

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

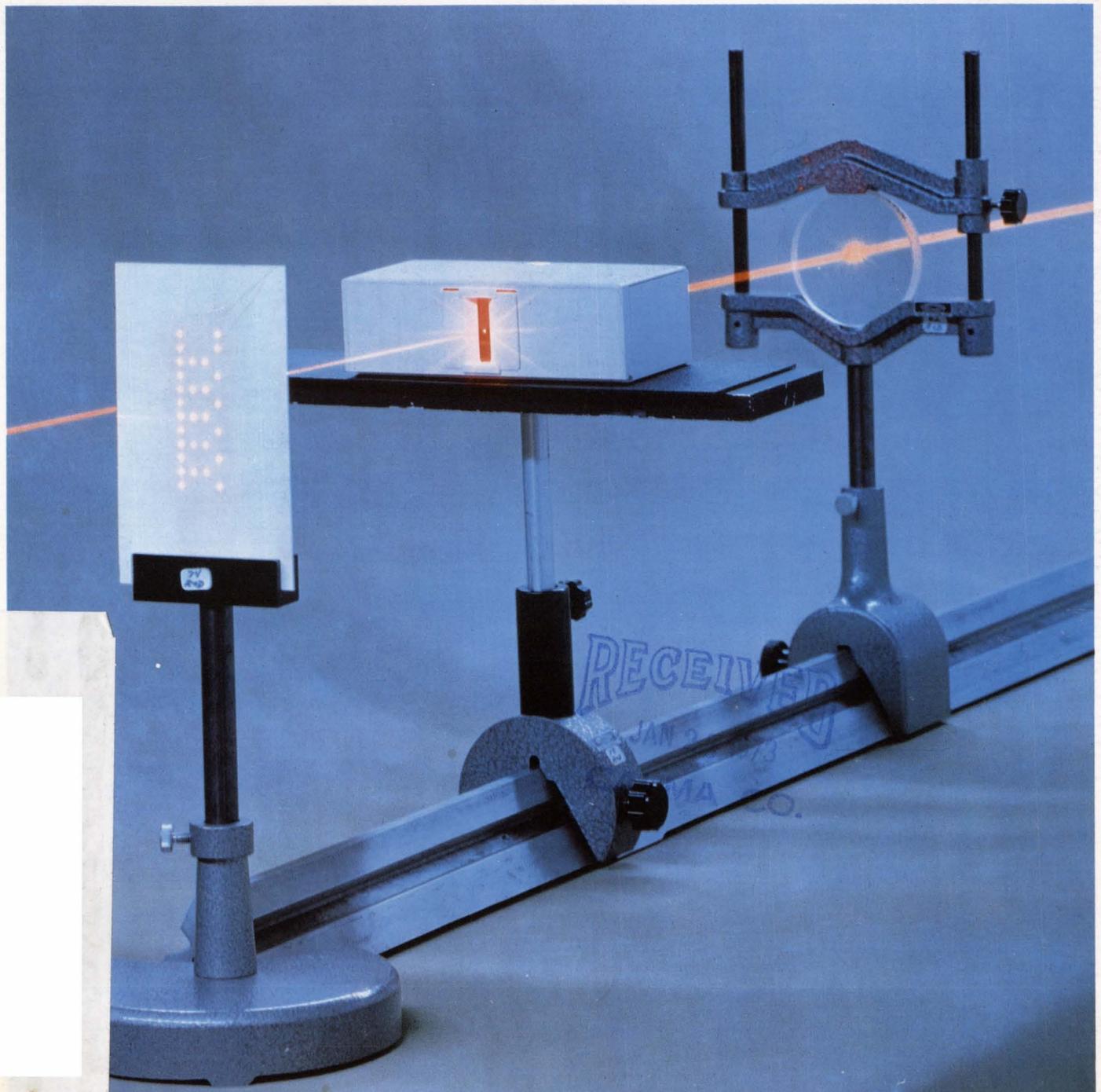
VOL. 21 NO.

2

JAN. 18, 1973

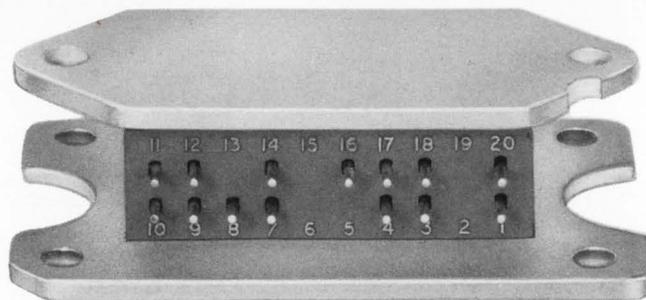
Low-power, low-cost lasers, both gas and semiconductor, have moved out of the laboratory and onto the production line. They are finding wide use in areas

like data processing, construction, communications and education. For assistance in using this new class of lasers more effectively, turn to the special report on p.24.



Do you face a make or buy decision on power supplies?

Announcing Lambda's new 85W negative power hybrid voltage regulator



85W, -5.2V, 5A

\$35 ea. (in quantity of 1) \$20 ea. (in quantity of 100) \$18 ea. (in quantity of 1000)

also available

**62W positive
power hybrid
voltage
regulators
62W, 5V, 3A**

\$25 ea. (in quantity of 1)

\$14 ea. (in quantity of 100)

\$11 ea. (in quantity of 1000)

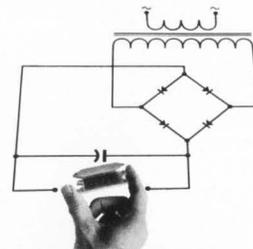
**85W positive
power hybrid
voltage
regulators
85W, 5V, 5A**

\$30 ea. (in quantity of 1)

\$18 ea. (in quantity of 100)

\$15 ea. (in quantity of 1000)

**Regulation: 0.2% line
0.2% load
Ripple: 2mV RMS**



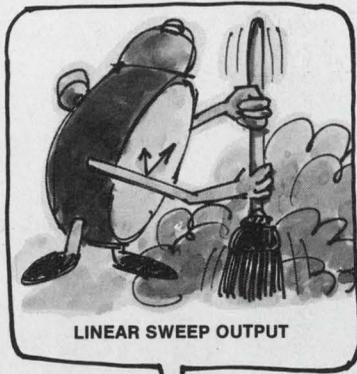
100,000 hours MTBF demonstrated

1-DAY DELIVERY

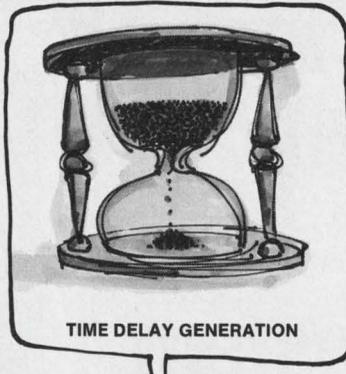
Send for 1973 Power Supply Catalog and Application Handbook

**WHETHER
YOU MAKE
OR BUY...**
LAMBDA
ELECTRONICS CORP.
A Veeco Company

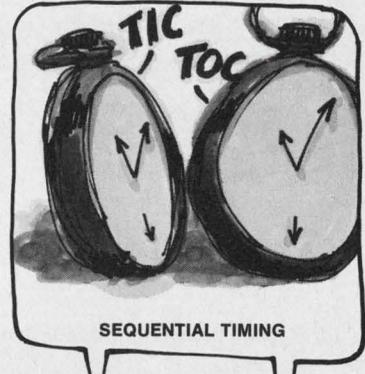
EXAR'S MONOLITHIC TIMER SPEAKS OUT...



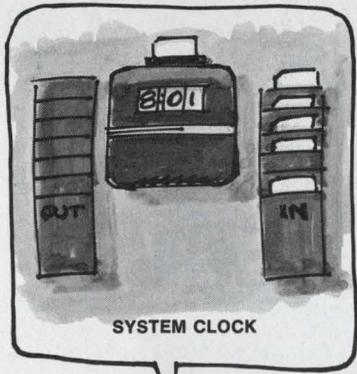
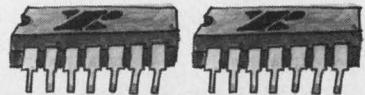
LINEAR SWEEP OUTPUT



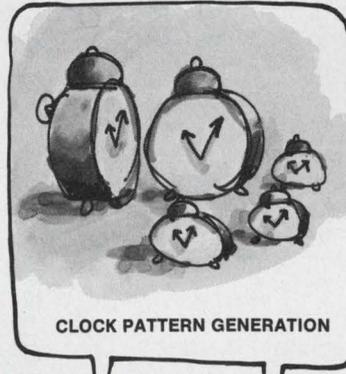
TIME DELAY GENERATION



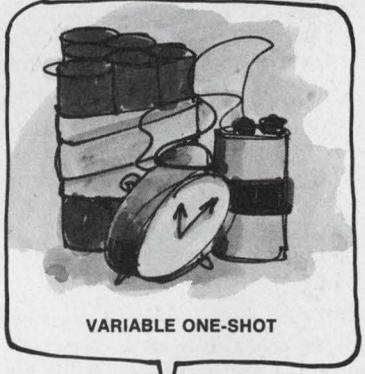
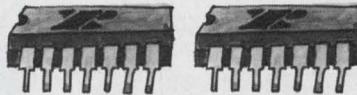
SEQUENTIAL TIMING



SYSTEM CLOCK



CLOCK PATTERN GENERATION



VARIABLE ONE-SHOT



If you're a systems designer stuck with the use of discrete or electro-mechanical timing devices, you should investigate Exar's new monolithic timing circuits.

The XR-220 and XR-320 generate precise pulses and delays variable from one microsecond to one hour, using a single external resistor-capacitor combination to determine the time, 2RC.

They are excellent for monostable or self-triggering timing pulse generation, linear sweep generation, and for pulse-width or pulse-position modulation timing. By combining two or more circuits, you can create an infinite variety of sequential and delayed timing cycles.

These Exar circuits are the only ones in hermetic DIP packages, and the only circuits which accept inverted or non-inverted inputs, and have outputs which are inverted or non-inverted, of high or low level.

You can buy the XR-320 for as little as \$1 in 100-up quantities. It operates from 0°C to 75°C and has a guaranteed accuracy of 5%. The XR-220 is our prime device, with accuracy guaranteed to 0.5%, selling for \$6.50 at 100-up. An XR-220M MIL version operates from -25°C to 125°C and sells for \$10.

Call or write for more information on these new Exar products. Ask for Bill Seibert: Marketing Manager.

EXAR SPEAKS YOUR LANGUAGE



EXAR INTEGRATED SYSTEMS

750 Palomar Sunnyvale, California 94086 (408) 732-7970 TWX 910-339-9233

EXAR SALES REPRESENTATIVES Alabama, Georgia, Mississippi, North Carolina, South Carolina and Tennessee: K&E Associates, Kennesaw, Georgia (404) 974-4264
 Arkansas, Louisiana, Oklahoma and Texas: Evans-McDowell, Dallas, Texas (214) 238-7157 California: De Angelo, Rothman and Co., Culver City (213) 398-6239, Logan
 Sales Co., Redwood City (415) 389-6726 Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont: Com-Sale, Waltham, Massachusetts (617)
 890-0011 Indiana, Kentucky and Ohio: McFadden Sales, Columbus, Ohio (614) 221-3383 Idaho, Oregon and Washington: SD-R Products & Sales, Bellevue, Washington
 (206) 747-9424 Illinois and Wisconsin: Mar-Con Associates, Inc., Skokie, Illinois (312) 675-6450 Maryland, Virginia and Washington, D.C.: Rep-tron, Inc., Silver Spring,
 Maryland (301) 593-4844 New Jersey (South) and Pennsylvania: Harry Nash Associates, Willow Grove, Pennsylvania (215) 657-2213 New Jersey (North) and New York:
 MOS Associates, Floral Park, New York (516) 694-5923 Canada: Harvard Electronic Sales, Laval, Quebec (514) 681-1400 **EXAR DISTRIBUTORS** California: Intermark
 Electronics, San Carlos (415) 592-1641, San Diego (714) 279-5200, Van Nuys (213) 782-0362 Colorado: Intermark Electronics, Denver (303) 936-8284 Massachusetts:
 Gerber Electronics, Dedham (617) 329-2400 Washington: Intermark Electronics, Seattle (206) 767-3160

INFORMATION RETRIEVAL NUMBER 4

Here's the perfect DAC-ADC team for your closed loop system

These Burr-Brown Digital-to-Analog and Analog-to-Digital converters are designed to work as an ultra accurate team. Both units have 16 bit resolution, the DAC has guaranteed monotonicity and the ADC has no missing codes. This makes them ideal for your process control, instrumentation, data logging and other closed and open loop systems. They are self-contained in 2" X 4" X 0.4" modular packages.

The ADC 100 features maximum linearity error of only 0.005 % and a maximum accuracy drift as low as 5 ppm / °C. The unit is available with BCD or binary coding and unipolar or bipolar inputs. The binary units have pin programmable resolutions of 12, 14, or 16 bits, while the BCD units offer 4 digit or 4 digit plus sign coding. Conversion time is just 30 msec. Optional card-mount and rackmount packaging is available. Unit price is \$225.00.

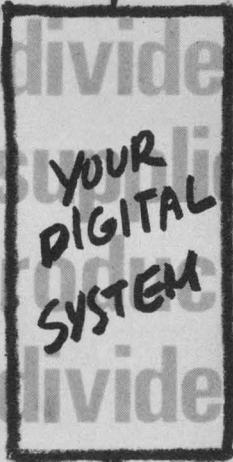
The DAC45 has a linearity error of only 0.003% and a maximum linearity drift of $\pm 1\text{ppm}/^\circ\text{C}$. The unit is TTL/CMOS compatible and accepts 16 bit binary or 4 digit BCD input codes at transfer rates as high as 20 kHz. Conversion speed is just 5 μsec for a .6mV step. Optional card-mount and rackmount packaging is also available for the DAC45. Unit price is just \$325.00.

FOR COMPLETE TECHNICAL INFORMATION, use this publication's reader service card or phone Burr-Brown.

BURR-BROWN
RESEARCH CORPORATION
International Airport Industrial Park • Tucson, Arizona 85706
TEL: 602-294-1431 • TWX: 910-952-1111 • CABLE: BBRCORP



CHICAGO OFFICE (312) 832-6520
UNITED KINGDOM OFFICE: Watford WD1 8BY PHONE 33080/30336



Burr-Brown conversion products deliver what they promise!

NEWS

- 21 **News Scope**
- 24 **More than 100,000 low-cost, low power helium-neon lasers have been sold.** These and other low-cost lasers are finding wide use.
- 32 **A \$4-billion hike in defense spending is expected in 1973,** with little, if any, of it trickling into R&D.
- 35 **Industrial electronics is becoming 'a way of life';** manufacturers see a year of growth ahead.
- 40 **Technology Abroad**
- 43 **Washington Report**

TECHNOLOGY

- 48 **Use current-mode IC amplifiers.** New quad versions replace conventional op amps, while avoiding dual-voltage supplies and lowering the cost and package count.
- 58 **Improve single-slope a/d accuracy.** Add a calibration cycle, and you get 0.01% accuracy in a circuit that is suitable for mass production of 4-1/2-digit DVMs.
- 66 **Design versatile d/a converters** by using constant current sources. Custom components are not needed to obtain devices for special applications.
- 70 **Ideas for Design:** Multiplexer technique solves X-out-of-Y bit pattern recognition . . . Analog divider simplifies ac ratio meter and yields ± 0.2 -dB measurement accuracy . . . Analog sorting network ranks inputs by amplitude and allows selection.

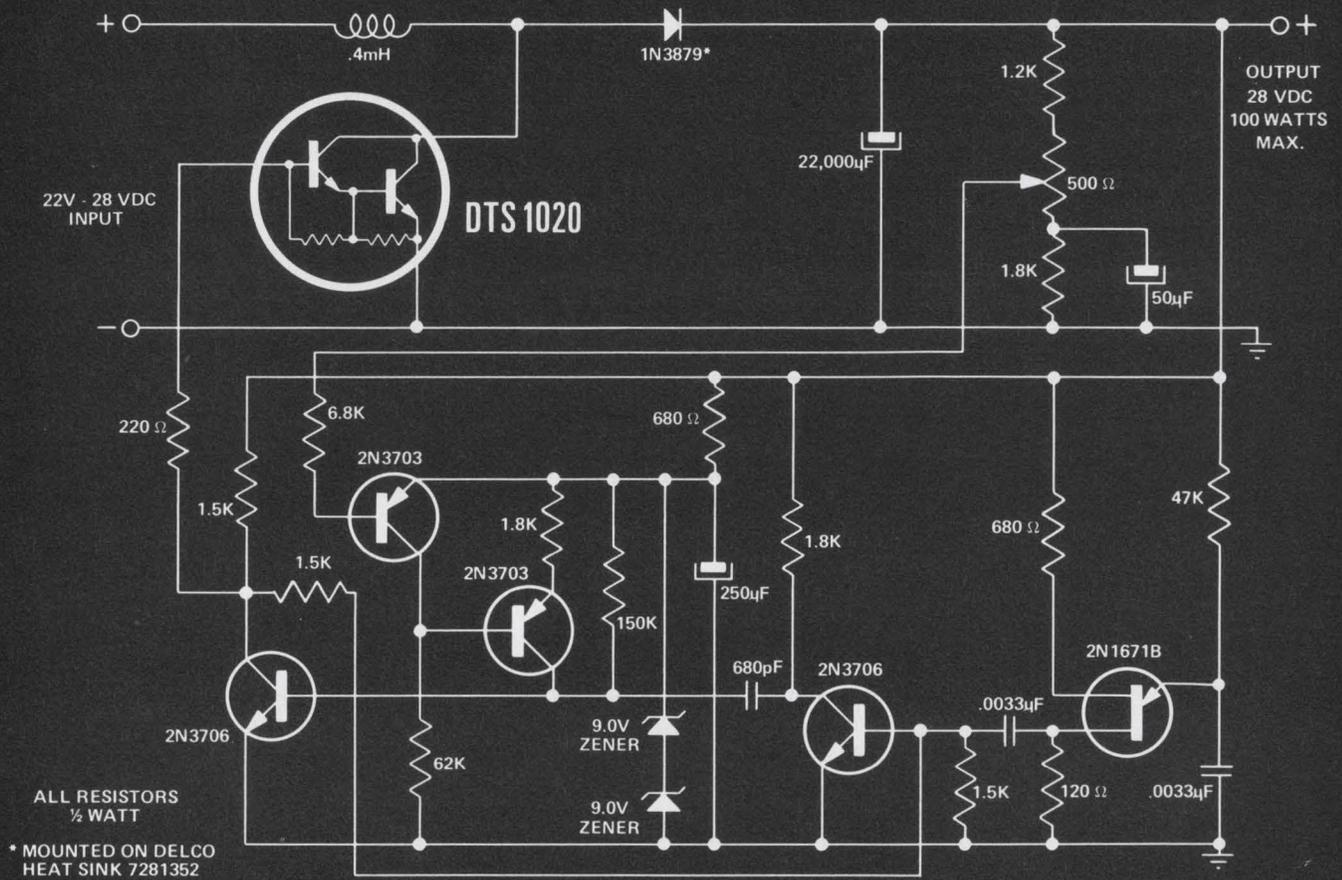
PRODUCTS

- 77 **Modules & Subassemblies:** 8-bit d/a converter module settles to 0.4% within 15 ns.
- 78 **Modules & Subassemblies:** Nonlinear low-pass filter exhibits zero phase shift.
- 82 **ICs & Semiconductors:** Stereo IC with all functions on chip, simplifies quadrasonic decoding.
- 86 **Instrumentation:** Plug-ons extend versatility of DMM measuring system.
- 80 **Data Processing**

Departments

- 47 **Editorial:** Selling is a dirty word
- 7 **Across the Desk**
- 88 **Application Notes**
- 89 **Evaluation Samples**
- 90 **New Literature**
- 96 **Advertisers' Index**
- 98 **Product Index**
- 98 **Information Retrieval Card**

Cover: Photograph by William A. Welch and Kent K. Sutherlin shows the replaceable read-only memory portion of Optical Data System Inc.'s storage and retrieval Holoscan system.

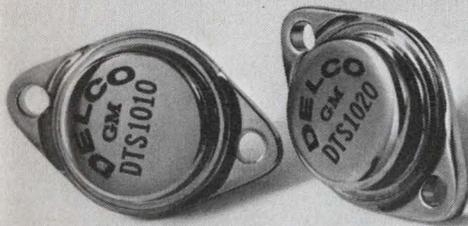


SWITCHING REGULATOR

	V_{CE0} @ 0.1 mA	V_{EBO} @ 50 mA	$V_{CE(SUS)}$ @ 500 mA	h_{fe} @ 1 MHz ($V_{CE}=10V,$ $I_C=200 mA$)	h_{FE} ($V_{CE}=5V,$ $I_C=10A$)	$V_{CE(SAT)}$ @ 5.0 A	I_C	P_T @ 75°C
DTS-1010	120V	7V	80V	12	200	1.8V	10A	100W*
DTS-1020	120V	7V	80V	12	500	1.5V	10A	100W*

*100 percent tested at 2.5A, 40V.

The Kokomoans now give you Darlington Switching Power.



Use a Darlington in place of an ordinary transistor, and you'll realize an additional magnitude of gain plus increased switching power. Use a Delco silicon power Darlington (DTS-1010 or DTS-1020) and you'll also realize a gain in dependability.

Delco's Darlington's are triple diffused mesa units housed in copper TO204MA cases and built for ruggedness. The design gives them high energy capability—the ability to handle surges of current and voltage simultaneously. They are ideal for switching inductive loads in circuits subject to transients or fault conditions.

Design a switching regulator circuit around a Delco Darlington or use it in any 60-100 volt

application to reduce circuit size, weight, and cost. In addition, the Darlington space saving feature allows you more design flexibility. Unlike an ordinary transistor, it's only energy-limited, not beta-limited. You can exploit its full energy capability in your circuit.

Call your nearest Delco distributor. He has them in stock and he's got the data on high energy switching for small spaces.

For details on the switching regulator circuit, ask for Application Note 49.



Delco Electronics

DIVISION OF GENERAL MOTORS CORPORATION.
KOKOMO, INDIANA

Now available from these distributors in production quantities.

ALA., BIRMINGHAM • Forbes Distributing Co., Inc. (205)-251-4104
ARIZ., PHOENIX • Sterling Electronics (602)-258-4531
CAL., LOS ANGELES • Kierulff Electronics, Inc. (213)-685-5511 • Radio Products Sales, Inc. (213)-748-1271
CAL., PALO ALTO • Kierulff Electronics, Inc. (415)-968-6292
CAL., REDWOOD CITY • Cramer/San Francisco, (415)-365-4000
CAL., SAN DIEGO • Radio Products Sales, Inc. (714)-292-5611
CAL., SAN DIEGO • Kierulff Electronics, Inc. (714)-278-2112
COLO., DENVER • Cramer/Denver (303)-758-2100 • Denver Walker Electronics (303)-935-2401
CONN., NORWALK • Harvey/Connecticut (203)-853-1515
FLA., MIAMI SPRINGS • Powell/Gulf Electronics (305)-885-8761
FLA., ORLANDO • Powell/Gulf Electronics (305)-859-1450
ILL., ROSEMONT (Chicago) • Kierulff Electronics (312)-678-8560
ILL., SKOKIE (Chicago) • Merquip Electronics (312)-282-5400
IND., INDIANAPOLIS • Graham Electronics Supply, Inc. (317)-634-8202
MD., BALTIMORE • Radio Electric Service Co. (301)-823-0070
MASS., NEEDHAM HEIGHTS • Kierulff Electronics, Inc. (617)-449-3600

MASS., NEWTON • The Greene-Shaw Co., Inc. (617)-969-8900
MICH., FARMINGTON • Harvey-Michigan (313)-477-1650
MINN., MINNEAPOLIS • Stark Electronics Supply Co. (612)-332-1325
MO., KANSAS CITY • Walters Radio Supply, Inc. (816)-531-7015
MO., NO. KANSAS CITY • LCOMP-Kansas City, Inc. (816)-221-2400
MO., ST. LOUIS • LCOMP-St. Louis, Inc. (314)-647-5505
N.J., CLIFTON • Eastern Radio Corporation (201)-365-2600, (212)-244-8930
N.Y., BINGHAMTON • Harvey/Federal (607)-748-8211
N.Y., EAST SYRACUSE • Cramer/Syracuse (315)-437-6671
N.Y., ROCHESTER • Cramer/Rochester (716)-275-0300
N.Y., WOODBURY • Harvey/New York (516)-921-8700, (212)-582-2590
OHIO, CINCINNATI • United Radio, Inc. (513)-761-4030
OHIO, CLEVELAND • Pattison Supply (216)-441-3000
OHIO, DAYTON • Kierulff Electronics (513)-278-9411
PENN., PHILADELPHIA • Almo Electronics (215)-676-6000
PENN., PITTSBURGH • RPC Electronics (412)-782-3770

S.C., COLUMBIA • Dixie Radio Supply Co., Inc. (803)-253-5333
TEXAS, DALLAS • Adleta Electronics Co. (214)-741-3151
TEXAS, FORT WORTH • Adleta Electronics Co. (817)-336-7446
TEXAS, GARLAND • Kierulff Electronics, Inc. (214)-271-2471
TEXAS, HOUSTON • Harrison Equipment Co., Inc. (713)-224-9131
UTAH, SALT LAKE CITY • Cramer/Utah (801)-487-3681
VA., RICHMOND • Meridian Electronics, Inc., a Sterling Electronics Company (703)-353-6648
WASH., SEATTLE • Kierulff Electronics, Inc. (206)-763-1550
CANADA, ONT., SCARBOROUGH • Lake Engineering Co., Ltd. (416)-751-5980
ALL OVERSEAS INQUIRIES:
General Motors Overseas Operations Power and Industrial Products Dept., 767 Fifth Avenue, New York, N.Y. 10022. Phone: (212)-486-3723.
Kokomoans' Regional Headquarters.
Union, New Jersey 07083, Box 1018, Chestnut Station, (201) 687-3770.
El Segundo, Calif. 90245, 354 Coral Circle, (213) 640-0443.
Kokomo, Ind. 46901, 700 E. Firmin, (317) 459-2175 (Home Office).



Our Bill Shuart doesn't work for Power/Mate.



**He works only for you...
and that's the way the new Power/Mate
wants it.**

Bill is the Power/Mate Quality Assurance Manager and he has 34 supervisors and perfectionists under him.

They also work for you.

The result is unexcelled and consistent quality that we at Power/Mate are genuinely proud of.

Bill does a lot more than making sure our products are produced in accordance with his high standards of workmanship. (He wrote the book on that too.)

Bill has developed a series of courses for all our employees on soldering techniques and workmanship standards.

□ He has developed a computer failure analysis program to insure that our vendors also maintain the consistent high quality you should expect when you use our power supply in your product.

□ He oversees the continuing MTBF studies (by computer of course) and worst case calculations on all our power supplies to insure the long life and trouble free performance you should expect.

□ He has developed a thermally cycled burn-in rack in which we subject *all* of our power supplies for 24 hours before shipment to insure there are no premature field failures.

□ He oversees the random sampling of all production-run power supplies. These are subject to a continuous night and day life test . . . for your continued assurance of a long-lived trouble free product.

We could go on . . . but we at Power/Mate are glad he works for you. That's why we can give a five year no-holds warranty.



THE NEW

POWER/MATE CORP.

514 S. River Street, Hackensack, N. J. 07601/ Phone (201) 343-6294
TWX 710-990-5023

Vice President, Publisher

Peter Coley

Editors

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

Editor-in-Chief: George Rostky

Managing Editors:

Ralph Dobriner
Michael Elphick

Associate Editors:

Jules H. Gilder
Richard Lee Goldberg
Morris Grossman
Seymour T. Levine
John F. Mason
Stanley Runyon
Edward A. Torrero
Richard L. Turmail

Contributing Editor:

Peter N. Budzilovich

Editorial Field Offices

East

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

West

David N. Kaye, Senior Western Editor
2930 West Imperial Highway
Inglewood, Calif. 90303
(213) 757-0183

Washington

Heather M. David, Bureau Chief
2506 Eye St., N.W.
Washington, D.C. 20037
(202) 338-3470

Editorial Production

Marjorie A. Duffy

Art

Art Director, William Kelly
Richard Luce
Anthony J. Fischetto

Production

Manager, Dollie S. Viebig
Helen De Polo
Maxine Correal
Anne Molfetas

Circulation

Manager, Nancy L. Merritt
Ron Deramo

Information Retrieval

Peggy Long

Promotion

Manager, Jeffrey A. Weiner
Karen Kerrigan

across the desk

A cheer for less work

I like most of your editorials, because they're novel and punchy. But the one in the Nov. 9, 1972 issue—"Get Enriched (If Not Rich) With Those High Flyers"—smelled too much of 19th-century optimism and the Protestant work ethic.

The editorial message was: "Get involved in a fledgling company. You'll work like hell. You probably won't get very rich. But the experience will be enriching." The trouble with this message is:

1. There are too many electronics companies right now, and they're competing for scarce business. A more optimum situation is the auto industry with four companies producing all the cars (more optimum for the men in the industry).

2. If 25 hours a day of work does not make you very wealthy, it is to be shunned.

3. Hard work of the sort done by fledgling company executives is not at all enriching (except monetarily); it serves to produce ulcers and coronaries, which are to be shunned.

There's a new movement in America that your editorial is blissfully ignorant of. It's the movement for less work and a better quality of life, with more leisure time. It's a movement that progresses:

1. A man should not be married to his career.

2. America has so much excess productive capacity, that people should work fewer hours, not more. (This produces the four-day work week, which is gradually gaining acceptance.)

3. A man's work should be emotionally rewarding. If it's not, he

should change his work if at all possible.

Like any other industry, electronics has its share of freaks, who thrive on grueling, exhausting, unnerving work. If your editorial is aimed at these few freaks, why print it? If it's aimed at the rest of us also, then please change the tune. It's out of key with the second half of the 20th century.

Robert Bruce, MSEE

15 Johnstone Road
Great Neck, N.Y. 11021

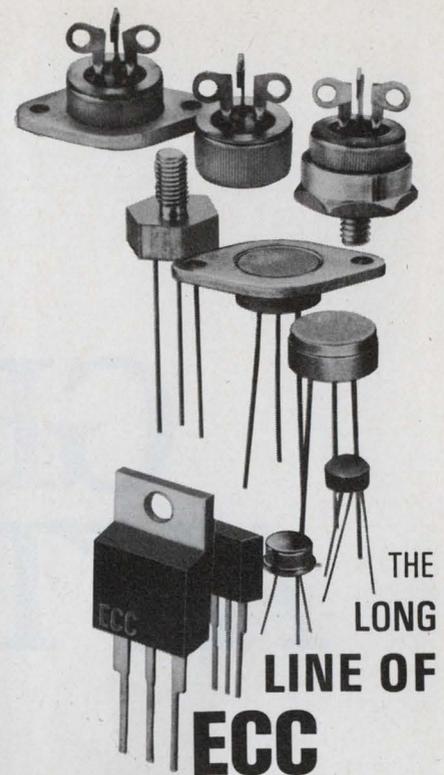
Wire-AND advice draws a complaint

In Dwight H. Sawin's discussion of wire-AND ("Use the Wired-AND and Implied-OR," ED 20, Sept. 28, 1972, p. 76), he very mistakenly says that up to 10 open-collector TTL gates can be wired together with no adverse effects. He goes on later to state that the wire-AND configuration is not only hazard-free but also provides a significant savings.

The problem with this reasoning is that it assumes unfortunately that the real world ends at the designer's bench. If those who utilize wire-AND connections only for package-count-savings had the onerous task of troubleshooting this design in production, or had the profit responsibility for field repairs, they would find another approach. Only when no other avenue is available does the TTL open-collector, wire-AND connection provide any real savings. The near impossibility of isolating a failure to the bad IC when several are wire-ANDed runs up test costs far exceeding any imagined savings of low-cost, standard TTL

(continued on page 11)

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



THE
LONG
LINE OF

ECC

LOW AND HIGH CURRENT

TRIACS

World's leading
Triac producer offers
fast delivery,
electrical isolation and
a variety of packages.

LOW CURRENT TRIACS

THERMOTAB® and THERMOPAK*; Swedge and TO-3; 5/8" Hex Stud, and TO-5 Metal and Plastic Packages

*trademark of ECC

$I_{T(RMS)}$ 0.8 - 16 amps

I_{gt} 1, 111 3, 10, 25, 50 ma max;
with or w/o internal trigger

I_{TSM} 20 - 150 amps

V_{DROM} 200 - 800 volts

For more information, circle No. 238

HIGH CURRENT TRIACS

3/4" Press-Fit, Stud and TO-3 Packages

$I_{T(RMS)}$ 25 - 40 amps

I_{gt} 1, 111 50 - 100 ma max

I_{TSM} 230 - 300 amps

V_{DROM} 200 - 800 volts min

For more information, circle No. 239

All packages are electrically isolated except TO-5 Metal Can. ECC triacs feature heavily glass passivated junctions for high reliability.

Contact your nearest ECC Sales Representative or Authorized Distributor for pricing and technical information.

ECC
CORPORATION

P.O. Box 669 • Eules, Texas 76039
817/267-2601

**GENERAL
AUTOMATION
SAYS
BUY DEC**

If you're shopping the minicomputer market for raw hardware at rock bottom cost, it's hard to know where to stop. With more than two dozen price lists to choose from, it can get confusing. And time consuming.

We're here to make it easy for you. Buy DEC.

When you cut through all the claims, DEC's priced as low as anyone else. And they have built a business fulfilling the needs of the low-end iron buyer.

We make low cost hardware too. And if you're price shopping, you'll find us competitive. But raw iron is not our primary business.

The cheapest machine vs. the cheapest solution:

Sure, our goal is to save you money too. But our long suit is squeezing these savings out of your total systems cost rather than off of our price list. So if you need more from the machine or the company that sells it to you, we recommend us. General Automation.

Take *the world's most powerful minicomputer*, for instance.

The General Automation SPC-16.

The SPC-16 possesses the most powerful instruction set you can buy in a minicomputer today. Think about that. The *most* powerful. As a result, the SPC-16 does more things in less time. It will actually reduce the total cost of your system.

Depending on your specific needs, you can choose from six different models in the SPC-16 family. Each backed by the best software and peripheral capability in the business. There's another very important reason why you should buy from us.

It's called involvement.

All the other big mini manufacturers

today are touting the fact that they're "end-user oriented" or that they're now "in the systems business."

We've been doing exactly that for more than five years now. And it's nice to see that others have begun to recognize our leadership.

We learned a long time ago that the only way to really help our customers in solving their systems problems was to fully understand those problems.

So we got involved with our customers. Both end-users and OEMs. Listened attentively. Learned a lot. Got answers. And wound up building systems to solve some very tough, very complex problems.

Emissions analysis and electrical test systems for the nation's largest automobile manufacturers.

Production machine control systems for some of the biggest companies in the machine tool business.

Telecommunications and message switching systems for the world's leading communications companies, to name just a few.

In short, we've built our company and our reputation by offering answers, not just iron.

Who's it gonna be?

Actually, we've made your choice fairly simple.

If all you need is raw minicomputer hardware at a "rock bottom" price, we recommend DEC.

If you'd like something more—from a mini with more oomph to the total solution of a complex systems problem—we recommend us.

General Automation.

Our phone number is (714) 778-4800.

Or write:

1055 South East St., Anaheim, Calif. 92805

General Automation

INFORMATION RETRIEVAL NUMBER 9

Fluke problem solvers

Introducing the Fluke 8100B. At \$595, you'll wonder how we did so much in a 4½ Digit Multimeter.



The new version of Fluke's most successful DMM, Model 8100B, gives you the most value for your money ever offered in a quality digital voltmeter.

With a basic dc accuracy of 0.02%, the Fluke 8100B measures ac and dc volts in four ranges from 100 microvolts to 1200 volts and resistance from 100 milliohms to 12 megohms. With an optional ac/dc current shunt accessory, it measures from 10 nanoamperes to 12 amps in six switched ranges.

Features include an active 2-pole switchable filter and automatic polarity indicator. All functions are push-button selectable.

For \$100 extra, a rechargeable battery pack can be

added to give the user complete portability with up to eight hours continuous operation. Other options include RF and high voltage probes, switched ac/dc current shunts, data output and a ruggedized case. Demonstrated MTBF is over 10,000 hours, to make the instrument the most reliable available. The 8100B has tough environmental specs to ease your workload. Fully backed by Fluke's no-nonsense 12-month guarantee and service policy, here's an instrument that will meet your greatest expectations.

Call your local Fluke sales engineer for a demo and details. In the contiguous U.S., get his location by dialing our toll free number, 800-426-0361. Otherwise, address one of the locations listed below.

Fluke, P. O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850.
In Europe, address Fluke Nederland (N.V.), P. O. Box 5053, Tilburg, Holland. Phone 13-670130.
Telex: 884-55237. In the U.K., address Fluke International Corp., Garnett Close, Watford,
WD2, 4TT. Phone, Watford, 33066. Telex: 934583.

FLUKE®

ACROSS THE DESK

(continued from page 7)

packages. I shudder to think of 10 gates wired together.

Jesse Pipkin,
Product Manager,
Digital Circuit Testing

Hewlett-Packard
5301 Stevens Creek Blvd.
Santa Clara, Calif. 95050.

The author replies

While Mr. Pipkin does make a good point, from the standpoint of reliability diagnosis, there are two sides to the discussion. The comment in the article concerning wiring 10 open-collector TTL gates together with no adverse effects refers to adverse *electronic* effects, if read in context. Specifically it refers to the disastrous results suffered when "totem pole output" TTL gates are wired together.

Furthermore the article offers a general technique that may be applied when any logic family is used to reduce the package count. Likewise power consumption and size are also reduced. Granted, trouble-shooting in large equipment is difficult enough without wire configurations; however, in an extremely simple, high-volume production article, it may be that discarding the faulty circuit entirely is the best course of action economically.

Dwight H. Sawin 3d

University of Idaho
College of Engineering
Office of the Dean
Moscow, Idaho 83843.

Who makes that cassette transport?

In our FOCUS report on digital cassette and cartridge recorders (ED 18, September 2, 1972, pp. 40-46) we showed a picture of a three-cassette peripheral unit offered by Data General for use with its Nova minicomputers. In the caption, however, we failed to mention that the cassette transports were developed and manufactured by Redac-tron Corp. The cassette transport was developed originally for Redac-tron's editing typewriter system and is currently being used by other firms in typesetting uses.



seal of improval

Improved reliability through the use of a glass-to-tantalum true hermetic anode seal is the prime feature of new Type 138D gelled-electrolyte sintered-anode Tantalox® Capacitors. This new construction eliminates all internal lead welds while retaining the strength of conventional internal lead-welded parts. In addition, the new construction offers outstanding resistance to extensive temperature cycling.

Type 138D Tantalox Capacitors are designed to meet or exceed

the environmental and life test requirements of MIL-C-39006. The gelled-electrolyte employed in these new capacitors gives premium performance for all capacitor parameters with respect to frequency and temperature variations.

Originally developed for use in aerospace applications, this capacitor design is now available for general industrial and aviation use where the utmost in component performance and reliability are primary necessities.

For complete technical data, write for Engineering Bulletin 3704A to: Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

INFORMATION RETRIEVAL NUMBER 11

45C-2126
SPRAGUE
THE MARK OF RELIABILITY

The Same Technology Instruments Makes Them

Take signal sources for example...

You can't see the automated testing and the other manufacturing advances that help lower the price of HP's quality signal sources. But you sure can see the versatility and extra performance you get for your money. From the simplest function generator to the most capable synthesizer, HP technology has brought the price of quality way down.



Brand New Function Generator 3311A shows what a performance plus you get from this technology in action. Priced at only \$249, it adds sweep capability and a separate high-power pulse output to the usual sine, square and triangular wave outputs. Sweep it over any 10 to 1 span within its 0.1 Hz to 1 MHz range. The pulse output drives up to

20 TTL loads. Note that price again. It's 15% lower than its nearest major competition.

Wide Range Function Generators 3310A/B deliver general-purpose waveforms with extended low-frequency response. These 0.0005 Hz to 5 MHz instruments equip you with a linear very-low-frequency ramp, in addition to sine, square, triangle and pulse waveforms. Prices are a modest \$595 for the 3310A, and \$735 for the 3310B that also provides free-run, single-cycle and multiple-cycle operating modes.



HP That Makes Better... Now Cost Less



Lowest Cost Frequency Synthesizers 3320A/B bring you synthesizer quality for as little as \$1,900. You get 1 part in 10^6 frequency resolution over the entire 0.01 Hz to 13 MHz range. Also, on the 3320B, HP's thermopile control of amplitude level gives 0.01 dB level resolution. If precise amplitude setting and calibration aren't required, get the 3320A for \$1,900. Or, get *both* frequency and amplitude precision in the 3320B for \$2,550 (add \$595 for full ASCII programmability). How's that for a blend of quality, performance and low price!

Top-of-the-line Automatic Synthesizers 3330A/B have a built-in "brain" that lets you avoid tying up a computer. They're like the 3320A/B, only these can be programmed to automatically sweep their frequency spectrum (and, on the 3330B, its precision amplitude level). With the 3330B you're getting a synthesizer, a sweeper, a marker generator, a counter, a programmable attenuator, a built-in controller and a precision level generator—in other words a lab-in-a-box—for just \$6,000. Or, cut that to \$5,100 for the manual-amplitude-control 3330A.

Whatever your needs in signal sources, satisfy them with one of HP's technology-leader instruments. They're packed with more capability than ever before—and priced lower, too. For more information on the entire family of HP signal sources, contact your local HP field engineer. Or, write



Hewlett-Packard, Palo Alto, California 94304. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa—Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

093/43

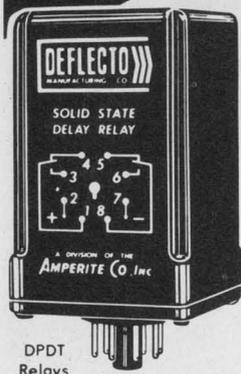
HEWLETT  PACKARD

SIGNAL SOURCES

INFORMATION RETRIEVAL NUMBER 12

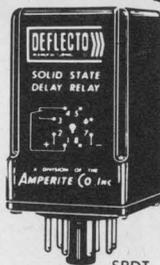
Now...from AMPERITE-

UTMOST RELIABILITY in SOLID STATE (HYBRID) TIME DELAY RELAYS



DPDT
Relays

(Illust. 1/2
actual size)



SPDT
Relays

Maximum Dependability
at **LOW COST**
--backed by over 30 years
of Relay experience.

FEATURES:

CONTACTS: SPDT, 3 Amps;
DPDT, 10 Amps.

VOLTAGES: 24V AC or DC;
28V AC or DC; 115V AC or DC.

5 TIMING RANGES:
From .1 to 300 Seconds.

- Repeat accuracy of $\pm 5\%$; screwdriver adjustable time delays.
- Recycle time of 100 milliseconds. Transient and polarity protected.
- Relays plug into standard octal socket.

PRICES:

SPDT Relays: \$8.45 in 100 lots; wt. 2 ozs.
DPDT Relays: \$13.65 in 100 lots; wt. 6 ozs.

Write for Bulletin No. DSR-1

DEFLECTO Mfg. Co.

Div. of Amperite Co., Inc.

600 Palisade Ave., Union City, N.J. 07087
(201) 865-5648

INFORMATION RETRIEVAL NUMBER 13

ACROSS THE DESK
(continued from page 11)

... And more ways to convert temperature

With respect to temperature conversion (see "A Foolproof Method to Convert Temperature," ED 17, Aug. 17, 1972, p. 7), I would like to suggest an approach that requires only the remembrance of the number 18 instead of any of the C/F or F/C conversion equations.

We all know that water freezes at 0 C, which equals +32 F. For each 10° increase/decrease of C, there is an 18° increase/decrease of F.

Therefore: +10 C = +50 F, +20 C = + 68 F and +30 C = +86 F (note that, fortuitously, 86 is the reverse of 68), etc., -10 C = +14 F, -20 C = -4 F, etc.

Also, for each 1° increase/decrease of C, F increases/decreases 1.8° for interpolating.

Using this approach, you can do most of the conversions mentally. I forgot the 5/9, 9/5, +32, -32, etc., 50 years ago.

Julius Bernstein

118 Rosedale Rd.
Yonkers, N.Y. 10710

The Aug. 17 issue includes a good method of Fahrenheit/Celsius conversion, but James W. Wrenn could have indicated the background for the use of the "40." It might have made the system a little easier to understand. Simply, both Fahrenheit and Celsius scales are exactly equal at -40° (-40 C = -40 F). Therefore if the known scale is brought to a new origin at -40 (add 40 to a positive degree value) and then converted by the 5:9 ratio of the size of each degree, and finally the 40 subtracted out to get to the 0° level of the new scale, the job is done.

This method described by Mr. Wrenn is so much more logical and understandable, yet is almost never mentioned in the schools.

Robert Fabris
Research Specialist
Systems Integration

Lockheed Missiles & Space Co., Inc.
Sunnyvale, Calif. 94088.

Correction

In a recent product feature introducing Motorola's dual-tracking voltage regulator, the MC1468 ("Improved Op Amp Regulator," ED 19, Sept. 14, 1972, p. 169) some erroneous statements crept into a comparison with Raytheon's RC-4194 dual-voltage regulator. To set the record straight, we note the following:

■ Both ICs usually require six components (two resistors and four capacitors) for ± 15 -V operation. However, Motorola's regulator can deliver ± 15 V with just the four capacitors; the two resistors are needed only to limit load current. For output voltages other than ± 15 -V, the Motorola IC requires two extra components, while Raytheon's general-purpose device can still operate with six external components.

■ Prices for commercial-temperature-range versions in quantities of 100 up and in a TO-66 package are \$3.90 for Raytheon's 4194 and \$3.75 for Motorola's 1468. In 10-pin metal packages, the MC1468 sells for \$2.80 (100-999), while Raytheon has a 14-pin DIP version of its regulator for \$2.66 (100-999).

For additional information on Raytheon's 4194, see "Dual-Tracking Voltage Regulator Extends Operating Range to 90 V," ED 8, April 13, 1972, p. 97.

Correction

In the article "Can't Decide Which Instrument to Buy?" (ED 24, Nov. 23, 1972, pp. 162-163), the instructions are garbled in one of the bottom blocks at the left of the Frequency Considerations chart (p. 162). As published, the instructions say: "Consider FG or Digital Dial and RC Osc (To 10 MHz)." They should say: "Consider FS or Digital Dial FG and RC Osc (To 10 MHz)."

Nobody
can match
Allen-Bradley's
resistor cost

...on the board.

