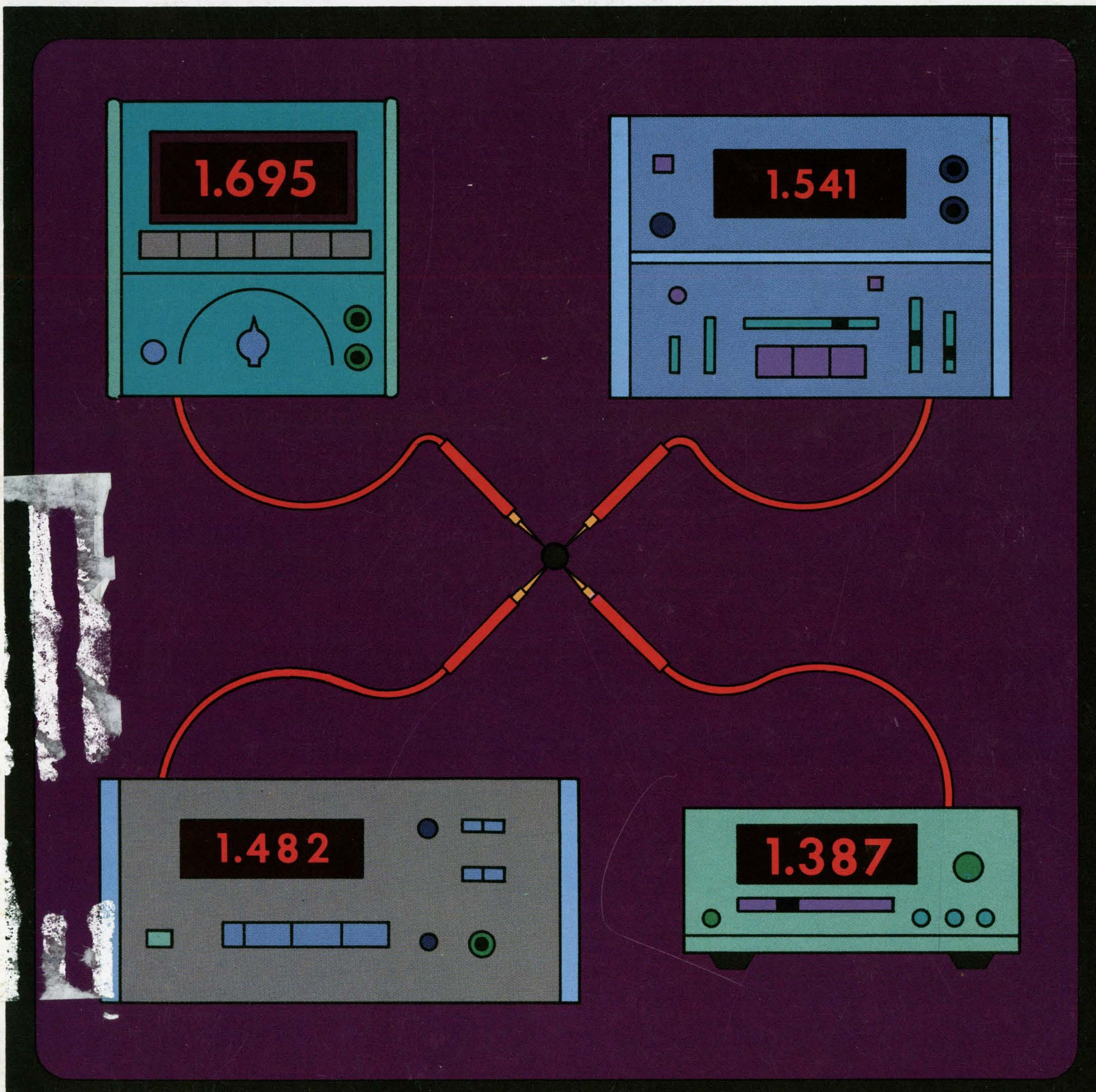
VOL. 21 NO.

Electronic Design 16

FOR ENGINEERS AND ENGINEERING MANAGERS

AUG. 2, 1973

Be careful with DMM readings. What you see may not be what you've got. Misleading accuracy specs, temperature changes and time can all gang up to give false readings. And noise, offset voltage and loading can tack on even more errors. Range in on how to use DMMs and interpret their specs. Start on page 58.



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LTS-CA-6	6±1%	6.6	6.2	5.5	4.6	80
LTS-CA-12	12±1%	4.4	4.1	3.8	3.2	80
LTS-CA-15	15±1%	4.0	3.7	3.4	3.1	80
LTS-CA-20	20±1%	3.1	2.9	2.7	2.4	80
LTS-CA-24	24±1%	2.6	2.4	2.2	2.0	80
LTS-CA-28	28±1%	2.2	2.2	2.0	1.8	80

*Includes fixed overvoltage protection at 6.8V±10%

LTD-CA DUAL OUTPUT MODELS
4 29/32" x 4 15/16" x 9 5/16"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	71°C	PRICE
LTD-CA-152	±15±1%	2.0	1.8	1.7	1.5	$110
LTD-CA-122	±12±1%	2.0	1.8	1.7	1.5	110

LTS-DB SINGLE OUTPUT MODELS
4 29/32" x 7 1/2" x 10 1/2"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	PRICE
LTS-DB-5-OV*	5±1%	12.0	10.8	9.0	$130
LTS-DB-6	6±1%	11.0	9.9	8.2	130
LTS-DB-12	12±1%	7.6	6.7	5.7	130
LTS-DB-15	15±1%	7.2	6.4	5.4	130
LTS-DB-20	20±1%	6.0	5.3	4.5	130
LTS-DB-24	24±1%	5.5	4.9	4.1	130
LTS-DB-28	28±1%	4.0	4.0	3.7	130

*Includes fixed overvoltage protection at 6.8V±10%

LTD-DB DUAL OUTPUT MODELS
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MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	PRICE
LTD-DB-152	±15±1%	3.8	3.2	2.6	$160
LTD-DB-122	±12±1%	4.0	3.4	2.8	160

LTS-DC SINGLE OUTPUT MODELS
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MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	PRICE
LTS-DC-5-OV*	5±1%	17.0	14.5	12.0	$150
LTS-DC-6	6±1%	16.0	14.0	12.0	150
LTS-DC-12	12±1%	11.0	9.7	8.6	150
LTS-DC-15	15±1%	10.0	8.8	7.7	150
LTS-DC-20	20±1%	8.0	7.1	6.0	150
LTS-DC-24	24±1%	7.1	6.4	5.4	150
LTS-DC-28	28±1%	6.0	6.0	5.0	150

*Includes fixed overvoltage protection at 6.8V±10%

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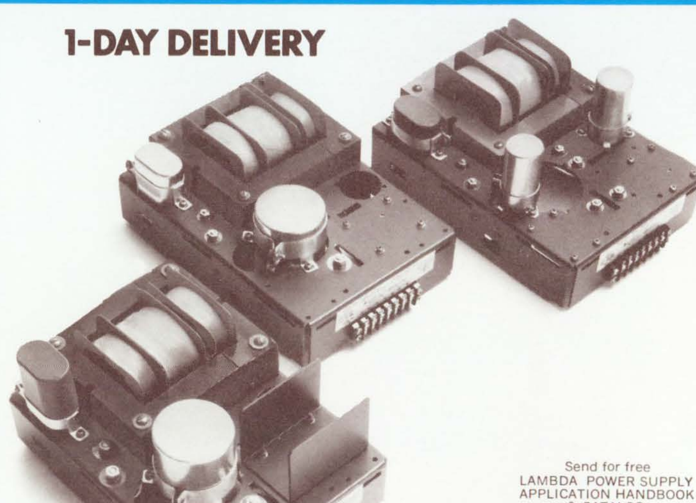

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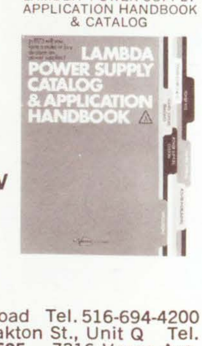

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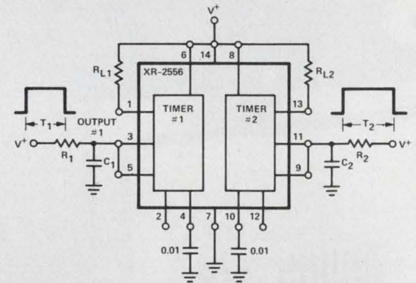
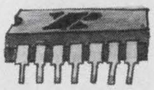
INFORMATION RETRIEVAL NUMBER 246

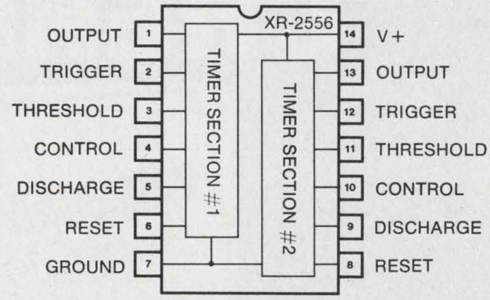
WHAT THIS COUNTRY NEEDS IS ONE GOOD DUAL 555 TIMER

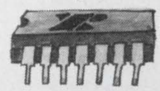
Generation of Two Independent Time Delays





Functional Block Diagram





2001 Uses, including:

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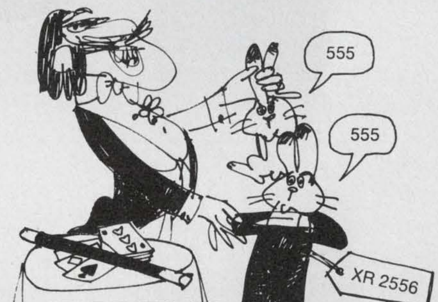
Pulse Generation
Sequential Timing
Pulse Shaping
Time Delay Generation
Clock Pattern Generation
Missing Pulse Detection
Pulse-Width Modulation
Frequency Division
Clock Synchronization
Pulse-Position Modulation

Synchronized Oscillator Outputs



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VOL. 21 NO.

Electronic Design 16

FOR ENGINEERS AND ENGINEERING MANAGERS

AUG. 2, 1973

NEWS

TECHNOLOGY

PRODUCTS

Departments

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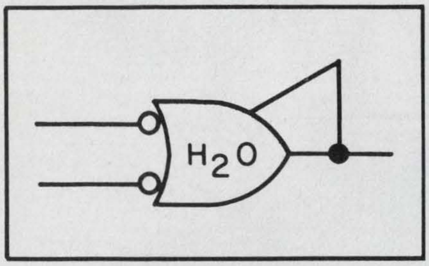
INFORMATION RETRIEVAL NUMBER 5

across the desk

Introducing, a new gate with expandable output

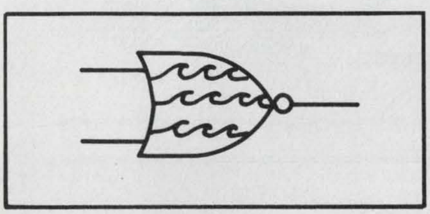
Lest engineers be accused of being humorless, we suggest the following schematic for the problems in Washington:



It's an active, low-level input Watergate with expandable output.

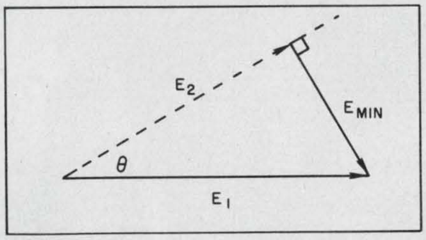
Jowdat Hallal
Csaba L. Kohalmi
Naval Avionics Facility
Indianapolis, Ind.

Ed Note: And here's another contribution. The artist preferred to remain anonymous.



An April 1 idea: Is it a joke?

The second sentence in the Idea for Design "Two Amplitude Measurements Determine Unknown Phase Angle," (ED No. 7 April 1, 1973, p. 86), states that the minimum difference voltage occurs when the two signals are of equal magnitude. This is not true. The actual relationship, as shown by the vector diagram



$$\tan \Theta = \frac{E_{min}}{E_2}.$$

The scheme, as described, will not work in the second and third quadrants, where $E_{min} = E_1$ and $E_2 = 0$. The addition of a transformer or additional amplifier and switch will allow signals to be inverted into the first or fourth quadrant where the scheme will work.

Is there some significance to be attached to the date of publication?

Frank W. Noble
Dept. of Health, Education & Welfare
Public Health Service
National Institutes of Health
Bethesda, Md. 20014

The author replies:

This method was devised to measure the magnitude of any phase angle. For small angles, nulling provides a convenient and accurate way of obtaining the approximate difference between two equal magnitude vectors. Larger angles, however, require that these vectors be made equal before the difference is taken. Although this determination is necessarily limited by the accuracy of the test equipment, it is theoretically exact and relatively good even with an oscilloscope. The proof, originally omitted for brevity in printing, is as follows:

(continued on page 10)

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.

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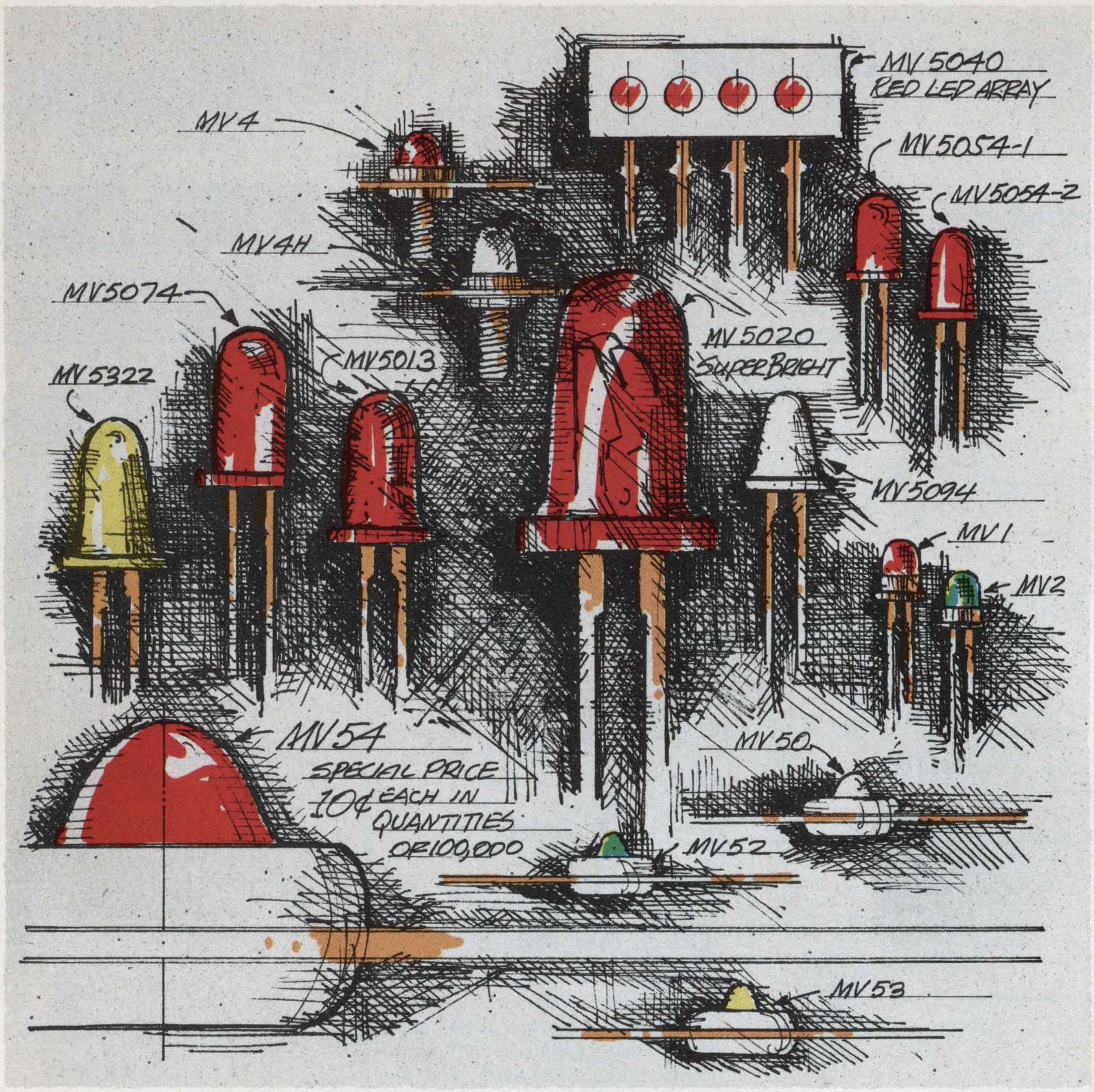

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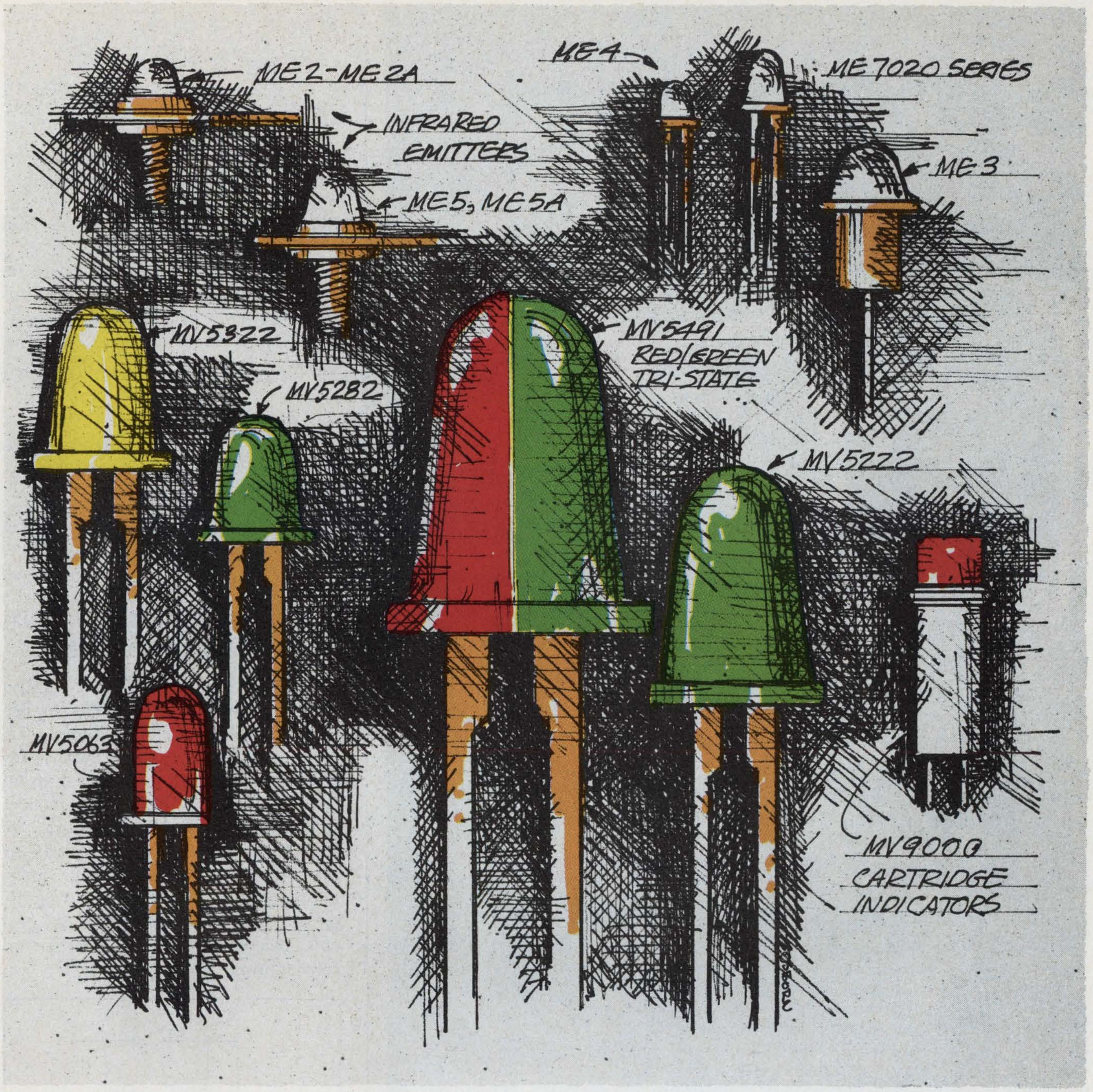

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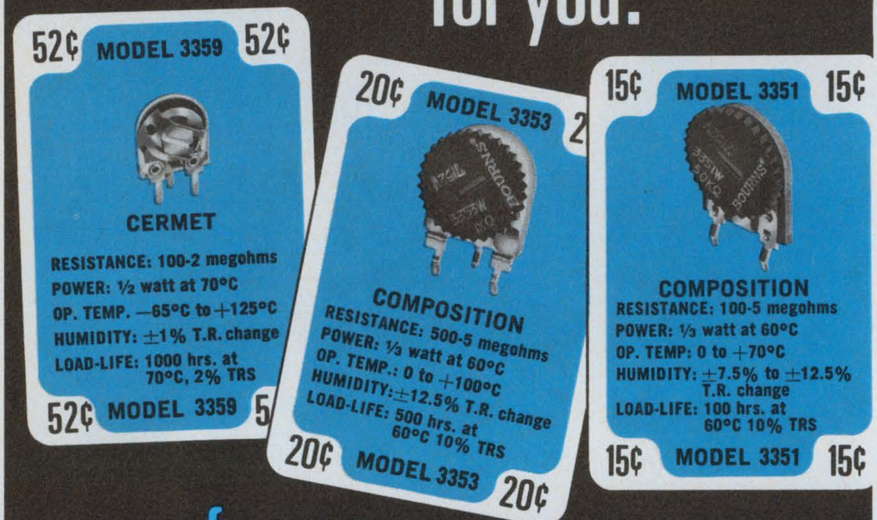

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INFORMATION RETRIEVAL NUMBER 8

ACROSS THE DESK

(continued from page 7)

$E[\sin(\omega t + \Theta) - \sin \omega t] = V \cdot F(\omega t)$ or $E[\sin(\omega t + \Theta/2) - \sin(\omega t) - \Theta/2)] = V \cdot F(\omega t - \Theta/2)$

and

$2E \sin \Theta/2 \cos(\omega t - \Theta/2) = V \cdot F(\omega t)$.

From this expression, $f(\omega t)$ is seen to be a cosine wave leading (ωt) by $\Theta/2$ with a peak amplitude equal to $E \sin \Theta/2$. Solving for Θ gives

$$\Theta = 2 \sin^{-1} \frac{V}{2E}.$$

S. J. Pirkle

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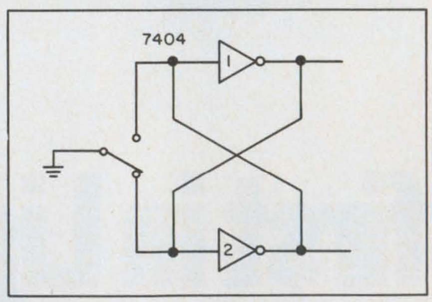
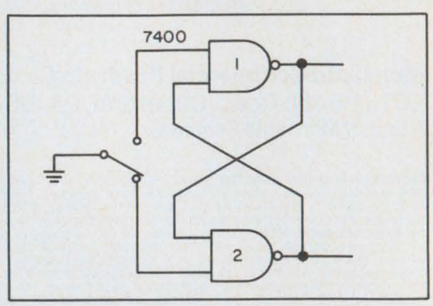
Waltham, Mass. 02154

More antibounce the conventional way

I would like to comment on the article "The Foolproof Way to Sequencer Design," by James H. Bentley (ED No. 10, May 10, 1973, p. 76). Although this has no connection with the author's main topic, let me respectfully point out that there is nothing foolproof in his implementation of the antibounce flip-flop in Fig. 7 and again on Fig. 11. I am showing his circuit below as compared with the conventional debouncing F/F:



1a. **Author's method.**



1b. **Conventional method.**

(continued on page 16)

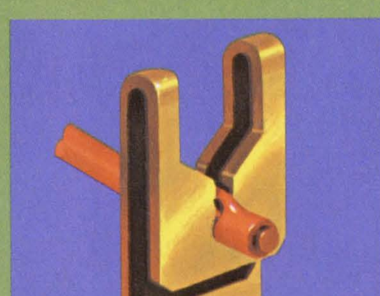
You can factory-install this 25-pair connector in less than 3 minutes. Without solder.

Impressive? Yes—especially since you can do it in your plant with our CHAMP 25-pair connector and semiautomatic application machine.

The machine automatically cuts to length and terminates 50 individual wires in highly reliable, easily replaceable, solderless contacts. In just over 2 minutes. Intermateable with existing connectors.

You can install the same connector in the field—and save time and cable—with our CHAMP hand applicator tool. With it, you can terminate our 25-pair connector to a cable in just 5 minutes. Again—without the problems of solder.

Find out more about our CHAMP products for telecommunications. Call (717) 564-0101 or write for a demonstration. AMP Incorporated, Harrisburg, Pa. 17105.



Unique design of contact provides insulation-displacing, gastight termination.

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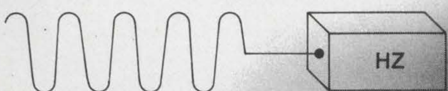
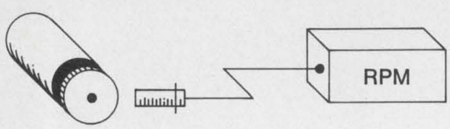
Measuring flow rates, draw ratio, rpm, rates, totals, speeds or time periods?

1.89"H x 4.39"W x 4.50"D

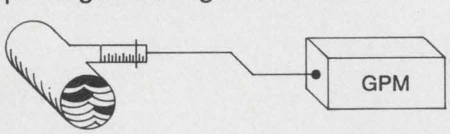
The DigiTec Model 810 Digital Process Indicator can be used to measure an infinite variety of parameters through the use of state of the art design.



Featuring programmable normalization for direct reading in engineering units, the 810 uses an internal crystal clock for precise, measurement.

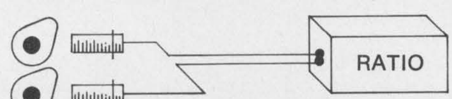


Available in models with 3, 4 or 5 digit non-blinking, LED displays, they have a basic input sensitivity of 10mV RMS for use with the outputs of magnetic pickups, photo cells, shaft encoders or any other pulse generating transducers.

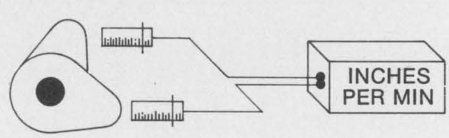


The 810 has an input frequency range beyond 100KHz.

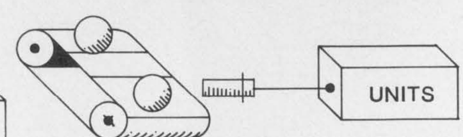
Although sensitive, the input can withstand up to 500V peak to peak without damage.



Once programmed for normalization and input sensitivity (both on a rear connector) the Model 810 Indicator becomes a "Hands off" readout, usable by non-technical personnel.



Optional stored BCD output for use with limit detector, recording peripherals and computer interface is also available.



To see a DigiTec Model 810 Digital Process Indicator and obtain quantity prices, contact your nearest DigiTec or Monsanto Representative or write United Systems Corporation.

Prices start at $234.

United Systems Corporation
918 Woodley Road, Dayton, Ohio 45403
Ph. (513) 254-6251 Twx: (810) 459-1728
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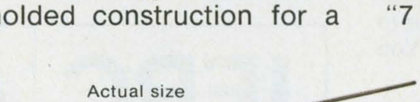
DigiTec

INFORMATION RETRIEVAL NUMBER 10

Are you cramped for board space but not in power handling capabilities? Is reliable performance vital? Then use Allen-Bradley 1/8 watt carbon composition resistors. Get the pulse handling and overload capabilities that are superior to resistors manufactured by other technologies. Exclusive hot molded construction for a dense resistance element which reduces noise, and results in a consistent performance. Most importantly, our 1/8 watt resistors have all of the quality and reliability common to our larger sizes. Quality that really can cut your fixed resistor costs. If you think resistors are identical, write for "7 Ways to Tell the Difference in Fixed Resistors." Available from your Allen-Bradley Electronic Distributor, or: Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, N.J. 07003. Canada: Allen-Bradley Canada Limited, Cambridge, Ontario. United Kingdom: Jarrow, Co. Durham NE32 3EN.

Actual size



A-B QUALITY

Allen-Bradley
Milwaukee, Wisconsin 53204

EC53

Introducing metal circuit boards . . .

How to stuff a lot of hot semiconductors into a small space and not get burned.

We've developed an ingenious new printed circuit board that conducts heat, radiates heat, and offers an effective area for convection of heat to the surrounding air, just like heat sinks and dissipators do.

So now you can mount concentrations of heat-producing devices directly on our new circuit board and save the space, weight, and cost of heat sinks, heat dissipators, blowers, and conduction planes while you operate your circuit at high power densities and let our circuit board keep junction and case temperatures at safe, comfortable levels.

Simple secret ingredient

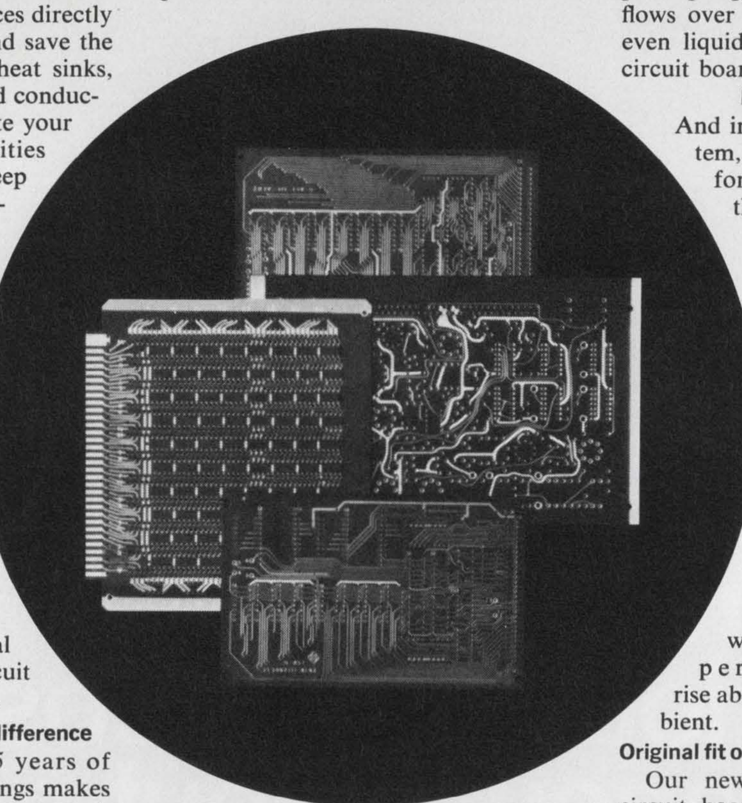
Our new circuit boards permit these power densities—from 4 to 13 times those possible using G-10 epoxy boards — because they are made out of aluminum.

So that our metal circuit board can function like normal circuit boards do, we coat it — all over and through the holes — with an electrically insulating material on which we plate the circuit and plate through the holes.

The difference that makes the difference

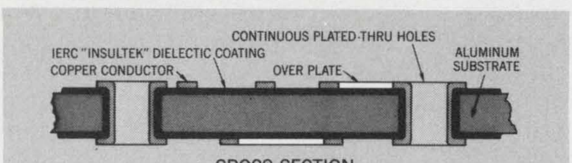
But here's where our 15 years of working with heat sink coatings makes heat dissipating metal circuit boards possible. Our exclusive new coating — tough, hard, resistant to solder, solvents and thermal shock, and displaying high dielectric strength plus high surface and insulation resistance — has excellent thermal qualities.

That means you can take one of our circuit boards — called "MCCB" for Metal Core Circuit Board — and put circuitry on it developing four times the power that a circuit on a G-10 board of the same size and weight can handle while both hold case and junction temperatures to the same, safe levels.



When you're hot, you're hot

Looking at it the other way, if you're stuck with a hot circuit and you'd like to tuck it away in a nook somewhere, loading it on an MCCB will let you put it in about half the space you could get away with using an epoxy board plus the required heat dissipators and other thermal management devices. And it will weigh about half as much to boot.

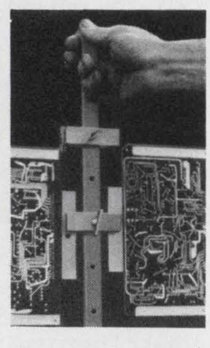


But here's where our MCCB really gets unfair to the G-10 competition: You can thermally ground it. And when you do, it will dissipate up to *13 times* the power of a simple epoxy board while maintaining recommended temperatures.

That kind of ratio means you're replacing big blowers moving strong air flows over bulky heat sinks — maybe even liquid systems — with a printed circuit board.

Missing link found

And in a thermally grounded system, MCCB supplies a heretofore nonexistent link between the heat generating semiconductor—or resistor or whatever—and the natural conduction path from metal board retainers through the chassis to the outside world. Another MCCB advantage you won't want to overlook is high conductor current carrying capacity. For instance, a .033″ wide conductor printed on our MCCB will carry over three times the current as the same conductor on G-10 with the same conductor temperature rise above ambient.



Original fit or retrofit

Our new metal circuit boards can revolutionize your next packaging design, and they can clear out hot spots in existing designs as well. Write, phone, or circle for all the details. Or send us your artwork for a quotation. International Electronic Research Corporation, a subsidiary of Dynamics Corporation of America, 135 West Magnolia Blvd., Burbank, Calif. 91502. (213) 849-2481.

IERC

INFORMATION RETRIEVAL NUMBER 12

Licon has added LED's to one LPB switch line . . .
another line offers neon or incandescent lamps . . .
both feature patented Butterfly® switching.

You always get a great choice with Licon® LPB switches. For example, take just two of our many lines—Types 01-700 and 01-600 single light switches. Our 01-700 line is now available with integral Light Emitting Diodes. That means virtually infinite light life and negligible operating current. And the 01-700's low profile design assures maximum light intensity. Or choose neon or incandescent lamps instead. In either line. Mounting styles? Type 01-600 line features bezel or bezel-barrier, in a single switch or multiple in matrix. Time-saving, snap-in mounting. Switching action? Choose from momentary or alternate—plus a selection of non-lighted switches or non-switching indicator lights in matching styles. But whatever you choose, you also get patented double-break Butterfly switching which offers greater reliability and other advantages not possible with single-break switches. Licon LPB's are easily installed and serviced.
Test light them yourself.

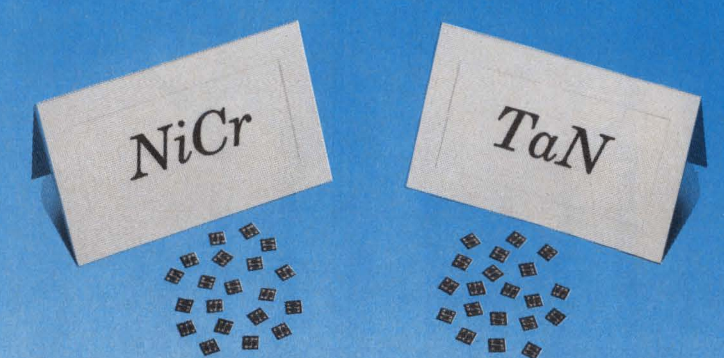
Call your local Licon rep or distributor for a lighted demo in your office. Or call or write for a Licon Switch Catalog.
Licon, Division Illinois Tool Works Inc., 6615 W. Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040. TWX 910-221-0275.

itw LICON

INFORMATION RETRIEVAL NUMBER 13

***The Innovating Electronic Group of* ITW... LICON ▪ ELECTRO MATERIALS ▪ PAKTRON**

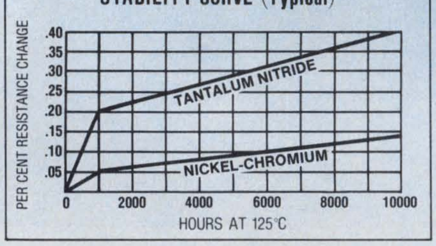
Choose your Chips



SPRAGUE THIN FILM RESISTORS and resistor networks in your choice of nickel-chromium or tantalum nitride chips come in a broad range of values and designs to meet your hybrid microcircuit requirements. Standard resistance values from 10 ohms to 1 megohm are available in a 30 mil. sq. design, while values up to 5 megohms in nickel-chromium are available on slightly larger chips. Proprietary processing techniques provide unmatched performance and reliability. Etched silicon backing assures easy, reliable die bonding.

Features include very low noise, uniform tracking, and excellent temperature characteristics . . . at low, competitive prices. Individual resistors are available as standard with ±5%, ±10%, or ±20% resistance tolerances. They can be custom laser trimmed to within ±0.01%.

STABILITY CURVE (Typical)



Sprague thin film resistors are also available in wafer form, ready for scribing in your plant, as well as in completed flat-pack or plug-in packages . . . in both standard and custom designs.

Characteristic	Nickel-Chromium	Tantalum Nitride
Resistivity Range	125Ω to 950Ω/□	100Ω to 300Ω/□
Resistance Range	10Ω to 5MΩ	15Ω to 800KΩ
Temperature Coefficient of Resistance	0 to +50 PPM/°C	−50 to −200 PPM/°C
Tracking Match	±1 PPM/°C	±1 PPM/°C
Stability	<.10% (125°C)	<.10% (85°C)
Noise*	0.01 μV/V max.	0.1 μV/V max.
Power Dissipation	100 W/sq. in.	25 W/sq. in.
Temperature Range	−55°C to +125°C	−55°C to +85°C

*Per MIL-STD-202D, Method 308

4SH-3110

Get complete information from Dick Cummings, Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Tel. 617/853-5000

SPRAGUE® THE MARK OF RELIABILITY

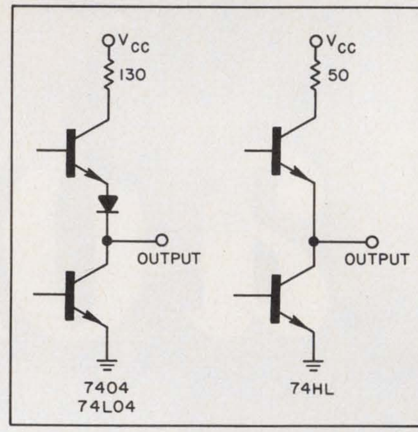
HYBRID CIRCUIT PRODUCTS

INFORMATION RETRIEVAL NUMBER 14

ACROSS THE DESK

(continued from page 10)

With the switch in the position shown in Fig. 1a, the output of Gate 2 is HIGH, and the output of Gate 1 is LOW. While the switch wiper is in transition, Gate 2 is kept HIGH by the LOW output of Gate 1. As soon as the wiper touches the upper switch contact, the output of Gate 2 becomes shorted to ground. Under this condition the totem-pole output circuit of Gate 2 (see Fig. 2) will draw heavy current from V_{cc} for a duration of $t_{pd1} + t_{pd0}$, or until the upper transistor in the totem-pole is cut off.



2. **Totem-pole outputs of TTL gates.**

Depending upon the type of gate selected, this current pulse will have a width of 15 to 100 ns. It can couple into neighboring circuits on the board with quite unpredictable results.

Brief contemplation will show why this problem does not exist in the conventional debouncing circuit.

Jeffrey Lowenson

AMF Inc.
1025 N. Royal St.
Alexandria, Va. 22314

Correction

In the product review "Mass Tape Memory Unit Stores Up to 10^{12} Bits" (ED No. 11, May 24, 1973, p. 178), the last sentence incorrectly states the data rate as 14-billion bytes/s. It should read 1.2-million bytes/s. The 14-billion refers to the storage capacity of the basic storage unit.

(continued on page 16C)

fhp options unlimited

Fractional horsepower *motors, gearmotors* and *controls.* Literally thousands of configurations. Including parallel shaft and right angle gearmotors. Chassis-type or encased controls. Designs to meet all kinds of mounting needs and power supply requirements. Every one is rigorously tested to assure performance as specified. Another important Bodine plus value: Application assistance. We're eager to help you solve any fhp problem you may have. And can give you answers about modifications, options and "special designs" fast. On orders large and small, you'll find no better source for ideas, service or results. Write for Catalog S. Bodine Electric Company, 2534 W. Bradley Place, Chicago, Illinois 60618.

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

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BODINE MOTORS/GEARMOTORS
SPEED CONTROLS

INFORMATION RETRIEVAL NUMBER 101

Within seconds after the match flame was applied to both the epoxy (left) and the silicone ICs (right), the epoxy burst into flame.

The hot issue in electronics today is flame retardancy. While epoxies and other plastics support combustion, silicone-packaged devices are virtually nonflammable. So, they don't need flame-retardant additives that alter the electrical and mechanical properties of epoxies and other materials.

And there are several other good reasons to specify silicone packaging compounds:

- excellent performance under thermal cycling
- low thermal expansion minimizes damage to components and lead wires
- basic electrical, physical, and chemical properties that remain constant over the widest temperature (—55 to 250 C), time, and frequency ranges
- uniform, lifetime electrical characteristics
- superior performance in 85 C/85% RH (biased) test
- total compatibility with *all* kinds of devices, including ICs, both digital and linear, MOS, CMOS, power transistors, SCRs, high-voltage rectifiers, etc.
- optimum reliability reduces manufacturing and repair/warranty costs
- safe, clean, inert, and require no special handling

Whether you are a device manufacturer or user, these advantages are important in semiconductor devices. Make the switch to nonburning silicone packaging compounds now. Write or call Jack Broser, Product Market Supervisor, Dow Corning Corporation, Department A-3312, Midland, Michigan 48640.

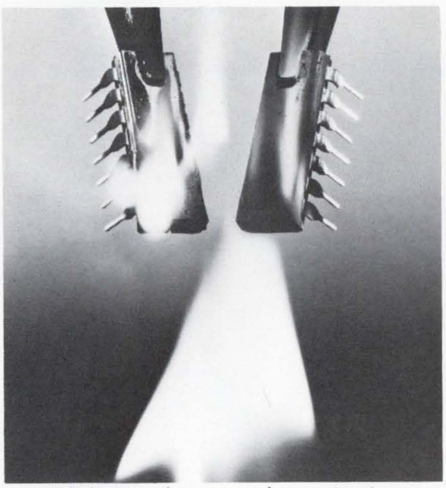
Silicones; simply the best way to protect electronic circuits

DOW CORNING

DOW CORNING

INFORMATION RETRIEVAL NUMBER 102

Six good reasons why Dow Corning should be your primary packaging-materials supplier.



In addition to the many important advantages of silicone molding compounds, there are other good reasons why it is to your advantage to plan your growth in the electronics market with help from Dow Corning.

1. We are helping to develop the market for you. Extensive publicity, promotion, direct mail, and trade-show appearances are all educating your customers about the very substantial advantages of silicones in all kinds of harsh electronic/electrical environments.

2. Since service is extremely important in helping manufacturers in the development of advanced packaging systems, we have Technical Service & Development men strategically located worldwide to help solve your problems.

3. Your competitive advantage with Dow Corning molding compounds is a complete family of products, totally compatible with each other and with most other materials used in electronic systems, devices, or components.

4. Product-line breadth gives you the ability to design or produce the most reliable and economical packaging to protect any system, regardless of its sophistication or environment.

5. Technical leadership constantly applied in our own laboratories and with our customers results in the development of product modifications and new technologies to handle the needs and requirements of next generation devices.

6. Worldwide delivery from strategically located distribution points enables us to work with you to supply standard or special molding materials as required.

Major commitments like these indicate the kinds of things we are doing to earn your business. We'd like to discuss with you in more detail how we can grow together in this rapidly expanding area. Call or write Jack Broser, Product Market Supervisor, Dow Corning Corporation, Department A-3313, Midland, Michigan 48640.
Phone: (517) 636-9460

Silicones; simply the best way to protect electronic circuits.

DOW CORNING

DOW CORNING

INFORMATION RETRIEVAL NUMBER 103

(continued from p. 16)

'Honest opinion' on jobs praised

A "thank you" for publishing the remarks of Joel B. Snyder concerning the engineering employment situation ("Scarcity of Engineers? Not So, Asserts IEEE" ED No. 8, April 12, 1973, p. 10). It is refreshing to hear an honest opinion once in a while. John D. Alden's reply on behalf of EJC, perpetuated the type of misleading statement that he accuses Synder of making ("Job Survey Defended as 'Creditable Job," ED No. 11, May 24, 1973, p. 16). Whether 91%, 95% or 100% of the 1971 graduates found employment is not a valid indicator of the true state of affairs, but rather equivalent to a mechanic concluding that the auto is in good order because the engine will start. Snyder is reminding us to also check the brakes—some much needed advice.

Also an "amen" to Robert S. Duggan Jr. for his "let's give them a chance" attitude toward the IEEE and its united efforts in the socioeconomic arena. The leadership does appear to be attempting to respond to the wishes of the majority, and they should be encouraged during this embryonic period.

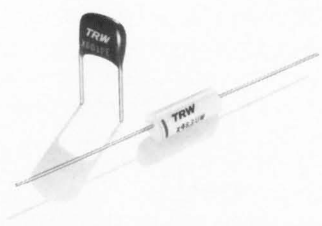
George V. Colby Jr.
7 Hawthorne Rd.
Lexington, Mass. 02173

An excellent article on DVMs, but—

Larry Potter's article, "Be on Guard When Using DVMs" (ED No. 12 June 7, 1973, p. 70) was excellent but completely omitted mentioning that some DPMs have true differential inputs that tend to give greater than 100 dB common-mode rejection (with filtering) at 60 Hz. Such a DPM is available from Newport Co., Santa Ana.

Robert Lowe
Xerox
El Segundo, Calif.

think small



. . . *with TRW metallized film capacitors.* For example, metallized polycarbonate ultra-miniatures (Type X463). Real problem solvers in precision circuitry where stability with small size is essential. Capacitances: .001 to 10.0 mfd in 50, 100, 200, 400 VDC. High IR, low DF, fully rated from −55 to +125°C—with less than 1½% capacitance change. Rugged, plastic film case. For similar performance in a metal enclosed unit, ask about Type X482. And for real space savings in a rigid pre-molded case, check the X440.

And then there are X601PE subminiatures in metallized Mylar* construction with dipped epoxy coating. Capacitances: .01 to 10.0 mfd—in 100 and 200 VDC. Temp.: −55 to +100°C (to 125°C with derating). Tough, self-healing. Great for high-density PC's, humid environments, precision applications. (Metallized Mylar units also available tape-wrapped or metal enclosed.)

One other thing. We figure you can't make quality capacitors and me-too capacitors under the same roof. Because sooner or later, one operation will goof the other one up. So we take the quality route. Count on it.

Write for catalog or application engineering assistance. TRW Capacitors, an Electronic Components Division of TRW, Inc. Box 1000, Ogallala, Nebraska 69153. (308) 284-3611.

**Du Pont T.M. for Polyester Film*

TRW® CAPACITORS

INFORMATION RETRIEVAL NUMBER 104

DISTRIBUTOR PRODUCTS

Centralab perspectives

FOR USERS OF ELECTRONIC COMPONENTS

CENTRALAB
Electronics Division
GLOBE-UNION INC.
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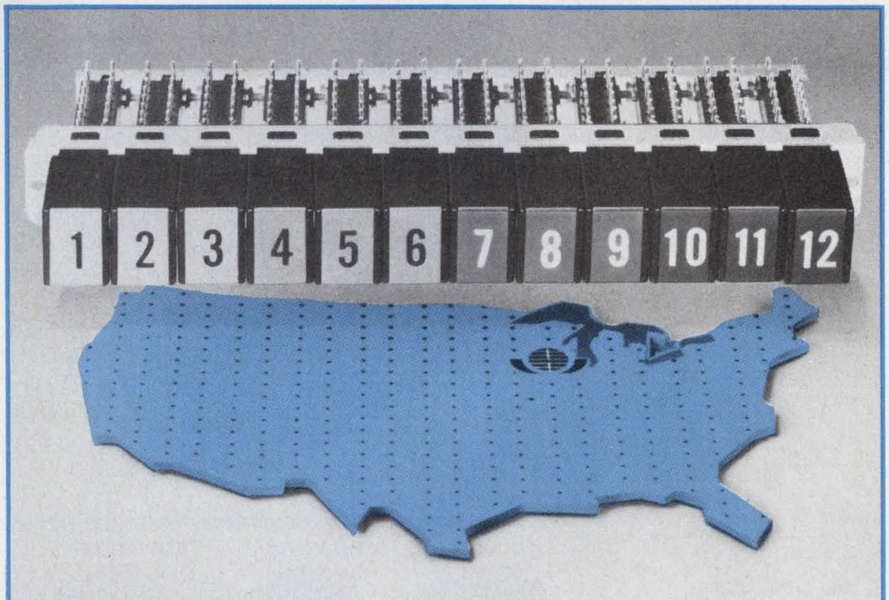
Custom push button switches. Samples in 3 days. Quantities in a week.

Companies in a hurry for made-to-order push button switches are taking advantage of Centralab's field assembly program, and not paying a premium for the service.



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Seattle 98109
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Let's say you're an engineer and you need samples of a 10-station push button switch for design mock-up purposes. A call to a Centralab Field Assembly Distributor will get you samples of 5 to 10 switches in 2 to 3 days. Now assume you're a PA and you want prototype or limited production quantities of push button switches.* A similar call will bring that initial run in a week's time.

This "hot button" service is part of Centralab's program to provide custom assembly of made-to-order push button switches as near to the customer as possible, without charging him more than he'd expect to pay for any similar factory-placed order. Now in its third year, the program has grown to include a great variety of push button options heretofore available only as special orders from the factory. The wide selection is proving to fill the lion's share of push button switch requirements.

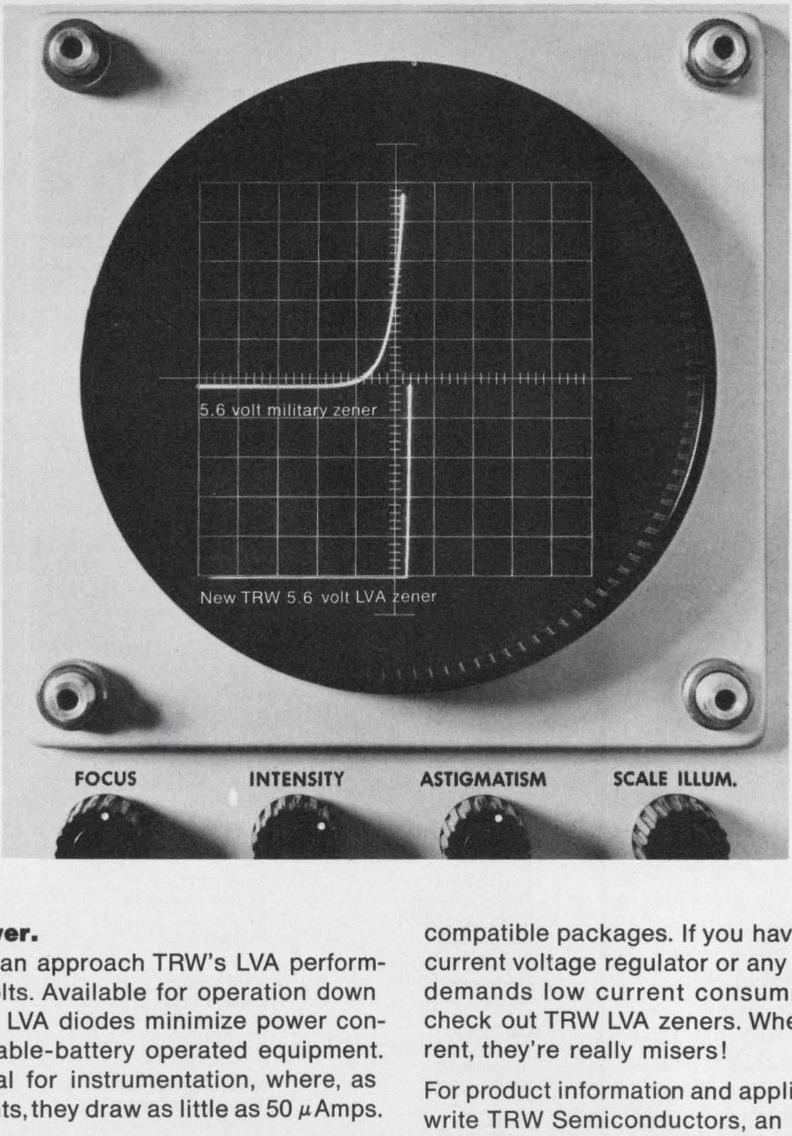
As a result, the customer can specify from a broad spectrum of these standard components and still obtain the switch that fits his particular needs. For example, you can order switches with up to 19 different stations and with 3 spacing options—10, 15 and 20 mm. You have a full choice of switching actions, such as interlocking, push push, or momentary, all available with lock-out. Electrical considerations include a choice of 2, 4, 6 or 8 pole double-throw designs and a new low profile 2 amp line switch.

Both non-lighted and lighted push button switches are available. In non-lighted, 12 button styles in 5 standard colors are offered. In lighted switches, there are 10 different colored lenses available.

For further details regarding the program, direct inquiries to the Distributor nearest you. Or write Centralab Distributor Products in Milwaukee, Dept. PB-1

* Isostat licensed.

TRW LVA diode... the sharpest knee below 10 Volts.



The current saver.

No other zener can approach TRW's LVA performance below 10 volts. Available for operation down to 4.3 volts, TRW LVA diodes minimize power consumption in portable-battery operated equipment. They're also ideal for instrumentation, where, as reference elements, they draw as little as 50 μAmps.

TRW LVA's are available in various package configurations, including passivated chip form for hybrid-compatible packages. If you have a need for a low current voltage regulator or any other product that demands low current consumption, you should check out TRW LVA zeners. When it comes to current, they're really misers!

For product information and applications assistance write TRW Semiconductors, an Electronic Component Division of TRW Inc., 14520 Aviation Boulevard, Lawndale, California 90260. Phone (213) 679-4561.

These products are available through the following authorized distributors:

Almo Electronics
Bell Industries
Cramer Electronics Inc.
De Mambro Electronics
Eastern Radio Corp.
Electronics Marketing Corp.
Elmar Electronics Inc.
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Harvey-Michigan Inc.
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TRW® SEMICONDUCTORS

INFORMATION RETRIEVAL NUMBER 16

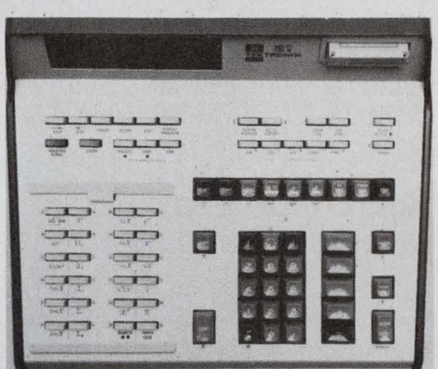
news scope

AUGUST 2, 1973

2 desktop calculators announced by Tektronix

Tektronix Inc. of Beaverton, Ore., has entered the desk top programmable calculator market with two machines. Competitors include such well established names in the field as Hewlett-Packard, Wang and Computer Design Corp.

Since acquiring the assets of Cintra in 1971, Tektronix has quietly continued the production of Cintra's Scientist 909 calculator. However, company spokesmen are quick to point out that the new machines are not just rehashes of the old designs.



