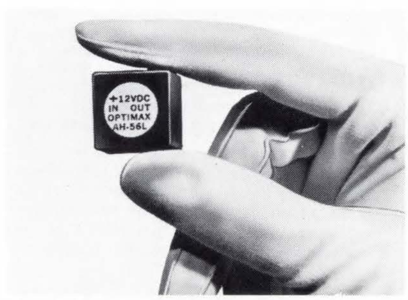
ELECTRONIC TIME-DELAY RELAY Series 319DC features six ranges: the shortest is from 0.2 to 3 sec; the longest is from 10.0 sec to 30 minutes. Repeat accuracy with constant line voltage, temperature, and reset time is 1% of setting. Setting accuracy is 10% of range and reset time after time-out is 20 msec. The timer's control output is via dpdt contacts rated at 5A at 24V dc. Prices start at $29. Automatic Timing & Controls, Inc., King of Prussia, PA 19406. Phone (215) 265-0200. **194**



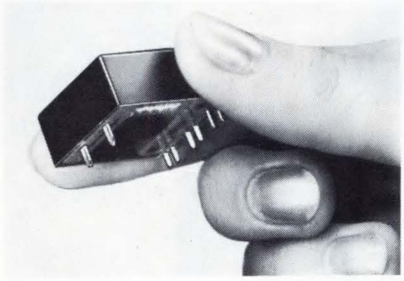
LOW-VOLTAGE CURRENT REGULATOR is available in standard 1 and 3W packages with fixed or adjustable current ranges from 0.5 to 50 mA in the 1W package and from 1 to 60 mA in the 3W package. Current regulation of ±1% starts with less than 4V in the circuit across the device. The unit costs from $10 to $45 depending on type and quantity. Electronic Modules, Inc., 2500 E. Foothill Blvd., Pasadena, CA 91107. Phone (213) 795-4231. **195**

LOW-COST FREQUENCY-TO-VOLTAGE CONVERTERS. Ten standard models cover input frequency ranges from 0-to-100 Hz, to 0-to-100 kHz with corresponding output levels of 0 to 10V. Output ripple components are negligible and output voltage vs input frequency is linear within 0.02% of range. The output will respond to input frequency changes with a time constant on the order of 25 periods of the full-range frequency. Price for any model is $175. North Hills Electronics, Inc., Glen Cove, NY 11542. Phone (516) 671-5700. **196**

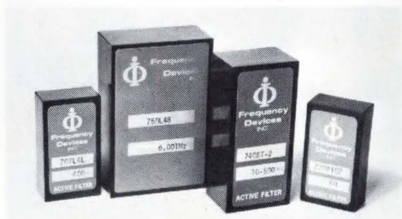
TO-3 OP AMP Model 750 features 1300-V/µsec slewing, 125 mA of output current, a 125-MHz bandwidth and a 20-MHz full-power output. This 8-pin hybrid amplifier operates over −55 to +125°C. It is designed to meet the drive requirements of 50, 75 and 91Ω coax systems and is output short-circuit protected. Price is $98. M.S. Kennedy Co., 2002 Teall Ave., Syracuse, NY 13206. Phone (315) 547-5616. **197**



PLUG-IN RF AMPLIFIER for the frequency range of 5 to 300 MHz features a noise figure of 6 dB maximum from 5 to 200 MHz and 7 dB maximum from 200 to 300 MHz. The AH-56L modular amplifier has power output at 1-dB gain compression of +10 dBm and VSWR of 1.7:1. Power requirements are +12V dc at 20 mA. Price is $37.50. Optimax, Inc., Box 105, Advance Lane, Colmar, PA 18915. Phone (215) 822-1311. **198**



DPDT RELAY, Thinpak Model 531, measures only 0.435-in. high and is capable of switching 2A at 26V dc. It is designed for 0.6-in. center-to-center PC-card mounting. Insulation resistance is more than $10^{10}\Omega$. The 531 is available in standard coil voltages from 6 to 115V dc with an operate and release time of less than 5 msec. Prices start at $1.95 (2500 quantity). American Zettler, Inc., 697 Randolph Ave., Costa Mesa, CA 92626. Phone (714) 540-4190. **199**



MODULAR ACTIVE FILTERS spanning 0.001 Hz to 50 kHz are the Series 700 filters with unity gain (non-inverting). Standard models include 2, 4, or 6-pole lowpass, highpass, bandpass and band-reject versions with Butterworth, Bessel and Tchebyscheff transfer functions. Also included are 4-pole lowpass filters externally tuneable (with resistors) up to a 500:1 ratio over 1 Hz to 50 kHz. Prices in 100 quantities start from $25. Frequency Devices, Inc., 25 Locust St., Haverhill, MA 01830. Phone (617) 372-6930. **200**

POWER MODULE Model NX-25 for Nixie indicators can power up to seven high-voltage indicator displays. It accepts a 115V ac input and provides a nominal output of 185V dc at 25 mA. Dimensions of 3.5 × 2.3 × 1 in. permit it to be integrated into a display assembly, or it may be soldered onto a PC board. Price is $35 and delivery is 3 days. Acopian Corp., Easton, PA 18042. Phone (215) 258-5441. **201**