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

Paying the lowest price doesn't mean you're getting the lowest cost. Many fixed resistor brands lose their identification in the PC board cleaning process. Some don't have true colors to begin with. Or the color bands darken and become illegible from the heat produced in normal usage. The result is costly identifica-

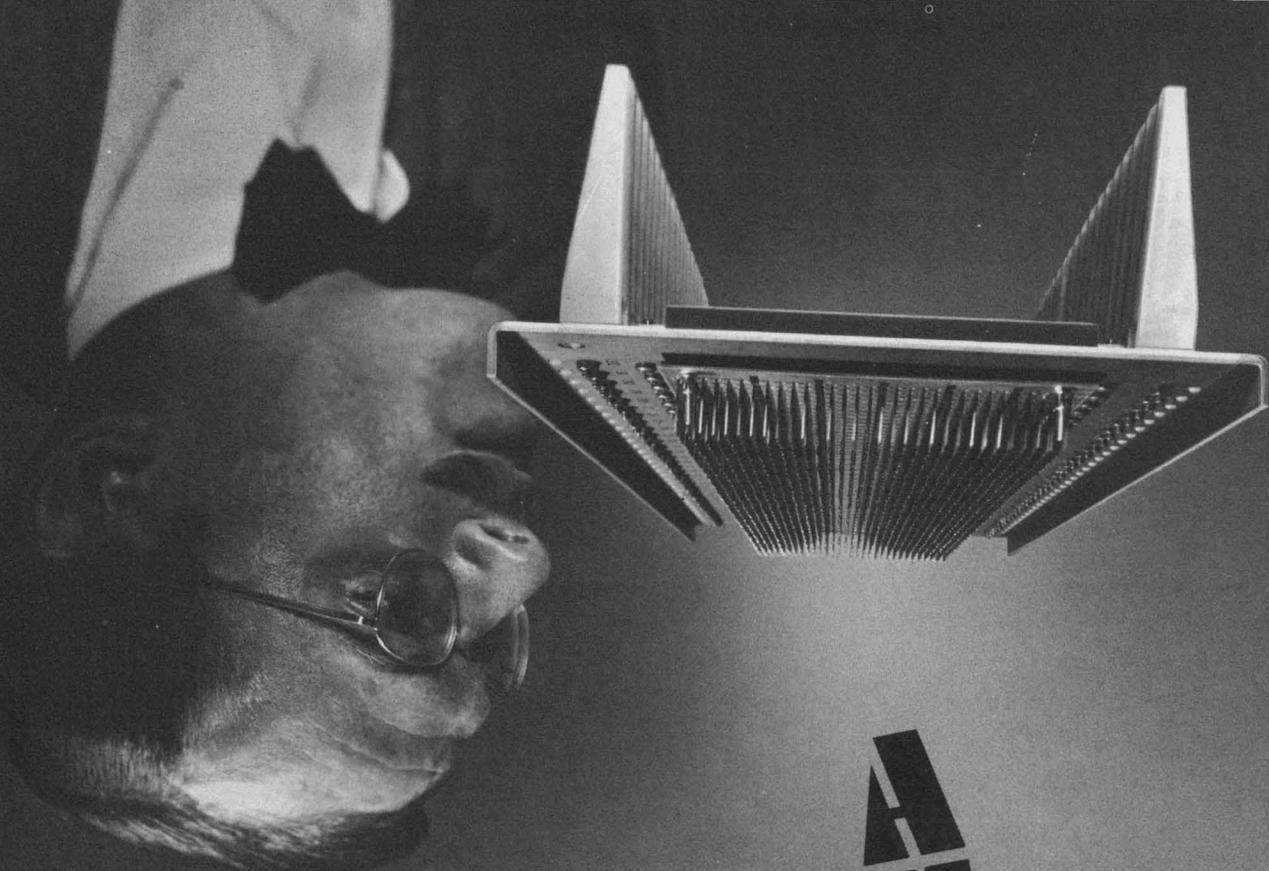
tion errors. Contrast this with the bright, crisp identification of Allen-Bradley's specially formulated paints. Baked on to resist aging, rough handling and solvents. Why gamble with questionable quality that can lead to unforeseen costs? Learn the facts. Ask your nearest A-B distributor for our free booklet,

"7 ways to tell the difference in fixed resistors." Or write Allen-Bradley Electronics Division, 1201 South Second St., Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Ltd., Galt, Ontario. United Kingdom: Jarrow, County Durham NE32 3EN.



Allen-Bradley

Milwaukee, Wisconsin 53204



BEAUTIFUL BOTTOMS UP STORY.

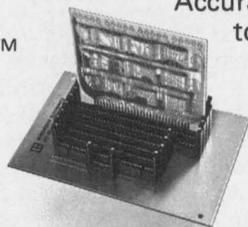
AccurSystem™ back panels from Winchester Electronics offer you the bottom-to-top versatility and reliability you need from one manufacturer. To give you the cost/performance target you're after.

Just consider the three basic AccurSystem offerings . . . bottoms or tops up.

On the bottom, AccurFrame®, AccurPlate™ and AccurPlane™ back panels are available ready for automatic or semi-automatic wire-wrapping with accurate, reliable terminal alignment. Or, they will be shipped already precision-wrapped to your specifications.

AccurFrame and AccurPlane back panels accept Winchester Electronics HW Series edgeboard connectors on grids of .100 x .200 and .125 x .250; and our DW's with .125 x .125 spacing. AccurPlate back panels accept our PW Series connectors for grids of .100 x .200 and .125 x .250; or, PDW's with .125 x .125 spacing. Plus all three types accept our RW Series input/output connectors on either a .100 or .125 grid with wrappable contacts.

On the top, we can give you .100 or .125 contact spacing.



Many AccurSystem back panels feature field replaceable contacts. And, our back panels accept standard .062 printed circuit cards. Custom designs will be quoted to suit your specifications.

AccurSystem is a proven, total interconnect solution to suit your design requirements. Exactly, even if it includes ground/voltage planes or ground bussing. You'll call it a beautiful bottoms up story, too. Because any way you go, the AccurSystem means you can order precisely the back panel you want. AccurSystem.

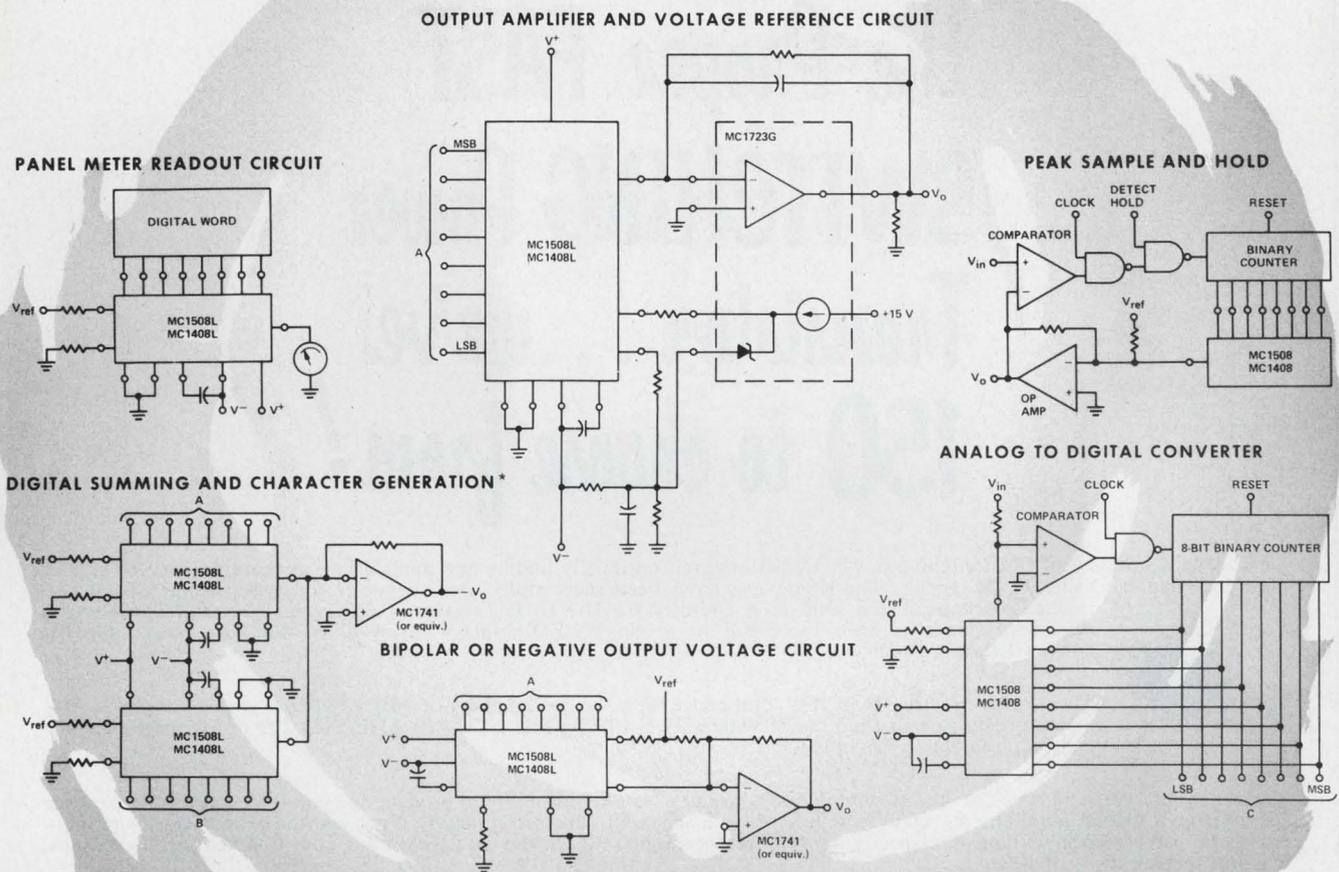
Developed by Winchester Electronics with your total needs in mind. Put our full scope of innovative ideas and practical knowledge to work for you, now. Winchester Electronics Division, Main Street & Hillside Avenue, Oakville, Conn. 06779. (203) 274-8891. Or, for discrete connectors, contact your local authorized distributor.



Litton

WINCHESTER ELECTRONICS

This Eight-Bit D/A Converter Does So Many Things... So Simply



Here Are Just A Few

Ever since we introduced the "basic" D/A converter, the MC1406 monolithic six-bit multiplying D/A, we've been getting requests to apply the same approach to an eight-bit type. By popular demand, then, here is the MC1508, a monolithic eight-bit multiplying D/A that's versatile, simple to use, and inexpensive.

The MC1508's flexibility is rooted in its simplicity. System requirements determine the voltage reference to be used, from simple zener to sophisticated IC. The op amp is chosen to meet the desired speed, accuracy and output range.

Choose among four variations covering a broad range of performance requirements. MC1508L-8 and MC1408L-8 provide worst case relative error of $\pm 0.19\%$ and full eight-bit accuracy. The MC1408L-7

and the MC1408L-6 have seven and six-bit accuracy, respectively, with eight-bit resolution. All four versions have a fast typical settling time of 300 ns, reference current slew rate of $4 \text{ mA}/\mu\text{s}$, and an extended output voltage swing of $+0.5 \text{ V}$ to -5 V . The non-inverting digital inputs are both TTL and CMOS compatible. Operating temperature ranges are -55 to $+125^\circ\text{C}$ for the MC1508 and 0 to $+75^\circ\text{C}$ for all MC1408 versions.

Prices (100-999) are in a class by themselves, with the MC1508L-8 naturally top priced at \$8.50, the MC1408L-8 in the middle at \$5.95, and the MC1408L-6 carrying a low \$3.95 tag. Get full information by using the reader service number, or write to Motorola Semiconductor Products Inc., Box 20912, Phoenix, Arizona 85036.



MOTOROLA LINEAR

— Serving a greater range of analog designs

*This approach does not result in a 16-Bit D/A Converter.

NOW CHOOSE

the Proper FAST

SWITCHING Power

Transistor...we've

150 to choose from!

Kertron's "KS Series" of fast switching power transistors are continually finding new applications as requirements for greater efficiency demand faster T_{on} - T_{off} times. The KS devices have been successfully used to power the Laser diode. They also replace mechanical and solid state circuitry for DC to DC converter (chopper) circuits. The Kertron KS series has also been successful in driving "LED displays" as well as switching power supplies and switching regulators.



The Kertron factory is in full compliance with the requirements of MIL-Q-9858A, and Hi-Rel assembly and processing is in accordance with MIL-S-19500, MIL-STD-750, MIL-STD-202 or any customer special requirement.

Kertron offers you 150 types of fast switching power transistors plus capability to produce for you the neatest little package for your own special requirement. Quality at Kertron is a serious business and quality gives you the assurance of optimum transistor performance without overspecifying your requirements. Check the chart below for your number and, if perhaps, it is not there, call us or write.

SELECTED SAMPLES

TO-3	TO-66	TO-59	TO-61	TO-63	MAX. RATINGS				Min. h_{FE}	SAT Voltages		Switching Times ns					
					V_{CB}	V_{CE}	V_{EB}	I_C		V_{CE}	V_{BE}	t_{on}	t_{off}	I_C			
KS6117 KS6118	KS6217 KS6218	KS6317 KS6318	KS6417 KS6418		100	100	4.5	10A	15	① $I_C=5.0A, I_B=0.5A$		37	120	5.0A			
					60	60	4.5	10A		0.6	1.25				45	140	5.0A
KS6140 KS6120 KS6121	KS6240 KS6220 KS6221	KS6340 KS6320 KS6321	KS6440 KS6420 KS6421	KS6540 KS6520 KS6521	120	120	4.5	15A	15	① $I_C=10.0A, I_B=1.0A$		37	120	10A			
					100	100	4.5	15A		1.0	1.5				37	120	10A
					60	60	4.5	15A		1.0	1.5				45	140	10A
KS6141 KS6127			KS6441 KS6427	KS6541 KS6527	100	100	4.5	20A	15	① $I_C=15A, I_B=1.5A$		45	140	15A			
					80	80	4.5	20A		1.8	3.0				45	140	15A
KS6142 KS6129			KS6442 KS6429	KS6542 KS6529	100	100	4.5	25A	15	① $I_C=20A, I_B=2.0A$		70	180	20A			
					80	80	4.5	25A		1.8	3.0				70	180	20A

STUD PACKAGES AVAILABLE ISOLATED OR NON-ISOLATED.



KERTRON

INCORPORATED

Contact U. S. Sales Headquarters for information and for name of Local or Overseas Representatives.

7516 Central Dr., Riviera Beach, Fla. 33404 Tel. 305/848-9606 TWX 510-952-7611

NASA aims to hold the line with a \$3.4-billion budget

NASA spending in calendar 1973 is expected to remain in stationary orbit. The budget for fiscal 1973 was \$3.4-billion, and the total for fiscal '74 is expected to stay at this level. Even if it drops slightly, spending for calendar 1973 won't be affected too much.

The main effort will be the space shuttle, which the agency will push along as quickly as it can, albeit cautiously. The big fear is that Congress might quash the whole thing if something big went wrong.

Except for a few items that will have to be bought for test purposes, almost all the work on electronic portions of the shuttle will be studies and analyses, says Ronald V. Murad, chief of avionics and ground systems for the shuttle program.

"This year, we'll put the finishing touches on our over-all avionics development plan," Murad says, "making phase-development schedules to tie in with the over-all program milestones. We will also study, with prime contractor North American Rockwell, the types of subcontractors we want."

Other action in the shuttle program this year will include the following:

- The Massachusetts Institute of Technology will begin systems analysis for guidance, navigation and control and performance monitoring. And IBM will begin an analysis of software design.

- Intermetrics in Cambridge, Mass., will begin developing the higher-order language, called Hal, for the shuttle computer, and later will develop the compiler. A computer will be selected by July.

- Honeywell will begin an analysis of the flight-control system and American Airlines an analysis of the problems of maintenance.

"We will also be firming up plans for a shuttle avionics integration

laboratory to be located in Houston," Murad says.

The emphasis in unmanned satellites continues to be for better sensors and instrumentation in the spacecraft to relieve the cost and size of equipment on the ground, according to a spokesman for NASA's Goddard Spacecraft Center in Greenbelt, Md.

Needed are sensors to monitor the earth's resources. Atmospheric and water-pollution monitors are being developed, but "as soon as we've gained some experience with them, we're going to want to improve them," the spokesman said.

Ocean color-monitoring sensors are needed, along with other instrumentation to look at the earth.

An example of the kind of sensor Goddard wants is a microwave instrument for the Nimbus meteorological satellite that will pierce clouds to measure the thermal emission characteristics of the earth. By interpolation, measurements can then be calculated for the temperatures at various altitudes below and above the cloud formations.

"We're asking sensors and instrumentation to do more and more," the spokesman pointed out, "and consequently they're costing more." Because of this, Goddard is asking industry to use existing technology wherever possible, rather than pushing to new, expensive approaches.

Balancing out the cost increase for NASA sensors is a decrease in money needed for ground-tracking facilities, which were recently upgraded and will be adequate for the next few years. Over-all spending at Goddard will remain at about \$500-million a year.

The biggest activity in the continuing exploration of the planets this year will be work on Viking, which is to orbit and land on Mars in 1975. NASA and the Jet Propul-

sion Laboratory will continue work on the camera, the line scanners, instruments to determine the atmospheric composition and pressure, and the nuclear-electric power generator for the lander.

The second Pioneer spacecraft will lift off in April to fly by Jupiter. It will be powered by a nuclear-electric engine. In October, Mariner will take off, powered by solar cells to fly by Venus and Mercury. Both craft will carry radiometers, spectrographs and imaging systems.

NASA's aeronautical work is picking up this year. Efforts are under way to reduce aircraft noise and airway and airport congestion. For noise abatement, a two-segment landing approach is being studied that would require a steeper descent to the final glide slope. Such a technique would require area navigation systems in all planes.

A STOL avionics program is under way to provide a short-takeoff-and-landing plane to operate in bad weather in a conventional aircraft terminal area. An automatic landing system is being developed for a VTOL (vertical take off and landing) plane. And improvements are being sought for landing conventional planes in bad weather.

A standard predicted for instrument interface

A de facto standard for the interface of programmable instruments will soon be in effect in the U.S., possibly by this summer. So says Robert Faulks, vice president of engineering for the General Radio Co. in Concord, Mass., and chairman of the U.S. Advisory Committee on Instrument-Computer Interfaces, which he helped form.

The standard is being considered for adoption by the International Electrotechnical Commission, the Scientific Apparatus Makers Association, the IEEE and other groups.

If the standard is adopted users of instrument systems will be able to interconnect a variety of instruments—such as signal generators, multimeters, recorders, card readers and computers—simply by plugging in cables. Any of the connected instruments could control or

feed information to up to 14 other connected instruments.

All manufacturers of program-mable or systems-oriented equipment would have to conform to the interface or risk incompatibility between their equipment and that of other manufacturers.

The interface system—as initially proposed—is identical to one designed and developed by Hewlett-Packard, and described in its *Journal*, Vol. 24, No. 2, Oct., 1972. Basically it is a byte-serial, bit-parallel system in which each multiple-bit byte of information is transmitted in parallel and bytes are transmitted serially.

Only 15 lines are required: Eight are reserved for data input/output, three for data transfer control and the remaining four for general bus management.

However, the data-transfer-control portion, called the three-wire handshake, is proprietary to HP. Thus its adoption would require licensing agreements with HP. Don Loughry, corporate interface engineer for HP—and one of the developers of the interface—states that HP will certainly license the technique and make it available to everyone. But the details of the license have yet to be worked out.

Faulks feels that whatever form the interface takes, it will be substantially completed by this summer, although not yet officially adopted. This means, Faulks explains, that there will be very little risk of substantial changes after this summer, and that he'll be confident in recommending that General Radio go ahead with the interface hardware. Other companies, he continues, will probably also follow suit.

Minicalculator to become 'major market'

The enthusiastic acceptance of the pocket calculator last year is continuing to build at a healthy pace, boosting the miniature electronic device into "one of the hottest consumer markets around—and one in which the Japanese are not yet ready to compete"—according to panelists at the "Outlook 73: Calculators" session of the Winter Consumer Electronics Show in Chicago this week.

"The U.S. market will absorb

eight to 10-million units," according to Herbert Barnett, national marketing manager of Commodore Business Machines, Santa Clara, Calif. "The rest of the world will take another two million."

Both Barnett and Robert Beachler, vice president of operations for Craig Corp., Compton, Calif., predict that most of the 1973 crop of small calculators will cost the consumer from \$59 to \$69.

Variations of the pocket calculator expected to appear this year include a slightly larger, more versatile desk-top minicalculator to cost from \$69 to \$74, Barnett predicts, and calculators with expanded memories for from \$100 to \$120.

The next big development in the minicalculator line, though not expected before 1974, will be a true electronic desk-model printing calculator with standard vertical printout, says Commodore Business Machine's Barnett. The only one available now, which is built by Canon, prints out a non-conventional horizontal serial form similar to ticker tape.

The reason the U.S. won't have to contend with Japanese competition right away is "because they are a year behind the U.S. in their technology," Barnett says. "There's only one chip manufacturer in Japan."

Users demand and get higher reliability ICs

Increased pressure by manufacturers for more reliable integrated circuits at lower costs has spawned efforts by a number of companies to meet their demands. Signetics' program is called Supr Dip, Texas Instruments has REL II, National Semiconductor calls its program Test, Motorola has Sentry and Raytheon also has a strong program.

News Briefs

The American Stock Exchange in New York City has an infrared transmission system that carries transaction data from the roof above the exchange floor to a computer complex two blocks away. The system, which now handles 5400 characters a second, may be expanded to carry 25,000 this year.

The users desire for guaranteed, factory-made reliability, according to Richard Kramer, National's manager of reliability engineering, is to avoid the expense of having to inspect ICs as they are bought. More important, Kramer notes, is the time and money wasted in reworking printed circuit boards where faulty ICs are used. Also, manufacturers have to worry about warranties and servicing, both expensive and time-consuming.

To overcome these problems, says Kenneth La Barbera, marketing manager for Signetics, Supr Dip was initiated, which resulted in a new category of IC that falls in between the military and commercial devices, both in cost and performance. For an additional 5 to 8¢ per IC, a customer can get a plastic device that has a guaranteed AQL (accepted quality level) of 0.15%, has undergone several visual inspections, thermal shock and electrical and high temperature functional testing.

The program has been so widely accepted, reports La Barbera, that "we plan to come out with a new version of it—Supr Dip II."

National Semiconductor also plans to come out with a new version of its Test program this quarter.

Texas Instruments' distributing arm, TI Supply, has just introduced its high reliability REL II program, which in addition to performing additional tests, provides for a 168-hour power burn-in to eliminate devices that fail early. It provides devices with an AQL of 0.25% and costs an additional 25¢ per unit.

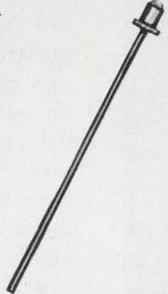
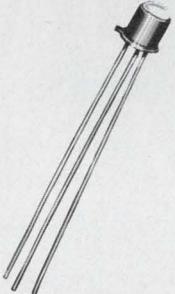
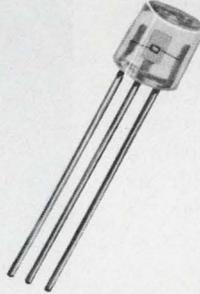
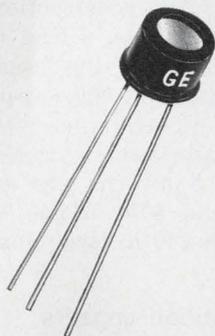
Motorola Semiconductor is about to introduce its Sentry program for consumer ICs. It differs from some of the other efforts in that its main emphasis is on meeting critical environmental requirements.

A publishing company, Gannett of Rochester, N.Y., has invested more than \$2.5-million in R&D on a system for producing printing plates through multiple laser-beam applications. The process would eliminate the need for a photographic negative, line-casting machines or other metal composition procedures.

GENERAL ELECTRIC

OPTOELECTRONIC

DETECTOR LINEUP

				
<p>L15A SERIES</p> <ul style="list-style-type: none"> ● hermetic phototransistor ● packaged for printed circuit board mounting 	<p>L15E SERIES</p> <ul style="list-style-type: none"> ● hermetic phototransistor ● sensitive, fast switching ● for detector arrays 	<p>L14A SERIES</p> <ul style="list-style-type: none"> ● hermetic phototransistor ● 3 μsec turn on, turn off <p>L14F SERIES</p> <ul style="list-style-type: none"> ● hermetic photodarlington ● high sensitivity <p>L1V SERIES</p> <ul style="list-style-type: none"> ● hermetic "SCS" 	<p>L14D SERIES</p> <ul style="list-style-type: none"> ● photodarlington configuration ● high sensitivity <p>L14E SERIES</p> <ul style="list-style-type: none"> ● phototransistor ● typical 3 μsec turn on <p>L14T SERIES</p> <ul style="list-style-type: none"> ● PNP photo switch 	<p>L8, L9 SERIES</p> <ul style="list-style-type: none"> ● hermetic photosensitive SCR ● switches 1.6 amp

OUR NO. 1 GOAL:
TO MAKE
GENERAL ELECTRIC
YOUR BEST BUY



AVAILABLE NOW FROM
YOUR AUTHORIZED
GENERAL ELECTRIC
DISTRIBUTOR

The low-cost, low-power laser: It's here, there, everywhere

Some six or seven years ago laser designers convinced the construction engineer to lay aside his \$5 ball of string and try using a gas laser for making straight lines.

The helium-neon laser, with its pencil beam of light might cost a little more, but it is more accurate, saves time and requires fewer people to do the job.

After the construction industry discovered this, a host of new industries joined the laser club, and more than 100,000 low-power, low-cost, CW helium-neon lasers have been sold—lasers with a power output of 5 mW or less and costing less than \$750. Some sell for as little as \$40 in large quantities.

Competition appears

Low-power lasers are high-power business today, and prospects are that the major growth still lies ahead. The result has been the rise of new laser types and a growing applications struggle between competitors.

About two years ago a low-cost gallium-arsenide semiconductor injection laser became commercially available.

Not able to emit a pencil-like beam, and therefore not suitable as a "straight edge" for alignment jobs, the semiconductor injection laser is finding applications in short haul communications, military ranging devices, security systems, special illumination for battlefield imaging systems and in many jobs in the laboratory.

Ranging in price from \$9.60 to \$950, more than 50,000 low-cost gallium arsenide semiconductor injection lasers have been sold, says



Helium-neon construction lasers, like this Metrologic system, are becoming more versatile.

RCA's product marketing manager for the devices, T. J. Grabowski in Lancaster, Pa.

A third laser, which appeared commercially about four years ago and has sold close to 1000 units, is the helium cadmium. Not quite "low cost" but getting close to that goal, this gas laser emits a blue (4420 Å) or ultraviolet light (3250 Å) that has attracted users who need to write on emulsions and films.

Its advantage over the HeNe laser is that available photosensitive papers are more sensitive—faster—in the blue-green region than in the red, thus making the HeCd laser handier for writing than the HeNe. The HeCd has a big advantage over the Argon laser, because it's cheaper and has better photosensitive paper available for its blue light than the Argon does for its green.

In the jockeying for market position, helium-neon laser has proved it can do far more than define straight lines for highway construction, bricklaying, tunneling, the laying of pipes and—when beamed through a rotating prism—the building of ceilings. HeNe lasers are also being used in the following applications:

- Alignment work. Engineers are using the lasers to align gun positions and antennas on ships and align wheels and other points on automobiles. And now that the devices have become so inexpensive, they are even being bought by small auto-repair shops where damaged car and truck bodies are straightened.

- Testing and precise measurements. Glass and sheet-metal manufacturers find HeNe lasers useful for nondestructive testing—for blemishes as large plates pass down a production line, for example. The lasers are also used for making flow and machine-tool distance measurements, for gauging thickness, for positioning automated machines, for inspecting large prisms and lens and for optical tooling operations.

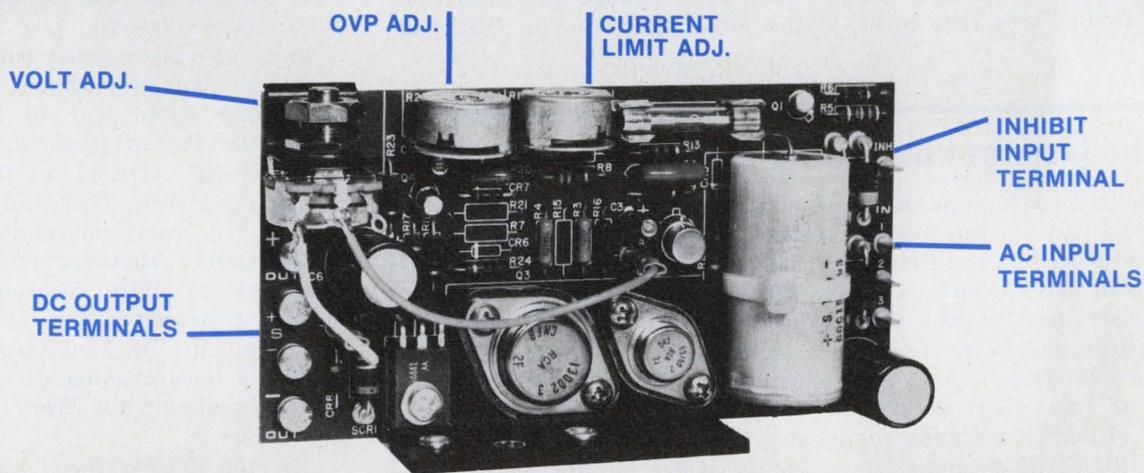
- Scanning. The gas lasers scan production lines to keep quantitative records on output. And they can read bar-code patterns on packages and letters and on supermarket products at the checkout counter, adding up totals and keeping inventories.

- Data processing. Lasers for character recognition for computer readouts "will eventually dwarf the laser market provided by the construction industry," says Philip H. Vokrot, manager of market planning for lasers at RCA's Electronic Components Div. in Lancaster, Pa. And Richard Roemer, manager of laser product sales at the Hughes

John F. Mason
Associate Editor

YOUR IN-HOUSE POWER SUPPLY IS ON OUR SHELF

25 WAYS



NEW, UNIQUE LOW COST BUILDING BLOCKS WITH BUILT-IN RECTIFIER, FILTER, REGULATOR AND OVP.

25 models, 5 power packages, up to 30v, up to 18a. Direct electrical connection to a transformer and mounting to a heat sink completes a quality d.c. power supply that meets your specific needs at the lowest possible cost.

OTHER EXCLUSIVE FEATURES:

- Regulation: Line/Load $\pm 0.075\%$
- Logic Inhibit Function
- Hermetic Transistors
- Remote Sensing
- Computer Grade Capacitors

No need to add external components.

No bag of parts: Everything you need for In-House use is already built-in. Write for new 8 page **Sub-Modular Power Supply brochure with do-it-yourself specifier** for In-House applications.

CUSTOM DESIGNS

Also these new standard sub-modules are ideally suited for custom designs at low costs and fast delivery. Custom designs are standard practice at Powertec.

SUB-MODULES OUTPUT RATING CHART AND PRICES.

MODEL	-100		-200		-300		-400		-500		PRICES*
	5V to 6V		8V to 10V		12V to 15V		18V to 20V		24V to 28V		
22A	1.0A	.875A	.725A	.625A	.575A	.500A	.475A	.450A	.425A	.400A	\$15.00
22B	3.0A	2.5A	2.2A	1.9A	1.7A	1.5A	1.4A	1.3A	1.2A	1.1A	18.00
22C	6.0A	5.2A	4.4A	3.8A	3.4A	3.0A	2.8A	2.6A	2.5A	2.3A	25.00
22D	12.0A	10.4A	8.8A	7.6A	6.8A	6.0A	5.6A	5.2A	5.0A	4.7A	35.00
22E	18.0A	15.6A	13.2A	11.4A	10.2A	9.0A	8.4A	7.8A	7.5A	7.1A	40.00

Typical ordering information for 5V, 1.0A, Model 22A-100; and 12V, 6.8A, Model 22D-300, etc.

*Consult factory for prices at other quantities.

POWERTEC INC. an Airtronics Subsidiary

9168 DeSoto Ave., Chatsworth, California 91311 • (213) 882-0004 • TWX (910) 494-2092

POWERTEC

INFORMATION RETRIEVAL NUMBER 21

Aircraft Electronic Dynamics Div. in Torrance, Calif., says: "A single customer might need tens of thousands of such units a year."

■ **Communications.** Gas lasers can carry large amounts of information, audio and video, and they have an excellent potential for short-haul data links, says R. A. Jeuch, engineering leader for RCA's Gas Laser Development in Lancaster, Pa. He points out the advantage of using a laser link at a football stadium to transport television signals to a transmitter van. "At a big game, 25 miles of cable might be needed," he notes. "At \$1 a foot for cable, a laser would do the job for far less money."

Other applications for the HeNe laser include holographic recording for checking filed data—such as the validity of credit cards (see cover

photo)—spectroscopy, particulate sampling in a pollution detection device, ranging systems and optical displays.

"Two applications with promising futures are noncontact printing and, in the home entertainment field, video playback systems to be used with home television sets," says Hughes' Roemer.

How HeNe lasers are made

The fundamental ingredient in most helium-neon lasers is a tube that is rugged and stable and can be mass-produced. Hughes and Spectra-Physics in Mountain View, Calif., have both substantiated tube lifetimes of more than 15,000 hours.

The tubes are, with a few exceptions, of a coaxial design—one of the key breakthroughs that took

the laser out of the laboratory and into the field. Developed and patented by Hughes, the coaxial construction resulted in a rugged, smaller tube. Another breakthrough, developed by Bell Telephone Laboratories, was the cold cathode-ray tube, which cut the need for heaters and permitted the use of an inexpensive power supply.

Some manufacturers offer tubes that are environmentally sealed in aluminum cylinders with end caps and flexible power cords, ready for operation. The cylindrical configuration of the laser heads permits easy mounting in clamps, V-blocks, rings and other hardware.

Permanent factory alignment of the output beam so it is concentric with the cylindrical mounting surface simplifies alignment of the laser relative to other components in the user's system.

The HeNe laser comes both as a neat and complete package, including power supply, or in components for the original-equipment manufacturer (OEM) to put together. At present most OEMs prefer to buy components and put them together. However, the trend, according to Marc Eliason, vice president of marketing of C W Radiation, Inc., in Mountain View, Calif., is toward assembly of custom packages by the laser makers for OEMs.

"In the future the OEM will know more what he wants and will tell us what the complete package is to be," Eliason says.

Hughes foresees demand for complete systems, including the laser power and optics.

At present there is a wide variety of laser ruggedness that the OEM can choose from. There are units for construction work that are protected from dust and heat and vibration and there are less rugged lasers for use in laboratories.

Available HeNe lasers operate in various modes. One is the TEM₀₀ mode, which offers the greatest concentration of light in the exact center of the beam. There are also random modes, which concentrate the light anywhere in the beam. According to Hughes, approximately 95% of OEM orders specify TEM₀₀. One reason is that this mode has roughly half the beam

(continued on page 28)

How the laser got out of the lab and into the field

How did a revolution in lasers take place in just seven years? Wasn't the laser an invention in search of an application?

"The laser used to look like some kind of plumbing facility with electrode arms sticking out all over it," says P. H. Vokrot, manager of market planning for lasers at RCA's Electronic Components Div., Lancaster, Pa. "It had gas reservoir bottles and a heater for its hot cathode—all of which made it too unwieldy to package."

Two breakthroughs were responsible for the helium neon laser's emergence from the laboratory into the field:

1. In 1965 the cold cathode became available. It eliminated the need for the hot cathode and all its accessories.

2. In 1966 the laser's two cavities—plasma and optical—became one.

Originally the gas laser was built with a plasma tube that was sealed at each end by Brewster windows. Two mirrors were used for the lasing action, but they were placed outside the tube. Then it was discovered that the mirrors could be put directly on the plasma tube,

permanently positioned and aligned, thereby significantly reducing the manufacturing cost.

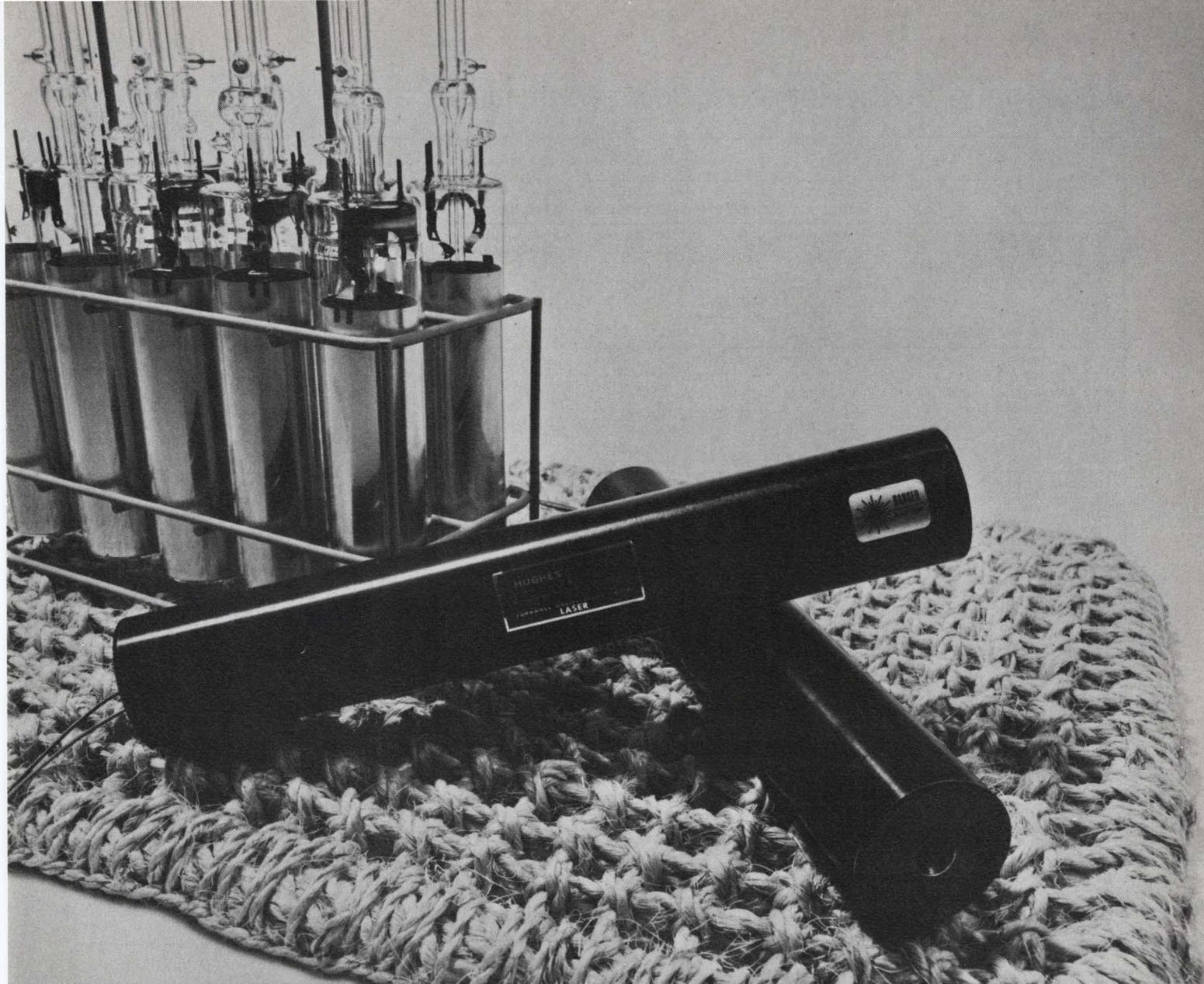
The semiconductor injection laser came into its own in 1970.

"The development of the single heterojunction structure reduced internal losses of the photons generated in the laser diode cavity, which cut the power requirement in half and provided longer life," says Richard Glicksman, RCA's manager of solid-state emitters, in Lancaster, Pa.

End coatings were also developed to reflect the radiation from the rear face of the diode—an area that previously was not utilized. This resulted in increased output of approximately 40% at room temperature and nearly 100% at cryogenic temperature.

GaAs crystal and epitaxy process improvements helped, too. They resulted in prolonged life, uniform radiation from the junction and lower cost through better yields.

The center wavelengths were extended to a range of 8000 to 9000 Å by the use of gallium-aluminum-arsenide diode structures. This permitted greater over-all system sensitivity.



The low-fat lasers. Now they come in rugged new packages, too.

We already streamlined the product, giving you all the minimum daily OEM requirements at a low, fat-free price.

Now we've gone to work on the packaging.

We've encased our bare-bottle helium-neon lasers in cylindrical metal packages and added them to our line of low-fat lasers.

The new models offer one or two milliwatts of polarized or unpolarized output power. They come with flying leads

and an internal ballast resistor and have the output beam precision aligned with the 10½" package.

We've built unusual tube ruggedness into these new models. With package construction that allows the lasers to be used in systems without worrying about high-voltage exposure or mounting directly to a glass surface.

These units come at low-calorie prices, too. Available in minimum quantity of 10, from \$139.95* each and from \$99.95* a

unit in lots of one thousand. With them, you get an 18-month, no-hour limit OEM warranty.

Bottle-only lasers or packaged lasers. Hughes gives you the best of both, along with delightfully slim pricing.

For complete information, write:
3100 W. Lomita Blvd., Torrance, CA 90509.

*U.S.A. and Canada

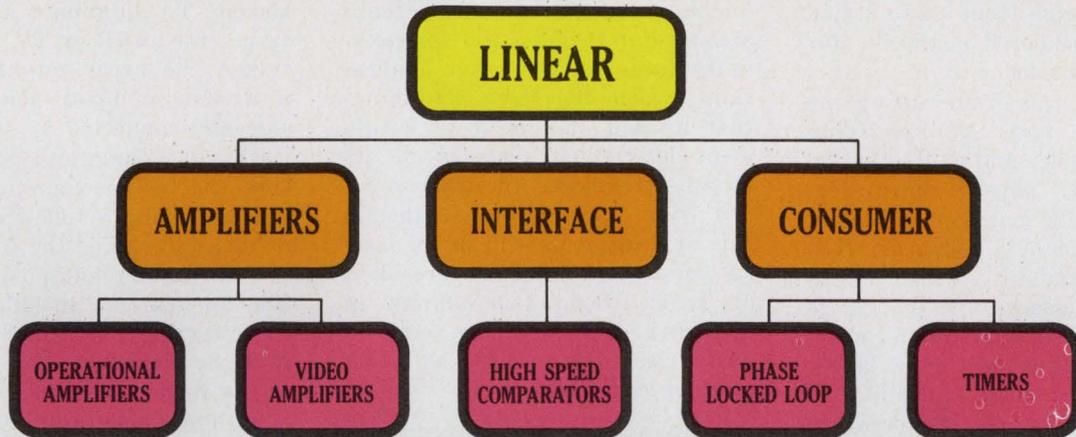


A sampling of the low-cost, low-power lasers available

Helium neon lasers							
Manufacturer	Power Range	Wavelength	Modes	Output	Power supplies	Packaging	Price range
Coherent Radiation 3210 Porter Dr. Palo Alto, Calif. 94304 (415) 493-2111 Contact: Carl Jordan General Sales Manager	1.5 to 5 mW	6328 Å	TEM ₀₀	Polarized Unpolarized	12 V dc	Components or complete laser.	\$250 to \$575
C W Radiation 111 Ortega Ave. Mt. View, Calif. 94040 (415) 969-9482 Contact: Marc Eliason Vice President	0.5 to 5 mW	6328 Å 11520 Å 33910 Å	TEM ₀₀	Polarized	12 V dc 115 V ac 220 V ac	Self-contained, weather-proof, detachable laser heads. Packaged systems.	\$99.50 to \$700
Hughes Aircraft Electron Dynamics Div. Torrance, Calif. 90509 (213) 534-2121 Contact: Dick Roemer, Sales Mgr. Eric Hass, Asst. Sales Mgr.	1 to 5 mW	6328 Å	TEM ₀₀	Polarized Unpolarized	12 V dc 115 V ac 220 V ac	Laser and power supply separate. Complete laser or components.	\$40 to \$280
Metrologic Instruments 143 Harding Ave. Bellmawr, N.J. 08030 (609) 933-0100 Contact: Larry D. Adams Program Manager	0.5 to 5 mW	6328 Å 11520 Å 33910 Å	TEM ₀₀ Random	Unpolarized	12 V dc 115 V ac 220 V ac	Complete lasers or tubes.	\$87 to \$275
RCA New Holland Avenue Lancaster, Pa. 17604 (717) 397-7661 Contact: P.H. Vokrot	1 to 5 mW	6328 Å	TEM ₀₀ Random	Polarized Unpolarized	12 V dc 120 V ac	Power supply separate or combined.	\$110 to \$440
Spectra-Physics 1250 W. Middlefield Mt. View, Calif. 94040 (415) 961-2550 Contact: Ron Elchesen	0.5 to 5 mW	6328 Å	TEM ₀₀ Highly multi-mode	Polarized Unpolarized	115 V ac 220 V ac	Laser and power supply separate or combined.	\$99.50 to \$675
Helium cadmium lasers							
Coherent Radiation (Same as above)	1 to 10 mW	4416 Å 3250 Å	TEM ₀₀	Polarized Unpolarized	12 V dc	Components or complete laser.	\$1600 to \$1750
Metrologic (Same as above)	3 to 25 mW	4420 Å 3250 Å	TEM ₀₀	Polarized Unpolarized	115 V ac 220 V ac	Complete laser.	\$780 to \$1080
RCA (Same as above)	5 mW	4416 Å 3250 Å	TEM ₀₀	Polarized	108 to 132 V ac	Complete system.	\$1725 to \$2125
Semiconductor injection lasers							
Manufacturer	Peak power	Wavelength	Output	Configurations	Power supplies	Packaging	Price range
Laser Diode Labs 205 Forrest St. Metuchen, N.J. 08840 (201) 549-7700 Contact: Robert Gill Vice President	Diodes 4 W to 60 W Stacks 25 W to 175 W Arrays 60 W to 1000 W	GaAs 9040 to 9050 Å GaAlAs 8000 to 8700 Å	Unpolarized	Discrete diodes Stacks Arrays	28 V dc 120 V dc Pulse generators and converters.	Laser and power supplies separate. Transistor type packaging.	Discrete diodes \$9.60 to \$95 Stacks \$55 to \$230 Array \$130 to \$2340
RCA Electro Optics Products New Holland Ave. Lancaster, Pa. 17604 (717) 397-7661 Contact: R. Swarbrick	1 W to 1000 W Diodes 1 W to 50 W Stacks 25 W to 100 W Arrays 25 W to 1000 W	GaAs 9040 Å at 27 C GaAlAs 8500 Å at 27 C	Partly polarized	Discrete diodes Stacks Arrays	Power supply not provided.	Transistor type packaging.	Discrete diodes \$10 to \$100 Stacks \$50 to \$250 Array \$50 to \$1000

(continued on page 30)

Economy: First Class



SIGNETICS LINEAR. First with phase locked loop! First with the universal IC timer! First with the Schottky-clamped comparator! Plus a solid line of standard-busters in between.

Class tells. In vastly extended design capabilities. In pared down device costs and function consolidation.

Old shoe linear gets the boot at Signetics. We never leave well enough alone. And from this commitment has come industry-shaking innovations. Spectacular enough to set new technological standards. Practical enough to expand your options without penalizing system design, compatibility or efficiency. But with so much versatility built in, the flexibility of each component reduces circuit count.

Phase Locked Loop. The world's first PLL devices eliminated tuned circuits altogether when Signetics put complete systems on a chip. Operating from dc to 30 MHz, our PLL invention has proved extremely versatile—useful for AM and FM demodulation, frequency multiplication and division, or frequency sensing (tone decoding). With no precision components required. Signetics ships the broadest PLL product line available anywhere: circuits 560, 561, 562, 565, 566, 567 now on the shelves.

555 IC Timer. The world's first standard timer has intrigued countless designers with time control on their hands. Low-cost, easy to use, Signetics 555 functions interchangeably as a resettable time delay, sequencer, power modulator or oscillator. So multi-applicable, you can't help turning creative yourself.

527/529 High Speed Comparator. A real two-in-one breakthrough, still another Signetics first. The fastest, least cantankerous voltage comparator to hit the market when introduced last year. The biggest improvement in comparators since the 710 (300% faster). By incorporating Schottky technology into 527/529, both high speed and precise input characteristics are maximized. Offering users a new generation of sense amplifiers as an alternate application of these devices.

When it comes to industry standards, Signetics linear shapes them up before we ship them out. So much so, they evolve into new circuits—pin-compatible but considerably

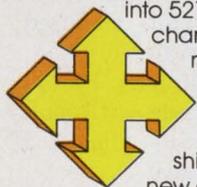
enhanced. So versatile, you can stock fewer parts yet accomplish a great deal more, while lowering total board costs.

592 Video Amplifier. Primarily applied as a magnetic head preamp for disc file read circuitry. Pin-for-pin with 733, but offering more refined performance and versatility. Proven useful for high frequency bandpass or highpass filtering because no matched passive components are required. So, less parts are needed—both inventory and board work costs go down.

531/536 Op Amps. Salt of the earth, economy-minded op amps for generalized performance requirements. The 536 FET Input Op Amp easily replaces the lower end of the modular op amp market without penalty, and saves up to 50% cost. Low-price 531 High Slew Rate Op Amp is priced under competitive devices, but functions more than adequately over most standard requirements.

540 Power Amplifier. Out-performs common power drivers with extra high speed. This Class AB audio amp on a single chip is economy-priced, but saves still more on unnecessary associated components. Output power limiting delivers total power protection and still allows smaller output transistors: less cooling is required.

Signetics: first class linear that never loses sight of budgetary needs. Far and away the most linear for the money: optimized circuits that let you do more. For less. Volume stocked now at your Signetics distributor.



Signetics-Linear 811 East Arques Avenue, Sunnyvale, California 94086		
Fill us in on Signetics economical first class linear devices. Please send:		
<input type="checkbox"/> PLL Applications Book		
<input type="checkbox"/> Linear Handbook, Vol. No. 1		
Name		
Title		
Company		
Address		
City	State	Zip
Telephone	Signetics Corporation. A subsidiary of Corning Glass Works.	

signetics
the IC professionals

(continued from page 28)

divergence of a multimode beam. This is important, because a narrow-beam divergence simplifies the optics for the total system and reduces the package size.

One specification that warrants attention, but not too much concern, is beam width. The beam diameters range from 0.6 to 2 mm, which is considered negligible for most applications.

"An OEM can often run up the cost of his laser by specifying beam divergence and width that he doesn't need," says Richard Gorton, marketing manager at Metrologic Instruments, Bellmawr, N.J.

Angular stability, which is inherent in a laser tube design, is an important specification. Imperfect construction will give lasing action but the angle will shift, so that, under given temperature variations, the beam may wander.