TEK 31 programmable desk-top calculator available from Tektronix.

A major selling point for both machines is that each provides a number of user-definable keys which can be customized to perform any sequence of math operation. Ronald V. Hill, calculators product manager for Tektronix, explains, "With an overlay, the customized keys can be labelled in the user's language, allowing an operator to solve multistep problems without necessarily being aware of all the math involved.

The units—TEK 21 and TEK 31—both have 35 math functions on their keyboard, a reader for programmed entry (The 21 uses magnetic cards; the 31, special tape cartridges), user definable keys (The 21 has 8; The 31 has 24,) and can be equipped with thermal printers and optional expanded memories.

The Tek 21 sells for $1850; the Tek 31 for $2850; both are available with a four-week delivery time.

8 Quadraphonic Systems being evaluated by EIA

Eight different proposed quadraphonic systems that would impress four discrete sound channels on an FM broadcast channel are being currently evaluated by the National Quadraphonic Radio Committee of the Electrical Industries' Association Consumer Electronics Group. There is no quadraphonic FM broadcasting station now in operation.

The following companies submitted proposals at a recent committee meeting: Quadracast Systems Inc., San Mateo, Calif., RCA Princeton, Laboratories (two systems), Zenith, Chicago (two systems), General Electric, Syracuse, N.Y., Motorola, Franklin Park, Ill., and Radio Programming Management, Southfield, Mich.

Ed Tangley, EIA staff engineer and secretary of the Quadraphonic Committee, explained that all of the proposed systems—with the exception of that proposed by Radio Programming Management—can be adapted to the present stereo approach in that the third channel is added in quadrature with one of the stereo subchannels. The principle difference in these systems lies in exactly how they obtain the fourth channel. For the fourth channel, Tangley says, seven of the proposed systems add the channel in an additional portion of the FM channel spectrum.

On the other hand, he points out that Radio Programming Management's system impresses both the third and fourth channels in the quadrature stereo subchannel. Thus, an additional portion of the spectrum used by the other is not required for the latter system.

The ultimate system chosen by the EIA committee will be submitted through the Federal Communications Commission for that body's approval and testing, probably some time in 1974.

Projectile fuze first to use MNOS circuits

MNOS nonvolatile semiconductor memories, a recent addition to memory technology, has already found a niche for itself in military applications in the form of electronic time fuze for projectiles. Developed by the Army Materiel Command's Harry Diamond Laboratories, Washington, D.C., the new electronic fuze is the first military application for metal nitride oxide silicon semiconductors. It is said to offer greater accuracy and longer time delays than conventional fuzes.

According to Norman Doctor, chief of the electronic timing branch of Harry Diamond Laboratories, the fuze has a setting capability of from 0.2 to 199.9 seconds with an accuracy of 0.1 second.

Mechanical fuzes employ engraved time and vernier scales to set the timer and are significantly less accurate than the new electronic fuze, notes Doctor. The mechanical devices have an accuracy ranging from 0.3 to 0.5 second and are rarely capable of providing delays longer than 100 seconds, he continues.

The fuze, notes Doctor, consists of five integrated circuits: a counter/memory, a time base, interface and firing electronics, a scaler and a safety circuit. The counter/memory chip contains the MNOS memory which stores the timing information and a 12-stage counter on a monolithic chip.

One of the main reasons that

MNOS was chosen, says Doctor, was because it could be integrated with other MOS devices, such as the counter, onto a chip. In addition, with no moving parts needed to set the fuze, field errors are significantly reduced, reports Doctor.

The fuze is set by an external device that slips over the nose of the fuze, makes contact with three metal rings, and writes information into the memory.

Timing information is entered into the MNOS memory in a new electronic fuze.

Sensitive IR bolometer developed for military

The most sensitive infrared broad-band detector reported to date, having nanosecond response and operating at room temperature, has been developed by researchers in the electro-optical Laboratory at the University of Illinois, at Urbana.

The new detector—a thin-film bismuth bolometer—developed for the U.S. Army Research Office for laser diagnostics and testing, is rugged. Peak laser power required to burn out this detector using 0.5 μs pulses, is exceptionally high, between 10^5 and 10^6 W/cm^2. Life time of the device according to Dr. O. L. Gaddy principal researcher, is apparently unlimited.

Key to the performance of the new bolometer is the use of bismuth for the electrical contacts instead of deposited silver, says Gaddy.

He reports a responsitivity of 2.20×10^{-2} V/W and a sensitivity, in terms of noise equivalent power (NEP), of 5×10^{-8} W/Hz$^{1/2}$. This, Gaddy points out, is a 45-fold improvement in sensitivity over the best previous bismuth bolometer using silver contacts.

Gaddy notes that, by contrast, the best room-temperature nanosecond pyroelectric detectors today have responsitivity of about 10^{-4} W/V while the responsitivity of photon drag detectors is on the order of 10^{-5} and 10^{-6} V/W.

Motorola offers prizes for innovative designs

An electronic project design contest, offering prizes totaling $9000, has just been announced by Motorola, Inc., Phoenix, Arizona.

According to Arthur F. Baldensperger, sales manager for Motorola's HEP semiconductors, the contest—called a Design-In—is divided into two separate categories: one for engineers and one for hobbyists, so that the hobbyist would not be competing against a professional engineer. The grand prize in each category is $2500. The first prize is $1000; second prize is $500; and the two third prizes are $250 each.

Baldensperger says that the contest runs from July 1 through December 31, 1973. Judging will be based on originality of the design, simplicity, usefulness of the project and convenience and ease of construction.

Motorola will provide semifinalists with all the parts required to construct their projects.

Official entry blanks and contest rules for the "Design-In" can be requested from Motorola by writing to HEP semiconductors "Design-In," P.O. Box 2953, Phoenix, Ariz. 85036.

New spacecraft system to cut fuel use in half

NASA plans to develop a navigation system for unmanned planetory probes that will determine the craft's en route position so precisely that it will avoid having to make a big, fuel-consuming course correction near the end of its trajectory. On a long trip to the outer planets, a late-course correction could burn up as much course-correction fuel as was used on the entire flight up to that point. Now such a probe would only need to carry half as much course-correction fuel, explains Peter Kurzhals, program manager for the Guidance and Control and Navigation Branch of NASA's Office of Aeronautics and Space Technology, Washington, D.C.

Called Approach Guidance, the system takes up to 10 television photographs of the planet the craft is approaching or of one of the planet's moons against its background of stars. The relative positions of the planet or its moons and the known navigational stars beyond it reveal the position of the craft.

An experimental version of the Approach Guidance system was first flown in 1971 on the Mariner 9 mission to Mars. This system telemetered its television pictures back to earth, where a computer worked out the celestial equations and determined the craft's position —an operation that took about four hours.

The new system is expected to do the job in six minutes, and to pinpoint the craft with an accuracy of only one kilometer. The tremendous timesaving will be made by not having to transmit all that data and by improved software.

Search for X-ray laser is expanding

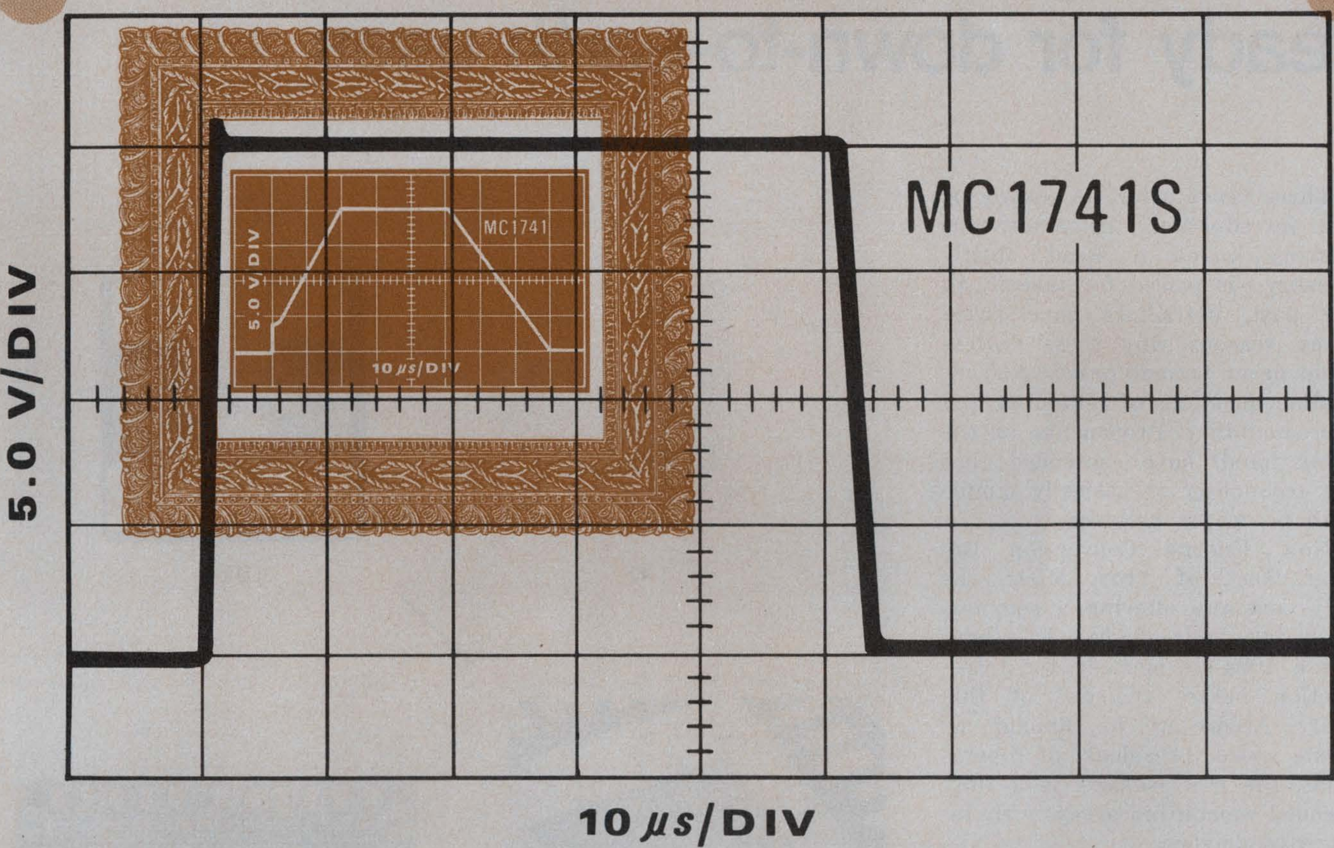
The search for an x-ray laser, the elusive hope of researchers for over a decade, is being joined by a team of scientists from the University of Rochester in New York.

According to Asst. Prof. James M. Forsyth, of the college's Institute of Optics, previous studies have indicated that x-rays can be produced by bombarding tiny pellets containing trace amounts of oxygen with 10 ps pulses from a neodymium glass laser.

"Although we know that oxygen gives off x-rays," Forsyth continues, "we don't know if the x-rays generated in this manner are coherent." The situation is complicated even further, he goes on, by the fact that it is difficult to demonstrate coherence with x-ray sources.

Despite the difficulties, Forsyth believes that his group of researchers can eventually demonstrate the production of coherent x-rays. "We know we can do it on paper," he says.

A Nostalgic Op Amp That's Quite Up With The Times



You wanted more speed than your classic 1741 could deliver. But without all the unneeded frills of the super op amps. Yesterday, the choice wasn't yours.

That was yesterday.

Our MC1741S can make those troubles seem so far away. It's an op amp that's up with the times. The times you need in digital-to-analog converters, or in any large-signal amplifier where distortion plays the bad guy. Times like a 10 V/µs specified minimum slew rate.

Which is 20 times that of the industry standard 1741.

Power bandwidth is likewise boosted for a wide range of distortion free performance. All the way up to 200 KHz (typ). Far outstripping the ordinary 1741's 10 KHz span.

Typical settling time will bring you into a new era, too. 3 µs to settle within 0.1% — made to order for D-to-A converters.

Other than being a speedy little devil, you'll find the new "S" version reminiscent of its heritage. Similar gain, short circuit protection and internal frequency compensation. Everything you've known and loved about the regular 1741. After all, good op amps never go out of style.

The charge?

A mere $1.25 will do it in plastic. (100-up, that is.)

Or, choose the metal can for slightly more. Commercial or military temperature ranges available, of course.

Post us direct at P.O. Box 20912, Phoenix, Arizona, 85036, or circle the reader service number so we can bring you up to date.

The MC1741S high-speed op amp from Motorola.

It looks as though it's here to stay.

MOTOROLA LINEAR

Practical Innovations for Systems Design.

INFORMATION RETRIEVAL NUMBER 17

news

'Blue sky' amorphous memory ready for down-to-earth uses

Three years after its controversial introduction, the amorphous memory—called a Read Mostly Memory—is poised for takeoff. In the past, detractors have posed many reasons why these devices could never become practicable, including questions of reliability and reproducibility. Proponents, on the other hand, have contended that the technology is basically simple with no major problems.

Now Energy Conversion Devices, Inc., of Troy, Mich.—the only company offering a commercially available device—is readying a 1024-bit memory for introduction before the end of this year. According to Ronald G. Neale, vice president of operations, the new memory is a fully decoded monolithic array with integrated drivers.

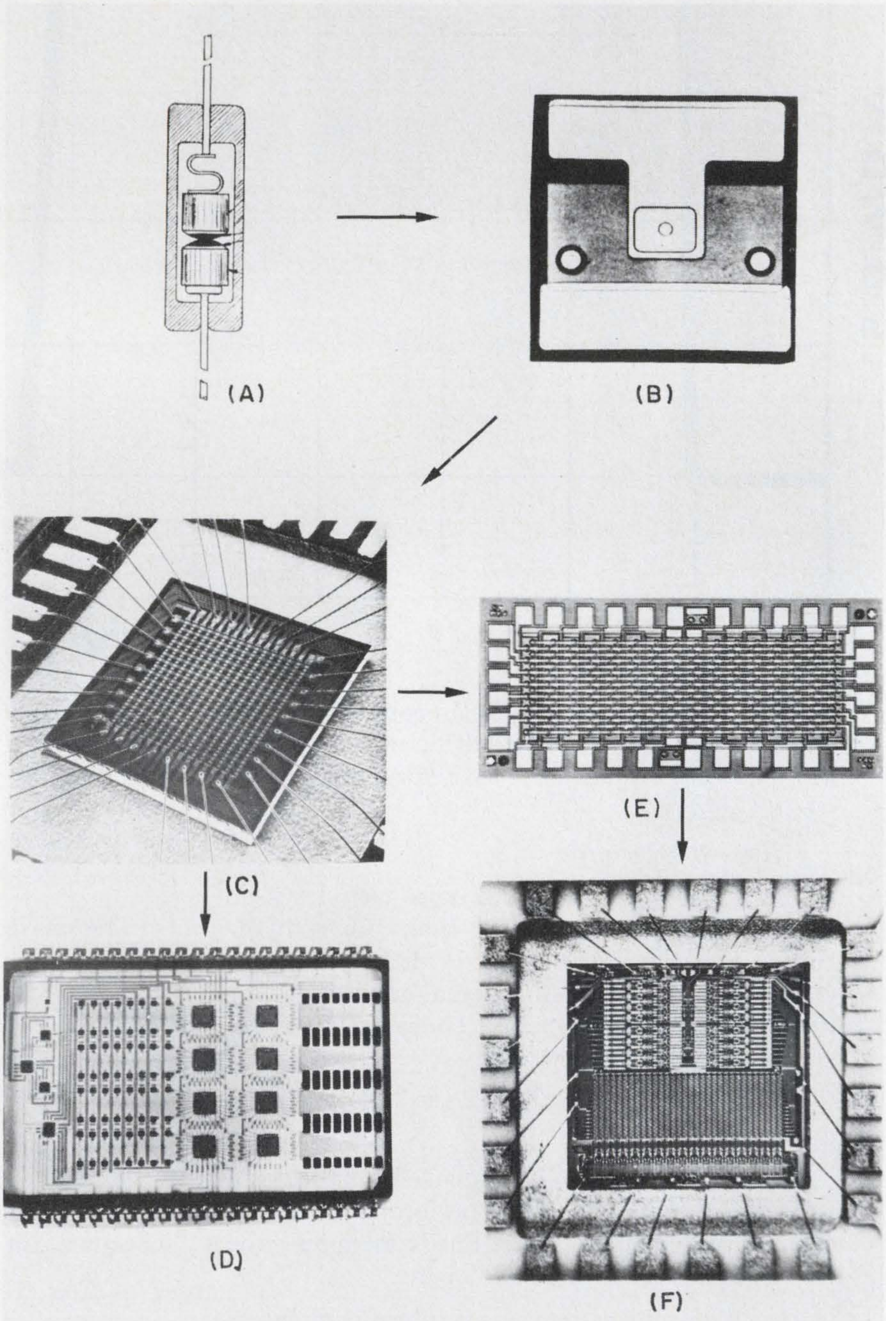
The chip, notes Neale, was originally developed to meet the requirements of a major commercial customer. Among the requirements was one that would allow the chip to be organized into one of three possible configurations: 256 by 4 or 512 by 2 or 1024 by 1. This is determined by which of the five enabled lines are activated.

Auto applications studied

Applications for the Read Mostly Memory, he continues, include those presently served by plated wire, ROMs and pROMs. New areas of application are also opening up. The much talked about automotive electronics market is one where amorphous devices could find wide application.

Two large automotive companies, both of which prefer to remain

Jules H. Gilder
Associate Editor



The first amorphous device (a) made the scene in 1968. Further work led to the development of a thin-film structure (b), which resulted in a 256-bit integrated array (c). This array was used to fabricate a 2048-bit hybrid memory (d). The size of the 256-bit array was reduced (e) by stacking the amorphous device on top of the silicon diode. This stacking led to development of the 1-k amorphous memory (f).

Remember

1953 . . . It was high noon for the bad guys when this famous movie ran. 1953 . . . President Eisenhower had just arranged a truce in Korea. 1953 . . . An American firm successfully demonstrated the first full color video tape recording. And engineering and purchasing were having a hard time getting electronic parts and components. Distributors were taking care of their best customers, and delivery of large piece quantities of discretes was out of sight.

1973 . . . We remember. We're U. S. Capacitor Corporation (a subsidiary of Globe-Union) and we know history repeats itself. During the intervening years, capacitor technology advanced exponentially, but the component market place still fluctuates with the economy.

Another bit of history . . . after each shortage and pipeline filling, the market place has restored to a higher level of consumption . . . 1953, 1973.

U. S. Capacitor Corporation is preparing to meet the current delivery crunch. We've made a substantial commitment to new, automated production machinery so that our customer's needs will be satisfied, and we're also expanding our facilities.

We know the history of our industry and we're investing in it.

We make excellent high-rel and commercial monolithic ceramic capacitors and EMI/RFI filters.

Remember. U. S. Capacitor Corporation.

USCC **USCC/Centralab**
Electronics Division ▪ Globe-Union, Inc.
2151 North Lincoln Street ▪ Burbank, California 91504

anonymous, are investigating the technology. One has developed an all-solid-state crash recorder, using 1024 bits of amorphous memory, and has placed it in some New York City taxicabs to evaluate new "soft" bumpers.

To achieve the high writing speed for the car-bumper application, the system has been designed to enter a ONE into all the memory cells and then to write the information to be stored in the form of ZEROs. This technique permits the use of a fast reset pulse and increases the writing speed of the amorphous memory.

Controversy apparently subsiding

The controversy that surrounded amorphous devices when they were introduced appears to have eased. "Anyone who has taken a serious look at the technology," notes Neale, "knows that it works well." A quick check lends support to this statement.

According to Dr. Robert Noyce, president of Intel Corp., Santa Clara, Calif., the amorphous technology is valid. "The doubts that people had a few years ago are not justified," he says. Asked about applications, he suggests that amorphous memories can be used in all applications where ROMs are now used, as well as in applications that require reprogrammability—from cash registers to military control systems.

Tom McCann, formerly with Energy Conversion Devices and now head of new-product development for Fairchild Semiconductor, Mountain View, Calif., says that amorphous technology is the most feasible nonvolatile semiconductor technology around. He dismisses MNOS technology—another contender for nonvolatile semiconductor memories—noting that its storage is not permanent and that it requires very fine manufacturing limits.

Dr. Cary V. Cezzoli, an amorphous researcher at the Picatinny Arsenal, Dover, N.J., is also a firm supporter of the new technology. He contends that 60 to 70% of the shortcomings attributed to amorphous devices have stemmed from abusive use of the devices.

David Redfield, a researcher at RCA Laboratories, Princeton, N.J., disagrees. He says that amorphous semiconductors, although a legitimate and interesting field of solid-state physics, have been oversold as a practical product.

It's a bistable resistor

Basically the amorphous memory cell is a bistable resistor with an on/off resistance ratio of between 10^3 and 10^4. The two resistance states provide the binary conditions required for a computer memory. The amorphous memory, reports Neale, can be switched between states by electrical pulses and both states can be maintained without power.

According to the Energy Conversion Devices vice president, the bistable characteristic of the memory results from an amorphous chalcogenide material that, while capable of exhibiting threshold switching, can also exhibit a reversible bistable phase change. The two states of the material are an ordered polycrystalline state and a disordered glasslike state.

When an amorphous material changes from one state to the other, Neale explains, the transition is accompanied by substantial changes in the physical properties of the material. These include electrical resistivity and optical transmissivity.

The new 1-k memory, like the current 256-bit device, contains memory cells that are composed of a conventional diode in series with an amorphous switch. The series diode eliminates any sneak paths that may occur and compensates for the negative temperature coefficient of the amorphous device's threshold voltage.

The amorphous memory has come a long way since it was first introduced three years ago, Neale points out. The write life of the original memory was specified at 600 alterations. It is now up to 100,000 write/erase cycles.

Improvements in the temperature range of operation are also taking place. New materials that can operate at 125 C and 150 C are under development, Neale reports.

High temperature materials are obtained, he explains, by changes in the composition combinations of the amorphous material.

Energy Conversion Devices' name for the amorphous memory, the Read Mostly Memory, results from the fact that it takes a long time—several milliseconds—to write information in and therefore the memory will probably be used in the read mode most of the time. But improvements are being made in the write speed, Neale points out. Experimental devices have been built with a write speed of 500 μs. This compares favorably with the 20 ms speed presently available. In addition Energy Conversion Devices has developed a fast write technique that can be implemented by use of the very fast (submicrosecond) threshold switching that precedes memory setting. The memory is thus treated as a RAM until it is required to store information in the nonvolatile mode.

The price of the 1-k memory should be in the same range—about 3 cents a bit—as that for 1-k pROMs, Neale says. The reason for this, he goes on, is that the process steps are equal in number, tolerance and complexity to those required to produce a pROM.

Other applications discussed

While many engineers play down the importance of a nonvolatile semiconductor memory, Neale points to the intensive efforts of silicon semiconductor manufacturers to bring MNOS—another nonvolatile memory technology—to market.

As for Energy Conversion Devices' memory, a major car manufacturer has just finished building a central processor for an automobile computer. The CPU contains an amorphous memory and is believed to be built around the Intel microprocessor set.

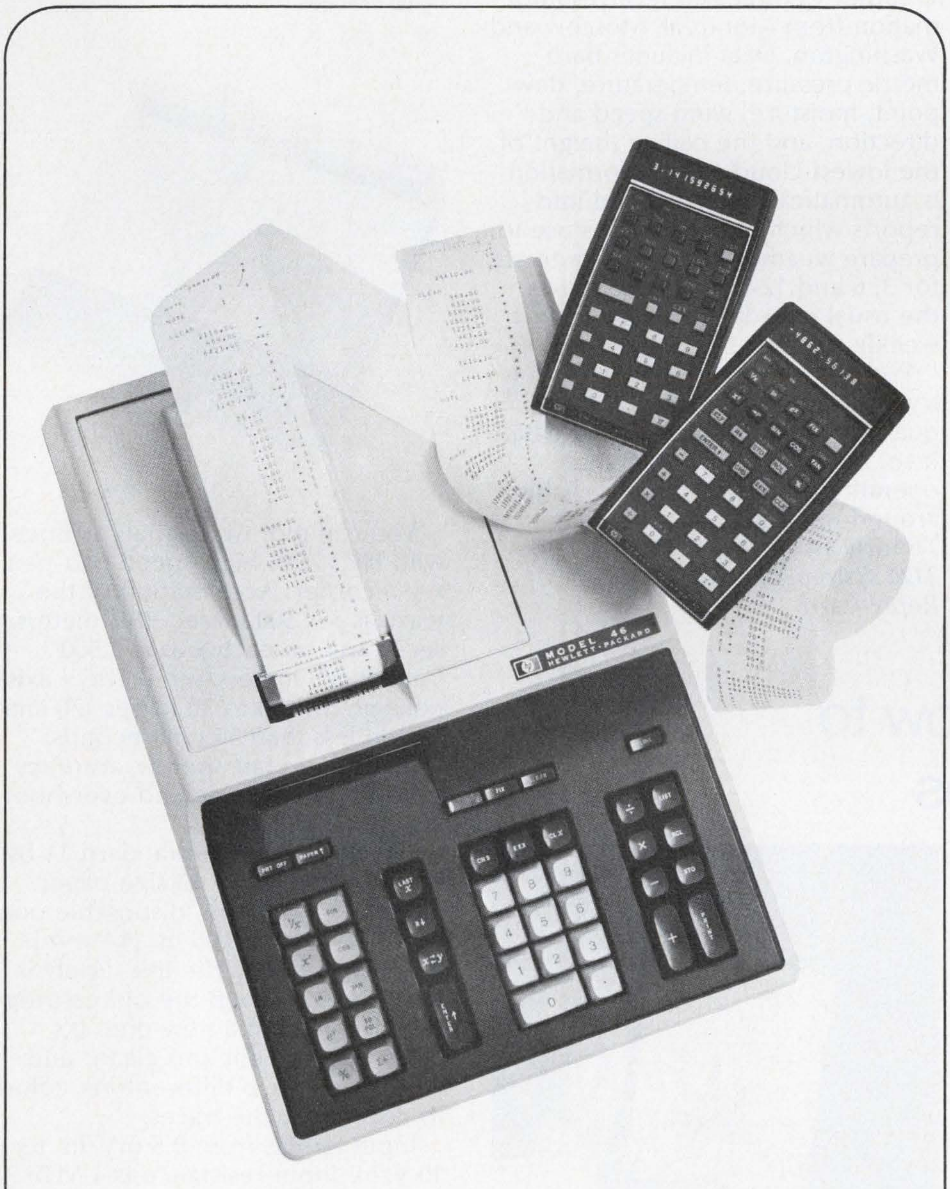
A second automotive company investigating amorphous devices has built a sequencer for a pollution control system. The sequencer regulates the emissions of a test vehicle.

Spokesmen for both auto manufacturers say that the reason amorphous technology was chosen was that they needed a small, low-cost, nonvolatile memory with noise immunity and low power. ■■

innovations from Hewlett-Packard

MEASUREMENT NEWS

AUGUST, 1973



in this issue

New answer machines for pockets or desktops

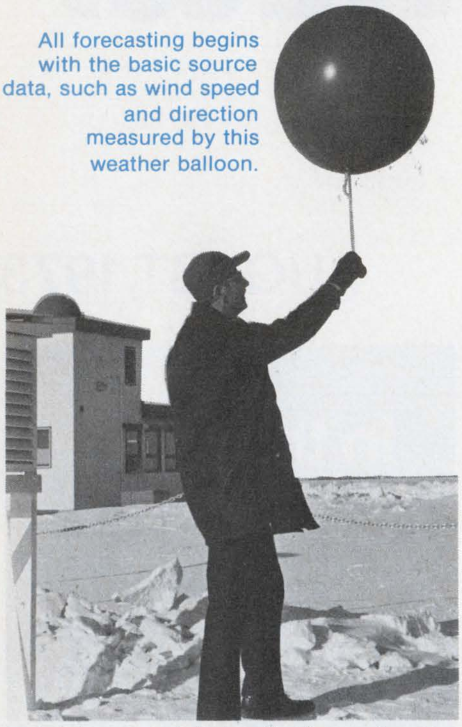
Polar-rectangular coordinate conversions, factorials, or metric conversions—now you can do them all in the palm of your hand . . . or at your desk.

Hewlett-Packard announces a new scientific calculator, available in both pocket and desktop versions—plus a price reduction for the popular HP-35. All three have solid-state memories similar to those used in computers and are designed for use in science, engineering, surveying, navigation, statistics, and mathematics.

The 9-ounce HP-45 is the first scientific pocket calculator with an addressable memory register system with *nine* storage locations, providing greater computational power, speed and flexibility. Besides the usual logarithmic and trigonometric functions, the HP-45 operates in

(Continued on page 3)

HP computer system speeds weather forecasts



All forecasting begins with the basic source data, such as wind speed and direction measured by this weather balloon.

Making rapid detailed weather forecasts requires gathering and analyzing thousands of pieces of meteorological data from hundreds of reporting stations. At Prairie Weather Central, the main forecasting station for central Canada, all this is done by an HP 2120 disc operating system in one-tenth of the time it took previously.

Approximately 250 weather stations in Canada and the northern U.S. send information hourly. Prairie Weather Central also receives information from Montreal, Moŝcow and Washington. Data includes barometric pressure, temperature, dew point, moisture, wind speed and direction, and the ceiling (height of the lowest cloud). This information is automatically summarized into reports which meteorologists use to prepare weather maps and forecasts for 3, 6 and 12-hour periods, plus the usual one-day, two-day and weekly forecasts.

Perhaps your own organization is trying to make sense out of vast quantities of rapidly-changing data. If so, consider an HP 2120 disc operating system that runs reliably around the clock.

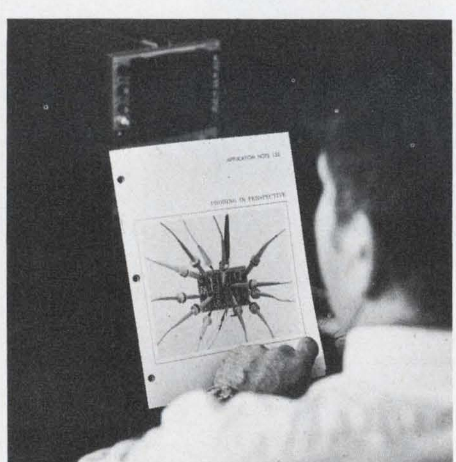
To forecast how you can use a 2120 system, check E on the HP Reply Card.

New booklet tells how to select scope probes

With the increased bandwidths in modern oscilloscopes, one probe cannot be used for all measurements. HP's new application note, "Probing in Perspective," helps you select the best probe for most common oscilloscope measurement situations. Major topics include:

- How to select the most accurate scope/probe for a particular measurement.
- How to quickly evaluate a given scope/probe in a particular situation.
- How to estimate errors caused by the probe.

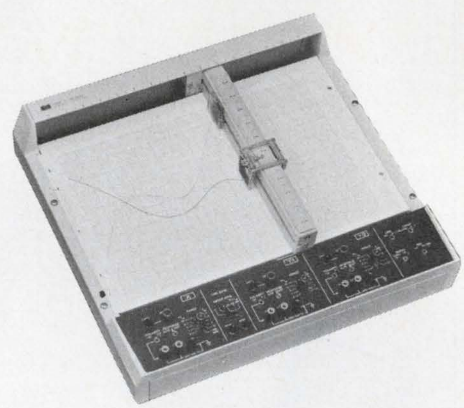
For your free copy, check U on the HP Reply Card.



This 12-page booklet helps you realize the full accuracy of your scope.

Two-pen recorder offers speed, convenience

High acceleration means quick response to small input changes; high slewing speed enables the 7046 to respond to large, fast signal changes.



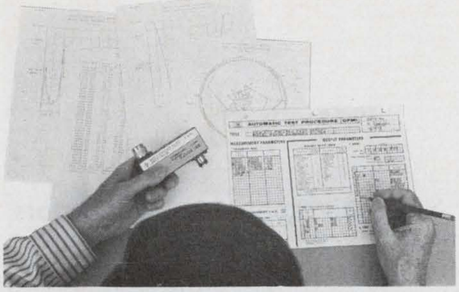
You can plot two signals at once with HP's 7046 high-speed two-pen x-y recorder. Acceleration of the y axis is > 2,500 in/sec^2 (6.3 meters/sec^2); and on each x axis, 1,500 in/sec^2 (3.9 meters/sec^2). The y axis pens go from 0 to 30 in/sec (76 cm/sec) in less than 15 milliseconds. Even at these fast speeds, accuracy is ±0.2% of full scale and overshoot is < 1% of full scale.

The recorder uses standard 11 by 17 in. or European A3 size paper. HP's flat, visible-ink, disposable pens trace as close as 0.05 in. (1.2 mm). When you notice the ink supply is low, merely detach the old cartridge pen and snap in a new one. It's quick, convenient and clean; and you can use two different ink colors to distinguish the traces.

Input ranges from 0.5 mV/in. to 10 V/in. Input resistance is 1 MΩ on all ranges. And metric calibration is available at no extra cost.

OEM discounts are available. For more information, check N on the HP Reply Card.

Let HP show you how easy microwave testing can be



Here are a few of the output charts from testing a bandpass filter.

HP has developed a new software concept for making microwave measurements with automatic network analyzers. The results are increased system utilization, reduced measurement time, no programming, and increased system availability—hence, lower operating costs.

The easy-to-use "automatic test procedure" form becomes the system front panel. In less than an hour, you can learn how to make tests and specify the output required for most microwave devices. Select up to 10 measurements at as many as 101 frequencies. You obtain 28 different output parameters and have a choice of printing, plotting or storing them on cassettes. Data can then be compared to specifications. It takes no more than 10 minutes to fill in the ATP form, even for complex devices.

The best way to learn more is to have your HP systems field engineer show you how easy it is to fill in the automatic test procedure for one of your devices. He can send the ATP and the device to one of our demo centers where we will test it to the ATP and quickly return it to you with the specified data.

Check R on the HP Reply Card for more information or to have your field engineer contact you.

(Continued from page 1)

degrees, radians or grads. Three metric/U.S. conversions are built-in, thereby serving the conventions of all nations and all disciplines—cm/in., kg/lb., and liter/gal.

The tiny HP-45 with 12-digit LED display contains many functions rarely found even on large machines: n factorial, percentage and % difference, mean and standard deviation, x^2 and 10 , and polar-rectangular coordinate conversions. It's easily the most powerful scientific calculator of this size or price.

The new HP-45 scientific pocket calculator

If you prefer a desktop calculator, the new HP-46 performs the same functions with an added plus: you can have a digital display, alphanumeric printer, or both. The printer provides a red and black listing of your calcualtions (just like an adding machine) at a speed of 2.5 lines/sec.

What about the handheld wonder that started it all? Over 75,000 HP-35 pocket calculators are currently used throughout the world. This economy of scale means it now costs less to perform logarithms, exponential and trigonometric functions in the palm of your hand.

Let us know which calculator appeals to you; check A or B on the HP Reply Card for more information.

New data analysis system uses calculator

Now, you can have automatic data acquisition, reduction and analysis at a fraction of the computerized system price. HP's new 3050A automatic data acquisition system scans up to 100 channels; measures dc, ac and ohms at up to 5 readings/sec; then calculates the results on-line or off-line.

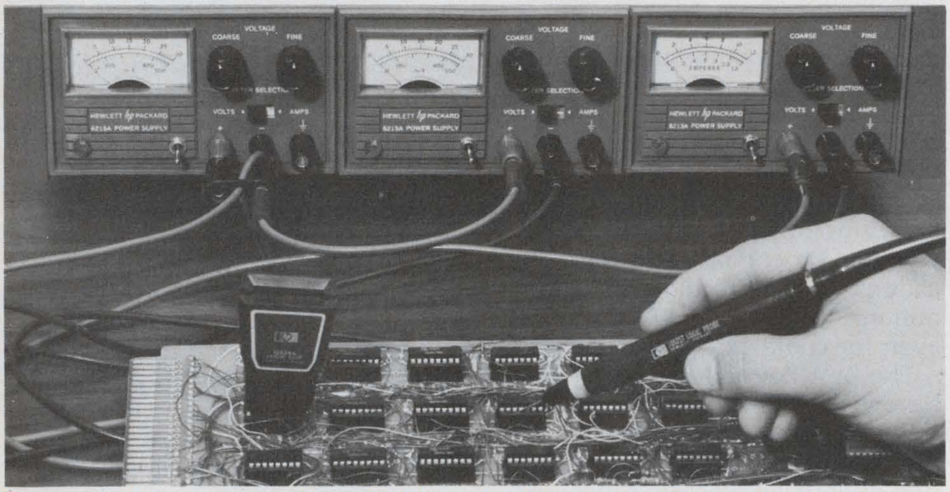
Basically the system is a scanner, multimeter, and a calculator. The HP 9820A programmable calculator handles data logging while simultaneously performing algebraic calculations such as transducer linearization or statistical analysis. With a scanner coupled to a digital multimeter, the 3050A system measures:

- dc in 5 ranges from 100 mV to 200 V with 1 μ V resolution.
- ac in 4 ranges from 1 V to 200 V with 10 μ V resolution over the frequency range, 20 Hz to 250 Hz.
- resistance from 100 Ω to 10 M Ω with 1 milliohm resolution.

The system is ideal for measuring multipoint physical parameters and testing printed circuit boards. You can run 100% device testing at significantly less cost.

Learn more about reducing data reduction costs. Check F on the HP Reply Card.

Low-cost power supplies for testing ICs



These supplies are packaged in molded impact-resistance cases that can be stacked vertically or rack-mounted in groups of three, as shown here.

At home in the lab, at school, or in the repair shop, these handy dc supplies are ideal for powering digital and linear IC circuits. Models 6213A (0 to 10V at 1A) and 6215A (0 to 25V at 0.4A) feature built-in short circuit protection, separate coarse and fine voltage controls, and switchable panel meter. Regulation is 4 mV (load or line), and ripple and noise is 200 μ V rms/1 mV peak-to-peak.

Eight models in this series of 10W bench supplies cover output ratings of 0 to 10V, 0 to 25V, 0 to 50V, and 0 to 100V.

For more information, check M on the HP Reply Card.

A new signal generator for avionics testing

HP's 8640B AM/FM signal generator (450 kHz to 550 MHz) is ideal for stringent testing of narrow-channel, crystal-controlled receivers because it delivers spectrally pure, accurate signals with crystal stability. To meet both the general and specialized needs of the aviation industry, the new 8640B opt. 004 NAV/COM signal generator has been developed for testing ILS and VOR equipment as well as the regular aircraft communications receivers.

Output stability of the 8640B is better than 5×10^{-8}/hr. Answers appear on a 6-digit LED display.

Specific additional features of the avionics version include: demodulated output for precise AM settings; one-dB stepped output attenuation for the best possible demodulated output linearity; and an amplitude-modulated system optimized to provide the flat response, low phase shift and constant group delay required for accurate VOR and ILS testing. The 8640B can also simulate 75-MHz marker beacon signals.

For more information, check Q on the HP Reply Card.

New current source tests semiconductors fast

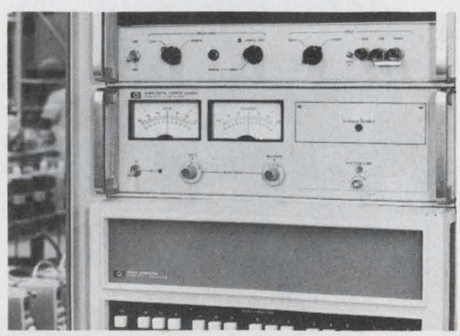
Now, you can test semiconductors and other current-controlled devices faster with HP's new 6140A digital current source. Here's how:

Many automatic test systems for current-sensitive devices use a programmable voltage source in series with a large resistor to approximate a current source. For the required accuracy, you must program a voltage, monitor the output current with a DVM, send an error signal back to the computer, then repeat the procedure until the current is within acceptable limits. Each iteration takes tens of milliseconds, and the entire procedure must be repeated every few seconds as thermal disturbances change the value of the series resistance.

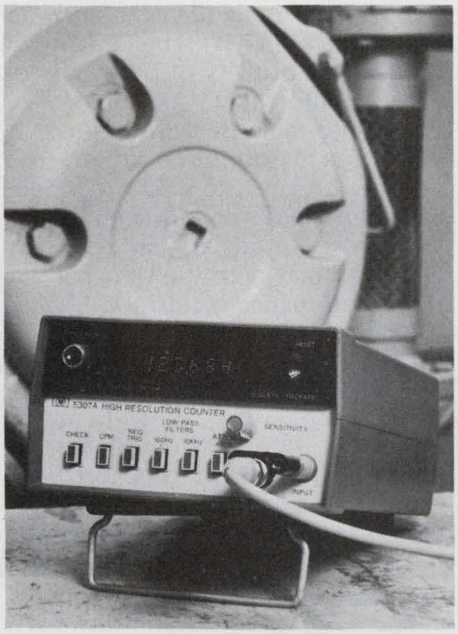
The 6140A replaces this awkward, expensive "program, measure, adjust" procedure by providing a programmable dc current with 1 μ A accuracy from –16 to +16 mA and 10 μ A accuracy from –160 to +160 mA at load voltages up to 100V. You don't need a DVM to monitor the output current of the source, and all current level changes are 99.9% complete within 300 μ s.

For current details, check L on the HP Reply Card.

The 6140A has an active guard circuit to minimize leakage and a programmable voltage limit to protect the unit under test.



Fast new low-frequency "snap-on" counter



No need to set gate times or make adjustments—the new 5307A counter rapidly measures low frequency events.

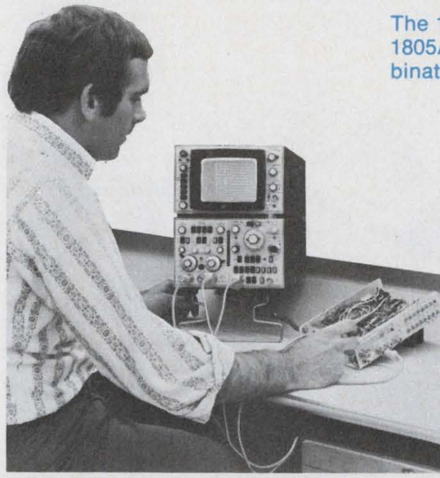
The latest module for HP's "snap-together" counters measures low frequency from 5 Hz to 2 MHz with high speed and resolution. A "counts-per-minute" mode reads rpm from 50 to 1 x 10^7. The new 5307A unit resolves rpm to 0.001 or frequency to 0.0001 Hz in less than a second—that's 10,000 times faster than a conventional counter. Sensitivity is 10 mV (high enough for low-level transducers).

Use the 5307A to calibrate audio frequency and other LF signals, to check mobile radio equipment or Touch-Tone telephones, and to measure line frequency and relay trip settings in the utilities area. The 5307A can operate unattended over its entire specified range with automatic range selection.

Besides this new module, the 5300 series includes 10-MHz, 50-MHz and 525-MHz counters and counter/timers, and a 5-digit multimeter. All are compatible with a 6-digit display, a battery pack and a d/a converter that will give high-resolution plots on an analog recorder.

For more information, check J on the HP Reply Card.

Plug-ins expand measurement capability of HP 180 scopes



The 184A fast-writing storage scope with 1805A and 1825A plug-ins is the ideal combination for capturing elusive transients.

Compact, plug-in instruments add versatility to HP's 180 oscilloscope line. Measurement capabilities include real time to 100 MHz, sampling to 18 GHz, time domain reflectometry, spectrum analysis and swept frequency testing.

For conventional use, select the economical, bright 180C/D or large-screen 182C scope. If you are plagued by dim traces, try storage—either the medium-speed 181A/AR or the high-speed 184A/B that writes up to 400 cm/μ s.

The 184A is ideal for low rep rate signals and transients yet has variable persistence to eliminate flicker. Add an 1805A vertical amplifier and you get a 100 MHz bandwidth, independent trigger selection, 5 mV deflection factor, and cascading to 50 MHz for 250 μ V/div deflection factor. The vertical amplifier also adds ± 200 divisions of offset on each channel.

Insert the 1825A time base and delay generator, and you have 5 ns/div sweep speeds, highly stable triggering to 150 MHz, ¾% differential delay accuracy, and trigger holdoff for maintaining calibration on complex waveforms.

Check C on the HP Reply Card for more information.

Universal bridge bridges the gap between accuracy and economy

Need to test components more accurately? HP's new universal bridge measures resistance, capacitance and inductance to an accuracy of 0.2%, as well as dissipation and quality factors to 5% accuracy. The measuring frequency is 1 kHz; other frequencies (50 Hz to 10 kHz) can be obtained with an external oscillator. Results appear on a four-digit display.

The 4265A universal bridge provides an accurate means of testing component specs.

An ideal aid for circuit designers, component manufacturers, radio/tv service, and educational institutions, the 4265A universal bridge checks:

- inductance—from 0.1 μ H to 1111H
- capacitance—from 0.1 pF to 1111F
- resistance—from 0.1 mΩ to 1.111MΩ
- dissipation factor (for parallel L or series C)—from 1 to 10.

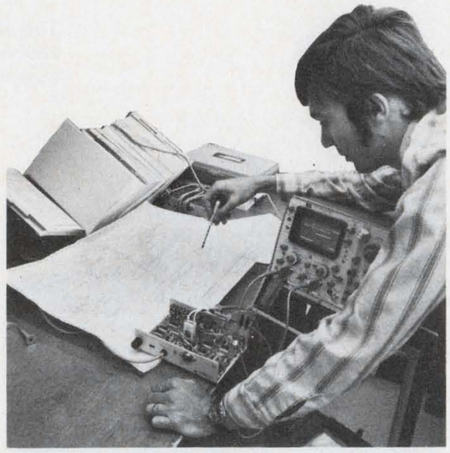
To learn more, check G on the HP Reply Card.

Get laboratory quality in a portable scope

Model 1710A is a portable 150-MHz oscilloscope that's well-suited for bench applications as well as field work. Quality is evident throughout the scope; for example, gold-plated printed circuit boards provide long life and better conductivity. Careful design of the vertical amplifier results in excellent pulse response, free from excessive perturbations.

Two features—bright scan mode and selectable input impedance—are particularly useful for servicing high-speed computer or communications equipment. The bright scan mode increases writing speed over a calibrated reduced scan display. You can use it to measure fast rise-time, low duty-cycle pulses where you need sharp resolution and an extra bright display.

Selectable input impedance provides a high Z input of 1 MΩ/12 pF or, at the flip of a switch, 50 Ω input. This convenient internal 50 Ω termination is compensated to match the scope's input capacitance, thereby eliminating reflections that might cause measurement error.



The 1710A scope is fast enough to test ECL, as shown here.

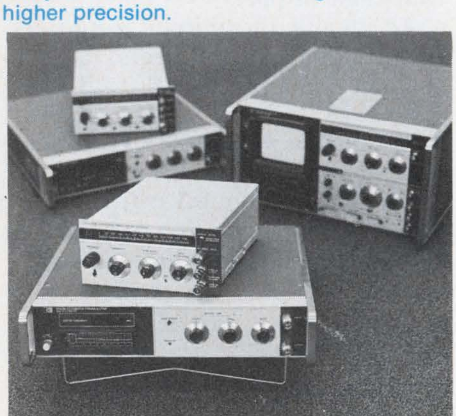
To learn more, check D on the HP Reply Card.

More capability in microwave spectrum analyzers

New versions of two HP spectrum analyzers offer noteworthy performance improvements. Model 8554B (1250 MHz tuning section) now has:

- Narrow 100 Hz resolution (vs. 300 Hz previously) that facilitates modulation analysis in VHF/UHF communications.
- 50 dB of RF input attenuation (vs. 20 dB) for greater measurement range.
- Lower frequency limit of 100 kHz (vs. 500 kHz) yet the spectrum analyzer is still protected against overload.

New HP spectrum analyzer products let you analyze UHF and microwave signals with higher precision.



Model 8445B, automatic preselector (1.8 to 18 GHz) for the HP 8555A, 18 GHz tuning section has these new advantages:

- 20 dB more rejection of unwanted signals (out-of-band, image, spurious and multiple responses).
- 2 dB less insertion loss.
- Flatter frequency response, typically 1 dB (vs. 3 dB previously).

These combine to improve overall measurement accuracy. The 8445B also has an optional LED display of frequency.

These two new units, along with the rest of the HP spectrum analyzer family, can perform virtually every frequency-domain measurement you might need, from 20 Hz to 40 GHz.

For more information, check P on the HP Reply Card.

New ultra-sensitive microwave counter

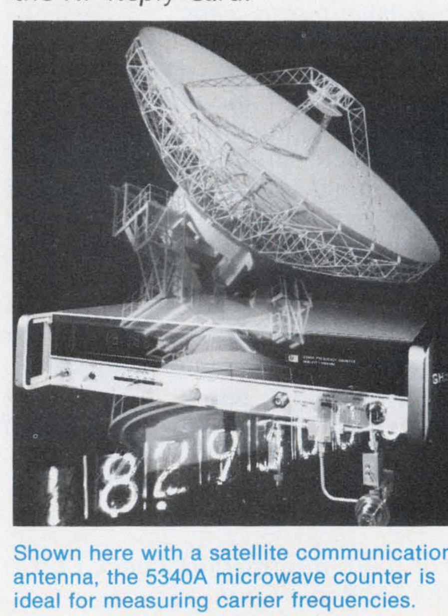
HP's 5340A microwave counter is the first to count signals as small as −30 dBm (10 Hz to 500 MHz), −35 dBm (500 MHz to 10 GHz), and −25 dBm (10 to 18 GHz). That's many times the sensitivity of other microwave counters, yet it's rugged enough to take +30 dBm inputs.

The 5340A counter is easy to use: apply your signal to a 50 Ω connector, then measurement is entirely automatic. Results appear on an 8-digit display with the decimal point automatically positioned and the unit notation specified as kHz, MHz, or GHz. You can select resolution from 1 Hz to 1 MHz. The dynamic range is 42 dB wide (−35 dBm to +7 dBm) and VSWR, low (< 2:1 from dc to 10 GHz and < 3:1 from 10 to 18 GHz). If you need higher input impedance, a second input, 10 Hz to 250 MHz with 1 MΩ impedance, can be used.

The 5340A is well suited to nearly every microwave application: measuring carrier frequency, receiver alignment, calibrating frequency-measuring devices and signal generators, ECM carrier identification, automatic testing of VCOs, tracking sweep generators, or to aid microwave communications systems. System interface is easy with the new ASCII bus programming and digital output.

Delivery has improved considerably.

For more information, check K on the HP Reply Card.



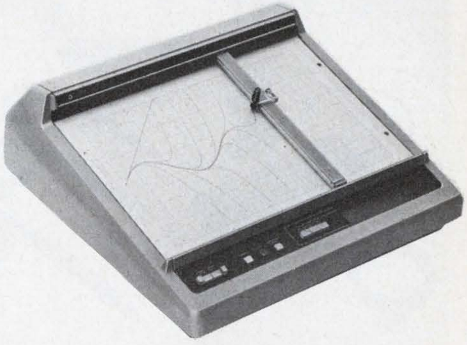
Shown here with a satellite communications antenna, the 5340A microwave counter is ideal for measuring carrier frequencies.

Plot graphics directly from your time-share terminal

With HP's digital graphic plotter, your time-share system can draw graphs from numbers or algebraic equations. Using data directly from the terminal, the 7200A plotter charts, scales and fits curves—leaving you free to program another problem. The source language can be any EIA type: ALGOL, BASIC, COBOL, FORTRAN, etc. Graph size is adjustable up to 11 by 17 in. (28 by 43 cm).

Engineers, scientists, businessmen, and educators will find the 7200A an impressive time-saver. Instead of struggling with massive printouts or formulating dull tables of figures, simply pick up a completed graph and insert it in your report. Your graph can be points, curves, circles, straight lines, bars, ellipses, or pie-shaped—whatever format you want. It saves the reader's time, too; a graphic solution is easier to understand, easier to interpret.

Utility routines are available. For details, check O on the HP Reply Card.



The 7200A draws graphs from standard EIA ASCII inputs without special software.

HEWLETT-PACKARD COMPONENT NEWS

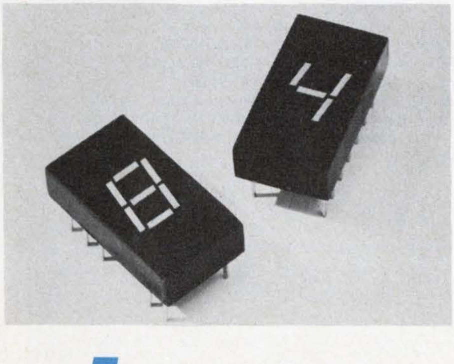
New low-cost LED display for commercial use

HP's new low-cost solid-state display is really something to see. A new optical magnification technique converts 8 discrete LED chips into 7 uniformly-intense bars plus a decimal point. Wide viewing angle and bright red numerals offer excellent readability. Designed for commercial applications, the 5082-7730 series offers a large 0.3 in. (0.8 cm) character with right or left-hand decimal points.

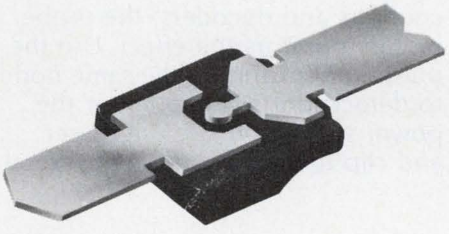
These displays are available for immediate delivery from HP and our franchised distributors.

Take a closer look; check H on the HP Reply Card.

The 5082-7730 and 5082-7731 displays come in a standard DIP package for easy socket and PC board mounting.



New beam lead diodes for mixer and detectors



HP's high-performance beam lead Schottky diode for hybrid circuits.

Two new beam lead Schottky diodes have been designed for mixer/detector applications. Use the 5082-2768 diode for X-band, and the 5082-2769 device for Ku-band. Both series have uniform RF characteristics and low noise. Maximum noise figure for the 5082-2768 at 9.375 GHz is 6.5 dB; for the 5082-2769 at 16 GHz, 7.5 dB. Either device can be mounted in a stripline or microstrip circuit by welding, thermocompression, or ultrasonic bonding.

For specifications, check I on the HP Reply Card.

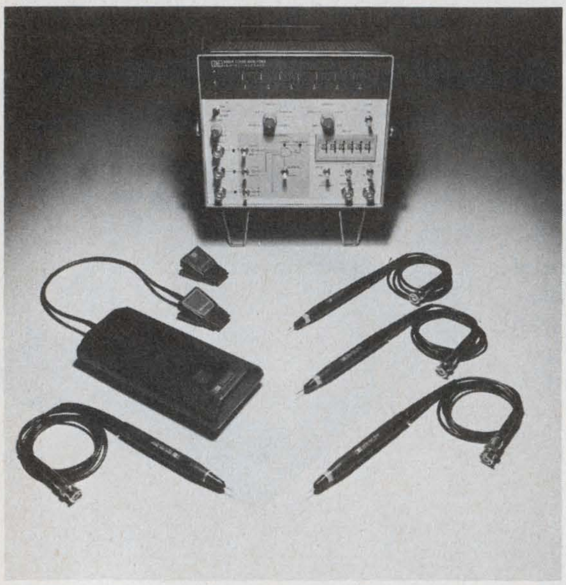
Send for our new RF components catalog

Hewlett-Packard's wide variety of high-frequency components for control and conversion of RF and microwave signals are now described in our new microwave components catalog. Types of devices featured are:

- Switches and switching modules
- Absorptive modulators
- Limiters
- Mixers/detectors
- Step-recover diode modules
- Coaxial switches
- Step attenuators

For your free catalog, check T on the HP Reply Card.