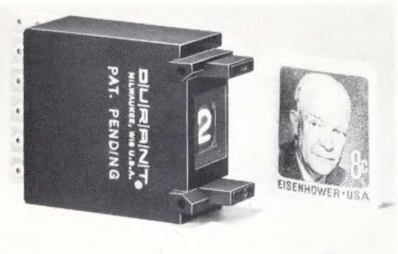
CIRCUITS

3-1/2-DIGIT BCD A/D CONVERTER CY3638 is a full-integrating unit with a list price of $49 in OEM quantities. The CY3638 incorporates a dual-comparator conversion scheme. At each measurement (100/sec on the standard unit, 1000/sec optional), the unit integrates the input voltage, converts it in coarse terms with a fast-reference ramp and makes a final high-resolution conversion of the remainder with a slow-reference ramp. Cycon, Inc., 1080E Duane Ave., Sunnyvale, CA 94086. Phone (408) 732-8311. **202**

POWER MODULE Model Z2.5 operates from 115V ac 60 Hz and delivers 2.5A in a package that measures 4 × 6 × 2-1/4 in. Dc outputs between 24 and 30V dc are regulated to within 0.15% for total input voltage changes of 100 to 132V rms and load changes of no load to full load. Ripple is less than 0.02% rms or 50 mV pk-to-pk. Price is $219. Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. Phone (212) 936-8185. **203**

TWO NEW A/D CONVERTERS are the Series ADC40 and ADC50, each offering 8, 10 and 12-bit resolutions at conversion speeds of 2.5 μsec/bit. The ADC40 12-bit model features ±7 ppm/°C gain drift while the ADC50 12-bit model gain drift is ±12 ppm/°C. A choice of five input ranges (±2.5, ±5, ±10, 0 to +5 and 0 to +10V) and TTL/DTL-compatible binary or BCD output is offered. Prices (100 pieces) range from $130 for the 8-bit ADC50 to $225 for the 12-bit ADC40. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone (602) 294-1431. **204**

ECONO/MATE SERIES OF POWER-SUPPLY MODULES consists of 45 regulated and low-cost modules in 3 package sizes. They are available with outputs from 5 to 24V dc at up to 12A. Each power supply contains self-restoring current limiting and built-in short-circuit protection. Overvoltage-protection is available as a built-in option. Prices for the Series start at $39.95. Power/Mate Corp., 514 S. River St., Hackensack, N J 07601. Phone (201) 343-6294. **205**

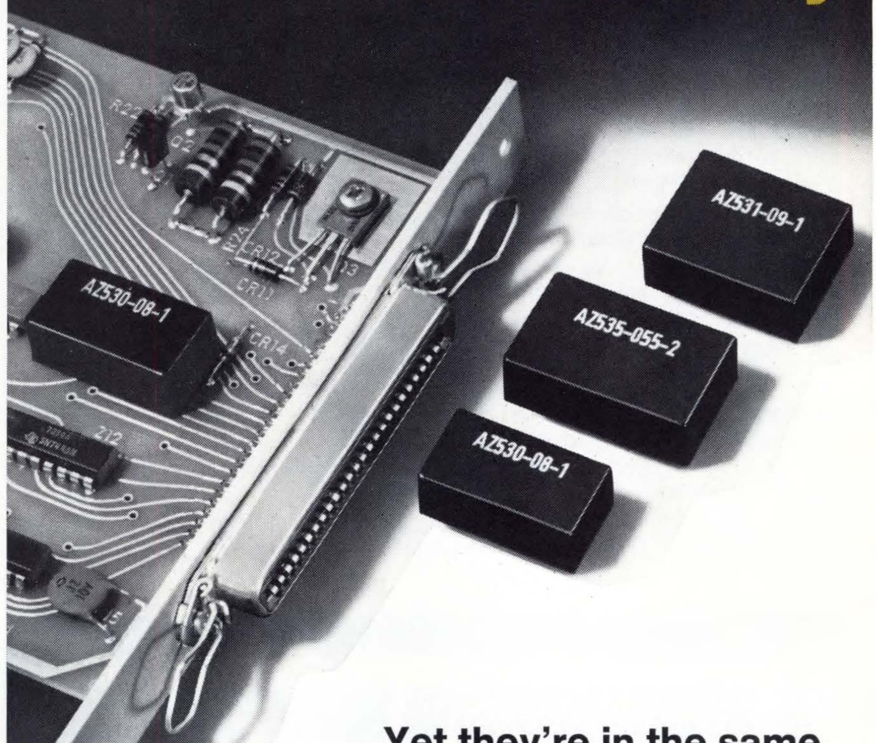


TEN-POSITION SELECTOR SWITCH ASSEMBLY offers designers a push-button-operated device with one button to add and the other to subtract. The switch has large 1/4-in. numerals and an assortment of standard readout codes including decimal, BCD, BCD complement and BCD with off-bit parity. Durant Digital Instruments, 622 N. Cass St., Milwaukee, WI 53201. Phone (414) 271-9300. **206**