Polarization of the beam is offered in some lasers. This is important for system compatibility if the OEM plans to use a polarized element in the optical system—in a lens, a beam splitter or mirrors.

"If polarization is not necessary, don't ask for it; it costs more," Gorton says. But Hughes' Roemer points out: "Polarization does give better beam purity, and if this is needed, it will be worth the cost."

In general, the advice to the OEM is to tell the laser manufacturer how he plans to use the laser and the performance he requires and then let the laser specialist write the specs.

Where the semiconductor works

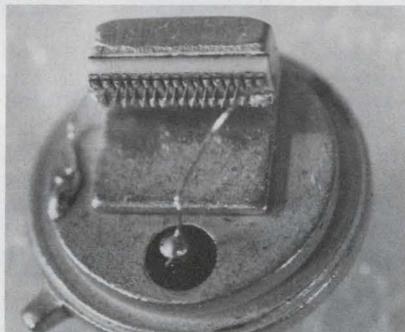
The semiconductor injection laser emits a wide beam of light rather than a pencil beam, and its emission is pulsed rather than continuous. It's surprisingly small—the size of a transistor—and it's finding many uses, particularly in short-distance operations. The applications include these:

- Intrusion alarms, Gallium-arsenide lasers are taking the place of tungsten bulb and filter systems in both military and industrial security systems. When an intruder enters the beam, he reflects light that triggers an alarm. The advantages of the laser system are lower cost, lower power drain and smaller, less detectable systems.

- Communications. Diode lasers are good for short-haul communications—between buildings, for example. And for secure communications for the military, infrared systems are finding application.

- Ranging. The military is buying small diodes for use as altimeters for helicopters, for range-finders to zero in on enemy tanks and similar targets, and for proximity fuses. In the latter applications, when the laser determines that a shell or missile is within a predetermined distance of its target, it explodes the weapon.

- Data processing. Although this application is still in its early stages, Robert Gill, vice president of Laser Diode Laboratories in Metuchen, N.J., sees the semiconductor laser being used as a device for computers.



RCA's 15-diode linear array provides a peak power output of 75 W.

Other applications that RCA and others foresee include real-time readout of holograms, collision avoidance for automobiles, traffic control, weapon simulation and "ceilometers" for measuring the altitude of clouds.

The trick for the OEM in choosing the right semiconductor laser is to order only the power he really needs, Gill says. "Engineers often ask for more power than they need," he notes.

The OEM has a wide variety of semiconductor injection lasers from which to choose. There are single-diode injection lasers, stacked diodes and diode arrays. They are made with gallium arsenide and emit in the 9040-to-9050-Å range.

Gallium-aluminum-arsenide injection lasers are also available for use with near-IR-sensitive (8000 to 9000 Å) image intensifiers and photomultipliers.

The single diodes have a peak

power range from 4 to 60 W. The stacks from 25 to 60 W, and the arrays from 60 to 1000 W. Single diodes are suitable for voice communications over short range. Stacks, which consist of two or more diodes in a stack, emit more power and are suitable for voice over longer links and for intrusion alarms. To illuminate a battlefield target for an IR or TV image converter, the array might be used; it consists of diodes placed side by side and connected by wires.

Though young, and not inexpensive, the helium cadmium laser is also gathering a following because of its ability to do the following:

- Write on photosensitive paper. The applications include information storage, particularly on film; in-flight recorders and data processing readout devices.

- Detect pollutants. Some particles are detected more easily by wavelengths in the blue region than in the HeNe's red.

- Display in full color. By use of a single 4416-Å beam to excite red, blue and green fluorescence, a full color display can be achieved.

- Conduct experiments in spectroscopy. New research in the fluorescence of microscopically small samples is possible, as are new studies of excitation and de-excitation processes of triplet states in organic molecules.

The HeCd laser is usually packaged with its power supply. The total package measures 30 to 40 inches in length and 6 by 6 inches on the sides.

The most inexpensive HeCd laser on the market, Metrologic's ML 442, emits a continuous beam of coherent deep blue light (4420 Å). The beam is randomly polarized and provides a 20-mW output in the TEM₀₀ mode. The integral mirrors are permanently aligned.

Design features include the laser's use of single isotope cadmium, a diffusion chamber for minimizing noise, and all-fused quartz-glass, sealed optics.

The tube has a directly heated tungsten matrix cathode with long life emission. Warm-up time for the laser is five minutes.

RCA offers a HeCd unit for \$1725. Hughes and Coherent Radiation are doing custom work in this field, and Hughes will soon announce a commercial line. ■■

The GI book



Here's almost everything you want to know about capacitors. Types. Specifications. Cross references. It's a real "how to" manual in an easy-to-use three ring binder. It's yours for the asking. From General Instrument ... the people who wrote the book on capacitors. Capacitor Division, General Instrument Corporation, 165 Front Street, Chicopee, Mass. 01014 Phone (413) 592-7795.



**General
Instrument**
the capacitor company

"Off the shelf" delivery from your **GI/NI** distributor.

INFORMATION RETRIEVAL NUMBER 24

OUTLOOK FOR '73

A \$4-billion hike in defense spending due, with little if any of it trickling into R&D

Defense spending is expected to increase slightly this year—by \$4-billion for fiscal 1974, if the Defense Dept.'s recommendation goes through. A total of \$80-billion is being sought. But because operating and personnel costs are also rising, it's unlikely that there will be any increase in research and development money.

Only two things would be dramatic enough at this time to cause a war-weary Congress and nation to increase arms spending significantly: a total breakdown of the SALT talks with the Soviet Union, which are intended to curb the arms buildup on both sides, or involvement in another war.

R&D and procurement will continue for what is considered to be the nation's fixed triad of strength: bombers (the B-1), Minuteman

land-based ICBMs, and submarine-launched ICBMs.

Army stressing versatility

Big Army programs include development of a large transport helicopter, a new attack helicopter, the ground-to-air SAM-D missile and a new tank.

Spending for ground and ship-based radar from the middle of 1972 to July, 1974, will exceed \$1-billion, according to a study by Frost & Sullivan, a New York-based market research firm.

Radar work is under way for the two Safeguard antiballistic missile sites, for the defense of Minuteman sites and for over-the-horizon radars.

The Army has assigned a high priority in 1973 to the improve-

ment of surveillance techniques, electronic warfare, command and control systems and communications.

Air Force looking ahead

The Air Force's Airborne Warning and Control System (Awaacs) and Advanced Airborne Command Posts will both go into the advanced development stage this year.

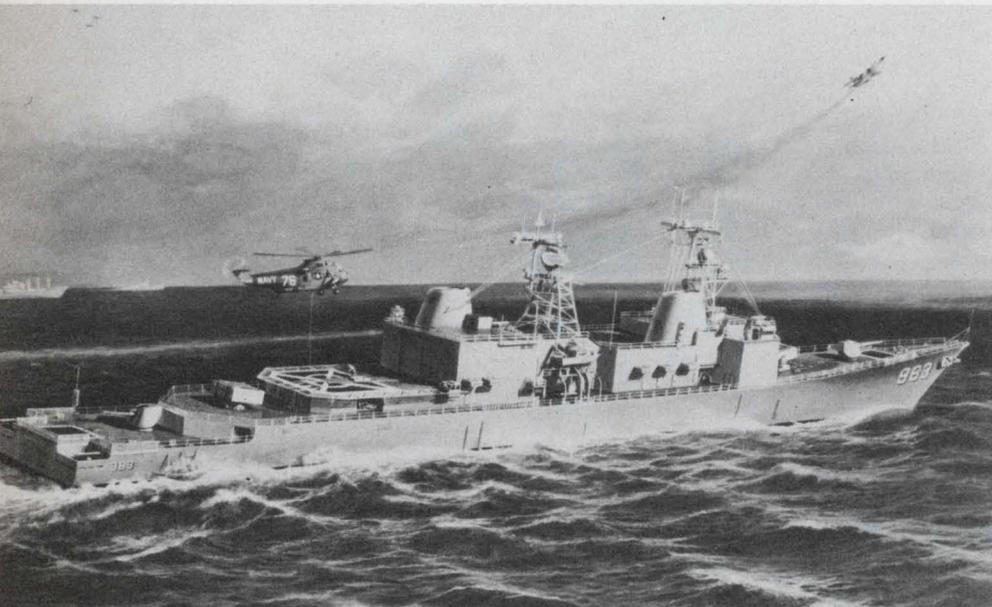
The Air Force will continue efforts to reduce the risks associated with over-the-horizon backscatter radar. It plans to develop automatic tracking and air traffic control for tactical aircraft, a new generation of highly reliable airborne uhf radios, other avionics and landing systems, including a new ground-control approach system.

Also, there will be increased emphasis on the survivability of weapons and equipment exposed to electromagnetic pulses and electromagnetic radiation. Tests are to be made after the development of electromagnetic simulation techniques. New techniques in information transfer systems will be explored, as well as advances in low-frequency communication and base security sensors.

Navy aiming to economize

For the Navy, the trend in ships is toward more inexpensive ones. Work will also continue on the DD 963 destroyers. Also in the works for 1973 is a fleet communications satellite system and a cruise missile to match the Soviet's Styx missile.

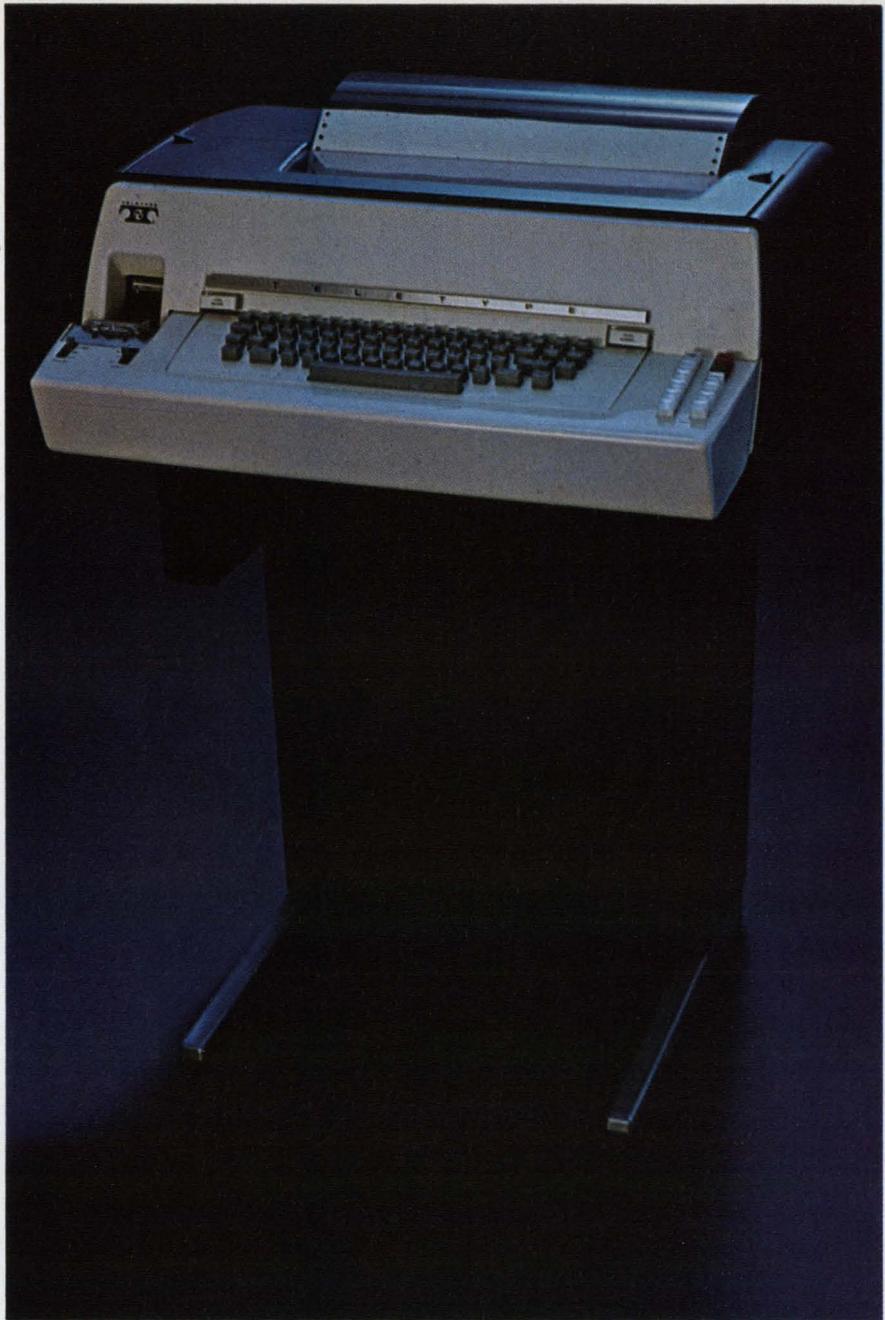
The Office of the Director of Defense Research and Engineering will attempt to overcome a number of technological deficiencies this



The Navy's Spruance class destroyer (DD 963) is being built by Litton Industries as a total system, down to the smallest black box. The contract calls for a design that leaves room for easy modifications, later innovations and new weapon systems.

Our new model 38 series.

**Even the most
expensive ASR is
a very inexpensive
\$1430.**



Teletype is a trademark registered in the United States Patent Office.

Just because you need big machine features, you don't have to pay big machine prices.

Not when you've got some new alternatives: the Teletype® model 38 series terminals. They offer a lot of features. For only a little money.

Prices for an RO model 38 start as low as \$905. KSR model 38 terminals begin at \$1168. Even ASR terminals go for as low as \$1402. And for less than \$200, you can equip any of them with a built-in, factory-tested modem.

Standard equipment on all model 38 terminals is a 132-character printing format on a 15-inch wide platen. Upper and lower case is also standard. So is two-color printing.

Speed? 100 words per minute. If you need more—up to 2400 wpm—the model 38 interfaces with the Teletype 4210 magnetic tape data terminal.

There's more, too. Like plug-to-plug compatibility with the model 33. So you can update your system without changing it.

The new Teletype model 38 series terminals. Where else can you get so much for so little?

It takes more than manufacturing facilities to build the machines Teletype Corporation offers. It also takes commitment. From people who think service is as important as sales. In terminals for computers and point-to-point communications.

That's why we invented a new name for who we are and what we make. The computer-communications people.

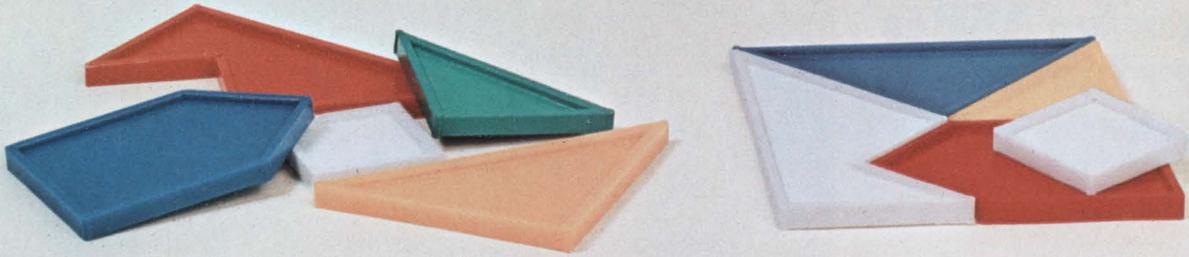


For more information about any Teletype product, write or call: **TERMINAL CENTRAL**; Teletype Corporation, Dept. 89N, 5555 Touhy Avenue, Skokie, Illinois 60076. Phone 312/982-2500

*Prices subject to change without prior notice.

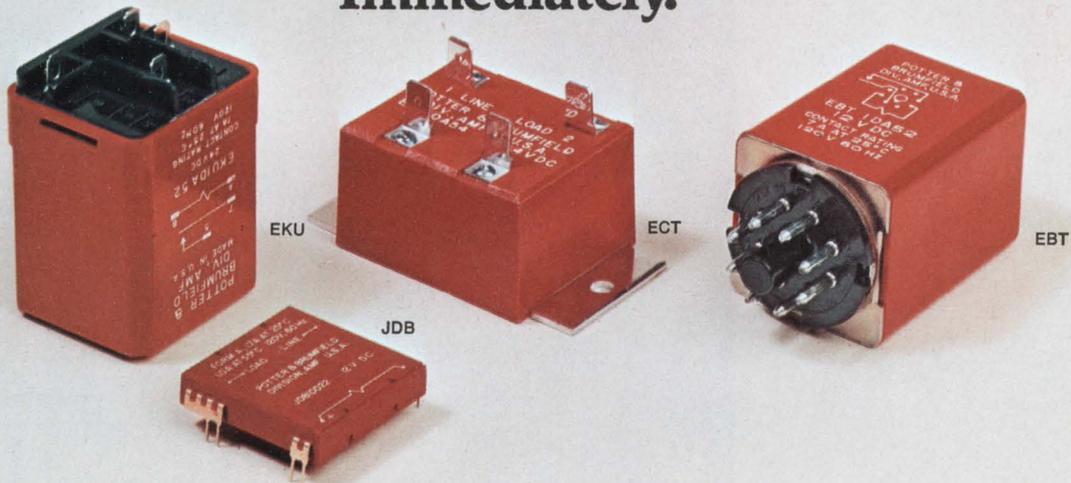
INFORMATION RETRIEVAL NUMBER 25

This problem should take you about 17 minutes to solve.



Four shapes make a perfect square.† So do five.
As an engineer, you should solve this in 17 minutes.*

With P&B's Reed-Triggered Triacs you solve critical switching, longevity and mounting problems. Immediately.



Controlled and isolated by a reed relay, these solid state AC switches provide a modern means for interfacing DC logic signals and AC-powered loads such as motors, relays, solenoids and lamps. Expected life exceeds 1 million operations so they are especially suited to highly repetitive applications.

Switching capabilities range from 1.7 to 20 A rms, 60 Hz depending upon type of package and mounting method. All have a 1 Form A (SPST-NO) "contact" as well as an internal RC network that provides dv/dt suppression. All feature the inherent long life and the ability to switch high inrush loads that characterize thyristors.

ECT Series. Steady-state rms current ratings (at 25°C) range from 2 to 20 amperes depending upon the method

of mounting. Coil voltages are from 5 to 48V DC. Power requirements are 290 mW for 120V, 60 Hz operation and 450 mW for 240V, 60 Hz. .250" quick-connect terminals are standard with .187" and .205" also available.

EBT Series. The solid-state "contact" is designed to carry a maximum load current of 7A rms, 60 Hz at 25°C ambient. This series provides the convenience of octal plug-in terminals and may be mounted in a socket having screw terminals.

JDB Series. This fully-encapsulated, low-profile (.350" height) hybrid will switch 1.7A AC loads. It is being used in modern machine tool controls, food packaging equipment and similar applications requiring DC input and AC out-put switching.

EKU Series. Rated at 7 amperes, 60

Hz at 25°C, the EKU is housed in the versatile KU-style case and has .187" quick-connect terminals. It may be mounted direct to a chassis or in a socket having screw, solder or printed-circuit terminals. A wide variety of P&B relays and solid state time delays are housed in this same case.

For complete information, call your local P&B representative or Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. 812 385 5251

**Like to try your hand at solving the puzzle shown above? Ask your P&B representative for one.*

Solving switching problems is what we're all about.



year, according to Edwin N. Myers, staff specialist in electronics sciences. Among them are these:

- Microwave tubes. "We got overcommitted in solid state microwave devices, and they won't do all we want them to do," Myers explains. "Meanwhile our laboratories dropped out of the tube business, as did much of industry."

Wanted are tubes with high average and peak power, more bandwidth—into the millimeter-wave region—and more efficiency. A typical application is for countermeasures equipment. "We're looking for new ideas and new techniques to push on into the millimeter regions," Myers says. "We haven't seen many new tube structures, so it appears that the answer will be based on conventional designs. But we'd like to see some breakthroughs."

- CMOS. The high-density package capability of CMOS interests the military, as does its low power consumption, but the devices must first be hardened against radiation.

- Semiconductor technology beyond silicon—"something to give us additional advantages in terms of speed and better infrared detectors," Myers says. "Gallium arsenide isn't the answer now, be-

cause there is no MOS technology feasible in the III to IV groups of the periodic table. What must be found is some compatible insulating material similar to silicon dioxide. We're encouraging our research people to tackle these problems."

- Magnetic bubbles. The Pentagon sees a limited military application for magnetic bubbles as replacements for tape recorders in unattended places. "For high-speed work, however, bubbles are too slow," Myers concedes.

- A nonvolatile memory—one that isn't wiped out when the power fails. The memory being used now is plated wire, "but the power consumption is too great and it is large and heavy, especially for space or airborne use," Myers points out.

- Amorphous semiconductor memories. They're being studied but have not yet been fully checked out, Myers reports. Receiving the most attention is the MNOS (metal nitride oxide semiconductor) memory. "They're attractive but there are still questions on their vulnerability to fatigue," Myers says. "If you design it for more than 10^9 write cycles, the device wears out. This limits the pro-

grammer badly. Until we solve the fatigue problem, the MNOS is not a very likely candidate for a true random-access memory."

- Far infrared. Imaging by infrared—including airborne forward-looking infrared (Flir)—has a big future in the military for night-viewing vehicles, sights for weapons, such as the TOW missile, and hand-held thermal viewers. An infrared imaging system gives a picture as good as that produced by television, and it does not require any light.

- Acoustic surface-wave devices. Basically signal-processing devices that work in the low microwave range, these devices, which are about the size of an IC, could replace pulse-compression filters in radars, delay lines and signal correlators. There are, however, still some technology problems. "We need materials that are uniquely tailored to the acoustic-wave needs to eliminate the need for a constant temperature," Myers notes. "Now, performance characteristics change with the temperature."

- Display techniques. "This spring," Myers says, "we're going to decide on the kind of large flat display we think is best and then put a lot of work into it." ■■

Industrial electronics becoming 'a way of life'; manufacturers see a year of growth ahead

Industrial electronic-equipment sales are climbing and are expected to continue to do so through 1973. This welcome observation is shared by most producers of the equipment and is based on inquiries and proposals received by them late last year.

"We expect a 10 to 20% increase in sales over 1972," says Donald Law, General Electric's manager of numerical-control operations in Waynesboro, Va. "The increase will be more in overseas sales than domestic, because Europe was slower to pull out of its recession than was the U.S. Domestic sales began to pick up in 1972 and will continue to increase, whereas in Europe they are just beginning to move."

There are several other reasons

for the over-all growth. With business in the U.S. much improved, electronics manufacturers are finding that automation equipment built for one industry—automotive or metal-working, for example—has application in other industries, such as textiles, chemical, wood-working and processing. Controls are getting smaller, smarter and cheaper. And people are losing their fear of working with sophisticated equipment. "It's become a way of life, and they're buying it," says Donald Chace, industrial product development manager for the Digital Equipment Corp. in Maynard, Mass.

Allen-Bradley in Cleveland is looking for a wider market for its computer-controlled system, which was introduced at the Ma-

chine Tool Show in Chicago last September. William Ware, the company's marketing manager for industrial controls, reports that inquiries have come in for systems for a wide variety of applications: warehousing, transfer lines, automatic assembly operations and the supervision of programmable controllers. The company is building systems now that will both supervise programmable controllers and control other aspects of the manufacturing operation at the same time.

Controllers on the move

Programmable controllers have moved out of the factory and into the gas and oil fields, says Edward Holmes, electronics production

manager for Camco, Inc., in Houston, Tex. Controllers are turning up in well-production facilities and pipelines, and Camco plans to extend the memory capacity of its current line.

Analog gas-flow computers are also gaining among gas-distribution companies, as are supervisor control systems. "Because of the energy shortage, people have to do a better accounting job of what's sold and what's available," Holmes says.

He also foresees an over-all upsurge in sales of electronic equipment for the petroleum industry because of an anticipated increase in exploration.

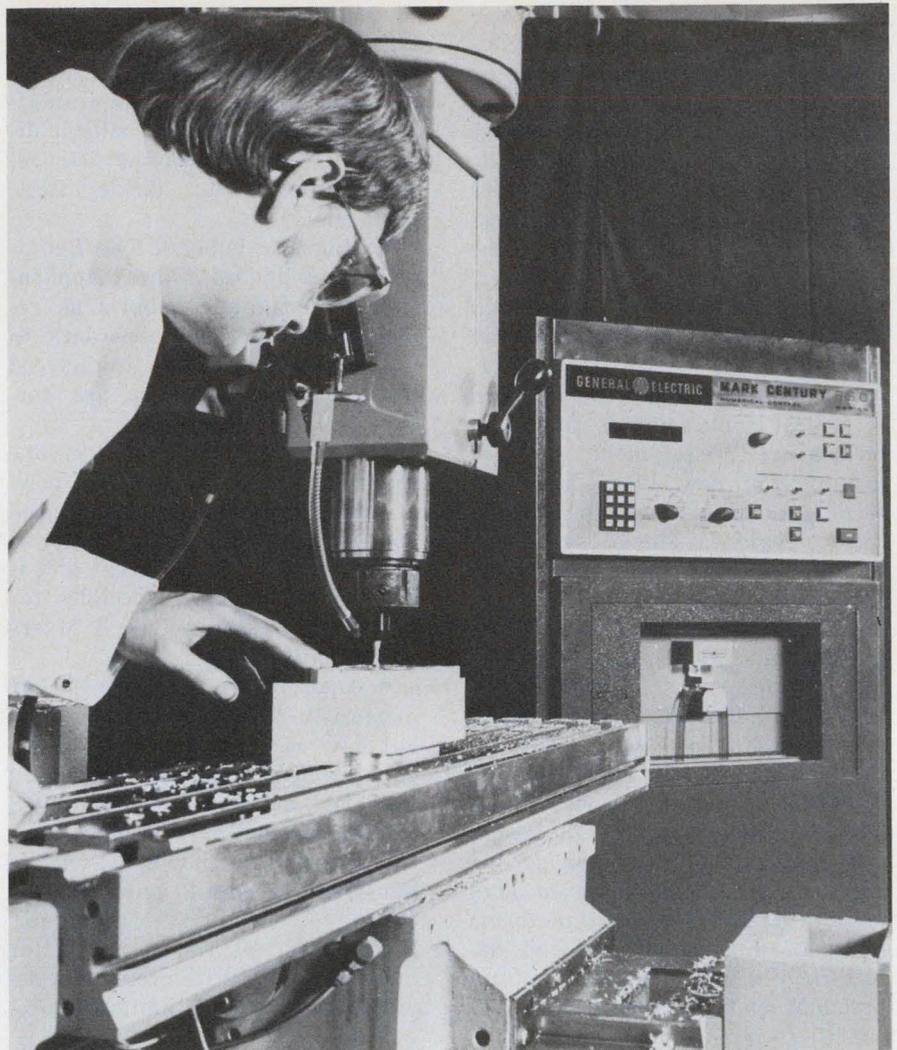
The trend in industrial controls is toward the use of more and more minicomputers and microcomputers—"toward the computer on a chip," Allen-Bradley's Ware says. "This development work will be under way this year," he continues, "with hardware expected in 1975 or 1976."

MOS and LSI are reducing the size and complexity of minicomputers. And programmable controllers are becoming more sophisticated. "Eventually there'll be a boom in small controls for industrial tools, similar to the one now for the hand held electronic minicalculators," Ware says.

Computerized numerical control (CNC) is expected to continue its lead over direct numerical control (DNC), says Allen Bradley's manager of product planning for numerical controls, L.O. Rexrode, in Highland Heights, Ohio. For the distant future, however, the company is developing a DNC system, he says.

Hardware vs software systems

Law of GE says the mix in demand for hardwired vs softwired systems will depend on how much the customer has been influenced by advertising. He sees a place for both systems. "Hardwired systems will continue to have a place," he says, "until software can be reduced to a chip—until the computer on a chip arrives. In many cases it's better to have hardware than to have to reprogram software in a minicomputer. Advertising this year may influence some people to buy software when they really need hardware."



General Electric's new Mark Century 550 Series numerical control is offered in two versions: 2 or 3-axis controls for contouring and positioning applications and 2-axis contouring controls for turning machines.

Within the automation equipment itself more electronic components will be used. A programmable solid-state interface will replace relay logic in Allen-Bradley's 4000 NC series, and DEC's Chace says that this year solid-state controls will make the biggest inroads to date into relays.

"Solid-state controls," Chace says, "will extend from the lowest level of factory automation up the hierarchy through the higher ones. This trend is coming into vogue very quickly." The reason: Solid-state controls allow machines to operate faster and offer longer life.

"Solid state is coming of age this year in all kinds of industrial equipment," says Robert A. Morgan, marketing manager for the Industrial Systems Div. at Westinghouse Electric in Buffalo, N.Y.

"One example is SCRs, which will go into adjustable speed and adjustable-frequency drive equipment—ac and dc motor controls.

"Installing SCRs in heavy machinery, some of it as large as excavation machines for open-pit mining, means going back to the drawing board.

"We're also using more cycloconverters for applications such as peak-power energy-storage systems and for load-compensation requirements."

A combination of solid-state rectifiers and converters is opening the door to a number of applications, such as fans and pumps, Westinghouse is finding.

Westinghouse agrees with other manufacturers that there is a good immediate future in computerized numerical control but not much for direct numerical control. ■■

Only Stackpole/Magsat™ keyswitches give tactile feel with n-key rollover for ultimate high thru-put speed.

Combine unique "human engineering" features with technical advances and you have the pace-setting Stackpole/Magsat mechanical keyswitch . . . new leader for data entry keyboards.

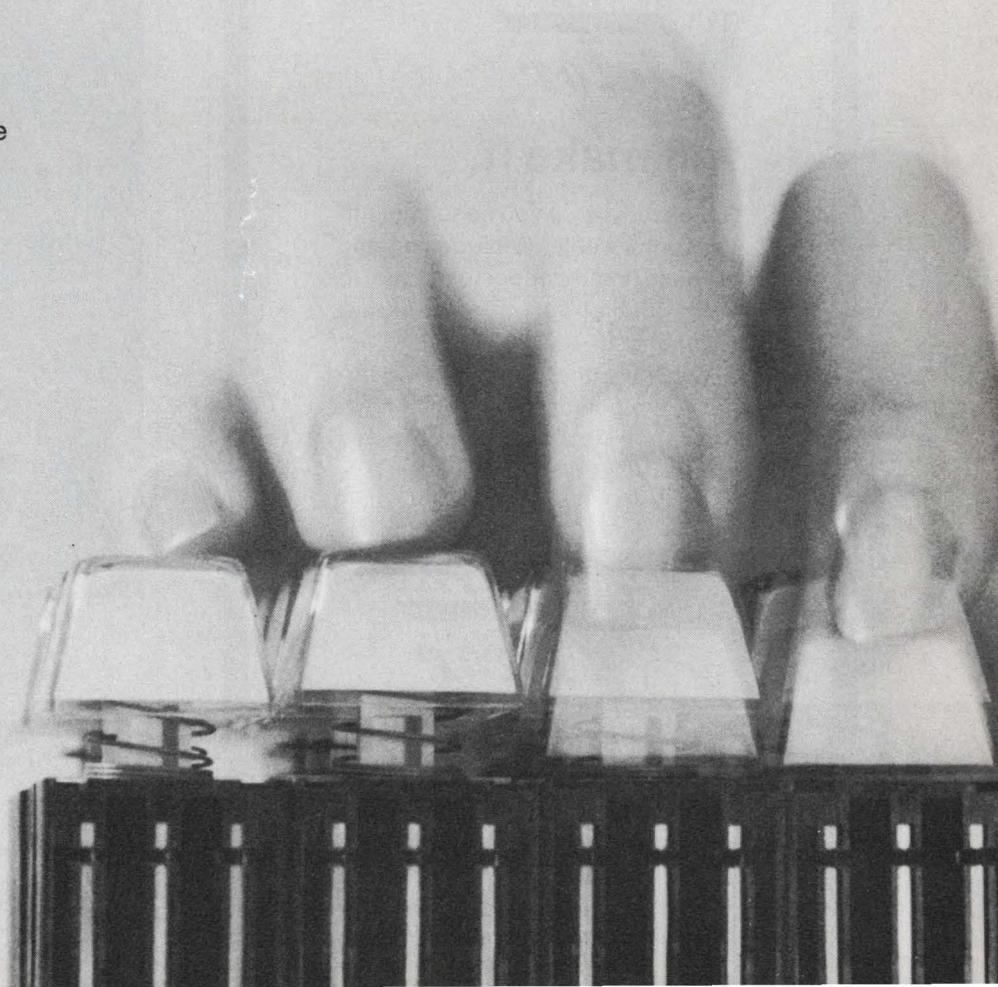
- + tactile/audible feedback and platform feel of an electric typewriter eliminate costly operator training.
- + positive trip (teaseproof) and true by-pass (n-key rollover) minimize operator errors.
- + one-shot, one millisecond pulse and dual strobed output with virtually bounce-free contacts simplify encoding.
- + open contact design requires no stand-by power, is insensitive to temperature, humidity, and stray magnetic and electrical fields.
- + Flexi-Legend™ buttons allow unlimited color and font flexibility.

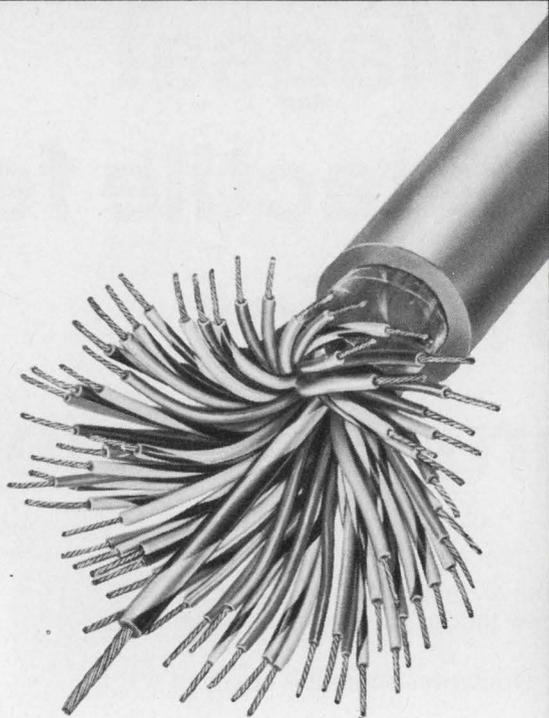
Stackpole/Magsat keyswitches or complete keyboards give data entry terminals a unique marketing advantage and the assurance of low field service costs. Write for complete information. Stackpole Components Company, P.O. Box 14466, Raleigh, N.C. 27610. Phone 919-828-6201. TWX 510-928-0520.



STACKPOLE
COMPONENTS COMPANY

INFORMATION RETRIEVAL NUMBER 27





What do you need in Multi-Conductor Cable?

Victor

will make it.

Get exactly what you need in multi-conductor cable. We'll design and produce multi-conductor cable to meet just about any individual requirement.

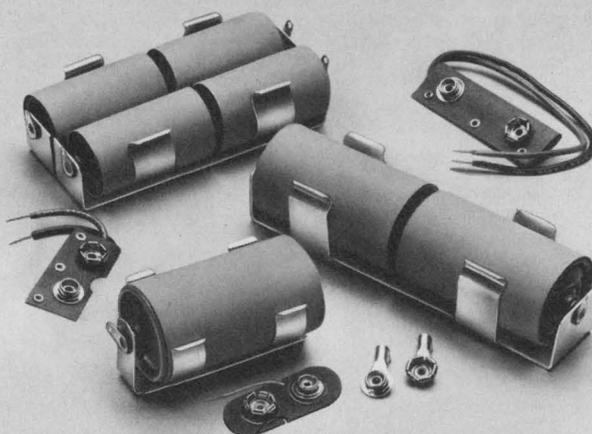
We have the plant, the equipment, the personnel and the know-how to solve your particular problem.

Victor
Electric Wire & Cable Corp.
WEST WARWICK, RHODE ISLAND

INFORMATION RETRIEVAL NUMBER 28

battery holders

PRE-TESTED · LOW COST · LIGHTWEIGHT



A complete standard line of battery holders and connectors, for use with all type batteries. Aluminum or steel nickel plated, single and multiple holders.

Free engineering service for your special custom built holders.

NEW FREE CATALOG ON REQUEST



Manufacturers of Standardized Hardware for Electronics

KEYSTONE

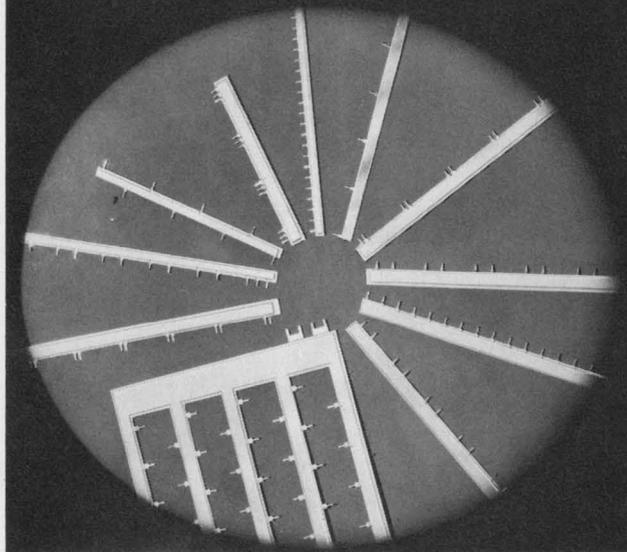
ELECTRONICS CORP.

49 Bleecker Street · New York, N.Y. 10012

INFORMATION RETRIEVAL NUMBER 29

Millions already in use

NEW KIT LETS YOU TRY IT



Evaluation kits @ \$25 in stock.
Standard parts on 2 weeks delivery, or less!
Custom parts 4 to 6 weeks delivery!

MINI-BUS The low-cost, noise attenuating, high packaging density, power distribution system for PC boards. Ask for data.

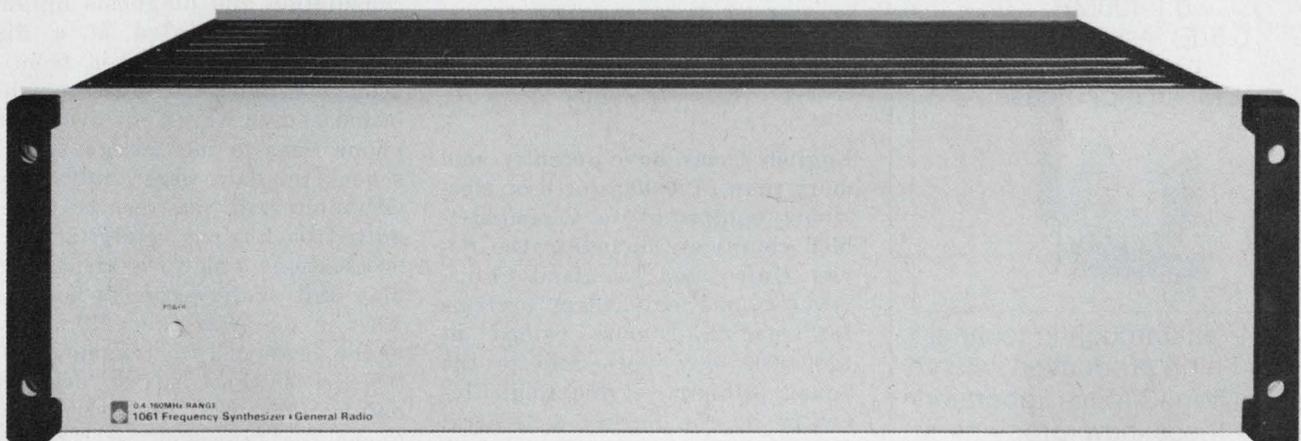


Rogers Corporation / Chandler, Arizona 85224
West: (602) 963-4584 East: (203) 774-9605

INFORMATION RETRIEVAL NUMBER 30

ELECTRONIC DESIGN 2, January 18, 1973

SWIFT*



... in fact 10 times swifter than any other comparably priced synthesizer – and that's only the beginning:

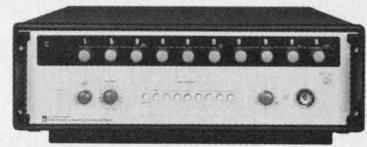
	GR 1061	Runner-up A	Runner-up B
Frequency	dc to 160 MHz	1 MHz to 160 MHz	10 kHz to 110 MHz
Switching Speed	< 100 μ s	1 ms	5 to 100 ms
Output Level	+20 dBm	+13 dBm	+13 dBm
Spurious	-80 dB	-70 to -100 dB	-80 dB
Phase Noise	-63 dB	-60 dB	-50 dB
Search-Sweep	standard	no	optional

Data current as of December, 1972

* **swift** \ 'swift \ *adj* ... quick to respond: **READY**
 Quick response, for example, means stepping the GR 1061 in 10-kHz increments from 100 to 150 MHz in under 500 ms (that's 5000 steps in less than half a second)! Not manually, of course, but by your system's programming signals.

Since your system, not your fingers, controls the synthesizer, we've left off the knobs to save you money. We've also left out the internal reference oscillator and five digits of resolution to save you some more money.

You now may be convinced the 1061 is the best synthesizer for your application, especially since the money you save means it will cost you only \$4700.



Or, you may be equally convinced we've left out too much. In that case, you can have any or all of it back because we offer an array of options to tailor the 1061 to **your** needs: A full control panel, two different reference oscillators, resolution to 10 digits, and phase-modulation capability. Stripped or full-house, the 1061 is unexcelled.



300 BAKER AVENUE, CONCORD, MASSACHUSETTS 01742 • NEW YORK (N.Y.) 212 964-2722, (N.J.) 201 791-8990 • BOSTON 617 646-0550 • CHICAGO 312 992-0800
 • WASHINGTON, D.C. 301 948-7071 • ATLANTA 404 457-2485 • DALLAS 214 234-3357 • LOS ANGELES 714 540-9830 • SAN FRANCISCO 415 948-8233 • TORONTO 416 252-3395 • ZURICH (01) 55 24 20
 • GR COMPANIES • Grason-Stadler • Time Data • Techware Computing Corp. • GR ASSOCIATE • Micronic Systems Inc.

INFORMATION RETRIEVAL NUMBER 31

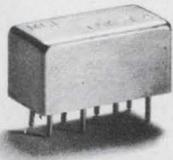
POWER SPLITTERS-COMBINERS

Great Value at

\$7.95
500 piece quantities.

\$9.95 in 6-piece quantities.

0.1-400MHz
0.5dB insertion loss
40dB isolation
EMI shielded case



A breakthrough in technology and high production volume enables Mini-Circuits Laboratory to offer these new products at an unprecedented low price.

In today's tough competitive market can you afford not to use these remarkably low priced and high performance units?

Ruggedness and durability are built in the PSC2-1. Packaged within an EMI shielded metal enclosure and hermetically sealed header. This new unit uses a broadband hybrid junction and uniquely designed matched transmission line transformers.

We invite you to convince yourself. Place your order now and check our delivery, product performance and reliability.

Mini-Circuits Laboratory

2913 Quentin Rd., Brooklyn, N.Y. 11229
(212) 252-5252, Int'l Telex 620156
A Division Scientific Components Corp.

FRANCE: S.C.I.E., *31, rue George-Sand, Palaiseau 91, France. GERMANY, AUSTRIA, SWITZERLAND: Industrial Electronics GMBH, *Klüberstrasse 14, 6000 Frankfurt/Main, Germany *UNITS IN STOCK

technology abroad

A triple-redundant computer system designed to accumulate no more than 30 seconds of downtime in five years is operational at London's Heathrow Airport. The system, called the most advanced fully automatic flight-plan-processing system in Europe, displays to air-traffic controllers the pilot's flight intentions and positions. There are provisions for rapid progressive updating of flight information for all aircraft under control. Designed by Marconi of England, the total system cost is about \$12-million.

CIRCLE NO. 441

English firms have recently sold more than \$700,000 worth of electronic equipment to Communist-bloc countries, including the Soviet Union and mainland China. Seven numerical-control systems for machine tools, valued at \$400,000, have been sold to the Soviet Ministry of the Radio Industry by the Survey & General Instrument Co., Ltd., of Kent. Each system consists of an x-y coordinate table, a television camera, a television monitor and a tape-punching machine. Radio and telecommunications equipment worth \$300,000 for use in Chinese radio and telephone factories has been ordered from Marconi Instruments, Ltd., in Herts.

CIRCLE NO. 442

A fuel cell powered from the glucose and oxygen in arterial blood has been demonstrated by Siemens of West Germany. Catalyst electrodes are embedded in a tissue-compatible porous structure. Hydrophilic membranes around these electrodes maintain catalyst activity and prevent hostile body reactions with the catalyst. In a demonstration, the experimental cell was immersed in a 7-pH glucose solution and saturated with air at 37 C. The cell, with a 12-cm² electrode area, de-

livered 100 μ W at 0.5 V. The ultimate expected use will be as a truly implantable battery for powering such devices as heart pacers.

CIRCLE NO. 443

A medical data link between the Royal College of Surgeons, London, and an exhibition center 1-1/2 miles away recently demonstrated the feasibility of bedside consultation and diagnosis by and with doctors located at a distance. Analog data taken from a demonstration patient at the exhibition center were sent over telephone lines to the college. At the school, the data were analyzed by computer and the results transmitted back along a digital communications link to a visual display unit at the patient's bedside. Also in use was the CRT Viewphone developed for telephones by the British Post Office Telecommunications unit. With the Viewphone the "surgeon" at the bedside could study X-ray charts and other graphics located at the college.

CIRCLE NO. 444

Custom-fabricated LSI arrays are now low-cost enough for low-quantity requirements, says Ferranti of England. Where development costs for LSI in small quantities were previously prohibitive, the English manufacturer has introduced a standard uncommitted logic array of 200 cells. Using the collector-diffusion-isolation technique licensed from Bell Telephone Laboratories, these arrays are prepared and held in stock as a semi-processed unit, complete except for the final aluminum interconnections. Only the final metallizing layer is needed to make each cell operational and to provide connections to external input and output circuits and power.

CIRCLE NO. 445

An incredible difference!

Nobody else makes them.



Voltage-to-Frequency, Frequency-to-Voltage Converters. Our Models 4701 and 4702, respectively. Offering high accuracy at low-low-cost. A modular concept so new that it is revolutionizing data acquisition and signal conditioning techniques.

The Model 4701 V/F converter provides precise conversion of analog data to a digital pulse train with a repetition rate proportional to the analog voltage. Linearity is typically $\pm 0.008\%$. Price: only \$51 in 100's.

The Model 4702 is the F/V converter. A perfect companion to the 4701 for unusually accurate encoding and decoding of data. Or use by itself. It provides precise conversion of Frequency-encoded information to an analog voltage whose amplitude is proportional to the frequency of the input signal. Again, linearity typically 0.008% , price \$51 in 100's.

Applications for these modules are virtually limitless, especially in process control and data acquisition and communication systems. Specific examples include isolated data conversion, phase detectors, synchronous speed controls, servo loops, flow meter transducers, optical or magnetic pickup amplifiers, and frequency monitors, to name just a few.

Get the full story from 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.

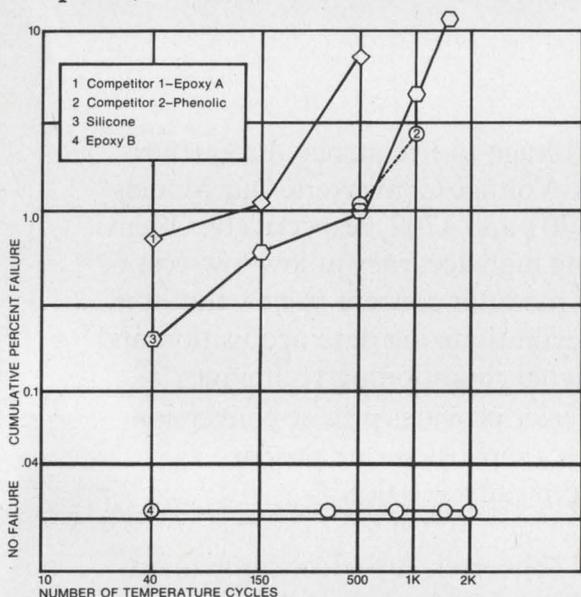
Philbrick Data Converters. The best makes the difference.

KISS YOUR THERMAL INTERMITTENT OPENS GOODBYE

Epoxy B is here.

As the molded package solution for every product we make, including all IC's and our TO-92 transistors.

Epoxy B eliminates thermal intermittent opens, for fewer field failures and

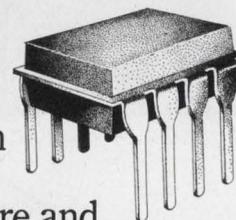


substantial savings in service calls.