Equipment and systems designers will be interested in this new high-frequency components catalog.



Digital solutions to digital problems- HP has the tools to match your needs

From handheld probes to a sophisticated logic analyzer, HP's logic test family handles most troubleshooting problems.

Whether you're looking for a single bad IC or debugging the lab prototype of a new digital system, HP offers a complete line of instruments for your logic troubleshooting needs. These easy-to-use test tools detect malfunctions quickly, efficiently and *in circuit.*

To detect a single-shot or intermittent error on one of several circuit nodes, start with the 10529A logic comparator. It automatically compares the suspect IC with a good reference IC, then indicates which pins are faulty. Once a failure has been located, use the logic probe to examine pulse activity. Merely touch the node with the probe tip, and read the band of light. A bright light indicates a logic high; no light, a logic low; blinking light, a pulse train; and a dim light, open circuits of voltages between the high and low thresholds.

There are three probes—one for each major logic family. Model 10525T checks TTL/DTL circuits; the 10525H checks HTL, HiNil, MOS, relay and discrete-component circuits; and the 10525E is fast enough to test ECL.

For stimulus-response testing, team the 10526T logic pulser with a probe or the 10528A logic clip. The pulser injects reset, shift and clock signals directly into flip-flops, counters and decoders; the probe or clip monitors the effect. Use the pulser and probe on the same node to detect shorts to ground or the power supply. Or use the pulser and clip to view response at several outputs—e.g., when testing sequential circuits.

To see bit streams digitally displayed, step up to the new 5000A logic analyzer that shows logic states vs. time. It analyzes long digital sequences and captures single-shot data streams. Unique delay and storage features let you view bit patterns both *before* and *after* the trigger event.

Techniques for using these instruments are described in a new booklet, *Digital Logic Troubleshooting.* These cost-effective tools are the logical choice for your production and field service testing.

For a free copy, check S on the HP Reply Card.

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Designers' touch needed to exploit acoustic surface waves to the hilt

Out of the laboratory and into the world of applications, after a few years of slow development, a new technology—acoustic surface-wave—is emerging. Offering high degrees of miniaturization, compatibility with integrated-circuit processing, simplicity and ease of design, it may slow the trend from analog signal processing to digital.

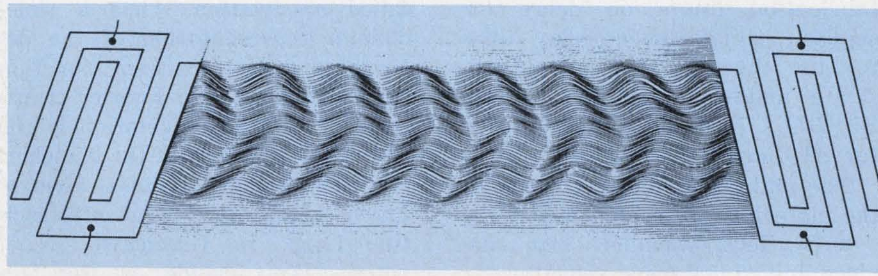
Using the basic principle of conversion of an electromagnetic wave into an acoustic wave and back again, such basic devices as delay lines, filters and correlators become very simple to build. Since an acoustic wave on such common piezoelectric substrates as lithium niobate or ST-quartz travels at about 1/100,000ths of the velocity of an electromagnetic wave in free space, transfer of a signal into an acoustic wave for a short distance creates a considerable time delay. If that time delay is made frequency-sensitive, the delay line becomes a filter. If the delay line is tapped, it can become a correlator.

"We have known that these devices could be made for a long time," says Dick Yaeger, manager of the Solid State Dept. at Teledyne MEC in Palo Alto, Calif. "But now we can crank some numbers into a computer program and come out with a design for a device that will come very close to the desired transfer function on the first try."

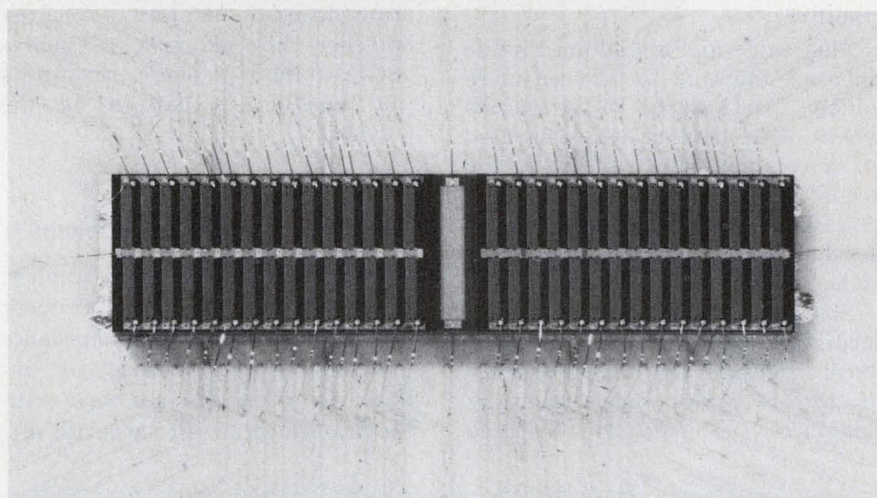
This view sums up the feelings of most researchers in the field who were interviewed by ELECTRONIC DESIGN. All that is needed now is a plethora of clever design techniques to allow the technology to develop.

Already acoustic surface-wave devices are being used in or proposed for electronic warfare, including pulse-compression networks; matched filters and coding equipment for secure communications; air traffic control; TV i-f filters; satellite communications and many other applications.

David N. Kaye
Senior Western Editor



Basic interdigital electrode patterns for excitation and detection of surface acoustic waves on a piezoelectric substrate. The surface-wave pattern shown was derived from voltage-probe measurements at the Lincoln Laboratory.



15-bit quadraphase progammable correlator from Motorola is integrated on a wafer of silicon. MOS transistors detect the outputs at the taps. A zinc oxide film is used for the delay line.

They're all delay lines

No matter what the acoustic surface-wave device is used for in a circuit, inherently it is a delay line. In its simplest form, it consists of a pair of interdigital transducers deposited on a piezoelectric substrate. When an electronic signal is introduced on one of the transducers, a bidirectional acoustic surface wave is created. The portion of the wave that is launched in the direction of the second transducer travels a finite distance and then is reconverted to an electronic signal by the second transducer. The time that it took to traverse the finite distance as an acoustic wave is the delay of the delay line. Energy launched in the other direction, relative to the first transducer, is either lost or acquired by a third transducer, usually deposited as a mirror image of the second transducer. The outputs from the second and third transducers can be coupled to provide higher efficiency, if necessary.

The most common piezoelectric materials for acoustic surface-wave work are lithium niobate ($LiNbO_3$), ST-quartz and bismuth germanium oxide ($Bi_{12}GeO_{20}$). According to Dr. Thomas W. Bristol, head of the Acoustic Techniques Group at Hughes Aircraft Co., Fullerton, Calif., "practical fabrication limits on delay for straight, single-ended delay lines for the three most common substrate materials are 120 μs for $Bi_{12}GeO_{20}$, 75 μs for $LiNbO_3$, 80 μs for ST-quartz.

The main advantages of each of the materials are as follows:

- $Bi_{12}GeO_{20}$—smaller size devices due to low wave velocity.
- $LiNbO_3$—low insertion loss due to high coupling efficiency.
- ST-quartz—high temperature stability.

Zinc oxide and aluminum nitride films are starting to be used more widely, particularly in situations where other devices are integrated on a common substrate with the acoustic surface-wave device. Much research is currently going on to develop better piezoelectric materials.

Spacing of the fingers of the interdigital launcher (input transducer) determines the frequency of the acoustic wave. Opposing fingers on the launcher are spaced on half-wavelength centers where the wavelength corresponds to the desired center frequency. If the spacing of fingers is varied along the length of the launcher, a whole range of frequencies can be launched. Since each frequency has a different delay on the line, the launcher is said to be dispersive. The coupling or weighting of each of the frequencies represented in the launcher can be varied by adjustment of the overlap of the opposing interdigital fingers. This is called apodization. Thus a time-domain representation of the desired launcher transfer function can be created. The Fourier transform of this representation is the frequency response of the launcher.

As Dr. Richard LaRosa, Electro-Physics Laboratory head at Hazeltine Corp. in Greenlawn, N.Y., notes: "You decide on the frequency response of the launcher, take its inverse Fourier transform and impress the pattern of the time-domain response on the launcher. For example, a square-bandpass-filter response transforms into a sin x/x pattern on the launcher."

Five main transducer problems

According to Bristol at Hughes, the main problems in transducer design include electrical impedance matching into the transducer; interaction of the surface wave with the transducer itself; acoustic diffraction; bulk wave generation, and electrical isolation of the input transducer from the output transducer. Much of the current work is aimed at improving transducer design. Related work is aimed at increasing frequency limits of the transducer.

Bristol notes that the practical upper frequencies of surface-wave devices that use conventional technology are 1 GHz for a small filter, 500 MHz for about 1 to 20 μs of delay and 300 MHz for longer delay devices.

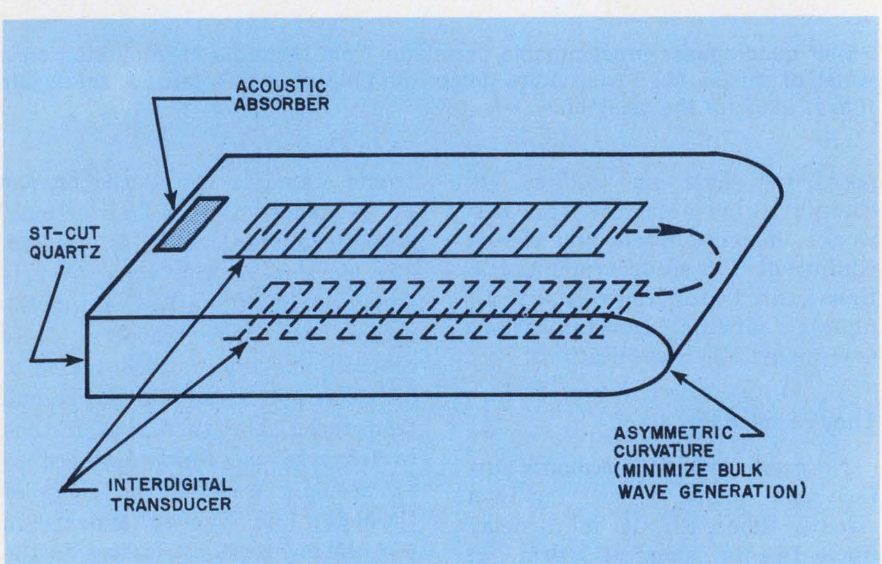
Electrical impedance matching into the transducer becomes a problem when the transducer becomes physically long. It then appears to be a transmission line with its own characteristic impedance. Care must be taken to terminate the launcher in its own characteristic impedance to effect efficient energy transfer.

Interaction of the surface wave with the transducer itself, says Bristol, takes three forms: reflections due to mass loading of the metal fingers; dispersion; and velocity slowing of the wave due to energy coupling as the wave moves along the detection transducer. Mass loading is minimized by choice of a metal for the transducer that has characteristics similar to the substrate—for example, aluminum on quartz or lithium niobate. Then the fingers are made thin to minimize their weight on the substrate. Dispersion and velocity slowing can be helped by splitting each finger of the transducer into a split pair of fingers spaced a quarter wavelength from center to center. This, Bristol says, causes reflections to cancel and also reduces bulk wave generation.

Diffraction will be a problem as long as apodized tranducers are used.

Bulk wave generation is reduced by the split-finger method and further reduced, according to LaRosa of Hazeltine, if a film of high coupling material, such as silicon dioxide or silicon monoxide, is deposited over the launcher. The taps of the delay line are then placed on top of the film for lower coupling. This film, LaRosa says, helps cut down all reflections.

Electrical isolation of the input transducer from the output transducer doesn't become a se-



Long delays can be generated with transducers on the top and bottom of the substrate. The wave goes around the curve.

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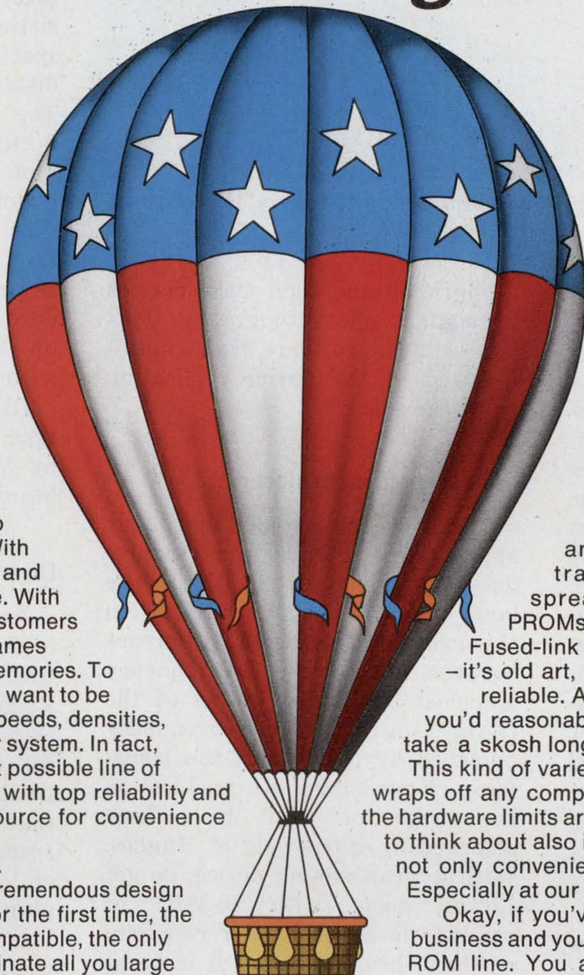

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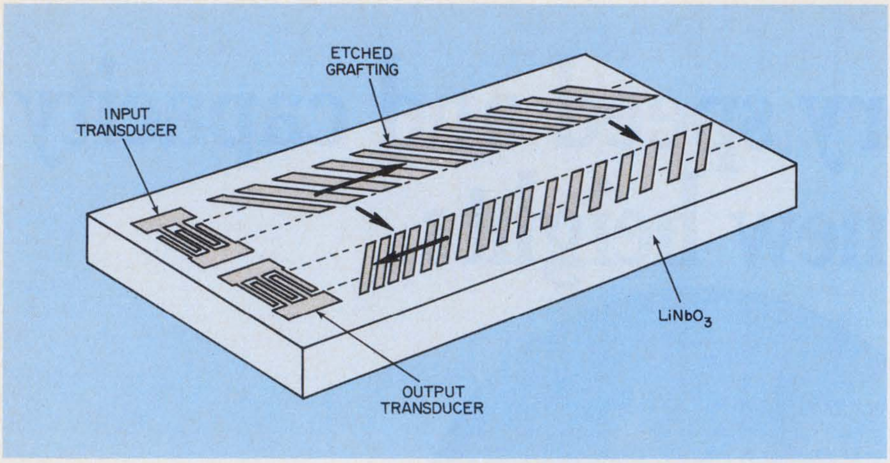


Reflective array conceived by Lincoln Laboratory bends the wave 180 degrees and provides time-bandwidth products of about 4000.

rious problem unless the transducers are physically close enough to couple to each other capacitively. When long delays are needed, a wrap-around delay line is sometimes used. In this case the substrate is a thin sheet with one edge rounded off. One transducer is placed on the top of the sheet and one on the bottom. The wave is propagated around the edge. With this technique, 120-μs delays have been achieved on quartz. To solve the isolation problem, Joseph Burnsweig, a senior scientist for Hughes Aircraft in Culver City, Calif., placed a grounded metal plate into a slot in the substrate to separate the transducers.

Higher frequencies sought

With use of conventional photolithography to produce the transducer patterns on conventional substrates, it is hard to get above 1 GHz. However, with electron-beam mask-making techniques, it is not difficult to achieve at least 2 GHz.

Rolf D. Weglein, senior staff engineer at Hughes Research Laboratories in Malibu, Calif., has used electron beam lithography to make high-efficiency and broadband devices in the range of 1 to 2 GHz. He has achieved bandwidths of 400 MHz to 1 GHz and delays of 200 ns to tens of microseconds. Most of his work is on lithium niobate. Although Weglein's technology is in the laboratory now, he looks to production techniques.

"While we are presently printing our devices directly on the surface," he says, "we will make chrome masks by electron-beam lithography and then make devices by contact photolithography. This is possible since there are no optics involved in the device replication from the mask."

Longer delays explored

For pulse compression and radar applications, it is desirable to produce dispersive filters that have large time-bandwidth products. In this case the time is the difference between the delay of frequency launched by the beginning of the transducer and the frequency launched by the end of the transducer. Time-bandwidth products on the order of 1200 have been achieved by Burnsweig at Hughes. With a wrap-around device, he got 120-μs delay with 10-MHz of bandwidth. Several other researchers have been working to increase the bandwidth to over 100 MHz while setting the delay at about 10 μs.

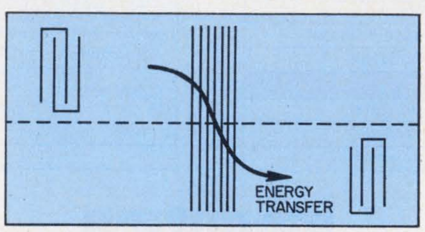
A novel idea for achieving time-bandwidth products of several thousand—first developed at the Lincoln Laboratory of the Massachusetts Institute of Technology in Lexington, Mass.—is called the reflective-array compressor. It consists of a pair of transducers positioned side by side and a chevron pattern of two rows of etched grooves on a $LiNbO_3$ substrate. A surface wave is launched by one of the transducers into one row of the etched grooves. This wave travels through an oblique grating consisting of 6000 grooves whose spacing increases as a function of distance from the input transducer. The surface wave is strongly reflected at a right angle in the region where the groove spacing matches the wavelength of the surface wave. The wave is reflected into the second grating, and then it travels back to the other transducer. Time-bandwidth products of up to 4000 have been reported with this device.

Experimental models of this type of device have also been built by Weglein at Hughes, with ion beams used to etch the grooves.

Directional couplers can be built

Another very useful new device is the multistrip coupler. It is, as Graham Marshall of the Royal Radar Establishment in Worcestershire, England, points out, "an array of parallel metallic strips deposited on a piezoelectric substrate that can transfer acoustic power from one acoustic track to another." The device is useful for tapping energy off an acoustic delay line without introducing reflections on the line.

Weglein notes that an ion beam could be used to raise selectively the resistivity of the piezoelectric substrate where needed, so that loads would be formed and the couplers would become highly directive. Bristol is also working on multistrip couplers.



Multistrip coupler from the Royal Radar Establishment transfers energy from one acoustic channel to another channel.

Hybrids and ICs

If diode switches are placed in series with the taps on an acoustic delay line, the number and position of taps can be electronically controlled. This is useful in such devices as programmable correlators or code-changeable secure communications devices.

If the diodes are discrete devices, wire-bonded to the taps, the assembly is a hybrid. If the diodes

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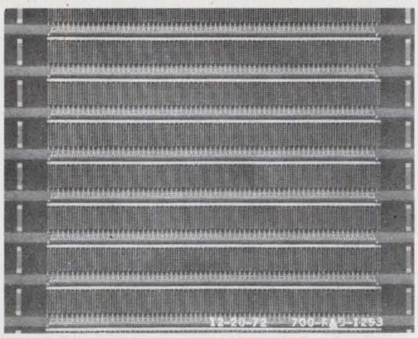
are monolithic and produced on a common substrate with the delay line, the assembly is an integrated circuit. Both approaches are used. Hybrids have been built by RCA in Van Nuys, Calif.; the Motorola Government Electronics Div. in Scottsdale, Ariz.; Hazeltine; Teledyne MEC and others. The main advantage of the hybrid approach is that the delay line can be on the material of choice. In the IC case the material will usually be zinc oxide over silicon.

Texas Instruments in Dallas was the first to detect a surface wave with an MOS transistor and to launch surface waves on a wafer of silicon. In addition integrated devices on silicon have been built by Motorola and RCA. According to Dr. Fred S. Hickernell, a senior physicist at Motorola:

"We built a 15-bit quadraphase programmable correlator for the Naval Electronics Laboratory. The taps were PMOS structures positioned to permit selection of any one of four different phases through a gate voltage bias. The device operates at 60 MHz and has a 10-MHz bandwidth."



Adjacent stripes of silicon and aluminum nitride are deposited on a wafer of sapphire. The delay line goes on the aluminum nitride substrate and the MOS detectors on the silicon. This is a 63-tap switchable delay line with a center frequency of 200 MHz.

Dr. David A. Gandolfo, a group leader at RCA describes his device as a five-tap correlator with PMOS detectors on a zinc oxide film. It operates at 70 MHz with a bandwidth of about 10 MHz.

Falling somewhere in between hybrid and monolithic is the approach being pursued by the Autonetics Group at Rockwell International in Anaheim, Calif. Peter Hagon, manager of physical sciences research and technology, describes the process as an alternate deposition of stripes of silicon and aluminum nitride on a sapphire substrate. The surface-wave device is deposited on the aluminum nitride and the electronic circuitry is grown on the silicon.

Hagon has developed a 63-tap nondispersive delay line at a center frequency of 200 MHz with 50 ns of delay between taps. Connected to the taps by deposited aluminum paths are PMOS silicon on sapphire diodes and their driving circuitry. Hagon is now building a 128-bit programmable coder using this technology. He expects to switch from PMOS to CMOS in the near future.

As the technology grows, so do the applications. Such developments as programmable variable time delay, FM-chirp data transmission, contiguous filter banks and TV i-f filters only scratch the surface of potential applications. ■■

ACES: New electrical system for space

A new method for solving electrical power reliability and management problems is being tested by NASA and may be used on the space shuttle and other future spacecraft.

Called ACES (for Automatically Controlled Electrical System), the new system was developed by the Westinghouse Aerospace Electrical Div., Lima, Ohio.

ACES is composed of remote power controllers that perform switching functions; a distribution control center, which is a general-purpose digital computer; remote input/output units that multiplex and demultiplex control signals, and a data-entry and display panel. Manual control and system status are provided at the panel.

In present aerospace electrical systems, heavy wire conductors called feeders lead from the power source to cockpit switches and thermal circuit-breakers to permit control of electrical loads by the flight crew. With the new Westinghouse system, the feeder cables, instead of going to the cockpit, run from the generators to electrical load centers, where the switching is done by remote control. The controllers used to do the switching are of the hybrid type and are made up of deposited resistors and conductors, power semiconductors and integrated circuits.

Automatically Controlled Electrical System is being tested in a mockup of the space-shuttle cockpit. The new system moves the power switching location from the cockpit to remote electrical load centers.

Electrical load control and sequencing is accomplished by logic programmed into the distribution control center. Signals from control switches and sensors are transmitted to the control center, which determines which remote-controlled switches will be activated. In addition the control center sets the appropriate status indicators.

ACES will automatically shed loads, in accordance with a preprogrammed load priority schedule, to prevent electrical source overloads when a portion of the generating capacity is lost.

The system also provides automatic self-checkout, start-up and shutdown sequencing. ■■

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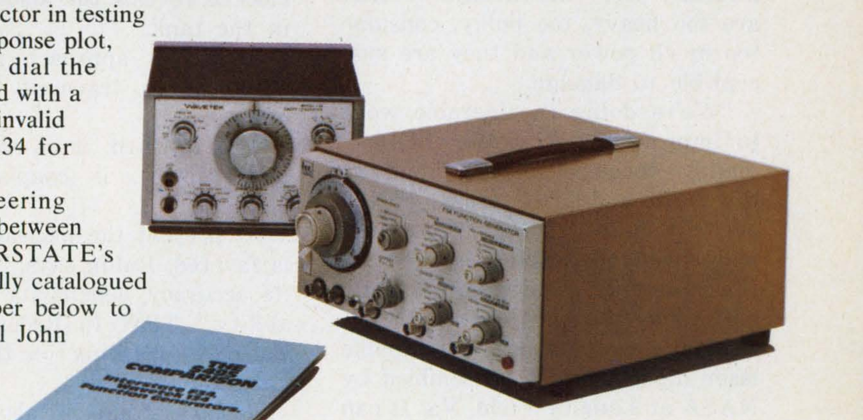

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INFORMATION RETRIEVAL NUMBER 21

Design in the 1980s: How NASA sees its equipment shaping up

The replacement of all CRT displays with LEDs or liquid crystals . . . a tunable laser diode that can identify pollutants in the air . . . a nuclear fuel gauge.

These are a few of the developments envisioned by NASA as it prepares for space and atmospheric flight in the 1980s with new-generation components and materials.

Will the tight budget problems of the 1970s kill such hopes?

"No, we can't sacrifice R&D," says Bernard Rubin, program manager for the Electronic Devices, Materials and Sensors Group of the Office of Aeronavtics and Space Technology Washington, D.C. "We'll just carry out the research over a longer period of time. We've got to move on, because you can't fly spacecraft in the '80s with technology you're using today."

A number of projects for new-generation devices are already under way, Rubin says, and many more will start moving soon.

"By the early 1980s CRTs will give way to LEDs or liquid crystals—not only in spacecraft but in aircraft, too," Rubin says. "CRTs are too heavy, too bulky, consume too much power and they are susceptible to damage.

"We're doing considerable work to improve materials for LEDs—mainly those elements found in the third and fifth groups of the periodic table. We're processing materials and making heterojunctions in them and then actually optimizing the light emission."

A laboratory model of a tunable laser diode has been assembled by NASA at Langley Field, Va. It can detect and identify pollutants in the air. Ultimately the plan is to install such a laser diode in an aircraft. The transmitter might beam its light out from the side of the fuselage to a reflector on the tip of a wing and back to a receiver in the plane.

"As we fly through the atmosphere at various altitudes, we can detect and identify constituents in the air by laser absorption spectroscopy," Rubin explains. The laser frequency range extends from 2 to 12 μ. Besides making constituent profiles in the earth's atmosphere, the laser diode could also be used on spacecraft to study the atmosphere of other planets.

A weightless gas tank meter

Development of a gauge to measure liquid fuel in a spacecraft in flight is also under way. Three approaches are being studied.

A nuclear system involves 20 or more gamma sources on one side of the tank and detectors on the other. Since fuel—liquid oxygen or liquid hydrogen—partially shields gamma ray transmission the number of gamma ray sources that are blocked reveals the amount of fuel in the tank.

A second approach uses small antennas to transmit radio frequencies.

And a third, a resonant infrasonic device, is coupled with a diaphragm.

At present the nuclear approach is favored, Rubin says, "because of its accuracy, sensitivity and availability." TRW in Redondo Beach, Calif., is working on the nuclear gauge.

Rubin's group is also studying these other projects:

- Sensors for telescopes in spacecraft that are sensitive to small amounts of light received from distant star fields.
- Strain gauges using ion-implanted silicon to measure very small forces with very high sensitivity.
- Charge-coupled devices for imaging and for information storage and processing. "We're just getting a program started at the Jet Propulsion Laboratory in Pasadena, Calif.," Rubin says. "We'd like to get rid of the vidicon tube used in Mariner and go to CCDs." NASA is also looking for an expansion of the CCD technology for infrared sensors, but this is still in the research stage.
- Bubble-domain memories for the storage of information—"about 10^7 to 10^8 bits per unit area." These may well be the solid-state replacement for tape recorders, which often have mechanical problems.
- An optical mechanical scanner with a small spectrometer microscope for the Viking spacecraft, which is due to land on Mars in 1976. "When Viking lands," Rubin says, "we would like to have a camera look around, then look down at the surface to magnify it for particle examination and then analyze the surface spectroscopically."
- High-efficiency solar cells using graded band gap semiconductors made from elements in the third and fifth groups of the periodic tables.
- Infrared photodetectors.
- An acoustic emission sensor to detect impending fractures in a spacecraft's structure.
- A battery-status monitor for the space shuttle.

Preparation for the big communications load between earth and spacecraft in the 1980s is also a big effort at NASA. "By 1982 we expect to be transmitting 400 megabits per second of data from a relay satellite; this is equivalent to 10 to 14 conventional television

John F. Mason
Associate Editor

channels," says Henry Anderton, project manager of NASA's Microwave and Optics Branch.

"The big push is for lasers," Anderton continues. "We feel the money we put into lasers will give us more than an equal amount would for microwave communications. We've tried microwaves but they are equipment-limited. You can get more out of a 5-inch laser antenna than a 200-foot microwave antenna, and there is very little spectrum left in the microwave region."

There are problems with lasers, Anderton says: "Pointing and modulation techniques have not been fully developed, and you need lasers with good spectral purity so they can stay on one wavelength. Also, we need to know what happens to laser beams when they pass through the atmosphere."

"Our main thrust in microwaves is to shift NASA's deep-space communications from S band to X band, from 2 GHz to 8 GHz. This will give us about 10 dB of gain.

Long life components are needed

Standardization and long life, are two key requirements for equipment in the Guidance and Control and Navigation Branch, says program manager Peter Kurzhals.

"We want to move to laser gyros for manned space flights, instead of ball bearings," he says, "and to gas bearing gyros for planetary missions. For outer planet flights, we must have systems that last 10 years. Present systems last three."

LSI will be used extensively in spacecraft in the 1980s, says Charles Pontious, deputy director of the Office of Aeronautics and Space Technology. "Farther on downstream is the whole wafer LSI—the Navy is already very interested in this."

CMOS in space equipment is also on the drawing boards for the '80s, Pontious says, with CMOS on sapphire coming a little later. "Probably the silicon gate and the beam-leader devices will be used for most of NASA's high-reliability applications," he speculates.

Amorphous semiconductors? "I don't see these being used for another decade," Pontious says. ■■

INFORMATION RETRIEVAL NUMBER 22 ►

Tektronix' new programmable calculators: Natural. Powerful. Significantly less expensive.

Natural

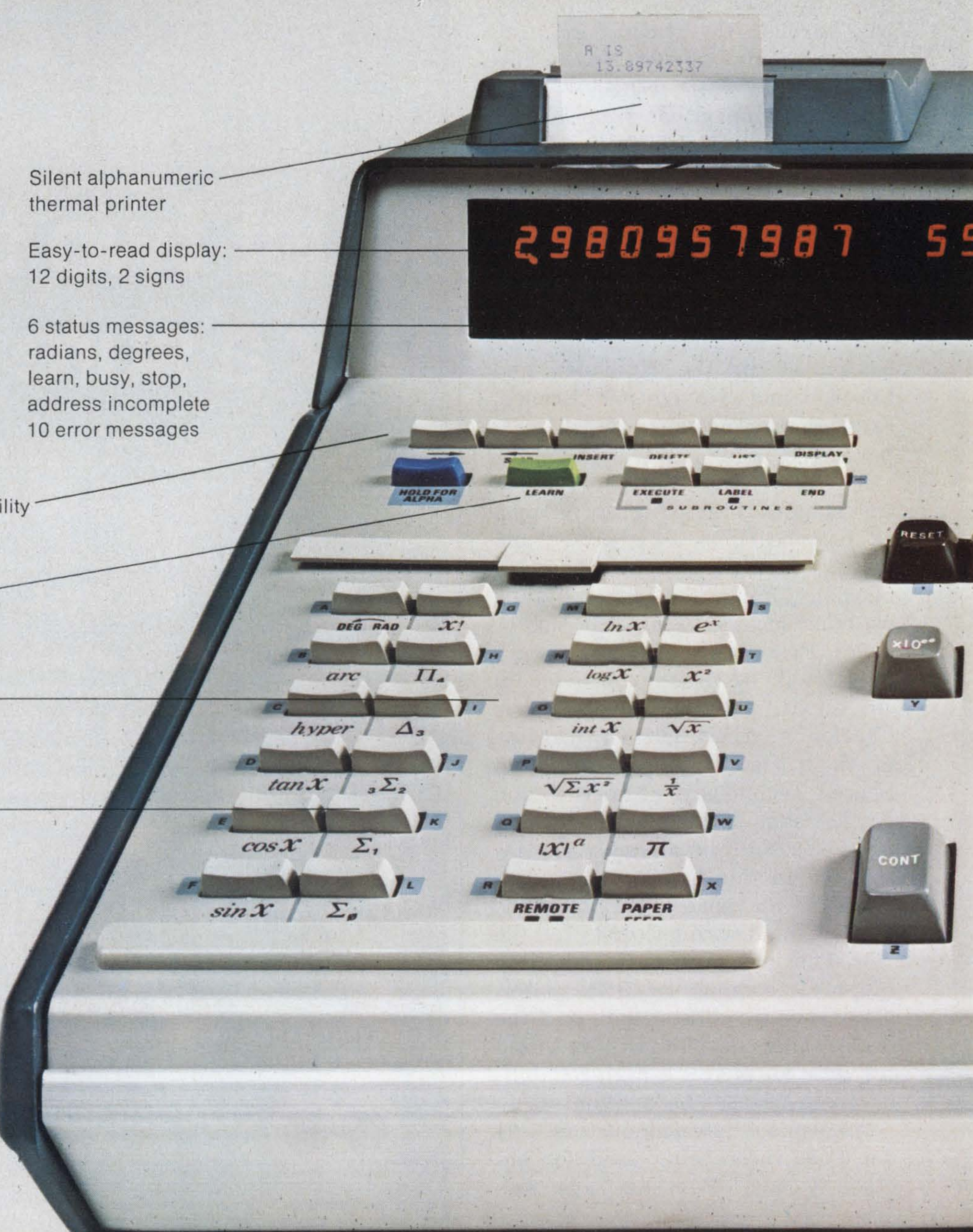
The new Tek 21 and 31 programmable calculators are designed for easy interaction between you and the machine. There are no machine rules or languages to learn. The new calculators have English-like programming keys and a simple keyboard that does math the way you write it.

Both machines have over 30 math functions built in. There are no extras or options to purchase: the math functions commonly used are standard.

Powerful

With one of our calculators, you can solve problems directly from the keyboard. Data can be stored in the calculator's memory and recalled by keystrokes. Or, you can put an entire routine into the program memory and have your calculator run programs,

Tek 21



execute key commands, and recall data automatically for you.

Memory capacity needs vary from one discipline to another. The data storage and program memories of our calculators are more than sufficient to meet most needs. However, the machines can be adapted to meet the needs for large capacities (up to 8,192 program steps, 1,010 data registers, or a combination of both on the Tek 31). Magnetic cards, cartridge tapes and plug-in PROMs (programmable read-only memory) can be added to expand memory or to perform specific functions. Input and output peripherals can be interfaced to provide more power.

Less Expensive

Through advanced design, based on unique concepts and unfettered by unnecessary computer-based technology, Tektronix is able to offer more problem-solving performance per dollar. The Tek 21 is only $1,850, and the Tek 31 only $2,850. Compare those prices, and all the features of Tektronix calculators, with any other scientific programmable calculators.

Programming

With both the Tek 21 and 31, you instruct the machine in simple English, plus common math symbols. The Tek 21 has eight keys for functions you define yourself. In your own language. The Tek 31 has 24 user-definable keys. In addition to conditional and unconditional branching, the 31 has full editing capabilities, symbolic addressing and nesting of sub-routines. Plus alphanumerics, so the calculator actually can communicate with you.

Output

Operations and results are simple to read on both the Tek 21 and Tek 31. A large, bright display flashes to indicate that the machine has exceeded its range or that it has been asked to perform an illegal math operation. In addition, a silent thermal printer, with alphanumerics on the Tek 31, gives a hard copy of results.

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FOR DEMONSTRATION, CIRCLE 132

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INFORMATION RETRIEVAL NUMBER 24

washington report

Heather M. David
Washington Bureau

If at first you don't succeed . . .

The Army is trying to restart two programs that it previously had to terminate because of technical problems and tremendous cost overruns. Two contractors—Bell Helicopter Co., Fort Worth, Tex., and Hughes Helicopters, Culver City, Calif.—have been awarded competitive contracts to develop the new advanced attack helicopter, which is to replace the canceled Cheyenne helicopter. Development and testing is expected to take five and a half years, during which time subsystems for night vision, fire control, navigation and comunications will be developed.

The Army also has awarded competitive contracts for a new tank, the XM1, which is to replace the canceled Main Battle Tank. Both tank prototypes, which will be built by Chrysler Corp. and General Motors, will feature computerized control and will eventually require substantial electronic fire-control and communications equipment.

SAM-D status under scrutiny

One Army program that may be in big trouble is the Army's complex, computerized tactical air-defense system, the SAM-D. The program is being eyed suspiciously in both the House and Senate, and the Pentagon's request for funds may well be denied this year, despite many years of effort. The total program cost of the SAM-D is estimated at $4.4-billion.

A recent General Accounting Office report, although it made no recommendations for cancellation of the SAM-D, advised Congress to consider whether the system, which was born in 1964, could survive an onslaught of antiradiation missiles. Also, would SAM-D even be needed when the similar, Improved Hawk missile becomes operational?

Defense Dept. gets a red light on spending

The Senate Armed Services Committee has told the Pentagon not to spend money on several major programs this fiscal year until the committee makes its mind up about those programs. The committee has advised the Defense Dept. not to enter into contracts for fiscal 1974 on the Navy's Trident strategic submarine missile program, the Army's Tacfire computerized fire-control system and the site-defense antiballistic missile system, a substitute for the Safeguard ABM system.

The House Armed Services Committee, meanwhile, finishing work on the defense authorization bill, is considering major cuts in the Air Force's

F-15 fighter aircraft program and the Air Force's subsonic cruise armed decoy (SCAD). The committee already has voted to add $116-million to keep the F-111 aircraft production line alive, and proponents of this controversial aircraft program say the F-111 will be voted by Congress despite the Administration's lack of support.

Trident may get independent guidance system

The Navy reportedly is quietly developing what would be the nation's first independent guidance system for the multiple warheads of a strategic missile system. Called the Mark 500 guidance system, the development could be applied to the multiple warheads of the long-range, submarine-launched Trident strategic missile system.

The current Poseidon and Minuteman strategic missiles have multiple independently targeted re-entry vehicles (MIRVs) that are carried over each target by a "space bus." The bus is equipped with a fairly complex guidance system, but each warhead, as presently built, is then dropped like a conventional bomb, without further guidance.

Congress asks NASA work on solar energy

Congress has passed a National Aeronautics and Space Administration authorization bill providing $3,064,500,000, which is $48.5-million more than the Administration requested. One specific directive that Congress gave the space agency was to "investigate the collection and conversion of solar energy (by a satellite) in synchronous orbit and the microwave transmission of such energy to earth."

NASA suffered no major damage at the hands of the House and Senate Appropriations Committees. A move by Sen. William Proxmire (D-Wis.) to knock out the space-shuttle program was, in his words, "overwhelmingly unsuccessful."

Capital Capsules:

The Senate's National Science Foundation subcommittee has **recommended allocating $646-million to the foundation for fiscal 1974, some $63-million more than the Administration requested.** The additional funds would go towards establishing an energy research division and for other research and science education. . . . The Naval Research Laboratory is **looking for contractors in shf/ehf communications R & D—X band through practical millimeter wavelengths—to developing system concepts for new communication nets.** The nets would perform the functions now provided by uhf or hf radio and satellite communications systems. It may involve fabrication of feasibility models and preparation of specifications for system models. . . . The Air Force's Cambridge Research Laboratories is **designing and constructing a telescope for eventual use in a solar observatory optical network** for the Air Force's Electronics Systems Div. The system, which would involve five telescopes, would locate and measure solar disturbances that affect electronic surveillance and warning systems as well as certain communications, satellite tracking and orbital. . . . **Firms able to provide automated design capabilities are being sought by the Naval Research Laboratory.** The Navy is looking for capability in the simulation, layout, fabrication and testing of unassembled and assembled multilayer printed-circuit boards or optional wire-wrap boards, which would be used in the development of high-speed digital processing systems.

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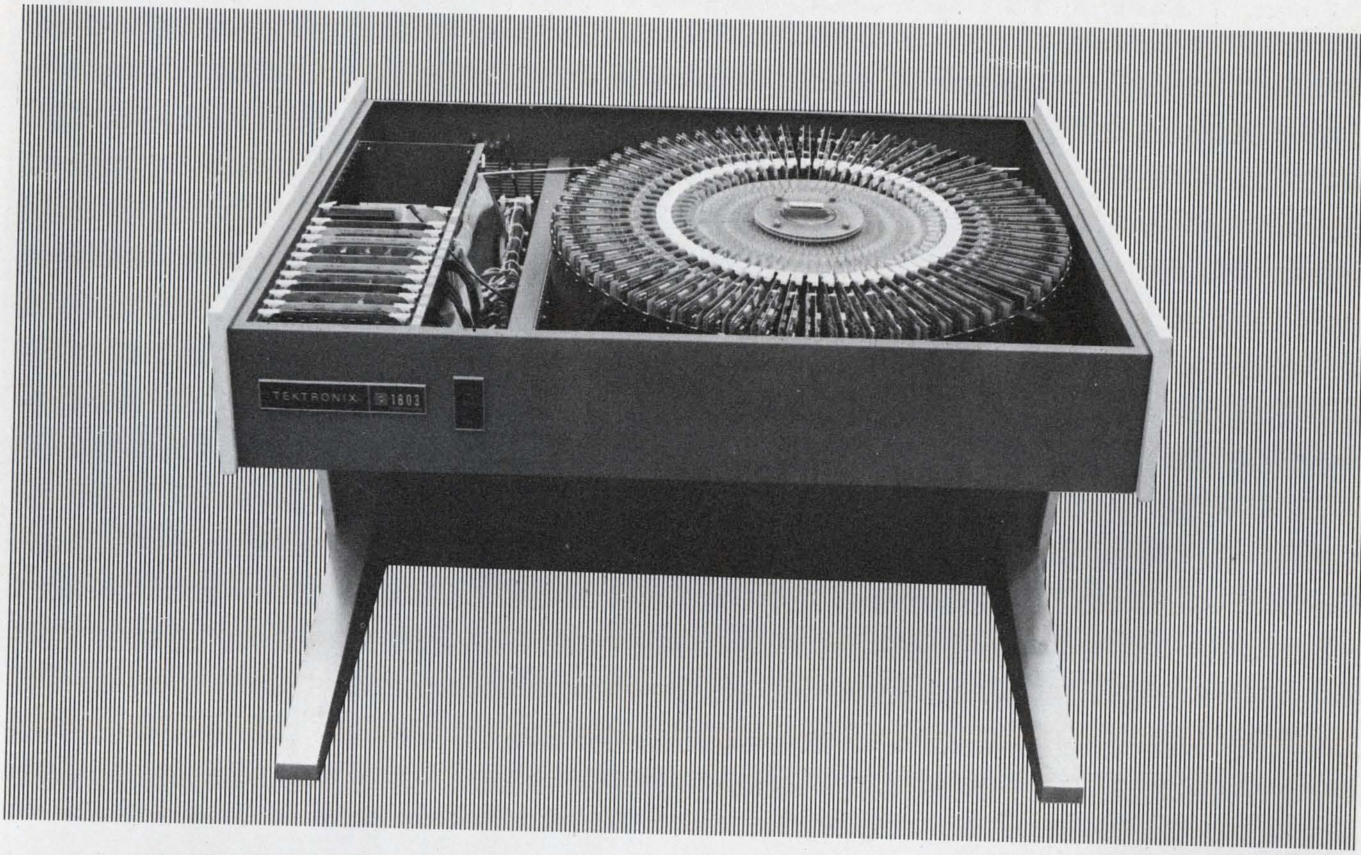

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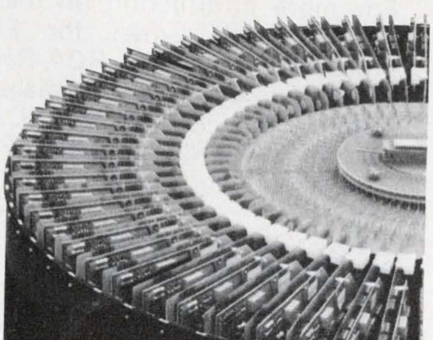

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The 1803 Test Station presents the first practical high-speed test fixture scheme. It uses pin electronic cards to bring signal generation and detection devices as close to the DUT as possible. Critical Path design permits clean signal paths to and from the device. To change DUTs on an 1803, the user need only change a small inexpensive socket board.

The S-3260 is the ultra-modern test system designed to test modules, discrete components, IC's of all types, and p.c. boards. Capable of performing DC, Timing and Function testing, it accesses up to 64 I/O pins. Built around a powerful minicomputer, seven-phase clock generator, and power supplies, the S-3260 is capable of applying test patterns up to 64 bits wide at rates from 600 Hz to as high as 20 MHz

Not being a special purpose, limited usage machine, the S-3260 will not become obsolete as your testing requirements change. Already delivered systems are being used in R/D, manufacturing and QC environments. To learn more about the system designed to solve your testing needs, contact your Tektronix field engineer, or write to Tektronix, Inc., P. O. Box 500A, Beaverton, Oregon 97005.

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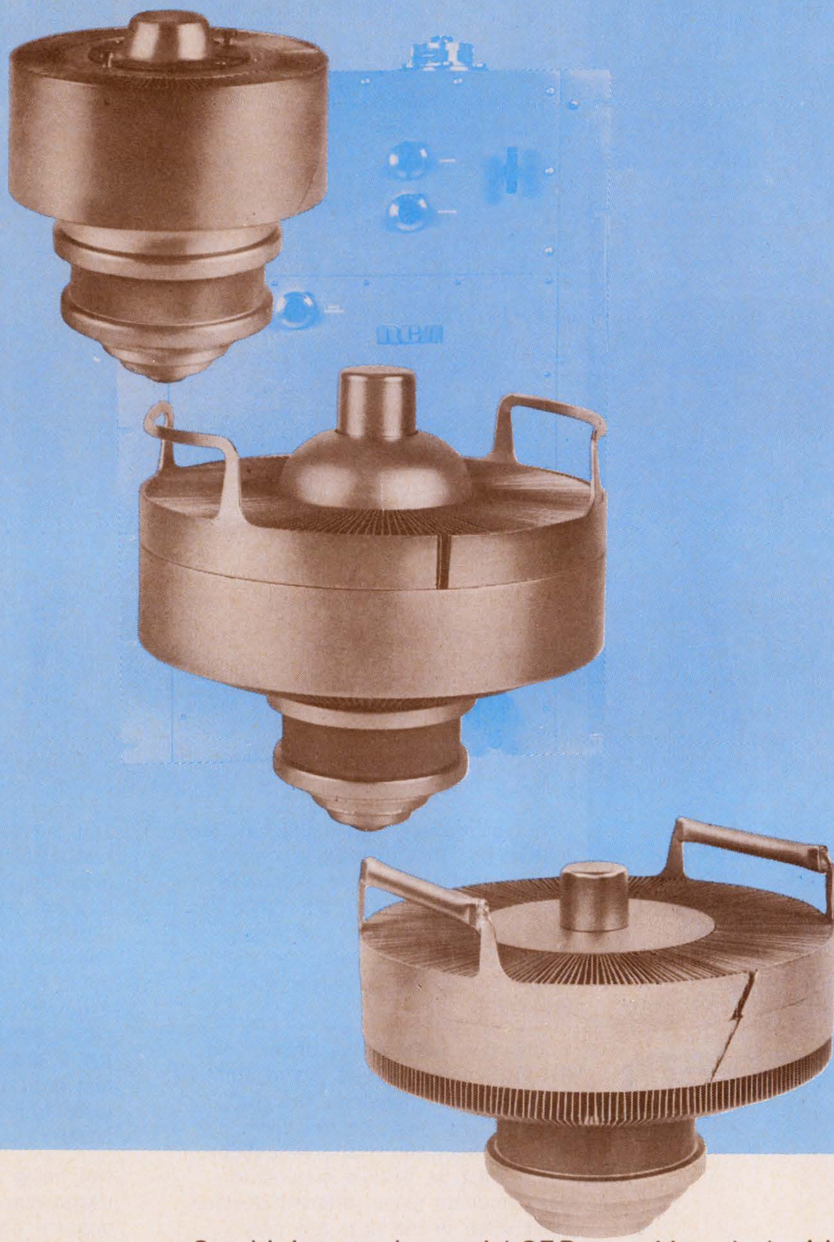
INFORMATION RETRIEVAL NUMBER 25

High-gain tetrodes and cavities for FM Broadcast



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• They require low driving power and few driving stages to achieve maximum performance.

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• You deal with only one source of responsibility for both tube and cavity . . . RCA.

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INFORMATION RETRIEVAL NUMBER 26

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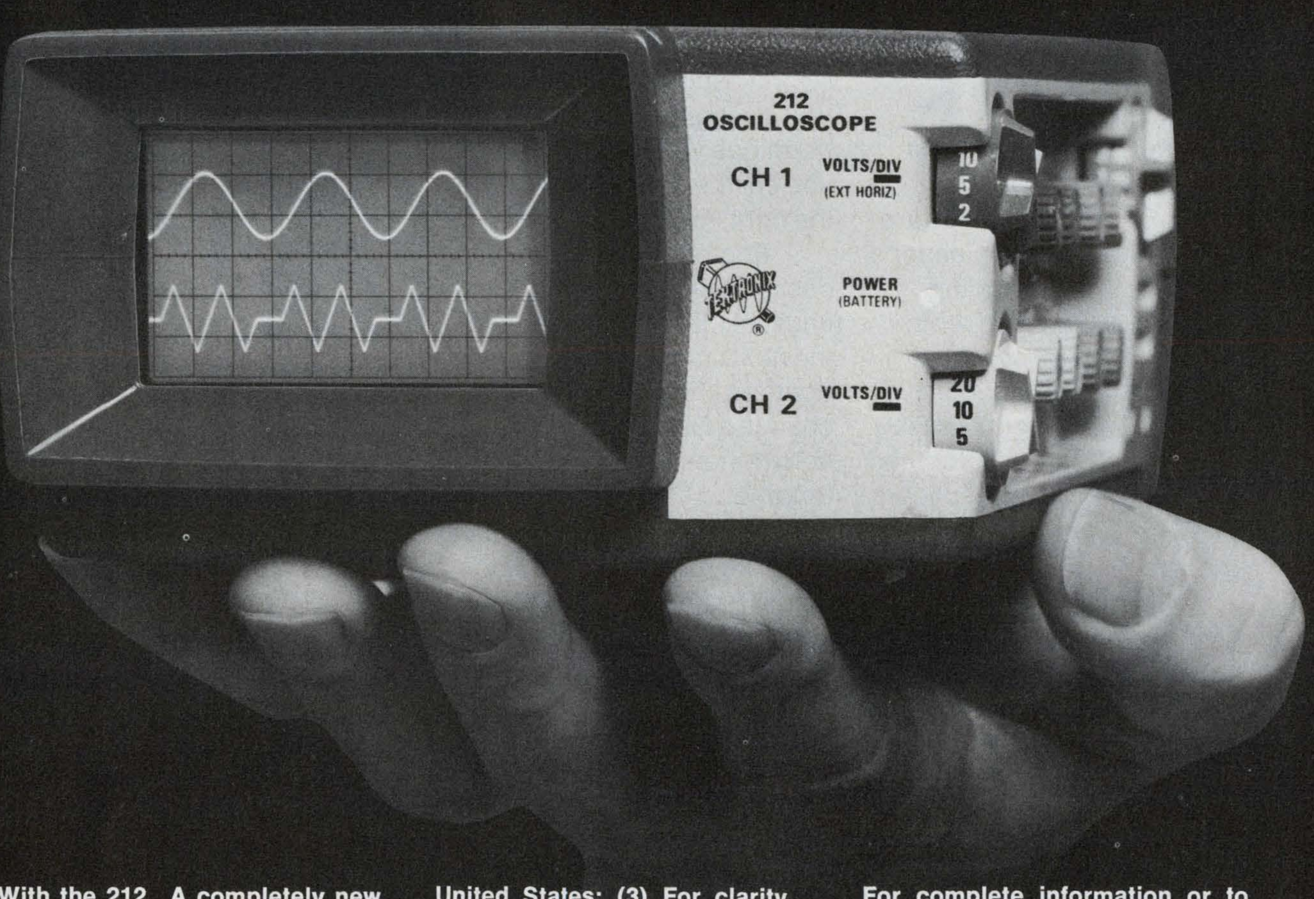

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INFORMATION RETRIEVAL NUMBER 27

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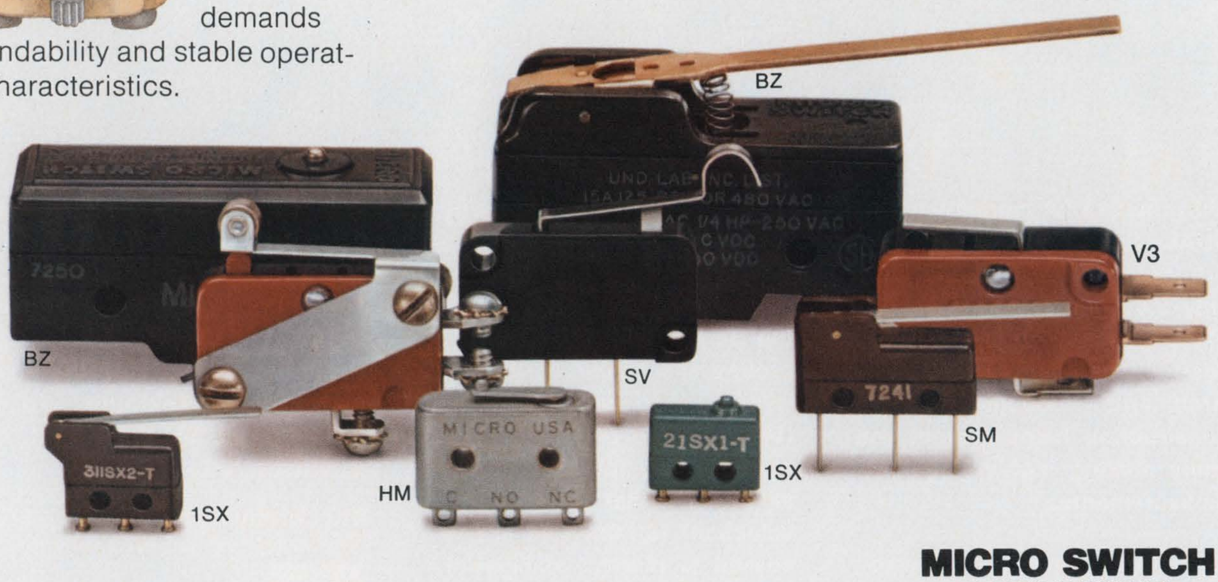

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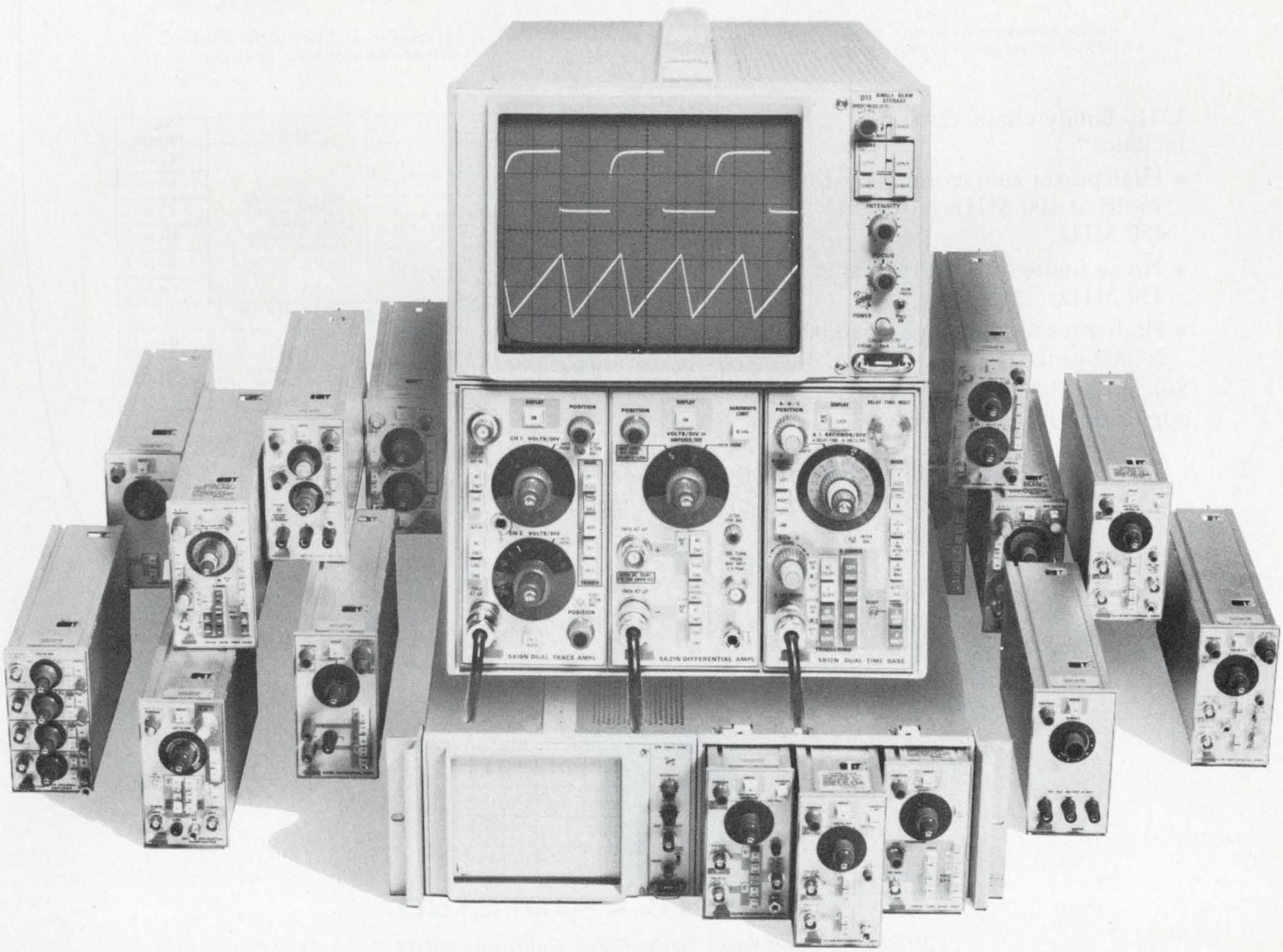


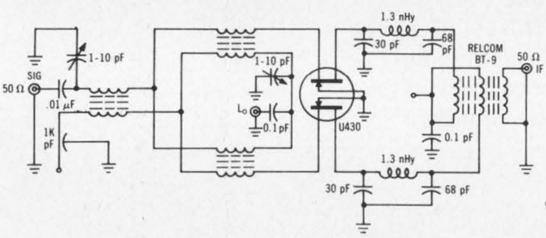
INFORMATION RETRIEVAL NUMBER 29
FOR DEMONSTRATION, CIRCLE 125

Meet our new series of high-frequency problem solvers . . .