BATTERY POWERED FET OP AMP Model A-214 for instrumentation has adjustable gain from 1 to 1000 with only one standard resistor. It also features adjustable output voltage, $10^{12}\Omega$ differential and common-mode input impedance and 20 pA of input bias current. Unity gain bandwidth is 1.5 MHz and output is ± 4V at ± 2 mA. Intech, Inc., 1220 Coleman Ave., Santa Clara, CA 95050. Phone (408) 244-0500. **207**

"ECONOPAC" POWER SUPPLIES EP-1 and EP-2 come in five single-output models of 5, 6, 12, 15, and 24V dc ($\pm 5\%$ adjustment), with current output to 6A. Regulation is $\pm 1\%$ for line and load combined and ripple is 0.2% +10 mV rms. The EP-1 Series is priced at $24.50. Power Pac, Inc., 24 Stage St., Stamford, CT 06901. Phone (203) 359-4377. **208**

These Thinpak™ relays switch loads that would destroy a reed relay



Yet they're in the same dimension and price ranges.

American Zettler's miniature AZ Series of THINPAK™ relays are available with 1, 2 or 5 amp contacts and coil ratings from 6 to 115 VDC. Operating power is as low as 125 mW and a sensitive version for T²L integrated circuits eliminates expensive drivers in many applications. These THINPAK relays are less than 0.450" high, allowing 0.6" center-to-center pc board or plug-in mounting.

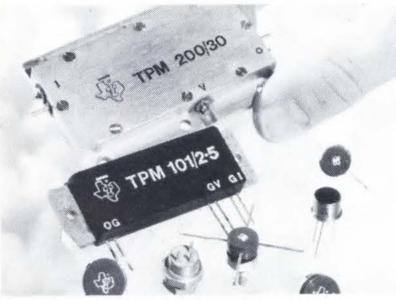
Contact arrangements include SPDT in 1, 2 and 5 amp ratings, and DPDT rated at 1 and 2 amps. Insulation resistance is greater than 10^{10} ohms, and contact resistance is less than 50 X 10^{-3} ohms. Constructed without the use of phenolic insulation, AZ THINPAK's have dielectric strengths up to 2500 volts between the contacts and the coil. A SPDT 1 amp version is also available as a magnetic latching relay. Prices start at just $1.44 each for the Model 530 SPDT, 6V coil, in 2500 piece quantity.

To obtain a free evaluation sample and complete technical information, write or phone:

American Zettler, inc.

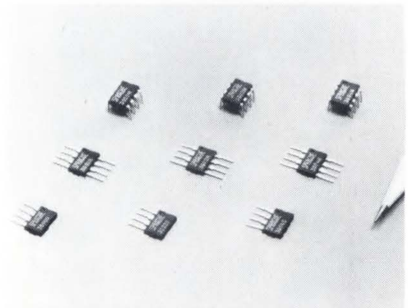
697 Randolph Avenue, Costa Mesa, CA 92626 Phone: (714) 540-4190 Telex 67-8472

CIRCLE NO. 62

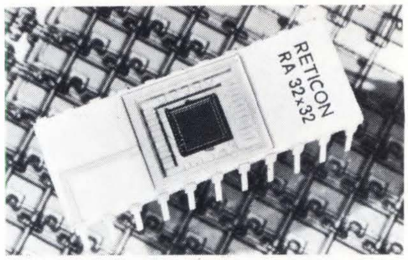


HIGH-FREQUENCY POWER TRANSISTOR LINE consists of 73 devices suited for the 2-30, 175, 470 MHz and 1 GHz bands. They can be used in both fixed and mobile equipments with 13 or 28-V rails. The devices are designed to withstand all voltage standing-wave ratios at the output for improved equipment reliability. Texas Instruments Inc., 13500 North Central Exp., Dallas, TX 75222. Phone (214) 238-2011. **221**

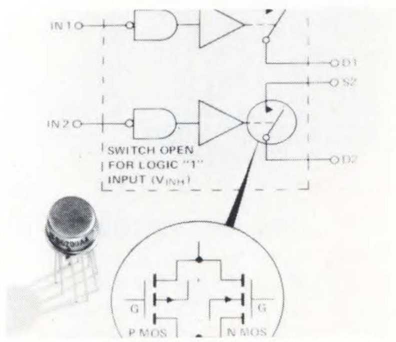
ACTIVE FILTER SECTION is available in a standard 8-pin TO-5 package. Model μAR1800 has a pin layout compatible to standard operational I/C amplifiers, and can be used to form virtually any second-order transfer function by the addition of external circuit components. It can be programmed for Q and center or cut-off frequency. Price is $4.25 each in quantities of 100. Integrated Electronics, Inc., 16845 Hicks Rd., Los Gatos, CA 95030. Phone (408) 265-2410. **222**



MAGNETICALLY-ACTIVATED INTEGRATED CIRCUIT the ULN-3000 includes a Hall effect cell and a Schmitt trigger on one IC. Switching is dependent on the proximity of an external magnet whose magnetic flux passes through the Hall cell perpendicular to the chip face. Sprague Electric Co., Marshall St., North Adams, MA 01247. Phone (413) 664-4411. **223**