You can see for yourself in the temp cycle test chart shown. The failure rate for Epoxy B even after 2,000 cycles is still zero.

In our previous ad about this development we told you that, as in the past, other semiconductor manufacturers "will soon follow our lead." And so they have.

Skeptics Test. But if you're skeptical, you need one of our Epoxy B Skeptics Test Kits. Each kit contains a bundle of data documenting tests pitting Epoxy B against alternative molded package solutions in such critical areas as moisture resistance, salt atmosphere and thermal intermittance.



Our kit also contains a chart form, pencil and free National device with which to conduct your very own temp cycle test.

For your Epoxy B Skeptics Test Kit, just call any of the sales offices listed below.

Our only restriction is that you are a bona fide purchasing agent, quality control or reliability engineer. Or for those of you who'd simply like more information, we'd be happy to send you our new Epoxy B Reliability Brochure. Call (408) 732-5000.



Or write National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051, and say goodbye to your thermal intermittent opens.

National

Scottsdale, Ariz. (602) 945-8473	Mountain View, Calif. (415) 961-4740	Sherman Oaks, Calif. (213) 783-8272	Miami, Florida (305) 446-8309	Chicago, Illinois (312) 693-2660	Lenexa, Kansas (816) 358-8102	Burlington, Mass. (617) 273-1350
Glen Burnie, Md. (301) 760-5220	Englewood Cliffs, N.J. (201) 871-4410	Syracuse, N.Y. (315) 455-5858	Chagrin Falls, Ohio (216) 247-5481	Beaverton, Oregon (503) 643-5445	Dallas, Texas (214) 233-6801	

washington report



Heather M. David
Washington Bureau

Army to improve its electronic camouflage

The Army is looking for industry help to improve its electronic camouflage and countersurveillance techniques. The research and development program will involve sophisticated techniques of disguising, blending and simulating Army weapons and their signatures, so they cannot be detected by ultraviolet or acoustic surveillance. The Army's Mobility Equipment R&D Center is searching for firms with experience in advanced computer-simulation techniques as well as broadband signature analysis and simulation, including visual, infrared, radar and acoustic modes.

AIA plan spurs talk of SST revival

A source of resuscitation for the supersonic transport program may be contained in a proposal by the Aerospace Industries Association. The AIA is asking the Civil Aeronautics Board, which is drawing up legislation to help airlines finance aircraft purchases, to add a provision for Government loans to companies doing R&D in the commercial aircraft field. Developments such as the SST and short-take-off-and-landing (STOL) craft would be candidates for loans from a \$3-billion fund in the AIA plan. Although considerable opposition to such a proposal could be expected in Congress, the AIA hopes to sell the idea on the basis that the U.S. is losing out in the world aircraft market to foreign, government-financed ventures.

Ash appointment stirs Senate countermove

Legislation will be introduced in Congress to require Senate confirmation of Presidential appointments for the post of director of the Office of Management and Budget. The move is a result of criticism of President Nixon's appointment to the job of Roy L. Ash, former Litton Industries chief executive. Critics, noting Litton's problems with cost overruns and schedule slippage in its shipbuilding program for the Navy, question whether Ash will perform any better as a Government manager. However, under the present law, Congress has no say in the matter. Attempts to cut funds for Litton's Landing Helicopter Assault (LHA) and DD-963 destroyer programs are expected when new budget proposals come before Congress in the spring.

One Navy procurement official—Gordon Rule, a civilian—testified before a joint economic subcommittee chaired by Sen. William Proxmire (D-Wis.) that the LHA contract should be terminated for default on

Feb. 28, when the Navy is scheduled to make the next decision on the program. As a result of his testimony, Rule was transferred from his job by high Navy officers.

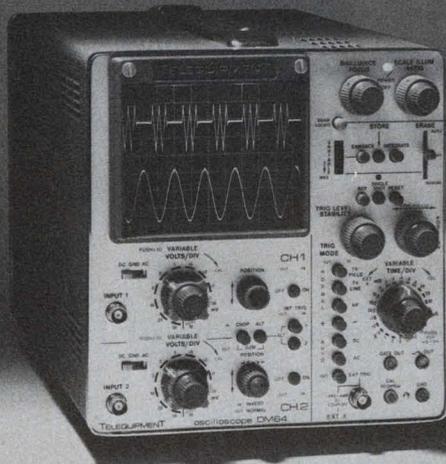
More storm clouds for F-14 program

The Navy's troubled F-14 aircraft program may face its biggest challenge from the powerful House Appropriations Committee, which with its Senate counterpart, are ultimate keepers of the Federal purse. The committee strongly criticized Navy management of the program last year, and some members were reported to be "extremely disgusted" over the service's inability to bring the contractor, Grumman Corp., into agreement on its contract. Unless the Navy does a super sales job explaining why it needs the F-14, the committee may well seek to cancel the program, sources say. The committee asked the Navy to study the possibility of adapting the Air Force's F-15 fighter, now being developed by McDonnell Douglas, but it met a wall of Navy resistance.

Capital Capsules: The National Science Foundation is pushing a program to encourage research in optical communications. Some 20 grants have been awarded to support basic studies, mostly in aspects of laser communications. . . . The Labor Dept. says it has placed 6000 professional people in new jobs through its Volunteer Engineers, Scientists and Technicians (DEST) program. The effort was set up 18 months ago to help those who had lost jobs in the defense and space fields. . . . The Electronic Industries Association estimates that U.S. electronics sales last year reached a record \$29.8-billion, almost \$2-billion more than in 1971. Within that total, the EIA says, the communications and industrial electronics segment grew 10% to about \$12.2-billion, consumer electronics reached \$6-billion, and defense and space stayed at about \$11-billion. . . . NASA wants scientists to propose instruments and experiments that can be carried on the Large Space Telescope system planned for launching in the early 1980s. Such instruments as photometers, polarimeters, astrometric instruments, infrared detectors and very high dispersion spectrographs are possible candidates. . . . The Army is planning a new research program on the biological effects of microwave radiation exposure. It will contract for experiments to simulate field exposures of both continuous and pulsed microwaves. . . . The Commerce Dept. has appointed an ombudsman to help businessmen who need assistance in their dealings with the Federal Government. He is Thomas E. Drumm Jr., Special Assistant to the Secretary of Commerce. . . . A new standard that will spell out how much vibration can be tolerated by humans in aircraft, transit systems, ships and near ground machinery of all types is nearing completion after 10 years of preparation at the American National Standards Institute. . . . The Army Combat Developments Experimentation Command is looking for a day and night, passive real-time imaging system sensitive to wavelengths from 0.4 to 10.6 micrometers and capable of reproducing scenes during bright daylight and overcast night at ranges of 5 kilometers or more. . . . A joint State-Federal survey in seven states has found serious shortcomings in safety practices in the use of potentially dangerous lasers in high school and college science classes. A laser operating with a power output of 2 mW has been reported to have produced a burn in the retina of a human eye, according to the Food and Drug Administration in Washington.

MORE
VALUE
IN

TELEQUIPMENT 
DUAL-TRACE
OSCILLOSCOPES



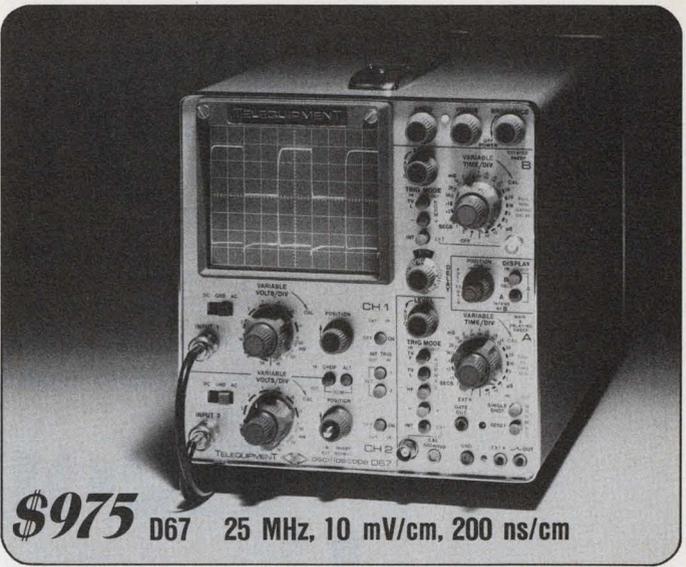
NEW

BISTABLE
STORAGE

DM64 10 MHz, 1 mV/cm, 100 ns/cm **\$1095**

The Telequipment line is growing . . . and offers you a greater selection for your next dual-trace scope. Take the new **DM64** . . . it offers 25 cm/ms bistable storage with auto erase, 10-MHz conventional operation, alternate or chopped dual-trace displays and convenient single-button X-Y operation. The new **D66** offers 25-MHz dual-trace performance and X-Y. The **D67** offers laboratory performance with delayed sweep, regulated power supplies, and 3% accuracy. The **D54** offers dual-trace convenience at lowest cost. All have triggered sweeps.

All are backed with the same warranty as other TEKTRONIX products, and are marketed and supported through an international network of Tektronix Field Offices, Service Centers, Distributors and Representatives. Call your nearest office or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.



\$975 D67 25 MHz, 10 mV/cm, 200 ns/cm



NEW

\$795 D66 25 MHz, 10 mV/cm, 100 ns/cm

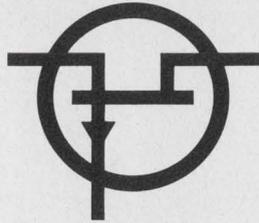


\$595 D54 10 MHz, 10 mV/cm, 200 ns/cm

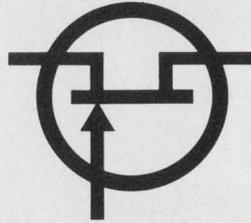
U.S. Sales Prices FOB Beaverton, Oregon

Part of the Telequipment line from Tektronix, Inc.

INFORMATION RETRIEVAL NUMBER 35



P-Channel
JFET



N-Channel
JFET

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

Economy Epoxy FETs

Siliconix, the world's leading supplier of FETs, now brings you a full line of plastic encapsulated field-effect transistors—at economy prices as low as 32c each in 1000-unit quantities. Why be concerned over alternate sources? Call on the FET leader for quality devices at rock-bottom cost.

The Siliconix line of epoxy products includes

- FETs for general purpose amplifiers
- FETs for VHF/UHF amplifiers and mixers
- FETs for switches, choppers, and commutators
- FET pairs for differential amplifiers
- FET diodes for current limiters and regulators

Use these new epoxy FETs with the same confidence you have placed in Siliconix products in the past—they are typed, manufactured, and tested specifically for the industrial and commercial markets.

A copy of our new epoxy FET cross-reference guide and full line catalog is yours for the asking. Just circle the bingo card number or call your nearest Siliconix distributor.

Write for Data



Siliconix incorporated

2201 Laurelwood Road, Santa Clara, California 95054

INFORMATION RETRIEVAL NUMBER 36

Selling is a dirty word.

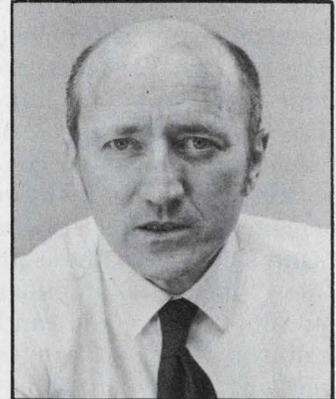
Compared with the major shows in Europe, ours in the U.S. are flops. Exhibits are dull; papers are duller; and attendance shrinks. At least in New York, show management has traditionally been slow to improve the show, though it's been zealous in policing it to see that no holy rules are violated. Some of these rules, exhibitors tell me, are perfectly asinine. One, for example, allows miniskirted girls to *stand* at the booths—but not sit down.

This year a new show management, imported from WESCON, is valiantly trying to pump new life into IEEE Intercon. For a start, the directors shifted the exhibit days to Tuesday through Friday, March 27 to 30, dropping the traditional Monday opening. This should help those who can't break away from the office on Monday. (The technical sessions still start on Monday, but not till 2 p.m.) The directors and Intercon manager Don Larson have planned other innovations. Some will no doubt help the show, others won't. But at least they have the guts and imagination to try things. They're not just watching the shows disintegrate.

It's likely that one of the toughest nuts will be a legal one. An exhibitor is not allowed to sell at the show, lest IEEE's tax status be endangered. So maybe we need to fight for new tax legislation. The furor created when Fluke sold some multimeters at WESCON would be hard to picture in Europe. The Europeans are more sensible. They design their shows for selling and buying in a convivial atmosphere.

Exhibitors there commonly provide a space where a visitor can sit with a company's engineers, enjoy a drink and something to eat, and discuss business. He can talk about technical specifications, delivery schedules and prices. And he can write an order. *WRITE AN ORDER*. What a horrible thought. At American shows we act as if writing business at a show is degrading, as if it's an imposition on an engineer to sell him something. We act as if he builds computers, television sets and communication systems with equations—and never dirties his hands with semiconductors, resistors, relays and test equipment.

Our loftiness and stupidity make our shows duller. While we try to preserve dignity, the Europeans keep looking for new ways to add sparkle, excitement, interest and usefulness. Are we smart enough to learn from them? I think so. The new IEEE Show management is intent on making this year's show a great one. It deserves our support, encouragement and thanks. I look forward to seeing you at the show.



A handwritten signature in dark ink, which appears to read "George Rostky". The signature is fluid and cursive.

GEORGE ROSTKY
Editor-in-Chief

Use current-mode IC amplifiers.

New quad versions replace conventional op amps, while avoiding dual-voltage supplies and lowering the cost and package count.

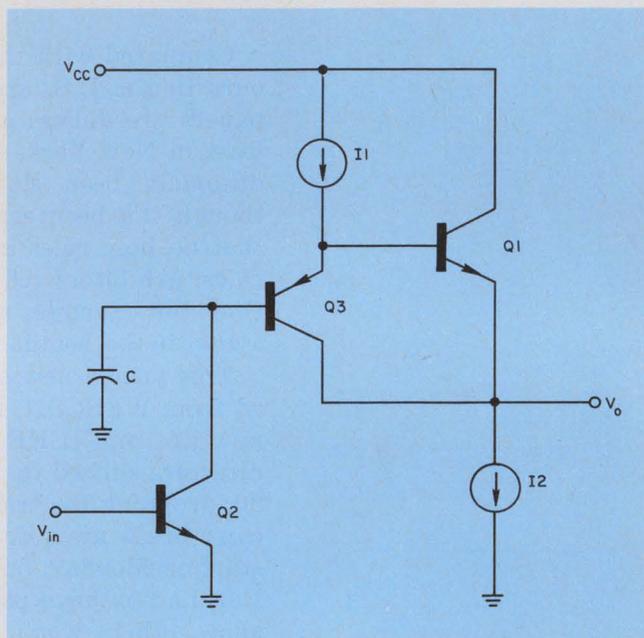
Because conventional operational amplifiers need a dual power supply—typically ± 15 V—this often poses a problem for system designers. Many systems are designed to operate from a single-power-supply voltage. If an op amp is used with the single supply, limited output voltage swings and unwanted common-mode offsets will probably result. In addition other important performance characteristics may be degraded.

One solution to these problems is provided by a new type of IC amplifier which has a current-mode input stage and can provide characteristics similar to those of conventional op amps while operating from a single power-supply line.

Amplifiers embodying this technique are already commercially available in quad versions—with four amplifiers in a single 14-pin DIP—from two manufacturers. National Semiconductor's version is designated LM3900, while Motorola has a version, the MC3401, which is very similar but not an exact replacement. Other companies are expected to provide alternative sources in the near future.

Both ICs can operate, with little change in performance, from a single voltage supply over a wide range of supply voltages. For the LM3900 the operating range is +4 to +36 V, while the MC3401 spans +5 to +18 V. The output voltage in both cases can swing from nearly ground—typically about 0.1 V—to about 80% of the power-supply voltage.

While, strictly speaking, not op amps, the new amplifiers can do the job of op amps in the vast majority of cases. The basic current-mode operation, therefore the name "Norton" amplifier, is a departure from conventional designs. Instead of using a voltage-differential input, the Norton amplifiers operate on differences in the input currents to their inverting and noninverting inputs. Many biasing advantages are thus realized. Also, because currents can be passed between the two input terminals, some unusual applications are possible. If external, large-value



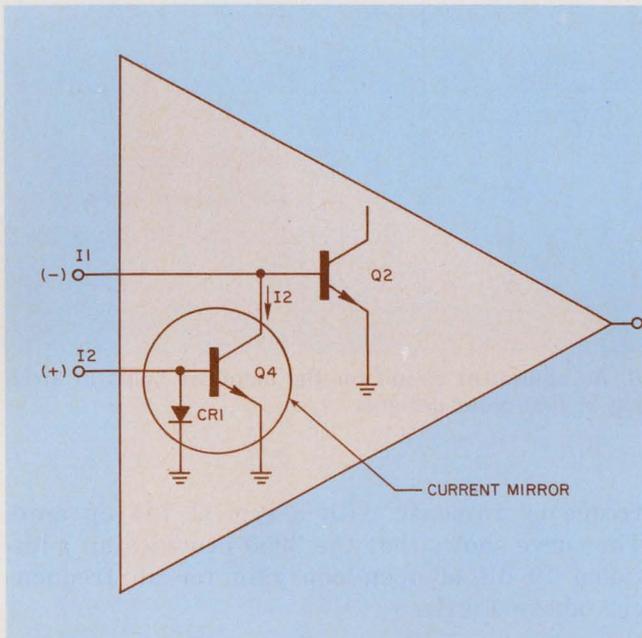
1. The basic gain stage is a common-emitter amplifier with a current-source load and emitter-follower output.

input resistors are used (input signal current can be in the low-tens of nanoamperes), standard op-amp performance can be realized.

Common emitter supplies gain

The basic gain stage is a common-emitter amplifier (Fig. 1). A large voltage gain is achieved by use of current-source loads, shown as I_1 and I_2 . The gain is stable over a wide temperature range. All of the voltage gain is provided by the gain transistor, Q_2 ; the output emitter-follower transistor, Q_1 , serves as the load driver and Q_3 acts as an interstage buffer. An on-chip capacitor ($C = 3$ pF) provides the single dominant open-loop pole that helps maintain closed loop stability. The output emitter-follower is biased for class A operation by current source, I_2 .

The gain stage can thus provide an open-loop voltage gain of about 70 dB and a large output voltage swing. However, the input current of this basic configuration tends to be larger than desired. It equals approximately the maximum



2. A differential input, using a current-mode of operation, is achieved with a "current-mirror" circuit.

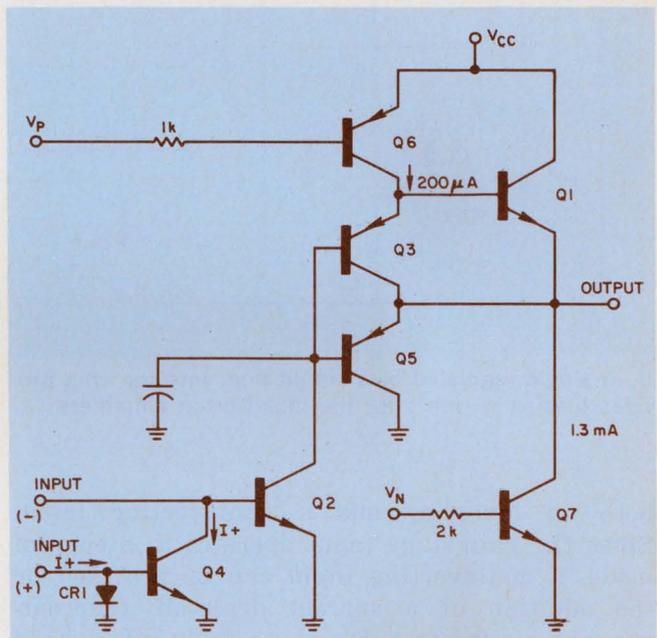
output current divided by β^2 , where β is the current gain per device. For an output current of 10 mA, the input current is $-1\mu\text{A}$, if $\beta^2 = 10^4$.

Input current can be reduced by the addition of a transistor to achieve a β^3 current reduction. If the output transistor, Q_1 , is converted to a Darlington pair, the peak-to-peak output-voltage swing is reduced. If, on the other hand, the input, Q_2 , is made into a Darlington pair, the dc voltage level present at the input would be undesirably doubled.

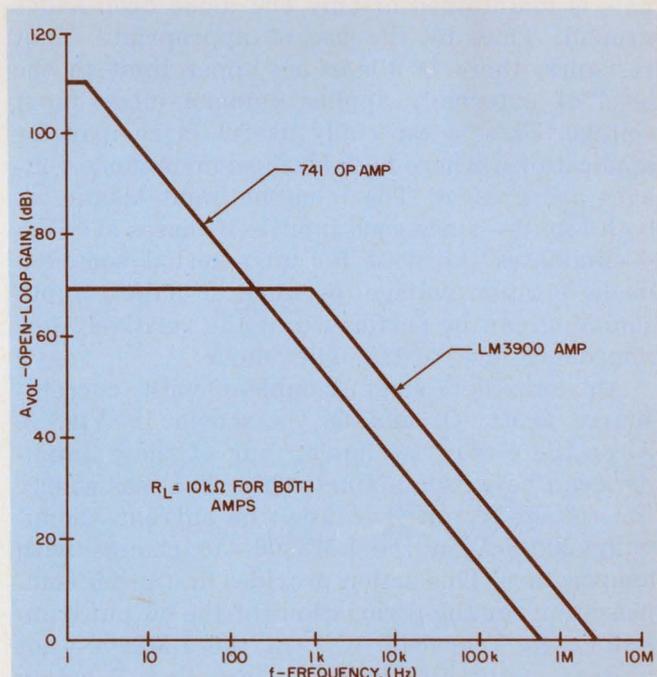
However, a lateral pnp transistor, Q_3 , while neither reducing the output voltage swing nor raising the input voltage, provides the additionally needed β . Note that the collector of Q_3 is connected directly to the output terminal. This bootstrap arrangement reduces the loading at the high-impedance collector of transistor, Q_2 .

Current mode provides balanced input

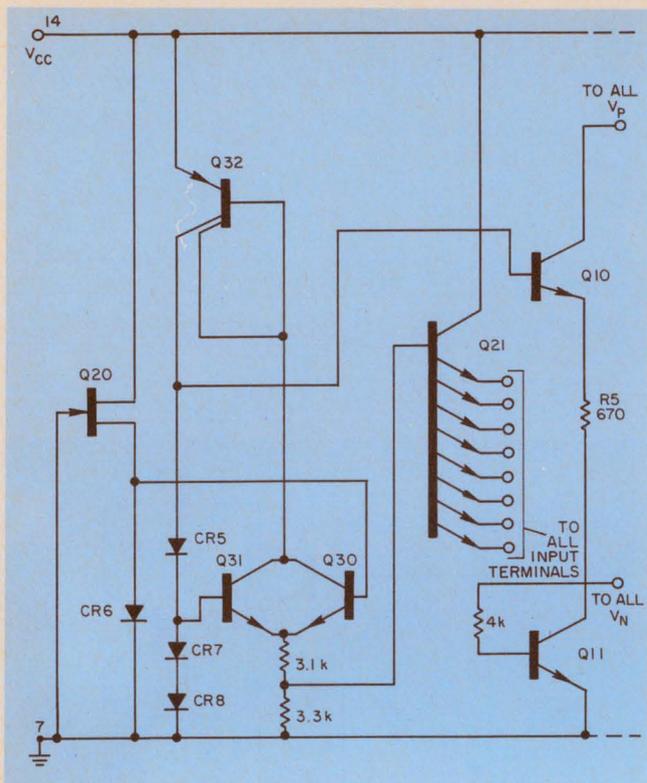
The gain stage of Fig. 1 has only an inverting input. But a general-purpose amplifier requires



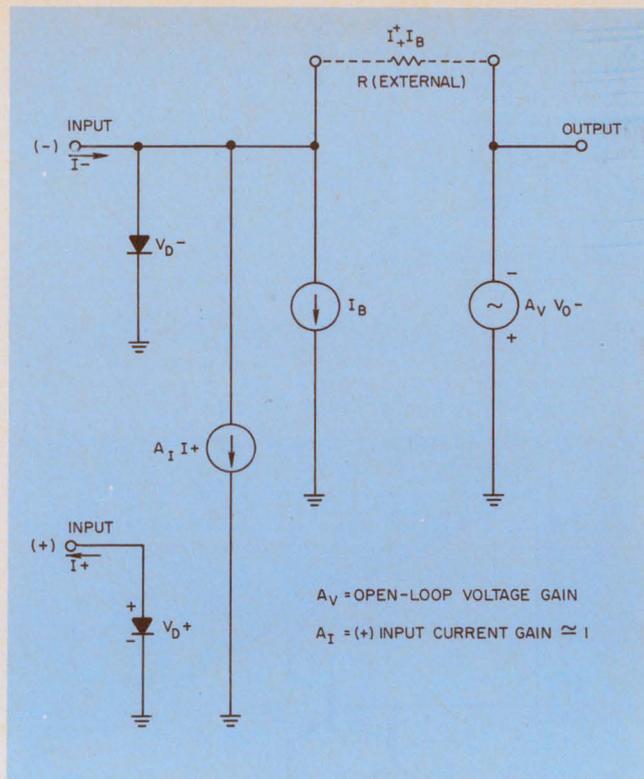
3. The complete amplifier uses transistors Q_6 and Q_7 as current-source loads.



4. The Norton amplifier's open-loop gain is about 10 dB more than the popular 741 op amp above 1 kHz.



5. A single regulated bias circuit built into the chip provides biasing currents for the four Norton amplifiers.



6. An equivalent circuit for the amplifier helps in arriving at first-order designs.

both an inverting and a noninverting input. Since the gain-stage input operates in a current mode, a noninverting input can be provided by the addition of a current drain-off (current-mirror) circuit to subtract or drain off current from the inverting input terminal (Fig. 2). The input common-mode voltage of the input terminals is maintained at only one diode drop above ground. Thus by the use of appropriate input resistors, there is almost no upper limit to the level of externally applied common-mode input voltage. This is especially useful in comparator applications, where high-level common-mode voltages are present. The inherent input biasing at both inputs—since each input self-biases at $+V_{BE}$ —eliminates the need for an external common-mode biasing voltage network. Further, input summing can be performed at the relatively low impedance level of the input diode.

An amplifier stage complete with current-source loads, Q_6 and Q_7 , is shown in Fig. 3. Since the circuit is simple, four of these amplifiers can be put on a single chip. The bias source for voltage V_p on Q_6 causes the current—nominally $200 \mu A$ in the LM3900—to change with temperature. This action provides first-order compensation for the β variations of the output transistor, Q_1 . Transistor Q_5 (in the LM3900—not present in the MC3401) provides class-B action together with Q_3 under large-signal conditions.

Figure 4 compares the LM3900's open-loop

frequency response with a typical 741 op amp. The curve shows that the 3900 provides an additional 10 dB of open-loop gain for all frequencies above 1 kHz.

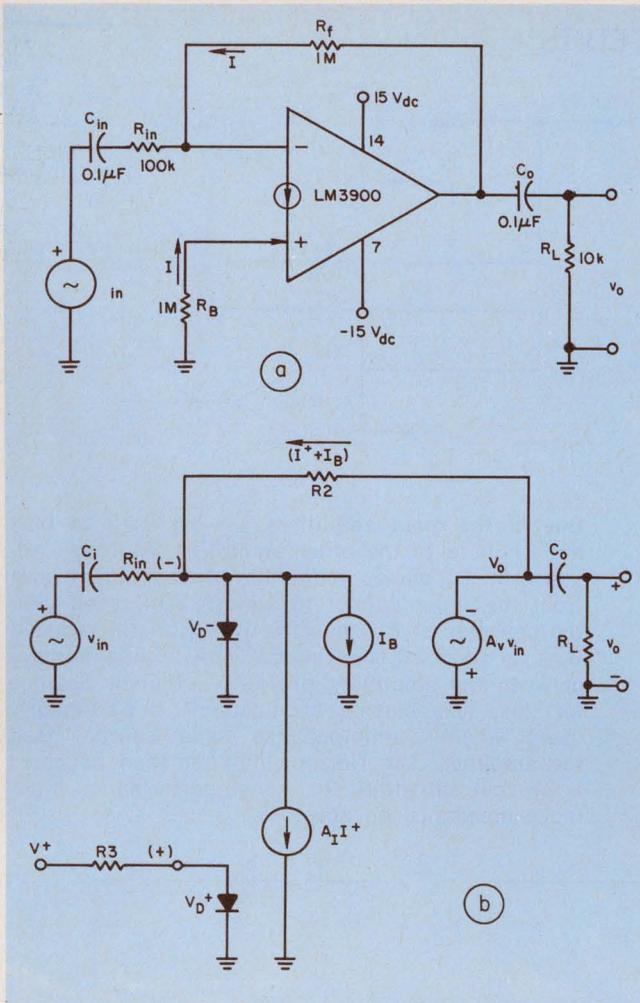
Regulated supply does the biasing

A single bias circuit (Fig. 5) in the 3900 serves all four amplifiers. The regulator circuit insures that only small changes in bias current occur as the supply voltage changes. Thus the open-loop gain changes only slightly over the wide power-supply range, and it is almost independent of the effects of temperature.

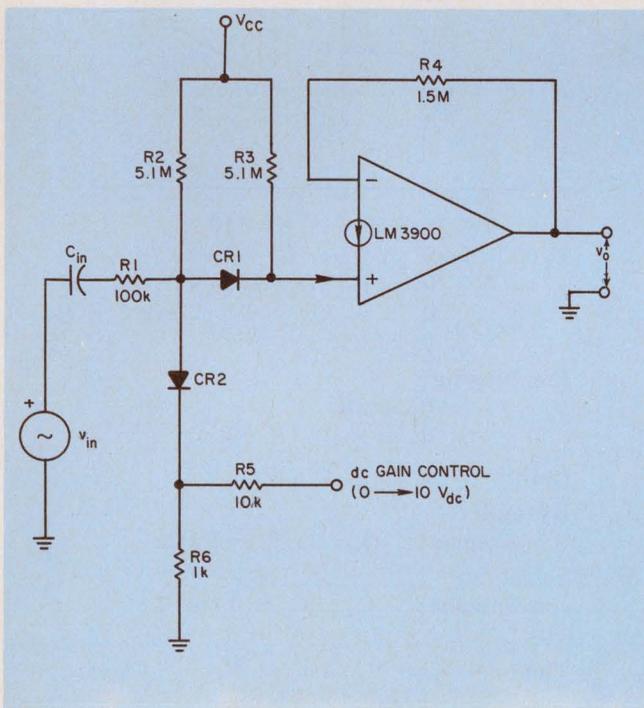
A single resistor, R_5 in Fig. 5, controls the power consumption of the whole chip and establishes the conduction of transistor Q_{10} in the bias supply. The emitter current of Q_{10} biases the Q_7 output current sources of all four amplifiers at points V_n (Fig. 3), and the collector current of Q_{10} biases the Q_1 current sources at points V_p .

When power is turned on, the biasing circuit transistors Q_{20} , Q_{30} and CR_6 conduct, thus starting the bias circuit. Current flow through the reference diodes CR_5 , CR_7 and CR_8 then turns off Q_{30} , and current through the amplifier circuits thus depends mainly on the V_{BE} of Q_{10} divided by R_5 . Power-supply current drain is then essentially independent of the power-supply voltage.

The multi-emitter transistor, Q_{21} , clamps negative input voltages at each of the eight input



7. This ac-coupled amplifier, operating from a ± 15 V power source, can also work on a single-voltage source when pin 7 is grounded.



8. Remote voltage-controlled gain is readily attained with the Norton amplifier.

terminals of the chip. One emitter of this transistor is connected to each of the input terminals. This clamping prevents parasitic transistor action if the inputs go negative.

Designing with the amplifiers

Though these amplifiers can be used instead of a standard op amp, a new design approach is needed. An equivalent circuit for a Norton amplifier is shown in Fig. 6. Both the plus and minus inputs are clamped by diodes, so they can be no more than one-diode drop above ground. Thus the input common-mode voltage at the input terminals is inherently restricted to within a few hundred millivolts of 0.5 V. Therefore, to apply current-mode amplifiers to operate with a voltage-mode input, the external voltages must first be converted to currents by use of series resistors. The use of external input resistors can extend the range of externally applied common-mode inputs almost without limit.

Also, only the minus input needs an externally supplied biasing current, I_B . As shown in Fig. 6, an external feedback resistor usually can supply the bias.

Though Norton amplifiers accept differential inputs, they are not true differential amplifiers. The output depends on the open-loop voltage gain, A_v , and only the minus input voltage, V^- —not the differential input voltage—is effective in generating output. With series input resistors however, V^- depends upon I^+ as well as I^- , thus the amplifier provides differential voltage amplification.

Let's analyze the ac-coupled inverting amplifier of Fig. 7a to see how a typical Norton amplifier such as the 3900 is used in a circuit. Figure 7b is an equivalent circuit that includes the biasing current path.

First, consider the dc biasing paths and make a dc analysis. The output quiescent voltage, V_o , is

$$V_o = V_{D^-} + (I_B + I^+) R_2 \quad (1)$$

and

$$I^+ = \frac{V^+ - V_{D^-}}{R_3}, \quad (2)$$

where

$$V_{D^+} \approx V_{D^-} \approx 0.5 \text{ Volts}$$

and

$$I_B = \text{bias current (30 nA)} \ll I^+.$$

Also, take $A_1 = 1$

$$\text{and } V^+_{(\text{max})} = V_{cc} \text{ (power-supply voltage).}$$

If Eq. 2 is substituted into Eq. 1,

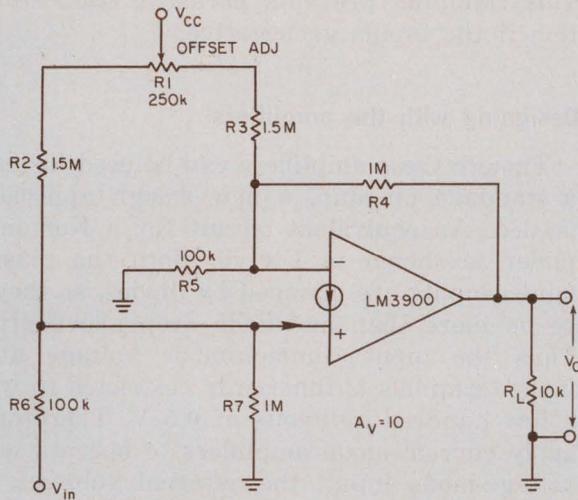
$$V_o = V_{D^-} + \left(I_B + \frac{V^+ - V_{D^+}}{R_3} \right) R_2, \quad (3)$$

which is an exact expression for V_o . But since

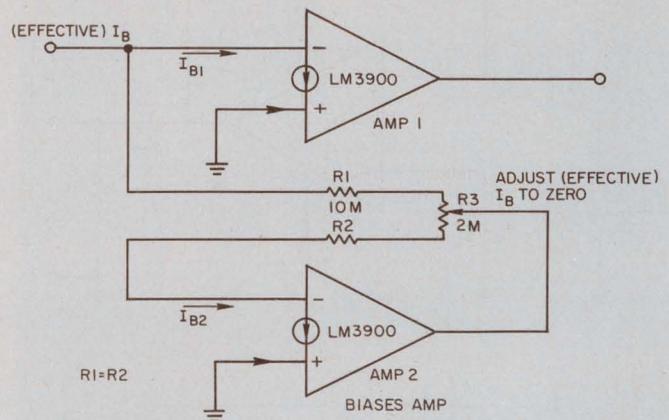
$$V_o \gg V_{D^-} \text{ and } V^+ \gg V_{D^+},$$

we can simplify Eq. 3 to provide a quick design relationship:

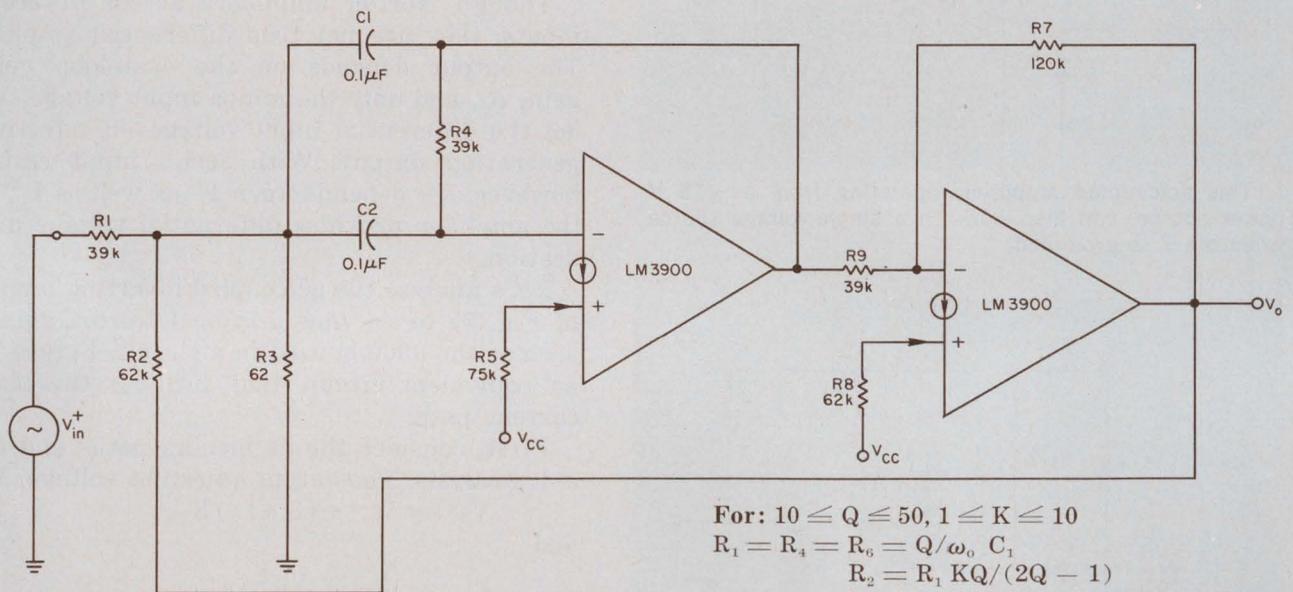
Analog circuits



When used as a dc amplifier with a single power supply, the Norton amplifier is not as precise as a standard op amp with a split supply. However, single-polarity inputs and noninverted outputs down to zero volts can be readily accommodated with the common-mode input biasing resistors R_2 and R_3 and offset adjustment R_1 . This circuit is adequate for most noncritical applications.



One of the quad amplifiers can be used to bias one or more of the other amplifiers. Although adjustment R_3 allows reduction of the bias drawn from the input source to almost zero, even with the omission of R_3 , the effective I_B is still reduced by a factor of 10 (typically to 3 nA). The symmetry between the amplifiers provides sufficient balance for this. This biasing arrangement is particularly useful where high-impedance signal sources feed the amplifier. The Norton amplifier then becomes a low-cost substitute for a high-performance high-input-impedance op amp.



$$\begin{aligned} \text{For: } 10 \leq Q \leq 50, 1 \leq K \leq 10 \\ R_1 = R_4 = R_6 = Q/\omega_0 C_1 \\ R_2 = R_1 KQ/(2Q - 1) \\ R_3 = R_1/(Q^2 - 1 - 2/K + 1/KQ) \\ R_7 = KR_1 \end{aligned}$$

For biasing:

$$\begin{aligned} R_5 &= 2R_4 \\ R_8 &= R_6 R_7 / (R_6 + R_7) \end{aligned}$$

Gain: $G = \sqrt{Q} K$

Example:

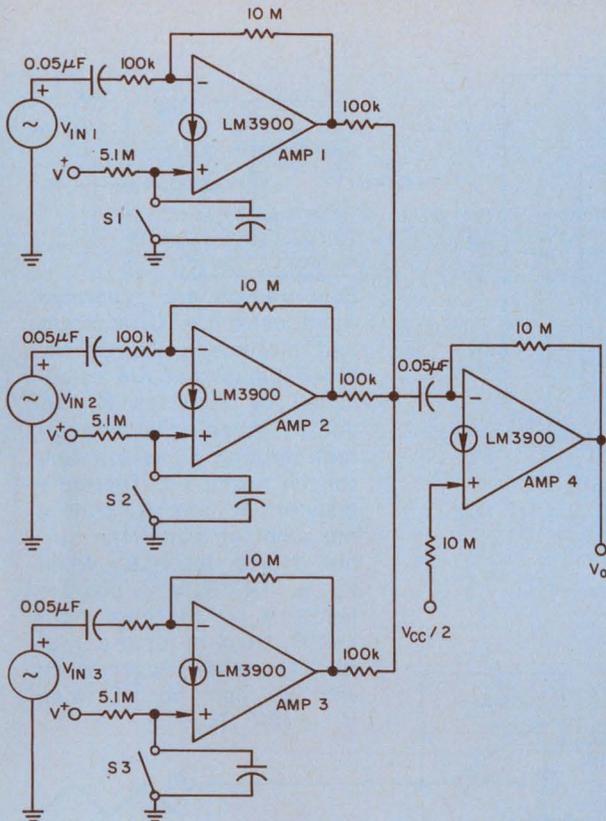
Requirements: $Q = 25, f_0 = 1 \text{ kHz}$

Select for

$$\begin{aligned} \text{convenience: } C_1 = C_2 &= 0.1 \mu\text{F} \\ K &= 3 \end{aligned}$$

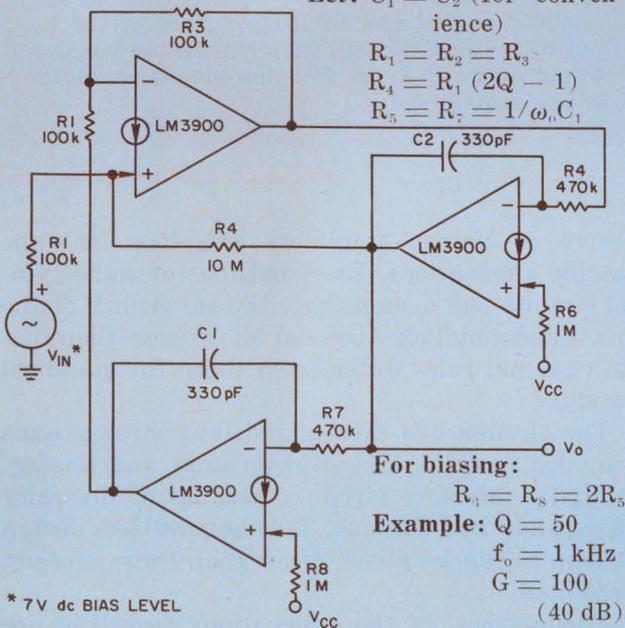
Then solve for R_1 through R_7
 $G = 15$ (23 dB)

A bandpass amplifier with a Q between 10 and 50 can be constructed with two amplifiers. The circuit uses only two capacitors. Resistors R_3 and R_8 set the bias so that the output voltage of the amplifiers approaches $V_{cc}/2$. To do this, resistor R_5 is chosen to equal twice R_4 , and R_8 is chosen to equal R_6 and R_7 in parallel. The value of the constant K is selected for either control of the spread of resistor values or for optimization of final gain.



The Norton quad-amplifier group makes an economical choice for audio mixing and channel selection. Three of the amplifiers summed into the fourth is a convenient arrangement. Individual amplifiers can be turned off when a dc control signal is applied to the plus input. The positive voltage, V^+ , unless shorted by switches S_1 , S_2 and S_3 saturates the respective amplifiers and they pass no signals.

For: $Q \geq 50$
 Let: $C_1 = C_2$ (for convenience)
 $R_1 = R_2 = R_3$
 $R_4 = R_1 (2Q - 1)$
 $R_5 = R_7 = 1/\omega_c C_1$



For biasing:
 $R_5 = R_6 = 2R_8$
 Example: $Q = 50$
 $f_0 = 1 \text{ kHz}$
 $G = 100$
 (40 dB)

A bandpass filter with a $Q \geq 50$ can be built with three amplifiers. The resulting increase in overall open-loop gain also reduces the effects of component variations.

$$V_o \approx \left(\frac{R_2}{R_3} \right) V^+ \quad (4)$$

And, if R_3 is made equal to $2R_2$, then $V_o \approx \frac{V^+}{2}$

The latter result shows that the output can be readily biased to one-half of the power-supply voltage, so that the full peak-to-peak swing can be made symmetrical and almost equal to V_{cc} .

This simple dc model is adequate for designing switching circuits.

Design procedure for ac amplifiers

What happens to ac signals? Since the circuit behaves as a standard op amp with its plus input grounded, the closed-loop voltage gain, $A_{v(CL)}$, is:

$$A_{v(CL)} = \frac{-V_o}{V_{in}} \approx \frac{R_2}{R_1}$$

The procedure for designing an ac-coupled inverting amplifier consists therefore of first selecting R_1 , C_1 , R_2 and C_o , as for a standard op amp.

Then R_3 is made equal to $2R_2$. Note that R_3 is the only additional resistor needed to complete the biasing requirements. This simplicity contrasts with the complications encountered in dealing with large common-mode voltages when trying to bias standard op amps for operation from a single power supply.

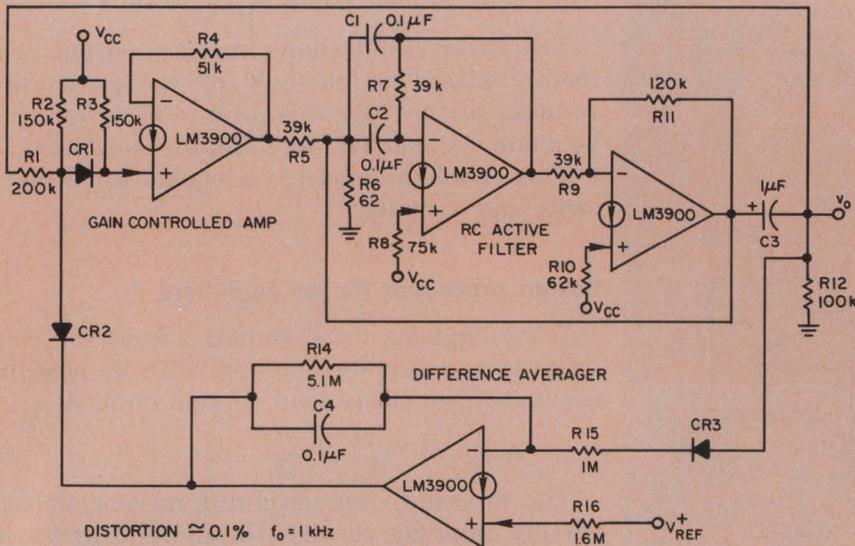
A practical ac amplifier design with remote voltage-controlled gain is shown in Fig. 8. For maximum gain, CR_2 is cut off and the current through R_2 and R_3 provides a bias to set the quiescent output of the amplifier at approximately $0.6 V_{cc}$. For minimum gain, CR_2 is turned on, and only the minimum bias current through R_3 enters the input to set the quiescent output at approximately $0.3 V_{cc}$. The bias is thus automatically varied to accommodate a large output swing when the gain is set to maximum. The signal swing required for gain control varies from 0 V for minimum gain to less than 10 V for maximum gain.

A distinctive symbol used

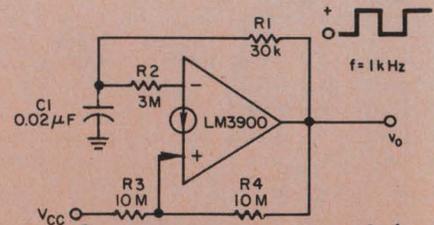
Note the new amplifier symbol that is used in Figs. 7a and 8 to represent this class of current-mode amplifiers. This symbol is recommended to avoid confusion with the standard op amp, since Norton-amplifier operation is quite different in many respects. The current-source symbol between the two inputs represents the new mode of operation. It signifies that current is removed from the minus input terminal. And the current-arrow symbol on the plus input lead indicates that this terminal operates as a current input. This new symbol is thus helpful in both clarifying the behavior of the circuits described here and in doing your own design work.