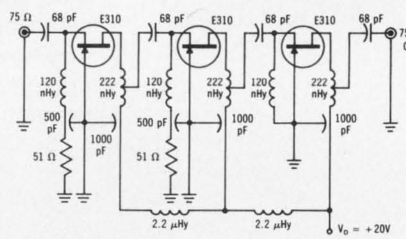
High-Performance VHF/UHF FET Family

Remember the U310? Some people call it the SuperFET. We introduced it a year ago: worst-case 75Ω input match VSWR of 1.25:1. Figure of merit 2.35×10^9 typical. Third order intercept point of +29 dBm.

Now we've extended the U310 technology to produce an entire family of high-performance N-channel junction FETs. They're ideal for VHF/UHF applications such as the two circuits shown below:



Single-balanced active mixer — 100 dB dynamic range, + 2.5 dB conversion gain, + 32 dBm intercept point, 50-250 MHz.



Wideband amplifier — 225 MHz center frequency, 1 dB bandwidth of 50 MHz, 24 dB gain.

U310 family characteristics include:

- High power gain (common gate) — 16 dB at 100 MHz, 11 dB at 450 MHz.
- Noise figure = 3 dB typical at 450 MHz.
- High transconductance = 10,000 to 20,000 μmhos.

Select the right FET for your application from this array:

Type	Package	Feature	Applications	Price (1K units)
E308	Epoxy TO-106	$V_P = -1.0$ to -6.0 V, $I_{DSS} = 12$ to 60 mA	High-frequency, small signal VHF or UHF source followers, amplifiers, mixers, or oscillators	$ 0.57
U308	Metal TO-52			$ 3.70
E309	Epoxy TO-106	$V_P = -1.0$ to -4.0 V, $I_{DSS} = 12$ to 30 mA		$ 0.75
U309	Metal TO-52			$ 4.45
E310	Epoxy TO-106	$V_P = -2.0$ to -6.0 V, $I_{DSS} = 24$ to 60 mA		$ 0.75
U310	Metal TO-52			$ 4.45
U310 family dual FETs have V_P, I_{DSS}, and g_{fs} parameters matched to 10%. Packages designed for easy insertion into printed circuit boards.				
E430 Dual	Epoxy Si-105	$V_P = -1.0$ to -4.0 V, $I_{DSS} = 12$ to 30 mA, $g_{fs} = 10$ to 20 mmho	VHF/UHF balanced mixers and cascode amplifiers	$ 1.70
U430 Dual	Metal TO-99			$ 9.95
E431 Dual	Epoxy Si-105	$V_P = -2.0$ to -6.0 V, $I_{DSS} = 24$ to 60 mA, $g_{fs} = 10$ to 20 mmho		$ 1.70
U431 Dual	Metal TO-99			$ 9.95

Get the complete story on this advanced high-frequency FET family.
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editorial

Can we see what's there?

An old buddy, president of a small power-supply company, sent me an article on switching-power supplies. The article, unfortunately, was too weak for publication in ELECTRONIC DESIGN. It rehashed material most readers already knew. It said basically that switchers were smaller, lighter and more efficient than power supplies with series-pass regulators. And their noise level had been substantially reduced—thanks, in part, to switching at high frequencies like 20 kHz.

So, with regrets, I rejected my friend's manuscript and told him why. He wrote back and argued that switching supplies were not well understood, especially in Europe. "At least four Japanese suppliers," he added, were looking to import his units because "Japanese technology is a year to two years behind ours."

Well, every man is entitled to his opinion, so I let this go unanswered. Further, I had already said in my earlier letter that manufacturers often feel that too few customers understand their product. But that didn't end the matter. Some weeks later, reading the May 24 issue of ED, my friend saw Powertec's 44-page advertisement and finally "understood" the reason his manuscript was rejected. It was "obvious" to him that we had chosen not to accept his manuscript because his competitor had placed an advertisement in our magazine.

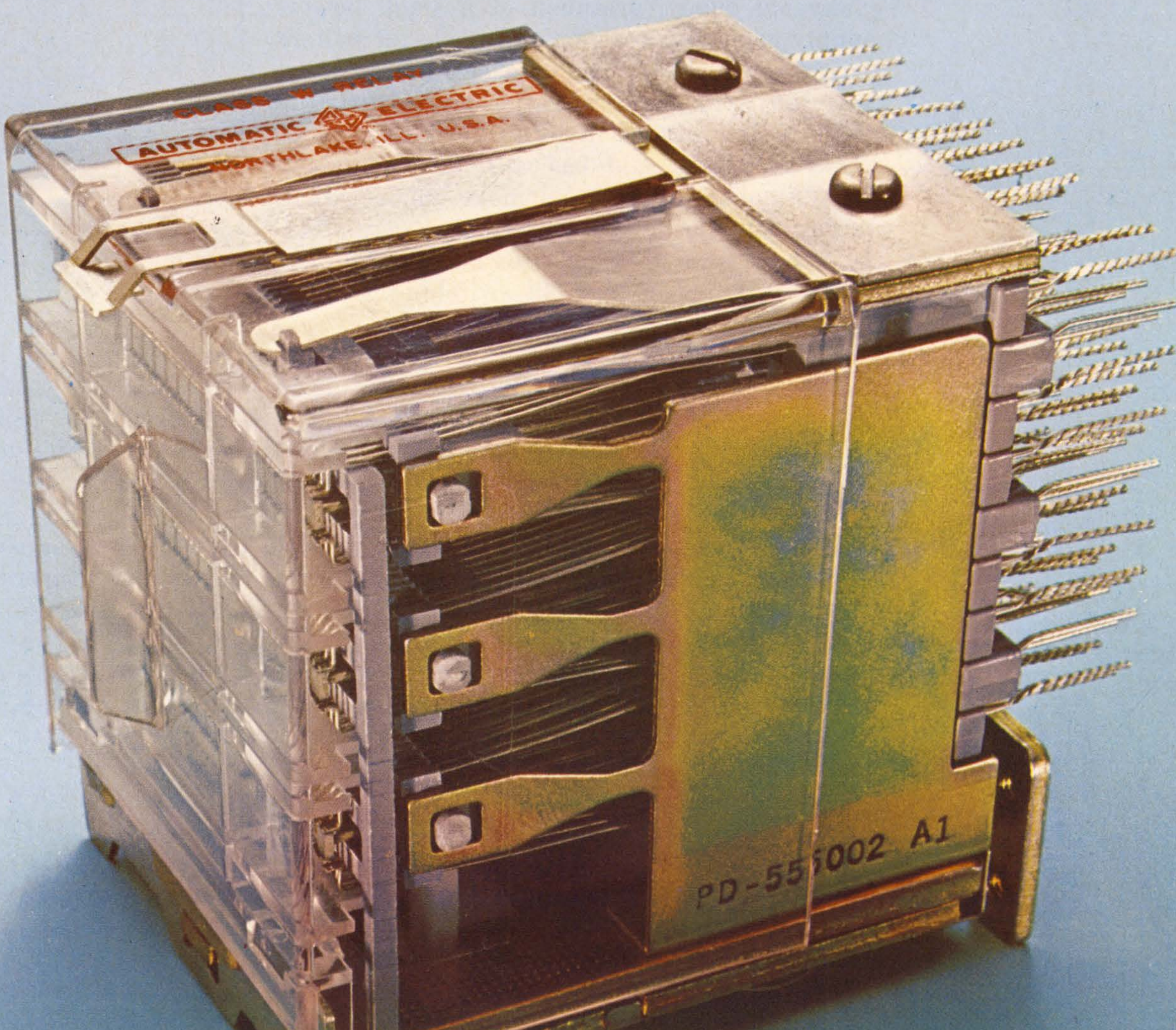
Since a reputable editor never allows advertising to influence his evaluation of an article, I was furious. What he had done was like telling a lady she was married to a cuckold. I wrote and told him that whoring may be a fine old profession, but it's not mine. I pointed out what he should have known—that I accept and reject manuscripts only on the basis of their value to our readers.

His next letter, a masterpiece of brevity (unlike his manuscript), said simply, "Bull!" I admired the succinct summary of his feelings, and my fury melted into amusement. But I was overcome by a sad thought. My friend couldn't accept the possibility that his manuscript wasn't strong enough. Its rejection, in his mind, could only be the result of dishonesty. Had I been ethical, he felt, I should certainly have accepted his article.

I wonder how many of us are like him. How many of us blame others for our setbacks? How many can accept full responsibility for our small failures—or large ones? How many of us assume, always, that we were blocked by the other fellow's dishonesty? How many of us are strong enough to look at ourselves and see what's really there?

GEORGE ROSTKY
Editor-in-Chief

Reliability is staggered steps and a hunk of DAP.



Expect over a billion operations.

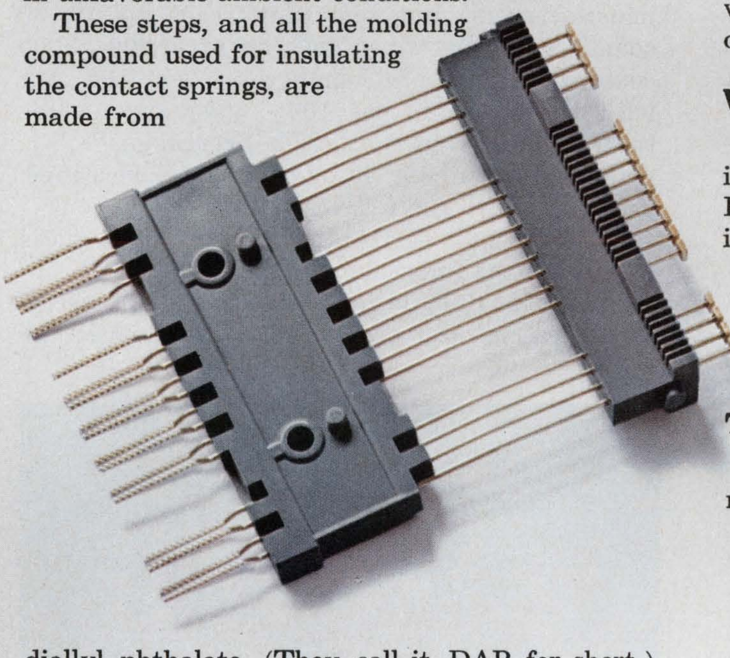
Our Class W wire-spring relay is different. In fact, there's nothing like it in the entire industry. Where else can you find a relay with lots of contacts and a mechanical life of more than a billion operations! That's about two and a half times the life of the best conventional relay around.

Another nice thing about our Class W is that it takes up a lot less space and costs less than using a bunch of other relays. That's because we build our Class W relay with one, two or three levels of contact assemblies, with 17 form C combinations per level. By the way, they're available with gold contacts for low-level switching.

Making it tough on creepage.

All those staggered steps you see on the side were put in to raise the breakdown voltage between terminals. These molded steps add extra creepage distance between the terminals. This really counts for high voltage testing, or when using our Class W in unfavorable ambient conditions.

These steps, and all the molding compound used for insulating the contact springs, are made from



diallyl phthalate. (They call it DAP for short.) It has great insulating properties and it wears like iron. Even if the humidity is high, you have excellent protection.

Redundancy—two springs are better than one.

Each of our long wire-spring contacts has an independent twin with the same function. One tiny particle of dust could prevent contact on other relays. Not with our Class W. You can be sure one of the twins will function. That's back-up reliability.

The twin contacts are twisted together at the terminal end. Then we give them a spanking (you might call it swedging) to provide solderless wrap.

We're for independence.

Our springs are longer, because the longer the spring, the more independent they get. And the better contact they make. Don't forget, the wire-spring relay is the most reliable way to get a permissive make or break contact. You can rely on it.

The middle contact springs have to be stationary. To make sure they stay that way forever, we actually mold them between two thick pieces of DAP on both ends. Just try to move one.

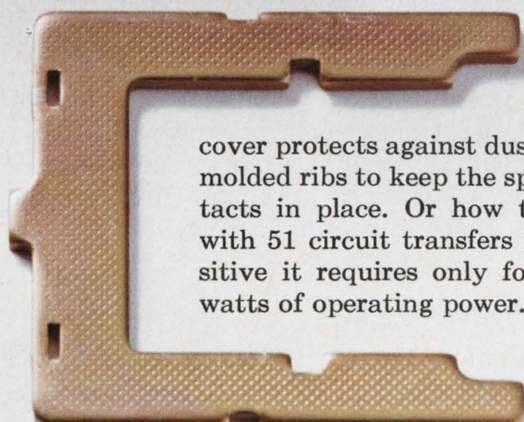
When we say flat, it's flat.

Each frame, banged out by a gigantic machine is extra thick and extra flat. Then they're planished. Planishing is another step we go through in forming the frame to add strength and stability by relieving surface strain.

We've made our spring-loaded pile-up clamp extra thick, too. Once it's tightened down, the whole pile-up is nice and tight, and stays tight.

There's more.

We could tell you a lot more about our Class W relays. Like how the tough high-temp molded



cover protects against dust and has molded ribs to keep the spring contacts in place. Or how this relay with 51 circuit transfers is so sensitive it requires only four to six watts of operating power.

But why don't you let us prove how much reliability we put into our Class W? We'll be waiting to hear from you. GTE Automatic Electric, Industrial Sales Division, Northlake, Ill. 60164.

GTE AUTOMATIC ELECTRIC

INFORMATION RETRIEVAL NUMBER 32

FOCUS on Digital multimeters

When Hamlet said, "There is nothing either good or bad, but thinking makes it so," was he peering into the future, and talking about digital multimeters?

There's a psychological finality about a digital display that leads one to place a great deal of confidence in the reading. But that reading may be as wrong as Hamlet was in some of his tortured reasoning.

Does this mean that DMMs can't be trusted? Not at all. It means that accuracy—as well as other DMM specs—is not an absolute, sacrosanct figure but can be, and usually is, affected by temperature, aging, humidity and other factors.

It also means that a DMM must be kept in calibration and must be used correctly to get the best accuracy.

But even the most careful measuring techniques can't compensate for a meter whose performance has been wrongly evaluated by the user—either inadvertently or because of misleading or confusing specs.

And a DMM specifier can expect plenty of confusing specs. They come in multiples—like a DMM's functions. Besides accuracy another spec that should be checked—probably first—is the number of digits in the instrument.

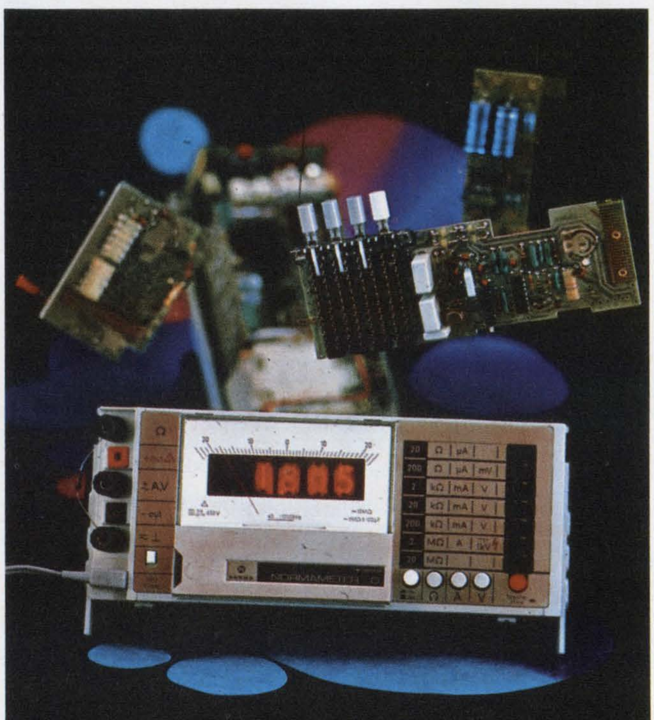
Don't count on your digits

Most suppliers classify DMMs in terms of the number of full digits displayed. When overranging is offered, some fraction of a digit is tacked on—for example, 3-1/2, 4-1/2 and 5-1/2-digits are common. But the fractional portion has no universal numerical meaning, and, in fact, its interpretation varies with the manufacturer.

For example, two rival commercial DMMs are both classified as 4-1/2-digit machines by the manufacturers. But one unit reads to 19,999 counts, while the other goes up to 11,999—8000 counts less. The problem here is that the unit with 19,999 counts has 100% overrange, while the 11,999-count unit has 20% overrange.

Other DMMs offer 40 or even 60% overrange. Combine these figures with oddball fractions—such as 3/4 of a digit—and it's anybody's guess as to what the full-scale reading is.

Fractional designations therefore don't necessarily tell the user what he'd like to know: the



An unusual instrument is the Normameter D, marketed by the General Rand Corp. The 1999-count unit also features a zero-centered, analog meter movement.

Stanley Runyon
Associate Editor

Weston's line of portable DMMs includes the 17-range 4440; the more-accurate 27 ranger, the 4442; and the 4444—an autoranging unit with 11,000 counts. All three units weigh less than 2-1/2 pounds.

full-scale values and the theoretical resolution. The only unambiguous way to designate these is with the maximum count, not with number of digits. An alternate method that's sometimes used is to list the number of "nines" that can be displayed, along with a figure for percentage overrange. Again, since there aren't any standards for overrange, this is not satisfactory.

Indeed, use of the maximum-count method clears the confusion with respect to overranging: It eliminates the need to spec it at all. Another point is also cleared: Overrange, a legitimate DMM function, is sometimes confused with going off scale—a no-no with sensitive measuring equipment.

Hewlett-Packard offers its 3470—a plug-on series of interchangeable modules—and the self-testing 3490A.

Fluke's 8000A—the first to use both analog and digital LSI chips. Featured are a high-impact case, overload protection and a weight of less than 3 pounds.

Of course, units that have overrange capability and are manually range-switched must somehow indicate when the range is to be changed. Flashing digits or an indicator light are commonly used.

When counts are given, a user can then determine at least the theoretical maximum resolution. For instance, with a three-digit box, you can resolve one part in 999, or approximately 0.1%. What this means in terms of a particular voltage, current or resistance reading depends on the location of the decimal point (range). Thus while the percentage of resolution remains constant, resolution in terms of units does not.

Theoretical resolution is often confused with sensitivity. But don't asssume that because the display can theoretically resolve a millivolt or less on the lowest range that the instrument's sensitivity and noise characteristics allow it to measure a millivolt accurately. They may not. Sensitivity is thus a statement of the smallest input quantity to which the instrument responds accurately. The key word here is "accurately."

Pinning down accuracy

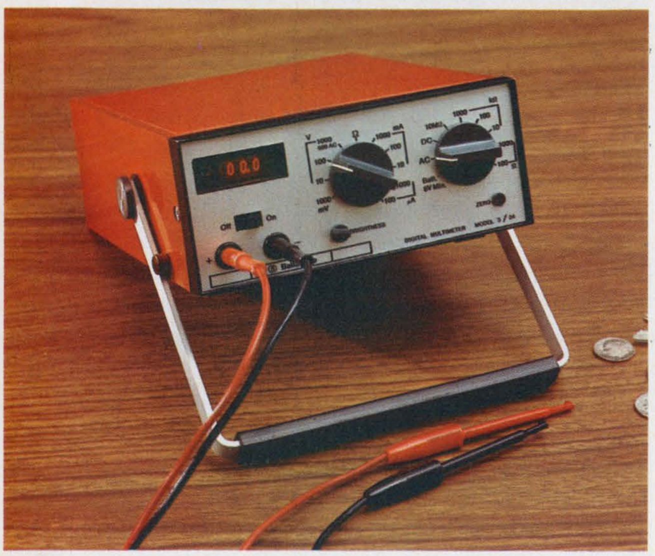
Of all DMM specs, accuracy probably causes the most headaches. An accurate accuracy spec is hard to come by. Since no standards exist, manufacturers are free to define accuracy in a way that's most favorable to their products.

And define they do—limited only by corporate policy, the competition or conscience. A quick survey of competitive data sheets reveals at least 10 different ways of specifying accuracy. As a result, a comparison of competing units, and in some cases even DMMs within one line, is almost impossible.

A potential DMM customer may well ask, Is there a correct, unambiguous way to state accuracy? At least one manufacturer says there isn't. Let's see if he's right.

In essence, a DMM "compares" an unknown quantity of voltage, current or resistance to a legal standard and then displays the numerical value of that unknown quantity.

A DMM's accuracy spec should therefore state clearly how well the comparison, and the display, can be made—that is, just how much the displayed number can depart from the true value, which is really a measure of inaccuracy. Any spec that doesn't do this is inadequate.



A new entry in the portable DMM derby is Ballantine's 3A-24, a 1200-count unit priced under $200.

With this in mind, we can clear up what is usually a specifier's first common mistake: Accuracy cannot be determined from the number of digits. Whether a machine has four, five or even 10 digits is immaterial; it can still read incorrectly.

Indeed, it's easy to add more digits. This can be done indefinitely, with price the only limitation. Adding accuracy, though, is tough, with limitations imposed by amplifiers, range resistors, the internal reference, the a/d converter and other circuitry. And, in fact, it's these multiple contributions to inaccuracy that make it tough to specify. Here's why:

In general, inaccuracy can be divided into three basic errors: those of offset, linearity and gain.

Offset error is the small—but finite—voltage or current reading that exists for a zero input (leads shorted). It can be defined as the input voltage needed to produce an all-zero reading.

Linearity error is the deviation of a DMM's transfer function (output vs input) from an ideal straight line. It's usually measured at the point of maximum deviation.

And gain, or slope, error is a scale-factor error in which the full-scale value—and hence the slope of the transfer function—departs from the nominal value.

To these three errors must be added the ubiquitous digitizing error of ± one count.

Unfortunately DMM manufacturers don't spec their units with these three basic—and probably least confusing—errors. Instead, to shorten and simplify the spec, most vendors distribute the three into percentages of the following: full scale, reading, or—most commonly—both. (Some vendors forget to say what the accuracy figure is a percentage of, thereby making it totally meaningless.)

Carving up the error

But each manufacturer is free to distribute these errors to make a unit look as good as possible—that is, to lower at least one of the two percentage terms. And, to make things worse, linearity can be defined in different ways.

For example, offset is usually placed into the percentage-of-full-scale term, while scale-factor error is put into the percentage-of-reading term. But both offset and scale factors, as well as linearity, depend on how the transfer function is plotted.

Thus the transfer function can be eyeballed as the best-fitting straight line, or it can be made to fit by use of least squares or some other mathematical method. Or it can be drawn straight through the end points.

In any case, how much of which error appears in which term is anybody's guess.

Actually distributing errors in this way wouldn't be so bad if a DMM user were at least told which errors were lumped into which percentage. Then he could safely compare competing units.

As it stands, even when two units appear to be specified in the same way, it isn't clear which instrument is the more accurate. The distribution of errors can make one DMM more accurate than another for, say, 80% of a range and less accurate within the remaining 20%. And the situation can be reversed when the range is switched. Moral: Know where most of your readings will be and then calculate the accuracy for each competing unit. Probably the best way to do this is to convert all percentages to a number of digits or counts.

Some vendors use just one term to spec accuracy—either the percentage of reading or the percentage of full scale. Or both terms may be used for the dc scales and one term for the ac scales.

When this is done, does this mean that there's no offset or scale-factor error? Possibly. For instance, on some scales the ± one-count quantizing error swamps out the offset error, so the full-scale term is dropped. But don't assume this is so. Ask. Note, too, that some vendors include the ± one count in the full-scale figure.

Stating accuracy as a percentage of full scale doesn't readily tell the user what he needs to know: the maximum error of his reading. To get this, you'll have to make a calculation for each reading. And you'll need to be aware that enormous percentage errors can occur at the low end of a scale.

Another problem: The term "full scale" means different things to different manufacturers. Some include overrange as part of the full scale value; others don't. Why include overrange? With 100% overrange, it makes the meter look twice as accurate as it really is. And with other meters it may mask the fact that accuracy is derated in overrange. PS: Don't expect the data sheet to tell if overrange is included in the accuracy spec.

Other terms are sometimes tacked onto an accuracy spec—for instance, "voltage coefficient" or "direct units of voltage."

Voltage coefficient is an additional error resulting from nonlinearities in the input attenuator—that is, the attenuation factor may not be a constant; it may depend on the value of the input voltage. The error is found when the given coefficient is multiplied by the input voltage.

Usually the coefficient is so small that the error becomes important only on the high-voltage ranges (1000 V, for example). But watch out when coefficients are buried in the footnotes in microscopic print.

In high-resolution instruments, noise, leakage and other factors can cause errors on the lowest ranges. Vendors occasionally indicate this by adding a voltage term—usually "microvolts." Watch for it.

A DMM buyer can expect to run into a number of other ways of specifying accuracy. For instance, it may be presented graphically as a function of input and other factors. Or it may be tabulated.

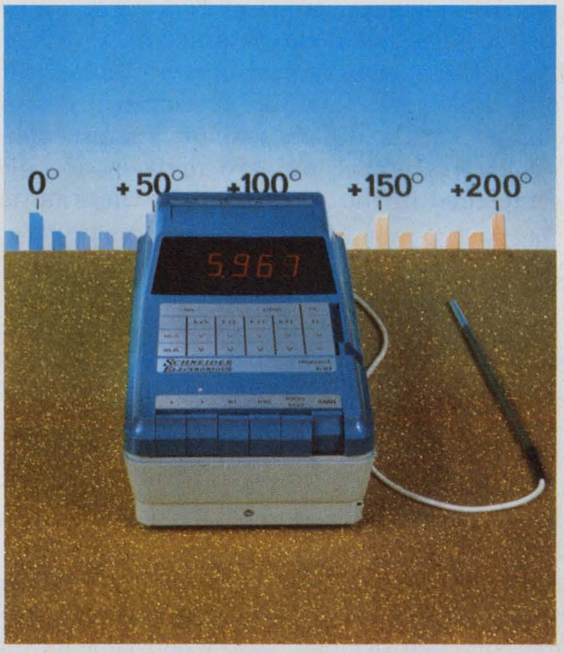
And, for those who are mathematically inclined, accuracy may be listed as a series of individual contributions—separate listings for accuracy of the converter, reference, attenuator, etc. In this case, you add the individual contributions—or maybe you root-sum-square them, or maybe . . .

But once the "percentage-of-what" issue has been settled, don't relax. Any accuracy spec, no matter how it's stated, is incomplete and possibly useless unless you know how it is affected by temperature, time and other factors. Let's look at them.

Getting the drift of tempco

An accuracy statement should be qualified by the conditions under which the spec holds. For example, temperature—a prime assaulter of offset, linearity and gain—can often swamp out otherwise accurate readings.

So a DMM user has to know the temperature range over which his unit will work to within



The Digitest 610 is Schneider Electronique's portable DMM. The unit measures temperature and V/I/Ω.

rated accuracy and how changes in temperature affect the reading. Finding out, though, may not be easy.

First of all, tempco may be completely missing from the spec sheet. Beware of these units: Every DMM has a temperature error, however small. Also, don't assume that tempco is included in the basic accuracy spec; it probably isn't. Second, as with accuracy, uniform standards for tempco haven't been agreed upon. As a result, tempcos usually are specified to a unit's best advantage.

Here are some common ways of expressing tempco:

- As a maximum error over some temperature range.
- In ppm/°C over a specified range.
- As a percentage of reading or of full scale per degree C.
- As a percentage of reading plus a fraction

of a digit or count.

- As a percentage of reading plus percentage of full scale (or range) per degree C.
- As a fragmented spec, with drifts of various factors scattered throughout the data sheet.

Many of the arguments for specifying accuracy also hold for tempco. And, as with accuracy, full scale can mean nominal or overrange full scale. Find out.

But however tempco is specified, here are some questions to ask: Over what temperature range is the tempco valid? Does the stated tempco account for all drifts that affect the reading—that is, that affect zero offset, linearity and gain? On the ac ranges, does the tempco hold throughout the stated frequency range of the DMM? What's the tempco for each range and function? And, finally, is the spec a typical or worst-case value?

Note that some DMMs automatically cancel zero offset, while others provide manual "zeroing" control. Tempco of zero drift is not likely to be included in the spec sheets of these units.

Keep it calibrated

After tempco has been established, pose this question: How long will the unit hold the listed accuracy? Beware of meters with spec sheets that don't give the answer. All DMMs age with time and must be re-calibrated at regular intervals.

Thus a manufacturer must list accuracy for a specific period. Some list a short-term spec of 24 hours; others use 90 days, six months or even a year. And still others state the accuracy for a number of time periods. But when time is missing, don't assume that the reported accuracy is long-term.

In general, both short and long-term accuracies should be known, the short term for users who must take a number of readings in a relatively short period and the long term to establish calibration intervals.

If, however, the calibration lab doesn't return the standardized unit within 24 hours, this spec may be useless. On the other hand, if company policy dictates a 60-day calibration recall cycle, then a 90-day spec, or longer, doesn't mean much either. Of course, to reduce costs, it's always better to extend the calibration cycle, if possible.

In any case, to maintain a unit's accuracy, keep it calibrated.

Humidity and line-voltage variations can also nibble at accuracy. And don't forget that accuracy varies with function, range and—on ac—with frequency. Also, some options can cause accuracy and other DMM performance characteristics to deteriorate. The spec sheet should tell all.

But even when everything seems kosher, a unit's full accuracy may not be obtained in a given measurement. The reason: input loading.

Look into the input terminals

It's a sad fact that loading errors can totally destroy that beautiful accuracy you've worked so hard to determine.

For instance, a 0.1%, 10-MΩ instrument connected to a 10-kΩ source starts off with a 0.1% loading error. To avoid this, if the 0.1% accuracy is necessary, a DMM with greater input impedance—say 1000 MΩ—is needed.

Or perhaps changing the range will do the job. A DMM's input impedance is not constant but goes up or down as range and function are switched. And, of course, if you can live with the loading error, then a machine with less accuracy will be adequate.

Systron-Donner's 7205 is a 130,000-count unit that features lead compensation on the ohms function.

We've established that input impedance can be critical. So special pains should be taken to find out just what a DMM's input impedance is.

First of all, data sheets don't always tell you that a DMM's input amplifier requires a bias or offset current. In fact, statements of input impedance are incomplete without bias specs, and that breathtaking Z_{in} of "1000-MΩ" can dazzle you into forgetting this. Bias current is especially important in portable and other DMMs that must be operated over widely varying temperatures.

Let's take a "hypothetical" four-digit DMM, specifying 1000-MΩ input impedance on its 1-V scale. Now if we optimistically assume that the DMM's bias current is 100 pA at 25 C, and that the current doubles every 7 C, the bias at 40 C will be roughly 700 pA. Now if we assume a 0.5-MΩ source resistance, an error of 700 pA $\times$ 0.5 MΩ $=$ 350 μV, or 3-1/2 counts, will occur.

If the DMM's accuracy is rated at 0.03% of reading ± one count, or 3 ± one count, then the bias error is equivalent to that of the unit. And if, as is likely, the bias current is actually 1 nA at 25 C, forget about using the instrument at its rated accuracy.

A similar situation can exist with DMMs that use FETs in the input stages. The FETs boost input impedance, but leakage current can occur. Although leakage is usually less than 10 pA, significant errors can exist when source impedance is high.

There's another spec that's often missing from the data sheet: input capacitance. On ac ranges, input impedance is meaningless unless capacitance is known.

For instance, suppose a DMM specs an R_{in} of 10 MΩ and a bandwidth of 25 Hz to 25 kHz. But the data sheet forgets to mention that, in effect, a 100-pF capacitor hugs the input resistance. At 25 kHz, the actual Z_{in} works out to be less than 64 kΩ. This makes the 10-MΩ Z_{in} just a dream.

One other point: A severe overload can change input impedance, even with protection circuitry.

When you do look into a DMM's input terminals to check impedance, don't be surprised to see something coming out. Noise and other unwanted signals can kick back voltage to the source and possibly damage a sensitive semiconductor junction. So roll up a scope and look.

Other specs influence readings and should be investigated as part of a DMM's input characteristics. These include the shunt resistances on the current ranges (compliance, the voltage across the shunt resistance, should be as small as possible); the maximum current output on ohms ranges (so that junctions aren't destroyed); and input overload protection. Let's consider the latter.

What's a volt-hertz?

Any DMM can be burned out. The spec sheet should therefore list maximum allowable input voltage or currents for all functions. On ac ranges, the dc limit should be given as well. Units with differential inputs should spec the maximum common-mode voltage along with the other limits.

When checking maximum voltage on ac, watch out for a curious, fine-print spec called volt-hertz product, or VHz. It can slice your voltage protection by more than half.

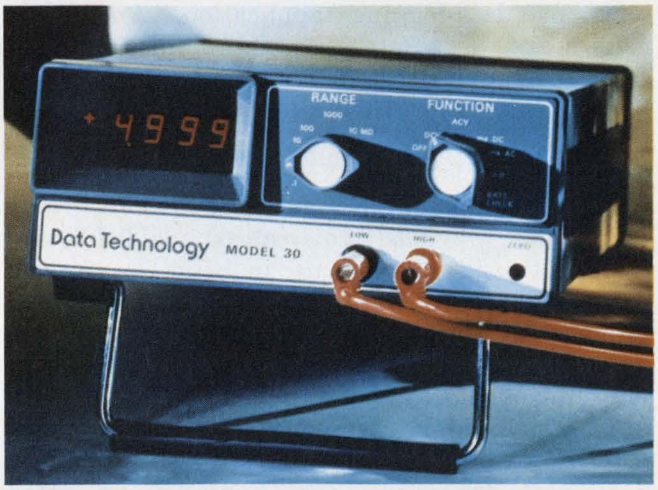
Suppose the spec sheet claims a maximum voltage of 1500 V on ac. Buried at the bottom somewhere else on the sheet is a statement that says, "Volt-hertz product not to exceed 10^7." At 25 kHz, the maximum allowable voltage turns out to be $10^7/25{,}000 = 400$ V—not 1500 V. Of course, this could be learned without reading the spec sheet—the hard way.

Practically all meters are protected on the most delicate function—ohms. Most also give protection on their current ranges. Fuses, circuit-breakers and voltage-limiters are commonly used for this protection. But don't assume anything. When a unit is said to be "fully protected," find out how—and check the limitations.

Remember, too, that opening a box to replace a fuse may negate calibration. That nickel fuse can cost $100 to replace when re-cal costs are added in.

A point worth noting: auto-ranging DMMs may trade off overload protection on ac. If this protection is important, manual ranging may be the way to go.

Other important specs, especially for units intended for systems or field use, are those that describe a DMM's noise characteristics. Included are normal-mode rejection (NMR), common-mode rejection (CMR) and such capabilities as floating, guarded inputs.



Model 30, Data Technology's latest DMM, offers an extended count of 5000 (500% overrange).

Tradeoffs: NMR vs reading rate

A normal-mode rejection spec should describe how well a unit "ignores" noise riding on the signal to be measured. Any noise that gets by the input stages, naturally, will cause erroneous readings.

To combat this, many DMMs use an integrating technique to make measurements, or they use filters at the input. Some units do both.

Integration is best for line-related noise—noise occurring at multiples of the line frequency—while filtering is best for other frequencies and for broadband noise. Filters, however, tend to slow a DMM. This isn't always mentioned in the DMM's specs.

This pocket-sized midget is manufactured by Data Precision. The Model 245 weighs 1.3 pounds, counts to 19,999 and has 21 ranges of volts and ohms. The unit sells for $295, including batteries and charger.

Much emphasis is placed on the number of readings per second a DMM can make in a systems or data-logging application. And some meters *are* fast: Successive approximation types can go as high as 1000 readings per second or higher. But to get this speed, the filter must be switched out.

When this is done, NMR drops to zero, and noise superimposed on a signal is free to invade the display. Obviously this can be avoided by returning the filter switch to "in." But the reading rate now drops to two to five readings per second (though at least one DMM is said to give 30 readings/sec while retaining 60-dB NMR with the filter out).

Though a high reading-rate spec guarantees poor noise rejection in most cases, it doesn't necessarily guarantee fast operation at rated accuracy.

To reach full accuracy, DMMs need time to settle after each new sample. This is (or should be) indicated on the data sheet by a statement such as, "Unit settles to 0.02% of final value in one second after a full-scale-step input."

If you're using a scanner, most of the inputs could be step inputs. Thus digitizing must be delayed until the unit settles to desired accuracy; otherwise the readings may be meaningless.

Since settling time depends on the amount by which the input changes between samples, and on whether or not range changes must be made in auto-ranging, a worst-case spec is needed.

True reading speed should therefore include all relevant factors: input settling, switching, auto-ranging, digitizing, etc.

Common-mode rejection becomes important when floating, or differential measurements are made—that is, when both signal leads are isolated from ground. It's a measure of how well a DMM rejects noise common to both the high and low leads.

Now, in a perfectly balanced circuit—one in which the impedance from source to DMM to ground through the high lead equals that through the low lead—CMR is infinite and no common-mode noise gets through to affect the reading.

Naturally, perfection doesn't happen in the real world, and some unbalance always exists. A CMR spec will thus depend on the amount of unbalance. And here's where a problem begins.

Since no formal standard exists for the amount of imbalance, vendors have license to spec CMR as they please. Most, though, have settled de facto on a 1-kΩ unbalance in the low lead. But if imbalance is missing from the data sheet, be suspicious. The CMR figure may not be as good as it looks.

Common-mode problems are inevitably linked with ground loops and undesirable coupling between circuit elements. Avoiding them can be a horrendous job. Thus for systems use, a guarded DMM is practically a must—as are isolated data outputs.

But the words "isolated outputs" on a data sheet don't tell the whole story. So ask: Isolated from what—chassis, signal common or power-supply common? Ideally it should be all three.

After all important specs are checked in the light of present and future applications, a number of other questions arise: How many digits do I need? How many functions and ranges? Which features should I buy? What about reliability?

Which DMM?

Engineers tend to overspecify when they select a DMM—especially when it comes to the number of digits and the nominal accuracy. On the other hand, some manufacturers can also be accused of overspecifying their units—that is, supplying so many sheets full of specs as to overwhelm and confuse the harassed purchaser. And, of course,

Lear-Siegler/Cimron's DMM-51 features ratio, four-wire ohms, autoranging and BCD data outputs.

other vendors are guilty of skimping.

Probably the only way out is to know your application and understand which specs and features are of prime importance to that application. This isn't always easy to do. For example, how do you choose between a 2-1/2 and 3-1/2-digit machine? Or between 3-1/2 and 4-1/2 digits? The tendency here is to confuse accuracy and resolution.

But you don't buy digits for accuracy; you buy them for resolution. This means you've got to know to what voltage levels you're going to measure and to what number of significant digits.

And buying accuracy that exceeds a machine's resolution means that you'll be throwing money away. Thus in 2-1/2-digit machines, it's usually meaningless to talk about accuracies of better than 0.5%. With 3-1/2 and 4-1/2 digits, the compatible accuracies are 0.05% and 0.005%, respectively.

What happens when maximum accuracy is not as good as the theoretical maximum resolution? Is the extra resolution useless? Yes, if you're looking for absolute numbers.

But the extra resolution may be useful to repeat a reading, match resistors, balance amplifiers or observe short-term variations in a circuit. In these applications, you're not after an absolute number.

Knowing your application also lets you range in on the functions and number of ranges you'll need. The most common functions are, of course, dc and ac voltage and current, and resistance. These five-function meters are available with up to 32 ranges. But regardless of the number of ranges make sure that all adjacent ranges overlap.

Special functions are also available—for example, dc/dc ratio and temperature. One manufacturer—North Atlantic Industries—offers a "super" DMM, a unit that measures—besides the common five functions—in-phase and quadrature voltage components, dc/dc and ac/dc ratios, complex impedance, phase angle and synchro/resolver angles.

There are features galore on some DMMs. Some may be necessary for a given application; some are nice to have but not so necessary. Your budget will be the limiting factor.

Available features include autoranging, automatic zeroing, leading zero blanking, special probes, four-wire ohms and true rms measurements.

One budget tradeoff you can make is to buy a basic modular unit and then add plug-ins at each new budget period. When you do this, make sure that "modular" means a true plug-in card or module and that you don't have to return the unit for a factory modification. Find out also what happens to a DMM's accuracy and other performance characteristics when plug-ins are added and also whether a module is rated at the same temperature and humidity conditions as the mainframe.

True rms is not generally found on inexpensive meters. Although the spec sheet may not say so, these are usually either peak or average responding meters that read correctly only for pure sinusoidal inputs.

Signals that aren't pure sinusoids—and most aren't—will, at the least, result in erroneous readings. At the worst, signals with high crest factor—the ratio of peak-to-rms voltage—may cause damage.

If your signal isn't a sine wave, or close to it, buy a true rms-responding DMM.

Bench, portable or systems?

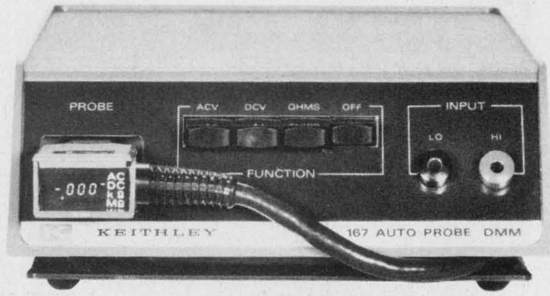
Separating DMMs into the three categories of portable, bench and systems units helps narrow the choice even more. Each category has its own set of requirements.

A subcategory that offers additional narrowing is: Who will use the unit—an engineer, a technician or a nonskilled assembler? High-accuracy, high-resolution and guarded units will require additional training for nonskilled people.

For battery-operation a number of questions should be asked, among them: Can the battery be recharged? What's the guaranteed number of hours between recharges? How long does it take to recharge? It there a battery check? Is the battery internal or an external hang-on? How many recharging cycles can the battery take? What's the battery replacement cost? Can the DMM be line-operated as well? And if it can be, is the supply internal or a hang-on? Finally, is the battery trickle-charged during line operation, so it's ready to go at any time?

In the field, the type of display used in the

Dana's 5800A is characterized by an rms, distortion-insensitive ac converter, and other systems features.



An in-probe readout makes Keithley's 167 an unusual DMM. The autoranging unit costs $325.

DMM can be important. For instance, small LEDs may be used for economy and to reduce power consumption. But how well can they be seen at a few feet?

Another point: Bright sunshine can wash out some displays; take the unit outside and check.

Note that the word "portable" means different things to different people. Some common definitions are: (1) Anything with a handle; (2) Anything on wheels; (3) Something with an internal battery; (4) IBM says its portable.

With this in mind, the latest crop of portable units offers a wide choice of characteristics, with counts ranging from 1199 to 19,999 and accuracies from 0.02% to 0.5%. Some are autoranging, some manual, and some are both.

Included in the "portable" category are Ballantine's 3A-24 a 1199-count, 24-range unit that sells for under $200; Data Precision's 245, which offers 19,999 counts and 21 ranges of V/I/Ω for $295; Data Technology's 5000-count unit—the Model 30—with 23 V/I/Ω ranges for $279; and Fluke's 8000A—a V/I/Ω meter with 26 ranges and 1999 counts, selling for $299.

Also included is the Keithley 167, an unusual instrument with the readout built into the probe. The autoranging 167 measures volts (ac, dc) and ohms counts to 1999 and sells for $325.

Miida's 6354 offers autoranging on its 26 scales, counts to 1999 and costs $290. Heath/Schlumberger markets the SM-4440, a 1999-count, 17-range unit that sells for $285.

Schneider Electronique offers its Digitest 610, an 11,000-count unit that measures temperature as well as V/I/Ω. The 610 costs 1750 francs in Europe.

And Weston manufactures a number of models. The 4444 is the company's autoranging version, featuring 11.000 counts, 18 ranges of V/I/Ω and selling for $575. The 4445 is a spanking new Weston unit with true rms measurements at 4:1 crest factor; it sells for $450.

Another unit—not battery-operated, but small in size and low in cost—is Linear Digital Systems' Model 3000. It counts to 1999, has 13 ranges of volts and ohms and sells for only $145.

For systems use, pay special attention to these features and considerations:

- Guarded, differential inputs.
- Long-term stability.
- CMR, NMR, reading rate and settling time.
- Data outputs—are they BCD, binary, serial, parallel, or what? Also, don't forget fanout.
- Isolation—what signals are isolated, from what and how much?
- Buffering and storage.
- Interface compatibility—interface circuits can cost more than the DMM.
- Programming characteristics.
- Four-wire ohms and ratio.

When selecting a systems DMM remember these additional points:

- Some programmable units can be manually operated, others can't.
- A remote display may be needed.
- You may want to multiplex several units.
- If you're using a two-wire scanner, why buy four-wire ohms?
- Don't buy a high-speed DMM and interface it with a device that outputs only two samples per second.
- If your scanner can't handle high-frequency signals, why should your DMM?

Systems DMMs are manufactured by Dana, Fluke, Hewlett-Packard, Julie Research Labs, Lear Siegler/Cimron, Non-Linear Systems, Systron-Donner and others.

Dana's 4700A counts to 19,999, is autoranging and offers isolated digital outputs and programming as standard. It costs $1095.

Fluke offers the 8375A for systems use. The 120,000-count unit is autoranging, reads true rms ac V and costs $1995.

Hewlett-Packard's 3490A features a self-test mode, 119 999 counts, autoranging and an optional ASCII serial or BCD interface. The price is $1650.

Julie Research Lab markets the DM-1000 series, highly accurate units intended for automated testing and calibration. With a count of 1,199,999, the series sells for $5500 to $8500, depending on the model.

Non-Linear Systems' MX-1 counts to 119,999, autoranges and measures volts, ohms and ratio.

The DMM-50 is Lear Siegler/Cimron's 119,-999-count unit, with such features as autoranging, autozero and dc ratio for $1195.

Non-Linear Systems' MX-1, an autoranging DMM with 119,999 counts and 15 ranges of V/Ω/ratio, costs $1000.

Systron-Donner's 7110A counts to 129,999, is autoranging and gives 30 readings/second with 60-dB NMR for $1995.

The third DMM category—bench units—is the least specific of the three. The bench can be in a cal laboratory, R&D laboratory or production area. In general, accuracy and resolution are important for bench use, and the primary functions are voltage and resistance. For production, tradeoffs must be made between many single-function instruments, a multipurpose box or a mixture of both.

For production, you might want low-resistance ranges for checking, say, bus bars, and perhaps ratio to determine potentiometer linearity, among other things.

Size may be important for cluttered areas—and as most benches and production facilities tend to be crowded look for compactness and stackability.

Many DMMs are available for use in bench, laboratory or general-purpose applications. And many manufacturers offer a choice of models.

Dana offers its 3300—a 1999-count unit—and its 4300, a 19,999-count box. Both units have 14 ranges of V/Ω, with the 3300 selling for $385 and the 4300 for $595.

Data Precision markets two series: the 2400, with 11,999 counts and the 2500, with 119,999 digits. The former ranges in price from $580 to $675, depending on model and features selected; the 2500 series sells for $995 to $1195.

Data Technology's 4-1/2-digit contender is the Model 40, a 14-range, $495 box using the Sperry gas-discharge display.

Fluke's 8100B counts to 11,999, has a 10,000-hour MTBF and provides 13 ranges of V/Ω—all for $595.

Hewlett-Packard's unusual 3470 system consists of various plug-on modules that offer a choice of displays (4-1/2 or 5-1/2-digits), measuring capabilities and features. Prices range from $600 upward. Other HP models are also available.

Offering 1-μV resolution on dc is Keithley's 171, a 32-range, 19,199-count unit selling for $895.

Autoranging, 14 000 counts and 18 ranges of V/I/Ω summarizes Lear Siegler/Cimron's DMM-40. The unit costs $695.

Model 6854 is Miida's autoranger. Specs include 19,999 counts and 27 ranges of V/I/Ω. The price is $689.

For $550, Non-Linear Systems offers the LX-2, an autoranging machine with 11,999 digits and 13+ scales of V/Ω and multifunction ratio.

Philips markets its PM2422A, a 1999-digit box with 26 ranges of V/I/Ω. The unit sells for $365.

Systron-Donner offers a choice of DMMs. Representative is the company's 7205, with such specs as 130,000 counts, 26 V/I/Ω ranges and 1-μV dc resolution. The 7205 is priced at $995.

Regardless of whether a DMM is small, medium or large, and regardless of its application, it always pays to look inside the unit.

Lift the lid and peek inside

It's a common mistake to forget that a DMM costs money to own as well as to buy—that is, to keep it repaired and calibrated. Of course, you'd like to minimize this cost of ownership; and the best way to do this is to buy reliability.

Reliability is hard to pin down, but you can get a good idea by borrowing a unit and checking its workmanship. Sloppy wiring and dangling components are sure to cause trouble.

In general, reliability decreases with increasing numbers of components, connections and PC boards; so start counting. Look for components with known lifetimes. For example, are reed relays or FETs used in the range switches? FETs should last longer.

As DMM prices tumble, the cost of repair can rapidly approach—or even exceed—the purchase price. This makes ease of repair and a high mean-time-before-failure (MTBF) even more important. (Of course when a manufacturer codes his components so that you can't replace them yourself, you no longer have to worry about doing the repair—just about paying the repair bill.)

In general, units with fewer parts should be easier to repair. And if one or two LSI chips make up the only components, then repair is even simpler. ICs mounted in sockets, rather than soldered, make life easier, too. A few DMMs offer a self-test feature, which helps even more.

Actually reliability can be, and in many cases is, quantified by a number for MTBF. But one man's 20,000-hour MTBF isn't necessarily the same as another's. They may have arrived at the figure in different ways.

Actual burn-in for a specified number of hours, accelerated burn-in and calculation in accordance with a MIL spec are some ways of getting an MTBF. However, statistical analysis is used in all cases.

But any way it's done and any way it's calculated, a large MTBF leads to a logical question: If a manufacturer believes in his MTBF, why is his meter warranted for only 90 days?

The latest machines

One trend in the latest crop of DMMs is toward increased use of LSI. Theoretically, at least, this should drastically improve MTBF.

LSI also allows power consumption, size and cost to shrink—and this has been happening in the newer units.

Other DMM trends are towards specials and towards combination units—units with the usual DMM functions, plus counters, power supplies and signal sources, for example, in the same box.

Included among these are Doric Scientific's instruments for measuring and for displaying in engineering units the outputs from thermocouples and force transducers; Tektronix' DM501—a temperature-measuring DMM plug-in for the company's TM500-series measurement system; Systron-Donner's Versatester—a V/Ω meter that also measures frequency and generates sines, squares, pulses and dc power for TTL/MOS circuits. And both Hickok and Valhalla Scientific offer a DMM that doubles as a counter.

For the do-it-yourselfers, Heath offers two kits: the IM-1202, a 199-count unit with 21 ranges of V/I/Ω (ac and dc) for $80, and the IM-102, a 1999-count box with 26 ranges of V/I/Ω for $230.

Nobex markets a 3-1/2-digit $150 kit, the 8700K, with 12 ranges of volts (ac/dc) and ohms.

With DMMs shrinking in size and cost, it's logical to wonder if more of the same is around the corner. The answer appears to be yes.

It's not unlikely that we'll see $100, shirt-pocket DMMs within the next year or two. In fact, look for DMMs to follow in the footsteps of handheld calculators—in size, price and marketing approach. ■■

Need more information?