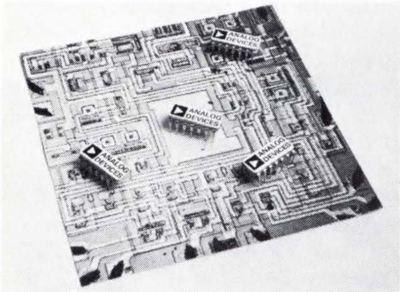


SELF-SCANNING OPTICAL ARRAY, Model RA 32 X 32, is a monolithic silicon array containing a 32 X 32 matrix of photodiodes, access switches and MOS shift registers for scanning in the X and Y directions. The device is functionally equivalent to a low-resolution vidicon camera tube. The photodiodes are spaced on 4 mil centers and operate in the charge storage mode. Frame rates can be varied from 20 to 5000 frames per second. Price is $600 each in OEM quantities. Reticon Corp., 365 Middlefield Rd., Mt. View, CA 94040. Phone (415) 964-6800. **224**



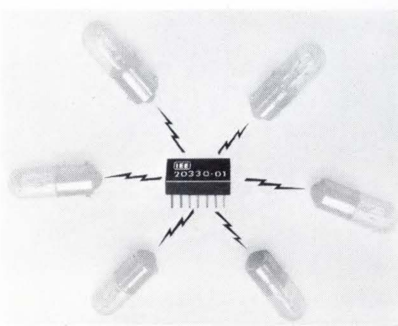
CMOS DUAL SPST ANALOG DRIVER/SWITCH has ±15V signal range. The DG200 analog transmission gate features break-before-make switching action, with t_{off} and t_{on} ratings of 500 and 1000 nsec at 25°C. The device has a ±15V analog signal range with ±15V supplies. 100-quantity prices are $8.75 for the DG200AA (military) and $3.50 for the DG200BA industrial version. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 246-8000. **225**

SOS DIODE ARRAYS are available for custom ROMs. With approximately 3200 bits available for encoding on each array, custom-encoded SOS/ROMs with 20 nsec access time can be fabricated quickly. A laser micromachine technique is used to custom-encode small quantities of the arrays, allowing shipment of encoded devices 24 hours after receipt of specifications. Prices are $30 each in quantities of 100-499 units. North American Rockwell Microelectronics Co., P.O. Box 3669, 3430 Miraloma Ave., Anaheim, CA 92803. Phone (714) 632-2321. **226**



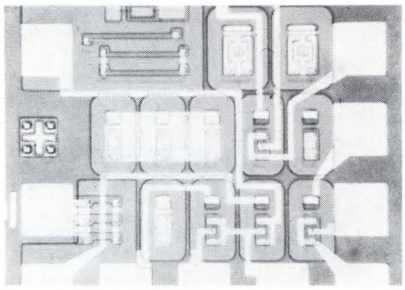
COMPLETE IC INSTRUMENTATION AMP offers high common-mode rejection, high input impedance, single-resistor adjustment of gains from 1 to 1000, and 0.01%/° C drift. Designated the AD520, the new monolithic chip unit features CMR of 110 dB at a gain of 1000. The unit is packaged in a 14-pin ceramic DIP and is priced at $18 (1-24 units). Analog Devices, Inc., Rte. 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. Phone (617) 329-4700. **227**

MOS STATIC SHIFT REGISTERS are bipolar-compatible. Push-pull outputs are featured and a recirculation path is included on the chips of both the dual 128-bit "2521V" and the dual 132-bit "2522V". Both units are P-channel, enchancement-mode, silicon-gate MOS and they are contained in an 8-pin miniature dual-in-line package made of silicone plastic. When ordered in a quantity between 250 and 999, they sell for $5 each. Signetics, 811 East Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **228**

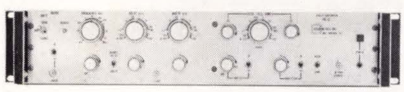


HEX LAMP DRIVER, the 20330, boasts high current capability. The unit can drive simultaneously either 3 (300 mA) or 6 (150 mA) incandescent lamps. The uncommitted collector outputs of the device have breakdown voltages in excess of 30V, while the gate inputs are one TTL load. Contained in a standard 14 pin dual in-line plastic package, the unit operates from a 5.0V logic supply. Quantity price (1-999) is $5.45. Industrial Electronic Engineers, Inc., 7720 40 Lemona Ave., Van Nuys, CA 91405. Phone (213) 787-0311. **229**

SEMICONDUCTORS

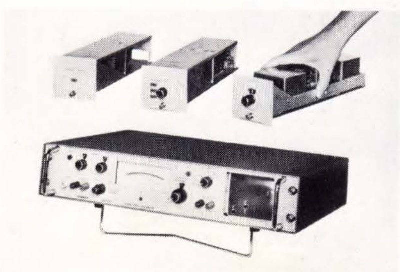


HIGH VOLTAGE TRANSISTOR ARRAYS are high-frequency, plug-in replacements for the popular 3018 and 3046 type monolithic NPN transistor arrays. The LA3118T and LA3118AT are available in a 12-pin TO-100 package at $1.18 and $1.68, respectively, in quantities of 100. The 14-pin DIP types LA3146E and LA3146AE are priced at $1.18 and $1.68. Lithic Systems, Inc., 10010 Imperial Ave., P.O. Box 869, Cupertino, CA 95014. Phone (408) 257-2004. **230**