Armed with an understanding of the internal

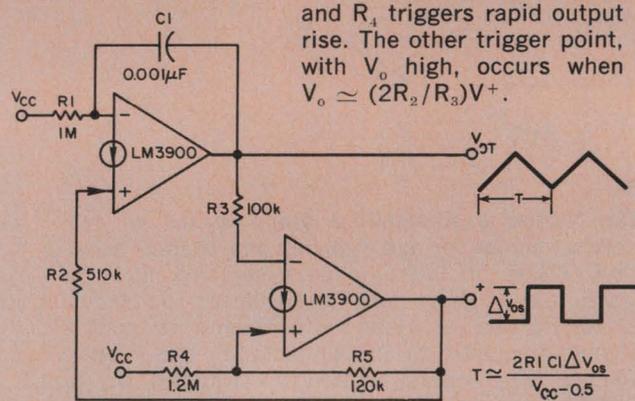
Signal generator



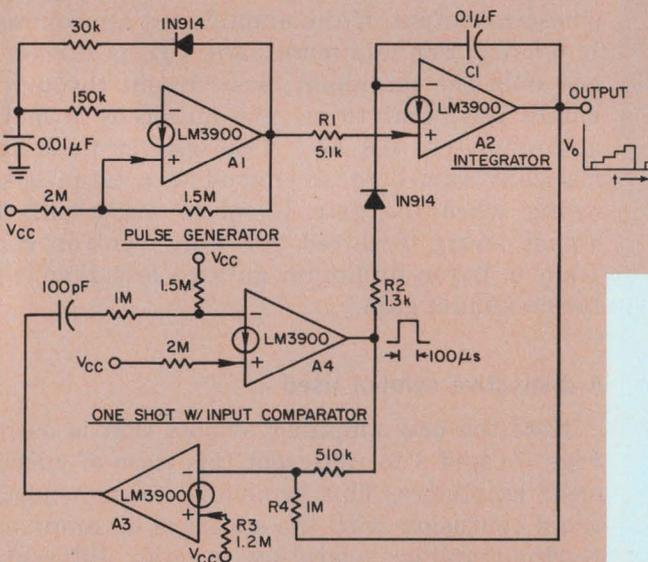
Sinewave oscillator using Norton amplifiers achieves amplitude stability and waveform purity. It uses a two-amplifier, RC active filter that requires only two capacitors. A third amplifier controls the gain around the filter. The fourth amplifier compares the sinewave amplitude to a dc-reference voltage and averages the difference. The values selected for R_{15} and R_{16} provide first-order temperature compensation for both CR_3 and the internal input diodes. The peak magnitude of the output sinewave is automatically regulated at twice the reference voltage, V_{ref} .



Squarewaves are generated when capacitor C_1 charges and discharges via R_1 between limits that are established by resistors R_2 , R_3 and R_4 . When V_0 is low, current through R_4 is low and can be neglected. Therefore resistors R_2 and R_3 control the point at which the output starts to rise. When $V_0 \approx (R_2/R_3)V^+$, positive feedback via the plus input and R_4 triggers rapid output rise. The other trigger point, with V_0 high, occurs when $V_0 \approx (2R_2/R_3)V^+$.



An integrator configuration generates triangular waveforms. Current through R_1 produces the negative-output slope. When the input to the second amplifier drops below the trigger point set by R_4 and R_5 , current through R_2 produces the positive output slope. If $R_1 = 2R_2$, the output waveform will be symmetrical.



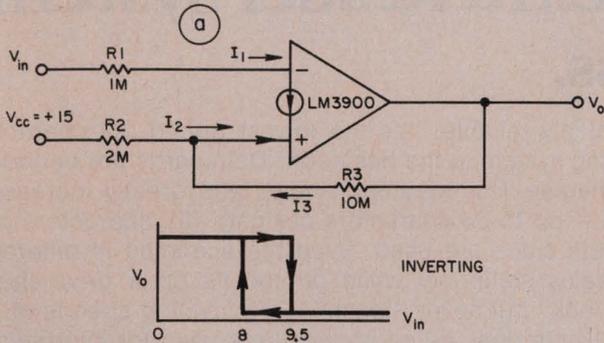
Free-running staircase generator uses all of the amplifiers on the quad chip. A_1 provides the input pulses that generate the staircase wave via resistor R_1 . Amplifier A_2 integrates and holds the pulses. Amplifiers A_3 and A_4 provide a combination comparator one-shot multivibrator function. Resistor R_4 samples the staircase output voltage and compares it with the power-supply voltage (V^+) via R_3 . When the staircase output exceeds approximately 80% of V^+ , the one-shot provides a $100\text{-}\mu\text{s}$ pulse. This pulse resets the integrator A_2 via R_2 .

design of Norton amplifiers let's look at some specific applications. Brief outlines of some typical circuits will demonstrate the versatility of the new quad-amplifier ICs and show how their design ground rules differ from those for standard op amps.

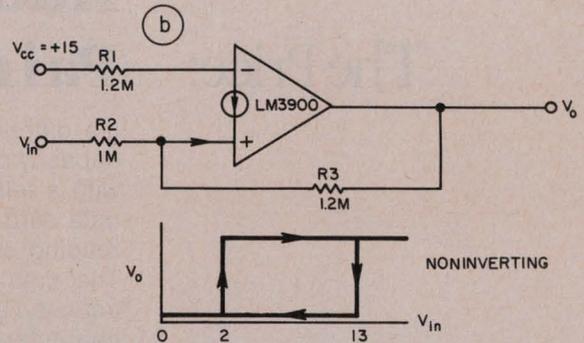
The circuits are categorized into three groups — analog circuits, signal generators and analog-to-digital interface circuits. Because of diversity of possible applications, few generalized design principles can be given, other than those already presented.

Though most of the applications described use the amplifiers in a linear mode, Norton amplifiers can be safely overdriven well beyond saturation and used in a wide range of logic circuits in addition to the a/d interface circuits shown.

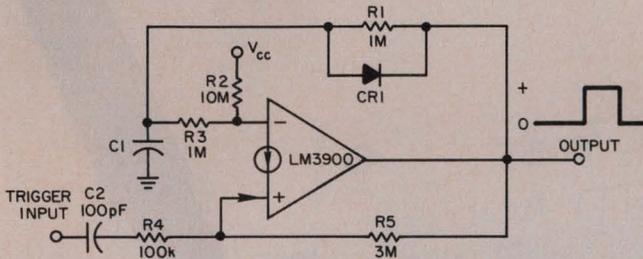
Analog-to-digital interface circuits



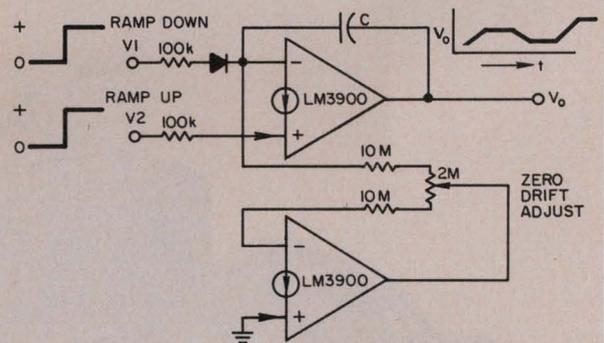
Hysteresis may be designed into a comparator to form a Schmitt-trigger circuit. The circuit can be made either inverting or noninverting. The lower switch point for the inverting circuit is determined by the amount of current flowing into R_2 . And since the output voltage is low, current through R_3 can be neglected. As the input current, I_1 , drops below I_2 , the output starts to switch to the high



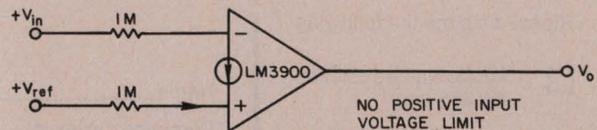
limit. Positive feedback via R_3 rapidly drives the circuit to saturation. With V_o high, additional current, I_3 , is driven into the plus input through R_3 . Therefore the input current, I_1 , required to switch V_o down is increased by the amount needed to overcome this additional current. Thus the circuit has different trigger point for high and low outputs—a hysteresis effect.



One-shot circuit uses only one amplifier. Resistor R_2 tends to keep the output in the low-voltage state. A positive voltage at the trigger input sufficient to overbalance the current through R_2 causes the output to switch to the high-voltage state. Resistor R_5 latches the amplifier in the high state until capacitor C_1 charges from near ground to a voltage that forces current into the negative input that is almost equal the current into the plus input. At this time the circuit returns to the low state.



Ramp-and-hold circuits that can be ramped up or down or allowed to remain at any desired output of dc level use only two Norton amplifiers. If both inputs V_1 and V_2 are at zero volts, the circuit is in a hold mode. Raising either input will cause the dc output voltage to ramp either up or down. The slope is a function of the magnitude of the input voltage. Additional inputs can be fed in parallel through series resistors, if desired, to increase the input control variables. The values of R_2 , R_3 , and R_1 are selected to set the switching values to the desired levels. The noninverting Schmitt trigger works the same way, except that the input voltage is applied to the plus input.



Norton amplifiers operate as inverting comparators. To insure proper operation, the reference voltage must be larger than the internal $V_{BE} \approx 0.5$ V. But there is no upper limit as long as the input resistors are large enough to limit the input currents to under $200 \mu\text{A}$.

Each amplifier can be thought of as a super transistor with a β of 1,000,000 (25-na input produces 25-mA output current). The amplifiers also have a noninverting input feature capable of providing positive feedback that can create sharp trigger points and hysteresis for Schmitt and one-shot circuits. Finally, the low-input currents allow the design of timing circuits with small capacitors and large resistors.

Of course, where the application demands unusually high performance, the designer may be forced to use a more expensive specialized op amp unit. This happens when very wide bandwidths, very high slew-rates, greater gain, very high input or very low output impedances are required. Also, the single source limits dc inputs and outputs to single-polarity excursions. ■■

The Product: **The touchless, punchless Audac Card Reader System.**

The Price: **Painless.**

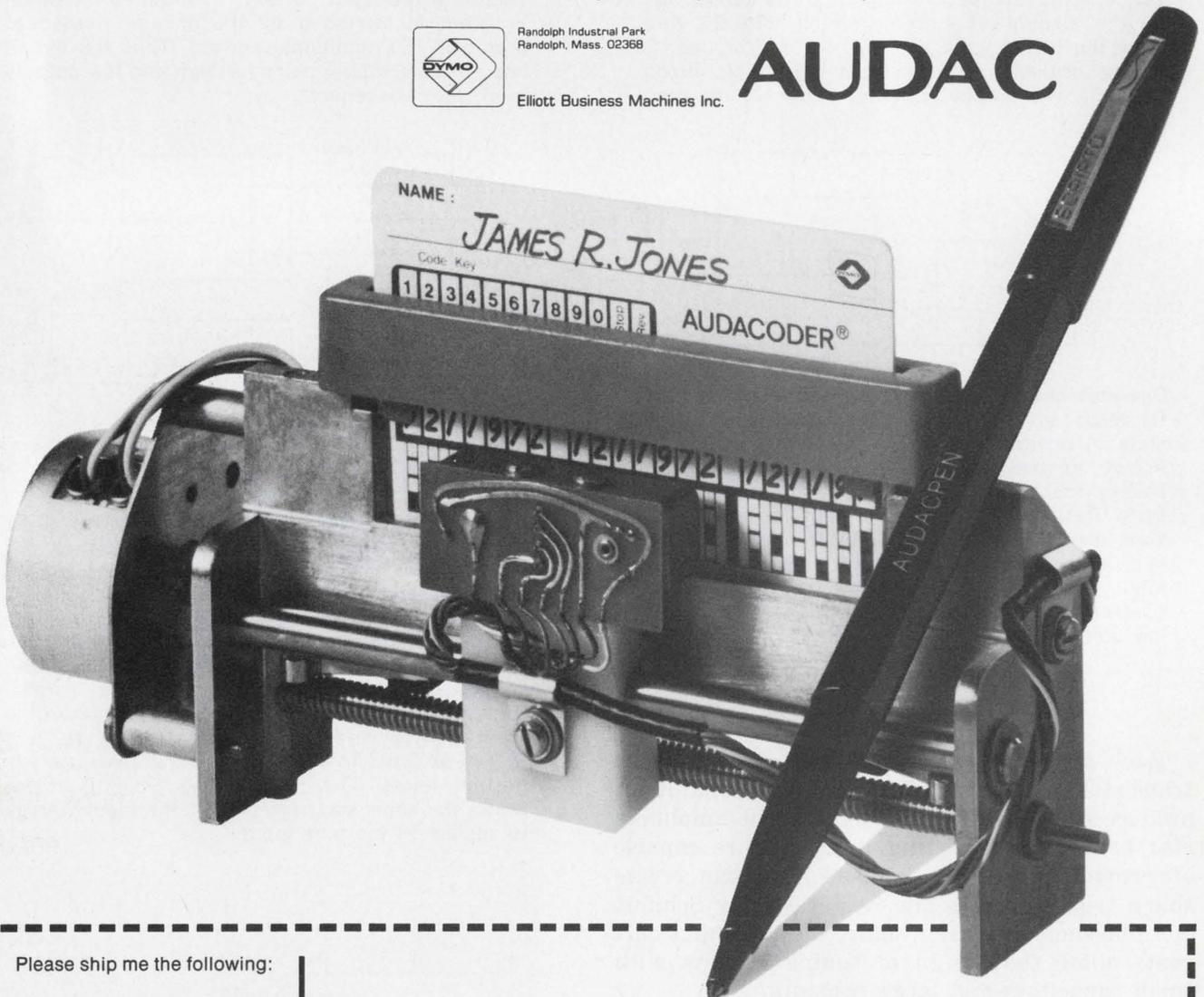
It's different. It's highly reliable. It's the lowest priced, 22-character capacity card reading system in the business. Data cards are encoded with a felt-tipped marker. This means no holes and greatly increased data card capacity — up to 66 characters per card (22 characters per reading cycle) if both sides are used. Even the scanning is different. The data card remains stationary while photocells on a drive-shaft-actuated scanner "look" but never "touch" — at cycling speeds of 10 characters/sec. A 16-pin dual in-line connector is used for interfacing. Available in both numeric and alpha-numeric versions complete with adjustable limit switches, Audac coding pen and 8 self-encoding cards. Send today for complete data and prices.



Randolph Industrial Park
Randolph, Mass. 02368

Elliott Business Machines Inc.

AUDAC



Please ship me the following:

- Audac Numeric Reader @ \$86 ea.
- Audac Alpha-Numeric Reader @ \$128 ea.
- More information

Name _____ Title _____

Purchase Order # _____

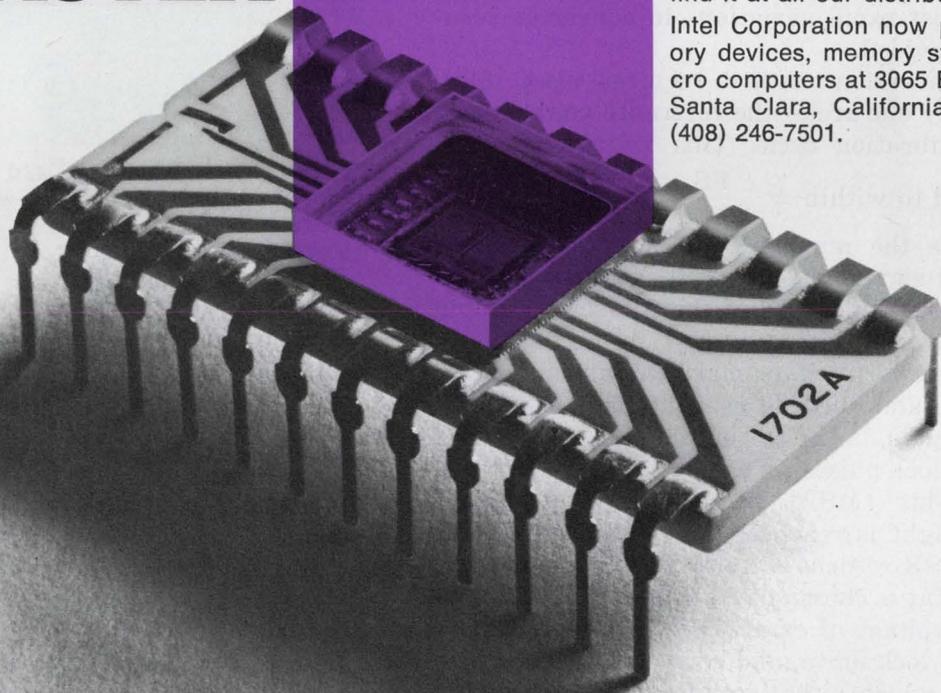
Company _____

Address _____

City _____ State _____ Zip _____

Authorized Signature _____

NEW
ERASABLE
MOS PROM
PROGRAMS
TEN TIMES
FASTER



The people who introduced the world's only erasable MOS PROM now introduce a static 2048-bit PROM you can program or reprogram in two minutes flat—ten times as fast as ever before.

It's Intel's new 1702A. You can program it with our Model 7600C programmer. Then you can erase it by shining ultra-violet light through the transparent quartz cap and reprogram it again as often as you wish.

Imagine the possibilities! Mistakes can be corrected easily. Programs can be modified quickly. PROMS in any quantity are economical to make—and unmake. Best of all, **Intel guarantees that 100%** of the PROMs you receive will program successfully. We know, because we actually program, test and erase every single PROM before we ship it.

Priced at \$45.00 in 100-piece quantities, the 1702A is the lowest priced 2048-bit PROM on the market. You can find it at all our distributors right now.

Intel Corporation now produces memory devices, memory systems and micro computers at 3065 Bowers Avenue, Santa Clara, California 95051. Phone (408) 246-7501.

intel[®]
delivers.

Improve single-slope a/d accuracy.

Add a calibration cycle, and you get 0.01% accuracy in a circuit that is suitable for mass production of 4-1/2-digit DVMs.

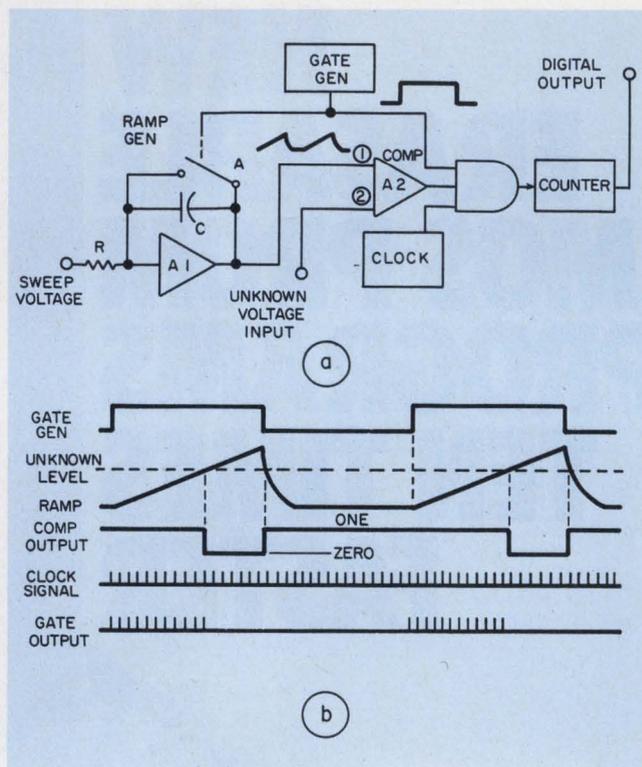
Although the single-ramp technique for a/d conversion is both simple and economical, the accuracy obtained seldom exceeds 1%, or eight bits. By introducing a calibration cycle, along with the normal measurement cycle, the designer can reduce errors to as low as 0.01%, allowing 4-1/2-digit operation without a drastic increase in circuit complexity. The technique, for which a patent is pending, also has many other possible applications in low-cost digital instrumentation.

The converter uses alternate Measure and Calibrate cycles to reduce the measurement error. A known analog input is measured, and the resulting digital number is compared with the correct answer. If this digital number is not correct, the converter is automatically adjusted so the correct answer will be produced. Since the calibration cycle is interlaced with a cycle that measures the unknown analog voltage, compensation for all but the most rapid variations in converter accuracy is provided.

This conversion method requires close tolerance in only one area—the reference voltage used in the calibration cycle. This voltage must be maintained to within $\pm \frac{FS}{2^{(n+1)}}$,

where n is the number of bits of accuracy if $\pm 1/2$ least-significant-bit (LSB) accuracy is to be expected. Voltage FS is the full-scale reading of the converter.

As the converter is primarily intended for use in a DVM and suitable readout devices require a BCD signal, a BCD counter is employed to count the clock pulses. In a BCD counter the most-significant-bit (MSB) is zero until a decimal count of eight is reached. At a decimal count of ten, the MSB returns to zero. Therefore the calibration point is chosen at 80% of full scale, and a reference voltage of exactly 8 V is used. The converter will lock on to, and correct for, error conditions in which either greater or less than an 80% of full-scale count is obtained before the



1. Simplified single-ramp a/d counts clock pulses to determine input voltages. The waveforms (b) show how a voltage-to-time conversion is performed by the ramp generator and comparator.

ramp voltage crosses the reference voltage and stops the count.

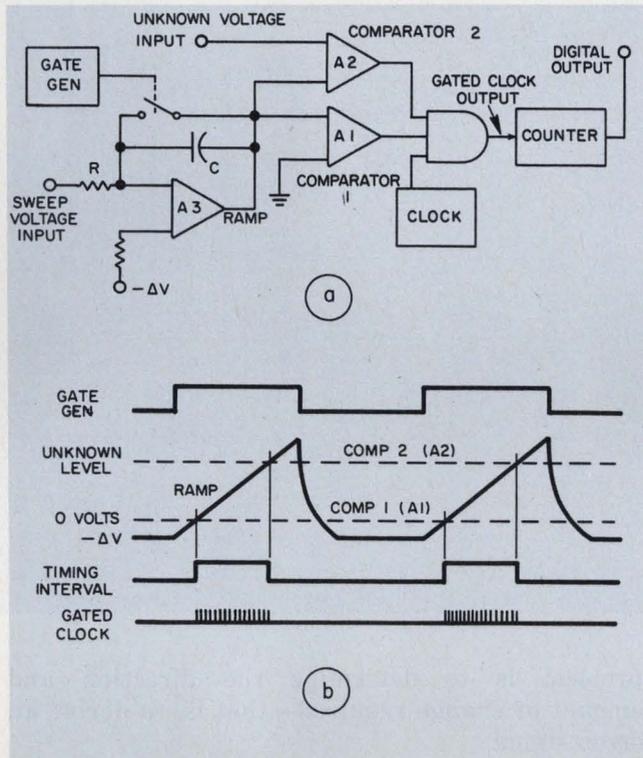
Basic converter counts clock pulses

The ramp a/d converter uses a linearly rising voltage ramp to convert an unknown voltage into an equivalent time interval. This time interval gates a portion of the output of a clock oscillator. The number of cycles of the oscillator passed by the time gate constitutes a digital number proportional to the unknown voltage. The train of pulses is normally converted to a more usable number system, such as binary, BCD, Gray, etc.

Figure 1 shows the single-ramp a/d converter in a simple form. In general, some time is required for recovery of the ramp after each use, as well as for whatever digital operations may be

required to produce the required type of digital word. Therefore timing gates are needed to separate the various operations. Fig. 1a includes a simple arrangement to accomplish the desired gating, and Fig. 1b shows typical waveshapes. Let's now consider the operation of the various components in the block diagram.

The ramp generator consists of an operational amplifier with a capacitor, C, in its feedback path. The input is from a constant-amplitude sweep voltage through a resistor, R. Because the



2. Comparator drift is minimized by use of a two-comparator scheme shown (a). The count begins (b) after the ramp crosses the level set by A₁, and it ends when the level of A₂ is reached.

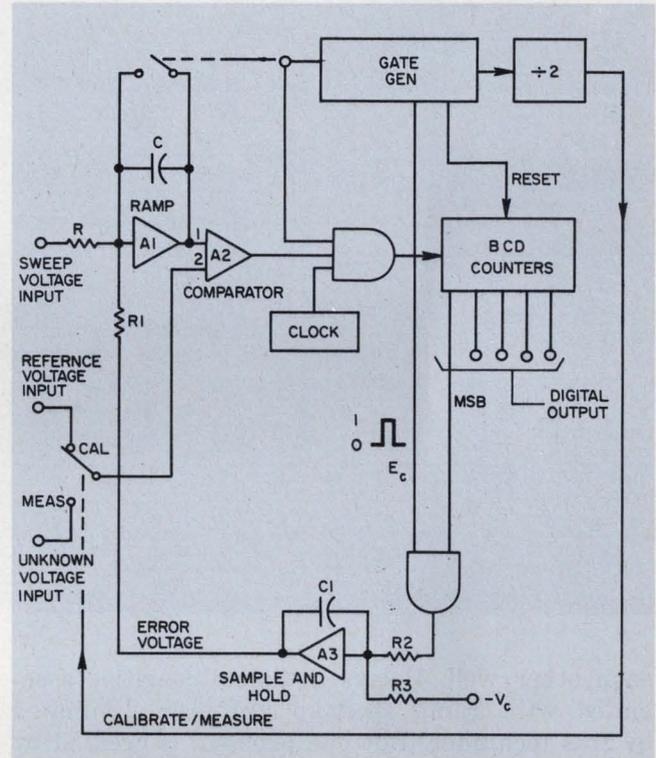
op-amp input terminal remains at virtual ground, the current through R is constant. This current is available to charge C, resulting in a linear ramp voltage. It is important that the ramp be linear, because this is the only significant source of error not corrected by the converter's calibration cycle. An op-amp IC performs the comparator function indicated in the block diagram. Its output is high when input 2 exceeds input 1, and low (clamped near ground) otherwise. The gate and clock generators provide the wave shapes shown. The AND-gate output is high when all its inputs are high.

Ramp and clock errors limit accuracy

The simple a/d converter of Fig. 1a works extremely well if only a few bits of accuracy are

required. However, as more accuracy is demanded, various errors begin to appear. These tend to fall into two major classifications: those associated with the ramp and those caused by clock inaccuracies.

There are two types of ramp errors, other than nonlinearities: those related to slope and those related to starting time. If the ramp starts late, fewer than the correct number of counts will be included. Also, if the slope of the ramp is too steep, it will reach the unknown voltage too soon



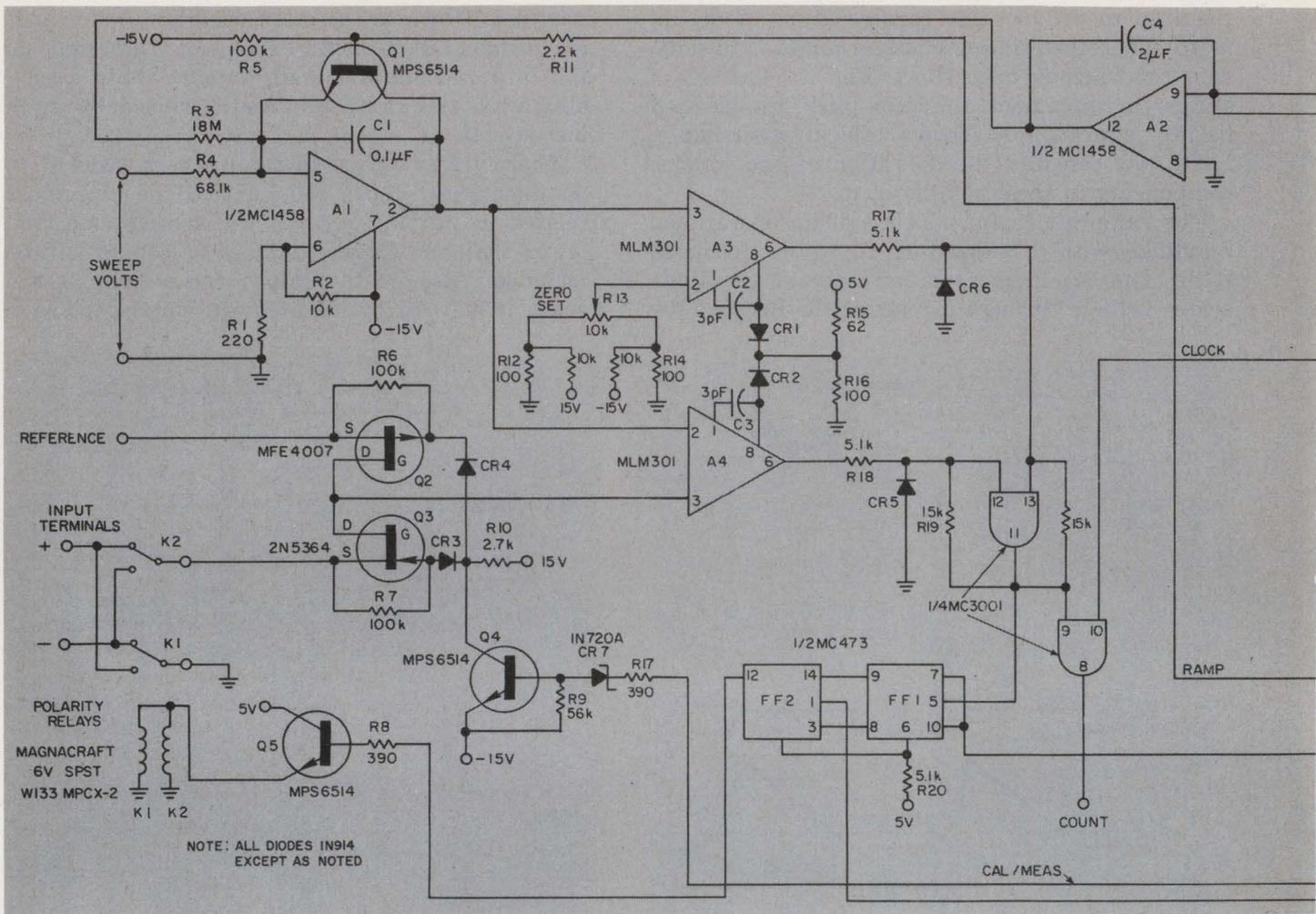
3. A digital feedback loop corrects for clock and ramp errors. During the Calibrate mode the reference voltage is substituted for the unknown. Ramp speed increases with BCD counter readings above 80% of FS.

and, again, the pulse count will be too small.

Comparator voltage offset and delay have effects similar to errors in ramp starting time. If the ramp voltage must exceed the unknown voltage by a given amount to change the state of the comparator, the gate will close late, and too many counts will be included. Likewise comparator propagation delay will cause too many counts to be indicated for a similar reason.

Somehow, ramp-delay errors must be minimized and made to behave predictably with environmental variations. A frequently used method is to start the ramp below the zero-reference voltage (Fig. 2). Then the timing gate is opened when the ramp crosses the zero reference and closed when it crosses the unknown voltage.

The two crossings are detected by identical comparator circuits and should therefore track



each other well. Delays and nonlinearities associated with ramp start-up are also eliminated by this technique. But one problem is created by this technique: It is very difficult to synchronize the clock with the opening of the timing gate, because the gate opening is an analog event not related to the clock. This nonsynchronization can result in a 1/2-LSB error if the gating occurs during the rise time of a clock pulse. With practical clock speeds and standard logic families, this error will normally occur less than 1% of the time.

The clock frequency, of course, has the same effect on count correctness as ramp slope does: If the clock is too slow, it will not produce a sufficient number of pulses during the gate interval. Variations in the clock frequency can be made small by use of a crystal or other high-Q, frequency-determining device.

Calibration cycle controls ramp slope

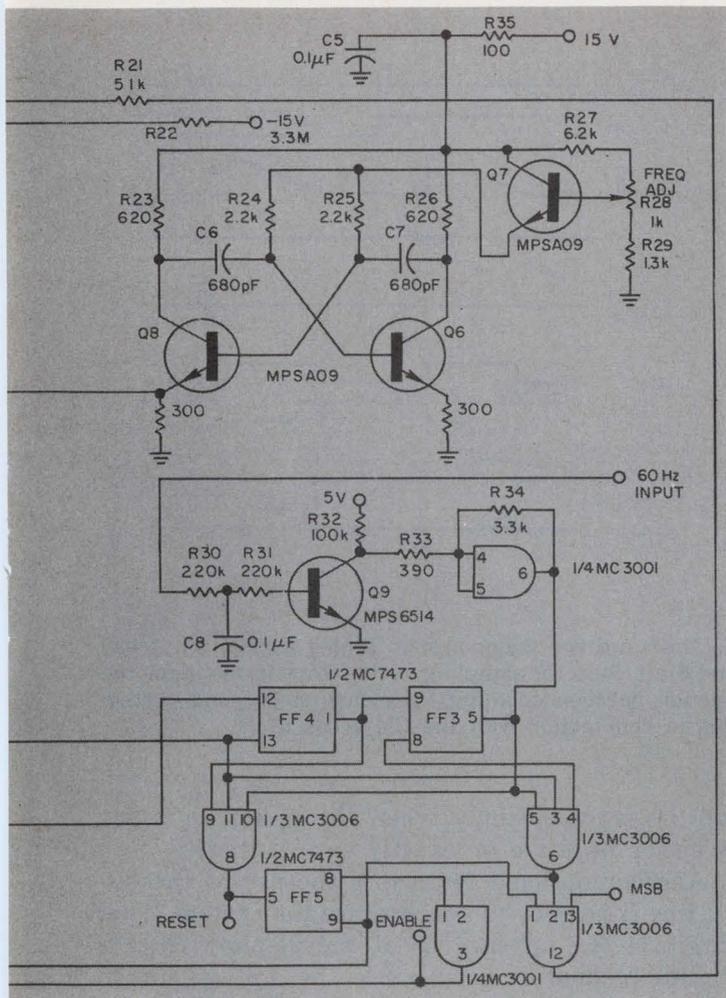
Errors caused by improper ramp slope or improper clock frequency are closely related and are compensated for in the calibration cycle. Both types can be compensated for if the ramp slope is adjusted properly, and this is easy to do. The

problem is to determine the direction and amount of change required—that is, to derive an error signal.

A trial-and-error method determines the required direction of the ramp-slope change. The known analog reference voltage is converted to a digital number, and the resulting value is observed. If the digital output is too high, the slope must be increased, and vice versa.

A block diagram of the calibration scheme is shown in Fig. 3. As explained earlier, the voltage reference is selected to be exactly 80% of the full-scale value of the converter. In a BCD counter the MSB is switched only once during the full-scale count—at exactly the 80% value. The comparator is switched to the reference voltage during this cycle. The MSB of the BCD output number is examined once during the calibration cycle by ANDing it with pulse E_c . The presence of a logical ONE during pulse E_c indicates that the ramp slope is too shallow, while a logical ZERO indicates the opposite. Since the error voltage is only present during the E_c pulse, a way must be provided to store the ramp-speed control-voltage value during the absence of this pulse.

In the system shown an op-amp integrator is used as a sample-and-hold circuit. The capacitor



4. The completed converter contains a dual-comparator feature as well as an error-correction loop. Transistors are used to switch between the reference and unknown input voltages, as well as to discharge sweep-integrator capacitor C_1 .

plied only when the gate count is too high, control in the other direction being provided by a fixed bias. With no error pulses, the derived error-control signal to A_1 drifts slowly positive, while with continuous error pulses it moves in negative steps at the same average rate.

Timing and gating functions are derived from an oscillator (or from the 60 Hz line) by a sequence of dividing and decoding operations. The ramp generating signal (Fig. 6) occurs at 1/4 the oscillator frequency. Two other signals, an enable pulse and a reset pulse, are generated by decoding the divider wave shapes. The enable pulse, during the calibrate mode, is designated E_c and gates the error signal into the sample and hold. In the measure mode, this pulse is called Display Enable and it latches the digital equivalent of the unknown analog voltage into the output display.

The reset pulse occurs immediately following the enable pulses, and resets the counters to zero. The trailing edge of the reset pulse also triggers the Cal/Meas signal, the longest of the converter. Within the period of the ramp signal, comparators A_3 and A_4 control the duration of the timing gate in a manner similar to that shown in Fig. 2. The clock pulses are counted only during the timing gate period.

The error control voltage changes rapidly during the E_c pulse and drifts slowly between pulses. With large errors, such as might be present for a short time when the unit is first turned on, a staircase error wave shape will be produced, but at near zero error the MSB error-decoder output will be toggling between a plus and minus value to produce a sawtooth wave. This toggling during the calibration cycle has no effect on the measuring cycle, because the ramp slope is only being shifted by an amount corresponding to $LSB/4$ —less than the resolution of the converter.

More features can be added

The converter so far described cannot distinguish between a negative input voltage and zero input. It gives a zero output for either. To correct this, additional circuitry is required. If a zero or negative input voltage is applied, we note that in the Measure mode a Stop pulse is generated before or simultaneously with the Start pulse—in other words, no timing gate is generated. In this case, input polarity can be

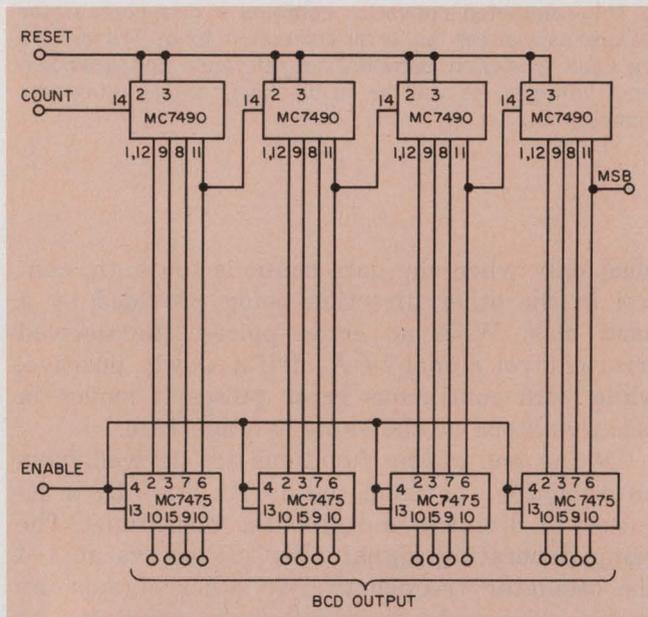
and charging-resistor values are selected so the resulting error control voltage will correct the ramp slope by an amount corresponding to $LSB/4$. Error pulses are supplied only when the gated count is high—MSB equal to ONE. Control in the other direction, toward a shallower ramp slope, is provided by the fixed negative bias.

Timing and control circuits complete the design

The circuit diagram of a converter using the calibration system just described is shown in Fig. 4. Counters and latches are in Fig. 5. To avoid the necessity for precision parts in the loop, a potentiometer is used to allow adjustment of oscillator frequency. This control is set so that no more than 10,000 counts can be passed in the calibration cycle during the time the ramp, no matter how shallow, reaches the 8-V reference.

From here the ramp-error control signal will always be of the correct polarity to increase the ramp slope, until 8000 pulses have been counted. This occurs at the moment when the ramp crosses the 8-V reference; at this point the loop will lock.

The error input to the integrating amplifier, A_2 , is single-ended—that is, error pulses are sup-



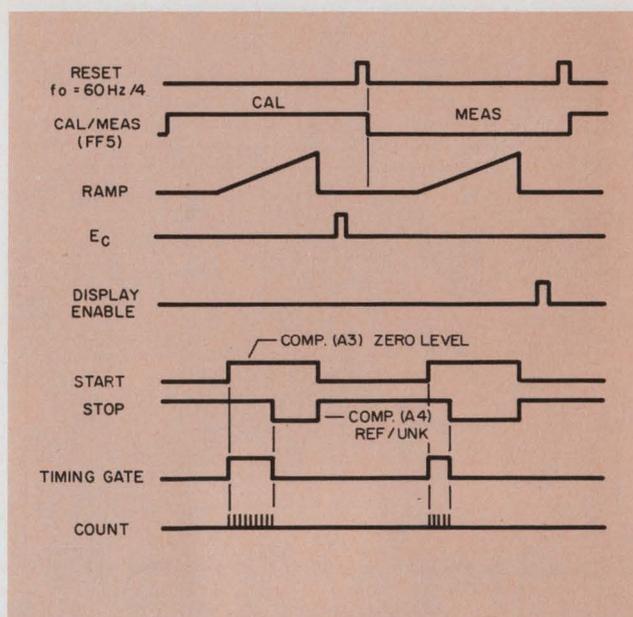
5. The converter output is available as four BCD digits. The Enable signal latches the measured voltage into the output display during the Measure mode. This section also supplies the MSB for ramp speed control.

reversed with a relay. If no timing gate is present during the following Measure mode, as would be the case with zero input, the input should again be reversed. Hence, with an exactly zero input, the input relay is reversed once each Cal/Meas cycle, and the plus-and-minus sign likewise alternates at the cycle rate.

The circuitry to accomplish the above polarity sensing is implemented as follows (Fig. 4): Polarity is indicated by a J-K flip-flop, FF₁, connected so that it will change state every time it receives a negative-going pulse. The timing-gate signal is connected to its input, so each occurrence of a timing-gate signal will trigger FF₁. Use of the negative-edge triggering assures that the flip-flop will not trigger until the end of the Timing Gate—that is, after the measurement is completed. Thus the flip-flop triggers when the ramp crosses either the unknown or the Reference voltage level.

During converter operation flip-flop FF₁ changes state at the end of each measurement of a positive voltage. The Timing Gate, which is always present during the Calibrate cycle (because the reference voltage is always positive), returns FF₁ to its original state, ready for the next measurement. However, if the input is negative or zero, the Timing Gate will be present only during the Calibrate mode, so the state of FF₁ will alternate with the mode.

A second J-K flip-flop, FF₂, is connected to FF₁ in such a way that its state is forced to be the same as that of first flip-flop at the time of the Display-Enable pulse. With two flip-flops connected in this way, the polarity relay (and readout)



6. There are two major system timing cycles: Cal/Meas and Start/Stop (or sampling cycle). Waveforms show the relation between counting for measurement and correction in conjunction with the Cal/Meas cycle.

will be activated only when the unknown input is either negative or exactly zero voltage.

Another optional feature is the use of the 60-Hz line frequency to synchronize the system. This improves the appearance of the display when a digital readout is used, since the voltage under measurement frequently has a small 60-Hz component. When the sampling rate is synchronized with this "hum," the reading is always taken at the same point in the hum wave shape, so the last digit is less likely to fluctuate. The actual reading obtained is, of course, the input voltage at this instant and may not be the rms value of the input signal plus hum.

When the converter is operated at a 60-Hz rate, only about seven corrections per second are made. In a 4-1/2-digit system, LSB/4 is only 1/40,000th of full scale, so if each correction is LSB/4, the correction rate is only 0.0175% per second. Therefore, if the initial error should happen to be 10% of full scale, it will take about 10 minutes for the system to stabilize. This time can be reduced by synchronizing a higher frequency oscillator to the line frequency and using its output to operate the converter.

Another desirable refinement is the use of a potentiometer to vary the offset of one of the comparators. This provides a zero-offset adjustment for the instrument and allows the output to read zero for a nonzero input, a condition sometimes desirable when the input comes from a transducer. Provision for this adjustment also allows the use of a less precise operational amplifier, such as the MLM301A, instead of expensive precision comparators. ■■

OUR ANGLE: Low Cost D/S and S/D Modules



TYPICAL S/D MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
S/D or R/D	11.8V	400Hz
R/D	26V	400Hz
S/D or R/D	90V	400Hz
S/D	90V	60Hz

TYPICAL D/S MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
D/S or D/R	11.8V	400Hz
D/R	26V	400Hz
D/S or D/R	90V	400Hz
D/S	90V	60Hz

How does a choice of 14-bit resolution, 60 or 400 Hz data frequency, high accuracy, 11.8V to 90V line-line voltages and all kinds of self-protection circuitry look from your angle?

North Atlantic's Series 780 is available now. Only 5 modules make up a complete S/D or D/S converter, and any set nests in an area less than 21 square inches.

S/D specifications include 3 minutes \pm 0.9LSB accuracy, and continuous tracking with low velocity errors. D/S specifications include 4 minute accuracy, 1.25 VA output and 25 μ sec settling time.

Key performance specifications for both converters include 14-bit (0.22°) resolution over 360°, 0-70°C operation and 4000°/sec data rates. Both units are DTL and TTL compatible.

To shrink your prototype schedule, we offer an interconnecting PC board. Or, if you plan to integrate a converter directly onto your own PC cards, we can supply proven mylar artwork.

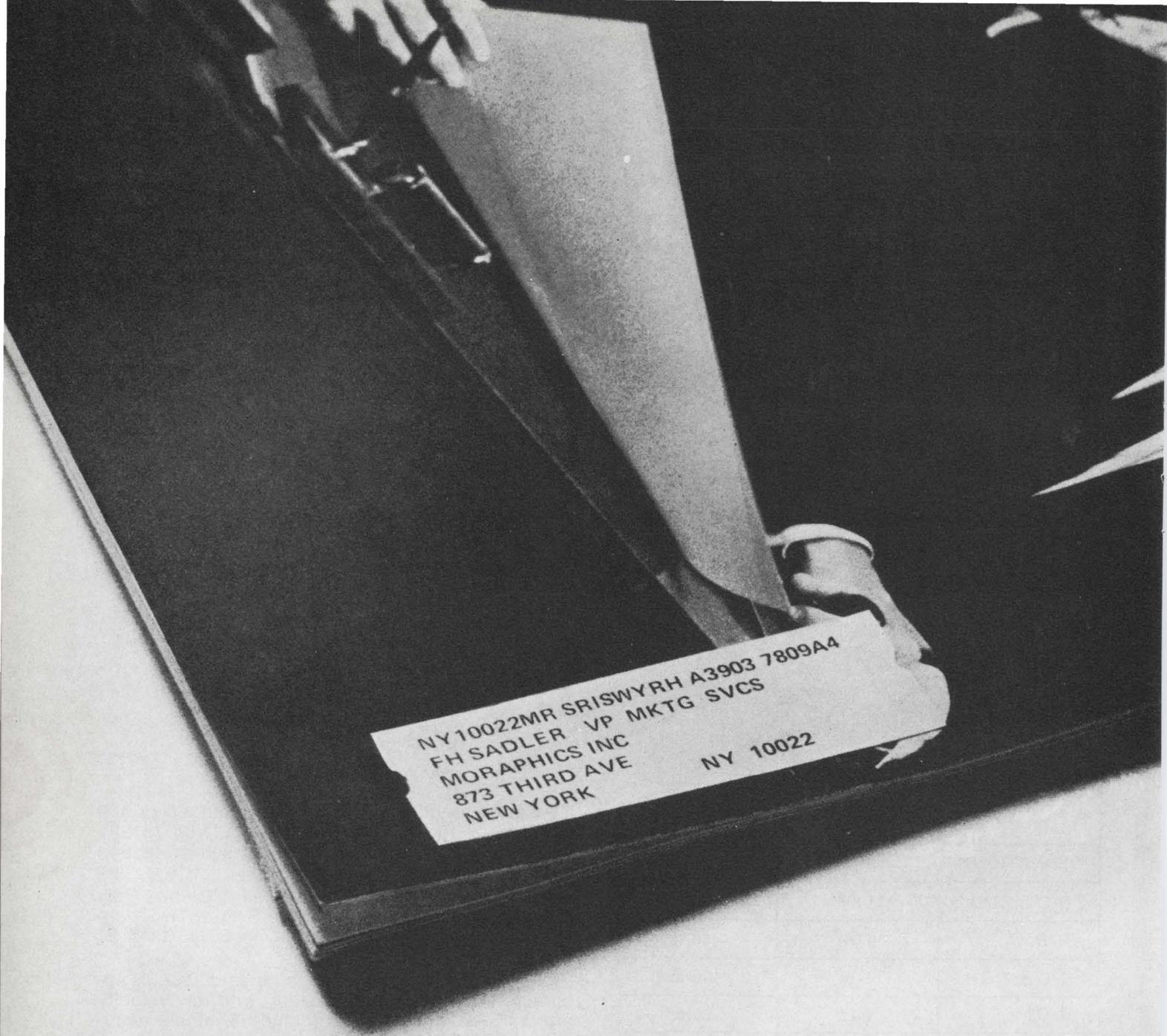
Any set of modules — \$650. Order a set today. North Atlantic sales engineering representatives are located throughout the free world.



NORTH ATLANTIC industries, inc.

200 Terminal Drive, Plainview, New York 11803 Phone (516) 681-8600
California District Office: 13418 Wyandotte Street, N. Hollywood, CA 91605; Phone (213) 982-0442

INFORMATION RETRIEVAL NUMBER 41



What you see is not necessarily what you get.

The man on the mailing label left that address, that company, that job a long time ago.

The magazine keeps coming, but he isn't there to get it.

Nor does the advertiser get *him*.

BPA-audited publications keep better track of their readers. Whether they pay for a subscription or get it free, they must be *qualified* — by industry, by job function — to begin with.

And BPA auditors keep re-checking to make sure the circulation lists carry the

people — and only the people — that the publishers promise.

Businessmen move about, as we well know. But when you advertise in a publication that's BPA-audited, you can be sure that what you see on the publisher's statement is what you get.

BPA

Business Publications Audit of Circulation
360 Park Avenue So., New York, N.Y. 10010

This symbol means:
edited for businessmen, *audited* for advertisers

the CTS eliminator makes you an offer you can't resist

It's CTS Series 760 DIP cermet resistor networks, available "off the shelf" from authorized CTS Industrial Distributors. Thirty-five standard 760 series resistor modules (in 2 package styles) make it easy to be a time, space, and money saver. They *eliminate* lead forming, lead trimming, and individual component insertions . . . *eliminate* costly PCB real estate . . . *eliminate* up to 12 separate components.