The products cited in this report don't represent the manufacturers' full lines. For additional details, check the appropriate information retrieval number:

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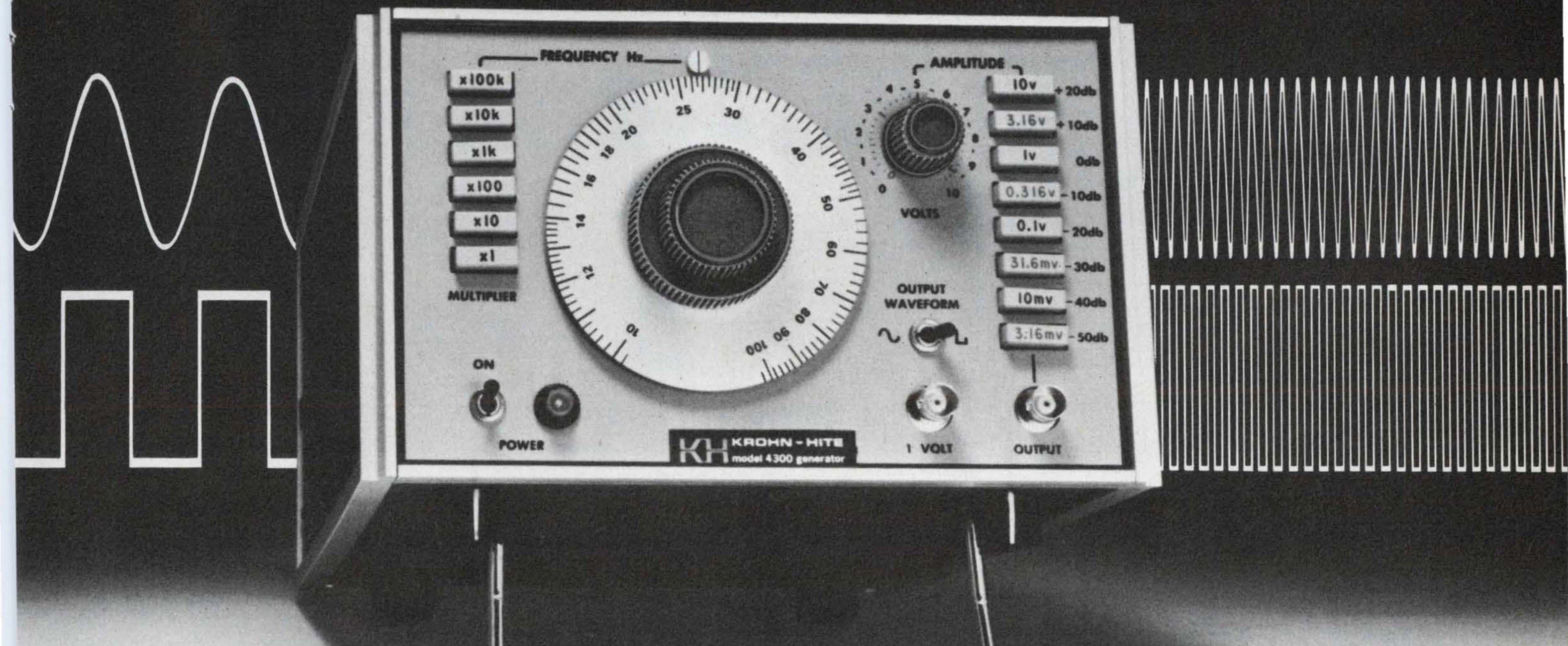

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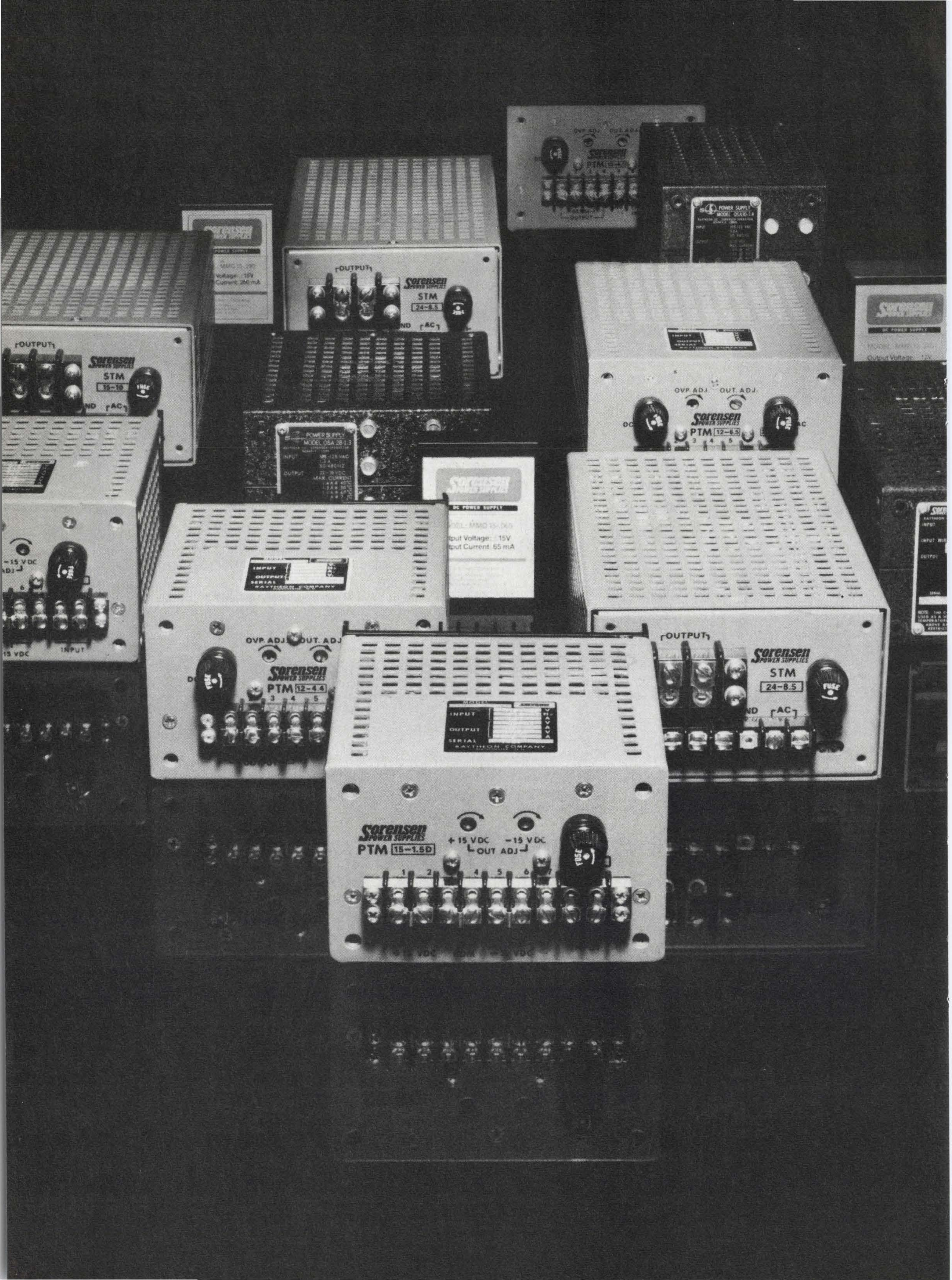

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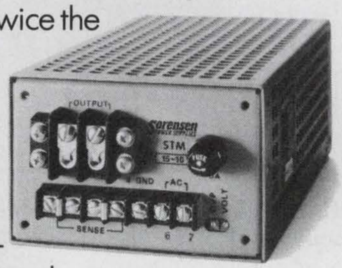

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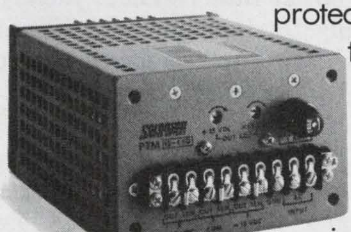

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INFORMATION RETRIEVAL NUMBER 34

Simplify amplifier selection by analyzing the environment. Decide whether you need a differential, instrumentation or isolation amp for your measurements.

For measuring low-level signals from remote sources, single-input operational amplifiers usually can't fill the need. These measurements call for adequate common-mode rejection (CMRR), gain, input impedance and stability. Usually instrumentation amplifiers—with performance tailored to these applications—can solve the tough measurement problems. But there are some situations where even they can't provide adequate performance. Here, isolation amplifiers offer high CMRRs and low leakage currents in the presence of large common-mode input voltages.

A need for improved instrumentation circuits occurs wherever temperature, pressure, force, speed, weight or other process signals must be carried over long distances. Despite the availability of instrumentation-grade op amps in both discrete and monolithic versions, many areas remain where inherent performance deficiencies limit their use.

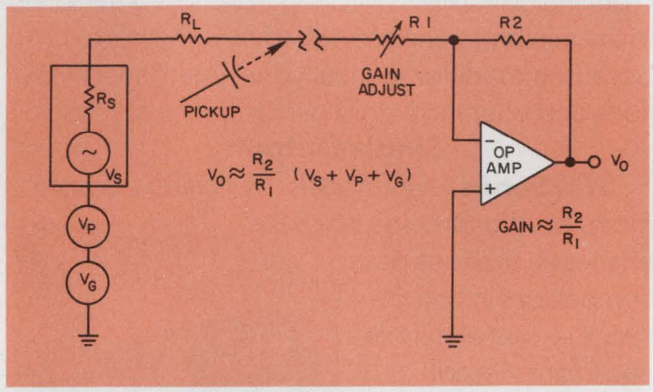
Pickups and ground potentials

Fig. 1 shows a common industrial situation where a typical signal transducer is placed 10 or more feet from its amplifier. In this type of environment there are two major sources of interference.

First, large 60-Hz electrostatic and magnetic fields couple noise into the signal cable. If a power cable carrying a load of 10 kW is spaced about one foot from a signal cable, approximately 10 mV of interference will be coupled into the signal cable for every parallel foot of cable run. Likewise leakage, ground-return currents, lightning pulses, feedback and electrolytically generated potentials add to the wide range of possible interference signals.

Second, if the sensor and amplifier are grounded at different points—even a few feet apart—the ground potentials can vary from a few millivolts to tens of volts. A conventional single-ended amplifier at the end of the cable sees both the noise and the potential differences merely as components of the signal being measured and amplifies them proportionally.

Fred Pouliot, Marketing Manager, Analog Modules, Analog Devices Inc., Route 1 Industrial Park, Norwood, Mass. 02062.



1. **With a simple op-amp measurement circuit,** many sources of error distort accuracy.

Thus interference from pickup, V_P, and ground-potential differences, V_G, can make ordinary single-ended op-amp measurements impossible. For the simplified circuit of Fig. 1, assume that R_1 is much greater than the sum of the line and source resistances, R_L and R_S, and that the amplifier gain is R_2/R_1. Then if for low-level signals, the sum of V_P and V_G is greater than the signal level, the data received will be meaningless.

Differential amps increase CMRRs

Special circuits have been designed to combat these problems. IC differential amplifiers offer higher CMRRs than single-ended op amps and can often yield an economical solution. The basic concept of the differential amplifier is shown in Fig. 2. This circuit is simple and can reject both pickup and ground-potential interference. Ideally the circuit responds only to the difference signal presented between its two input terminals; it ignores the pickup and ground voltages that appear in phase on both signal lines.

Common-mode voltage, V_{CM}, is defined as voltage applied simultaneously to both the inverting and noninverting inputs of an op amp. The CMRR can be considered as the ratio of the differential gain to the common-mode gain.

An unbalance of input resistance causes an error signal, E_{CM}. But E_{CM} can be expressed as a constant, ψ, times V_{CM}, where ψ

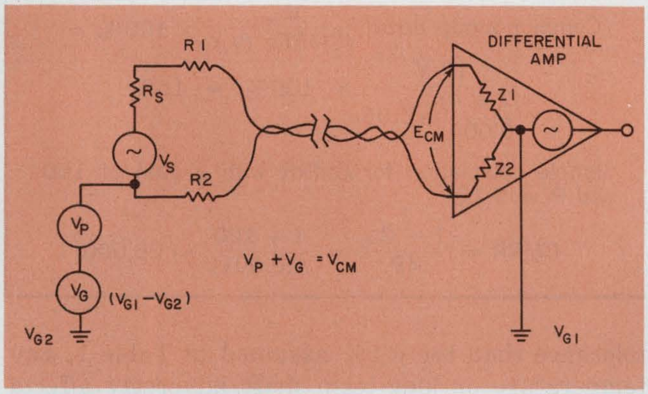
$$\psi = \frac{Z_2}{Z_2 + R_2} - \frac{Z_1}{Z_1 + (R_1 + R_S)} .$$

By combining fractions, letting $Z_1 = KZ_2$ and assuming that

$$Z_1 Z_2 >> Z_1 R_2 + Z_2 (R_1 + R_S) + R_2 (R_1 + R_2),$$

we see that E_{CM} becomes

$$E_{CM} = V_{CM} \left(\frac{\text{resistor unbalance}}{KZ_2} \right).$$



2. **The basic differential amplifier** can reject all common-mode error voltages.

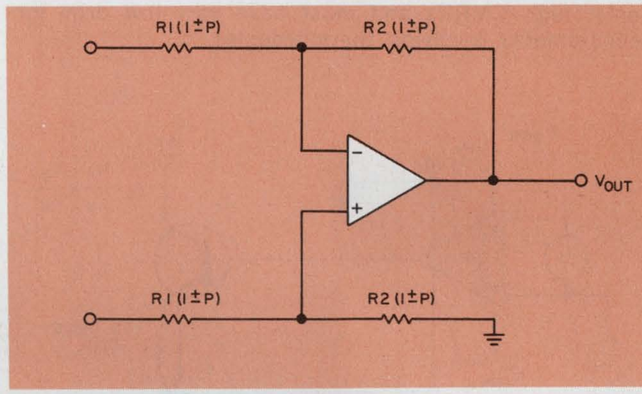
For most cases $Z_1 = Z_2$; therefore K becomes 1, and the resistor unbalance can be called ΔR. The voltage E_{CM} now simplifies to $(V_{CM})(\Delta R)/Z_2$. To minimize the possibility of one signal line being more susceptible to pickup, both wires should be twisted together, thereby guaranteeing that they are an equal distance apart and have an equal capacitance to the source of pickup.

From this analysis, we can see that the amplifier remains relatively immune to ground noise and pickup—but only if its two input terminals present a high impedance to ground. Often specifications allow for a source unbalance of up to 1000 Ω. Thus if the amplifier's input impedance is 100 MΩ, and the V_{CM} is 10 V, the equivalent differential error input is 0.1 mV. If the circuit is for measuring signals of 100-mV pk-pk, the error created by the source unbalance is 0.1 mV/100 mV, or 0.1%.

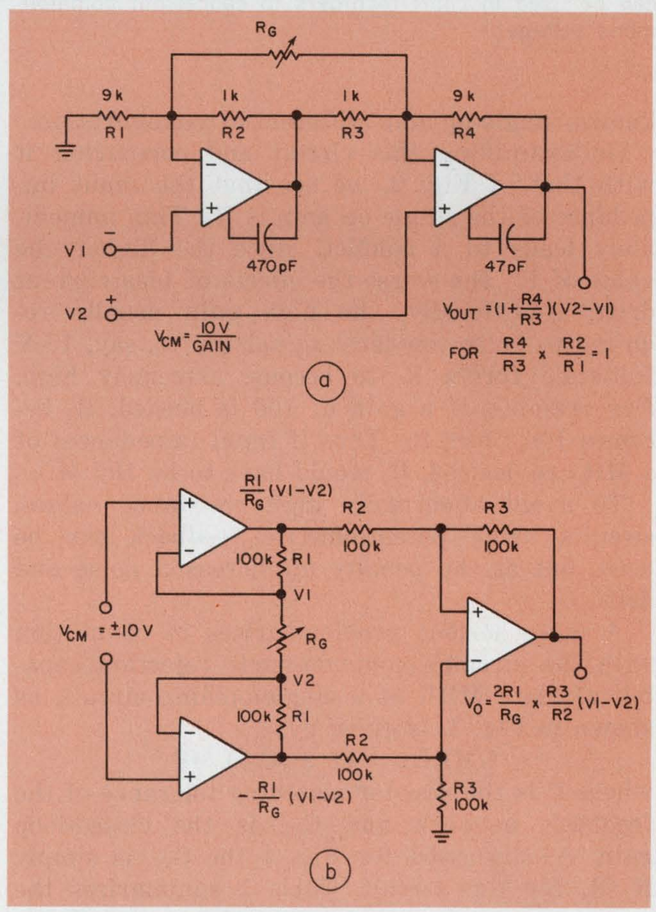
The relationship between V_{CM}, applied to both input terminals, and the equivalent differential input component is V_{CM} divided by the CMRR. Thus, for a typical differential amplifier with a V_{CM} of 10 V and a CMRR of 10^4, the differential component of V_{CM} becomes 1 mV. If the same amplifier has a differential range of 100 mV, the proportionate common-mode error is the ratio of differential common-mode voltage to actual differential signal (or 1 mV divided by 100 mV, which equals 1%). That result sets a limit on the accuracy of the signal measurement. Other error sources, such as drift and nonlinearity, would degrade performance still further.

Various op amps compared

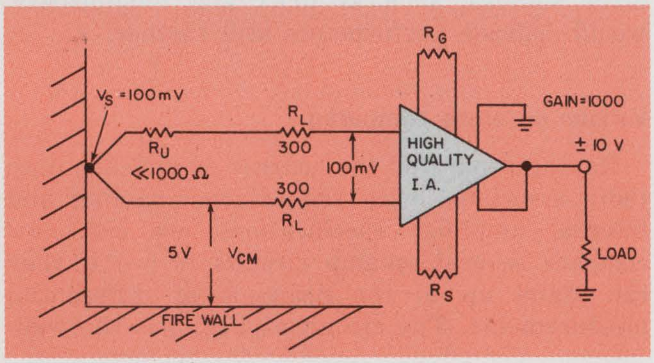
Having separated the sources of difficulty into those associated with the external cabling and internal amplifier specifications, we can now compare several op-amp circuits to see if they can stand up to the demands of differential measurements. The circuit of Fig. 3 is the well-



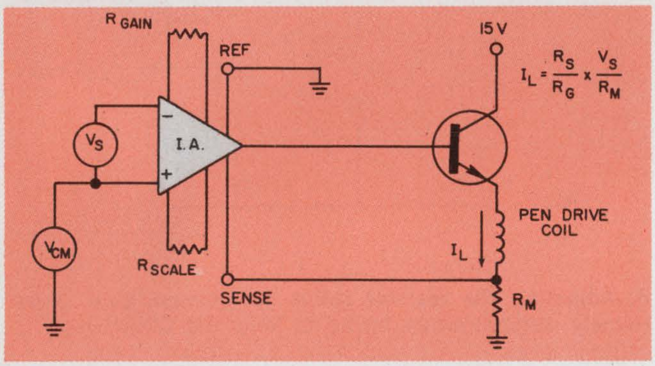
3. **Adjusting the resistor ratios** to increase gain is extremely difficult when trying to keep the CMRR high.



4. **Easier gain adjustments** are possible with a dual op-amp circuit (a) and a triple op-amp circuit (b), but at the expense of higher noise, drift, instability and cost.



5. **Instrumentation amplifiers have** simple gain adjustments, high CMRRs and must have very low drift for measurements involving thermocouples.



6. **A typical general-purpose** instrumentation amplifier can be used in chart recorders to cancel out common-mode voltage.

known single-op-amp differential configuration.

On examining this circuit and comparing it with that of Fig. 2, we see that the input impedance of the single op amp is R_1. This immediately leads to a conflict, since the higher the value of R_1, the worse the effects of bias current drift. Additionally, the high gain usually required to bring low-level signals up to, say, 10-V full-scale forces R_2 to become extremely high. For example, if a gain of 100 is needed, R_2 becomes 100 times R_1. Thus if input impedances of 1 MΩ are desired, R_2 would have to be 100 MΩ.

To avoid abnormally high resistance values, circuits using potentiometric feedback can be used, but at the penalty of increased noise and drift.

A more serious problem arises in connection with the circuit's common-mode rejection capability. The CMRR of a single-op-amp circuit, as shown in Fig. 3, is given by:

$$\mathrm{CMRR} = (1 + G_{CL})/4P$$

where P is the resistor matching tolerance of the feedback network and G_{CL} is the closed-loop gain. As discussed for Fig. 1 the G_{CL} is simply R_2/R_1 for this circuit. Table 1 summarizes the performance of a typical circuit over a three-decade range of gain.

While it is possible to trim resistors to a tighter tolerance than the 0.1% assumed in Table 1, any temperature or long-term drift adversely affects the CMRR. The final blow is the difficulty of making gain adjustments—varying the ratios of R_2 to R_1 in both input legs at the same time. It is difficult and uneconomical to buy ganged potentiometers that can track to within 0.1%. So any gain adjustments require subsequent "tweaking" to restore the CMRR to the original level.

Table 1. Performance analysis for circuit of Fig. 3

Gain (G_{CL})	1	10	100	1000
CMRR = $(1+G_{CL})/4$ k	500	2750	25,250	250,250
Common-mode error for V_s = 100 mV V_{CM} = 5V	10%	2%	0.2%	0.02%

Sample calculation for percent-common-mode error in circuit with G_{CL} = 4 and measuring 50 mV signals in presence of 10-V common-mode (use 0.1% resistors).

$$\text{Common-mode error } \frac{V_{CM}}{(\mathrm{CMRR})\,(V_s)} \times 100\% = \frac{10\text{ V}}{\frac{(1+4)}{0.004} \times 0.05} \times 100\% = 16\%.$$

Sample calculation for CMRR with a gain of 100 and P = 0.1%.

$$\mathrm{CMRR} = \frac{1 + G_{CL}}{4P} = \frac{1 + 100}{4(0.001)} \approx 25{,}000.$$

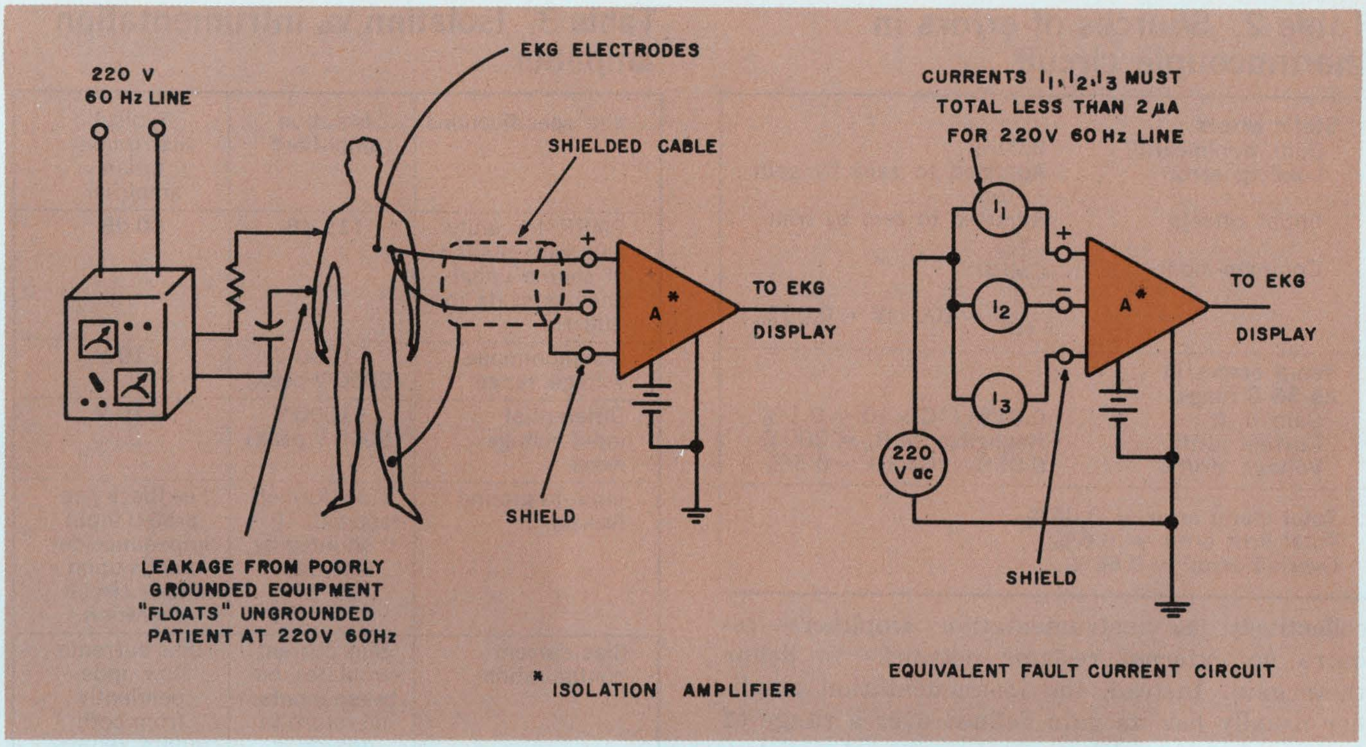
Try using multiple op amps

The circuits in Figs. 4a and 4b are alternatives that permit single-resistor gain adjustment and provide high input impedances without excessively high feedback resistance values. These circuits use multiple amplifiers, connected in the noninverting feedback mode, so that the feedback bootstraps the input resistance to values of 10^9 Ω and higher. The penalty paid in this case is the additional drift and noise of the extra amplifiers. Also, two or three amplifiers are more costly than one, especially when each must have extremely low drift, high CMRR, high gain, high input impedance, etc.

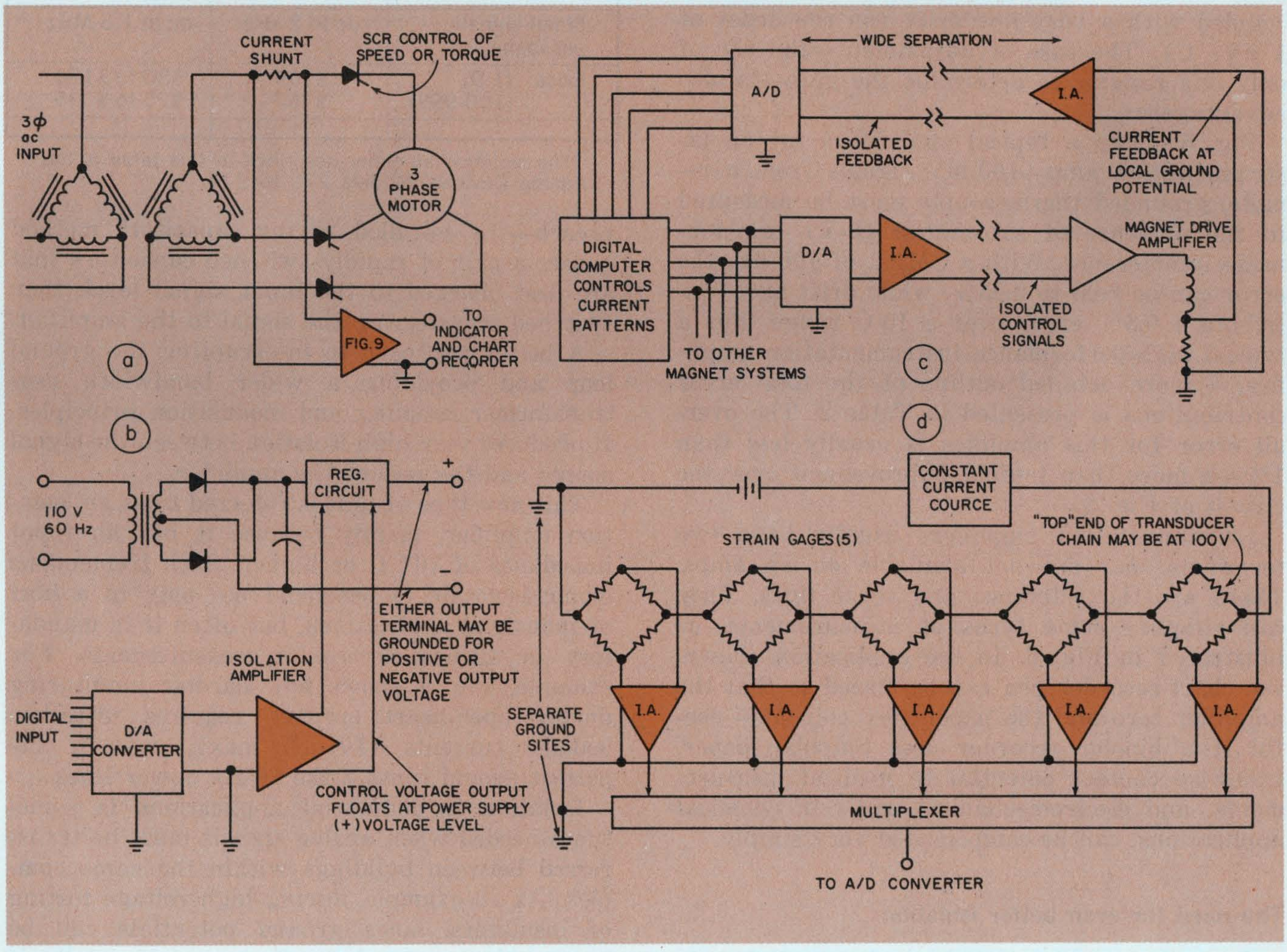
Alternatives to the op amps

Instead of modifying the single-op-amp circuit of Fig. 3, or using the circuits of Fig. 4, we can buy "committed" differential amplifiers designed specifically for data measurements. Such amplifiers can handle signal-acquisition problems in which the low-level signals are impressed on high levels of common-mode interference.

Committed differential amplifiers—referred to



7. **Biomedical measurements require** extremely small input currents and large isolation resistance values.



8. **Isolation amplifiers** can be used to monitor current in motors (a) to control high-voltage regulators digitally (b) to send control signals for a computer-run magnetic focusing system in a nuclear accelerator (c) and to eliminate common-mode voltages from a series string of transducers (d).

Table 2. Sources of errors in thermocouple circuit

Static errors	
Gain nonlinearity	0.01%
Loading error	Adjusted to zero by gain trim
Initial offsets	Adjusted to zero by trim
Common-mode	$\frac{V_{CM}}{CMRR} \div V_s =$
	$\frac{5}{10^5} \div 100\ mV = 0.05\%$
Temp errors in 25-35 C range	
Gain drift	$0.01\%/°C \times 10 = 0.1\%$
Current drift	Negligible for $R_L = 300\ \Omega$
Voltage drift	$0.05\%/°C \times 10° = 0.5\%$
Total static error = 0.06%	
Total drift error = 0.6%	
Over-all error = 0.66%	

collectively as instrumentation amplifiers—require no external resistor networks to define their gain. Instead, the instrumentation amplifier usually has its gain defined over a range of 1 through 1000 with a single external resistor. The desirable features of the amplifier are its high common-mode rejection (around 100 dB) coupled with a very low drift (on the order of 1 μV/°C). The ease of adjustment—the use of only one resistor to determine the gain—is also advantageous.

Fig. 5 shows a typical application for an instrumentation amp—100-mV signals from a remote, grounded thermocouple must be measured in the presence of substantial (5-V) common-mode interference. With a CMRR of 100 dB, the error can be held to 0.05%, while drift may contribute a 0.5% error over a 10-C range. For a typical high-performance instrumentation amplifier, a more detailed outline of the total error contributions is presented in Table 2. The over-all error for this amplifier is usually less than 1%—a more than tenfold improvement over the circuit of Fig. 3.

Instrumentation amplifiers usually have two terminals that are not available on op amps. These are the reference and sense lines. They can simplify some types of measurements, as illustrated in Fig. 6. In the application shown, the chart-recorder pen can be biased so that the amplifier zero and the paper zero coincide—useful if a bipolar recorder uses unipolar paper. Likewise contact potential in medical measurements, and electromechanical emf's in chemical applications, can be compensated very simply.

The need for even better isolation

Over the years a number of approaches to separating common-mode voltages from remote transducer signals have evolved. One such approach—the so-called "flying capacitor" method —uses a pair of rapidly switched capacitors that are first charged to the input signal level, then switched transferring the signal to the amplifier.

A better approach to interrupting the ground loop and providing a wider bandwidth uses transformer coupling and modulation principles. It produces very high isolation between the signal source and the rest of the amplifier.

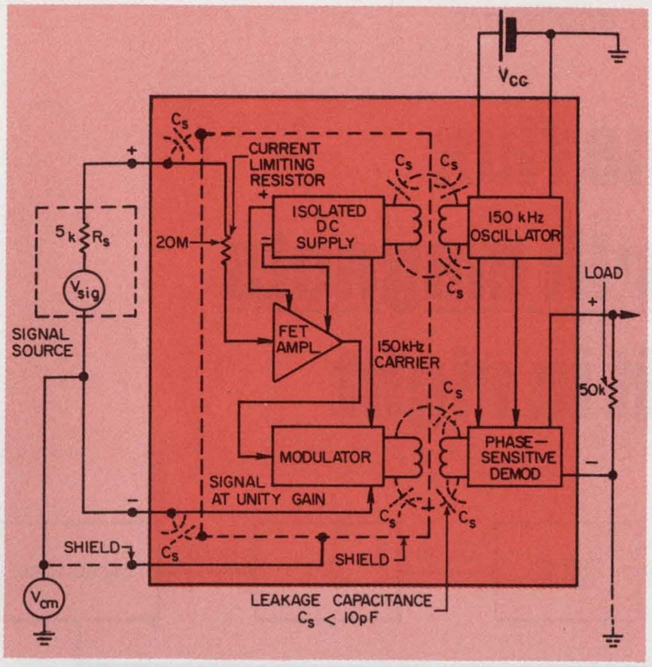
This new type of unit is referred to as an isolation amplifier, mainly because it has an input impedance of $10^{10}\ \Omega$ or higher. Such tremendous ohmic isolation is beneficial not only in a host of industrial applications, but often it is mandatory in medical-electronics measurements. For example, Fig. 7 shows how cardiac monitoring during open-heart surgery requires ultra-low leakage currents (10 μA max), even if the patient should contact the 60-Hz power lines.

Isolation in industrial applications is sometimes needed when analog signals must be transferred between buildings within the same complex. As an example, during high-voltage testing of insulators, large ground potentials can be created during insulator flashover. Normally it would be dangerous to expose instrument operators to the hundreds of volts of short-lived

Table 3. Isolation vs intrumentation amplifier

Key specifications	Isolation amplifier*	Typical instrumentation amplifier
CMRR for unity gain with 5000 Ω of source unbalance from dc to 100 Hz	115 dB	80 dB
Common-mode voltage range	±1000 V (5000 V peak)	±10 V
Differential input-voltage range	±1000 V (5000 V peak)	±10 V
Input-to-ground leakage	Transformer isolated; 10^{11} Ω shunted by less than 10 pF.	Feedback generated input impedance depends upon linear circuit operation.
Bias current configuration	Bias current circulates between inputs; no return to ground is needed.	Bias currents flow independently from both inputs, requiring third wire for bias return.
Small-signal passband	dc to 2 kHz	dc to 1.5 MHz
Price: (1-9) (100-999)	\$109 \$ 67	\$30 to \$150 \$25 to \$ 35

*The isolation amplifier described in this table is the Analog Devices' Models 272 to 274.



9. Patented circuitry of this isolation amplifier gives it a 1000-V, common-mode voltage and a 115-dB CMRR.

ground-potential signals. By use of an isolation amplifier to connect the two areas, the ground potential problems are eliminated and common-mode measuring errors are minimized.

Other typical industrial applications are illustrated in Fig. 8. Some situations arise where "super" instrumentation amplifiers are needed. There are cases where input voltages exceed the capabilities of most semiconductors and reach levels of 1000 V—common-mode. In this case an amplifier like the one in Fig. 9 could do the job. It features a common-mode input impedance of 10^{12} Ω, an internal shield to isolate the input circuitry from the output, single-supply operation and a minimum CMRR of 115-dB at 60 Hz with a 5-kΩ source unbalance.

As a final comparison, Table 3 shows the differences between specifications of available isolation and instrumentation amplifiers. ■■

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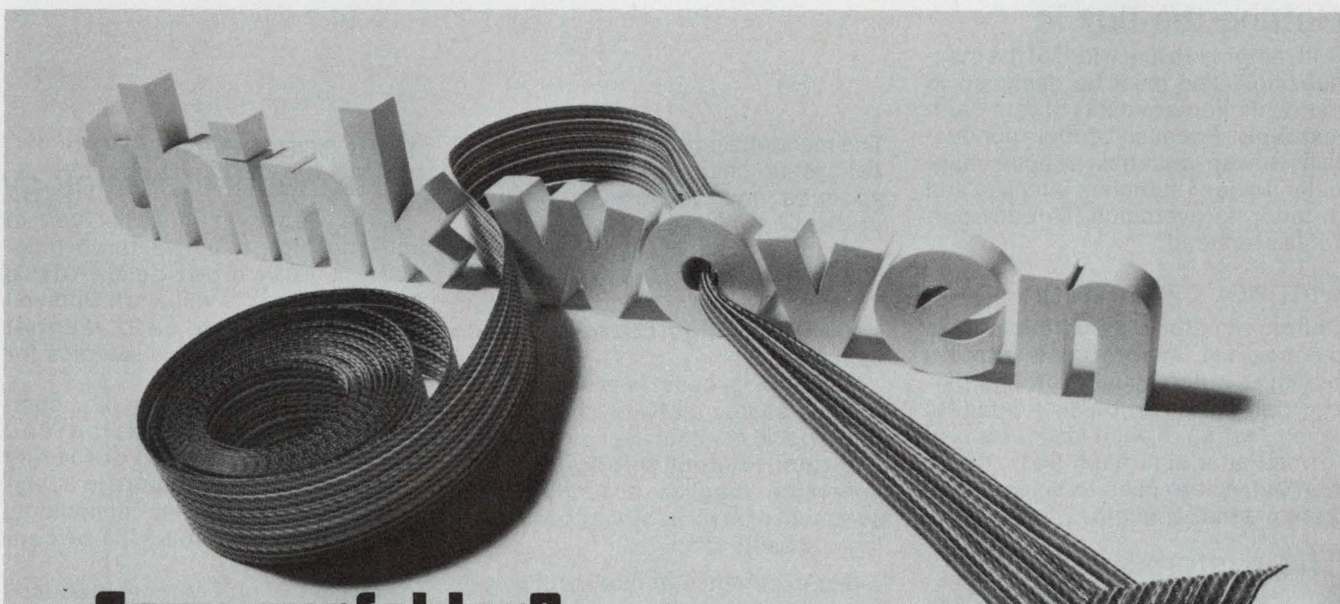

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INFORMATION RETRIEVAL NUMBER 35

One of a series of quick guides for design engineers

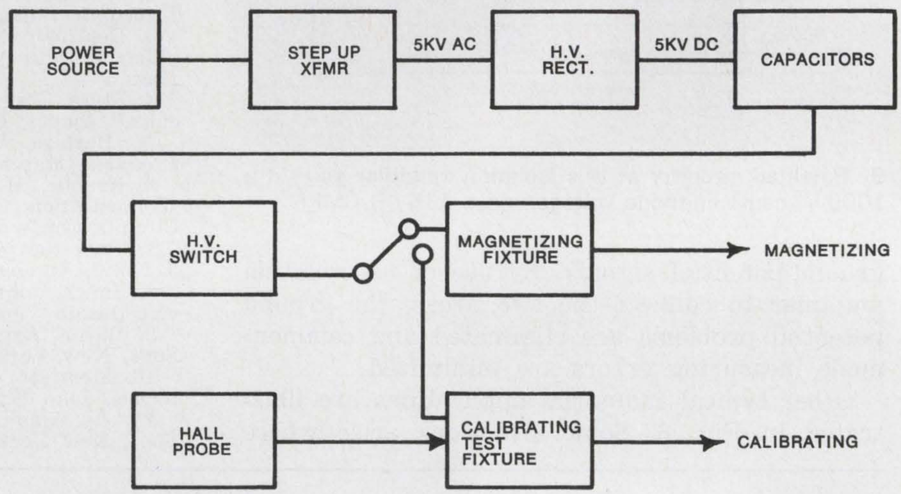
Get all the flux from rare earth magnets by putting it in right

To get all the flux available with high coercive force magnets you need magnetizing equipment designed for their higher field strength requirements.

Magnetizing and calibrating materials such as rare earth cobalt also require close control of field shape and direction to achieve optimum properties.

	saturation requirements	electrical resistivity
Alnico	3-6 K oersted	low
Indox	10-12 K oersted	high
Incor*	35-100 K oersted	medium

*Indiana General's rare earth magnets.



Getting the flux in

Both amplitude and width of the magnetizing pulse must be designed to match the requirements of rare earth materials. Because of their conductivity, these materials require magnetic fields of sufficient intensity and duration to overcome the eddy currents produced.

Magnet calibration

Uniform flux for a group of magnets or magnet assemblies can be achieved automatically through partial demagnetization to a specific level. Testing of each magnet is performed after saturation and calibration pulses are used to achieve uniform magnet strength.

The system approach

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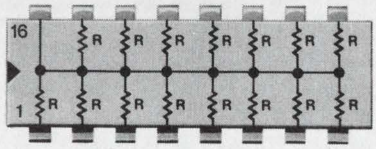

898-1 (15 resistors)
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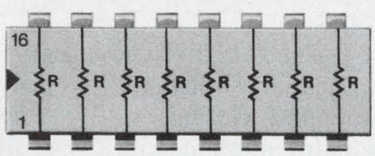

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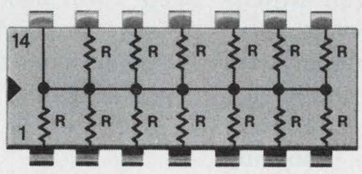
STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

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.



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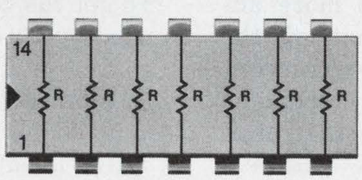

899-3 (7 resistors)
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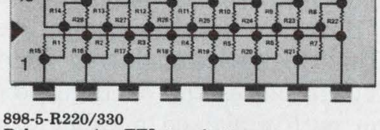
STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

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		



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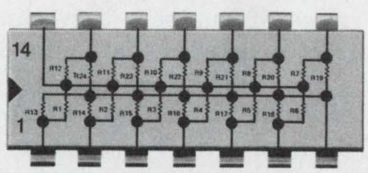

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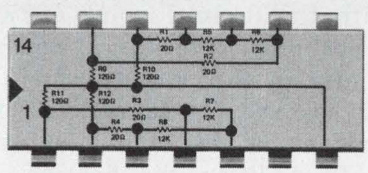

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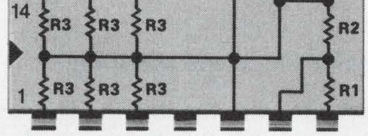
DIP interface network providing resistors for μA711 core sense amplifier configuration.
Price (1,000-4,999) $1.18



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DIP network provides six line terminators and the threshold setting divider for the Intel 3208A sense amplifier.
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INFORMATION RETRIEVAL NUMBER 37

BCD decimal-point location: Accounting machines are best served by a fixed-point system, but scientific calculators need the exponential notation.

This is the fourth in a series of articles on binary-coded-decimal logic. The first three discussed the four basic arithmetic operations. This article covers techniques for placing the decimal point.

Most modern calculators have a floating decimal-point capability. And there's a good reason for this. Computing devices like the slide rule, and even early computers and calculators, operate with only the mantissa of numbers. An operator decides where to position the decimal point when the calculating device gives him the mantissa of the answer.

Second-generation calculators and computers are somewhat better, with their fixed-point arithmetic. Here the operator must present input information to the calculating device in a fixed format: He places the decimal point at a specific location within a fixed number of digits.

But fixed-point machines are seriously limited in the range of numbers they can handle: They can't directly accommodate simultaneously two numbers like 0.123456 and 1234.56. Even adjustable fixed-point techniques, which allow a selection of decimal-point locations in a number, still limit the range of numbers that can be handled.

Floating-point arithmetic can accept a number with the decimal point anywhere. Floating point not only determines where the decimal point goes in the output but, in the more advanced systems, optimizes the format of the answer for the maximum number of significant digits. In addition the floating-point technique extends by many orders of magnitude the range of numbers the calculator can handle within a finite word length.

Fixed point has some advantage

In accounting machines, the decimal point is fixed to the left of the second least-significant digit to separate dollars and cents. There can be no ambiguity as to what the various digit locations mean. However, when making scientific computations with fixed-point arithmetic, the programmer must continually keep track of the decimal point. He must adjust the data to avoid losing the most-significant digits beyond the machine's fixed register length. Should this occur, an overflow results, and usually the calculator stops until the data are shifted manually.

A 10-digit machine, at the extremes, can process integers between the values of 1 and 10^{10} or fractions between 10^{-10} and 1. Beyond these the machine overflows or underflows. An overflow would cause the number 11,000,000,000, say, to look like 1,000,000,000 in a 10-digit machine. A fractional number, .000|000|000|01, would appear simply as zero.

To use a fixed-point machine, the programmer must scale, or multiply numbers, by a convenient power of 10 so the inputs and partial results stay within the machine's capacity. Then the operator rescales the output to get the correct answer.

For example, multiplication of X = 20,480 by Y = 51,200 requires a 10-digit machine. But in, say, an eight-digit machine, with the decimal point fixed at the extreme right, X and Y must be scaled. X must be shifted one digit and Y two digits to the right. Thus:

$$X' \cdot Y' = Z'$$

or 00,002,048. × 00,000,512. = 01,048,576.

To get the correct answer, Z′ must now be multiplied by $10^1 \times 10^2 = 10^3$. Thus

$$Z = 10^3 Z' = 1{,}048{,}576{,}000.$$

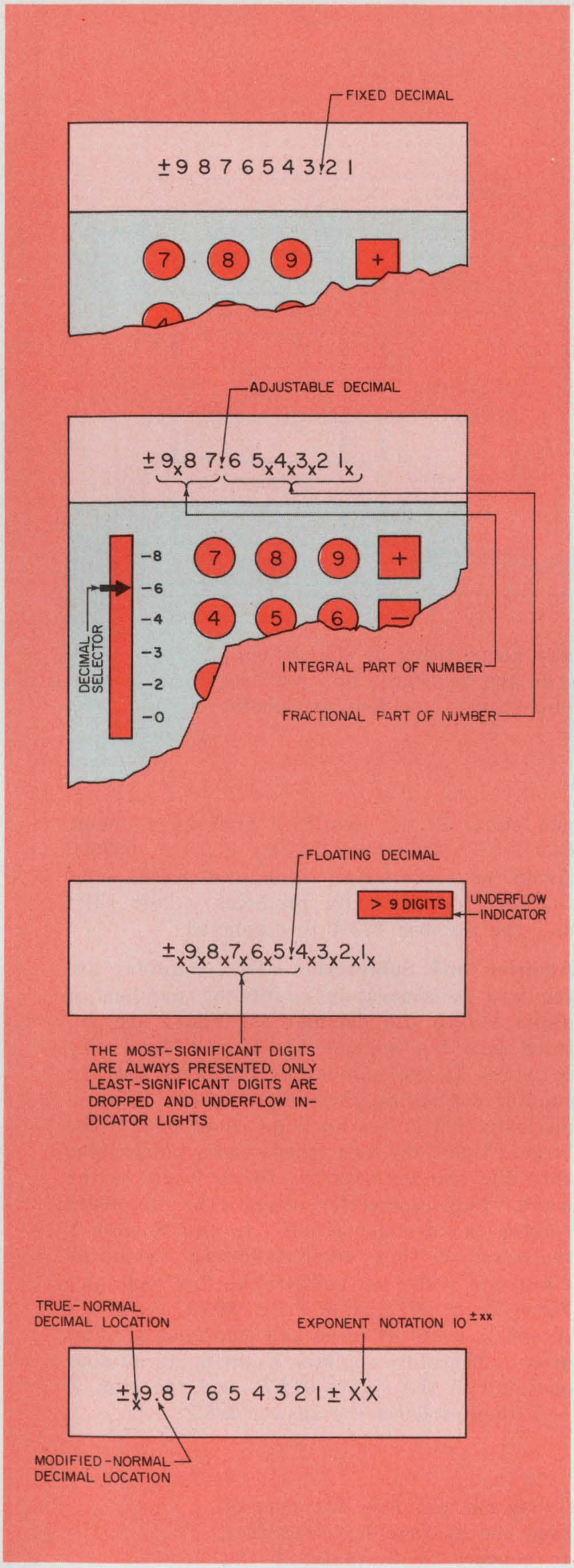
A similar procedure must be followed when multiplying fractions.

But fixed-point operation does have some advantages. When properly scaled, it provides maximum accuracy and resolution. It is faster than any floating-point method, and it results in a machine that is less complex and costly. Also, as mentioned before, in applications like accounting and other business transactions, fixed-point operation is preferable.

An adjustable decimal can help

An adjustable decimal-point system can always do what any fixed-point machine can do,

Hermann Schmid, General Electric Co., Box 5000, Binghamton, N.Y. 13902.



Calculator displays use a variety of methods for handling the decimal point. They vary from the simplest fixed-point system used in accounting machines to the most advanced floating-point and exponential notation methods for scientific calculations.

and in addition it can help eliminate the need to keep track of the scaling factors. However, some accuracy and resolution must often be sacrificed. In an adjustable system the operator can set the decimal point manually at a choice of positions—from the left of the most-significant digit to the right of the least-significant position. But the decimal point remains fixed, unless the operator decides to set it to another position.

Assume that X = 0.02048 must be multiplied by Y = 51.2. With a fixed-point accounting machine, X would have to be scaled by 10^3 and Y by 10^{-1} to make both numbers fit the fixed decimal location. After multiplication, the product would have to be scaled again, but by 10^{-2}. However, in an adjustable-point, eight-digit machine the decimal points can line up as follows: For

Z = XY,
X = 00.02048,
Y = 51.200000,
Z = 01.048576.

The operator need do no manual scaling.

But problems arise when the input variables have greatly different magnitudes. In the example

divide Z = 01.048576 by Y = 51,200,000

the operator, again, must do manual scaling, as with fixed-point arithmetic. An eight-digit machine does not have sufficient room to hold Y to the left of its decimal point, if the decimal points of Z and Y are aligned. Also, the answer X = Z/Y = 0.000 000 020 48 would not fit to the right of the decimal point:

01.048 576
51,200,000.000 000
|00.000 000|020 48
→|eight-digit|←
capacity

Hence Y must be scaled by 10^{-6} to produce Y′ = 51.2. Then X′ = 0.02048, which must then be multiplied by 10^{-6} to obtain the correct answer:

$$X = 10^{-6} X' = 0.000\,000\,020\,48.$$

Floating point is better

Though the adjustable decimal-point system is helpful, it still requires a conscious decision by the operator—the equivalent of manual scaling—before data can be entered into the calculator. In a long sequence of calculations this may require the operator to reset the decimal location repeatedly to avoid underflow or, worse, overflow problems. With a floating-point system, the calculator user can enter a problem like

$$0.2048 \times 51.\ 2 = Z$$

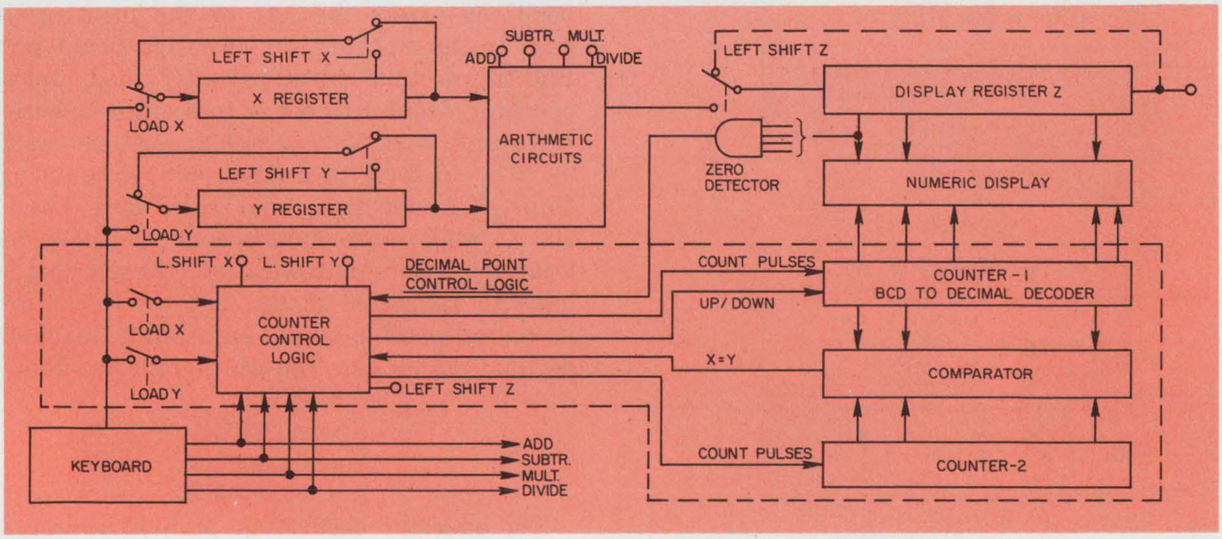
exactly as it is written. An eight-digit machine would automatically give this answer:

$$Z = 10.485760.$$

But a six-digit machine would show

$$Z = 10.4857 + \text{(underflow signal)}.$$

Floating-point system diagram



A floating-point calculator automatically keeps track of the decimal with the help of the decimal-point key on the keyboard. The routines performed by the circuit are different for each of the four arithmetic operations, thus:

Multiplication—The count of the number of digits in front of the decimal point for the multiplicand and multiplier are accumulated in counter-1. The circuit then uses this total to place the decimal of the product. For example, when 43.5 is multiplied by 375.4, counter-1 accumulates a count of five, and therefore the answer—15329.9—has five digits before the decimal. However when numbers like 2 × 32.2 are used, the answer inside the machine becomes 064.4, to provide for three digits before the decimal. But the presence of the zero in the most-significant place automatically causes a left shift of the number and decimal so that the display shows 64.4 with only two digits before the decimal.

Division—The dividend adds and the divisor subtracts from counter-1 a quantity equal to the number of digits each has in front of its decimal. However the counter starts from the count of one when division is called for (multiplication starts from zero). The quotient then has a number of digits before its decimal equal to the resulting difference. Thus, 64.4/2 = 32.2, but 15329.9/43.5 = 0375.4. Again, as for multiplication, the presence of the zero automatically produces a left shift and the number 375.4 is displayed.

Addition and Subtraction—Two counters are required to separately count the number of digits before the decimal as inputs are entered into the augend (X) and addend (Y) registers. If the number of digits differ, the counter containing the smaller count is automatically fed pulses until its count equals the larger. Simultaneously, these same pulses also shift the number with the fewer digits to the right. This correctly aligns the numbers (aligns the decimal points) in the X and Y registers so that correspondingly weighted digits are added or subtracted. For example: When X = 273.5 and Y = 14.70, counter-1 records a count of three and counter-2 a count of two. Therefore register X shifts its number one step to the right—014.7—and the sum X + Y then produces the answer 288.2.

Although the implementation in this diagram provides for control over the display of the decimal location, the average logic-designer can instead easily figure out how to convert the outputs of the counters to a numerical readout (with a sign) for an exponential type of display. In addition, the circuit must be made to work with either a normalized or modified-normal mantissa.