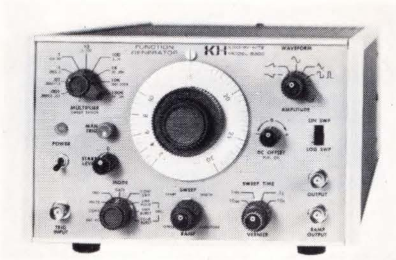


MULTI-MODE PULSE GENERATOR PG-12 has continuously variable rise/fall times, duration, delay, amplitude, offset and repetition rates. Repetition rate is continuously variable from 0.1 Hz to 50 MHz and may be derived from an internal clock or an external source. Pulse duration from 10 nsec to 1 sec and pulse delay from 15 nsec to 1 sec are available. Chronetics, Inc., 500 Nuber Ave., Mt. Vernon, NY 10550. Phone (914) 699-4400. **244**

DIGITAL MILLIVOLTMETER, DigiTec Model 268, with 6 ranges has 1-μV resolution and measures up to 1000V dc. The 4-1/2-digit instrument has 0.02% to 0.05% accuracy (of reading), a guarded input for high common-mode rejection, isolated BCD and system functions. Indication is by LED displays. Price is $795. United Systems Corp., 918 Woodley Rd., Dayton, OH 45403. Phone (513) 254-6251. **245**



PHASE-ANGLE VOLTMETER PAV-4 makes precision measurements over 30 Hz to 300 kHz. It has a wide dynamic range of 300 μV to 300V, harmonic filtering and 10 MΩ input impedance with or without input isolation. The unit's fixed-frequency plug-ins give minimum-phase accuracy of 0.5° at all frequencies. Signal and reference inputs may be direct or floating from ground. The Singer Co., Los Angeles Operation, 3211 S. La Cienega Blvd., Los Angeles, CA 90016. Phone (213) 870-2761. **246**



MODEL 5300 FUNCTION GENERATOR offers nine modes of operation and adds an exponential ramp function for logarithmic sweeping, in addition to separate waveforms and ramp outputs, pulse, sweep and burst modes, and external voltage control of the main output frequency. In external and sweep modes, the frequency range extends from 0.00003 Hz to 3 MHz. Maximum main output is 10V across 50Ω. Price is $695. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, MA 02139. Phone (617) 491-3211. **247**

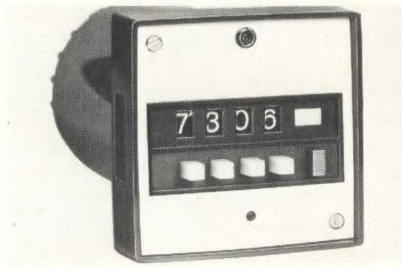
10-BIT A/D CONVERTER has 3-MHz word rates. Model 5103 is capable of 10-bit resolution at any random or periodic word rate through 3 MHz. It is completely self-contained, complete with internal track and hold, power supplies and built-in test words. Model 5103 costs $6500. Computer Labs, 1109 S. Chapman St., Greensboro, NC 27403. Phone (919) 292-6427. **248**

RF POWER AMPLIFIER Model 350L can be driven from any signal generator to produce up to 50W of linear power over the frequency range of 250 kHz to 105 MHz. A highly linear Class-A unit, the 350L will faithfully reproduce inputs of AM, FM, SSB, TV, and pulse modulations with minimum distortion. The Model 350L includes an integral power supply and rf output meter and is priced at $3890. Electronic Navigation Industries Inc., 3000 Winton Rd. South, Rochester, NY 14623. Phone (716) 473-6900. **249**

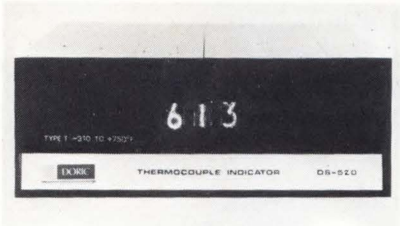
EQUIPMENT

FOUR-DIGIT DPM Model 2430-537 is said to fill the gap between 0.1% and 0.01%-accuracy low-cost DPMs. The 0.05%-accurate unit costs $149 (100 quantities) and includes such options as ac measurement, linearizers, resistance measurement, low-level amplifiers, and active filters. Range is +0.9995 (±0.9995 bipolar version available), input resistance is 1000 MΩ and power supply voltage is 115/230V ac, 50 to 400 Hz. Digilin, Inc., 1007 Air Way, Glendale, CA 91201. Phone (213) 240-1200. **250**

POCKET-SIZE PULSE GENERATOR Handy-Pulse Model BG-2 weighs just 3 oz. and requires no internal power. Its internal design allows its use in TTL, DTL, RTL, ECL and MOS logic. The generator enables the operator to set or re-set flip-flops, trigger logic counters and shift registers and test for pulse immunity. It projects a single negative pulse of 1-μsec duration for every depression of the momentary switch and will not double trigger. EREM Corp., 505 S. Douglas St., El Segundo, CA 90245. Phone (213) 772-5431. **251**