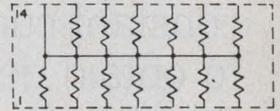
And, we *eliminate* long delivery times too! These cost savers are stocked for immediate delivery. All have 1.5 watts power capabilities per module and provide proven CTS cermet reliability.

Doesn't it make sense to make the switch to CTS standard networks . . . non-standards are available, too, from CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Phone: (219) 589-3111.

CTS CORPORATION
Elkhart, Indiana



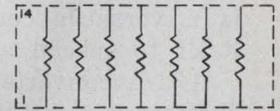
A world leader in cermet and variable resistor technology.



Model 760-1

Resistance values 100 ohms thru 22K ohms. Applications: MOS/ROM pull-up/pull-down; open collector pull-up; "wired OR" pull-up; power driver pull-up; high speed parallel pull-up; TTL unused gate pull-up; TTL input pull-down; digital pulse squaring.

Prices ($\pm 2\%$ std tolerance):
1-99 \$1.45
100-499 1.24
500-999 .91



Model 760-3

Resistance values 68 ohms thru 22K ohms. Applications: "Wired OR" pull-up; power driver pull-up; power gate pull-up; line termination; long-line impedance balancing; LED current limiting; ECL output pull-down resistors; TTL input pull-down.

Prices ($\pm 2\%$ tol standard)
1-99 \$1.25
100-499 1.07
500-999 .74

The complete line of CTS series 760 cermet resistor modules are in stock at:

ALABAMA—Cramer/EW Huntsville, Inc. ARIZONA—Cramer/Phoenix CALIFORNIA—Santa Monica Bell Electronics • Bell Electronics • Cramer/Los Angeles • Cramer/San Diego • Cramer/San Francisco • Hollywood Radio & Electronics, Inc. • Rose Electronics • Terminal—Hudson West COLORADO—Cramer/Denver • Waco Electronics CONNECTICUT—Cramer Electronics, Inc. FLORIDA—Cramer/EW Hollywood • Cramer/EW Orlando • Lykes Electronics Corp. GEORGIA—Cramer/EW Atlanta ILLINOIS—Allied Electronics Corp. • Cramer/Chicago • Merquip Electronics MARYLAND—Arrow Electronics • Cramer/EW Baltimore MASSACHUSETTS—MINNESOTA—Cramer/Bonn • Electro-Com NEBRASKA—Scott Electronics NEW JERSEY—Cramer/Penn., Inc. • Cramer/New Jersey • Radio NEW YORK—Arrow Electronics • Cramer/Binghamton, Inc. • Cramer/Long Island • Cramer/Rochester • Cramer/Syracuse • Summit Distributors • Terminal—Hudson Electronics NORTH CAROLINA—Cramer/EW Raleigh • Cramer/EW Winston-Salem OHIO—Cramer/Cleveland • Cramer/Tri-States, Inc. • ESCO Incorporated • Hillebrand Electronic Supply • Sun Radio Company OKLAHOMA—Cramer/Tulsa PENNSYLVANIA—Arrow Electronics • Cameradio Company • Cramer/Penn • Radio Electric Service Co. TEXAS—Adleta Electronics Co. • Cramer/Texas • Southwest Electronics, Inc. UTAH—W. H. Bintz Co. • Cramer/Utah WASHINGTON, D. C.—Cramer/EW Washington WASHINGTON (State)—Cramer/Seattle, Inc. • Far West Electronics WISCONSIN—Cramer/Wisconsin

Design versatile d/a converters by using constant-current sources. Custom components are not needed to obtain devices for special applications.

Designing "one-of-a-kind" digital-to-analog (d/a) converters presents a formidable problem to the designer. If, for example, the input code is unusual, a suitable off-the-shelf converter may be unobtainable or prohibitively expensive. Yet a completely new in-house design may also involve high expenditures and long delays. What's needed is a versatile conversion technique that lends itself to special applications.

A d/a converter designed with constant current sources can handle a wide range of requirements. Almost any type of digital input coding can be accommodated. Precision resistive ladder networks are not needed, so no time is spent waiting for delivery. Also, most commercially available resistive-weighting networks are restricted to binary inputs.

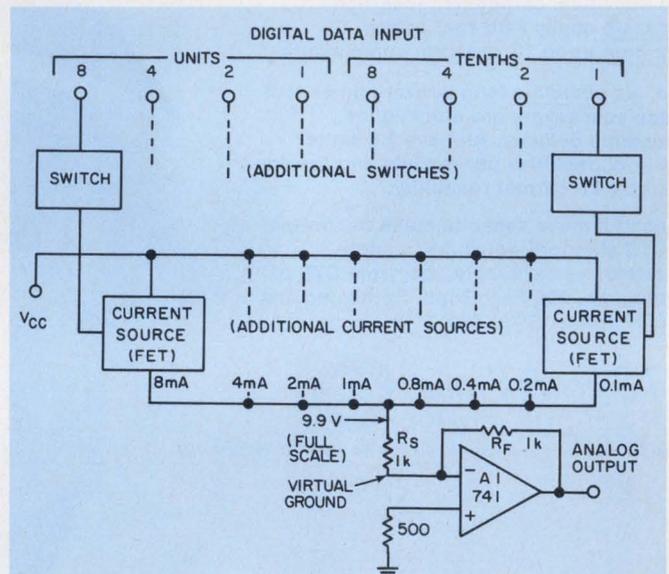
In a constant-current d/a converter, the outputs of all the current sources are connected by a common bus to a constant-impedance load. Each source is individually adjusted so it supplies a steady current value that is equal in weight to the input data bit that controls it. For example, the converter shown in Fig. 1 uses a weighting factor of "one unit equals 1 mA" and the output voltage is developed across an impedance of 1000 Ω . But any other weighting factor and load impedance can be chosen. Extra digits can be added to this type of converter if additional sources are used. But, of course, there is no reason to design and build a five-digit d/a converter when the output of the analog device has only two-digit resolution.

Design the switched current source

The heart of the constant-current converter is the current source shown in Fig. 2. The characteristics of the field-effect transistor (FET) and the value of the source resistor, R_s , determine the value of drain current, I_D , flowing through the device. The value of V_{GS} required for a given I_D can be found with the formula

$$V_{GS} = V_P (1 - \sqrt{I_D/I_{DSS}}),$$

Jon L. Turino, Test Equipment Engineer, Xerox Corp., El Segundo, Calif. 90245.



1. The design concept for a two-digit BCD-to-analog converter. The analog output voltage goes from zero for an input code of (0, 0, 0, 0 - 0, 0, 0, 0) to 9.9 V for a code of (1, 0, 0, 1 - 1, 0, 0, 1).

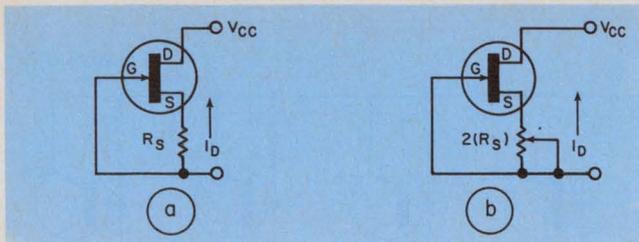
where: V_{GS} is the required gate-to-source voltage for the FET,

V_P is the pinchoff voltage of the device,
 I_D is the required drain current, and
 I_{DSS} is the zero-bias drain current of the transistor.

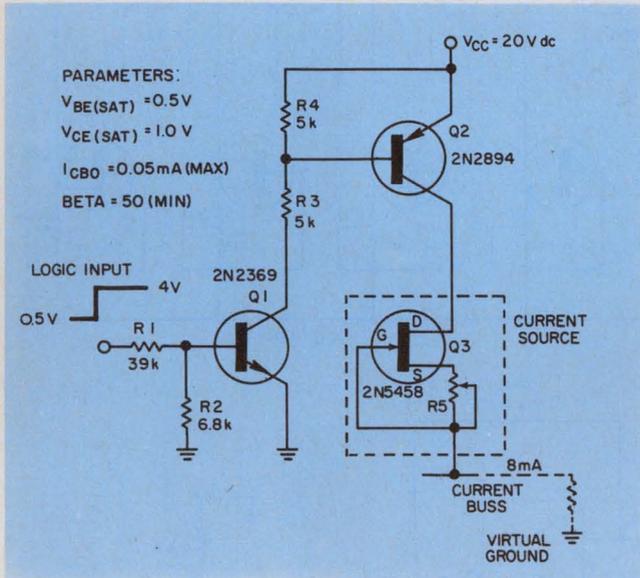
The value of R_s is then $R_s = V_{GS}/I_D$.

Since device parameters vary considerably from their published specifications, it is wise to use a potentiometer with a total resistance of twice the calculated value of R_s instead of a fixed value. This insures that the required I_D can be obtained, and it allows the precise adjustment required for accurate calibration of the current source.

The selection of the V_{cc} for the current sources is very important for proper operation of the converter. It must be large enough to insure that, even with the converter inputs and output at almost full scale, there is enough voltage to keep the least-significant-bit (LSB) current source operating in the constant-current region. A sure way to determine this value is to add the full-scale voltage needed at the current-source output



2. The heart of the d/a converter is the current source (a). A variable resistance (b) is preferred so that each constant-current source can be adjusted exactly to the required values.



3. Complementary transistors, Q_1 and Q_2 , are used in a combination, level-shifting and saturated-switch circuit. A true input (4 V) causes Q_1 and Q_2 to saturate, thereby turning on the preset current source Q_3 .

point to the highest value of V_{GS} required in any of the current sources. To this value, add about 25% as a safety margin.

This method of selecting V_{cc} will insure that there is adequate drain-to-source voltage (V_{DS}) across each FET. For example, assume that the circuit of Fig. 1, with a full-scale voltage of 9.9 V at the top of R_S , requires a V_{GS} of 5 V for the 0.1 mA output. The V_{cc} supply should then be

$$(9.9 \text{ V} + 5 \text{ V}) + (.25) \cdot (9.9 \text{ V} + 5 \text{ V}) = 18.6 \text{ V}.$$

In practice, a well-regulated voltage of 18-20 V dc will work satisfactorily.

Interface with the logic levels

With the current-source values and components selected, the remaining part of the circuit to be designed is the input-switching interface. This interface must take the digital input levels and cause them to turn the individual current sources either fully on or fully off. Since the required interface depends on the specific digital device connected to the converter input, no hard and fast rules can be made for its design. An exam-

ple, however, should serve to point to the concepts.

Suppose the interface logic levels are 0.5 V maximum for a ZERO (saturated collector-emitter junction) and 4.0 V minimum for a ONE (a pull-up resistor connected to +5 V dc). A circuit suitable for converting these levels to an on-off control for the current source is shown in Fig. 3. The design procedure starts with the value of the collector current of Q_2 and works back to the input terminal with some rules of thumb.

First, select the I_C of Q_2 as 16 mA—that is, twice the value of the current source output. (Although no more than 8 mA will flow in the circuit, this rule insures that there will always be enough base current applied to Q_2 to cause saturation.)

Next, find the I_B of Q_2 , using the minimum β of the transistor. For this example, assume a minimum β of 50, so that $I_B = 0.32$ mA. Select R_4 so that less than one-half of the $V_{BE(SAT)}$ of Q_2 can be dropped across it when the I_{CBO} of Q_1 is at its maximum. Then if

$$(V_{BEQ2})_{SAT} = 0.5 \text{ V}$$

$$\text{and } (I_{CBO})_{Q1} = 0.05 \text{ mA},$$

R_4 should be $0.25 \text{ V} / 0.05 \text{ mA} = 5000 \Omega$.

Next the value of R_3 can be selected. It should drop

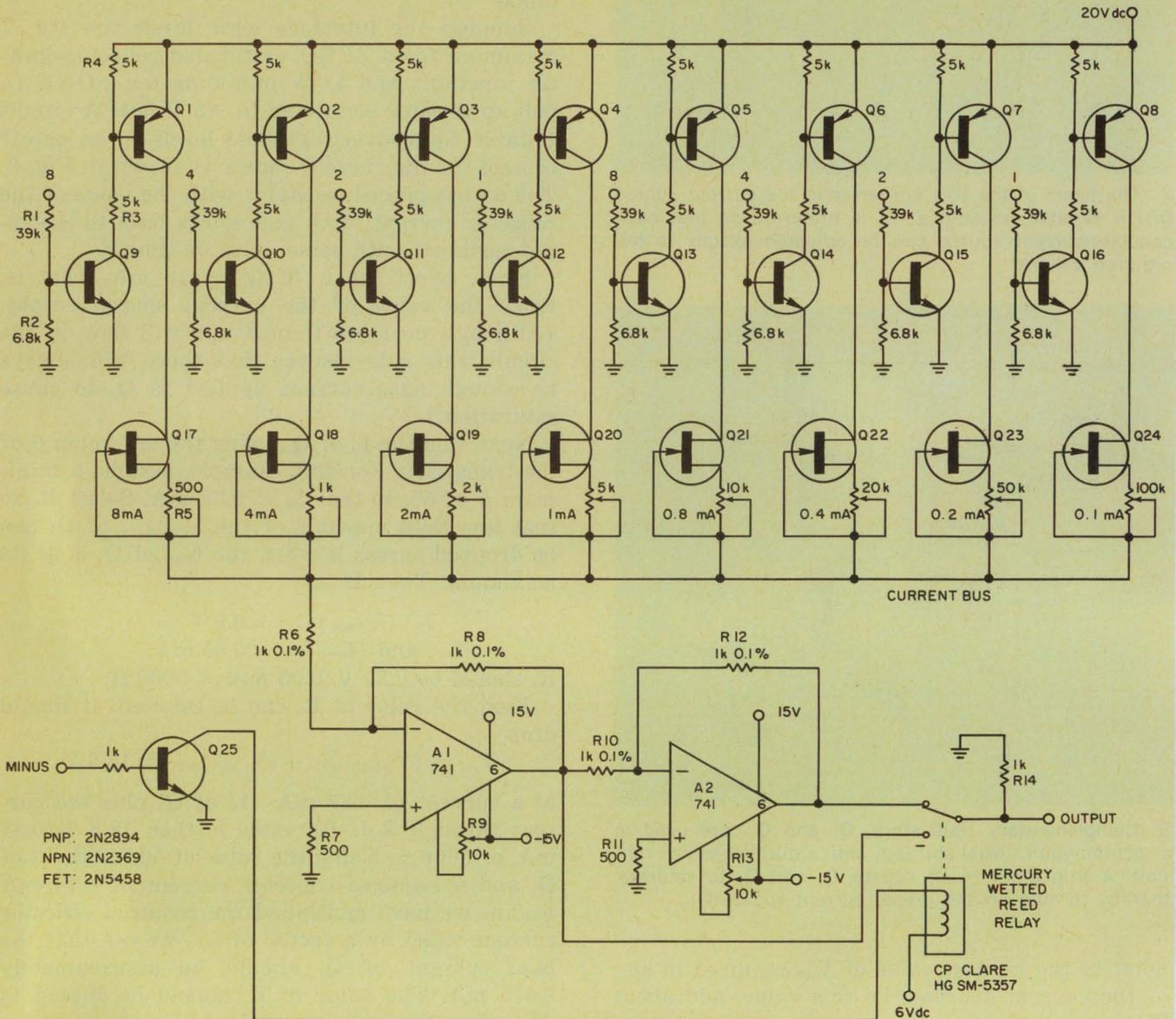
$$V_{cc} = (V_{BEQ2})_{SAT} - (V_{CEQ1})_{SAT} = 18.5 \text{ V}$$

at a current of 0.37 mA (I_B of Q_2 plus the current through R_4). Its value is then $18.5 \text{ V} / 0.37 \text{ mA}$, or 5000Ω . Using the value of 50 for the β of Q_1 and a required collector current of 0.74 mA (again we have multiplied the required collector current value by a factor of 2), we see that the base current of Q_1 should be approximately 0.015 mA. The value of R_2 should be chosen to drop five times $I_{B(Q1)}$ at $V_{BE(SAT)}$, so its value should be $R_2 = 0.5 \text{ V} / 0.075 \text{ mA} = 6700 \Omega$. A resistor with a standard value of 6.8 k Ω should be close enough. The value of R_1 can then be calculated. It should drop $4 \text{ V} - 0.5 \text{ V} = 3.5 \text{ V}$ at a current of 0.09 mA. The value is 39 k Ω .

The schematic of the final version of the two-digit BCD-to-analog converter is shown in Fig. 4. Although a precise dc circuit design procedure may be used when the interface circuits are designed for a specific application, the use of the assumptions and rules of thumb previously discussed insure that the transistors are off when the input is low and on when the input is high.

Calibrate with external voltages

All that remains is the calibration of the converter. This is done very simply. First, connect all input terminals to a +0.5 V source and adjust the offset control of op-amp A_1 for zero output voltage (pin 6). Then connect each input indi-



4. The complete two-digit BCD-to-analog converter requires only the appropriate power supplies and a simple

calibration routine. A Minus signal from the input device actuates the relay to allow bipolar operation.

vidually to a +4.0 V source and adjust the current-source potentiometers to give the proper output voltages at pin 6 of the op amp (8 V for Units position 8 and 0.4 V for Tenths position 4, etc.).

The output of the converter can drive most analog devices directly. If more driving power is required, it can be obtained in the usual ways (such as with a complimentary-symmetry stage).

Semiconductor-device selection is not critical. The switching portion of the circuit is designed for worst-case operation. A large amount of negative feedback regulates the current-source portions. FETS are used as current-source elements to achieve design simplicity and a low

parts count. The total cost of the components comes to only \$45.

Measurements show that the circuit has a zero drift of less than 0.1 mV from 15 to 50 C. Linearity is better than 0.5%, and the overshoot when codes are changed is less than 1%. The maximum spike duration is less than 50 μ s, which is much too fast to disrupt the indications of most analog devices.

The only critical voltage is the V_{cc} for the current sources. This must be regulated so it does not fall below the minimum required voltage. Only the minimum value is important; an increase of 25% affects the converter output by less than 1%. ■■

Multiplexer technique solves X-out-of-Y bit pattern-recognition

Straightforward application of Boolean techniques becomes unwieldy when the logic designer needs a pattern of X true bits from a field of Y bits. A technique that uses digital-multiplexer ICs easily yields solutions for any range of X and Y. And it is especially useful when Y exceeds six, as often happens with error-correcting codes.

A multiplexer with N addressing (select) bits can produce all Boolean products of N variables. A ONE output results when the selected input line also equals ONE. The input lines are labeled as the decimal equivalent of the N addressing bits. For example, the select addresses of 011, 101 and 110 each produce a ONE output if input lines 3, 5, and 6 are all ONES, as shown for Z₁.

In this case, a ONE output is produced when two out of the three bits are ONES. Similarly, the inputs can be wired so as to recognize one out of three and three out of three ONES on the select lines.

A three-of-six pattern detector where, X = 3, Y = 6 and N = 3, is shown in the schematic. The output is true whenever three, and only three, of the six inputs are true. The technique used is to work from the output backwards, providing one level of multiplexers for every subset

of N = 3 input variables.

If $Y_4Y_5Y_6 = 000$ the three-of-three input to the final multiplexer will be selected. Hence the final output will be ONE if $Y_1Y_2Y_3$ are all true.

If $Y_4Y_5Y_6 = 001, 010, \text{ or } 100$, thereby selecting inputs 1, 2 and 4, then the output will be true only if two of the other variables $Y_1Y_2Y_3$ are true.

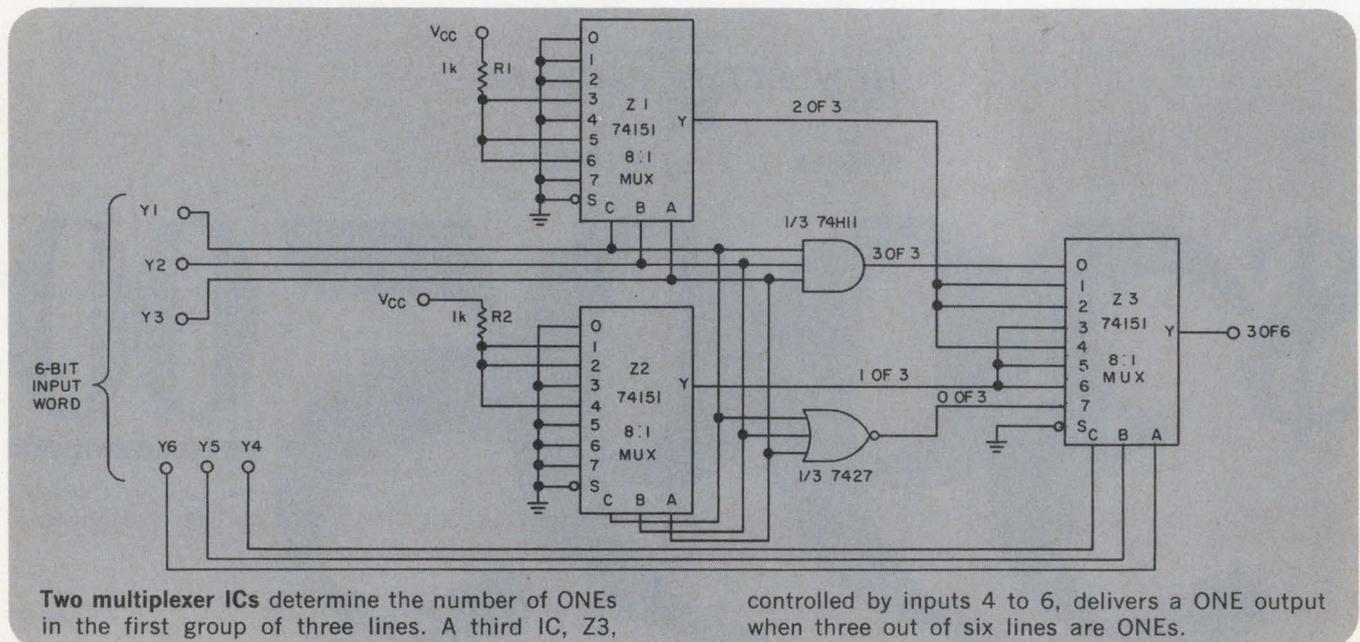
If $Y_4Y_5Y_6 = 011, 101 \text{ or } 110$ (3, 5, 6), then the output will be true only if one of the other variables, $Y_1Y_2Y_3$, is true.

When variables $Y_4Y_5Y_6 = 111$ (7), the output will be true only if none of the other variables is true.

In the first level the presence of none-of-three, one of three, two of three, and three of three true variables must be detected. Single gates will detect none of three (000) and three of three (111) patterns; multiplexers economically detect one of three and two of three patterns. Note that only one polarity of the Y variables is required.

Les Furnanz, Development Engineer, Fairchild Systems Technology, 3500 Deer Creek Rd., Palo Alto, Calif. 94304.

CIRCLE NO. 311



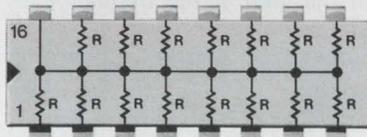
191 FLAVORS OF BECKMAN DIPS



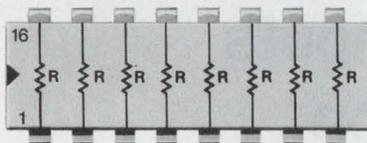
All 191 flavors of RESNET™ DIPs offer system compatibility because we use the same packages you use for I.C.s; plus you get ceramic dependability at plastic prices.

Whether you're inserting resistors automatically or by hand — call your local Beckman/Helipot representative and ask how you can save money using RESNET DIPs. He stocks locally for immediate delivery.

To request technical data, call your local Beckman/Helipot representative. Or write to Beckman Instruments, Inc., Helipot Division, 2500 Harbor Blvd., Fullerton, Calif. 92634.



898-1 (15 resistors)
Price (1,000-4,999) \$.85

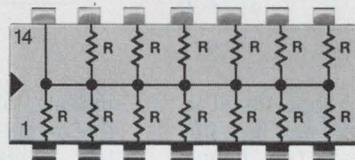


898-3 (8 resistors)
Price (1,000-4,999) \$.76

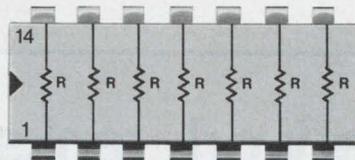
STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

62*	110	330	1.0K	2.2K	6.0K	15.0K
68	150	470	1.5K	3.3K	6.8K	22.0K
100	220	680	2.0K†	4.7K	10.0K	

* Standard in 898-3 only.
† Standard in 898-1 only.



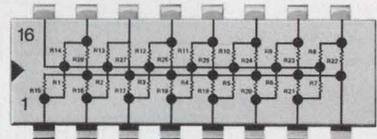
899-1 (13 resistors)
Price (1,000-4,999) \$.81



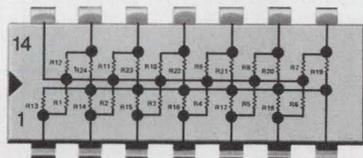
899-3 (7 resistors)
Price (1,000-4,999) \$.72

STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

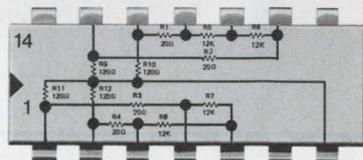
22	62	180	510	1.5K	4.3K	11K
24	68	200	560	1.6K	4.7K	12K
27	75	220	620	1.8K	5.1K	13K
30	82	240	680	2.0K	5.6K	15K
33	91	270	750	2.2K	6.0K	16K
36	100	300	820	2.4K	6.2K	18K
39	110	330	910	2.7K	6.8K	20K
43	120	360	1.0K	3.0K	7.5K	22K
47	130	390	1.1K	3.3K	8.2K	
51	150	430	1.2K	3.6K	9.1K	
56	160	470	1.3K	3.9K	10K	



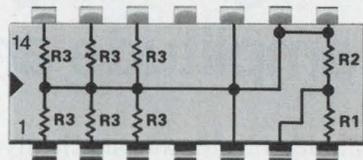
898-5-R220/330
Pulse squaring TTL terminator.
Price (1,000-4,999) \$1.45



899-5-R220/330
Pulse squaring TTL terminator.
Price (1,000-4,999) \$1.35



899-19
DIP interface network providing resistors for μA711 core sense amplifier configuration.
Price (1,000-4,999) \$1.18



899-40
DIP network provides six line terminators and the threshold setting divider for the Intel 3208A sense amplifier.
Price (1,000-4,999) \$1.35

Beckman

HELIPOT DIVISION

INFORMATION RETRIEVAL NUMBER 43

Analog divider simplifies ac ratio meter and yields ± 0.2 -dB measurement accuracy

An ac ratio meter simplifies frequency-response measurements by determining the output-to-input voltage ratio at any given frequency. The circuit shown measures the voltage ratio to within 0.2 dB and has a parts cost of hundreds of dollars instead of the thousands that commercial units cost.

The circuit consists basically of an analog divider and two peak detectors. The latter converts the ac voltages, V_1 and V_2 , to proportional dc magnitudes at the input to the divider. A read-out device such as a DPM, indicates the ratio V_2/V_1 from the output of the divider.

The simple op amp peak detectors shown work adequately at audio frequencies. An uncompensated op amp should be used and preferably should have wide bandwidth.

If capacitors C_1 and C_2 have large values, the op amps should be current-limited at their outputs, to prevent damage when the capacitor

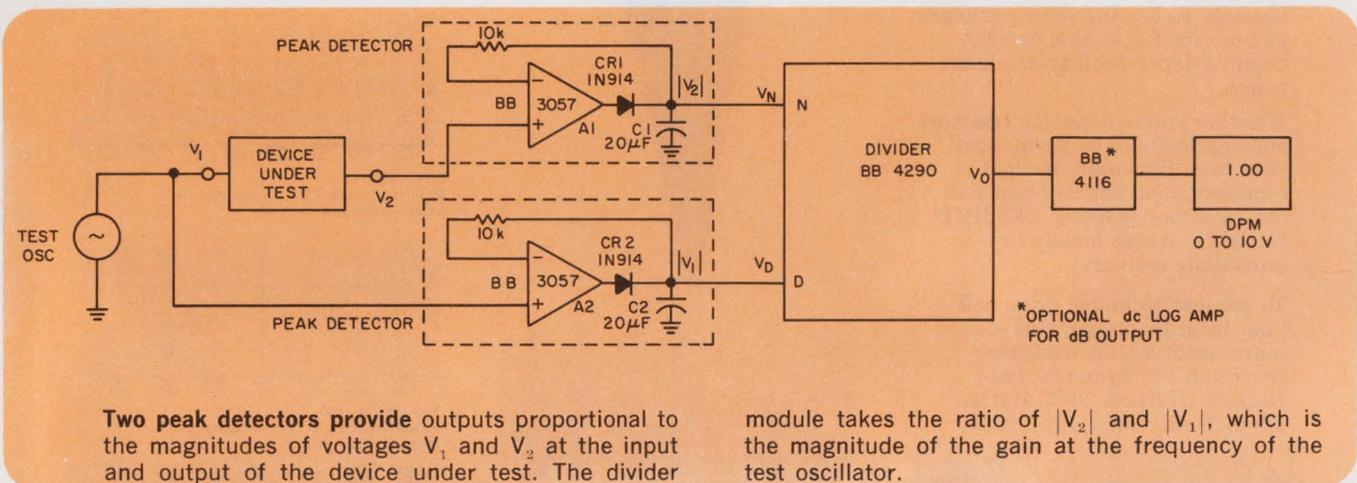
charges toward the peak input voltage.

With the components shown, the ratio meter exhibits a frequency response of ± 0.2 dB from 20 Hz to 20 kHz, provided the inputs to the divider are near their full-scale value of 10 V. The dynamic range is 0 to -40 dB, ± 0.2 dB, under the constraint that $V_D \approx 10$ V, and that $10 V \cong V_N \cong 0.1$ V.

The inputs V_D and V_N to the divider must be scaled so that V_o is more than 1 V. This limits the divider error to ± 0.1 dB but restricts the dynamic range to -40 dB. Scaling amplifiers used before the peak detection will extend the dynamic range to ± 60 dB.

Larry Choice, Product Specialist, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706.

CIRCLE No. 312



Analog sorting network ranks inputs by amplitude and allows selection

An analog circuit automatically selects the M th largest signal in an arbitrary set of N analog inputs. The N analog inputs are ordered from lowest to highest value $V_{1R} < V_{2R} < V_{3R} \dots < V_{NR}$; and the M th member of the sorted sequence is chosen. Thus,

$$V_o(M) = V_M$$

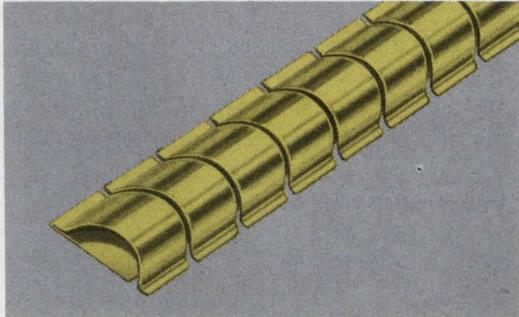
where M is a variable parameter selected by the

designer and R denotes sorting. In the special case, where, for example, $N = 3$ and $M = 2$, we have a mid-value selector. In another case where N is odd and $M = (N + 1)/2$, the $V_o(M)$ represents the median input voltage.

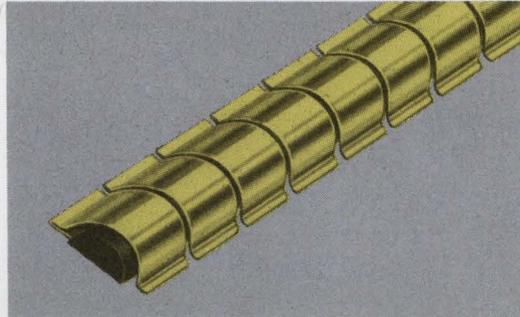
An arbitrary number of voltages, N , are connected to the noninverting inputs of N op amps (Fig. 1). Each amplifier output is connected to a

When RFI problems get sticky, try **stickn fingers**®

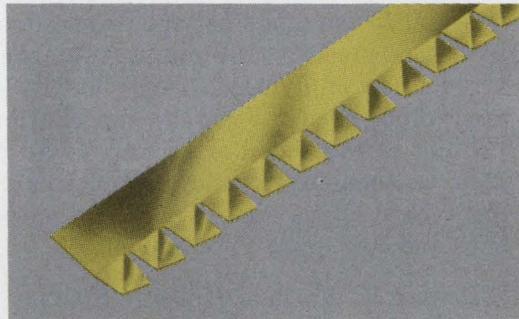
Attaches faster, shields better than anything else!



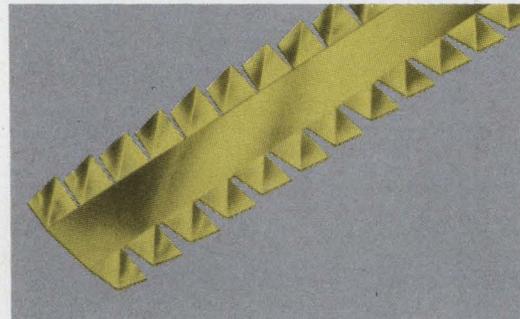
SERIES 97-500 The original Sticky Fingers with superior shielding effectiveness.



SERIES 97-510 Provides even better magnetic shielding with Magnefil® insert strips.



SERIES 97-555 New Single-Twist Series for use when space is at a premium. Measures a scant $\frac{3}{8}$ " wide.



SERIES 97-560 New $\frac{1}{2}$ " wide Double-Twist Series, ideal for panel divider bar cabinets.

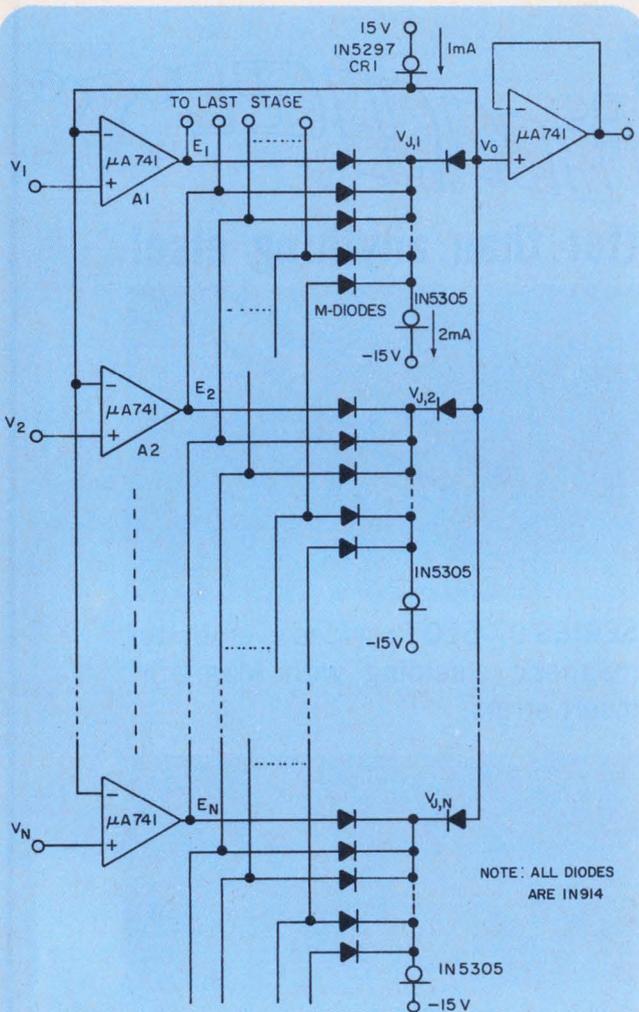
Now you can specify the exact type beryllium copper gasket that solves just about every RFI/EMI problem. Perfect for quick, simple installation; ideal for retro-fitting. Self-adhesive eliminates need for special tools or fasteners. Write for free samples and catalog.



INSTRUMENT SPECIALTIES COMPANY, Dept. ED-65

Little Falls, N.J. 07424

Phone—201-256-3500 • TWX—710-988-5732



By making M comparisons per amplifier and by choosing the lowest values found, the analog circuit selects the Mth largest input voltage.

single diode in a cluster of M diodes. The diodes then select the largest voltage from among the next M amplifier output, where $1 \leq M \leq N$.

A diode OR-gate circuit, with one input per cluster, causes unity gain feedback of the lowest cluster voltage, V_o , to the input amplifier inverting terminal bus. V_o is the minimum of V_{J1} through V_{JN} .

Circuit operation can be explained mathematically as follows: Assume (without loss of generality) that $V_1 < V_2 < \dots < V_N$. Let E_i and V_{Ji} denote the i th op-amp output and diode voltage respectively, for $1 \leq i \leq N$. Also let V_D be the forward drop of any single diode. Then, $V_o = \min(V_{J1}, V_{J2}, \dots, V_{JN}) + V_D$. Also V_{J1} is defined by the diode clusters $V_{J1} = \max(E_1, E_{i+1}, \dots, E_N, E_1, E_2, \dots) - V_D$, where M terms are included in the parenthesis. Since all of the op-amp inverting inputs are common, we have

$$E_1 < E_2 < \dots < E_N.$$

Substituting into the above, we get,

$$(V_{J1}, V_{J2}, \dots, V_{J(N-1)}, V_{JN}) = (E_M, E_{M+1}, \dots, E_N, E_N) - V_D$$

and so $V_o = E_M$ which implies that $V_o = V_M$ by virtue of the feedback.

The constant-current sinks (1N5305) are chosen to draw twice the current of the constant-current source (1N5297). This will cause equal currents through the two active diodes and thereby equalize the diode voltage drops. Resistors can be used instead of the diodes. But there will be a reduction of dynamic range and a loss of the exact diode forward-voltage cancellation.

Input voltages to almost ± 15 V can be handled with reasonable accuracy. The circuit also features high input impedance, low output impedance and low input-to-output offset.

Dennis R. Morgan, General Electric Co., Electronics Laboratory, Syracuse, N.Y. 13201.

CIRCLE NO. 313

IFD Winner of September 14, 1972

John Svalbe, President, Magnetic Electronics, Inc., P.O. Box 25517, W. Los Angeles, Calif. 90025. His idea "Packaged pulse-width modulator simplifies series-switching regulator design" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Information Retrieval Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of \$1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive \$20 for each published idea, \$30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of \$1000.

ELECTRONIC DESIGN cannot assume responsibility for circuits shown nor represent freedom from patent infringement.

ELECTRO-OPTICS MEASUREMENT LAB IN YOUR HANDS!!



\$495.00

Complete:

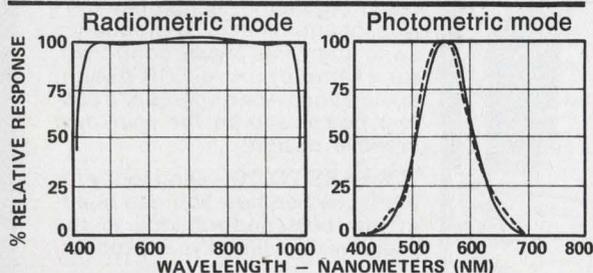
- Instrument
- Detector Head
- Radiometric Filter
- Photometric Filter
- All Calibrations

40A OPTO-METER

The personal, portable radiometer/photometer for every electro optics worker. As easy to use as a multimeter, with unmatched sensitivity and accuracy. All solid state electronics and detector for ruggedness and long term stability. The 40A displays both intensity and integrated intensity, linearly and logarithmically, over seven decades in 36 ranges.

- 10^{-9} watt to 10^{-2} watt* (power)
- 10^{-9} joule to 10^{-3} joule (energy)
- 10^{-3} ft. cdl. to 10^4 ft. cdl. (intensity)
- 10^{-3} ft. cdl. sec. to 10^3 ft. cdl. sec. (integrated intensity)
- 10^{-2} to 10^3 μ W, on one log scale
- Computer designed correction filters

* to 1 watt with optional beam splitter



UNITED DETECTOR TECHNOLOGY INC.

1732 21ST STREET, SANTA MONICA, CALIFORNIA 90404, (213) 829-3357
TELEX 65-2413

WRITE OR CALL FOR A DEMONSTRATION TODAY

OUR STANDARD "OFF-THE-SHELF" TRIMMERS ARE BETTER THAN OTHER MANUFACTURER'S SPECIALS

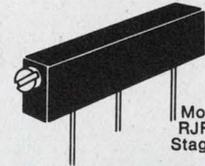
Accutrim™ trimmers RJ12 Styles

TC: 10 PPM/°C MAX

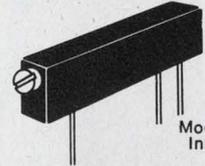
NOISE: 10 Ω ENR MAX

RANGE: DOWN TO 2 Ω

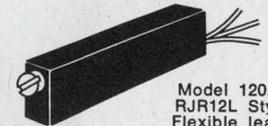
RESOLUTION 0.05% SETABILITY



Model 1202Y RJ12Y Style Staggered pins



Model 1202P Inline pins



Model 1202L RJ12L Style Flexible leads



Model 1202LB Panel mounted

Circle 198 on reader service card

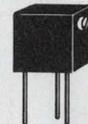
Accutrim™ trimmers RJR26 & RJR50 Styles

TC: 10 PPM/°C MAX

NOISE: ONLY 10 Ω ENR MAX

RANGE: DOWN TO 2 Ω

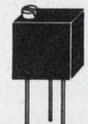
RESOLUTION: 0.05% SETABILITY WITH 20 FULL TURNS OF ADJUSTMENT!



Model 1240X Style RJR26X



Model 1240PS Style RJR50P



Model 1240W Style RJR26W



Model 1240P Style RJR26P

Circle 199 on reader service card

To send for FREE design and application information, circle reader service numbers above.



VISHAY RESISTOR PRODUCTS

63 LINCOLN HIGHWAY ■ MALVERN, PENNA. 19355
TELEPHONE: (215) 644-1300 ■ TWX: 510-668-8944

EMI/RFI CONTROLLER



This USCC/Centralab expert can control your EMI/RFI problems. Call his hot line collect at (213) 843-3822.

He's a highly qualified applications engineer ready to suggest one of our broad lines of standard ceramic or layer-wound filters. He can design a custom unit for your specific application or even immediately ship an evaluation sample.

We feel solving EMI/RFI problems should be our worry, not yours. Call (213) 843-3822 now.

Is your requirement not that urgent? Send for USCC's EMI/RFI Filter catalog containing complete technical data on: Button, Miniature and Subminiature Ceramic types; the New UL recognized 8000 Series for Data Processing Units and Systems; and the 9000 Series Ceramic Feed-thru Filter/Capacitors.



USCC/Centralab

Electronics Division • Globe-Union, Inc.

2151 North Lincoln Street • Burbank, California 91504



INFORMATION RETRIEVAL NUMBER 47

APGEN 1 increases NOVA performance

APGEN 1 is a unique hardwired arithmetic and logic unit which speeds up the array processing capabilities of any NOVA computer by a factor of 6 to 70.

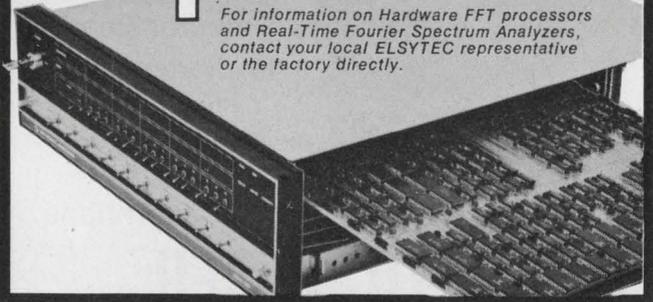
Typically, multiplication time of two 1000 element array is:
19 ms—using a NOVA 800 with hardware \times and \div
2.8 ms—using a NOVA 800 with **APGEN 1**

- Performs $+$, $-$, \times , \div , $\sqrt{\quad}$ and f
- Array size from 2 to 8192 16 bit words
- Calculations with matrices or complex numbers
- Plugs into any NOVA computer
- Price: \$4,000 FOB Syosset, N. Y.

elsytec

212 Michael Drive
Syosset, N. Y. 11791
Phone (516) 364-0560

For information on Hardware FFT processors and Real-Time Fourier Spectrum Analyzers, contact your local ELSYTEC representative or the factory directly.



INFORMATION RETRIEVAL NUMBER 48

OUT OF THE ORDINARY PERIPHERALS...

call for MCD Custom Power Supplies for precise, dependable performance.

YOU CAN TAKE ADVANTAGE of Magnetic Components Divisions' 15 years of **Control Data**® "inside" computer experience. The talent that supplied CDC with unique power-supply packages—with MTBF's to 100,000 hours, sophisticated regulation techniques (ferroresonant, linear, hi-frequency switching, and phase controlled, for example), pure EDP design applications—*can engineer a custom power source for your own creative design!*

IT'S EASY TO DO—send today for the facts. See how you can build-in low cost-performance to the user over the life of your product!

MAGNETIC COMPONENTS DIVISION **CONTROL DATA CORPORATION**

7801 Computer Ave. So., Minneapolis, Minn. 55435
(612) 920-8600 TWX 910-576-2978

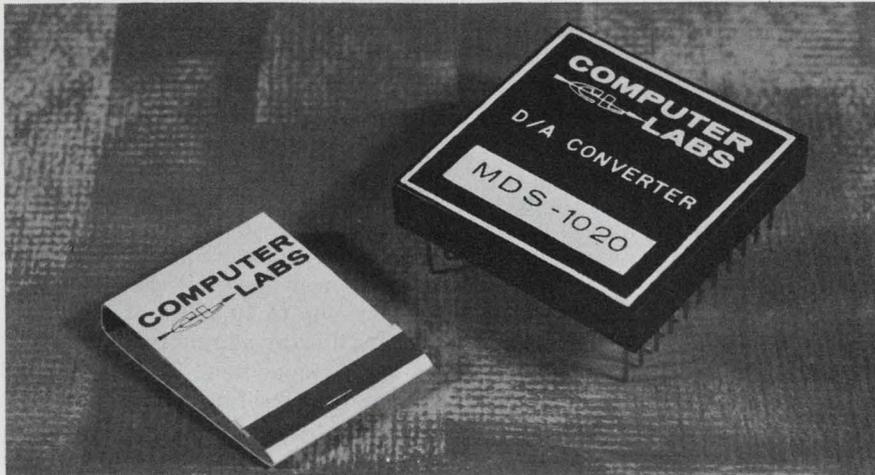


INFORMATION RETRIEVAL NUMBER 49

ELECTRONIC DESIGN 2, January 18, 1973

new products

8-bit d/a converter module settles to 0.4% within 15 ns



Computer Labs, 1109 S. Chapman St., Greensboro, N.C. 27403. (919) 292-6427. See text.

Computer Labs, known for high-performance analog-to-digital converters, has entered the low-cost, miniature converter field. The company's first entry in the low-cost arena is a modular line of 12 ultra-fast current-output d/a converters, with resolution of either eight or 10 bits. The MDS/815 is the fastest of the new units, with a settling time of only 15 ns to 0.4% of full scale (1 LSB). It costs \$109 in unit quantities.

Two other eight-bit units are available, with settling times of 30 ns and 50 ns, respectively, to 0.4% of full scale. These are designated the 830 and the 850. Accuracy of the eight-bit units is adjustable to $\pm 0.2\%$ (1/2 LSB). In addition three 10-bit converters are offered—the 1020, 1040 and 1080—with respective settling times of 20, 40 and 80 ns to 0.1% of full scale. Accuracy of the 10-bit units is adjustable to $\pm 0.05\%$.

Any of the converters can be ordered as the MDS Series, with a temperature coefficient of ± 30 ppm/ $^{\circ}$ C, or—for an additional \$20—as the MDP series, with a tempo of only ± 15 ppm/ $^{\circ}$ C. All units operate from -20 to $+75$ C.

With 15-ns settling time, the MDS/MDP 815 appears to be the

fastest eight-bit modular d/a converter available today. One example of a competitive unit is Datel Systems DAC-HI Series, which comes in either eight or 10 bits, settles to $\pm 0.1\%$ of full scale in 25 ns and has a tempo of ± 15 ppm/ $^{\circ}$ C. The eight-bit DAC-HI costs \$149. Another example is the Analog Devices MDA-10F, a 10-bit converter with a settling time of 40 ns to 1/2 LSB.

But it must be pointed out that most companies specify settling time to 1/2 LSB for a full-scale change in the input code—that is, all ONEs to all ZEROs or vice versa. Computer Labs, on the other hand, measures settling time for the major-carry input code transition, in which the MSB switches out of phase with all the other bits.

When this occurs, a d/a's output should theoretically change 1 LSB around the half-scale point. But because transistor turn-on and turn-off times are not equal, a temporary state—or glitch—can occur, in which the output swings toward zero before recovering to the half-scale point. Thus worst-case transients—and hence worst-case settling time—can result. This bit-to-bit, rather than full-scale settling time, is important in tracking applications, such as staircase generation.