The most-significant numbers of the answer are retained and the least-significant dropped. In the extreme, the decimal can move to the far right of the display's capacity. Thus the machine never overflows. With overflow, the most-significant digits are lost and answers become meaningless. But underflow only drops the least-significant digits, and the answers are still usable. When least-significant digits are dropped, a round-off procedure helps improve accuracy. To round off, the circuit merely adds the number 5 to the dropped digit and only propagates the carry, if any, to the displayed digits. This feature is included in the better calculators.

However, should the decimal point move beyond the right-most position (go off scale), there is no indication of the number of places the integral part of the number has, and the data again lose their meaning. Some calculators provide a free-floating decimal input and a fixed selectable decimal output, but then the overflow problem must be contended with. Similarly for fractional answers, the underflow feature may completely lose the number. In the example

$$1.048576/51,200,000 = 0.000\,000\,002\,48,$$

the answer is completely lost in an eight-digit machine, though a 12-digit machine could handle this problem. But even such a machine could easily reach its limit in many scientific problems. A calculator's numerical range is vastly expanded by the use of exponential notation.

Exponential notation extends the range

In exponential notation, a number N is represented in two parts: the significant numbers or mantissa (F) and the characteristic, or power of 10 (E). Thus:

$$N = F \cdot 10^E$$

The mantissa can be either in a true-normal range—$0.1 < F < 1.0$—or in a modified-normal range—$1.0 < F < 10$. The modified presentation has the advantage of eliminating the need for a zero ahead of the decimal point.

The exponent E can be any integral number, but it is limited to two digits in almost all calculators. Both F and E can be positive or negative. Thus, with a signed, two-digit exponent, the numbers handled can range from 10^{-99} to 10^{+99}. (Note that, though part F is called the mantissa, this is only by analogy to logarithmic numbers; numbers in this notation are not logarithms.) The figure shows the exponential notation as it is usually presented in calculators.

Though the exponential notation finds extensive use in scientific calculators because of its tremendous numerical range, there are a few disadvantages:

- The available resolution is reduced by the number of digits used for the exponent.
- The zero value is not uniquely defined—True zero would require an infinite number of zeros after the decimal point. But the advantages far outweigh the disadvantages, and the disadvantages needn't be too serious. For example, in one 13-digit calculator three digits are used for the exponent and its sign, so that only a 10-digit mantissa can be displayed. This is a small price to pay for the large increase in range.

With exponential notation, true zero requires an infinite number of zeros to the right of the decimal point. Thus, when the exponent is greater than the number of available displayed mantissa digits, a number may or may not be a zero, even if all the displayed mantissa digits are zero. Therefore the presence of a true zero with exponential notation—or, for that matter, with any floating-point system—must be checked carefully. This also is a small price to pay for the advantages gained.

Operations with exponential notations

Besides being careful with zeros, an operator using an exponential-notation machine must also follow certain rules for addition or subtraction. To add or subtract two numbers their exponents must be the same. If the two numbers are

$$X = F_x \cdot 10^x$$
$$Y = F_y \cdot 10^y,$$

exponents X and Y must be made equal. But first the machine has to decide which to change. Decreasing the exponent of any number is undesirable, since it makes the mantissa larger and the most-significant digits may be lost in the overflow. But increasing the exponent shifts the mantissa to the right, and at worst, some of the least-significant digits can drop into the underflow. Accordingly, the machine increases the smaller exponent until it equals the larger.

As an example take

$$X = 1.23456 \times 10^4$$
$$Y = 6.543 \quad \times 10^{-2}.$$

The exponent of Y must be made equal to that of X. Hence the numbers to be added become

$$\begin{aligned} X &= 1.234560000 \times 10^4 \\ Y &= +\,0.000006543 \times 10^4 \\ \hline X + Y &= 1.234566543 \times 10^4 \end{aligned}$$

in a 10-digit-mantissa calculator.

If only eight digits are available for display, the two least-significant digits, 4 and 3, are lost and the answer is only slightly less accurate.

When the sum of two numbers has a carry beyond the digit capacity of a machine, the better calculators shift the sum automatically one digit to the right and add a one to the exponent of the sum—to avoid an overflow and loss of data.

But, when the difference between two mantissas generates a borrow into the overflow, as when a larger number is subtracted from a smaller, a mere shift and exponent change can't produce a correction. The difference is a nines complement, and only with further processing can it be changed to a true negative quantity.

Thus:

$$\begin{array}{lcll} X & = & 5.67890 & \times 10^{3} \\ Y & = & 7.89003 & \times 10^{3} \\ \hline X + Y & = & \textcircled{1}\ 3.56893 & \times 10^{3} \\ \text{overflow} \lrcorner & & & \\ \text{shift right} \rightarrow & & 1.35689\ \textcircled{3} & \times 10^{4} \\ & & \llcorner \text{underflow} & \end{array}$$

Multiplication of two numbers in exponential notation requires no alignment of the exponents. The two input mantissas are multiplied together and the exponents are summed. No overflow in the mantissa of the product can result if the numbers are in the true-normalized range. This is an advantage in working with true normalization rather than the modified normalized range. However, the exponent of the product can underflow or overflow. For a two-digit exponent, this means that the product is outside the range of $10^{\pm 99}$. And, of course, the sign of the product is determined by the signs of the two multiplied mantissas. An Exclusive-OR is all the logic needed for this function.

Division in exponential notation is very similar to multiplication. The two input mantissas are divided and the exponents are subtracted. Again, the sign of the quotient can be determined with the use of Exclusive-OR logic. However, in division, if the dividend mantissa is larger than the divisor when both are in the true-normalized form, the quotient mantissa will generate an overflow. This overflow is handled by an automatic one-digit shift of the quotient mantissa to the right and the addition of a one to the quotient exponent. Thus:

$$\begin{array}{lcl} Y/X & = & \dfrac{.6543 \times 10^{-2}}{.1234 \times 10^{-4}} \\ \text{overflow} \urcorner & & \\ & = & \textcircled{5}\ .30226 \times 10^{-6} \\ & = & .503226 \times 10^{-5} \end{array}$$

and the answer is automatically presented in the desired true-normal range.

Conversely, for inputs in the modified-normal range, when the dividend is smaller than the divisor, a zero will appear in the most-significant position. This is automatically changed by a one-digit shift to the left and the addition of a one to the exponent, as follows:

$$\begin{array}{lcl} Y/X & = & \dfrac{6.543 \times 10^{-3}}{12.340 \times 10^{2}} \\ & = & 0.503226 \times 10^{-5} \\ & = & 5.03226 \times 10^{-6}. \end{array}$$

This provides an answer in the same modified, normal form as the input numbers. ■■

The fifth article will discuss BCD square-root.

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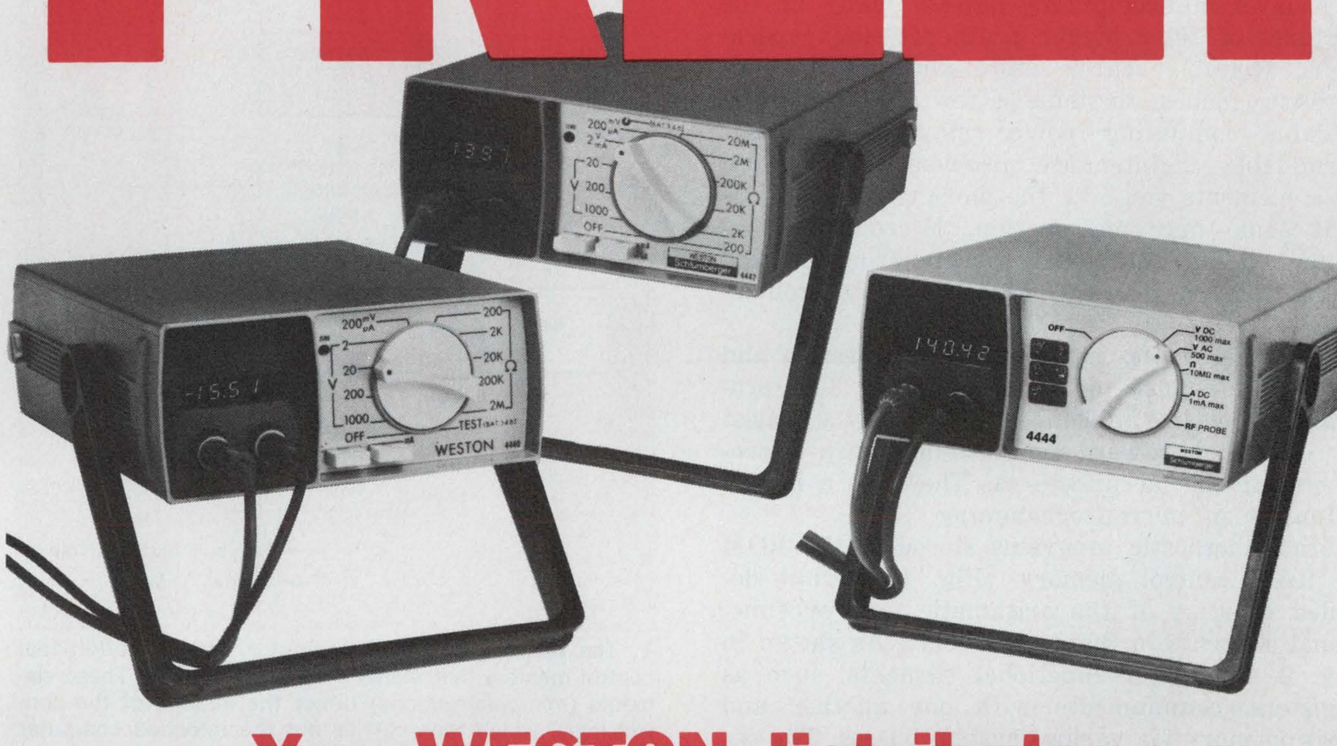

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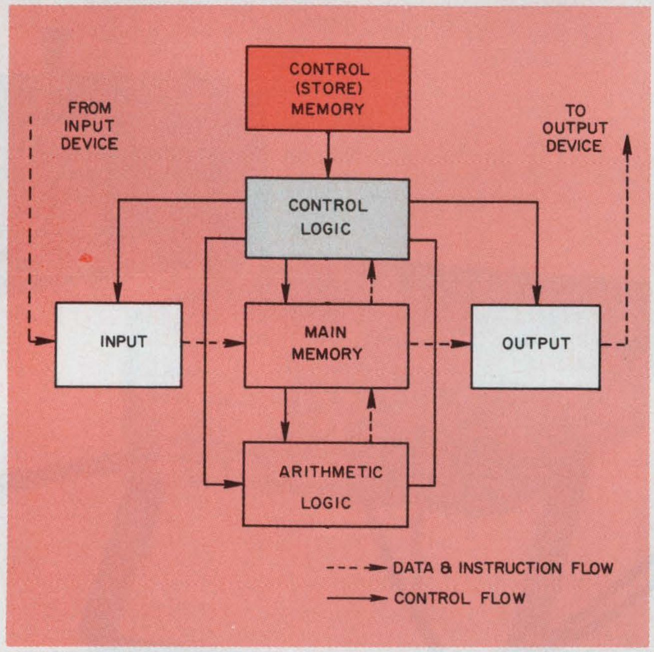
Simplify minicomputer maintenance

with microdiagnostics. The programs provide fault-isolation to single functional elements.

Today's minicomputers possess many of the features of their bigger brothers—stack operations, writable control store and multiple addressing modes, to name a few. But such formidable computing power may also present formidable maintenance problems. The more logic elements you add, the more chance there is that some may malfunction. Microdiagnostics, which exercise functional elements from a stored microprogram, are an efficient way to troubleshoot.

Microdiagnostics perform in-house testing and field maintenance on minicomputers. The programs are easily implemented with only a modest increase in hardware, on machines with microprogrammable architectures. They are a logical extension of microprogramming.

Microdiagnostic programs stored in the ROM or RAM control memory (Fig. 1) permit detailed exercise of the arithmetic unit or functional elements in the control logic. As shown in Fig. 2, the major functional elements, such as registers, communicate with one another and main memory via various system busses. The objective of this or any other diagnostic procedure is to observe a predetermined bit pattern through a given data path of short length. An appropriate microdiagnostic program, residing in the control store can retrieve the test pattern—usually all ONEs or all ZEROs from main memory—transfer it through some short path and compare the resulting test pattern with the original. For short enough paths, any mismatch can be traced to a specific single gate or flip-flop.



1. **The microprogrammed computer** uses an additional control memory that stores program elements. These elements (microinstructions) direct the actions of the control logic, which then carries out the intended computer operations in the conventional manner.

A typical microdiagnostic setup

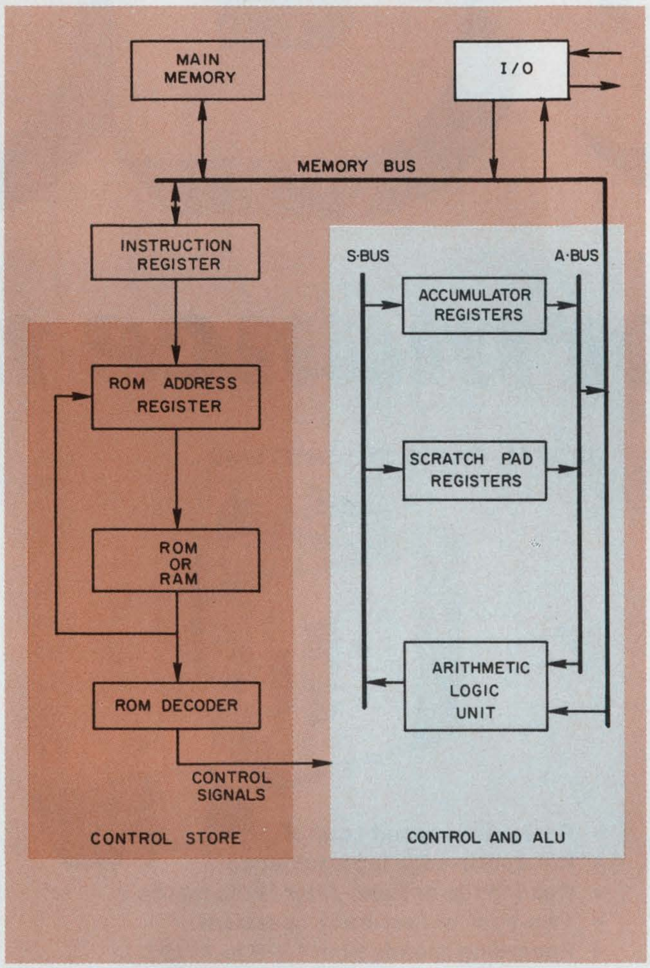
Suppose the test objective is to check one of the accumulator registers (Fig. 2). With the typical microdiagnostic facility, some additional hardware is required—a set of Exclusive-OR gates, lamp drivers and a maintenance panel, the latter having a loop-test switch. The incorporation of this hardware in a typical computer data path is shown in Fig. 3.

Two bits of the microinstruction word are reserved for testing. Test 1 loads all ONEs and Test 0 loads all ZEROs. This control field assignment is valid only for the microdiagnostic mode. These bits normally control other functions during the run mode.

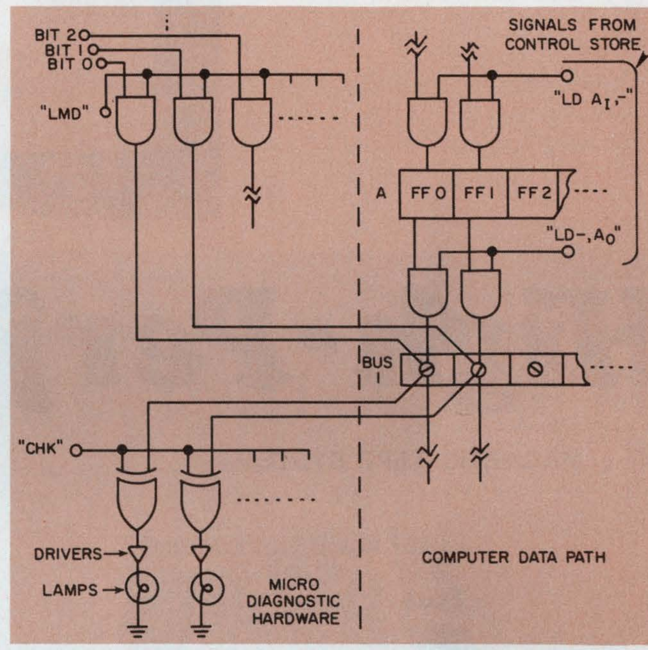
A simple microprogram (see table) suffices to test register A. Execution of the LMD (load microdiagnostic) microprogram instruction loads ZEROs into register A. The second microinstruction reloads A with itself, thereby exercising the input/output gates of the register. The third microinstruction tests the loop switch (a manual toggle switch on the maintenance panel). The previous instruction is repeated if the switch is set. The indicator lamps (Fig. 3) display the Exclusive-OR of bus 1 (contents of A) and the predefined pattern (all ZEROs in this case).

During repetitive looping the operator spots malfunctions with the lamps. Also, he can moni-

Michael Andrews, Assistant Professor, Engineering Dept., California State University, San Diego, Calif. 92115



2. **Control signals from the decoder** direct the movement of data between registers, arithmetic unit and main memory. The control signals operate various gates that transfer data between the registers and the busses. I/O and memory operations are omitted for simplicity.



3. **Microdiagnostic hardware** permits direct examination of a register by intercepting and displaying the signals on the bus that serves the register. Signals from the control store load the requisite test patterns. The Exclusive-OR gates compare the actual pattern with the theoretical.

Microdiagnostic program for register A

MICROPROGRAMS	COMMENTS
• • •	
LMD BUS I TEST - 0	LOAD A WITH ZEROs
LD A_I , A_0	
CHK LOOP SW (SWITCH SET → back to LD; SWITCH RESET → next)	GO TO NEXT PROGRAM IF SWITCH IS RESET

tor each gate or flip-flop with an oscilloscope and replace or repair suspect hardware. To proceed to the next data-path diagnosis, the operator simply resets the loop switch. A comprehensive test results from programming each data path test with the three instructions.

Microdiagnostics offer higher resolution in fault isolation and detection than tests based on machine-language instructions. In the latter—the most elementary operation—a single instruction requires exercise of several functional elements. For example, testing register A requires the support of the program counter and instructional register. With microdiagnostics, tests occur at the primitive function level. The microdiagnostic routines are segmented to address given data paths such as the adder and secondary storage paths. This inherent modularity allows for a building-block approach that incorporates successfully exercised functional elements into subsequent tests without destroying resolution. ■■

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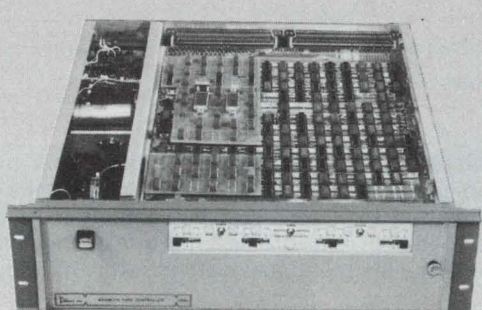

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They'd rather switch than take flight,

says this European manager, who keeps his engineers in the company by making it easier for them to move to other departments.

Cicero once said, "It is pleasant to recall past troubles." The trouble that existed in our company and in many other companies in our industry not long ago was that most of the engineers who had been with the company for a while were worried about their future. They felt that career progress lay in sales, administration or production where the money was, but that the opportunities to move there were limited. And, to a large extent, they were right.

Engineers were mostly locked into design work. As employees, they believed they were just part of the expense budget, with no real control over their future. They showed their unhappiness with a loss of enthusiasm for their work.

The problem was complicated by ill will between engineers and production people. There's a lot of technical talent in the production group, but the engineers often suspected that their designs were being altered needlessly and without consultation.

The solution was obvious. To make our engineers happier and more productive, we had to open opportunities for them to shift around in the company and advance.

Fashioning a marketing mentality

We put new engineers—those in their creative period and filled with enthusiasm—in the development department. Later on we gave them an option to go into sales, production, or application.

We also opened new opportunities for professional development in the engineering department. We encouraged engineers, for example, to travel with the product managers, so they could meet customers and discuss firsthand the problems of their product designs. Because we wanted to promote a marketing-oriented mentality in the engineering department, we encouraged more contact with marketing and the factory. Engineers were urged to get involved with the production people, especially when their designs were in the early prototype stage.

Today we have engineers who are prepared to take over jobs in different areas of the company. For example, an applications engineer we have is ready now to work in the sales department; development engineers are ready to take control of a production line; one engineer who's been involved in cost problems in a design is ready to go into industrial administration. With this kind of preparation, we meet two objectives: We keep engineers happy and productive, and we fill important jobs from within the company.

Engineers now realize that they don't have to stay in engineering indefinitely; they can move into other functions if they want to. There's a bonus for the company, too—the various departments are getting knowledgeable people. The sales department, for instance, gets engineers who understand the whole web and skein of the product.

Our loss is our gain

Most engineers, we find, want to get into administrative work. The scientist type—about 40% of all engineers—is no problem; he's always happy designing. We lose a good many of our engineers in the engineering department, but we lose them to other departments in the company, not to the competition. If we didn't give the engineers a chance to work in other departments, we'd have a group of unhappy, relatively unproductive people on our hands who were ready to quit the company.

Three or four years ago I tried to glue engineers to engineering, but engineering can be a very static job over a long time. Now there are more opportunities. Our engineers do the design work, but they don't feel that it has to be their life's work. It hurts to lose good engineers, but we'd lose them anyway. And, of course, we've been able to hire more good engineers than ever before because of our policy of giving them the option to move to other departments.

We have a smaller pool of good engineers in Europe than you do in the U.S. When we get a good engineer, we want to keep him. ■■

Dr. Ingeniere Raimondo Paletto, Vice Director General, SGS-ATES, Agrate, Italy.

Dr. Ingeniere Raimondo Paletto

Education: Graduate in electrical engineering, Polytechnic of Turin, Italy.

Responsibility: Vice General Manager, SGS-ATES Componenti Elettronici Spa, responsible for new products, research and development.

Experience: Four years research in advanced electronics at the Istituto Elettrotecnico Nazionale, Galileo Ferraris, Turin, followed by two years teaching electronic circuit design, at the same institute; nineteen years industrial experience including design of studio TV equipment with RAI (Italian State Broadcasting Company), and of avionic electronics with Fiat's Aviation Division. Previous management experience as assistant to Fiat Vice General Manager, and as technical Director ATES Componenti Elettronici Spa.

Articles: Various technical articles and patents in the field of power supply, vhf antenna coupling systems and semiconductor technology.

Personal: Married with two daughters, aged 13 and 11.

Hobbies: Amateur fruit growing; tennis and skiing; reading history books.

Employer: SGS-ATES Componenti Elettronici Spa was formed in late 1972 through the merger of the two leading Italian semiconductor manufacturers, SGS and ATES, both with experience in the development and manufacture of semiconductor and integrated circuits dating back to the late fifties. SGS-ATES has subsidiary companies in the U.S. (SGS-ATES, Semiconductor Corporation, Newtonville, Mass.) France, Germany, Sweden and the Philippines. Production is carried out in factories located in Agrate and Catina, Italy; Falkirk, Scotland; Rennes, France; and Singapore while development and applications is mainly concentrated at the group's large research and development centre at Castelletto near Milan.

Among the company's more recent achievements: The Planox patent diffusion process for MOS integrated circuits; 2nd generation integrated audio power amplifiers with full short-circuit protection; a large range of bipolar digital high noise immunity circuits; and a series of discretes and ICs to back its innovations in partitioning for B/W and color TV.

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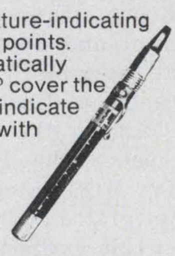
3. **TEMPILSTIKS°:** temperature-indicating crayons of calibrated melting points. Available in over 100 systematically spaced temperature ratings, Tempilstiks° cover the range from 100° to 2500°F. Tempilstiks° indicate the specified temperature, by liquefying with a tolerance of ±1% of its rating.



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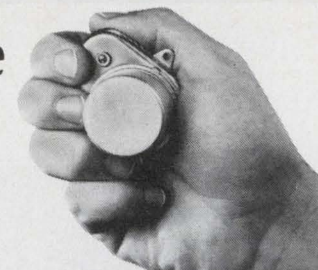

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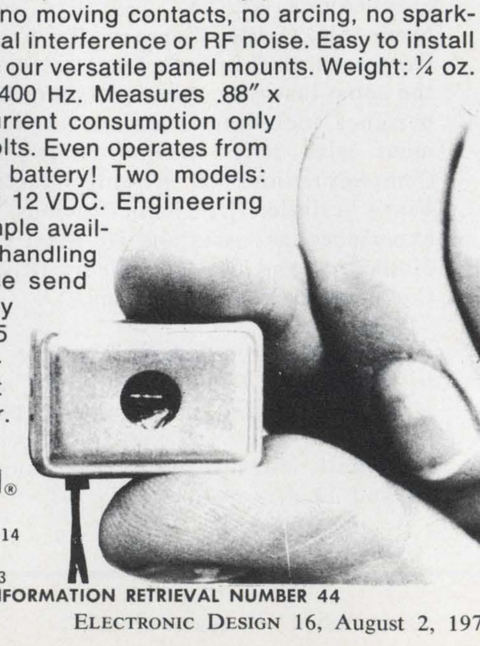

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INFORMATION RETRIEVAL NUMBER 44

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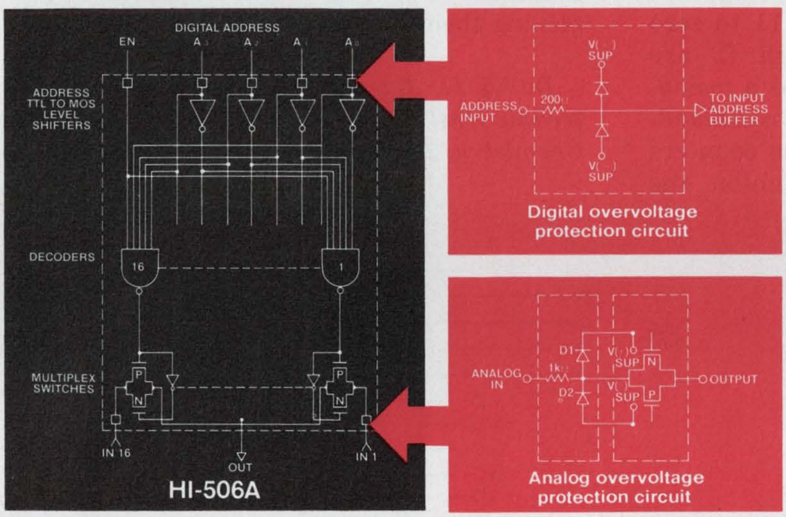
Our new 16-channel analog multiplexer– the only monolithic multiplexer with internal overvoltage protection. Features performance characteristics previously unavailable, and it's pin-for-pin replaceable with the DG-506.

Designated the HI-506A, this new Harris 16-channel multiplexer combines DI/CMOS (dielectric isolation) processing and unique circuit design to provide on-board protection against analog input overvoltage. Therefore, in the event of overvoltage in one channel, there is no output error when other channels are being addressed. This same protection circuit eliminates latch-up as well as unpredictable operational characteristics that could result from transient voltages originating in either the signal or supply. A second similar protection circuit provides the device with the necessary safeguards against static charges. In addition, break-before-make switching eliminates undesirable channel interaction.

Applications include data acquisition, telemetry systems, process control and general analog switching. The device is available in volume now for off-the-shelf delivery. For details see your Harris distributor or representative.



Features:

Internal overvoltage protection, both analog and digital
No channel interaction with power loss
Break-before-make switching
DTL/TTL and CMOS compatibility

Supply current	**4mA at 1 MHz toggle rate**
Power requirement	**7.5 mW disabled**
Power requirement	**7.5 mW enabled**
Access time	**500 ns**
Power supply	**±15V**
Signal range	**±15Vdc**
Supplied 28-pin DIP	

	100-999 units
HI1-506A-5 0°C to +75°C	**$28.60**
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INFORMATION RETRIEVAL NUMBER 45

ideas for design

Multiplexer converts BCD to serial ASCII characters

A few common ICs can be used to construct a simple asynchronous ASCII transmitter for BCD data. Such transmitters find many uses in data logging and transmission, where teletypewriters, asynchronous computer interfaces or modems are involved.

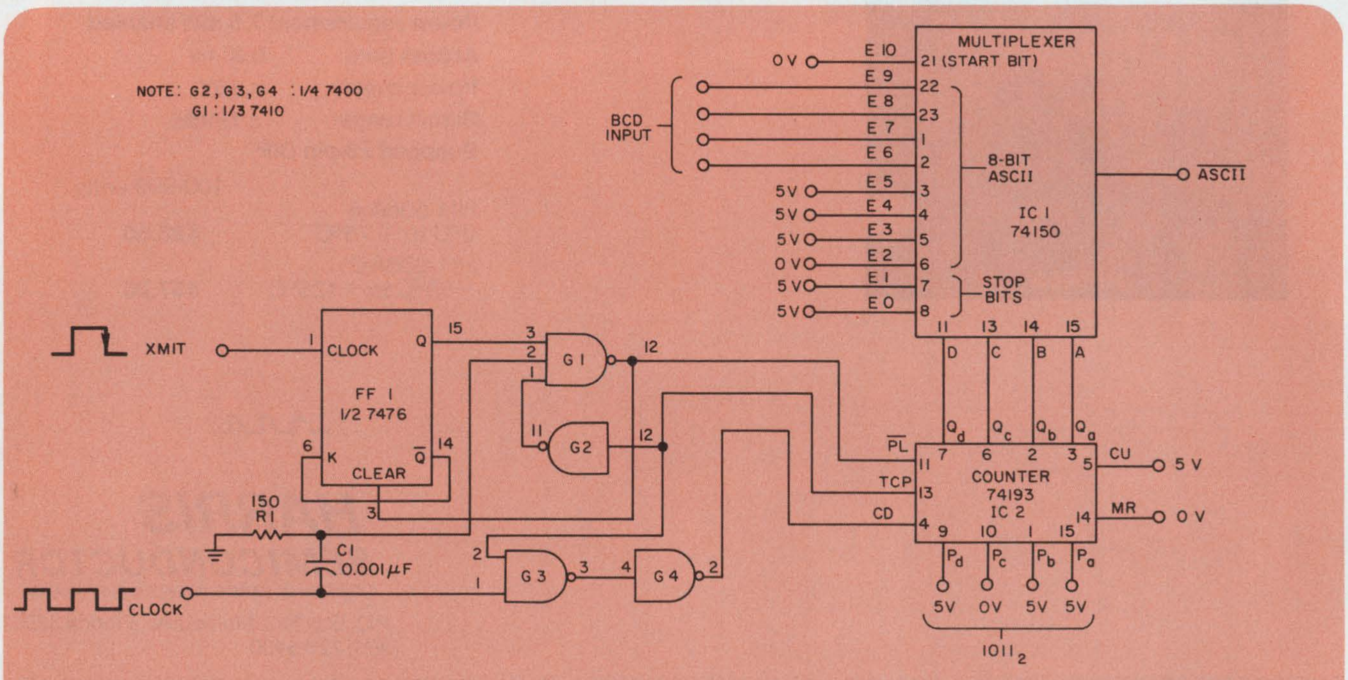
A 74150 multiplexer performs a serial-to-parallel conversion to convert a parallel BCD digit to eight-bit ASCII. Inputs E_2 through E_5 are hard-wired to form part of the eight-bit character; 5 V represents a ONE and zero volts a ZERO. The start bit is wired to E_{10} and the two stop bits to E_0 and E_1.

The 74193 counter controls the multiplexer address lines by counting down from 11 to zero for each character. Lines E_{10} through E_0 are selected in descending order. FF_1 acts as a memory for the trailing edge of the send command. If FF_1 is set during a transmission, the counters "borrow output", TCP and gate 2 inhibit the generation of a "parallel load" command to the counter through gate 1. When the counter output reaches zero, line TCP goes low, enabling G_1 at input 1. The monostable action of C_1 and R_1 furnish another enabling input to G_1 during the leading edge of the clock pulse. ANDing of Q, the clock leading edge and the output of G_2 starts the counter for the next transmission. The borrow line also inhibits clock pulses to the counter when the count reaches zero.

The circuit operates well with clock rates up to 500 kHz. Use of a 150-ns monostable in place of R_1 and C_1 extends operation to 5 MHz. Any number of BCD digits can be handled by multiplexing them into inputs E_6 through E_9.

David G. Larsen, Instructor, Virginia Polytechnic Institute & State University, Dept. of Chemistry, Blacksburg, Va. 24061.

CHECK NO. 311



Multiplexer IC furnishes complemented eight-bit serial ASCII output with each countdown of IC_2. A single countdown by IC_2 provides the eight-bit character, as well as start and stop bits. FF_1 stores requests for the next transmission. Gate G_1 provides the start command.

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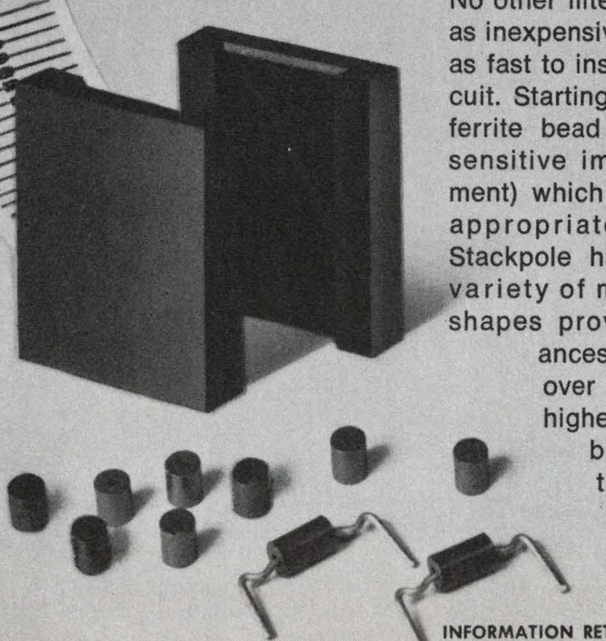
Ceramag® Ferrite Beads on Lead Tape

Stackpole Ceramag® ferrite beads provide a simple, inexpensive means of obtaining RF decoupling, shielding and parasitic suppression without sacrificing low frequency power or signal level.

Now beads are available with leads, cut and formed or on lead tape. Most equipment that is capable of automatic insertion of lead tape components can be modified to accept this special Stackpole bead.



No other filtering method is as inexpensive . . . and now as fast to insert in your circuit. Starting with a simple ferrite bead (a frequency-sensitive impedance element) which slips over the appropriate conductor, Stackpole has available a variety of materials and shapes providing impedances from 1 MHz to over 200 MHz. The higher the permeability, the lower the frequency at which the bead becomes effective.

CERAMAG® FERRITE BEAD CHARACTERISTICS

GRADE NUMBER	24	7D	5N	11
Initial Permeability	2500	850	500	125
Volume Resistivity @ 25°C	$1.0x10^2$	$1.4x10^5$	$1.0x10^3$	$2.0x10^7$
*Effective Suppression At:	1 MHz	20 MHz	50 MHz	100 MHz
Curie Temperature	205	140	200	385

*A tutorial guide on how these passive components behave with frequency and geometry is available from the Electronic Components Div.

Impedance varies directly with the bead length and log [O.D./I.D.]. Beads are available in sleeve form in a range of sizes starting at .020″ I.D., .038″ O.D., and .050″ long. The bead on lead tape is .138″ O.D. and .175″ long. Where quantities warrant, other beads on leads and/or lead tape are a design possibility. Tight mechanical tolerances are held in sizes and shapes as varied as the pair of giant, mating channels shown on the left which are used to eliminate the effect of transient noise in computers.

Sample quantities of beads are available for testing. Consult Stackpole Carbon Company, Electronic Components Div., St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.

STACKPOLE
ELECTRONIC COMPONENTS DIV.

INFORMATION RETRIEVAL NUMBER 46

Phase-locking increases range of wide-range phase controller

Wide-range phase detectors can be built with phase-locked-loop techniques. The techniques require just a few ICs and some passive components, and comfortably allow a phase control of $\pm 6\ \pi$ radians.

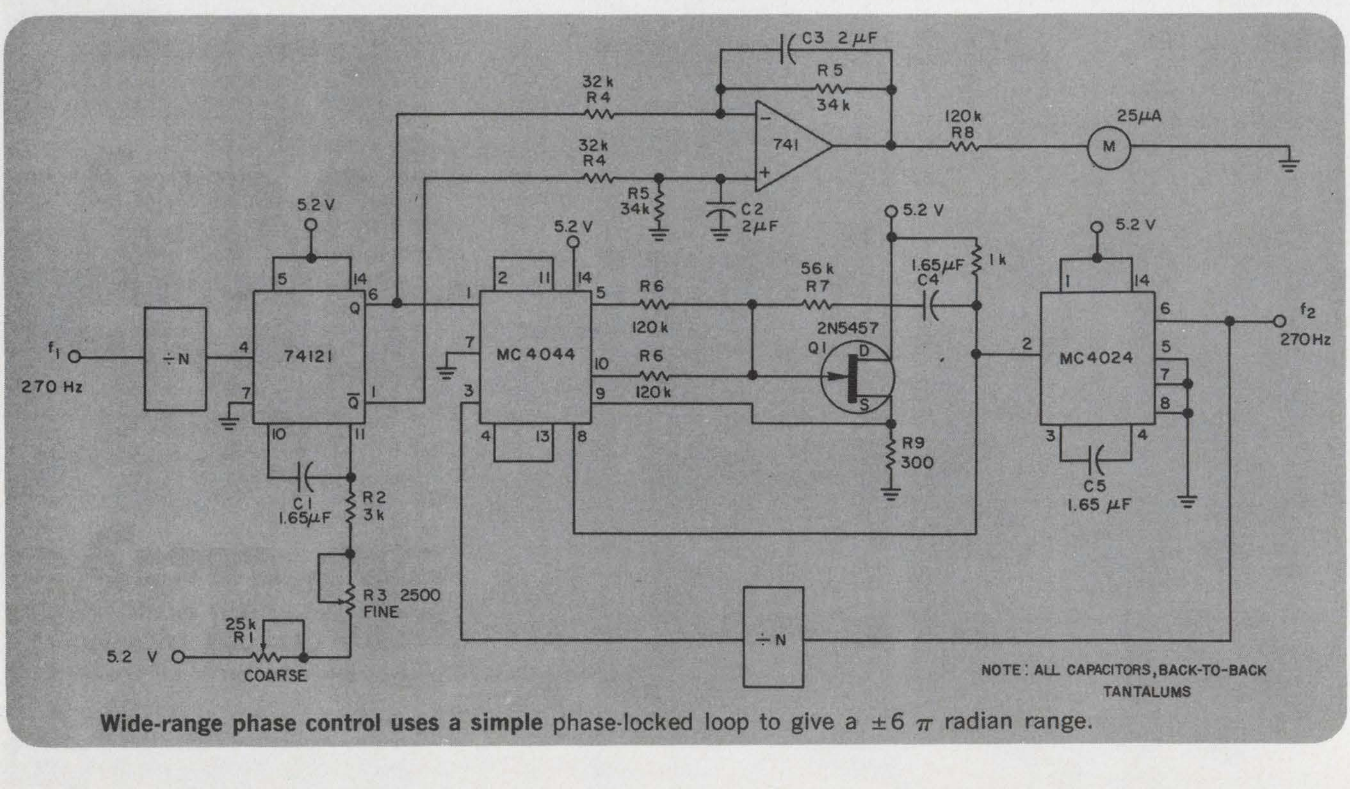
In the accompanying circuit the input frequency, f_1, is divided in the divide-by-N block and triggers the 74121 one-shot. The output frequency, f_2, is also divided by N. The phase detector of the MC4044 compares the negative-going edges of the input and output signals and produces an error signal that is proportional to the phase difference. This error signal is amplified, filtered and applied to the voltage-controlled multivibrator, the MC4024. Thus f_2 is phase-locked to the negative-going edge of the 74121 output and frequency-locked to f_1. The duty cycle of the 74121 is proportional to the phase shift desired between f_1 and f_2, and a phase shift of zero is set to coincide with a 50% duty-cycle. In this way the two outputs of the 74121 can be amplified differentially and filtered to drive a zero-center meter whose reading will indicate the phase of f_1 with respect to f_2.

When the 74121 is limited to a maximum duty cycle of 90% and $N = 8$, the circuit gives a phase control of $\pm 6\ \pi$ radians. With the same limitation but $N = 16$, a range of $\pm 12\ \pi$ radians will be available. Transistor Q_1 provides buffering between the high impedance of the loop filter (R_5, R_6, R_7, C_4) and the internal loop amplifier of the MC4044.

The set-point accuracy is determined chiefly by the consistency of the peak levels from the 74121. Therefore, after the gain of the 741 is set for the particular 74121 in use, set-point stability is directly proportional to the output pulse width of the 74121.

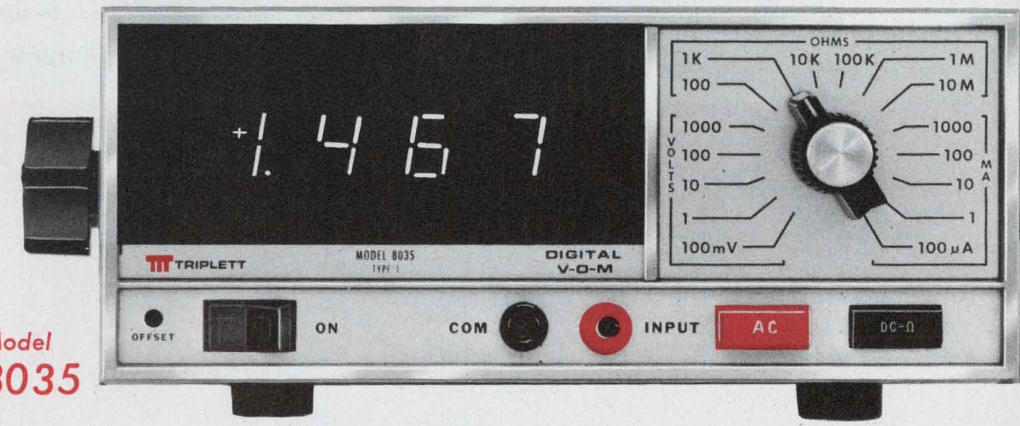
Since the 74121 has internal compensation for temperature and power-supply variations, the long-term system stability depends mainly on the temperature coefficient of the time constant $(R_1 + R_2 + R_3)C_1$. A 1% change in this time constant produces a 1% change in the 74121 pulse width. The $f_2 \div N$ signal would then change phase by 1%, which means that f_2 is shifted N% in phase. Thus the desired stability limits N and the dynamic range.

Glenn B. Shelton, Senior Staff Engineer, Dept. 521, Sperry Space Support, 716 Arcadia Circle, Huntsville, Ala. 35801. CHECK NO. 312



Wide-range phase control uses a simple phase-locked loop to give a $\pm 6\ \pi$ radian range.

If you need a high quality 3½-digit V-O-M at your price . . . buy Triplett's new 8035



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Designed for R&D, production, quality control, maintenance and classroom use, Triplett's new Model 8035 Digital V-O-M features an automatic polarity display, 100% overrange capability, out-of-range display blanking and high input resistance to make it nearly foolproof.

With 26 ranges, the Model 8035 boasts accuracies from ± 0.1% to ± 0.7% of reading ± 1 digit . . . ranking it among the best on the market. Its green, polarized window and its single-plane, seven-bar, fluorescent display combine to insure bright, reflection-free readability from virtually any viewing angle.

Hardware for rack mounting is available.

See the Model 8035, priced at $385, at your local distributor. For more information, or for a free demonstration of the convenience and accuracy of the 8035, call him or your Triplett representative. Triplett Corporation, Bluffton, Ohio 45817.

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INFORMATION RETRIEVAL NUMBER 47

Binary adder technique recognizes m out of n bits

Error-correcting codes often require the detection of m true bits in a field of n. Multiplexer techniques (see reference) work well for $n \leq 6$. For larger n, a circuit that sums the number of true bits and compares the value with m is simpler to design and requires fewer ICs.

As shown, the n lines are partitioned into groups of three and fed into carry-save adders. The four one-digit sums are added at the next level to form two two-digit sums. At the third level, IC_3 outputs the four-digit sum. The comparator, IC_4, then compares the sum with the expected sum, as generated by the connections to the 5-V supply.

The sum portion of the technique can be realized with $1 + \log_2 (n/3)$ logic levels, and this number is considerably less than that required for the multiplexer technique. The sum circuit, essentially a subset of an adder tree, can be further simplified by logic techniques.

Warren Y. Dere, Research Assistant, University of California, Berkeley, Calif. 94720.

Reference

Furnanz, L., "Multiplexer Technique Solves X-Out-of-Y Bit-Pattern Recognition," *Electronic Design*, No. 2, Jan. 18, 1973, p. 70.

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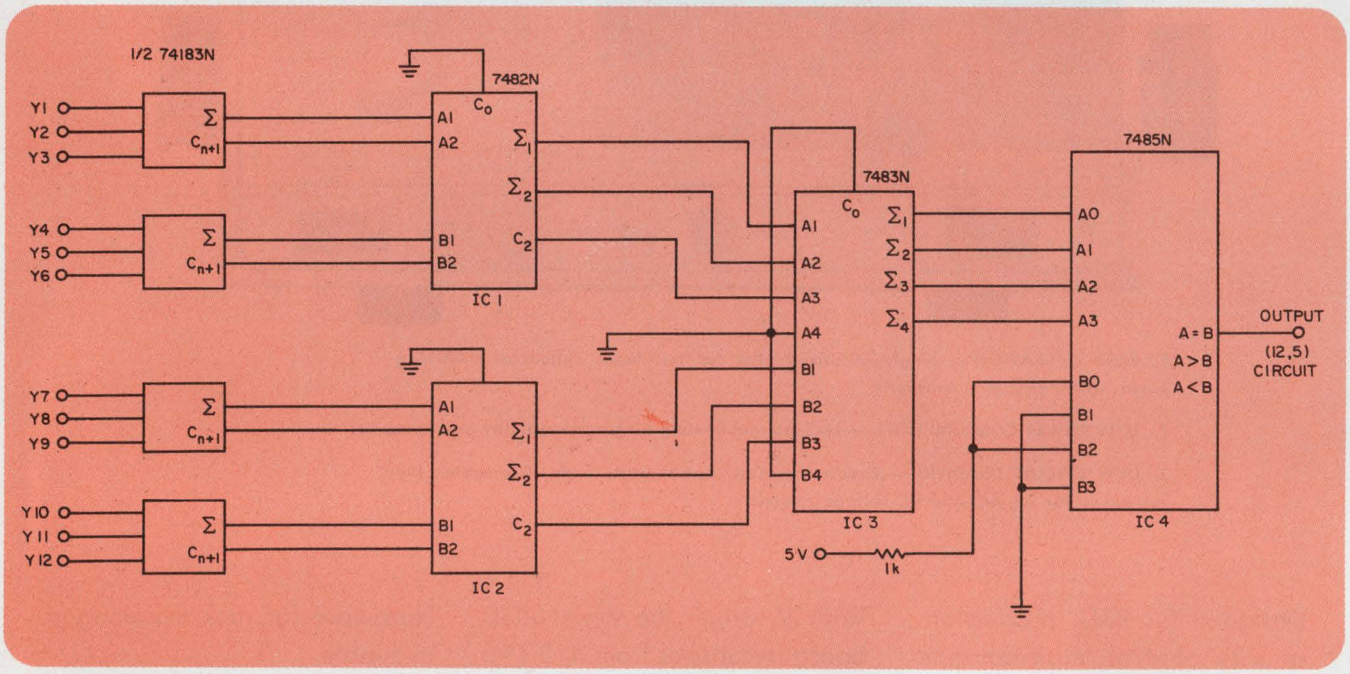

Circuit detects when five out of 12 inputs are true, by examining the binary sum at the output of IC_3.

IFD Winner of April 1, 1973

S. J. Pirkle, Project Engineer, Hewlett-Packard Medical Electronics Div., 175 Wyman St., Waltham, Mass. 02154. His idea "Two amplitude measurements determine unknown phase angle" has been voted the Most Valuable of Issue Award.

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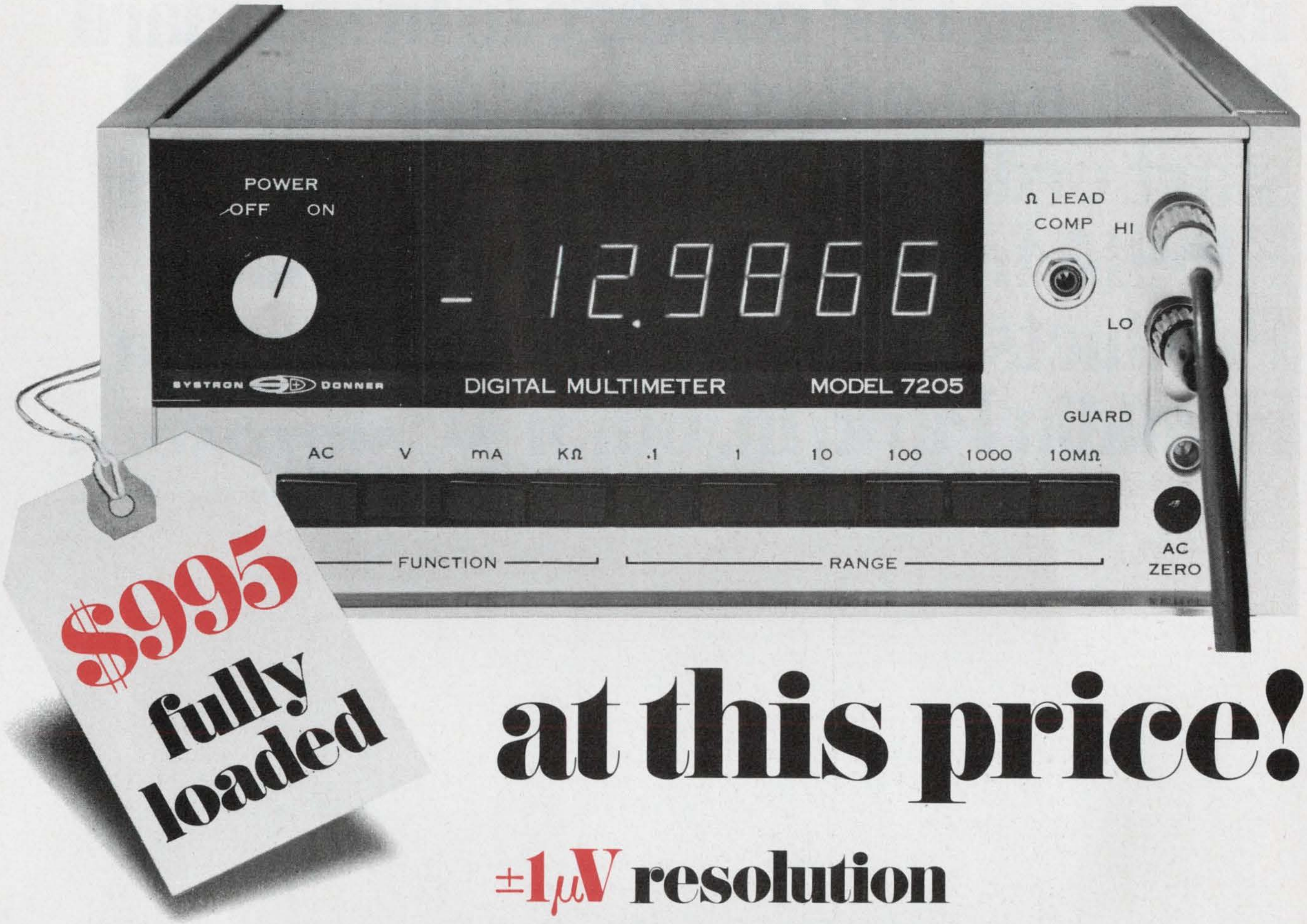

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If you've been looking for a miniature crystal-controlled clock oscillator in a 14 pin DIP package to fit standard PC board sockets, stop looking and start ordering. Get details on model K1091A from Motorola Component Products Dept. 2553 No. Edgington Franklin Park, Ill. 60131

MOTOROLA

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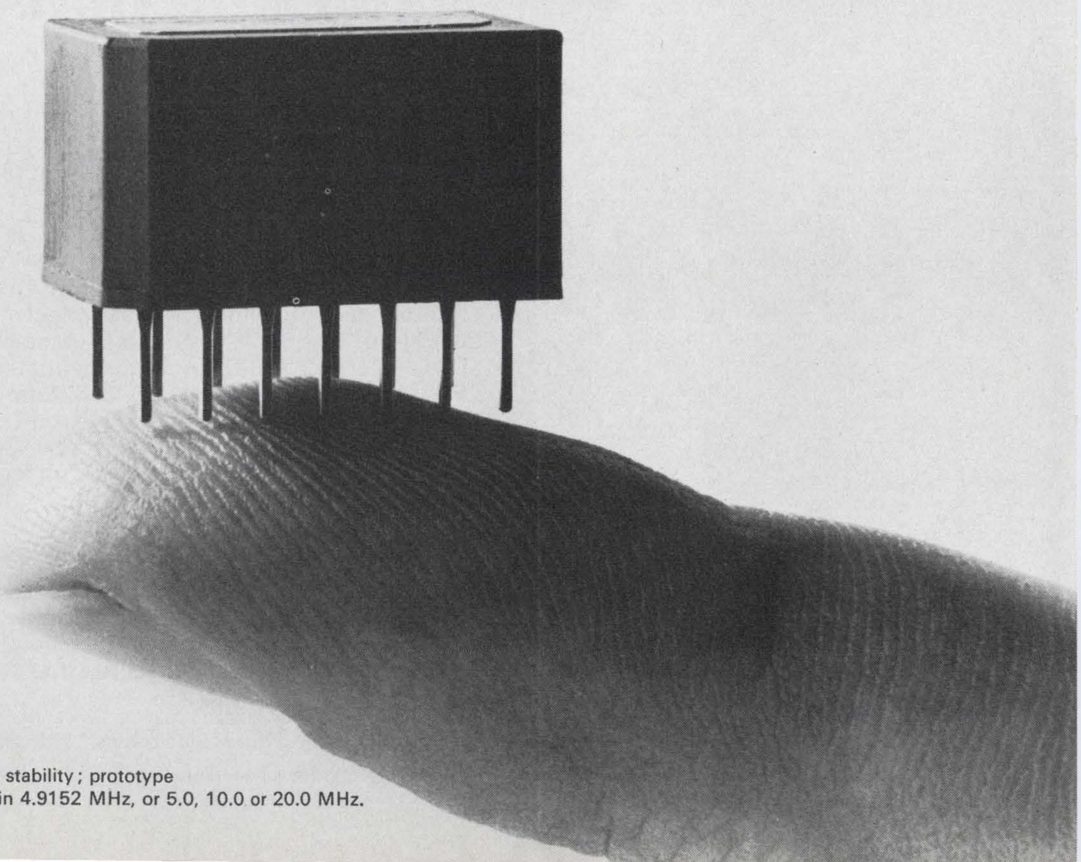


Specifications: 4 to 20 MHz range; 0.01% stability; prototype quantities available for immediate delivery in 4.9152 MHz, or 5.0, 10.0 or 20.0 MHz.