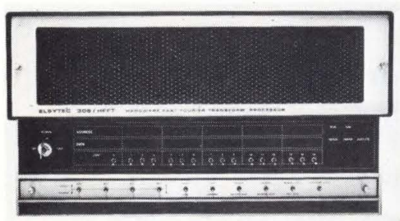


PHOTOELECTRIC PREDETERMINING COUNTER Series 706 is priced at only $180. The four-decade digitally-set counter includes a 5.9V dc power supply for the light source, a solid-state photoelectric amplifier that operates with photoresistive photocells, phototransistors or photodiodes and a plug-in spdt relay. The digital preset switches can be set to count out anywhere from 0001 to 9999. Automatic Timing & Controls, Inc., King of Prussia, PA 19406. Phone (215) 265-0200. **252**



DIGITAL THERMOCOUPLE INDICATOR, 3-1/2-digit Model DS-520-T3M, costs only $395. Standard ranges handle J, K, and T type thermocouples in °F and °C with one-degree precision. Auto-zero, digital linearization, guarding for high-noise rejection, filtering and high-stability digitizer are included. Doric Scientific Corp., 7601 Convoy Court, San Diego, CA 92111. Phone (714) 277-8421. **253**

2-1/2 AND 3-1/2 DIGIT DPMs Series 101 and 102 operate either 5V or 115V ac. Available with gas-discharge, incandescent or LED readouts, they feature 300V common-mode-voltage isolated inputs, up to 200 readings/sec, and 80-dB CMRR at 60 Hz. Accuracy is ±0.25% (2-1/2-digit) and ±0.5% (3-1/2-digit). Full-scale input range is ±1.999V (±199.9 mV optional). BCD output is standard. Price is $115 (2-1/2-digit) and $130 (3-1/2-digit). Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **254**



HARDWARE FAST FOURIER TRANSFORM PROCESSOR Model 306/HFFT is integrated within the mainframe of a NOVA 800 computer. The self-contained unit is capable of performing the forward and inverse Fast Fourier transform of 128 to 8192 real points (64 to 4096 spectral lines). Price of the entire system is $24,000 and delivery is 120 days. Elsytec Inc., 212 Michael Dr., Syosset, NY 11791. Phone (516) 364-0560. **255**

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

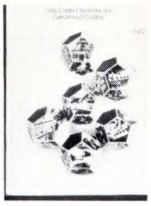
CHICAGO
Terry McDermott, District Manager
Frank Sibley, District Manager
15 Spinning Wheel Rd.
Hinsdale, Illinois 60521
(312) 654-2390

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
Eli W Warsaw, District Manager
5670 Wilshire Blvd.
(213) 933-9525

LITERATURE



DATA COMMUNICATIONS EQUIPMENT. The 12-page catalog includes sections devoted to signal conditioning equipment; FM multiplexing and demultiplexing equipment; typical systems; manual and computer programmable PCM decommutation equipment; test & calibration equipment; and FM accessories and modular assemblies. Publications Mgr., Data-Control Systems, Inc., Commerce Dr., Danbury, CT 06810. **269**

BALLANTINE'S LINE OF ELECTRONIC INSTRUMENTATION is detailed in a condensed catalog. Product categories covered are: computer-compatible digital ac instrumentation; true-rms wideband ac voltmeter/amplifiers; logarithmic voltmeter/amplifiers; Ballantine "Classics;" wideband portable scopes and accessories; calibrators; ac/dc precision high-voltage calibrators; primary ac/dc transfer standards and accessories; and accessories usable with a number of instruments. Ballantine Laboratories, Inc., Box 97, Boonton, N J 07005. **270**

POWER-CONVERSION DEVICES for electronic systems and equipment are described in a catalog. The illustrated brochure describes a wide range of military and commercial inverters and converters, including ac-to-ac, ac-to-dc and dc-to-ac modular units. Power Conversion Products Div., of Rotron Inc., Woodstock, NY 12498 **271**

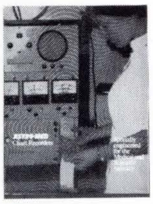
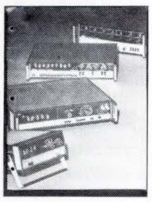


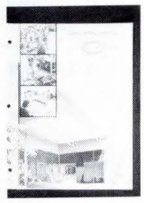
CHART RECORDERS for medical and industrial electronic applications are described in a six-page illustrated folder. The folder includes details and photographs of a heated inkless stylus that is replaceable in seconds by untrained personnel. Detailed specifications, photos of vertical and horizontal models, dimensional drawings, mounting, and wiring information for horizontal and vertical-travel recorders are included. Astro-Med, A Div. of Atlan-Tol Industries, Inc., Atlan-Tol Industrial Park, W. Warwick, RI 02893. **272**



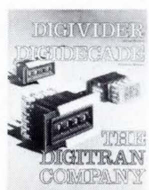
ELECTRONIC TEST INSTRUMENT catalog from Dana Labs describes four lines of instruments. Specifications are given for a series of fully automatic counters, a series of universal counter/timers, two series of five-digit voltmeters, two series of four-digit voltmeters, a series of three-digit voltmeters, two series of data amplifiers and a series of frequency synthesizers. Two easy-to-use selection guides are also included to give a fast glance comparison of Dana's counters and DVMs. Dana Laboratories, Inc., 2401 Campus Dr., Irvine, CA 92664. **273**