The MDS/MDP series offers

more output current than competing modules: Full-scale output is 15 mA at 1.5 V max. for unipolar operation, and ± 7.5 mA at ± 1 V for bipolar operation. However, the eight-bit units consume a high 120 mA at 11 to 16 V, and -15 mA at -11 to -16 V; the 10-bit converters require 105 mA and -15 mA at the same voltages. Power-supply rejection is 0.04% per volt. The output impedance of all units is a nominal 165 Ω and the output zero offset is less than 15 nA. The units can drive five TTL H loads or seven standard TTLs.

The converters accept either straight-binary parallel input coding for unipolar output or offset binary or TWOs complement for bipolar output. Inputs are DTL/TTL-compatible.

The $2.315 \times 2.315 \times 0.43$ -inch converters weigh 2.5 ounces and are packaged in fiberglass epoxy. Single-quantity prices for the MDS 815, 830 and 850 are \$109, \$99 and \$89, respectively; the MDS 1020, 1040 and 1080 cost \$129, \$119 and \$109. Add \$20 to each unit for the MDP Series.

CIRCLE NO. 250

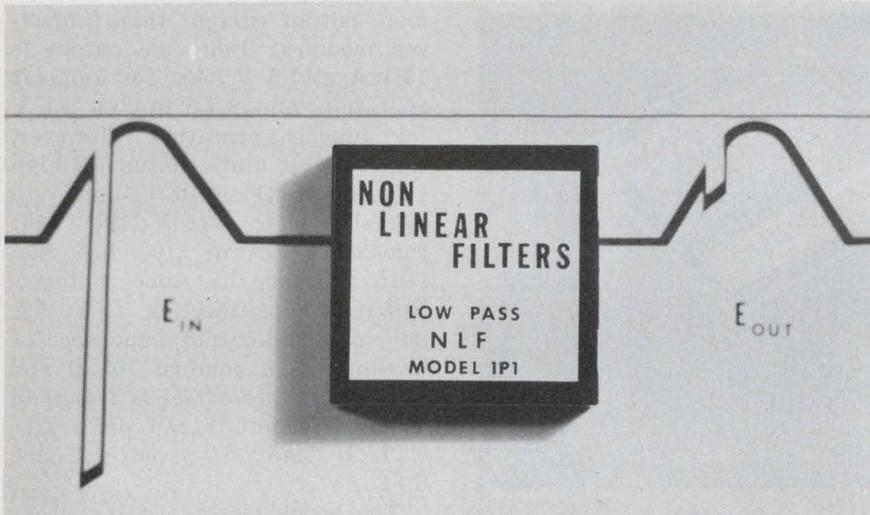
Module corrects CRT pincushion distortion

Intech Inc., 1220 Coleman Ave., Santa Clara, Calif. 95050. (408) 244-0500. \$495.

The A-740 performs all mathematical operations necessary to correct for the pincushion effect seen on CRTs with flat or semiflat screens. It also corrects dynamic focus distortions and other distortions resulting from nonideal deflection yoke and tube geometries. Correction accuracy is within 99.8%, bw is 10 MHz and slew rate is 40 V/ μ s in both horizontal and vertical axes. The plug-in module measures $3.5 \times 2.5 \times 0.87$ inches.

CIRCLE NO. 251

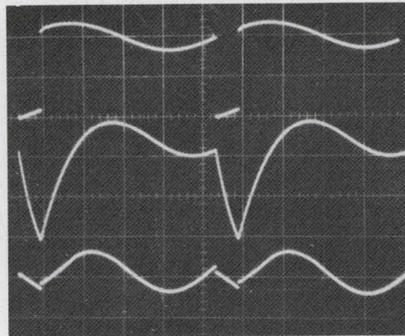
Nonlinear low-pass filter exhibits zero phase shift



Non Linear Filters, P.O. Box 338, Trumbull, Conn. 06611. (203) 268-6309. \$100 (1-9); \$70 (100s); 30 to 60 days.

Engineers working in digital communications, spectroscopy, voice communication and music reproduction are often plagued by phase-delay distortion and noise spikes. Impulse noise cancellation networks, phase-locked loops and other complex techniques are usually used to reduce such noise. Now, a fledgling company, Non Linear Filters, has come up with an encapsulated $2.56 \times 2.56 \times 0.8$ -inch module that appears to eliminate noise spikes more effectively than previous methods.

The device—designated the Model 1P—is an active, nonlinear low-



Response of the nonlinear filter to a 10-V, 800- μ s noise pulse riding on a 3-V pk-pk, 200-Hz sinusoid (top trace). The output of the filter is shown at bottom. The center trace is the response of a single-pole, linear low-pass filter to the same input. The nonlinear filter has no phase shift, while the linear filter gives a 45-degree lag.

pass filter that attenuates frequencies above its corner frequency. This in itself is obviously not earthshaking. What is different, however, is the fact that the device introduces virtually no phase shift either above or below the corner frequency. Thus spikes and other types of noise are reduced without phase-delay distortion.

The user selects corner frequency—up to 10 kHz—of the nonlinear filter by adding two nominally equal capacitors. The capacitor values in microfarads (C) are determined by division of the number 1.7 by the desired corner frequency in Hertz. The dV/dt of the input is then limited to $1.65/C$ —the maximum slew rate of the device. Also, three external resistors determine the transfer function.

The Model 1P requires a nominal supply voltage of ± 15 V at 20 mA. Over the operating range of 0 to 70 C, the unit's input bias current is 3 nA, and input-to-output offset voltage is 750 mV maximum. The linear voltage region of the filter is confined to ± 11 V for both input and output.

Input resistance, from dc to 100 kHz, is a minimum of 2.7 k Ω , while output resistance is 1 Ω max. Voltage gain of the device is nominally 1, but it can vary from 0.8 to 1.2. Both input and output are protected against short-circuits.

CIRCLE NO. 252



ANALOGY:
FOR THAT EXTRA KICK IN HIGH VOLTAGE REQUIREMENTS, USE THE A-302, FET INPUT, ± 150 V OP AMP. IT SUPPLIES A LOT OF ZAP (± 20 MA) WHILE INPUT BIAS CURRENT IS LESS THAN 10 pA. LET ANA TURN YOU ON, WRITE.

intech INCORPORATED
(408) 244-0500
1220 COLEMAN, SANTA CLARA CA. 95050

NOTHING ISOLATES LIKE OUR ISOLITES

Replace those old relays, reed relays and pulse transformers with up-to-date opto-isolators.

Litronix IsoLites give you faster switching speeds, no contact bounce, better reliability and 2500 volts electrical isolation. IsoLites can transmit from low frequency ac down to dc and eliminate ground loop problems. In long lines where common mode noise can build up, they may protect your equipment against a thousand volt jolt. Write for **free** application note and data sheets.

The 
bright guys
litronix

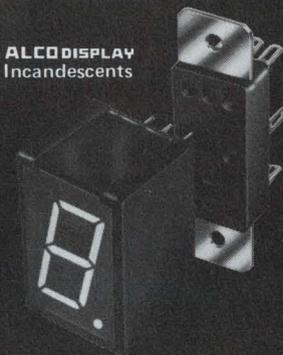
19000 Homestead Road, Cupertino, California 95014
(408) 257-7910 TWX: 910-338-0022

INFORMATION RETRIEVAL NUMBER 51

7-SEGMENT READOUT

New, low-cost, 7-segment incandescent readouts provide large, easy-to-read .8" numerals, plus decimal point. Model MS-5030E (5V 30 mA/seg.) available with choice of red or clear lens filters. Conventional & PC sockets available.

ALCO DISPLAY
Incandescent

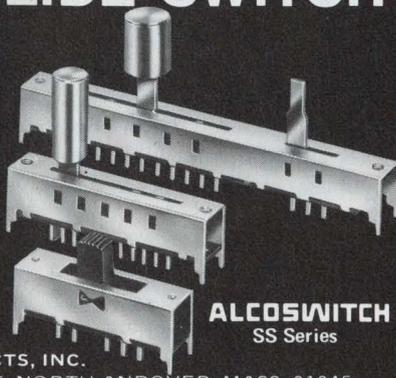


ALCO® ELECTRONIC PRODUCTS, NORTH ANDOVER, MASS. 01845

INFORMATION RETRIEVAL NUMBER 84

MULTIPLE POSITION SLIDE SWITCH

High density Switch Series designed specifically for P.C. boards. No wiring errors. Actuators have ball bearing spring detent. Make Before Break action in 1, 2, 4, 6 and 8-pole circuits. 4 to 13 positions.

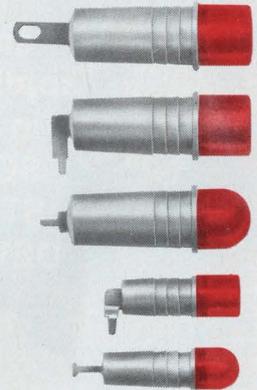


ALCO®
ELECTRONIC PRODUCTS, INC.
1551 OSGOOD STREET, NORTH ANDOVER, MASS. 01845

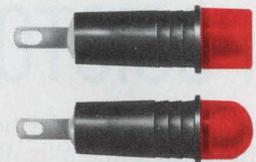
INFORMATION RETRIEVAL NUMBER 52

ELECTRONIC DESIGN 2, January 18, 1973

The smallest*



re-lampable
indicators are



Marco-Oak
QT Series
incandescent,
neon, and
LED indicators



- Long-life reliability
- Simplified press-in panel mounting
- All popular lens colors and styles
- Distributor on-shelf availability now

*Actual size shown

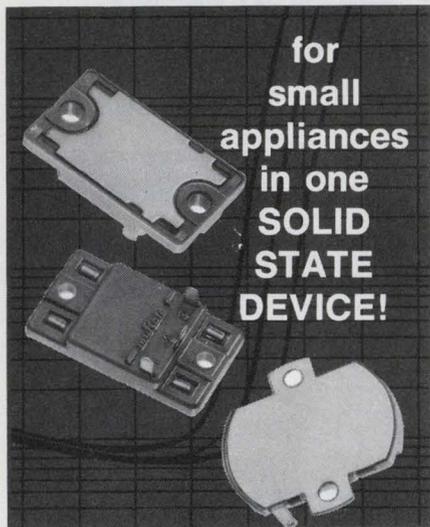
MARCO-OAK

Subsidiary of OAK Industries Inc.

P.O. Box 4011
207 S. Helena Street, Anaheim, Calif. 92803
Tel. (714) 535-6037 • TWX — 910-591-1185

INFORMATION RETRIEVAL NUMBER 53

Now... Heat Generation and Temperature Control



for
small
appliances
in one
**SOLID
STATE
DEVICE!**

muRata
POSISTORS®

That's right. Hot wire heating elements and bimetallic thermostats can be replaced with one simple solid state device. No exotic circuitry. No expensive transistors or SCR's. Few, if any, additional components.

Murata's Posistors provide both heat and temperature control for small appliance applications with heating requirements up to 100 watts. What's more, when higher heating capacities are required, Posistors may be utilized to provide smooth, stepless and extremely accurate temperature control.

Want to learn more? Write today for Murata's complete technical specifications.

muRata

MURATA CORPORATION OF AMERICA

2 Westchester Plaza, Elmsford, New York 10523

Telex: MURATA EMFD 137332

Phone: 914/592-9180

A Subsidiary of

Murata Mfg. Co., Ltd., Japan

INFORMATION RETRIEVAL NUMBER 54

DATA PROCESSING

Unit offers speedier facsimile transmission



Visicon, Inc., Box 1008, State College, Pa. 16801. (814) 237-6521. See text.

Model GX-100 is designed to allow high-speed transmission of large size documents over telephone lines. Black-and-white information is transmitted at a resolution of either 100 or 200 lines/in. Letter size documents (8-1/2 by 11 in.) can be transmitted in 30 s or less, "B" size drawings require as little as 70 s. This system is configured around a 16-bit minicomputer. Outputs can be provided in two forms of reconstructed hard-copy, graphic displays or magnetic tape recordings. The system sells for \$100,000, depending on configuration and can be leased for approximately \$3000/mo.

CIRCLE NO. 253

Video snapshots recorded on cartridges

Arvin Systems, Inc., 1771 Springfield St., Dayton, Ohio. 45401. (513) 254-1797. \$4000.

Called the "Discassette," the Arvin video recorder uses a flexible magnetic medium in cassette form to store 300 still frames. The image quality is determined by a 4.2 MHz bandwidth with a 40 dB signal-to-noise ratio and a time-base error of under 400 ns. Pictures can be taken directly from a TV monitor with record/playback rates of 1, 3, 6, 10 or 15 frames/s. Cartridges cost \$25 and can be changed in less than 20 s.

CIRCLE NO. 254

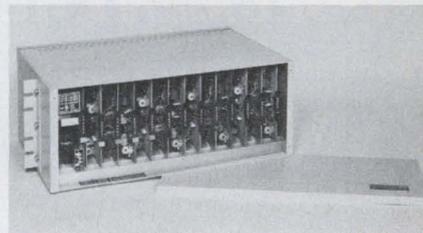
Fast minicomputer offers interleaved memory

Interdata, 2 Crescent Pl., Oceanport, N.J. 07757. (201) 229-4040. \$14,900.

With its MOS solid-state memory, the 16-bit Model 80 has an average cycle time of 270 ns. Typical instruction execution times range between 530 and 1010 ns. Each storage unit consists of two 8000-byte memory modules having separate address circuitry but sharing common sense and data lines. This design reduces memory contention and cycle time. All 16-k bytes of memory are directly addressable. Other features include hardware multiply/divide, hardware floating point and list processing. Both the software and the peripheral interfaces are compatible with the other members of Interdata's "New Series" family of processors.

CIRCLE NO. 255

Device shunts phone calls to another number

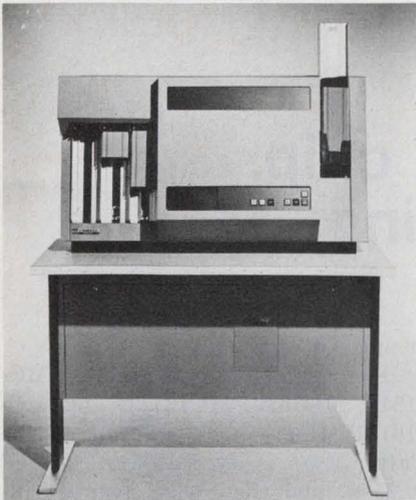


G-V Controls, 101 Okner Pkwy., Livingston, N.J. 07039. (201) 992-6200. See text; 30 days.

Designed for installation in a "Central Office" equipment room, the devices will automatically transfer calls from one telephone number to another. Also, no additional amplification will be required to make up for "double-loop" losses incurred by subscriber premise location. Model 907115 is for pulse and Model 907116 for tone signalling. Either unit obviates the "disconnect" problems inherent in other call diverter devices and may be turned on and off from a transfer switch on the subscriber's telephone instrument. Prices range from \$478 for a single unit to \$1675 for a fully equipped shelf of four units.

CIRCLE NO. 256

Card printer/punch handles 96 columns



Decision Data Computer Corp., 100 Witmer Rd., Horsham, Pa. 19044. (215) 674-3300. \$6900; 4 mos.

Model 9640 is a fully buffered printing punch with an optional card-reading capability. The standard unit features a 2000 card input hopper and three output stackers. It can punch or print 96-column cards at the rate of 120 to 240 cards/min., depending on the number of positions used. At the lowest speed, four rows of 32 positions each can be printed. A stacker overflow condition can be handled automatically or via programming, thereby eliminating the need to halt operations for card unloading. A field installable 1000 cards/min. read-before-punch option is also available. The additional cost is \$850. OEM quantity discounts are available for the Model 940.

CIRCLE NO. 257

Buffer matches slow devices to fast channel

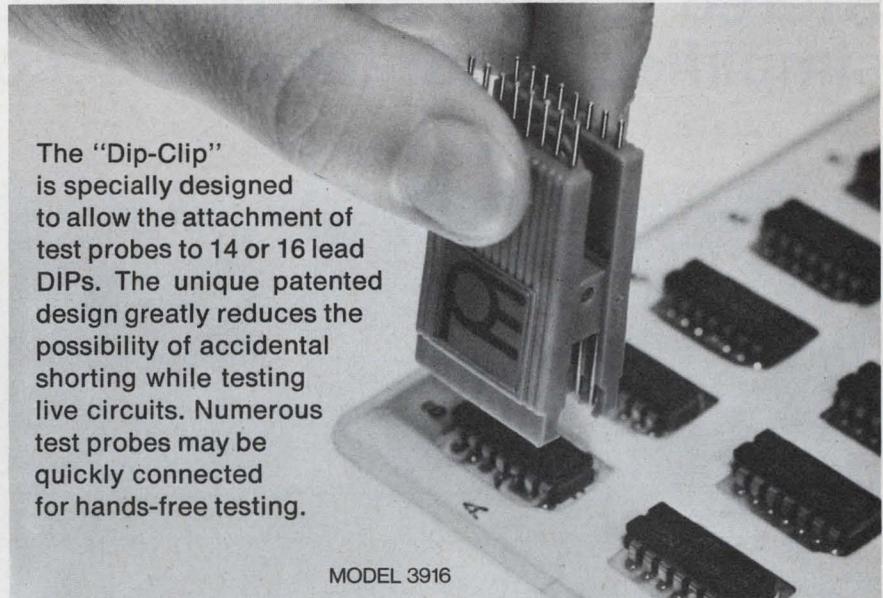
Pulse Communications, Inc., 5714 Columbia Pike, Falls Church, Va. 22041. (703) 820-0652.

Models 7132 are a series of terminal buffers for mating printers such as TTYs with high-speed data links. The buffer units contain 4000-character memories and all the circuits and controls required for editing, automatic transmission, answer-back and control handshaking. Modules are available for memory capacity expansion.

CIRCLE NO. 258

dip clip

T.M.



The "Dip-Clip" is specially designed to allow the attachment of test probes to 14 or 16 lead DIPs. The unique patented design greatly reduces the possibility of accidental shorting while testing live circuits. Numerous test probes may be quickly connected for hands-free testing.

MODEL 3916



POMONA ELECTRONICS

1500 E. Ninth St., Pomona, Calif. 91766 • Telephone: (714) 623-3463

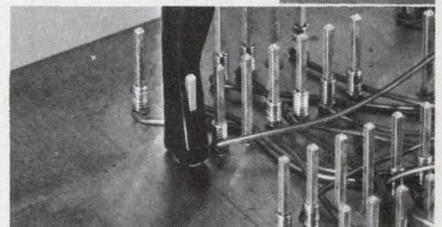
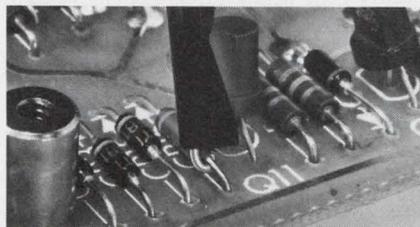
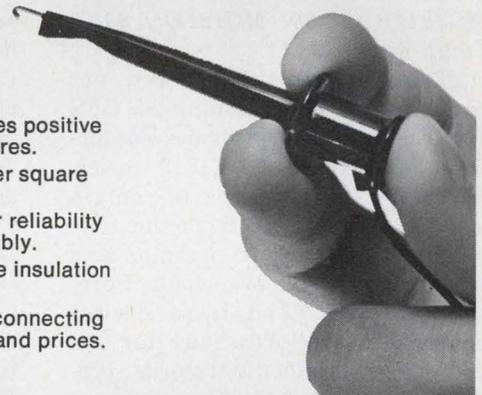
INFORMATION RETRIEVAL NUMBER 55

the grabber

T.M.

Our plunger action Mini-Test Clip is designed specifically for reaching into densely packaged miniaturized circuitry to make rapid, reliable tests.

- Gold plated copper contact hook makes positive connection, and won't damage lead wires.
- Specially designed tip slides down over square Wire-Wrap pins for solid contact.
- Integrally molded wire assures greater reliability and eliminates time-consuming assembly.
- Molded nylon probe provides complete insulation to point of connection.
- Four models offer widest selection of connecting plugs. Write for complete information and prices.



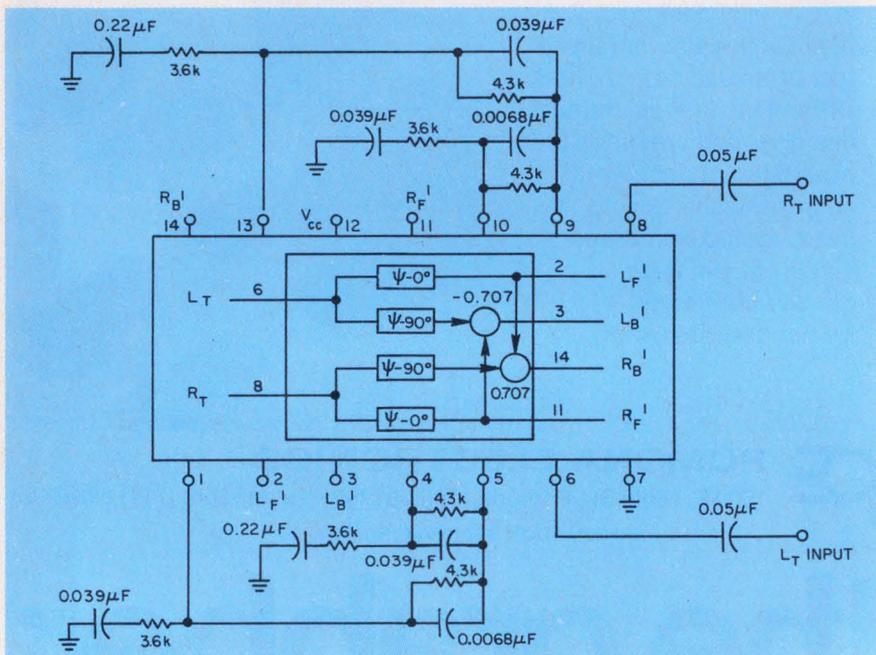
POMONA ELECTRONICS

1500 E. Ninth St., Pomona, Calif. 91766 • Telephone: (714) 623-3463

*Registered trade-mark of Gardner-Denver Co.

INFORMATION RETRIEVAL NUMBER 56

Stereo IC with all functions on chip, simplifies quadraphonic decoding



Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, Ariz. 85008. (602) 273-6900. MC1312P: \$2.80; MC1213P: \$3.10 (unit quantity).

Matrix systems have been put on chips for the decoding of CBS SQ four-channel systems—Motorola's MC1312 and MC1313 series. They are the first ICs to contain all the circuitry to drive the four channels, with their preamps and power amps, from two-channel program sources. And these devices conform to specifications for decoding quadraphonic records produced by some of the largest record companies.

Available in 14-pin TO-116 plastic packages, the new ICs consist of two preamps and two all-pass networks of the Wien bridge form. External resistors can be connected between pins 2 and 11 and 3 and 14 to permit blending the four-channel outputs for enhancement of center-front to center-back separation (see diagram).

The quadraphonic signal results from the matrixing of four channels into the two through a special encoder. The two matrixed channels, right total (R_T) and left total (L_T)—obtained after record is played on conventional stereo—are then processed through the decoder and the four original channels are recovered. The circuit consists of two preamps that receive L_T and R_T signals. The preamps each feed two all-pass networks to derive two pairs of quadrature signals. The four signals are matrixed to yield left front, left back, right front and right back (L_F' , L_B' , R_F' and R_B') output signals.

The resistive arms of the Wien bridge all-pass networks are realized in the IC, but the RC arms are formed by external components. The user can choose values for these components within certain constraints.

With the components shown, bandwidth of 100 Hz to 10 kHz is provided, together with a phase

ripple of $\pm 8.5\%$.

Four models are available: MC1312, MC1313, MC1312P and MC1313P. Harmonic distortion in the latter two is typically 0.1% and 0.25%, and they have average input impedances of 3 M Ω and 1.8 M Ω . Signal-handling capability is at least 2.0 V rms for the MC1312P and 0.8 V rms for the MC1313P. The MC1312 is designed for home-entertainment systems and for operation from 0 to 75 C with $V_{cc} = 20$ V, while the MC1313 is designed for automotive use at $V_{cc} = 12$ V and a temperature range of -40 to 85 C.

The only system similar to the CBS SQ is the Electro-Voice EV-4, which uses the EV8-7743 decoder chip. The latter is designed specifically for that system.

CIRCLE NO. 259

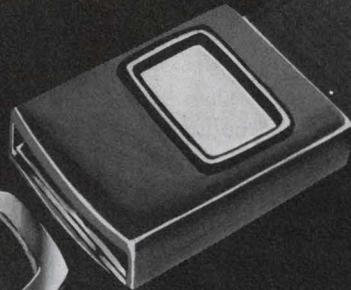
pROMs assemble programs

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. (408) 246-7501. \$364; stock.

A set of pROMs enables an MCS-4 microcomputer prototype to assemble programs for itself. The four pROMs (AO-740, 741, 742 and 743) plug into the prototyping board (S1M4-01 or S1M4-02) and perform all the functions of a Fortran IV assembler, eliminating the need for a general-purpose computer. The pROMs translate symbolic assembly language into bit patterns suitable for entry into the microcomputer's control pROMs. The assembler accepts input source text from a teletypewriter on each of two required passes.

CIRCLE NO. 260

**safety is
on our side.**



**cmos...
FROM SOLID STATE SCIENTIFIC**

For the automotive industry. It started with the government mandate that all '74 models be equipped with a seat belt interlock system. At Solid State, we began designing the device that could make it happen—a CUSTOM CMOS IC that delivers the sophisticated logic, timing and sensing techniques required to activate such a system.

TODAY, WE'RE LEADING THE FIELD—BECAUSE WE HAVE THE CMOS CIRCUIT THAT CAN DO IT! We took the design to Detroit, where they tested and proved SOLID STATE'S IC—in their environment, at their proving grounds.

SOLID STATE'S CMOS—operating reliably and consistently from a single source of supply (3 to 15 V), over a wide temperature range with noise immunity and minimal battery drain.

SOLID STATE SCIENTIFIC—check out the potential on our side—just to be on the safe side.

SOLID STATE SCIENTIFIC, INC.

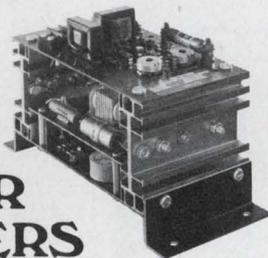
Montgomeryville, Pa. 18936 • (215) 855-8400 • TWX-510-661-7269



INFORMATION RETRIEVAL NUMBER 57

VECTROL

**"CUBE-PAC"
a new
dimension in
SCR POWER
CONTROLLERS**



**offers low cost
high performance**

Keep pace with the needs of today's modern control systems. The unique CUBE-PAC VPAC 500 Series Power Controller, with options, allows the user to custom tailor the VPAC 500 to meet specific requirements . . . at a significantly lower cost than competitive units without options.

Measuring only 9" x 6 1/4" x 5" this compact unit provides: phase control - 0 to 100% output • SCR protection • clipping network and hard firing gate pulse • soft start • single phase and three phase, 30 thru 80 amps • back-to-back SCR output.

Options include: current limiting • voltage/current regulation • manual, current, offset and gain adjustments.

Request Bulletin 3105.



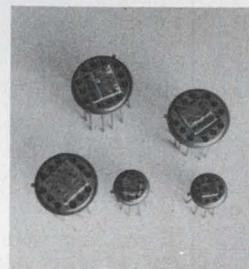
VECTROL INC.

1010 WESTMORE AVE., ROCKVILLE, MD. 20850
(301) 424-6900

INFORMATION RETRIEVAL NUMBER 58

ELECTRONIC DESIGN 2, January 18, 1973

HALEX, INC.



**Second sourcing.
Immediate delivery:**

- 0007 Clock Driver
- 0009 Dual Clock Driver
- 0032 FET Operational Amplifier
- 0033 High Speed Buffer
- 0034 Level Shifter

Coming in 1973:

- 0002 Buffer Amplifier
- 0013 Dual Clock Driver
- 0021 High Power Operational Amplifier
- 0041 High Power Operational Amplifier

For prices and data sheets on these and other high-quality thin-film microcircuits and resistor networks, please write or call collect: Yutaka Tonai

HALEX, INC.

Box 2940
Torrance, California 90509
(213) 772-4461, 542-3555

INFORMATION RETRIEVAL NUMBER 59

there's no such thing as "custom standard" but we come close.



FREE-STANDING

NEMA 12 single door; single door, dual-access; two-door; two-door, dual-access. Versatile mounting panel and relay rack angle arrangements. EMI/RFI shielding optional.

CONSOLES, CONSOLETS

Nearly 2 dozen models with a large variety of accessories. Sturdy 14 gauge steel construction. All-welded seams, gasketed doors, oil tight. NEMA 12. EMI/RFI shielding optional.

INSTRUMENT ENCLOSURES

Oil-tight. 12 standard sizes, 6 x 6 x 4 to 14 x 12 x 6. 14 gauge steel, continuously welded seams. No holes or knockouts. Gasketed covers. Optional interior mounting panels.

Your needs for instrument enclosures vary widely and delivery is important. That's why there are Hoffman distributors strategically located throughout the U.S.A. Offering precision-built enclosures of all different sizes and shapes. With factory backup on all catalog items. NEMA 12 and JIC type electrical/electronic enclosures, including pushbutton boxes and wireway. We also do custom fabrication. Write for catalog and name of nearest distributor.

Hoffman[®]

ELECTRICAL ENCLOSURES

HOFFMAN ENGINEERING COMPANY
Division of Federal Cartridge Corporation
ANOKA, MINNESOTA DEPT. ED-212

INFORMATION RETRIEVAL NUMBER 60

ICs & SEMICONDUCTORS

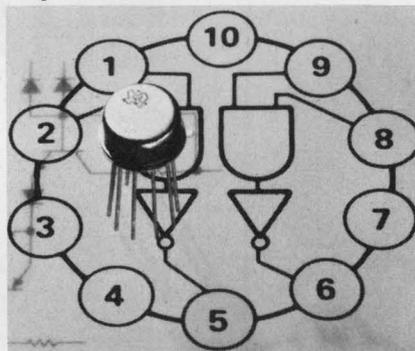
Op amp upgrades LM118

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. (408) 732-2400. \$19.95 to \$22.95 (100 up).

The Am118, a high slew rate, internally compensated op amp, offers the highest stability rating in the industry, according to the company. The Am118, which is pin compatible with the like-numbered circuit from National Semiconductor, has a phase margin of 35° and less than 2 dB of peaking at unity closed-loop gain. Other features (all typical) include slew rate of 70 V/μs, input offset voltage of 2 mV, input bias current of 120 nA and offset current of 6 nA. The device has a 15 MHz small signal bandwidth and operates over a ±5 to ±20-V range.

CIRCLE NO. 261

Dual voltage translator replaces DM7800

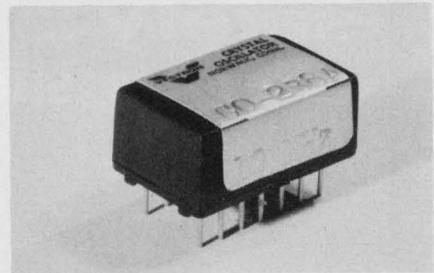


Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN75180: \$2.40 (100 up); stock.

A dual voltage translator, designated the SN55/75180, is a second source IC to the DM7800/DM8800. This device can interface from standard TTL or DTL voltage levels to those levels associated with high impedance junctions or MOSFET-type devices. The SN55 version (for -55 to 125 C temperature applications) replaces the DM7800 while the SN75 version (for industrial temperature range applications) replaces the DM8800.

CIRCLE NO. 262

Schottky TTL clock comes in DIP

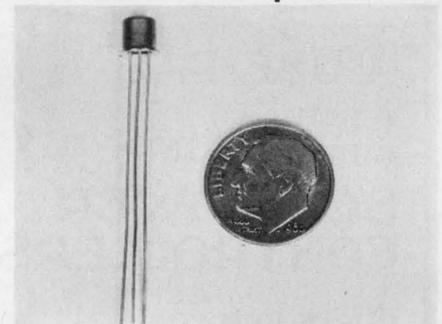


Vectron Laboratories, Inc., 121 Water St., Norwalk, Conn. 06854. (203) 853-4433. 4-6 wks.

The CO-238 crystal oscillator, available in a 14-pin DIP, can drive Schottky TTL circuits at frequencies to 100 MHz. It operates from 5 V dc and drives 10 TTL loads. The standard CO-238 provides stability of ±.0025% over 0-70 C. Options include the MIL range CO-238-2 with stability of ±.005% over the -55 to +125 C and the high stability CO-238-3 with stability of ±.0003% over 0-50 C.

CIRCLE NO. 263

Radio circuit arrives on a chip



Ferranti Electric Inc., E. Bethpage Rd., Plainview, N.Y. 11803. (516) 293-8383.

The ZN414, a ten-transistor circuit fabricated with Collector Diffusion Isolation techniques, provides the basis for a complete AM radio circuit. It operates from 1.1 to 1.8 V and requires only battery, earphones and antenna plus a tuning capacitor and two decoupling capacitors to form a radio. Other features include output of typically 30 mV rms, current of 1 mA and harmonic distortion of ≤ 1%. The ZN414 operates over the temperature range of 0 to 70 C and is available in a 3-pin TO-18 package.

CIRCLE NO. 264

ECL 1024-bit memory uses isoplanar process

Fairchild Camera and Instrument Corp., Semiconductor Components Group, 464 Ellis St., Mountain View, Calif. 94040. (415) 962-3816. \$100 (25-99); 6-8 wks. (large qty.).

An ECL 1024-bit RAM—the industry's first, according to the manufacturer—is fabricated with Fairchild's Isoplanar process. Designated the 95415, it features a 45-ns access time and is packaged in a standard 16-pin ceramic dual-in-line package. It has power dissipation of 0.5 mW/bit and an uncommitted collector output for simple memory expansion.

CIRCLE NO. 265

Low-cost op amp settles in guaranteed 1 μ s

Teledyne Philbrick, Allied Dr. at Route 128, Dedham, Mass. 02026. (617) 329-1600. P: See text; stock.

A guaranteed settling time of 1 μ s to 0.01% at a price of \$7.50 (100 up) are the key features of the Model 1324, a monolithic IC op amp fabricated with standard triple-diffused processing techniques. Other features of the 1324 include excellent bandwidth and slew rate (10 MHz and 35 V/ μ s, respectively), freedom from latch up and TO-100 packaging with 715-compatible pin-out.

CIRCLE NO. 266

Silicon-on-sapphire kit for advance designs

Inselek Co., 743 Alexander Rd., Princeton, N.J. 08540. (609) 452-2222. \$1950.

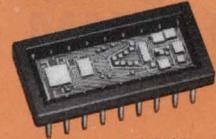
Designers can now build their own integrated circuits using silicon-on-sapphire (SOS) technology with a "do-it-yourself" kit. Called an Instant SOS Kit, the package includes a set of photomasks, instructions and sufficient p-type and n-type SOS wafers for building p-channel, n-channel, deep-depletion and complementary circuits. And these can be built right on present solid-state production lines, according to the manufacturer.

CIRCLE NO. 267

8 BIT SUCCESSIVE APPROXIMATION

1st A to D in a DIP

MN500



actual size

OTHER FIRSTS FROM MICRO NETWORKS

- 1st 8 bit D/A in a DIP
- 1st 8 bit D/A with Registers in a DIP
- 1st Complete 10 bit D/A in a DIP
- 1st 4 Quadrant Multiplying D/A in a DIP
- 1st 12 bit D/A in a DIP
- 1st Function Generator in a DIP
- 8 bit Resolution
- $\pm 1/2$ bit Linearity (0° to 70°)
- 1 μ sec bit Conversion Time
- 600 mW Power Consumption
- 18 Pin Hermetic DIP Package
- Input Range 0 to $-10V$ or $+5$ to $-5V$
- Parallel and Serial Output

Stocked Nationally by Cramer ©

Call or write Bruce Smith for further information



Micro Networks Corporation

5 Barbara Lane, Worcester, Mass. 01604
(617) 753-4756

INFORMATION RETRIEVAL NUMBER 61

COMPLETE PACKAGING CAPABILITY

only from Vero

CASES
CONNECTORS
CARD FRAMES
MODULE RACKS
VEROBOARD
CARD HANDLES
FRONT PANELS
PANEL HANDLES

ALL
DELIVERED
FROM
STOCK



VERORACK 3

The ULTIMATE PC CARD FRAME

- Exceptional Strength • Precision Aluminum Extrusion Guide Rails • Concealed Guide Mounting • Identification Strip Standard in Front — Optional in Rear • Noryl Guide Temp. Range -60 to $+125$ C • Selection of Guide Lengths • 4" & 4 1/2" Wide Guide Blocks With 5" Cards Spacing for Fastest Assembly Guides Slide Into Extrusions • Individual Variable Spaced Guides form 4" Available • Combine Guide Lengths for Extra Length Cards With Special Center Extrusion • Unique Extruded Connector Rails Allow Connector Mounting at any Point and Identification of Connector Position.



Vero Electronics Inc.

171 Bridge Road, Hauppauge, N.Y. 11787
Tel.: 516-234-0400 • TWX510-227-8890

INFORMATION RETRIEVAL NUMBER 62

Plug-ons extend versatility of DMM measuring system



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. See text; March.

Hewlett-Packard has expanded the capabilities of its snap-on DMM measuring system with three new additions: the 34750A, a 5-1/2-digit mainframe display; the 34703A multifunction module, and the 34722A preamp/ammeter module.

The line now includes six possible instrument combinations, each made up of a top display module and a bottom function module. Any of the six combinations can be converted to portable operation by the addition of a center battery-pack module. Or a BCD output package can be added as a center module to provide printout information.

Except for the additional digit, the 34750A LED display is similar to its 4-1/2-digit predecessor. The second new module—the 34703A multifunction snap-on—can be used with either the 4-1/2 or 5-1/2-digit display, as can its older counterparts, the dc voltmeter and multimeter plug-ons.

The 34703A snap-on measures

resistance (four-wire measurement), dc voltage and dc current. Six voltage ranges from 10 mV to 1000 V are provided, as well as six current ranges from 1 μ A to 100 mA and eight resistance ranges from 1 Ω to 10 M Ω . Full autoranging of the functions is provided, or the user can step through ranges merely by pushing a button. In most cases autoranging is completed within 250 μ s. And if the user manually selects an improper range, the unit flashes the correct range-annunciator LED.

In addition the 34703A can troubleshoot itself. When the user flips the function switch to the test position, the ROM-based logic controller interrogates its own circuitry for proper operation.

Specifications of the unit include an input resistance of 10 M Ω on dc volts; 10 k Ω on the 1- μ A range, decreasing to 1 Ω on the 100-mA range; 100% over-range, except for 20% overrange on the 1000-V range; and 120-dB CMR on dc volts. Accuracy holds for 30 days at 23 C and depends on both the range setting and the

particular display used.

Some representative accuracy figures are: $\pm 0.04\%$ of reading $\pm 0.01\%$ of range for the 10-V through 1000-V ranges and with a 4-1/2-digit display; $\pm 0.25\%$ of reading $\pm 0.025\%$ of range for 10-mA and 100-mA ranges and for the 5-1/2-digit display; and $\pm 0.04\%$ of reading $\pm 0.01\%$ of range for 10 Ω through 1 M Ω and for the 4-1/2-digit display.

The third new module, the 34722A preamp/ammeter, goes in the center of the assembled instrument, and it can increase the sensitivity of the older voltmeter and multimeter plug-ons and provide current-reading capability. Its preliminary specs include a preamp gain of 10 for ac and dc volts and current ranges (ac and dc) from 100 μ A to 1 A. The full-scale insertion loss is 100 mV.

The 34750A display and the 34703A V/I/ Ω meter cost \$550 each, with first deliveries scheduled for March. The 34722A has not been priced yet and will be available at a later date.

CIRCLE NO. 268

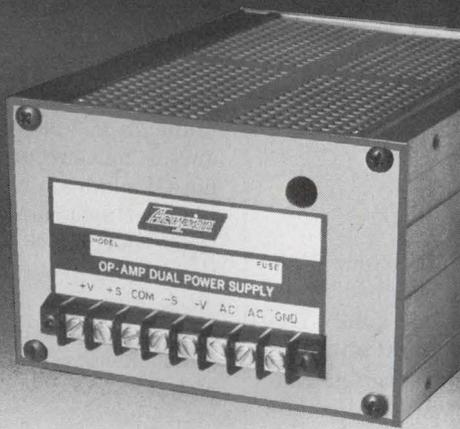
Spectrum analyzer has variable persistence

Systron Donner Corp., Microwave Div., 14844 Oxnard St., Van Nuys, Calif. 91409. (213) 786-1760. \$2600; 60 days ARO.

A spectrum analyzer mainframe with a variable persistence CRT display is now available from the Microwave Div. of Systron Donner Corp. The S/D Model 711 variable persistence display unit offers a persistence range of 300 ms to 100 s. In addition, the Model 711 can store an image for up to six hours, or be used in a conventional, non-store mode. The unit uses plug-in tuning modules covering the audio, video and baseband frequency ranges.

CIRCLE NO. 269

Best buy
power
module
for
op amps



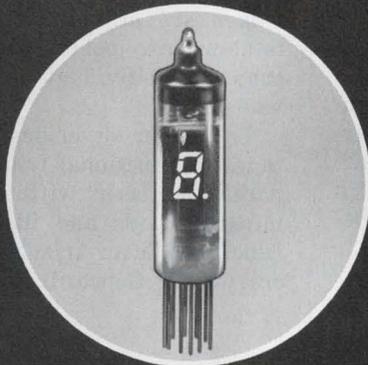
± 15 V (tracking) @ 400 ma...\$85

Line/load regulation of $\pm 0.1\%$ and ripple of 1.5 mv. 3.4" H x 5.1" W x 5.1" D. Order Model TD 15-40. For 1.0 amp outputs, specify TD 15-100. Price \$125. Other great buys are available to power balanced loads drawing from 25 ma to 8.5 amps. Three day shipment guaranteed. Five year warranty.



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

INFORMATION RETRIEVAL NUMBER 63



New NL-8051

from

NATIONAL ELECTRONICS

- Segmented Phosphor Display
- Low Cost • Low Power
- Direct Drive from MOS



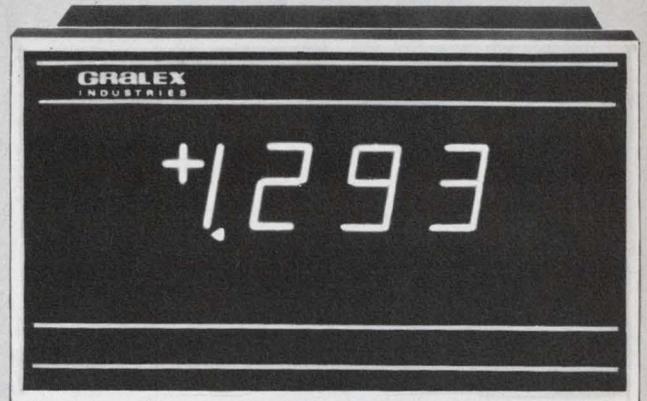
NATIONAL ELECTRONICS

a varian division
geneva, illinois 60134 (312) 232-4300

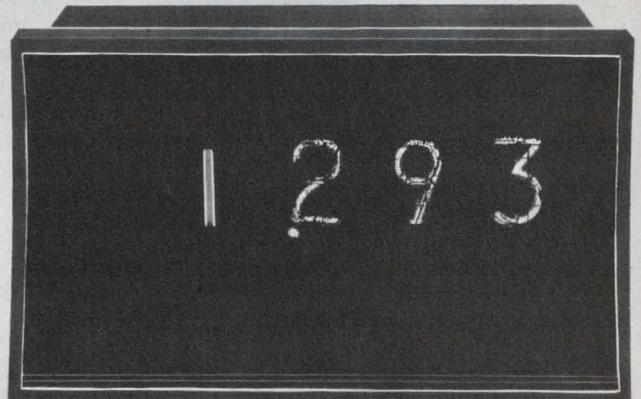
INFORMATION RETRIEVAL NUMBER 64

INFORMATION RETRIEVAL NUMBER 65

3½-digit DPMs:



**Ours.
Theirs.**



**When we talk about reliability,
we put our money where our mouth is.**

With a full one-year warranty!

At first glance, our Model 36 looks about the same as most other 3½-digit DPMs (it even fits in the same panel cutout as the AN2532). But that's where the similarity ends:

RELIABILITY: In plain language, ours works better and keeps on working longer than theirs. To back up this promise, our Model 36 comes with something you don't get with theirs: a *full service, one year warranty covering parts and labor!*

PRICE: Our Model 36 sells for less than \$100 in 100-piece quantities, and gives you a lot more for your money.

PERFORMANCE: Ours outperforms theirs. Check our Model 36 specs and features: 0.05% accuracy, 50 ppm/°C stability. 7-segment Sperry non-blinking planar display. Small size, 2.0" H x 3.5" W x 2.8" D. Lower power drain, less than 3.5 watts. Ultra-high input impedance, > 1000 megohms. Standard models include autopolarity, automatic blanking and programmable decimal point at no extra cost.

DELIVERY: Ours can be delivered to meet your production schedules. Why wait for theirs?

WANT MORE REASONS TO BUY OURS? That's easy—just drop us a line or give us a call.

**GRALEX
INDUSTRIES**

DIVISION OF GENERAL MICROWAVE CORP.
155 MARINE ST., FARMINGDALE, N. Y. • 516-694-3607

MORE!

new

V-PAC* POWER SOURCES

for

- Op amps
- Line receivers
- Comparators



Now, use standard +5v source to power your linear IC's. Simplify design, reduce system volume, eliminate extra power supplies, reduce manufacturing costs, with V-PAC power sources.

Operate from 7 to as many as 35 of these types from a single V-PAC source: 709, 741, 710, 711, 720.

Less than a third cubic inch, standard DIP pin configuration, V-PAC sources can be mounted on half-inch center cards with other components.

TYPE:	VA 12-12	VA 15-15	VA 12-6
VOLTAGES:	+12 -12	+15 -15	+12 -6

Write or call for full specifications.

WEST:	EAST:
213-843-5200	513-761-5432
214-233-4489	201-992-2505
505-298-1875	803-288-4450
312-654-8645	416-743-9130
415-593-2189	617-272-7655
206-747-9424	305-941-5544



Reliability, Inc.

5325 Glenmont, Houston, Texas
77036 • 713-666-3261

Europe and the Far East: TISCO (TI Supply Co.)

TWX: 910-881-1739 *TM, Reliability, Inc.

INFORMATION RETRIEVAL NUMBER 66

application notes

Counter/display

The MK 5002 P MOS four-digit counter decoder is described in an eight-page application note. The note contains information on using the unit, display interfacing, cascading the 5002 (eight-digit application) and annunciator applications. Mostek Corp., Carrollton, Tex.

CIRCLE NO. 270

Stepping motors

A 60-page Stepping Motor Handbook describes types of stepping motors and their characteristics, drive circuits, use of power amplifiers, heating considerations, operating modes and typical applications. Sigma Instruments Inc., Braintree, Mass.

CIRCLE NO. 271

Polarimeter, saccharimeter

Technical Bulletin 371 describes the general applications, features, accessories and operating principles of laboratory, precision and high-precision polarimeters and saccharimeters. The generation of a half-shade using polarizing and Lippich prisms is described. Rudolph Research, Fairfield, N.J.

CIRCLE NO. 272

Lead

"Lead . . . As A Modern Design Material" describes properties, forms and design applications of lead. The uses of lead for soldering and ceramics are also discussed as are lead's lubricating qualities and its solid-state properties. The eight-page booklet includes a listing of the forms in which lead is available. The booklet concludes with a listing of the physical, thermal, low-temperature, electrical and mechanical properties of lead. Lead Industries Association, Inc., New York, N.Y.

CIRCLE NO. 273

C-V plotting

An illustrated, 10-page technical note, TN-102, discusses the advantages of the lock-in amplifier technique in C-V and related semiconductor measurement analyses. The note includes three sets of curves illustrating typical C-V and capacitance derivative plots made with the lock-in technique and a set of block diagrams illustrating typical measurement setups. Princeton Applied Research Corp., Princeton, N.J.

CIRCLE NO. 274

CMOS ICs

A six-page brochure describes CMOS integrated circuits in automotive applications. Block diagrams are included. Solid State Scientific, Inc., Montgomeryville, Pa.

CIRCLE NO. 275

Laser trimming

"Functional Trimming: Discussion of a Problem, Description of a Solution" by Danial Abenaim details the laser's contribution to the coming-of-age of functional trimming, wherein circuit-component values are adjusted for optimum total-circuit performance rather than to individual prescribed values.