Surface-wave devices gain on two fronts in Europe

An acoustic-surface-wave device that can perform frequency-selective scanning of the surface wave has been fabricated by Thomson-CSF in Domaine de Corbeville, France. Five frequency channels can be obtained in the device, and the delays corresponding to each channel are different. An interdigital transducer array with curved fingers gives an effective array of 80 acoustic surface-wave point sources. The direction of propagation of the surface-wave beam emitted by this transducer depends on the frequency. A transmitting-array transducer and five receiving array transducers are deposited on a quartz substrate, and each of these five outputs corresponds to a different frequency and delay de-

(continued on p. 102)

Laser checks roundness of auto tire molds

A laser measuring system, developed by Siemens of West Germany, is being used to check—to an accuracy of 5 parts in 10^5—if automobile tire molds are exactly round. The system has a helium-neon laser with an output of 1 mW and uses a triangulation technique for measurement. The laser and a photodetector are arranged at an angle of 90° above the tire being measured. The laser beam scans the tire at a frequency of several hundred hertz, using a piezoelectrically driven mirror. A reference plane and reference pulse are compared with the laser light that is reflected back from the object's surface. The system can also measure thickness, distance and velocity.

CHECK NO. 401

Color TV display generated by 3 lasers reported to give 1125-line resolution on a large screen

A large-screen, laser-generated, color television display developed in Japan reportedly provides both high resolution and improved color. The display is the result of a joint effort by engineers of the Japan Broadcasting Corp. and Hitachi's Central Research Laboratory, both in Tokyo.

The display is formed by three separate lasers:

The red primary color is generated by a krypton ion laser of 2-W multimode output for simultaneous oscillation at 6471 Å and 6765Å.

The other primaries are obtained from an argon ion laser of 8-W multimode output. The green primary of 3 W at 5145 Å and the blue primary of 0.9 W at 4765 Å are separated by a prism. The green beam is passed through an attenuator to obtain the white balance.

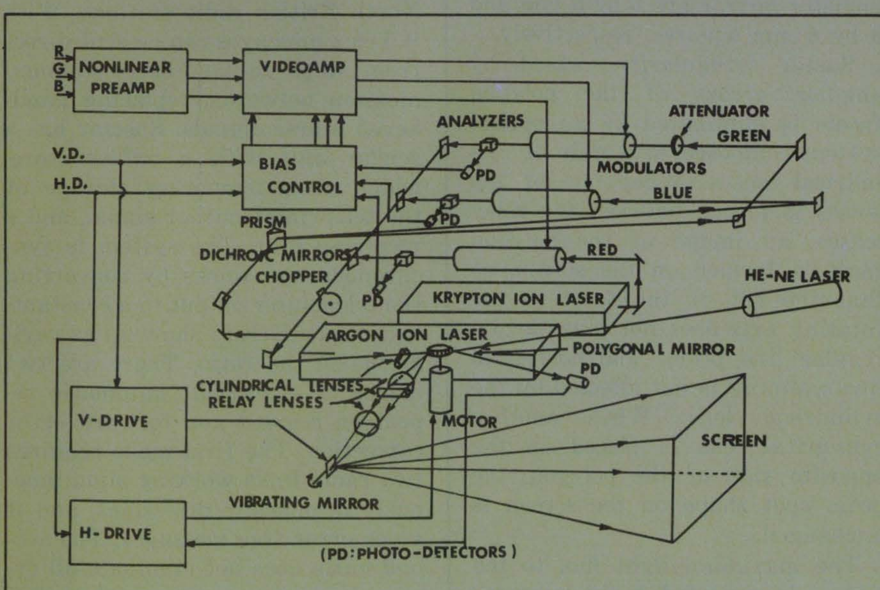
The third laser, a helium neon instrument, is used in the raster-generation operation.

The argon ion laser, which generates green and blue, has been designed to have an optical cavity length of 110 cm. The narrow-bore active region of the instrument's discharge tube is made of beryllium oxide. Power into each of the discharge tubes is approximately 12 kW.

The three primary-color beams are modulated by light modulators and then combined into a single beam by dichroic mirrors. The light beam is deflected in the horizontal direction by a rotating mirror and in the vertical direction by a vibrating mirror. The beam is focused on the screen by a relay lens.

The 1125-line raster is generated by a 25-facet polygonal spinner for horizontal scanning and a galvanometer for vertical scanning. The polygon of aluminum alloy is driven at 81,000 rpm by a synchronous motor, which has a rotor supported in the vertical direction by

(continued on p. 102)



Three lasers generate a display in an experimental Japanese large-screen, 1125-scanning-line color television system. The video bandwidth is 24 MHz.

(cont'd) Acoustic-wave

termined by the positioning. Scanning has been obtained for a frequency variation of 7.6 MHz about a central frequency of 60 MHz, corresponding to a delay variation of 18 μs. The device can also be used for a dispersive delay line.

In a related development a team of German workers has made an important contribution to the theory of layered structures, in which acoustic surface waves can be used for such applications as dispersive delay lines, pulse-compression filters and monolithic amplifiers. The efficiency of interdigital transducers and the acousto-electric interaction for semiconducting layers is determined by the coupling coefficient between the nonpiezoelectric layer and the piezoelectric substrate. By measuring the change in acoustic-surface-wave velocity across the interface, the German team has determined this coupling coefficient for a cadmium-selenide/Y-cut-lithium-niobate structure at 100 MHz. Measurements of this parameter have been complicated in the past by the capacitance and filling factor of the transducer. The German team reports it has overcome these difficulties and has obtained values of the coupling parameter that are in good agreement with theoretical predictions.

'Thinking' robot excels at parts-assembly work

A robot known as Freddy can assemble objects from a selection of parts randomly laid out in front of it. The robot-machine, developed by a research team at the University of Edinburgh, corrects its own errors as it goes along and rejects parts that do not belong to the finished objects. The researchers are now working on a concept known as "Multi-Fred," in which a central co-ordinator program will control a number of robots operating various tools. The aim is to provide for a type of "creeping automation" that can be incorporated into a factory without any disruption or rebuilding.

Waveguide communications test planned

British Insulated Callender's Cables is to supply the British Post Office with 16 km of waveguide for use in a full-scale field trial of waveguide communications. Using the 50-mm hollow tube, which the company will make on specially designed machinery, Post Office engineers will send up to 300,000 telephone calls simultaneously on frequencies from 32 to 110 GHz. The waveguide will be housed in a four-inch welded steel pipe, which has already been buried about four feet deep alongside the main road between Martlesham and Wickham Market, Norfolk, in eastern England.

The waveguide itself has been designed by the Post Office, and it comprises a close-wound helix of superfine enameled copper wire surrounded by an outer wall of glass fibers impregnated with a loaded epoxy resin. The helical construction inhibits transmission of most parasitic modes. Signals are transmitted in digital form as pulse-code modulation of millimetric radio waves, which travel inside the waveguide in the low-loss TE_{01} mode. The signal loss should be less than 3 dB/km for straight lengths and less than 2 dB/km at frequencies in the middle of the useful operating range. Transmission losses increase at bends in the waveguide, and one purpose of the trials is to confirm the scale of these losses over a typical town-and-country route.

CHECK NO. 402

(cont'd) Laser TV display

a magneto-static repulsion force and held radially by a gas-dynamic bearing. The helium-neon laser beam reflected by the polygon facet provides the phase signal to be compared with the reference.

The galvanometer is driven by a wave form to generate 60-Hz linear vertical scanning and rapid retrace. The polygon facet and the galvanometer mirror are 5 by 5 mm and 6 by 6 mm squares, respectively.

Raster irregularity caused by angular errors of the polygon facets is eliminated by an optical system composed of a pair of cylindrical lenses. When one of the lenses is placed between the relay lenses, an image of the polygon facet is formed on the screen, so that the tilt of the facet to the rotating axis does not cause an irregular line pitch. The horizontal line scanning is not affected by the cylindrical lens. When another cylindrical lens is placed on the opposite side of the polygon, the beam spot shape on the screen is unchanged.

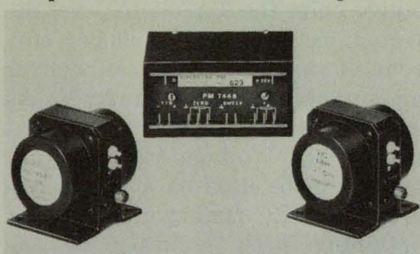
The maximum light flux to the screen is reported to be approximately 100 Lm. The contrast ratio is said to be better than 30:1.

Radio-teleprinter errors controlled by system

A system that controls errors in high-frequency radio-teleprinter transmission introduced by fading, interference and random bursts of static has been developed by Marconi Communication Systems in Chelmsford, England. The system, called Spector, has been ordered by the British Post Office for its North British radio stations. With it Telex messages can be sent direct from ships to land-based communication networks, replacing hand-keyed Morse signals. Spector has a sender unit with a buffer store, which gives temporary storage of the teleprinter output signal, and a receiving unit. The system is synchronous and works by converting the teleprinter output to a constant-ratio code. Errors show up as variations in the ratio. There are two modes of operation: automatic repeat on request and forward error correction. The first mode requires two radio links working simultaneously in opposite directions, and it gives error-free messages. The second mode does not eliminate all errors, but it prints a special symbol to indicate the occurrence of an error.

international products

YIG filters offer major improvements on specs

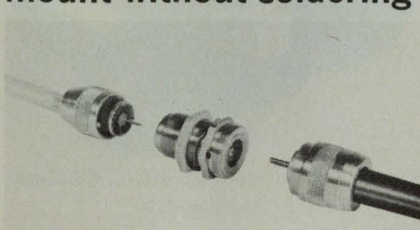


Sivers Lab, Box 42018, S-126 12, Stockholm 42, Sweden.

The PM7423X series of YIG filters include 2, 3 or 4-stage units and a dual 2-stage unit covering the frequency range of 1 to 18 GHz. The three-stage unit, for example, covers the 8-to-12.4-GHz range, has a maximum thermal drift of 10 MHz max over a temperature range of 0 to 60 C. It also has a hysteresis of 12 MHz max., and a deviation from linear of ±5 MHz max.

CHECK NO. 389

CATV cable connectors mount without soldering



Radiall, 101 rue Philbert Hoffmann, Zone Industrielle ouest, 93116 Rosny s/Bois, France.

Coaxial connectors for cable TV can be mounted on coaxial cables without soldering. The connection of the two cable elements is by means of two male plugs and one female central adaptor. Coaxial cable diameters from 8 to 20 mm can be accommodated. Main characteristics of the connectors are: impedance of 75 Ω, VSWR of less than 1.13 at 860 MHz, frequency range of 0 to 1000 MHz and a current rating of 4 A.

CHECK NO. 390

Modem delivers 9600 baud on five-mile wire

Computer Terminals Ltd., Carterfield Rd., Waltham Abbey, Essex, England.

The 1602 modem is designed for communication over four-wire private lines at distances up to five miles. A selector switch furnishes a choice of six data rates from 1800 to 9600 baud. Differential current drivers plus optical isolation help minimize noise problems.

CHECK NO. 391

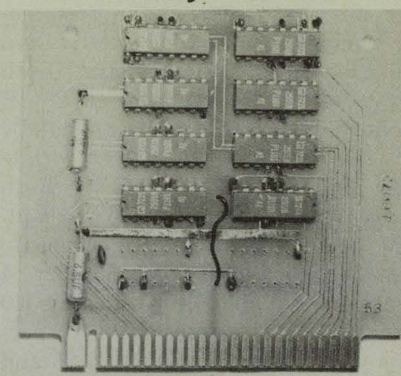
AM-FM signal generator spans 50 kHz to 520 MHz

Jarre Jacquin 18, rue Pierre et Marie Curie, 75005 Paris, France.

The MS30 AM-FM signal generator is a precision signal source. The frequency coverage is continuous from 50 kHz to 520 MHz and is indicated on an eight-digit display with a resolution of 10 Hz. The synthesizer accuracy and stability is ±10 Hz. Residual FM is less than 2 Hz and nonharmonics are at least 80-dB down. The output level can be adjusted from +10 dBm to −126 dBm by means of an electronically controlled 1 and 10-dB step attenuator and a vernier. The output level is digitally displayed in either μV, mV or dBm. The rf output includes an on/off facility, and is protected against unwanted signals of up to 20 W. Two built-in modulation generators, one with six fixed frequencies and the other with a variable frequency between 300 Hz and 3 kHz are supplied. The mode, the frequency and the AM% and FM dev. of either generator is digitally displayed. Both modulation frequencies may be used simultaneously. In the FM mode, the display indicates 0 to ±10 kHz or 0 to ±100 kHz and for AM 0-80%. FM distortion is less than 0.5% and AM distortion less than 1%.

CHECK NO. 392

Static 1-k by 8-bit RAM card is only 3.5 in²

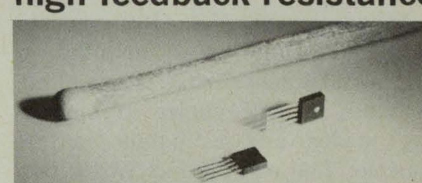


Jasmin Electronics Ltd., Boston House, Abbey Park Rd., Leicester, LE4 4AN, England. £90 (15-up); 4 wk.

A card containing eight 1-k by 1-bit n-channel RAMs forms a 1-k by eight-bit memory that is only 3.5 in. square. Features include: static operation (no internal clocking), 1 μs cycle time, fully bipolar compatible, power consumption of 0.2 mW per bit and an expandable design. Outputs can be wire-ORed together with word lengths from one to 10 bits.

CHECK NO. 393

Miniature amplifier has high feedback resistance



N. V. Philips, Elcoma Div., P.O. Box 523, Eindhoven, The Netherlands.

Smaller decoupling capacitors are used with the OM200/S2 hearing-aid amplifier due to its high value of feedback resistance. Minimum feedback resistance is 170 kΩ, with a typical value of 400 kΩ. It has a gain of typically 85 dB (77 dB minimum) and "extremely low" flutter noise.

CHECK NO. 394

(contiuued on p. 104)

High-power circulators handle 500-W of power

Ferranti Ltd., c/o John Fowler & Partners Ltd., 6-8 Emerald St., London, WC1N 3QA, England.

Designated 16CP12 and 16CP13, the circulators cover the frequency ranges of 8.5 to 9.6 GHz and 9.5-10 GHz, respectively. Both types offer a minimum of 20-dB isolation. Type 16CP12 can handle up to 150-W mean power, while the 16CP13 handles 500 W. Both designs can operate at up to 250-kW peak power, and incorporate matched terminations on port 4 that are capable of absorbing 40 and 200 W of mean power, respectively, for short periods and 25 and 150 W continuously.

CIRCLE NO. 395

Ultrasonic scanner has wide range of uses

Nuclear Enterprises Ltd., Sighthill, Edinburgh EH11 4EY, Scotland.

Diasonograph NE 4102 consists of an ultrasonic probe mounted on a kinematic measuring frame. This provides a wide choice of operating modes and a mobile control console. The console has two interchangeable oscilloscopes, either of which has three display modes: A-scan, cross-sectional scan, and time/position scan. Thus, providing an accurate measurement of structural dimensions and allowing the visualization of both fixed and moving structures. A caliper system for measuring the distance between points on the screens uses a large-scale illuminated digital readout to give direct readings irrespective of the scale selected for the display.

CIRCLE NO. 396

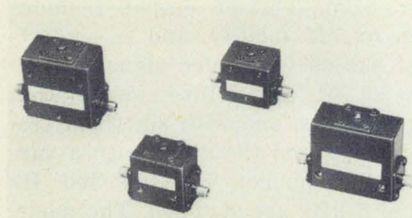
Frequency synthesizer spans 0 to 180 MHz band

Schlumberger, Instruments and Systems, 12, Place des Etats Unis, 92120 Montrouge, France.

The 4601 180-MHz programmable synthesized signal generator provides full frequency coverage of the hf and vhf radio bands. It has very low phase noise—typically −140 dB at ±20 kHz from carrier. Also a built-in attenuator from ±17 dBm to 132.9 dBm by 0.1 dB steps gives a 2 V to 0.05 μV output level. The internal 10-MHz crystal oscillator has a stability better than 10^{-9}/day. Frequency, modulation and level settings are displayed by LED readouts and all function controls are selected by pushbuttons. The synthesizer is entirely programmable on all functions—frequency, output level, modulation and sweep rate—with a switching time of less than 1 ms.

CIRCLE NO. 397

Octave coax isolators cover 1 to 18 GHz range



Sivers Lab, Box 420 18, S-126 12 Stockholm 42, Sweden. Stock.

The PM 7415 series of isolators cover 1 to 18 GHz in octave bands. They are designed as terminated T-junction circulators with SMA-female connectors. The temperature range is −54 to +110 C and the isolation exceeds 17 dB at the temperature extremes.

CIRCLE NO. 398

Level detector combines MOS and npn transistors

Phillips, P.O. Box 523, Eindhoven, Netherlands.

With a MOSFET and an npn bipolar transistor integrated on a single chip, the TAA320A level detector has an input leakage current of only 1 pA. It can deliver an output of 60 mA at 20 V. As an additional feature, the input gate-source voltage is constant enough to be used as a stable reference for RC timing circuits. For obtaining high accuracy of the level sensor, the gate-source voltage is factory selected and indicated on the wrapper in four voltage groups: group 1, typ. 10 to 11.2; group 2, 10.7 to 11.9; group 3, 11.4 to 12.6; and group 4, 12.1 to 13.3 V.

CIRCLE NO. 399

Q(ka)-band magnetron is tuned by new method

English Electric Valve Co., Chelmsford, Essex, England.

The Q(ka)-band magnetron, type M5059, uses a new frequency-agile tuning method. It is tuned by applying a voltage waveform to the input of a piezoelectric transducer which, because of its high impedance, requires low drive power. The agile range can be swept at frequencies up to 1 kHz. The tube has a peak output power of 50 kW and is tested at more than 400 kV/μs. Ratings of the M5059 are: peak anode current of 15.5 A, peak anode voltage of 15 kV, duty cycle of 0.0005, pulse length of 0.5 μs and a rate of rise of voltage pulse of 350 kV/μs.

CIRCLE NO. 400

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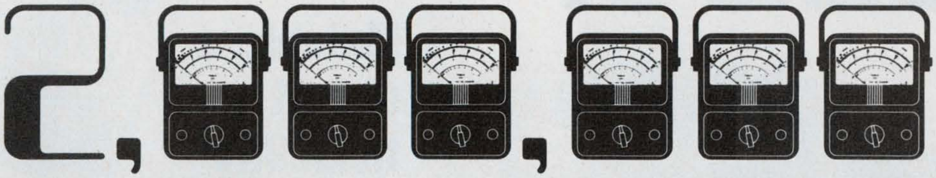

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SERIES 6

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New Amp-Clamp, Model 150 Adaptor.

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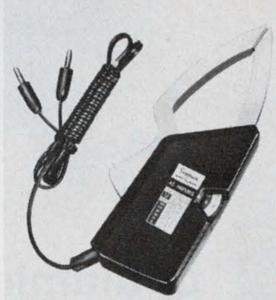

260-6, Complete with batteries, test leads and manual **$70.00**

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INFORMATION RETRIEVAL NUMBER 50

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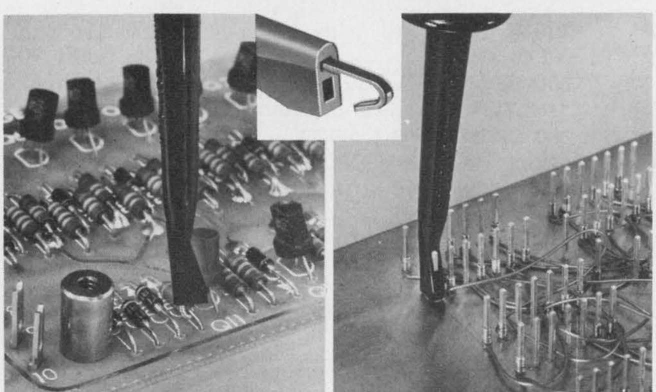
MODEL 3925
hooks onto components or slips over square Wire-Wrap pins



*Lexan is a General Electric trade-mark. †Registered trade-mark of Gardner-Denver Co.

POMONA ELECTRONICS
A Subsidiary of ITT
1500 East Ninth St., Pomona, Calif. 91766
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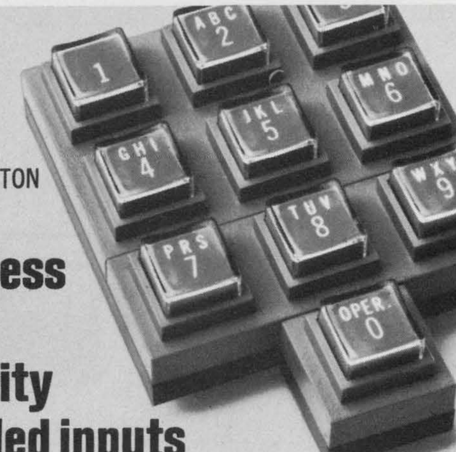
INFORMATION RETRIEVAL NUMBER 91



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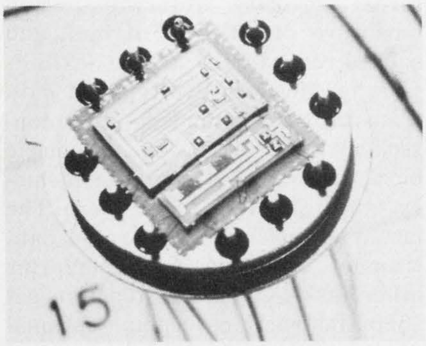
INFORMATION RETRIEVAL NUMBER 93

new products

Fast op amp has a slew rate of 500 V/μs

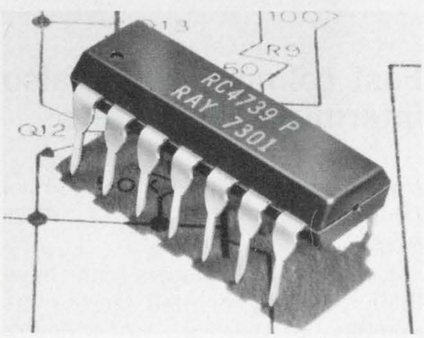


Halex, 3500 W. Torrance Blvd., Torrance, Calif. 90509. (213) 772-4461. 100-qty prices: $40 (0032), $18 (0032C); 2 to 3 wk.

Model HX0032 is a high-speed, JFET-input op amp. It has a bandwidth of 70 MHz, slew rate of 500 V/μs and an input impedance of 10^{12} Ω. The performance characteristics of the HX0032 are useful in d/a summing amplifiers, sample-and-hold circuits, integrators and video amplifiers.

CHECK NO. 253

Dual op amp introduced

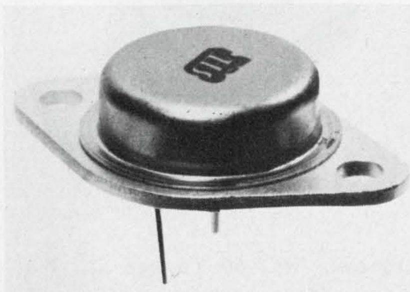


Raytheon Semiconductor, 350 Ellis St., Mountain View, Calif. 94040. (415) 968-9211.

The RC4739 dual op amp features a 2.5-MHz unity gain-bandwidth, a 110-dB open loop gain and can provide a signal-to-noise ratio 76 dB below a 10-mV signal level. The RC4739 also features single or dual supply operation, short circuit protection and the ability to operate over a supply voltage range of ±3 to ±18 V.

CHECK NO. 254

High-speed transistors handle 10,000 V-A



Silicon Transistor, Katrina Rd., Chelmsford, Mass. 01824. (617) 256-3321. $6.00 to $7.14.

The 2N6249 through 2N6251 high-voltage power transistors can control over 10,000 volt-amps. Supplied in TO-3 packages, the units switch currents of 30 A, at up to 400 V, in under 5 μs. The V_{sat} at 10 A is 1.5 V maximum and total device dissipation is 175 W.

CHECK NO. 255

16-channel multiplexer offers improved specs

Harris Semiconductor, P.O. Box 883, Melbourne, Fla. 32901. (305) 727-5407. HI1-506A-5: $28.60 (100 up); stock.

A monolithic 16-channel multiplexer using the company's DI/CMOS processing—the HI-506A—offers fast access time, low power requirements and internal overvoltage protection, The HI-506A has an access time of only 500 ns and a power spec of 7.5 mW in both the disabled and enabled mode. It requires only 4 mA at a toggle rate of 1 MHz and can be used for an analog signal range of ±15 V. The internal protection circuit guards against an analog-input overvoltage at one channel causing an output error when other channels are addressed. The same circuits protect against latch-up, channel interaction and device destruction up to ±35 V. Channel switching is break-before-make to eliminate interaction effects. The multiplexer comes in a 28-pin DIP.

CHECK NO. 256

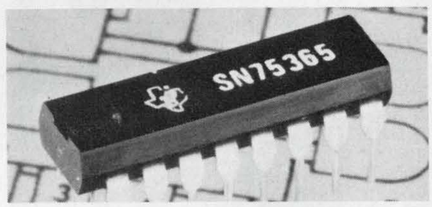
FET analog gates for $1 per switch point

Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. 02140. (617) 491-1670. P: See below; stock to 3 wks. (sample qty.).

The IH5009 series of FET analog gates, featuring ON-resistances of less than 150 Ω, are priced at $1 per switch point in 100-piece quantities. The ON-resistances are matched within as close as 5 Ω and units include an extra FET for temperature compensation. The series can provide shunt or summing-point switching of signals up to ±15 V or series switching of signals under 200 mV.

CHECK NO. 257

TTL-to-MOS driver introduced



Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. $3.24 (100 up).

A monolithic quad bipolar-to-MOS level converter accepts standard TTL/DTL input signals and provides high current, high voltage output levels. The circuit can be used over wide V_{SS} and V_{BB} power supply ranges. Maximum voltages are 22 V for V_{SS} and 27 V for V_{BB}. In some applications, the V_{BB} power supply can be eliminated by connecting the V_{BB} pin directly to the V_{SS} pin.

CHECK NO. 258

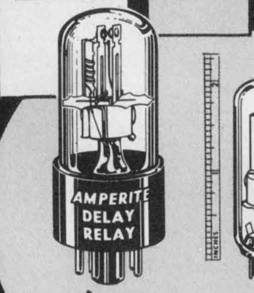
Monolithic Darlingtons switch 20 A at 400 V

TRW Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. 90260. (213) 679-4561.

The SVT6060 series of monolithic Darlington amplifiers can switch up to 20 A at 400 V. Available in TO-3 packages, the devices have sustained breakdown voltage ratings (collector to emitter) of 300 V (SVT6060), 350 V (SVT-6061) and 400 V (SVT6062). The V_{CE} (sat) is 2 V at an I_C of 20 A, and typical rise and fall times are 400 ns.

CHECK NO. 259

AMPERITE
DELAY
RELAYS



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PROBLEM? Send for Bulletin No. TR-81.

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Write for 4-p. Bulletin No. AB-51.

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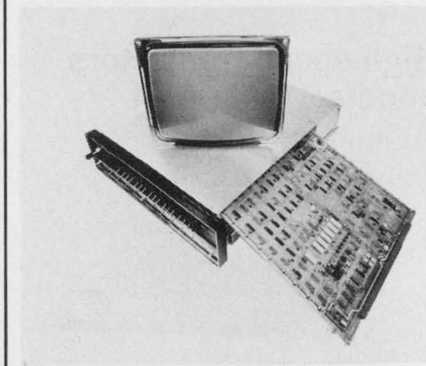
Telephone: 201 UNion 4-9503
In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

INFORMATION RETRIEVAL NUMBER 52

Display controller lets mini drive CRT display



Lexicon, Inc., 60 Turner St., Waltham, Mass. 02154. (617) 891-6790. $1585; 45 days.

Called Lexiscope 2000 this display controller is contained on a single card that plugs into the I/O slots of Nova-series computers. The unit provides refresh storage for a 2000-character remote CRT display of 80 characters by 25 lines. One or more monitor screens can be placed at convenient locations while the controller is housed in the computer itself. The unit provides such editing features as cursor movement, blinking characters, tabbing, deletion of a character, page or line, and insertion of a character or line. The Lexiscope 2000 includes a keyboard control at no extra cost.

CHECK NO. 260

Punched tape reader slews at 500 char/s

Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif. 92701. (714) 547-5651. $895; 3-4 wk.

To meet higher speed computer peripheral requirements, model TR-500 tape reader operates in the slew mode at 500 char/s and in the step mode to 400 char/s. The reader is available in five configurations—mini, standard, fan-fold, 5-1/4-in. reader/spooler and 7-1/2-in. reader/spooler. All units have self-cleaning heads, LED/phototransistor readout and dc stepping motors. All models can read standard five, six, seven and eight-level punched tape with 40% or greater opacity. Input and output signals are compatible with DTL and TTL logic.

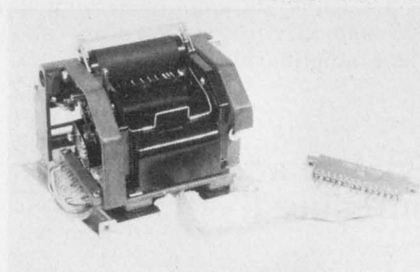
CHECK NO. 261

Medium-scale computer meets real-time needs

Datacraft Corp., P.O. Box 23550, Fort Lauderdale, Fla. 33307. (305) 974-1700. $19,900; August.

A medium-scale computer, the Slash 4, features 24-bit word length, 750-ns cycle time, four external priority interrupts, and hardware multiply, divide and square root. Input/output flexibility is provided by two types of data transfer: programmed (via controller and CPU) or automatic block transfer between the memory and interface controller. The latter approach permits rapid data transfer while the CPU performs other tasks. A rich instruction set (580 instructions) plus optional floating point hardware (typical convert and add in 2.25 μs) help meet the requirements of scientific and real-time users. The basic price includes 24 k bytes of core memory. The manufacturer can supply a variety of peripherals as well as software that includes seven languages and four operating systems.

CHECK NO. 262



Fast column-printer also intermixes characters

Hycom Inc., 1641 McGaw Ave., Irvine, Calif. 92705. (714) 557-5252. See text.

Electronic calculators can have their answers printed across 21 columns at the rate of 6-lines/s with this silent printer. Characters are printed on "electro-discharge" paper from a standard 5-by-7 dot matrix. The capability of intermixing character, signs and symbols makes the model DC-2106 printer suitable for a variety of specialized terminal applications such as inventory control, billing and point-of-sale. An evaluation sample costs $150 (3 wks); the units will sell for under $100 in quantities of 1000 or more.

CHECK NO. 263

Up to 96 terminals share a single line

Applied Digital Data Systems, 100 Marcus Blvd., Hauppauge, N. Y. 11787. (516) 231-5400. From $2430; 45 days.

Up to 96 Series "A" CRT terminals can share a single communications line. The pollable terminals can operate as stand-alone stations. Or they can be clustered in groups by simply cabling between the terminals. This "daisy-chain" approach eliminates the need for a separate cluster controller. The Series "A" terminals are available in rack-mounted or desk-top versions. They provide format capability such as variable and fixed data. The operator fills in the blanks on the fixed display with variable data and the terminal transmits only the operator entered data. Both the rack-mounted version (MRD-700 "A") and the desk-top version (Consul 800 "A") display 24 lines with 80 char/line or 16 lines of 64 characters. A graphics feature is available on the Consul 880A. Each rectangular graphic element occupies one-sixth the area of a normal character.

CHECK NO. 264

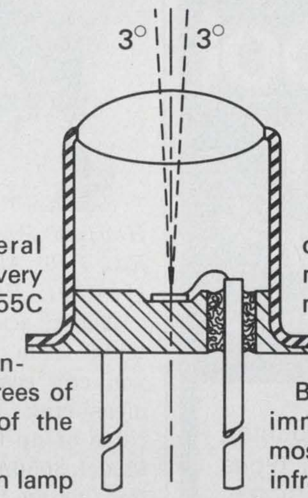
Digital printers offer 10 or 18-column copy

John Fluke Manufacturing Co., P.O. Box 7428, Seattle, Wash. 98133. (206) 774-2211. See text.

Model 2010 A digital printers log instrument outputs at a minimum speed of 2.5 lines/s and print in red or black on fan-fold paper. The 10-column version prints eight data and two function columns; the 18-column unit prints 16 data and two function columns. Internal data storage permits removal of input data 4 μs after issuance of the print command signal. The 10-column version costs $795 and the 18-column version costs $875.

CHECK NO. 265

You gain fundamental design advantages with General Electric infrared SSL's (LED's).



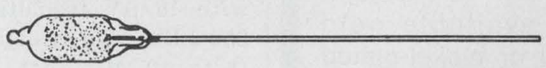
For example, General Electric guarantees* every SSL-55B and SSL-55C infrared lamp for:

Precision beam alignment, to within 3 degrees of the mechanical axis of the lamp.

Power output of each lamp will be within the less than 2 to 1 range, as published; the SSL-55B output ranges from 3.5 mW minimum to 6.0 mW maximum; the SSL-55C from 4.8 mW minimum to 7.5 mW maximum.

Both types are available for immediate delivery, as are most other General Electric infrared SSL's. For prices and complete SSL infrared data write or call today.

Green Glow Lamp for flexibility.



Actual Size

This GE broad spectrum bright green glow lamp gives you greater design flexibility than ever before. It also emits blue, with suitable color filter.

Called the G2B, it is directly interchangeable electrically and physically with GE's high-brightness C2A red/orange/yellow glow lamp. You can use the G2B alone for 120 volt green indicator service. Or together with the C2A to emphasize multiple functions with colors. For example: for safe/unsafe functions, for dual state indications and to show multiple operations in up to 5 colors.

They should be operated in series with an appropriate current limiting resistor. Both the G2B and C2A save money because of low cost, small size and rugged construction.

Now Wedge Base Lamps in two sizes.

If space for indicator lights is your problem, the GE T-1¾ size all-glass wedge-base lamp is your solution. It measures only .240" max. diam. The wedge-base construction virtually ends corrosion problems; it won't freeze in the socket. Like its big brother—the T-3¼ wedge base lamp with a .405" max. diam., the filament is always positioned in the same relation to the base. And it makes possible simplified socket design.

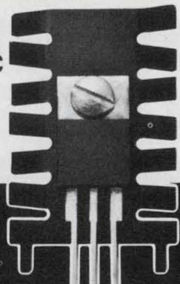
For free technical information on any or all of these lamps, just write: General Electric Company, Miniature Lamp Products Department, #4454-L, Nela Park, Cleveland, Ohio 44112.

*Lamps not meeting published specifications will be replaced or money refunded.

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 53

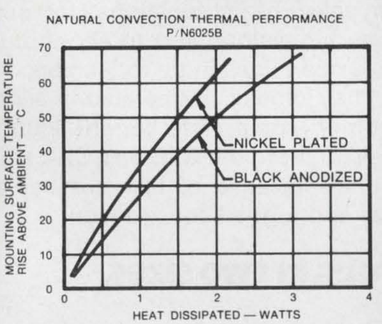
YOUR PLASTIC
PACKAGE
DEVICES



We can cool 'em for 10¢ each*

No board room required

Low-cost vertically mounted heat sinks accept all types of plastic packaged SCR's, transistors, and triacs, including center-tabbed devices. Typical R_θ: 26°/W. Black anodize is standard, but also available gold chromated or nickel-plated for dip soldering to PC board. Weight only 0.07 oz.



Available from your local Thermalloy distributor.

Thermalloy offers a complete line for cooling everything from TO-5's to disc compression devices.

Write for FREE CATALOG.

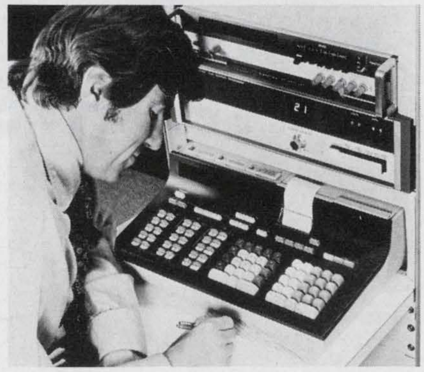
*Chromate finish, 1000 quan.

Thermalloy
P.O. BOX 34829
2021 W. VALLEY VIEW LANE/DALLAS, TEXAS 75234
PHONE 214-243-4321/TWX 910-860-5542

INFORMATION RETRIEVAL NUMBER 54

DATA PROCESSING

Calculator controls data-acquisition system



Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. From $14,200; Sept.

Add a scanner to a multimeter, team them with a calculator and you can scan up to 100 channels measuring dc, ac and ohms at rates of up to five readings/s. The Model 3050A data acquisition system, using the 3490A digital multimeter, measures dc in five ranges from 100 mV to 200 V with 10 μV resolution. Ac is measured in four ranges from 1 V to 200 V with 10 μV resolution (20 Hz to 250 kHz) and resistance from 100 Ω to 10 MΩ with 1 mΩ resolution. The Model 3050A affords a 120 dB common-mode ratio and 50 dB normal-mode noise rejection ratio. Data logging is under control of an HP 9820A programmable calculator. The calculator can be programmed to perform algebraic calculations ranging from transducer linearization to statistical analysis.

CHECK NO. 266

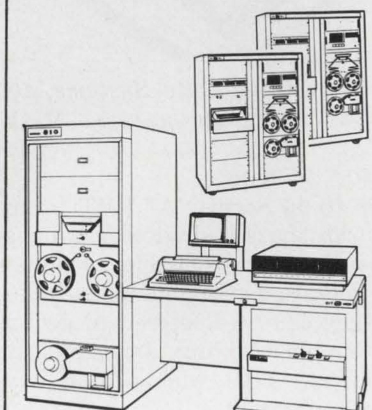
Multiplexer lets mini drive eight channels

Advanced Electronics Design, 3197 Park Blvd., Palo Alto, Calif. 94306. (415) 493-4914. $2250; 30 days.

The AED 2408 multiplexers interface any Nova-line computer to eight serial asynchronous I/O devices. Each channel can have one of six selectable baud rates ranging from 4800 to 150 or 3520 to 110. Each channel has its own DMA address register for the loading of a 12-bit starting address. The multiplexer board fits into a single Nova I/O slot.

CHECK NO. 267

DIT-MCO'S GONE COMPUTER!



The New SYSTEM 810

A MULTICHANNEL REAL-TIME, ON LINE MULTIPROGRAMMED CONTROLLER AND PROGRAM LIBRARY FOR AUTOMATIC TEST EQUIPMENT AND NUMERICALLY CONTROLLED MACHINES.

- Multiprogrammed operation — permits simultaneous multichannel control and file changes.
- Designed to provide a centralized 8 channel control for several satellite stations operating at the same time.
- Can control a mix of automatic wiring analyzers and numerically controlled machines remotely located from System 810.
- Combines speed, reliability, and user convenience with DIT-MCO's proven standard of quality.
- Complete computer programs library with edit capabilities.
- All software furnished and maintained by DIT-MCO.

Give us a test problem and we'll show you how to control it.

DIT MCO

DIT-MCO: The difference in testing.

DIT-MCO INTERNATIONAL
A division of Xebec Corporation
5612 Brighton Terrace • K.C., Mo. 64130
Telephone (816) 363-6288
Telex Number 42-6149

INFORMATION RETRIEVAL NUMBER 51

Low-cost CRT terminal has editing features

Lear Siegler, 714 N. Brookhurst St., Anaheim, Calif. (714) 774-1010. $1500.

The ADM-1 CRT terminal displays up to twelve 80-character lines on a 12-in. screen. A 5 × 7 dot matrix format is used to form 64 USASCII alphanumeric characters. The terminal is designed for RS232 communications at rates of 110, 300, 600, 1200, 1800, 2400, 4800, and 9600 baud. In the Transmission mode, block or line transmission is read from the start of the page or start of line to the cursor. In the Conversation mode, all data are simultaneously transmitted to the computer and displayed on the screen, or each character can be transmitted to the computer and echoed back to the screen. Editing capabilities of the ADM-1 allow clearing the screen or using a destructive cursor for character change. Cursor control allows the user to skip, backspace, forespace, move up, down, return or home. A field-protect mode, specified by delimineters at the start and end of the field to be kept, allows the user to maintain desired information on the screen. The protected field is displayed at a lower intensity level. Available options include a 1920-character display, polling data editing. The keyboard is a standard TTY type.

CHECK NO. 270

Mini features 16-k bytes plus hardware mult/div.

Interdata, 2 Crescent Pl., Oceanport, N.J. 07757. (201) 229-4040. $3180 (61 qty.); Aug.

For a price of $3180, the New Series Model 74 minicomputer offers 16-k bytes of core, hardware multiply/divide 16 general registers and up to 225 I/O interrupts with automatic vectoring to service routines. The unit is upward compatible with all other Interdata New Series processors and is designed for OEM applications. The one μs core memory is directly addressable to 64-k bytes and expandable in eight to 16-k increments. Available options include a/d and d/a converters, data set adapters and a wide range of peripherals.

CHECK NO. 271

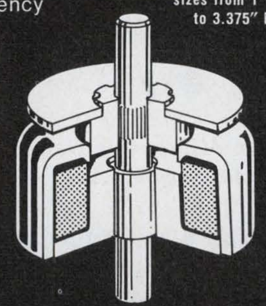
LEDEX®

push-pull solenoids

a shape and size for the action you need...

short stroke efficiency

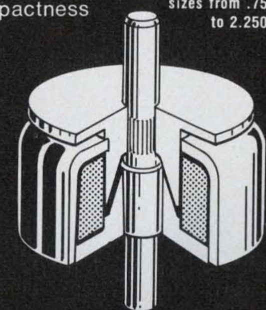
20 shelf models
sizes from 1" D. x ½" to 3.375" D. x 1⅞"



Flat face plunger and pancake shape give you action in 5 to 10 milliseconds. Best for strokes to about .060" and when space is at a premium.

medium stroke compactness

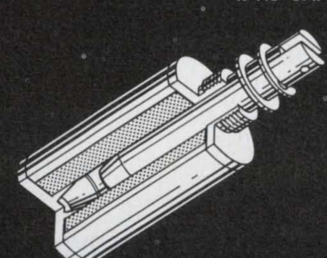
31 shelf models
sizes from .750" D. x ½" to 2.250" D. x 1½"



Conical face gives added surface pulling power—extends the stroke to about .250" without increasing solenoid size.

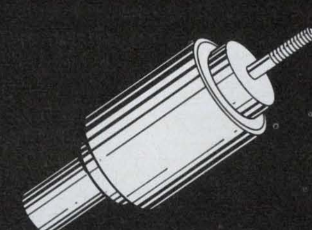
long stroke economy

21 shelf models
sizes from ½" D. x ½" to 1½" D. x 2½"



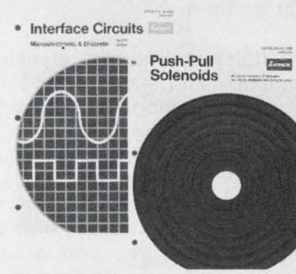
Tapered plunger lengthens the travel capacity to .750" and more. Construction simplicity permits production economy.

special strokes custom performance



At Ledex we custom design for special strokes. This solenoid, for example, delivers maximum force in the middle of a 2" stroke, then tails off toward the end.

To help you decide which size and shape solenoid is best for the action you need, we furnish precise force, stroke and speed curves. Usually you'll find your answer among some 70 variations on the shelf. If not, we'll custom the exact solution for you.



Companion Ledex interface circuits let you control acceleration and deceleration, program pulses, or work from logic level sources.

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

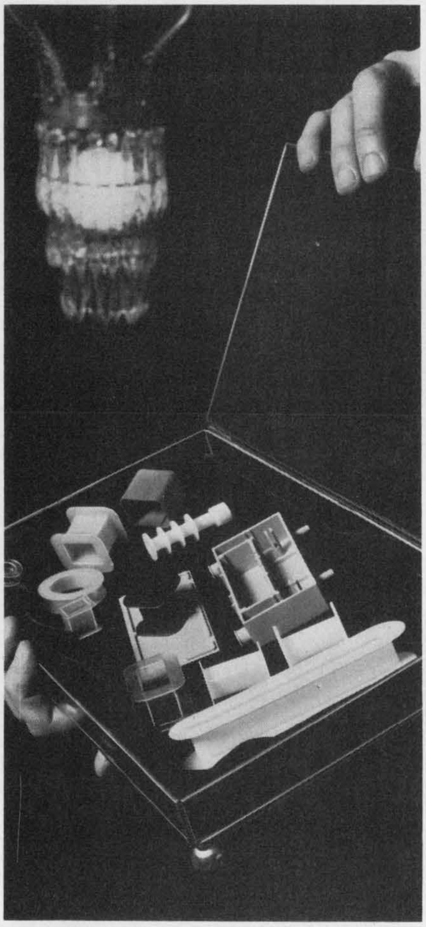
LEDEX®

Positioning • Switching • Interface Circuits

Toll free number for name of your nearest representative: 800-645-9200; New York firms call 316-245-0990.

INFORMATION RETRIEVAL NUMBER 55

The Elegant Molded Parts



For elegant applications. Custom-made or standard, EPC parts come with thin walls down to 5 mils, tolerances to ± .05% – even threaded bushings. In six different materials: fluorocarbon, nylon, glass-reinforced nylon, DAP, polyester and epoxy. For temperature ranges that go up to 200°C.

It's just the sort of selection and craftsmanship that you expect from EPC as an EAI component company. Look to EPC also for transformer kits. Or to EAI

for thick-film audio amps. Capacitors. Custom coils. Solenoids. Active filters. Analog / digital converters and other special function modules. Plus a growing list of other elegantly crafted etceteras.

EPC

Electrical Plastics Corporation
500 Long Branch Avenue
Long Branch, New Jersey 07740
Tel. (201) 870-9500
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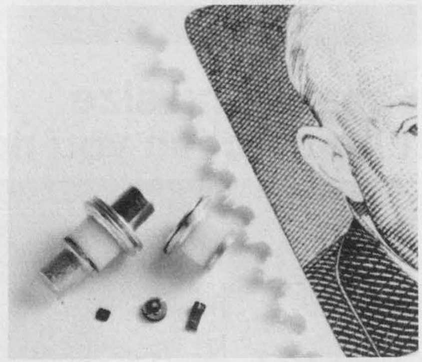
INFORMATION RETRIEVAL NUMBER 56

Diodes switch in less than 5 ns



Raytheon Microwave Devices Operation, 130 Second Ave., Waltham, Mass. 02154. (617) 890-8080.

Eight p-i-n and n-i-p diodes feature switching speeds of less than 5 ns. Low capacitance—less than 0.1 pF—and low series resistance —less than 1 Ω—even at low bias levels combine to also provide the new diodes with high-isolation/insertion-loss ratios. Models MS6101 and MS6102 are rated at 100 V minimum breakdown voltage and 0.20 pF maximum junction capacitance; MS6103 and 6104, at 200 V and 0.15 pF; MS6105 and 6106, at 100 V and 0.12 pF, and Models MS6107 and 6108 are rated at 200 V and 0.10 pF.

CHECK NO. 272

Stub antenna covers the 1030 to 1090 MHz range

Kings Electronics, 40 Marbledale Rd., Tuckahoe, N.Y. 10707. (914) 793-5000.

The stub antenna, designated KC-89-95, has a VSWR of less than 1.25:1 in the range of 1030 to 1090 MHz. It is 3-1/4 in. long and weighs less than an ounce. It is provided with a quick-disconnect female BNC type connector.

CHECK NO. 273

TEMP-R-TAPE:

GREAT ELECTRICAL PROPERTIES

PLUS

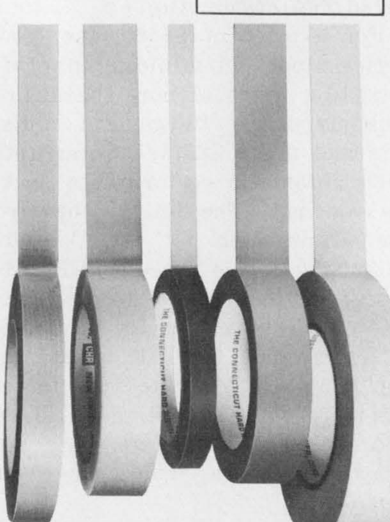
MOST ANYTHING ELSE YOU MIGHT WANT IN A TAPE.

Like high tensile or tear strength; excellent abrasion, thermal, and chemical resistance; exceptional dimensional stability; excellent conformability; and a low-friction, easy-release surface. Because Temp-R-Tape® is a complete tape "family" available in a variety of materials like polyester, polyester/rope paper laminate, Teflon*, Kapton*, and fiberglass. Supplied with thermosetting, silicone, or acrylic pressure-sensitive adhesive.

Find your CHR distributor in the Yellow Pages under "Tapes, Industrial" or in industrial directories. Or write for details and sample. The Connecticut Hard Rubber Company, New Haven, Connecticut 06509.

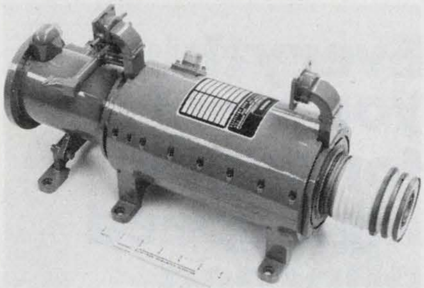
*T.M. of DuPont

a HITCO company CHR®



INFORMATION RETRIEVAL NUMBER 57

X-band TWTs for airborne radar

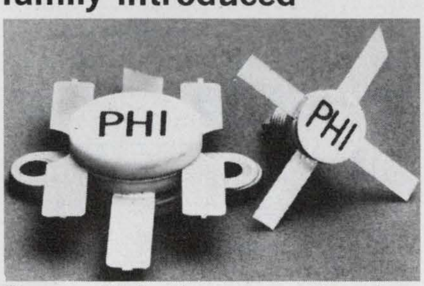


Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, Calif. 90509. (213) 534-2121.

Two versions of a high-power X-band TWT are now available for applications in phase-coherent radar systems. They consist of a PPM version, Model 796H, with minimum peak power output of 40 kW, and a solenoid focusing version, Model 786H, with a minimum peak power of 50 kW. The Model 796H features a duty cycle of 5% and weighs 28 lbs. The Model 786H has a 10% duty cycle and weighs less than 50 lbs. Both models feature a 7.5% bandwidth, gain of 54 dB and employ liquid cooling and a nonintercepting shadow grid for low-power modulation.

CHECK NO. 274

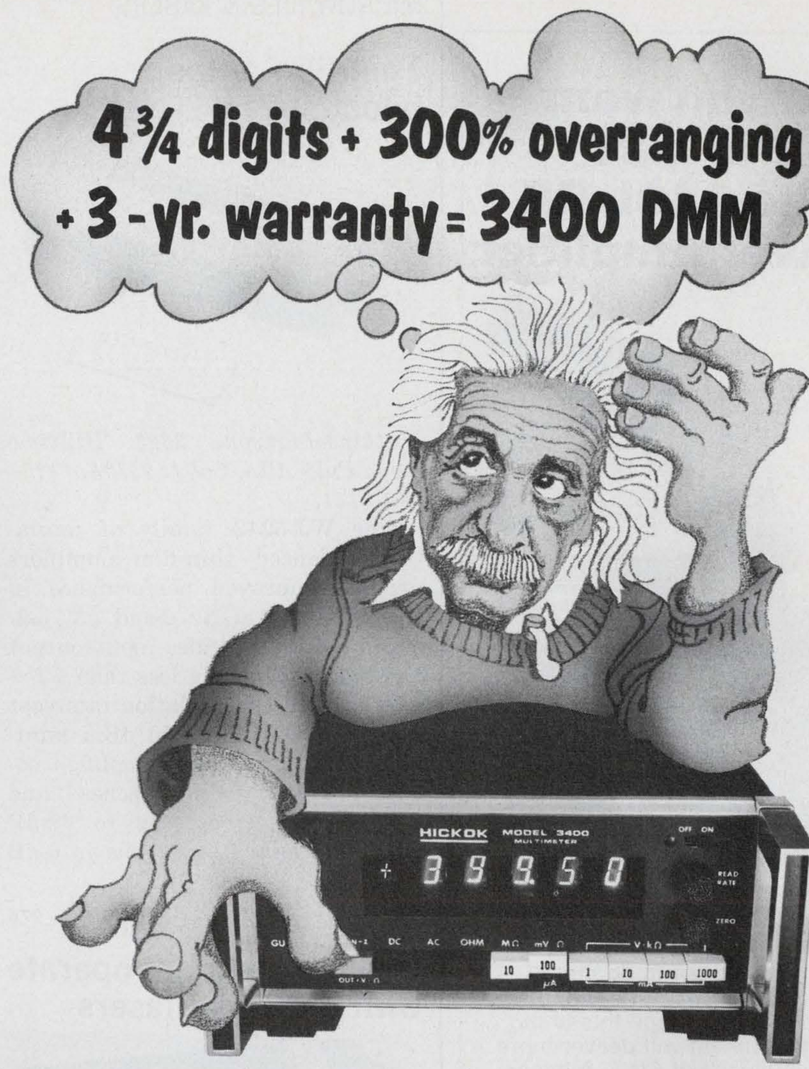
225-400 MHz transistor family introduced



Power Hybrids, 1742 Crenshaw Blvd., Torrance, Calif. 90501. (213) 320-6160. $20 to $140 (1-24); stock to 2 wks.

A series of six broadband, silicon npn power transistors are available for the 225-400 MHz frequency range. All transistors feature gold metallization, emitter-resistor ballasting and hermetic packages. One basic device design provides output power levels from milliwatts to over 50 W in six octave steps. The 25-W and 50-W transistors are both input matched with a low Q, diatonic impedance curl.

CHECK NO. 275



It's all relative in a Hickok Multimeter...

You get more than 4 digits in the Hickok 3400 Multimeter. You can also get 300% overranging, so you can read to 39999 on all 5 functions. This is for AC/DC voltage from 10 μV to 1 kV, for resistance from 10 mΩ to 40 MΩ, and for AC/DC current from 10 nA to 2 A.

With the 300% option, you can read critical power supply outputs between 20 and 39 volts to 5-digit resolution at 4-digit DMM prices.

In addition, Hickok backs up the reliability of the 3400 with a 3-year warranty. This developed from Hickok's long experience as a pioneer in the use of LSI circuitry in test equipment.

Price of the Hickok 3400 is $595. Send for the 3400 Series Data Sheet for complete specifications on the 3400, as well as the Microvolt Multimeter and the Multimeter Counter.

HICKOK
the value innovator

Instrumentation & Controls Division
The Hickok Electrical Instrument Co.
10514 Dupont Ave. · Cleveland, Ohio 44108
(216) 541-8060 · TWX: 810-421-8286

INFORMATION RETRIEVAL NUMBER 58

If you want to hurt the 240L RF Power Amplifier

...you've got to do more than short circuit its output.

As a matter, of fact, this *brand new* instrument will deliver more than 40 watts of Class A linear power and up to 150 watts of CW and pulse power to any load impedance (from an open to a short circuit). Immune to load damage and unconditionally stable the 240L covers the frequency range of 20 KHz to 10 MHz with a flat 50 db gain. Completely *solid state* the 240L will faithfully reproduce input waveforms from any signal or function generator in its range.

If you need a transducer drive source for ultrasonics, RFI/EMI, biological research, electro or acousto optics the 240L was designed for you.