POWER MODULES, over 2700 models of them, are detailed in a 56-page catalog. Each model is detailed with complete electrical specifications, operating parameters, dimensions and prices. Three types of power-conversion devices are covered: types for military, aerospace and commercial applications. All models are available in current ratings of a few milliamps up to 20A. Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. **274**

MODULAR POWER SUPPLIES are described in an 8-page catalog. Fifty-four standard models of high-power-density, cost-effective power supplies for microelectronics applications are shown. All are characterized by high efficiency, small size, light weight, automatic overload and over voltage protection and system protection from momentary loss of input power. Trio Laboratories, Inc., Dupont St., Plainview, NY 11803. **275**



LINE OF PRECISION INSTRUMENTS and systems for use in measuring, monitoring or controlling ac and dc voltages and currents, resistance, frequency, ratios, analog magnetic-tape recorder data and single, two and three-phase ac power are briefly described in a 6-page short-form catalog. Included are ac power sources, programmable oscillators, systems and line correctors, digital multimeter/counters, digital ohmmeters and a line of digital panel meters. California Instruments Co., 5150 Convoy St., San Diego, CA 92111. **276**



THUMBWHEEL-SWITCH DECADES that serve as voltage dividers and resistance decades are featured in a new brochure. The 12-page catalog contains specifications, drawings, photographs, wiring diagrams and installation data. The Digitran Co., 855 S. Arroyo Pkwy, Pasadena, CA 91105. **277**

ADVERTISERS INDEX

Application Notes

ANALOG TIMING EQUIPMENT is described in a comprehensive, 16-page brochure dealing with equipment and methods for time-tagging analog data for correlation and indexing. The family of timing instrumentation equipment is useful at nearly all facilities where data is recorded on analog, audio, or video tape, film, or oscillographic recorders. The brochure describes each of the six different models in the line. Datatron, Inc., 1562 Reynolds Ave., Santa Ana, CA 92707. **281**

A WALL-CHART OF WAVEFORM COMPARISONS IN TIME/FREQUENCY AND PROBABILITY DOMAINS is available free. For those analyzing random data such as noise, vibration, shock, underwater acoustic signals and radar, Federal Scientific's new engineering tool is a convenient picture-reminder of how 10 different basic waveforms look in terms of 5 different processing domains. Federal Scientific Corp., 615 W. 131st St., New York, NY 10027. **284**

PROGRAMMABLE INSTRUMENTS FOR AUTOMATIC TESTING are listed in a booklet. The booklet lists hundreds of instruments manufactured by such major companies as Hewlett-Packard, Fluke, Dana, General Radio, Kepco, Systron-Donner, Wavetek and others. Entitled "From A to Z In Programmable Instruments," the slimline booklet includes sections on amplifiers, switches, synthesizers and voltmeters. Zehntel, Inc., 1450 Sixth St., Berkeley, CA 94710. **287**

PHASE AND AMPLITUDE-RESPONSE of a variable electronic filter is the title of a new 16-page application note. A simple, general method for determination of phase and amplitude response of high-pass, low-pass, and bandpass filters is provided for four-pole Butterworth and Bessel filters. Tables and normalized plots of phase and amplitude response are provided. Ithaco, Inc., 735 .W. Clinton St., Ithaca, NY 14850. **282**

CONVERSION FACTORS BOOKLET. Need to convert abcoulombs into statcoulombs, acres into square feet, meters, miles or yards . . . barrels into cubic inches, quarts, or gallons . . . and countless other factors of volume, length and space? Available is a pocket-size conversion factor booklet that covers every measurement from abcoulombs to yards. Excellent as a reference for engineers and draftsmen, it can be obtained from Forney's Inc., Box 310, New Castle, PA 16103. **285**

THE AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) 1972 CATALOG has just been published. Listing more than 4000 American National Standards and 2400 international recommendations, the 144-page catalog includes all ANSI-approved standards during 1971, as well as international recommendations (standards) received last year. Catalog copies are available free from the American National Standards Institute, 1430 Broadway, New York, NY 10018. **288**

D/A CONVERTERS APPLICATIONS HANDBOOK. A comprehensive 32-page handbook includes three sections devoted to D/A converters. One section provides basic theory with typical circuits and definitions of key parameters. Another section describes a wide variety of applications for such devices, while a third section describes a line of ultraminiature D/A converters, including detailed mechanical and electrical specifications of 48 models of four series. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **283**

TROUBLE-SHOOTING ELECTRIC MOTORS. Seven "how-to" tests for shorts, opens, grounds, defective centrifugal switches and capacitors in electric motors using a clamp-on volt/ammeter are explained in a four-page folder. The bulletin also includes explanations of how to determine the capacitance of capacitors and how to test squirrel-cage rotors. Ten illustrations make the tests easy to understand and follow. Amprobe Instrument Div. of SOS Consolidated, Inc., 630 Merrick Rd., Lyn brook, NY 11563. **286**