The paper describes the advantages of functional trimming, compares the laser with other trimming methods and illustrates one functional laser trim system. General Radio, Concord, Mass.

CIRCLE NO. 276

IR optical materials

"Kodak IRTRAN Infrared Optical Materials," a 52-page book, describes the selection, application and production of these materials. It also explains uses at discrete wavelengths in the infrared portion of the spectrum. In addition to photographs, diagrams and tables, the book also contains a comprehensive section of transmittance curves, a bibliography and a computation worksheet. Eastman Kodak Co., Kodak Apparatus Div., Rochester, N.Y.

CIRCLE NO. 277

evaluation samples

Solderless wrap terminals

Nurl-Loc Wire-Wrap Terminals, used in packaging panels for integrated circuits, feature a knurled cylinder which permits material flow for a better bond, increasing torque resistance and preventing twisting during the wrapping operation. Electronic Molding Corp.

CIRCLE NO. 278

Terminal clamps

A tipping-type terminal clamp consists of only two pieces—the screw and a coined clamp plate—and provides virtually identical load on two different size wires. Called Teeter Terminal, it comes in the following sizes: 4-40 × 9/32-in., 6-32 × 5/16-in. and 10-32 × 3/8-in. A fourth size will be added soon. Elco Industries, Inc.

CIRCLE NO. 279

Solder pads

Tin-plated and flux-coated donut pads offer solderability for PC board construction or repair applications. The pads are etched copper on 2.5-mil epoxy glass film backed with a pressure sensitive adhesive and quickly laminate to any circuit board. They are available in five sizes from 0.062 × 0.025 in. up to 0.250 × 0.040 in. and each size is packaged in precisely spaced multiple rows. Circuit-Stik.

CIRCLE NO. 280

Test panel

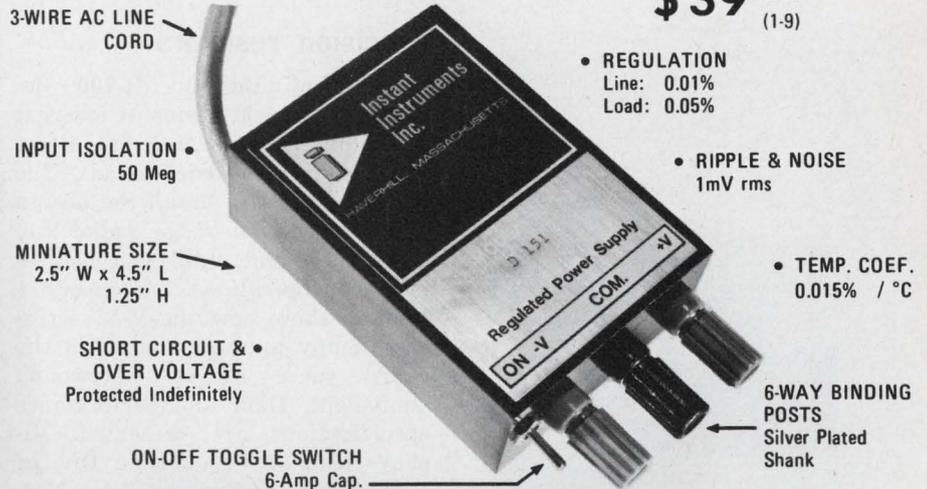
Mounted in a test panel are samples of nylon Heyco hole plugs, snap bushings, universal bushings, strain relief bushings, miniature bushings, open/closed bushings, terminal bushings and snub bushings. Data relative to sizes available and typical applications are included. Heyman Manufacturing Co.

CIRCLE NO. 281

NEW POCKET-SIZE LAB POWER SUPPLIES

PRECISE, PRESET VOLTAGE SOURCES START AT

\$39.00
(1-9)



• REGULATION
Line: 0.01%
Load: 0.05%

• RIPPLE & NOISE
1mV rms

• TEMP. COEF.
0.015% / °C

INPUT ISOLATION •
50 Meg

MINIATURE SIZE
2.5" W x 4.5" L
1.25" H

SHORT CIRCUIT & •
OVER VOLTAGE
Protected Indefinitely

ON-OFF TOGGLE SWITCH
6-Amp Cap.

6-WAY BINDING
POSTS
Silver Plated
Shank

SINGLE OUTPUT			
MODEL	VOLTAGE	CURRENT	PRICE
M55	5.0	500 mA	\$ 49
M510	5.0	1000 mA	\$ 69

DUAL OUTPUT			
MODEL	VOLTAGE	CURRENT	PRICE
D15.5	± 15.0	50mA	\$ 39
D151	± 15.0	100mA	\$ 49
D152	± 15.0	200mA	\$ 69



Instant Instruments Inc.

306 RIVER STREET ■ HAVERHILL, MASSACHUSETTS 01830
TEL: (617) 373-9260

INFORMATION RETRIEVAL NUMBER 67

REON VARIABLE RESISTORS MEET OR EXCEED MIL-R-94 SPECS



1/2" Conductive Plastic
RV6 TYPE
Variable Resistors

SINGLE UNIT HOUSING Construction
Provides Humidity Seal at NO EXTRA
COST!



1-1/8" Dia Carbon Element
RV4 TYPE
Variable Resistors

UNIQUE PERIMETER COOLING ar-
rangement permits 3 WATT commercial
rating without INCREASE IN SIZE!



1/2" Dia Conductive Plastic
FULL MIL SPECS IN AN
INDUSTRIAL UNIT!

These low cost commercial variable resis-
tors are QC checked to All MIL specs
(noise, temp cycling, etc.)

Wide selection of mounting styles available
including bushing, PC-bracket, and con-
centric-tandem.

Write or call for application bulletins

REON reon resistor corporation
420 lincoln highway
malvern, pa. 19355

operated by Vishay Resistor Div.
420 Lincoln Highway • Frazer, Pa. 19355
(215) 647-5420

INFORMATION RETRIEVAL NUMBER 69

**How
long must
you keep
records**

Write for
FREE
Record
Retention
Schedule

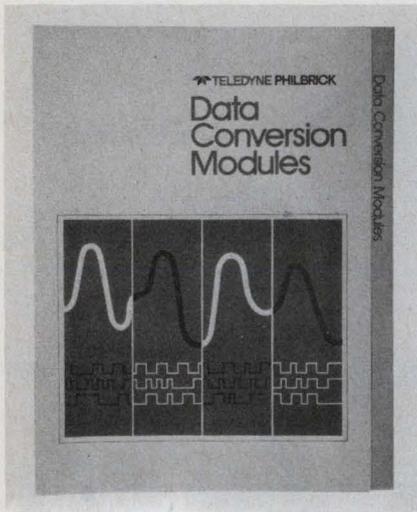


*Suggested
minimum retention
periods and
when to destroy
important papers*

the
SHREDMASTER
CORPORATION

891 So. Ocean Ave.
Freeport, L. I., N. Y. 11520

INFORMATION RETRIEVAL NUMBER 68



Data conversion

A fold-out data-conversion short-form catalog features a line of data converters. Analog-to-digital and digital-to-analog converter specifications are arranged for quick selection by key parameters. Also included in the two-color brochure are accessory modules. Teledyne Philbrick, Dedham, Mass.

CIRCLE NO. 320

Status indicator

LED and resistor construction have been integrated in a solid state status indicator which is described in a data sheet. The indicator is designed in a mini-DIP size flat pack for PC board mounting and is compatible with DTL or TTL logic. Eldema Div., Genisico Technology Corp., Compton, Calif.

CIRCLE NO. 321

Instrument rentals

A catalog features an expanded line of instruments offered on a rental basis from General Electric. The catalog lists the nationwide network of rental agencies and inventory centers. Related services performed include measurement consulting services, environmental quality testing and instrument repair and calibration. GE, Schenectady, N.Y.

CIRCLE NO. 322

Precision resistors

Technical Bulletin R-700 describes V and M series of low-cost precision resistors that are direct replacements for wirewounds. The bulletin shows in detail the design and construction of the radial lead (V series) and axial lead (M series) configurations. Drawings are used to show how the V-53 series can occupy approximately 1/8 the board space of its wirewound equivalent. Data and performance specifications are presented. Vishay Resistor Products, a Div. of Vishay Intertechnology, Inc., Malvern, Pa.

CIRCLE NO. 323

Push-button switches

A full-color, 12-page catalog with an accompanying color-coordinating kit describes and illustrates push-button rotary switches. The switches come in green, red, yellow, blue, white and grey. Janco Corp., Burbank, Calif.

CIRCLE NO. 324

Impulse generators

Two data sheets describe three impulse generators. Singer Instrumentation, Los Angeles, Calif.

CIRCLE NO. 325

Component recorders

The Flying Spot component recorders, for producing pattern, plot or picture records, are described in a 16-page catalog. The catalog contains specification information. Featured applications contained include frequency-spectrum analysis. Recordings of "whistlers" i.e. low radio-frequency emanations from lighting and other electromagnetic phenomena of interest in communications studies are clearly illustrated along with recordings of ionospheric back scatter made during long range communications studies by radar in real time. Alden Electronic & Impulse Recording Equipment Co., Inc., Westboro, Mass.

CIRCLE NO. 326

Modular terminal blocks

A complete line of modular terminal blocks, terminal strips and specialty items is described in a 12-page, quick-reference catalog. Drawings and photos illustrate the features and design of these products. Product categories are: control and power circuit terminal blocks, high-capacity terminal blocks; test terminals; fuse terminals; compensating terminals; slide-on connection terminals; ground terminals; micro terminals and a complete line of terminal strips. Applications, material specifications, ratings, accommodating wire sizes, mounting dimensions and physical dimensions are also included. Electrovert Inc., Mount Vernon, N.Y.

CIRCLE NO. 327

Precision decade capacitor

An engineering bulletin features a precision decade capacitor. Sprague Electric Co., N. Adams, Mass.

CIRCLE NO. 328

Line printer

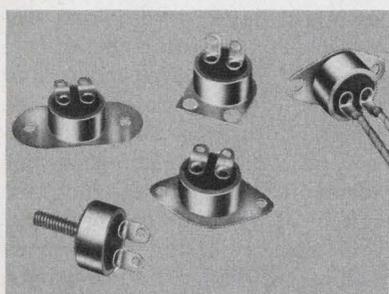
Features of the Model 200 line printer are described in a six-page brochure. Included are detailed specifications on font sets and codes; the use of the multifont buffer and font belt to provide increased speed, interface information and forms handling capabilities. Iomec, Inc., Digitronics Div., Southboro, Mass.

CIRCLE NO. 329

Vacuum equipment

A catalog of vacuum equipment includes data sheets and prices on all current products. The catalog presents vacuum pumps, hardware, systems and accessories. In convenient loose-leaf form, the catalog documents equipment for high vacuum and ultra-high vacuum work. Other products described are processing equipment for semiconductor manufacturers, evaporation and sputtering equipment, leak detectors, gas analyzers, Marshall furnaces and surface analysis instruments as well as vacuum flanges, valves and gauges. Varian Vacuum Div., Palo Alto, Calif.

CIRCLE NO. 330



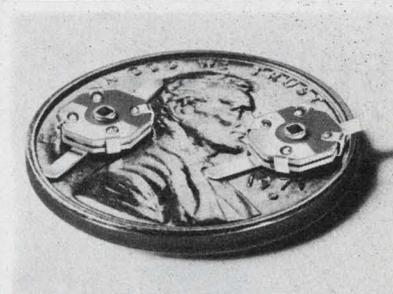
Prototypes of precision snap-action thermostats from Elmwood, widely specified for quick, reliable response; proven industrial and military performance record. Environ. expos. -65° to 550°F; narrow or wide diff.; rated to 15 amps. Wide choice of brackets, terminals. Elmwood Sensors, Inc. (401) 781-6500. TWX 710-381-6413.

INFORMATION RETRIEVAL NUMBER 182



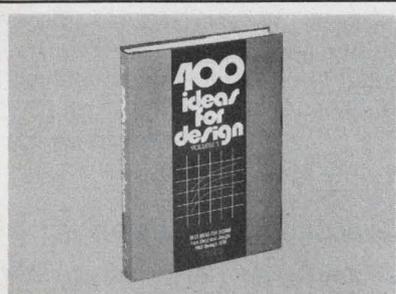
Dietzgen's new 12-digit electronic slide rule does even more than your slide rule. All trig. and exponential functions—including hyperbolics and natural log—with a single function key. Converts degrees, minutes, seconds to decimal; degrees to radians or vice versa. Dietzgen Corp., 2425 N. Sheffield, Chicago, 60614. (312) 549-3300.

INFORMATION RETRIEVAL NUMBER 185



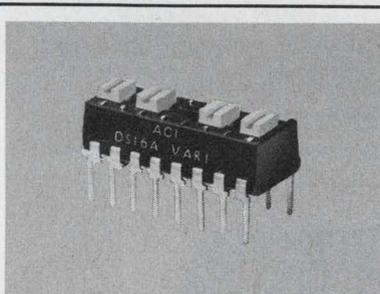
Thin-Trim® variable capacitors are designed to replace fixed tuning techniques. Applications include crystal oscillators, CATV amplifiers, communication and test equipment. Series 9410 has high Q's with five capacitance ranges from 1.0 - 4.5 pf to 10.0 - 50.0 pf. Johanson Manufacturing Corporation, Boonton, N. J. (201) 334-2676

INFORMATION RETRIEVAL NUMBER 183



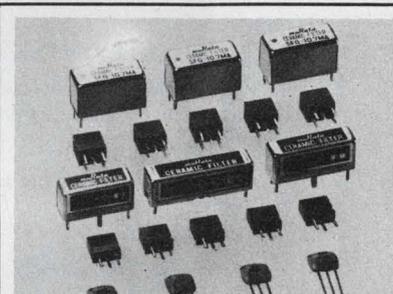
400 Ideas for Design, Vol. 2, Edited by Frank Egan. Ready to borrow, modify, or adapt, the top recent contributions to Electronic Design's popular "Ideas for Design" column range from amplifiers to switching circuits. 288 pp., illus., cloth, \$11.95. Circle below for 15-day examination copies. Hayden Book Co., New York, N.Y. 10011.

INFORMATION RETRIEVAL NUMBER 186



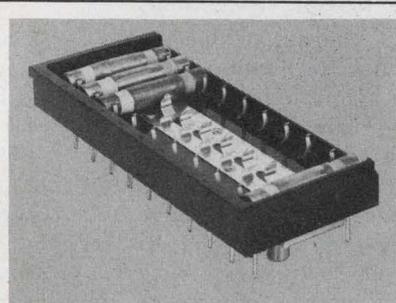
Unique dip switches. Positive BREAK BEFORE MAKE slider action. Self cleaning contacts. Wide variety of styles stocked all with standard 16 lead configuration. For low cost communication, computer, machine tool programming, etc. Max. dims. 0.799" x 0.330" x 0.335". Technical Lit. ACI, 8 Ave., Conshohocken, Pa. 19428. (215)-828-6240.

INFORMATION RETRIEVAL NUMBER 188



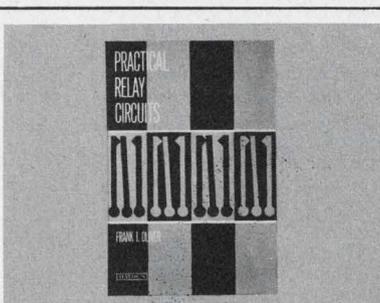
Murata ceramic filters provide solid state reliability for AM, FM, TV and com. receiver IF strips. 455 KHz, 10.7 MHz and 4.5 MHz filters including ladder types are offered. Narrow and "flat top" bandwidths allow maximum design versatility. Most types shipped from stock. Murata, 2 Westchester Plaza, Elmsford, N.Y. 10523. (914) 592-9180.

INFORMATION RETRIEVAL NUMBER 187



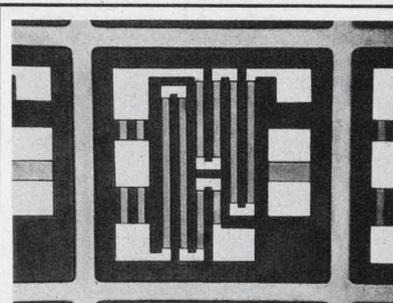
TII-700 series multiple pair arrester assemblies — available up to 30 arresters in wire-wrap pin, coated for solder, high density package. For use in signaling, data processing, carrier and security equipment. Telecommunications Industries Inc., Copiague, N.Y. (516) 842-5000.

INFORMATION RETRIEVAL NUMBER 181



Practical Relay Circuits, by Frank J. Oliver. Time-saving guide classifies relays by function, presenting a rapid overview of the circuits that can solve the problem at hand. 384 pp., illus., cloth, \$14.95. Circle below for 15-day examination copies. Hayden Book Co., New York, N.Y. 10011.

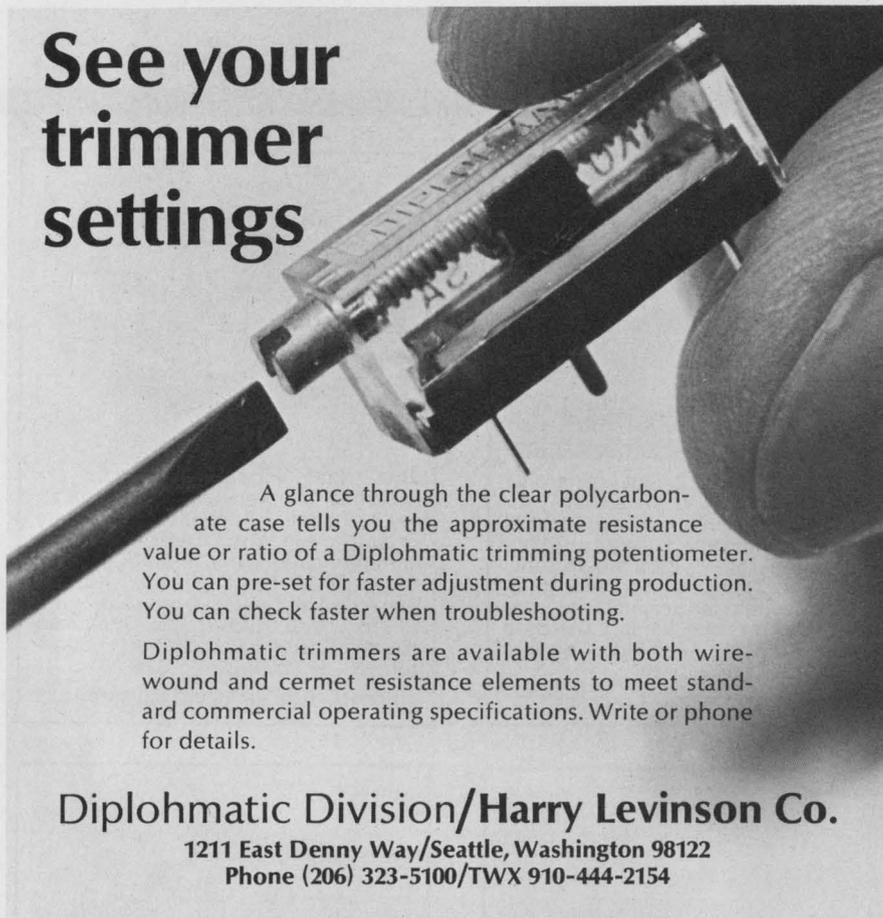
INFORMATION RETRIEVAL NUMBER 184



Chip resistor packing densities are greatly increased with Semi-Films tantalum nitride thin film networks. Many more resistive elements are possible on a given chip as well as much higher single resistor values. Fast delivery on prototypes. Semi-Films Technology Corporation, Box 188, West Hurley, N.Y. 12491. 914-338-7714.

INFORMATION RETRIEVAL NUMBER 189

See your trimmer settings



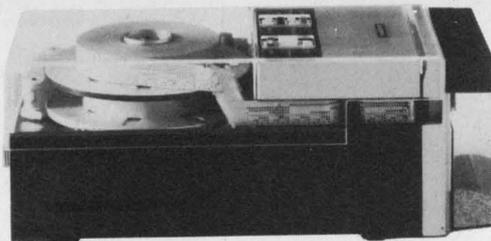
A glance through the clear polycarbonate case tells you the approximate resistance value or ratio of a Diplohmatic trimming potentiometer. You can pre-set for faster adjustment during production. You can check faster when troubleshooting.

Diplohmatic trimmers are available with both wire-wound and cermet resistance elements to meet standard commercial operating specifications. Write or phone for details.

Diplohmatic Division/Harry Levinson Co.

1211 East Denny Way/Seattle, Washington 98122
Phone (206) 323-5100/TWX 910-444-2154

INFORMATION RETRIEVAL NUMBER 70



OUR PUNCH FEATURES OUTNUMBER YOUR PROBLEMS

- 75 cps
- 5-8 track standard, 6 track TTS optional
- Automatic tape monitoring system
- Back spacing for accuracy control
- Includes control and drive electronics
- Modular construction
- Powered, wired and space provided for extra PC board
- Built in tape supply and take-up spools
- No routine lubrication necessary
- Very quiet—54 db.
- Lightweight
- Low power consumption
- Immediate delivery from stock

ED-13

Facit®Odhner Inc.
501 Winsor Drive
Secaucus, N.J.

Gentlemen:
I am interested in receiving detailed data on your Tape Punch

Name _____	Title _____
Phone _____	
Company _____	
Address _____	
City _____	State _____ Zip _____



INFORMATION RETRIEVAL NUMBER 71

NEW LITERATURE

Recording head poles

An eight-page, two-color brochure covers recording head pole pieces—how they are made and how to generate specifications for specific applications. Detailed electrical specifications for each are supplemented by curves for permeability, flux density, and loss factors. Because of the great diversity of recording head applications, however, pole pieces are usually made to order to suit individual requirements. They are obtainable either as individual pieces or in glass or epoxy-bonded sets. The design and machining of the pieces and the special advantages of the two bonding techniques are described in detail. Finally, a list of pointers, limits and tolerances is provided for the user to consider in specifying special pole pieces for any specified set of requirements. Ferroxcube Corp., Saugerties, N.Y.

CIRCLE NO. 331

Stereoscopic television

A four-page illustrated technical paper surveys various three-dimensional television systems and describes the company's system which optically converts normally flat closed-circuit television to 3D. Stereotronics Television Co., Sherman Oaks, Calif.

CIRCLE NO. 332

Terminal specifying aid

A Terminal Specifying Aid, a four-page brochure, is designed as an aid in determining the physical and functional characteristics for the company's tailor-made CRT terminals. Approximately 200 characteristics are listed under the headings of general, display, character codes, cursor, keyboard layout, editing functions, tabulator format, communications functions and peripherals. The aid includes diagrams of three sample keyboard layouts plus a blank master diagram for the customer to use in specifying his requirements. SYS Computer Corp., Hackensack, N.J.

CIRCLE NO. 333

Attention Advertisers:

Could you use copies of your ad exactly as it appeared in ELECTRONIC DESIGN? Then order your reprints directly from us; the minimum unit order is 500 copies.

Please specify if you would like the reprint line omitted on your copies and mail your/written order to:

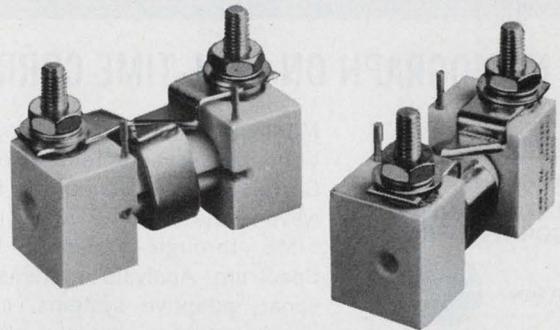
**Production Dept.
ELECTRONIC DESIGN
50 Essex St.
Rochelle Park, N.J. 07662**

	500	1,000	Add'l M
8x10 or smaller			
1 color, 1 side	\$74.70	82.95	18.15
2 color, 1 side	95.47	108.00	25.28
4 color, 1 side	311.03	342.00	44.33
Spreads			
1 color	113.66	126.65	25.98
2 color	191.19	205.98	29.58
4 color	354.17	380.76	53.19

Prices FOB Waseca, Minn.

Tells THE STORY!

Hathaway Drireed Current Sensor



Hermetically sealed, with the built-in reliability of Hathaway Drireed switches, the Hathaway current sensor combines simplicity with economy. Designed for applications where indication is needed when dc current exceeds a set level. 20 milliamps to 120 amps dc models. Adjustable trip level. Flame resistant. It makes sense.

Send for Current Sensor Bulletin.
Testing samples also available.

HATHAWAY

c o m p o n e n t s

A HATHAWAY INSTRUMENTS INC. COMPANY

P. O. BOX 45381 • SOUTHEAST STATION • TULSA, OKLAHOMA 74145

PHONE: (918) 663-0110

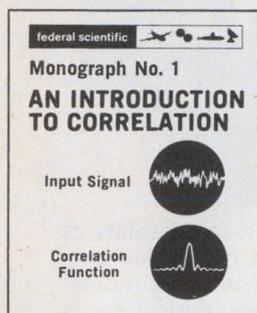
TWX 910-845-2129

INFORMATION RETRIEVAL NUMBER 83

**PERSONNEL
RECRUITMENT
ADVERTISING
IN
Electronic Design
REACHES THE
RIGHT PEOPLE
AT A LOWER COST
PER THOUSAND**

*Call the
HOTLINE
today
for complete
information:
(201) 843-0550
extension 209*

FREE MONOGRAPH ON REAL-TIME CORRELATION



Monograph #1 explains how auto- and cross-correlation are as versatile & useful as Fourier transform. Correlation, a method for finding similarity between wave-forms & time delays, is made practical in REAL TIME through Federal's Ubiquitous® Correlation/Spectrum Analysis systems. For radar, geophysics, sonar, adaptive systems, communications, filter design, reactor control, etc. Detailed applications: reception of signals in noise, direction finding, decoding of magnetically recorded digital data, detection of a periodic signal immersed in noise.

CIRCLE NO. 171

Federal Scientific Corp.

615 West 131st Street, New York, N.Y. 10027
(212) 286-4400

NEW! BISHOP COOLGLO™ LIGHT TABLES



Free Bulletin Available! Tables feature unique Cool-Glo illumination system that floods work surface with even, shadow-free light, yet generates less heat so negatives and artwork won't tend to curl or lift. Easily converts from horizontal to 15° tilt position. 1¼" clear glass plate work surface can be quickly replaced with Bishop Plate Glass precision grids; overlaid with ACCUFILM® Precision or Non-Precision Grids or underlaid with grids, patterns or other references. Three different size table top models and universal base available. All steel construction for long life. Write for FREE Technical Bulletin No. 1013.

CIRCLE NO. 172

The Innovators

Bishop Graphics, Inc.

Dept. ED173, 7300 Radford Avenue
North Hollywood, Ca. 91605
(213) 982-2000 Telex: 67-4672

Real-Time Analyzer, Averager and Display Combined



SPECTRASCOPE (Model SD330) is a Real Time Analyzer, Spectrum Averager and Display 'Scope' all in one. Compact and self-contained . . . as much at home in the field as in the laboratory.

- 0.15 to 20 kHz operation
 - 250-line Spectrum Analysis
 - Built-in flicker-free display — 20 analyses per second
 - Displays (1) raw data; (2) spectral content in 9 ranges from 25 Hz to 20 kHz; (3) averaged spectra to counteract noise or instability
 - Intensity marker for precise frequency location
 - Captures transient input signals
- Write for "SD330" brochure.

CIRCLE NO. 173

Spectral Dynamics Corporation
P. O. Box 671, San Diego, CA 92112

ELECTRONIC DESIGN's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

Want a subscription? ELECTRONIC DESIGN is sent free to qualified engineers and engineering managers doing design work, supervising design or setting standards in the United States and Western Europe. For a free subscription, use the application form bound in the magazine. If none is included, write to us direct for an application form.

If you do not qualify, you may take out a paid subscription for \$30 a year in the U.S.A., \$40 a year elsewhere. Single copies are \$1.50 each.

If you change your address, send us an old mailing label and your new address; there is generally a postcard for this bound in the magazine. You will have to requalify to continue receiving ELECTRONIC DESIGN free.

The accuracy policy of ELECTRONIC DESIGN is:

- To make diligent efforts to ensure the accuracy of editorial matter.
- To publish prompt corrections whenever inaccuracies are brought to our attention. Corrections appear in "Across the Desk."
- To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.
- To refuse any advertisement deemed to be misleading or fraudulent.

Microfilm copies are available of complete volumes of ELECTRONIC DESIGN at \$19.00 per volume, beginning with Volume 9, 1961. Work is now in process to complete the microfilm edition of Volumes 1-8. Reprints of individual articles may be obtained for \$2.00 each, prepaid (\$1.50 for each additional copy of the same article) no matter how long the article. For further details and to place orders, contact the Customer Services Department, University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106 telephone (313) 761-4700.

Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor
ELECTRONIC DESIGN
50 Essex Street
Rochelle Park, N.J. 07662

BOEING

Engineers. Experienced or Beginning

Opportunity is knocking in the Pacific Northwest Aerospace industry.

The Seattle area, a great place to live and work, has challenging aerospace opportunities in varied commercial and military programs. Especially . . .

- Analysis of EMP effects. RF communications, including antennas, link analysis, and equipment design. RF and microwave circuit design.

- Design and implementation of subsystems level status monitoring, fault detection and fault isolation.

- Design of subsystems impedance matching circuitry, amplifiers and monitoring circuitry.

- RF equipment specification preparation, proposal evaluation, performance determination and monitoring of subcontracts for HF and VHF equipment.

Please send your resume to the Employment Office, The Boeing Company, P.O. Box 3707-EAD, Seattle, Washington 98124.

BOEING
An Equal Opportunity Employer

Electronic Design

Advertising Sales Staff

Bryce Gray
Sales Manager

Rochelle Park, N.J. 07662

Robert W. Gascoigne
Daniel J. Rowland
50 Essex Street
(201) 843-0550
TWX: 710-990-5071

Philadelphia

Thomas P. Barth
50 Essex Street
Rochelle Park, N. J. 07662
(201) 843-0550

Boston 02116

Richard L. Green
20 Columbus Avenue
Boston, Mass.
(617) 482-7989

Chicago 60611

Thomas P. Kavooras
Berry Conner, Jr.
200 East Ontario
(312) 337-0588

Cleveland

Thomas P. Kavooras
(Chicago)
(312) 337-0588
(call collect)

Los Angeles 90303

Stanley I. Ehrenclou
Burt Underwood
2930 Imperial Highway
Inglewood, Calif
(213) 757-0183

San Francisco 94022

Jerry D. Latta
P.O. Box 1248
Los Altos, Calif.
(415) 965-2636

London W. 1

For United Kingdom and Holland
Brayton C. Nichols

For Eastern Europe
Peter Kehr

The American Magazine Group
9 Warwick Street
London, W. 1, England
Phone: 437 5462

Cable: Ammagnic, London

4800 Verviers, Belgium

For Continental Europe
Andre Jamar
Rue Mallar, 1
(087) 253.85 Telex 41563

Tokyo

Haruki Hirayama
Electronic Media Service
5th Floor, Lila Bldg.,
4-9-8 Roppongi
Minato-ku
Phone: 402-4556
Cable: Electronicmedia, Tokyo



INDICATORS/SWITCHES



IC COMPATIBLE INFINITE LIFE

LED — latest state-of-the-art indicator made practical, readily useable, by TEC-LITE. Brightest LED's made brighter, side viewing by highly efficient lenses. Dozens of body and lens styles and sizes. Terminal options. Fast mounting. Priced from \$1.50.*

SWITCH/ INDICATORS

TEC-LITE has combined rugged, long life LED with a full range of integral switches — momentary, alternate, and snap action in ratings to 15 amps. Price: \$4.50.*

T-1 1/4 BASED LED-LITE



Direct LED replacement for flanged base incandescent lamps in 5 to 28 volt models (with internal resistor). Converts all TEC-LITE replaceable lamp devices to LED! Lamps priced from \$1.30.*

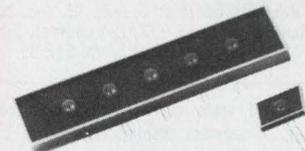
*100-499 quantities.

SPECIAL LED DESIGNS

ILLUMINATED ROCKER SWITCHES



LED's mounted adjacent to each rocker switch provide status indication. Multiple switch assemblies available with a variety of handsome bezel designs.



LED DISPLAYS

One or more LED indicators incorporated in easy-to-mount bezels provide a new, attractive method of adding LED's to panels, instruments, etc.

See TEC-LITE for the complete line of readouts, indicators, switches, display panels, keyboards, CRT terminals.

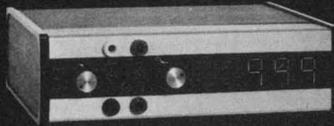
TEC, Incorporated; 9800 North Oracle Road, Tucson, Arizona 85704; or phone (602) 297-1111



INFORMATION RETRIEVAL NUMBER 73

LOW COST DIGITAL KITS

NEW BIPOLAR MULTIMETER: AUTOMATIC POLARITY INDICATION



Model ES 210K

Displays Ohms, Volts or Amps in 5 ranges
Voltage from 100 Mv to 500 V • Resistance
from 100 Ohms to 1 Megohm. • Current from
100 Micro Amps to 1 Amp \$77.00
Case extra: \$12.50 (Optional probe) \$5.00

40 MHz DIGITAL FREQUENCY COUNTER:

- Will not be damaged by high power transmission levels.
- Simple, 1 cable connection to transmitter's output.



ES 220K — Line frequency time base. 1 KHz resolution. 5 digit: \$69.50 Case extra: \$10
ES 221K — Crystal time base. 100 Hz resolution. 6 digit: \$109.50 Case extra: \$10.00

DIGITAL CLOCK:



ES 112K/124K • 12 hr. or 24 hr. clock \$46.95
Case extra: Walnut \$12.00 • Metal \$7.50

I D REMINDER

ES 200K Reminds operator 9 min. 45 sec. have passed. Mounts inside ES 112/124 cabinet. Silent LED flash \$9.95. Optional audio alarm \$12.95

Dependable solid state components and circuitry. Easy reading, 7 segment display tubes with clear, bright numerals. These products operate from 117 VAC, 60 cycles. No moving parts. Quiet, trouble free printed circuit.

Each kit contains complete parts list with all parts, schematic illustrations and easy to follow, step by step instructions. No special tools required.



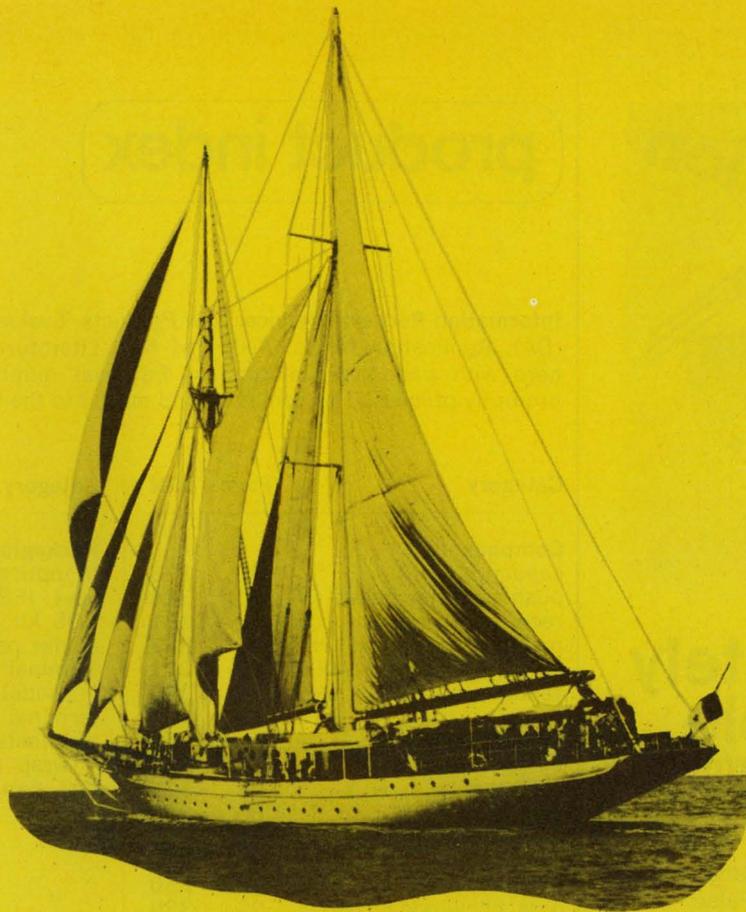
ORDER YOURS TODAY:
Use your Mastercharge or BankAmericard
Money Back Guarantee

506 Main St., El Segundo, Ca. 90245
(213) 772-6176

INFORMATION RETRIEVAL NUMBER 74

advertiser's index

Advertiser	Page	Advertiser	Page
ACI, Incorporated	91	Kertron Incorporated	20
Acopian Corporation	87	Keystone Electronics Corp.	38
Alco Electronic Products, Inc.....	79		
Allen-Bradley Co.	15	Lambda Electronics Corp.	Cover II
Amperite Co., Inc.	14	Levinson, Harry	92
		Litronix, Inc.	79
Beckman Instruments, Inc.,			
Helipot Division	71	Marco-Oak, Subsidiary of	
Bishop Graphics, Inc.	94	Oak Industries	79
Boeing Co., The	95	Micro Networks Corp.....	85
Burr-Brown Research Corporation....	2	Mini-Circuits Laboratory	40
Business Publications Audit of		Molex, Incorporated	Cover III
Circulation	64	Motorola Semiconductor Products,	
		Inc.	19
CTS Corporation	65	Murata Corp. of America.....	80, 91
Control Data Corporation,			
Magnetic Components Division.....	76	National Electronics, Inc.	87
		National Semiconductor Corporation	42
Delco Electronics, Division of		North Atlantic Industries, Inc.....	63
General Motors Corporation.....	4, 5		
Dietzgen Corp.	91	Pomona Electronics Co., Inc.....	81
		Potter & Brumfield Division of	
ECC Corporation	7	AMF Incorporated	34
ESE	96	Power/Mate Corporation	6
Elliott Business Machines Inc.,		Power-Tec, Inc.	25
Div. of DYMO Industries.....	56	Pulse Engineering, Inc.	98
Elmwood Sensors, Inc.	91		
Elsytec Inc.	76	RCA Solid State Division.....	Cover IV
Exar Integrated Systems	1	Reliability, Inc.	88
		Reon Resistor Corp.	89
Facit-Odhner, Inc.	92	Rogers Corporation	38
Federal Scientific Corporation.....	94		
Fluke Mfg. Co., Inc., John.....	10	Schweber Electronics	34AB
		Semi-Films Technology Corp.....	91
General Automation, Inc.....	8, 9	Shredmaster Corp.	89
General Electric Company,		Signetics Corporation, A Subsidiary	
Semiconductor Products		of Corning Glass Works.....	29
Department	23	Siliconix Incorporated	46
General Instrument Corporation.....	31	Solid State Scientific, Inc.....	83
General Radio Company	39	Spectral Dynamics Corporation.....	94
Gralex Industries, Division of		Sprague Electric Company.....	11
General Microwave Corp.....	87	Stackpole Components Company.....	37
Halex, Inc.	83	TEC, Incorporated	95
Hathaway Instruments, Inc.	93	Tektronix, Inc.	45
Hayden Book Company, Inc.....	91	Telecommunications Industries, Inc..	91
Hayden Publishing Company, Inc....	97	Teledyne Philbrick	41
Heath Schlumberger Scientific		Teletype Corporation	33
Instruments	17, 18		
Hewlett-Packard	12, 13, 69	United Detector Technology, Inc.....	75
Hoffman Engineering Company.....	84	U. S. Capacitor Corporation.....	76
Hughes Aircraft Company,			
Electron Dynamics Division.....	27	Vectrol, Inc.	83
		Vero Electronics, Inc.....	85
Instant Instruments, Inc.	89	Victor Wire & Cable Corp.....	38
Instrument Specialties Company, Inc.	73	Vishay Resistor Products, A Division	
Intech, Incorporated	78	of Vishay Intertechnology, Inc.....	75
Intel Corporation	57		
		Winchester Electronics, Division	
Johanson Manufacturing Corp.....	91	of Litton Industries	16



Don't Miss This Boat!

There's still time to enter *Electronic Design's* 1973 Top Ten Contest. You can win a free Windjammer Cruise in the Caribbean . . . \$1,000 in cash . . . free jet transportation . . . color TV . . . Bulova electronic timepieces . . . free ad reruns. There are 100 prizes in all!

Complete information and rules appeared in the Jan. 4 issue. Dig out your Jan. 4 copy and enter the contest now. (If the entry cards are all torn out, you can use the form that is printed below.) Entries must be postmarked before midnight, February 15.

DO NOT SELECT ADS FROM THIS ISSUE — USE ELECTRONIC DESIGN ISSUE NO. 1 — THE TOP TEN CONTEST ISSUE — PUBLISHED JANUARY 4, 1973



1973 SUPER TOP TEN CONTEST

HERE'S MY ENTRY FOR:

READER CONTEST ADVERTISER CONTEST

I have read all of the rules and estimate that the "Top Ten" advertisements receiving the highest Reader Recall "Percent Seen" scores in the January 4, 1973 issue will be:

ADVERTISEMENT OF: (Company or Organization)	INFORMATION RETRIEVAL NUMBER
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

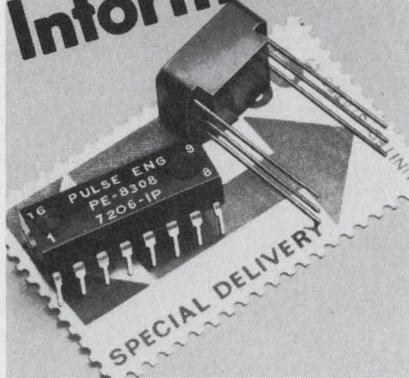
Do not include the advertisements of Electronic Design, Hayden Publishing Company, or divisions. Show Information Retrieval Number. DO NOT show page numbers.

**ENTRY MUST BE POSTMARKED BEFORE
MIDNIGHT FEBRUARY 15, 1973**

ENTRANT'S NAME _____
 COMPANY _____ TITLE _____
 ADDRESS _____
 CITY _____ STATE _____ ZIP _____

Clip and mail to: Top Ten Contest, c/o Electronic Design,
50 Essex Street, Rochelle Park, New Jersey 07662.

New Information



Immediately available Pulse Transformers Delay Lines

Now you can save time and money by specifying standard Pulse transformers or delay lines from our wide range of in-stock components. We have the most commonly used designs—complete and reliable. And Pulse engineers are ready to assist you with unique designs.

Typical Applications

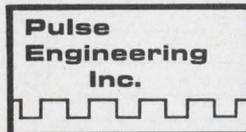
1. SCR and TRIAC control
2. Small signal coupling and isolation
3. Baluns
4. Floating switches
5. Line drivers and receivers
6. DC isolation
7. Timing delays

For the broadest selection of in-stock components, available for immediate delivery in any quantity, call our catalog sales department.

DIP DELAY LINES

Catalog Number	Impedance Z_0 (ohms $\pm 10\%$)	Total Delay (ns $\pm 5\%$)	No. of Taps	Rise Time (ns max.)	Total Delay Rise Time Ratio (min.)
9821	50	50	10	8.5	6
9822	50	100	10	17	6
9823	50	125	10	21	6
9824	100	50	10	8.5	6
9825	100	100	10	17	6
9826	100	125	10	21	6
9827	100	150	10	25	6
9828	100	200	10	34	6
9829	100	250	10	42	6

Send for our free catalog.



A Varian Subsidiary
P. O. Box 12235
San Diego, Calif.
92112
(714) 279-5900
TWX 910335-1527

INFORMATION RETRIEVAL NUMBER 75

product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

Category	Page	IRN	Category	Page	IRN
Components			Packaging & Materials		
capacitor (NL)	90	328	IR optical materials (AN)	88	277
pushbutton switches (NL)	90	324	lead (ES)	88	273
recording head poles (NL)	92	331	SOS kit	85	267
resistors, precision (NL)	90	323	solder pads (ES)	89	280
stepping motors (AN)	88	271	terminal blocks, modular (NL)	90	327
vacuum equipment (NL)	90	330	terminal clamps (ES)	89	279
Data Processing			terminals, solderless wrap (ES)	89	278
buffer, data rate	81	258	test panel (ES)	89	281
CRT terminals (NL)	92	333			
call diverter	80	256			
card printer/punch	81	257			
component recorders (NL)	90	326			
d/a converter	77	250			
data conversion (NL)	90	320			
ECL 1024-bit memory	85	265			
facsimile, digital	80	253			
line printer (NL)	90	329			
minicomputer, paged memory	80	255			
pROMs	82	260			
recorder, video	80	254			
ICs & Semiconductors			new literature		
C-V plotting (AN)	88	274	CRT terminals	92	333
counter/display (AN)	88	270	capacitor	90	328
ECL 1024-bit memory	85	265	component recorders	90	326
IC, stereo	82	259	data conversion	90	320
ICs, CMOS (AN)	88	275	impulse generators	90	325
op amp	84	261	instrument rentals	90	322
op amp	85	266	line printer	90	329
pROMs	82	260	pushbutton switches	90	324
radio circuit	84	264	recording head poles	92	331
SOS kit	85	267	resistors, precision	90	323
Schottky TTL clock	84	263	status indicator	90	321
voltage translator	84	262	stereoscopic television	92	332
			terminal blocks, modular	90	327
			vacuum equipment	90	330
Instrumentation			application notes		
capacitor (NL)	90	328	C-V plotting	88	274
digital multimeter	86	268	counter/display	88	270
impulse generators (NL)	90	325	ICs, CMOS	88	275
instrument rentals (NL)	90	322	IR optical materials	88	277
polarimeter, sacchari- meter (AN)	88	272	laser trimming	88	276
recorder, video	80	254	lead	88	273
spectrum analyzer	86	269	polarimeter, sacchari- meter	88	272
stereoscopic television	92	332	stepping motors	88	271
Microwaves & Lasers					
laser trimming (ES)	88	276			
Modules & Subassemblies			evaluation samples		
d/a converter	77	250	solder pads	89	280
filters, active	78	252	terminal clamps	89	279
op amp	84	261	terminals, solderless wrap	89	278
op amp	85	266	test panel	89	281
pincushion connector	77	251			
status indicator (NL)	90	321			
voltage translator	84	262			



MAKE YOUR CONNECTIONS: FAST. With Molex standard and miniature connectors. They're easier to work with. Simplify wiring. Speed production. Save assembly steps. Make installation and servicing extra easy, too. This is why circuitry idea men everywhere are making connections with Molex. From one circuit to 104 or more. Production keyed and available in a variety of colors to meet design requirements. Molex has the

connector. Plus the design and engineering capability to solve the most complex wiring problems . . . fast. For a colorful free sample of the Molex connector write: Molex Incorporated, Lisle, Illinois 60532. . . Or you can make connections by calling (312) 969-4550.

... creating components that simplify circuitry



RCA's new amplifier may turn you off!

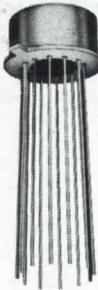
Actually, it may turn your system off. Or turn it on. Because the new CA3094 linear amplifier is also a very effective Power Switch that can operate off a single power supply. That's right!...a programmable Power Switch/Amplifier all in one TO-5 package. And this makes it one of the most flexible devices available to you today.

For example, the CA3094 has high power capability (10 watts peak or 3 watts average), ideal for controlling thyristors, relays, lamps, etc. Yet it can be programmed to idle at microwatt power levels, a real plus in low duty cycle applications.

And its programmable input impedance allows you to design economical timer circuits with delays in excess of four hours.

Add to this, programmable strobing, gating, squelching and AGC capabilities and an excellent THD (@ 0.6 W in class A operation of 1.4% typ), and you can see why applications for the CA3094 are almost endless.

And variety of applications is where this device really shines. Whether you're designing error signal detector sys-



tems (temperature, motor speed controls), alarm systems, analog timers, long time ramp generators, high power single-ended class A amplifiers, automotive or process control systems or even household appliances, the CA3094 should be your top choice.

Best of all, it's available in quantity right now in the following configurations:

*Type	Voltage Single Supply	Gain	Voltage Dual Supply	Output Current	
				Peak	Average
CA3094T	24V	100dB typ.	±12	300 ma	100 ma
CA3094AT	36V	100dB typ.	±18	300 ma	100 ma
CA3094BT	44V	100dB typ.	±22	300 ma	100 ma

*These three types are also available in formed-lead TO-5 for dual-in-line socket configuration, as CA3094S, CA3094AS, and CA3094BS.

Interested? Let us send you a Data Sheet and Application Note (ICAN-6048). Write: RCA Solid State, Section, 57A-18 Box 3200 Somerville, N.J. Phone: (201) 722-3200

RCA Solid State

products that make products pay off

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