A TEMPERATURE MEASUREMENT AND CONTROL HANDBOOK presents a complete technical dissertation on the theory and techniques of temperature measurement and control. It includes information pertaining to electronic and proportional controllers, component selection for thermocontrol systems, and in-depth information on the many aspects of temperature measurement with control. Data may be used as a guide in selecting a system. RFL Industries, Inc., Boonton, N J 07005. **289**

REFERENCE COPIES AVAILABLE

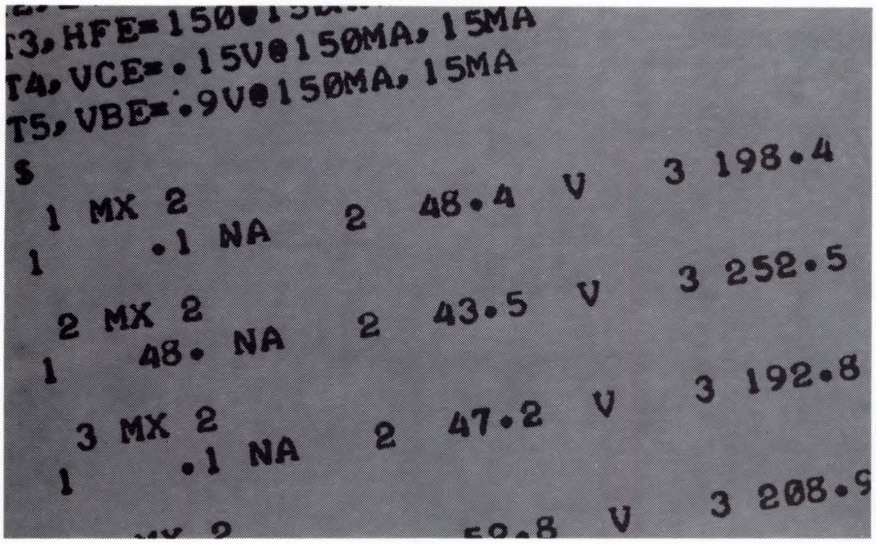
Reference copies of the following articles are available without charge:

R.S. NO.	TITLE	PAGE NO.
161	Don't let avoidable reed-relay pitfalls cripple your design	26
162	Stepping-motor controller costs little but performs well	34
163	Test IC voltage regulators with one general-purpose circuit	40
164	Donald K. Wilkin of Hewlett-Packard speaks out on scope vs logic	46
165	One circuit performs both binary-to-BCD and BCD-to-binary conversions	55
166	How to tailor your memory needs with a minimum of external parts	60

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

( ) DENOTES INFORMATION RETRIEVAL NUMBER

If you buy transistors, find out what you're buying. Data doesn't cost that much anymore.



Maybe the basic go/no-go type of transistor tester is all you really need. Fine. We can sell you the best there is, for as little as $12,500.

But know this. The computer-operated system that cost maybe $50,000 last time you looked is now yours for $29,000.

What can computer control give you?

Data. Measured values and lot summary statistics. In hard copy.

Fast setup. Test programs that automatically flow into memory at the flick of a switch.

Multiplexing. Testing different types of transistors at different stations, simultaneously.

The system that gives you all this is our T241, the most widely accepted, thoroughly field-proven system of its kind. More than 150 T241s are at work the world over, most of them on production lines.

Now we have packaged an incoming-inspection version of the T241, complete with special software. Program writing couldn't be easier. In T241 talk, I_{CBO} is ICBO. H_{FE} is HFE.

Like all Teradyne test equipment, the T241 carries a 10-year warranty and is built to work without worry at least that long.

And it costs only $29,000.

Learn more.

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

TERADYNE

CIRCLE NO. 81


DOWN WITH
UNTOLERANCE
UP WITH
WIREPOWER
Dale's way with wire matches your need for precision at a price...and meets your special design needs.
Shuntsmanship
Your meter needs Dale's new LVR. Dale has slashed shunt resistor prices as much as 66% and reduced resistance values to as low as .008 ohm. 2, 5, 10 watt styles. Circle 181
Fuse News
Two Dale styles combine precision resistance with predictable fusing times. Axial lead (CFR) has ¼ to 2½ W power. Special disc type for use in socket applications. Circle 182
Wirepower in RN50 Size
Dale's tiny new RS-⅛ dissipates up to ¼ watt in .155″. Operates to +275°C. Molded body can be automatically inserted. T.C. as low as ±20 PPM. Circle 183
Networks with Muscle
WDP wirewound network handles up to 3.5 watts in standard 14-pin DIP size. Contains up to seven resistors which can have closely-matched tolerance (.1%) and T.C. (±5 PPM). Circle 184
It's all in the family. If the resistance function you need isn't in Dale's Catalog A... don't worry, we have it. No one beats our ability to mix and match resistance parameters.
DEPENDABLE DALE...comes to you with the courtesy of the best representatives and distributors in the business. There's a source of information near you...or call 402-564-3131 today.
DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebr. 68601
A subsidiary of The Lionel Corporation
In Canada: Dale Electronics Canada, Ltd.
DEPENDABLE
DALE®