Solid state reliability is here at $1450.00.

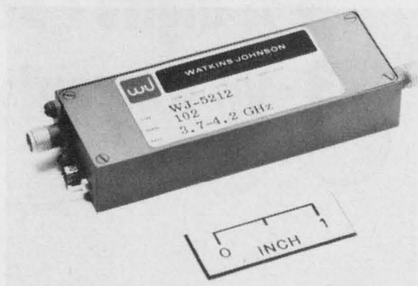
For further information or a demonstration contact ENI, 3000 Winton Road South, Rochester, New York 14623 (716) 473-6900 or TELEX 97-8283

ENI

The world's leader in solid state power amplifiers

INFORMATION RETRIEVAL NUMBER 59

Thin-film amps boost specs

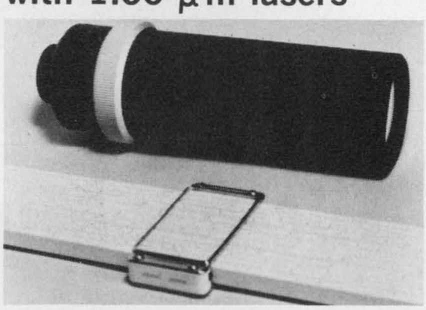


Watkins-Johnson, 3333 Hillview Ave., Palo Alto, Calif. 94304. (415) 493-4141.

The WJ-5212 family of miniature, balanced, thin-film amplifiers provide improved performance in the 3.7-to-4.2 GHz band. A balanced circuit provides input/output VSWRs of typically less than 1.2:1 and high intermodulation intercept points of +17 to +20 dBm minimum. A 24-dB gain amplifier occupies 1.45 cubic inches and weighs only 2 oz. Up to 48-dB minimum gain is available in 6-dB steps.

CHECK NO. 276

Beam expanders operate with 1.06-μm lasers



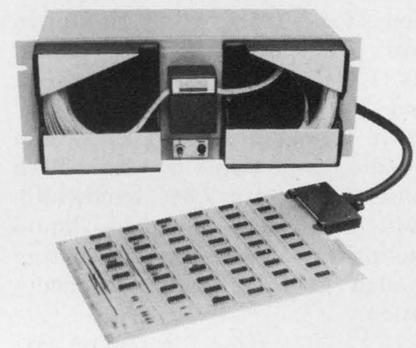
General Photonics, 3004 Lawrence Expwy., Santa Clara, Calif. 95051. (408) 736-7114. 101: $590; 102: $690; 2-4 wk.

Two beam expanders are designed for use with the company's YAG TWO lasers or other low and medium power cw or pulsed 1.06-μm lasers. Called the Models 101 and 102, they have a beam expansion ratio of 3:1 and 6:1, respectively. The respective output apertures are 21 and 36 mm, and effective f/numbers are 3.6 and 4.2. Both expanders have a focusing range of infinity to three meters, maximum average power rating of 50 W and peak power density of 10^8 W/cm^2.

CHECK NO. 277

Everything you need for adding high-speed punched tape reading to your computer.

(At significant savings, too.)



Decitek can supply a complete, ready-to-run reader-interface package to operate reliably with your particular mini-computer—at an attractive price that can add to savings you may already be gaining by buying other peripherals directly.

The Decitek package includes our universal, widely-proven photoelectric reader for 150/300/600 cps reading...PC board circuitry to plug into your mini's card rack...connecting cables...complete installation information.

For the special systems builder and computer user, here's a money-saving yet reliable way to add the capability of high-speed punched tape reading to a computer system. Come directly to Decitek. For full details, call or write Decitek, 15 Sagamore Rd., Worcester, Massachusetts 01605. Tel. (617) 757-4577.

DECITEK
A DIVISION OF JAMESBURY CORP.

INFORMATION RETRIEVAL NUMBER 60

GENERAL ELECTRIC'S 92F ADVANCED CAPABILITY COMPUTER-GRADE CAPACITOR...

Now! A highly reliable long life capacitor designed for applications requiring large amounts of ripple current at operating temperatures of 85 C and above. Ideal for power supplies, particularly the new switching mode types, energy storage and discharge, input filters for SCR power supplies . . . anywhere large amounts of ripple current are needed. Features include:

- 3,000 hour life rating at 85 C
- Ratings to maximum volt-microfarads per case size
- Capable of operating up to 125 C
- Standard screw-type terminal inserts
- Standard units available in 21 case sizes — over two hundred ratings

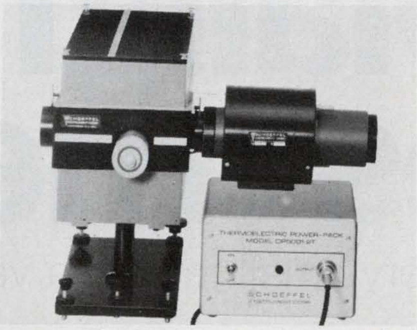
For more information on these, or any of General Electric's wide range of capacitors, call your nearest GE sales office today, or write Section 430-53, Schenectady, N. Y. 12345.

MAKE SOMETHING OUT OF IT!

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 61

Monochromator covers UV through IR range



Schoeffel Instrument, 24 Booker St., Westwood, N.J. 07675. (201) 664-7263. Under $2600; stock to 30 days.

The quarter meter GM-250 monochromator provides continuously variable high-energy monochromatic radiation over the range from ultraviolet through visible wavelengths to the infrared region: 1750 to 30,000 Å, depending on grating selected. The GM-250 uses a 64 × 64-mm plane diffraction grating in a modified Ebert-Fastie mount. The standard grating is blazed at 240, 300 or 600 nm. Efficiency at blaze is 55-90% and resolution is better than 2 Å at 3131 nm.

CHECK NO. 278

Tunnel-diode detectors for flat response

Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086. (408) 732-0880.

The DOZ118B and DOZ218B tunnel-diode detectors, for the 1-to-18 and 2-to-18 GHz frequency band, respectively, feature a voltage sensitivity of 400 mV/mW minimum. Moreover, frequency-response variations are typically ±0.5 dB, and ±1.0 dB maximum. Typical VSWR is 2:1 and 3:1 maximum. Both detectors have an input impedance of 50 Ω and an output capacitance of 8 or 12 pF.

CHECK NO. 279

A pushbutton switch for "peace of mind" applications--that's yankee ingenuity.

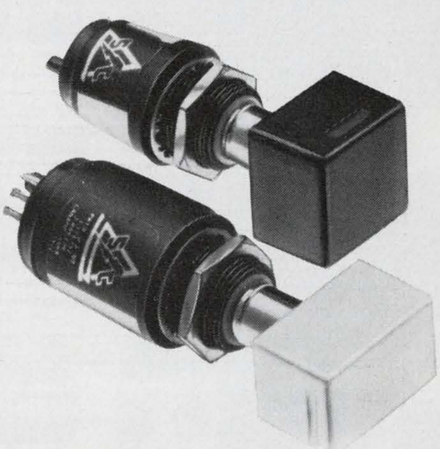
Switchcraft's ORCON pushbutton switches are designed and manufactured specifically for applications where economy is measured only by maximum reliability. Where "peace of mind" is mandatory.

ORCON Series OA lighted pushbutton switches provide you with 2PDT through 6PDT circuitry in a 3/4" diameter package. ORCON Series OB offers SPDT, DPDT switching in a 23/32" diameter housing. Both offer features that give you that extra peace of mind. Consider ORCON's exclusive snap-slide migration-free lifting and wiping action of the self-cleaning cobalt-gold contacts which eliminates arcing.

ORCON switches accept single lamp, redundant-lamp pushbuttons in a variety of colors and shapes—square, round, rectangular. And we have them all. You can specify momentary silent, momentary positive, alternate action or push lock/push release functions.

When you want to specify a little extra peace of mind, see what ORCON—and a little yankee ingenuity—can do for you. Contact your Switchcraft Representative, or Switchcraft Inc., 5555 N. Elston Avenue, Chicago, Illinois 60630. Or phone (312) 792-2700.

SWITCHCRAFT



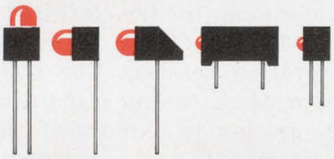
INFORMATION RETRIEVAL NUMBER 62

Dialight sees a need:

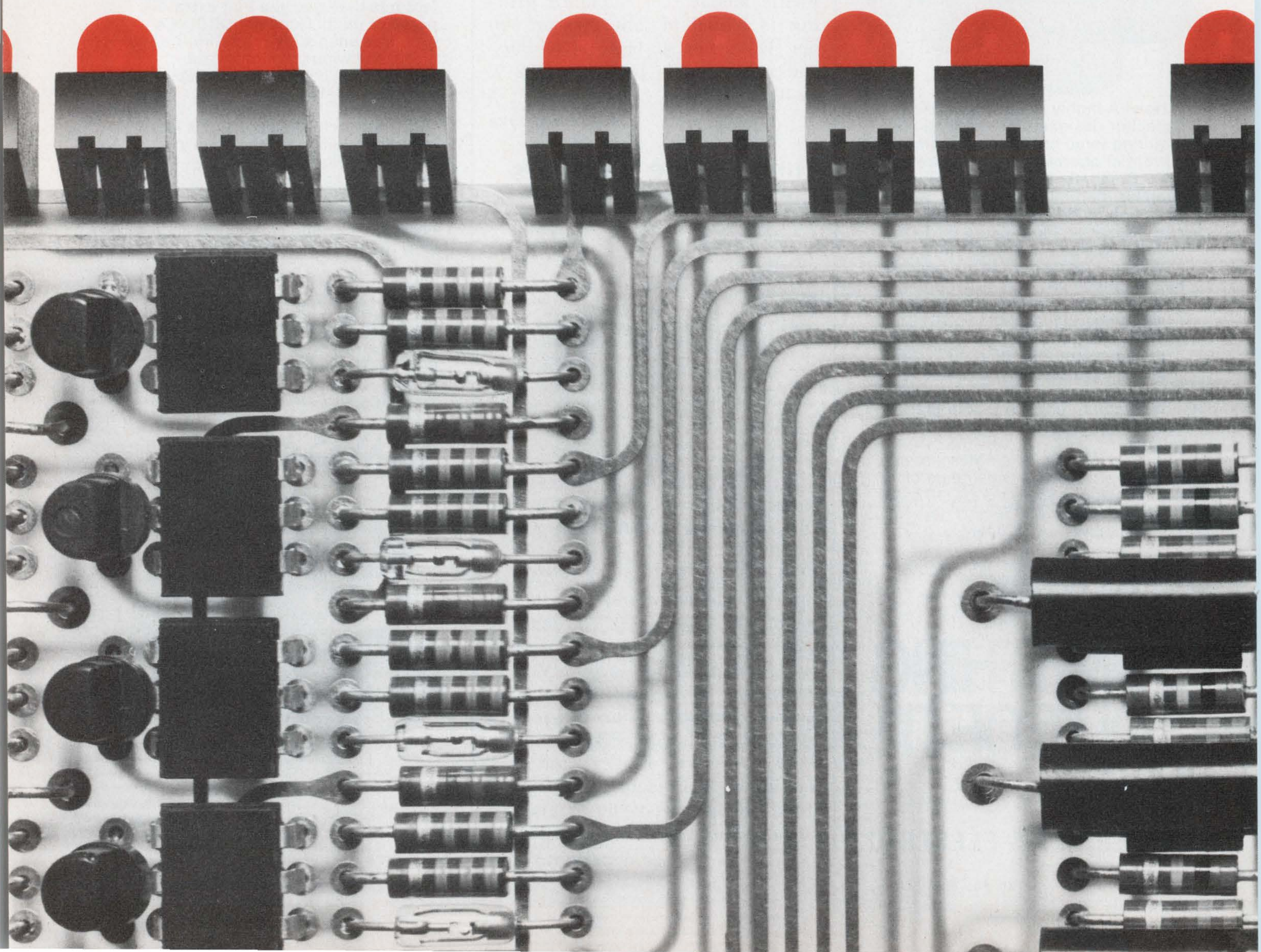
(**Need:** Find a very small fault in a very large system.)

See Dialight.

All printed-circuit boards need a fault indicator; that's why Dialight has developed such a broad family. These tiny LED devices signal where and when a fault occurs in a complex electronic circuit — and this can reduce downtime to a minimum. With some Dialight fault indicators, you can get as many as 10 units in just 1″ of space. These devices, which come in a variety of sizes, are designed to operate from 1.6 to 14 volts and are available with both axial and right angle leads. They



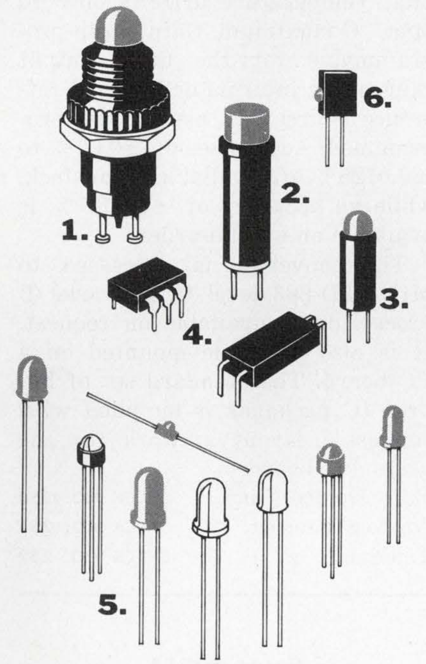
can be driven directly from DTL or TTL logic and can also serve as logic-state indicators, binary data displays, or just as indicators, as in this p-c board furnished by Struthers-Dunn,Inc.* But Dialight's fault finders are only a small part of their fast growing family of light-emitting diodes. Additional opto-electronic devices are extensively used in cartridges, lighted push-button switches, opto-isolators, and readouts, all supplied by Dialight. A wide variety of discrete LEDs further adds to the broad family.



Dialight is a company that looks for needs . . . and develops solutions. That's why we developed the industry's broadest line of switches, indicator lights and readouts using LEDs. No other company offers you one-stop shopping in all these product areas. And no one has more experience in the visual display field. Dialight can help you do more with them. Talk to the specialists at Dialight first. You won't have to talk to anyone else. We can help you do more with LEDs than anyone else because we've done more with them.

Here are a few products in this family: **1.** Ultra-miniature indicator lights **2.** Datalamp cartridges **3.** Bi-pin LED lamp **4.** Opto-isolators **5.** LED solid state lamps **6.** Logic state fault indicators

*Used in their VIP Programmable Controller



Please send data on your LED products.

NAME ____________________

TITLE ____________________

COMPANY ____________________

ADDRESS ____________________

CITY __________ STATE __________

DIALIGHT

Dialight Corporation, A North American Philips Company
60 Stewart Avenue, Brooklyn, N.Y. 11237 (212) 497-7600

INFORMATION RETRIEVAL NUMBER 63

POWER SOURCES

Dc-to-ac inverter draws only 30 mA for standby

Emhiser Rand, 7721 Convoy Ct., San Diego, Calif. 92111. (714) 278-5080. $389; 6 wk.

The UPC-178A 300-W dc-to-ac inverter forms a standby power supply when connected to a 115-V, 60-Hz line and to a 12-V battery. A load of 300-VA max can then be connected to the inverter output. If the 115-V line fails, the unit will switch over to the battery supply. Circuitry in the 178A converts the 12-V dc to 115-V, 60-Hz ac. A built-in charger maintains the 12-V battery at full charge as long as the main 115-V supply is available. When connected to a battery the unit draws only 30 mA until a load is applied. The charger output is 14 V ±1%. Weight of the inverter is 18 lb and its size is 4 × 8-1/2 × 9-1/2 in. Optional outputs are 115 V, 50 Hz; 115 V, 400 Hz and 220 V at 50, 60 or 400 Hz. Optional battery input voltages are 6, 24, 36 and 48 V.

CHECK NO. 280

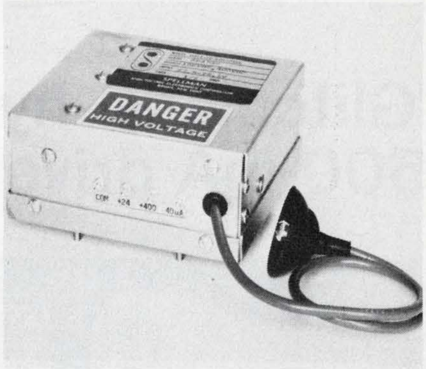
Lithium primary cells feature 5-yr shelf life

Power Conversion, Inc., 70 MacQuestan Parkway S., Mount Vernon, N. Y. 10550. (914) 699-7333.

A line of primary batteries, the Eternacell, which uses lithium as the anode and an organic electrolyte, is available in six standard sizes that include sizes C and D. Compared to conventional primary batteries, they offer these advantages: 2.8 volts-per-cell nominal operating voltage, twice that of ordinary batteries; high energy-per-unit weight and volume; shelf life exceeding 5 yr; performance down to −65 and up to 165 F; and a high discharge rate.

CHECK NO. 281

High voltage CRT supply has multiple outputs

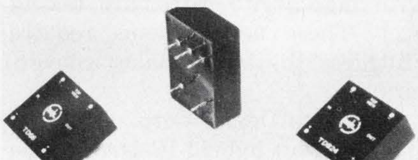


Spellman, 1930 Adee Ave., Bronx, N.Y. 10469. (212) 671-0300.

The RM10PX/MIL modular CRT high voltage power supply has two outputs. One is ±10 kV at 0 to 300 μA, and the other is +400 V at 5 μA. A +400 V monitor terminal can be connected to a microammeter to monitor the 400 V output. Line and load regulation on the 10-kV output are ±0.1% and ±0.5%, respectively, with 0.25% ripple, pk-pk. The temperature coefficient is 0.025%/°C. Load regulation on the 400 V output is 5% with 0.1% ripple, pk-pk. The temperature coefficient is ±0.1%/°C. The RM10PX/MIL measures 4-1/2 × 4 × 8 in., weighs less than 2 lb and meets Mil specs.

CHECK NO. 282

Drive Nixies from low dc with minisupplies

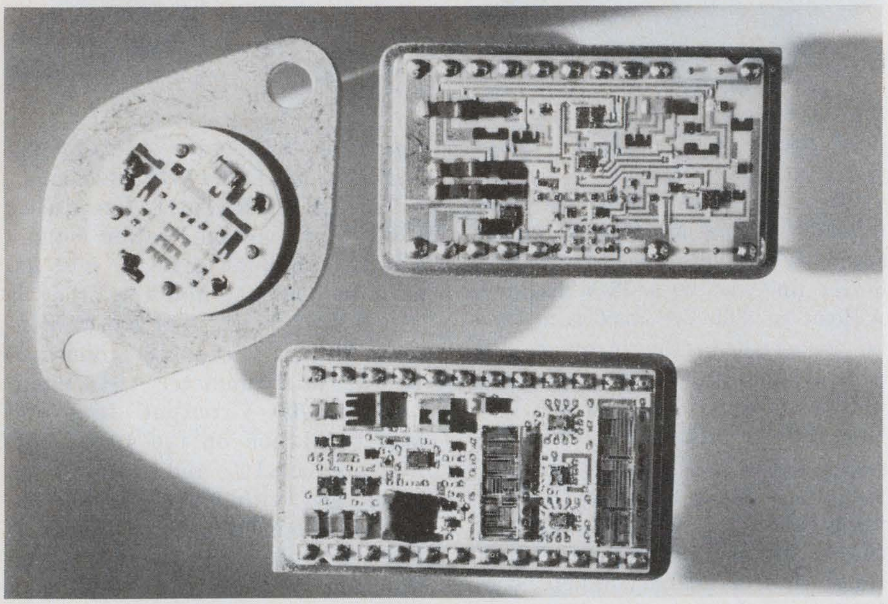


Mil Electronics, 176 Walker St., Lowell, Mass. 01854. (617) 453-4142. $15.95 (T series), $29.95 (N Series); stock.

Power supplies for "Nixie" tubes are available in the T and N series. Series T is a 1 × 1 × 1/2 in. package and delivers 200 V at 3 mA. series N is 1 × 1-1/2 × 1/2 in., and delivers 200 V at 12 mA. The N units can drive up to four or five tubes simultaneously. All packages are designed for printed-circuit-board mounting. Models are available for input voltages of 5, 6, 12, 24 or 28 V.

CHECK NO. 283

'Glitchless' hybrid-IC DAC has 500-mA drive capability



Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801. (516) 433-5330. From $485; stock.

The new generation of CRT displays is moving away from the conventional plan position-indicator and raster displays. Computer-controlled vector/stroking systems, with high write rates, are taking over. These new systems require glitchless digital-to-analog converters.

ILC Data Device Corp. claims its DDAC 13-bit hybrid-IC DAC is the smallest, glitchless unit available. It is housed in three packages: two 24-pin DIP-compatible metal cases, 1.4 by 0.8 by 0.2 in., for the conversion circuitry, and a TO-3 for the coax driver.

Two units that compete with the DDAC are the Analog Devices DAC-10DF 10-bit model and the Teledyne-Philbrick 4017 13-bit unit.

The output drive capability of the DDAC is listed at 500 mA (current limited for short-circuit protection) at ±2.5, ±5 or ±10 V. This compares with 100 mA for the DAC-10DF and 50 mA for the 4017. Settling time for the DDAC is given as 375 ns, while for the 4017 it is 5 μs. There is no comparison with the Analog Devices unit, since it has only 10-bit resolution.

Also guaranteed for the DDAC are a maximum glitch amplitude of 10 mV, an absolute linearity of 0.0061% and a 5-MHz word rate. The Analog and Philbrick modules guarantee a 20-mV glitch amplitude and linearities of 0.05% and 0.01%, respectively.

The output of the DDAC is monotonic over the temperature range of 0 to 70 C for the full 13 bits and over −55 to 85 C for 12 bits. Temperature drift is only 10 ppm/°C maximum. Gain is pin-programmable for the three output ranges. An internal or external reference source can also be pin-programmed. Accuracies of ±0.05% to ±0.0125% are available from stock, while an accuracy of ±0.0061% is available on special order.

The converter is processed to MIL-STD-883 level C, and level B processing is available on request. It is also available mounted on a PC board. The standard set of hybrid IC packages is supplied with suggested layout artwork for the users PC board.

Data Device Corp. **CHECK NO. 250**
Analog Devices **CHECK NO. 251**
Teledyne **CHECK NO. 252**

ANALOGY

GOTTA GET UP EARLY IN THE A.M. TO BEAT THE 3010 IC TONE ALARM. EXCEED ITS DC REFERENCE BY 5mV, AND IT TURNS ON BOTH AC AND DC. DC OUTPUT DRIVES TTL, LED OR LAMP LOADS. AC OUTPUT DRIVES A SPEAKER, LIGHT OR TONE. 5 TO 15V SUPPLY. LOW STANDBY CURRENT.

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

INFORMATION RETRIEVAL NUMBER 64

Select either current or voltage outputs from dac

Sprague, North Adams, Mass. 01247. (413) 664-4411.

The series UHM-700 d/a converters are available with 8, 10, or 12-bit complementary binary inputs or two or three-digit complementary BCD inputs. The device inputs are fully compatible with most TTL/DTL logic. An internal voltage reference and drift compensation circuitry give relative immunity to temperature and power supply variations. Operation can be specified over the temperature ranges of 0 to 70 C or −25 to +85 C for ±1/2 LSB maximum error. Additional features are a 200 ns settling time, selectable voltage outputs to ±10 V or current outputs to 2 mA, and provision for external gain and offset trim.

CHECK NO. 284

OSHA requirements met by solid-state time-delay

Regent Controls, Harvard Ave., Stamford, Conn. 06902. (203) 348-7734.

The Regent TM6470 timer provides two time-delay periods. One is fixed and tamper-proof at 4 s; the other is knob-adjustable between 1 s minimum and 2 s maximum. The unit provides safety-alarm and delayed-start to meet the requirements of OSHA (Occupational Safety and Health Act).

CHECK NO. 285

Input bias current of comparator is 0.5 nA

Pioneer Standard Electronics, 4800 E. 131 St., Cleveland, Ohio 44105. (216) 587-3600. $45 (1-24).

Model-33 high-impedance comparator operates from a single-ended power supply of 10 to 18 V dc and has a response time of less than 100 μs. The device has an input bias current of less than 0.5 nA and an input range from 0 to 5 V dc, inverting and noninverting. Other features of the comparator include: input overload capacity up to 100 V dc, output-current sinking capability, and built-in hysteresis. A 6.2 V dc reference source is included and normal functioning is guaranteed within a temperature range of 0 to 75 C. The potted module measures 2.35 by 2.125 by 0.75 in., with terminals on a 0.2 in. grid spacing.

CHECK NO. 286

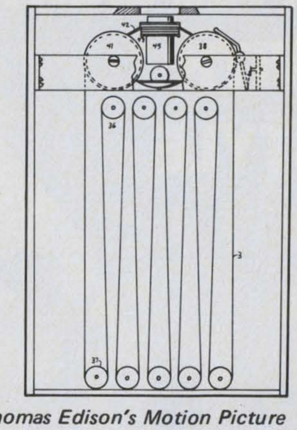
Eight-channel MUX lets signals go bidirectionally

Hybrid Systems, 87 Second Ave., Burlington, Mass. 01803. (617) 272-1522. $49 (1 to 9); stock to 2 wk.

The MUX201 is an eight-channel multiplexer—claimed to be the smallest TTL/DTL compatible unit available, only 1.4 × 0.6 × 0.4 in The unit contains three-bit binary-address logic plus a control bit. More than one unit can be paralleled to give a capability of up to 64 single-ended or 32 differential channels. It is completely self-contained and requires no external adjustments or trimming. Input range is ±10 V when operated from ±15 V power supplies. A unique feature of the unit is that the signals may be passed bidirectionally thus, the unit can be used to distribute an analog voltage to any one of eight channels.

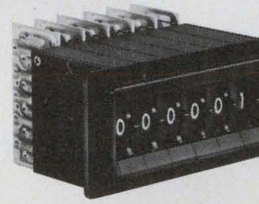
CHECK NO. 287

innovation yesterday



Thomas Edison's Motion Picture Machine

innovation today



DIGIVIDER DIGIDECADE

Dial the exact voltage or resistance you want

The motion picture camera has come a long way since Edison introduced it. Thumbwheel switches have come a long way too since we developed them in 1959. Now you can buy a Thumbwheel switch that acts as a digital voltage divider, potentiometer or resistance decade. Dial the values you want, and that's what you get. Accurately with repeatability. Digivider or Digidecade. An innovation in switching. So, ask for our new catalog. We think that's a great idea too.

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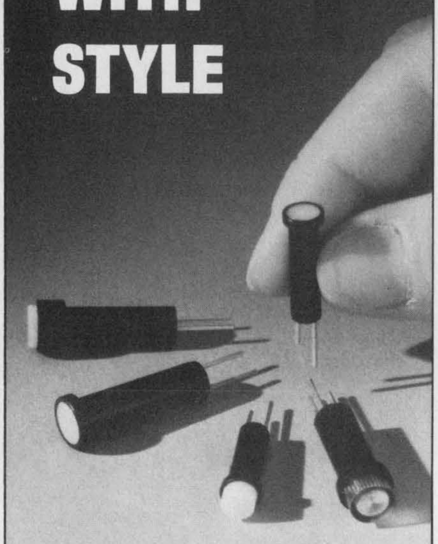
A Division of Becton, Dickinson and Co. B-D
855 So. Arroyo Parkway, Pasadena, Ca. 91105
Tel. (213) 449-3110 • TWX 910-588-3794

INFORMATION RETRIEVAL NUMBER 65

NOW... LITTLE LIGHTS WITH STYLE



Plus
High Performance...
Low Cost...
Immediate Availability

LED's—with built-in resistors for 3 to 28 volt applications.

SELF DRIVEN INCANDESCENTS — with built-in drivers & keep alive bias. Interface directly with TTL and MOS. Life ratings to 10+ years.

STANDARD INCANDESCENTS AND NEONS—single unit prices start below $1.00.

CUSTOMS TOO!

All Data Display Products panel indicator lights are ruggedly built. They are available with low profile or standard lens projections.

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the little light people

DATA DISPLAY PRODUCTS

5428 W. 104th St., Los Angeles, Ca. 90045
(213) 641-1232

INFORMATION RETRIEVAL NUMBER 66

Digital multimeter doubles as electrometer

Keithley Instruments, 28775 Aurora Rd., Cleveland, Ohio 44139. (216) 248-0400. $995.

The Model 616 digital electrometer measures voltage, current, resistance and charge with extremely high input impedance and sensitivities. The unit has voltage sensitivities from 10 μV per digit to 200 V, with an input impedance of greater than 2×10^{14} Ω. It is fully autoranging over its five voltage decades. Additionally, this new digital will measure current from 10^{-16} A per digit to 200 mA and is autoranging over any five decades in that span. It also operates as an ohmmeter and measures resistance as high as 2×10^{14} Ω. The Model 616 is also operable as a current integrator with ranges from 10^{-15} to 2×10^{-5} coulombs.

CHECK NO. 288

Six-digit counter measures to 50 MHz

Analog Digital Research, 1051 Clinton St., Buffalo, N.Y. 14206. $399; stock to 30 days.

The CM50 is a completely solid-state, six-digit frequency counter that measures frequency, frequency ratio, single and multiple periods, and totalizes. Sensitivity of the 1-MΩ input is 50 mV over the entire frequency range of 5 Hz to 50 MHz. The input is fully overload protected, and equipped with a slide-switch attenuator. The CM50's six gate times (100 ms to 10 s) are derived from either the standard 10-MHz crystal oscillator, or an optional high stability TCXO. The unit operates from either 115 V ac (±10%), or an external 12-V-dc source.

CHECK NO. 289

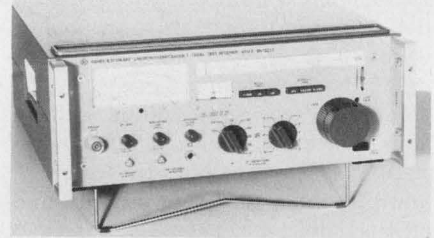
Prescalers extend range of counters to 250 MHz

Instru-Mech, 1275 Bloomfield Ave., Fairfield, N.J. 07006. (201) 575-1860. DS 250-S: $134.95; DS 250-D: $199.95; stock to 4 wk.

The DS 250 series are prescalers that extend the frequency range of existing counters to 250 MHz. Two models are offered, Model DS 250-S, a basic scaler that divides by 10; and Model DS 250-D, a switchable divide by 10 or 100, with sensitivity control and meter level indicator. Input frequency range is 10 to 250 MHz, with a sensitivity of better than 100 mV.

CHECK NO. 290

Test receiver covers 1 to 13 GHz



Rohde & Schwarz, 11 Lexington Ave., Passaic, N.J. 07055. (201) 773-8010. $8030; 30 days.

USU3 solid-state test receiver is a selective/relative-voltage meter for 1 to 13 GHz (with harmonic mixing from 3 GHz), and 12 μV to 40 mV (−87 to −15 dBm) fundamental sensitivity. Each of the five frequency subranges can be covered in three turns of the tuning knob. Fine tuning is 1:100. Frequency scales are linearized and scale can be recalibrated every 50 MHz. Automatic tuning with a lock-in range of ±1 MHz becomes effective after 10 μV.

CHECK NO. 291

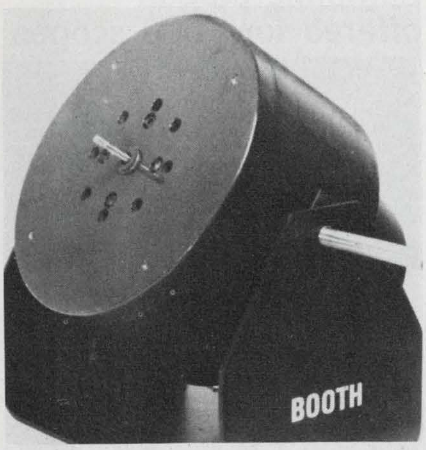
100-MHz scope costs $1675

Dumont, 40 Fairchild Pl., West Caldwell, N.J. 07006. (201) 575-8666. $1675; 45 days.

Features of the Model 1100 scope include 100-MHz bw at 5 mV/cm; 100-MHz triggering selection on CH 1, CH 2 or display; a special feature for setting trigger level; and a unique independence between position and trigger-level controls.

CHECK NO. 292

Vibrate equipment with long stroke at low cost



Booth Development, 128 Shore Drive, Short Beach, Conn. 06405. (203) 481-2206. From $1890; 4 to 8 wk.

Vibra-Gen 500 systems are sources of vibrating force for industrial testing applications. Forces of 25 to 130 lb and displacements to 2-1/2 in. are provided. These units are used to test electronic products. The vibration, shock or earthquake environment the product may see can be simulated in the laboratory. Each system consists of a vibration exciter and a power amplifier. The seven systems in the series include two exciters with a pk-pk capability of 1-1/4 in., two vibration exciters with a pk-pk displacement of 2-1/2 in., and three power amplifiers with outputs of 75, 300, or 750 W.

CHECK NO. 293

Slimline counters offered for systems use

Durgin & Browne, 80 Allen Rd., South Burlington, Vt. 05401. (802) 863-6873. Start at $54; stock to 2 wk.

DPC-200 series is a slimline digital counter that totalizes TTL/DTL-level pulses up to 18 MHz. Powered from 5 V dc, the DPC-200 gives 8-4-2-1 true, positive-BCD output, reset line, decimal-point programming, half-digit or overrange provision. The counter module is housed in an ABS package requiring less than 0.6-in. of rear panel space and a 2.8 × 4.3-in. cutout. Standard models are available with two, three, four and five digits, with 3/8-in. segmented display.

CHECK NO. 294

Who said a digital-readout signal generator has to be hard to handle, hot and heavy, and cost $4,450?

Not us! Our Model 102A, at $2,975, has everything you need for just about any AM/FM application — *plus* seven performance and convenience features you won't get in the $4,450 design.

What did we leave out?

Phase-lock synchronization, for one (but our dc-coupled FM channel can be externally locked if you need better stability than our typical 4 ppm); and narrow-pulse modulation (belongs in a different class of generators).

What did we add?

Four different signal-generation techniques — for optimum performance in *each band,* from 4.3 to 520 MHz, without the usual compromises in noise, stability, or residual-distortion characteristics.

The most logical panel layout and convenient control setup you've ever seen. And a unique adjustable "feel" main drive mechanism for narrow-band receiver setting with ease — even without our electrical vernier.

Separate meters for modulation and output — no annoying autoranging or out-of-range annunciators . . . we don't need them.

15 minute warmup to typically meet 10 ppm/10 minute stability — made possible by low internal dissipation (only 30 watts; no fan!)

Wider FM deviation at low carrier frequencies than any other design in this class (how does 2 MHz peak-to-peak grab you?)

A detected-AM-output option, to verify our negligible phase-shift for VHF-omni testing.

Versatile modulation features — like five internal frequencies, 30% and 100% AM scales, and true-peak-responding AM and FM metering.

All these performance pluses are coupled with low spurious and close-in noise, excellent low-frequency phase integrity, really effective leveling, a low and flat VSWR curve, accurate wide-range attenuation, high output power . . . all of it buttoned up tight for low leakage in a lightweight 30 pound package.

. . . and it's all yours for $2,975. Get the full specs today — before you spend 50% more .

For complete data or a demonstration write or call Boonton Electronics Corp., Rt. 287 at Smith Road, Parsippany, N. J. 07054, (201) 887-5110.

BOONTON

SECOND ARRESTING OFFER...

One MOS Encoded ASR-33 Keyboard with N-Key Rollover for $59.00

Why $59.00? For the same reasons the $98.00 ANSI keyboard was offered at $49.00.

First. Because of the quality and features offered by the fully assembled ASR-33 compatible keyboards • MOS reliability • N-key rollover • 25c BI-PAC switches featuring dual gold spring contacts (used in most all U.S. made electronic calculators) • less than 200 mA power consumption • standard ASCII encoding • tri-state or TTL output compatible • full repeat function, and more.

Second. The keyboard is $59.00 because that's the cost for 5,000 ($125 for 1-25). Your first is from stock. Quantities in 6-8 weeks.

Like to try one? See your local CRC rep's keyboards. He'll arrange for you to take the first or second arresting offer.

CRC **Controls Research Corporation**
2100 South Fairview, Santa Ana, California 92704
Phone: (714) 557-7161 • TWX-910-595-1106

INFORMATION RETREIVAL NUMBER 68

MEMO

FROM: Bill Wright Purchasing
TO: Engineering Dept.
Looks Interesting

2 BILLION MODELS!
2 DAY DELIVERY
"OMNI SERIES"
Modular Power Supplies

- 1 to 12 outputs
- 5 to 28 volts — to 635 watts
- .01% IC regulation
- competitive cost
- masterfully engineered

FREE bulletin 115A tells how we make it happen!

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NEMA MEMBER
L-205

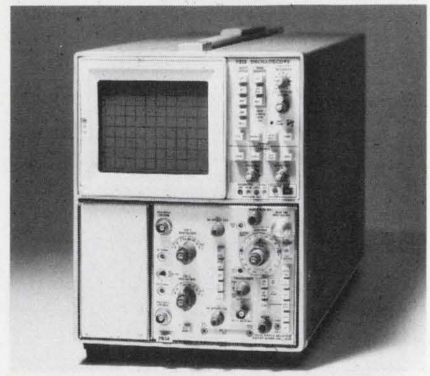
INFORMATION RETRIEVAL NUMBER 69

The gift that grows.

Take stock in America.
With higher paying U.S. Savings Bonds.

INSTRUMENTATION

Sampling plug-in offered for 7000 scopes

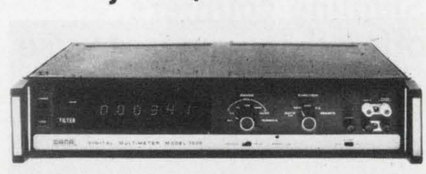


Tektronix, P.O. Box 500, Beaverton, Ore. 97005. (503) 644-0161. $1850; 6 wk.

The 7S14 is a dual-trace sampling plug-in for the 7000-series scopes. The unit measures pulse rise times of less than 350 ps and signal frequencies from dc to 1000 MHz. All of this at deflection factors ranging from 2 mV/div to 500 mV/div. Each of the two 7S14 input channels has a built-in delay line. The scope can be triggered internally and the leading edge of the triggering waveform can be displayed. The 7S14 also has two time bases, one for undelayed and another for delayed sweep operation.

CHECK NO. 295

Five-digit DVM costs just $995

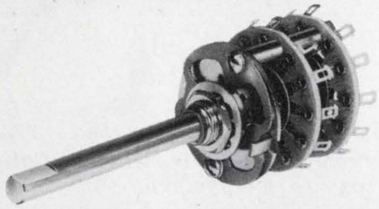


Dana Laboratories, 2401 Campus Dr., Irvine, Calif. 92664. (714) 833-1234. $995.

Two developments, delayed dual-slope integration and internal autozero without kickback, allow the Model 5000 five-digit DVM to sell for $995. Delayed dual-slope integration reduces noise and increases linearity, making possible 100% overrange and the reduction of bouncing digits. The basic instrument has five dc ranges handling 1 μV through 1000 V. Autoranging is offered in all functions.

CHECK NO. 296

Need rotary switches? 2-million combinations, 72-hr. delivery from your Oak Moduline™ distributor.



Quick-and-easy ordering of Oak-quality rotary switches in lots of 1 to 99. The Moduline system lets you specify switch components by number (no drawings needed). Your order is shipped within 3 days. Contact these Moduline distributors:

DRW

MASSACHUSETTS, Watertown. (617) 923-1900*
NEW YORK, Farmingdale...... (516) 249-2660*

HALL-MARK

ALABAMA, Huntsville........ (205) 539-0691
FLORIDA, Orlando........... (305) 855-4020*
GEORGIA, Atlanta........... (404) 963-9728
ILLINOIS, Chicago........... (312) 437-8800
KANSAS, Kansas City......... (913) 888-4747
KANSAS, Wichita........... (316) 682-2073
MARYLAND, Baltimore........ (301) 265-8500
MINNESOTA, Minneapolis.... (612) 925-2944
MISSOURI, St. Louis.......... (314) 521-3800
NORTH CAROLINA, Raleigh... (919) 832-4465
NEW YORK, New York........ (516) 293-7500
OHIO, Dayton................. (513) 278-6963
OKLAHOMA, Okla. City..... Enterprise 50094
OKLAHOMA, Tulsa........... (918) 835-8458
PENNSYLVANIA, Philadelphia. (215) 355-7300
TEXAS, Austin............... (512) 454-4839
TEXAS, Dallas............... (214) 231-6111
TEXAS, Houston............. (713) 781-6100
WISCONSIN, Milwaukee...... (414) 476-1270

INDUSTRIAL COMPONENTS

MINNESOTA, Minneapolis... (612) 831-2666*

SOLID STATE

TEXAS, Dallas............. (214) 352-2601*
TEXAS, Houston........... (713) 785-5205

WEATHERFORD

CALIFORNIA, Glendale...... (213) 849-3451*
CALIFORNIA, Palo Alto..... (415) 493-5373

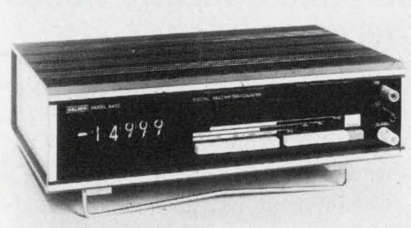
*Assembly Locations

OAK Industries Inc.

Crystal Lake, Illinois 60014

INFORMATION RETRIEVAL NUMBER 71

DMM/counter simplifies calibration



California Instruments, 5150 Convoy St., San Diego, Calif. 92111. (714) 279-8620. $695; stock.

This 4-1/2-digit multimeter/counter, the Model 8420, offers the four most-used functions in a single instrument: ac and dc voltage, resistance and frequency. Full scale on the pushbutton-controlled instrument is from 1 to 1000 V in four ac and dc ranges, from 1 kΩ to 10 MΩ in five resistance ranges, and from 10 kHz to 10 MHz in four frequency ranges. Resolution is 0.01% on all ranges. Circuitry common to various functions makes it possible to reduce the meter's normally required 17 calibration points—one for each scale—to only 12.

CHECK NO. 297

Level tracer measures channel properties

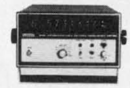
Sierra Electronic Operation, Philco-Ford, 3885 Bohannon Dr., Menlo Park, Calif. 94025. (315) 322-7222. $3195; stock.

The 850A is a level tracer that measures gain, impedance and return-loss of voice or program channels, transmission lines and equipment. Transmission level is adjustable from −30 to +10 dBm. The manually tuned or automatically swept signal can be selected for voice (200 Hz to 4 kHz) or program channel (30 Hz to 20 kHz). The receive section can measure levels from −52 to +26 dBm, return loss from −50 to 0 dB, and impedance from less than 50 to more than 2800 Ω.

CHECK NO. 298

BERKELEY IS BACK

PROGRAMMABLE FREQUENCY METER



Direct Counting to 500 MHz

Model 6421 B 500 MHz $1,340.00
Model 6420 200 MHz $ 990.00

Other measurements include ratio and periods. Measurements are instantaneous! In one second, read frequency to one Hertz.

PROGRAMMABLE UNIVERSAL COUNTER-TIMER

Two Counters in One!

Model 6401 200 MHz $1,290.00
136 MHz $1,190.00

Each input channel is equipped with a separate attenuator to allow frequency ratio and time interval measurements between two signal sources.

UNIVERSAL 21-COLUMN DIGITAL PRINTER

Reliability, flexibility, portability, low cost.

Model 1454 $1,055.00

Offers IC or transistor compatibility, flexible input format and BCD column expansion capability. Accepts data in many codes.

LINE NOISE GENERATOR

Controlled Line Noise!

Model 3020 $695.00

Perfect for testing instruments and systems for line noise immunity. Also measures noise up to 1kW peak power.

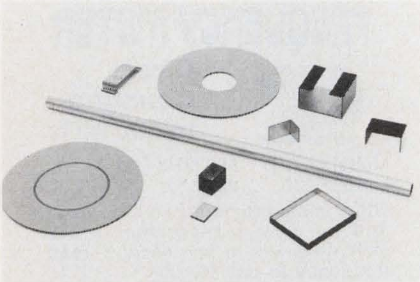
Berkeley Instruments, Inc., has acquired their high-quality line of digital instruments from Beckman Instruments, Inc. and will maintain the same high standards of excellence established over the years.

For more information, call TOLL-FREE
800-854-3253
(outside California)

Bi
BERKELEY INSTRUMENTS INC.
1701 Reynolds, Santa Ana, Calif. 92705
(714) 556-0623

INFORMATION RETRIEVAL NUMBER 72

Copper-clad glass epoxy comes in many shapes



Stevens Tubing Corp., 128 N. Park St., East Orange, N.J. 07019. (201) 672-2140.

Copper-clad fiberglass epoxy is now available in shapes other than flat sheets, on open stock tooling. The material conforms to 150 C MIL-R-9300 and MIL-C-9084 requirements and the copper is 1-oz foil. Many sizes of square, round or rectangular tubes, and structural angles and channels, with walls generally 0.030 in. thick, are available.

CHECK NO. 300

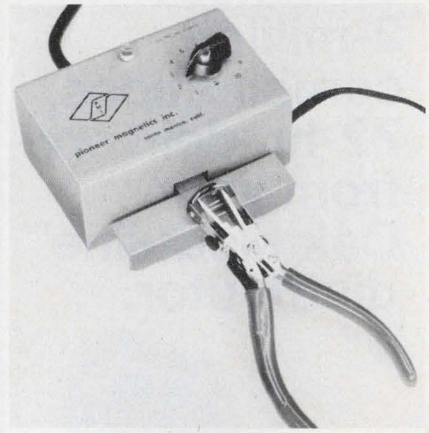
Ceramic adhesive bonds thermocouples

Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N. Y. 10510. (914) 762-0685. $34 per quart; stock.

Ceramacoat 512 is a ceramic adhesive usable at temperatures where epoxies fail. It is suitable to as high as 2500 F. It was previously used only for high temperature coatings, but has recently found use in attaching thermocouple leads to metal surfaces. Bonding platinum-platinum/rhodium thermocouple leads to a stainless steel container produced peel strengths up to 50 lb. after exposure to 2000 F. The adhesive is available in a premixed paste and it's brush coated over the leads and surface to be attached. Then after air drying, a bakeout at 200 F makes the bond suitable for use to 2500 F. The dielectric strength is 40 V/mil at 400 F and the bond has good resistance to oils, solvents and all acids except hydrofluoric.

CHECK NO. 301

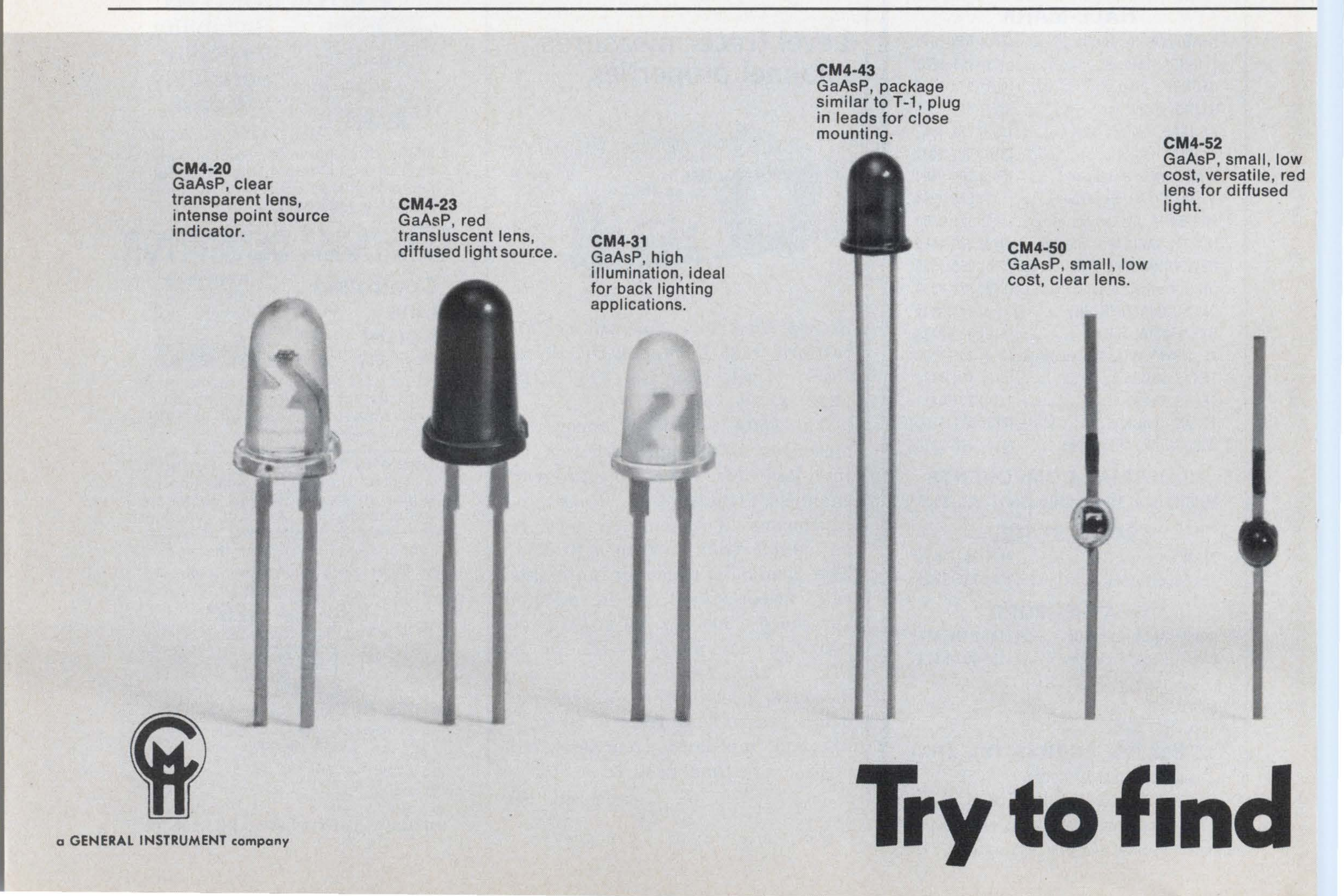
Thermal wire stripper works on H-film



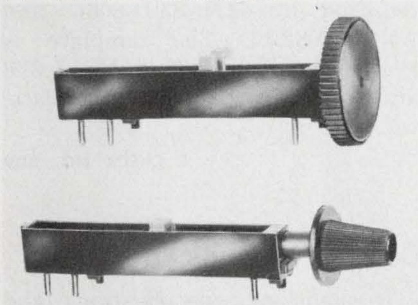
Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, Calif. 90404. (213) 929-3305.

The Model PM 1056-H thermal wire stripper, incorporates high-friction grippers and special elements to reduce thermoplastic and H-film (Kapton) stripping to a single, simple procedure. The tool strips wires in sizes 20 to 36 AWG. With available accessories, No. 12 wires can also be stripped.

CHECK NO. 302



Rectilinear pot tunes TV uhf channels

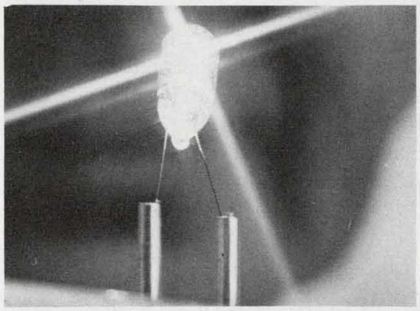


CTS Corp., Mills Gap Rd., Skyland, N.C. 28776. (704) 684-6451. $0.27 (OEM qty).

The 120 series of small, rectilinear multiturn, variable resistors for use in varactor-diode tuning will help the TV industry comply with latest FCC regulations on tuning uhf frequencies. One transversal of the composition resistor element needs 25 turns of the knob. Several knob configurations, sliders and indicator arrangements are available.

CHECK NO. 303

Tiny lamp delivers 15 cp, consumes 13 W

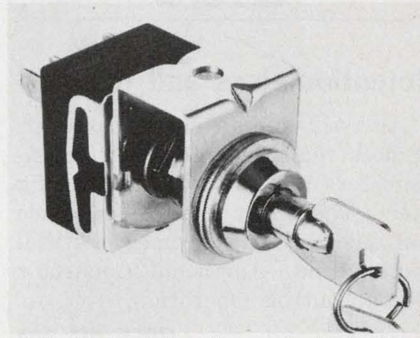


General Electric Co., Dept. 3382, Nela Park, Cleveland, Ohio 44112. (216) 266-2121. $2.70 (500 up).

A tiny new light bulb, the No. 3026, is only a quarter of an inch in diameter, but it is as bright as bulbs three times its size. The 6.3-V, 13-W tungsten-halogen lamp, according to G.E., sets new industry standards for its size and light output of 15 cp. It maintains a nearly constant level of brightness throughout its 75-h average rated life. At 75% of average life, the No. 3026 still produces an average of 95% of its original brightness.

CHECK NO. 304

Heavy-duty switch operates with key



Oak Industries Inc., Switch Div., Crystal Lake, Ill. 60014. (815) 459-5000. $5 (typical) (OEM qty); 8-10 wk.

A new line of 120/240 V ac, UL and CSA-listed, key-operated switches, which have ratings of 5 to 38 A at 2 hp, is designed for security applications that require tamper-proof control. The switches feature a tumbler lock. Designated the Keylock 390 series, they come in single or double-pole versions with an indexing capability from two to 12 positions.

CHECK NO. 305

an LED we don't have...

design aids

Potentiometers and dials

An easy-to-read chart cross-references multiturn precision potentiometers to related turns-counting dials. The chart provides a guide for selecting the proper pot/dial combination. Amphenol Connector Div.'s Controls Operation.

CHECK NO. 306

Smith charts

A set of normalized Smith-chart overlays for use with polar displays on the company's 1710 rf network analyzer sells for $75. The set contains seven overlays including two compressed charts, one unexpanded chart and four expanded charts that represent full-scale losses of −40, −30, −20, −10, 0, +10 and +20 dB. General Radio, 300 Baker Ave., Concord, Mass. 01742.

Cover and choke flanges

Cross-reference charts for cover and choke flanges list alpha-band designations (S, J, X, P, etc.), freqency range, ASTM material type, MIL-W-85/ID waveguide part numbers, AN-RG designations and MIL-F-3922 UG part numbers. All military and EIA numbers are cross-referenced to the company's part numbers. MSC Corp.

CHECK NO. 307

Dielectric selector guide

Basic information on the properties of thick-film insulating compositions is shown in a selector guide. The pamphlet lists the dielectric constant, dissipation factor, quality factor, temperature coefficient of capacitance, insulation resistance, breakdown voltage, thermal expansion coefficient, via resolution, and firing temperature range for all of the company's cross-over dielectrics, resistor encapsulants, screenable capacitor dielectrics and solder dam compositions for flip chips. Du Pont.

CHECK NO. 308

Templates

The "L" series templates feature standard graphical symbols specifically designed for use in the preparation of logic diagrams for systems of two-state devices as required by MIL-STD-806C and ANSI Y32.14. The template is available in full, 3/4, 1/2 and 3/8 drawing sizes. Tangent Template, Inc.

CHECK NO. 309

Control systems, devices

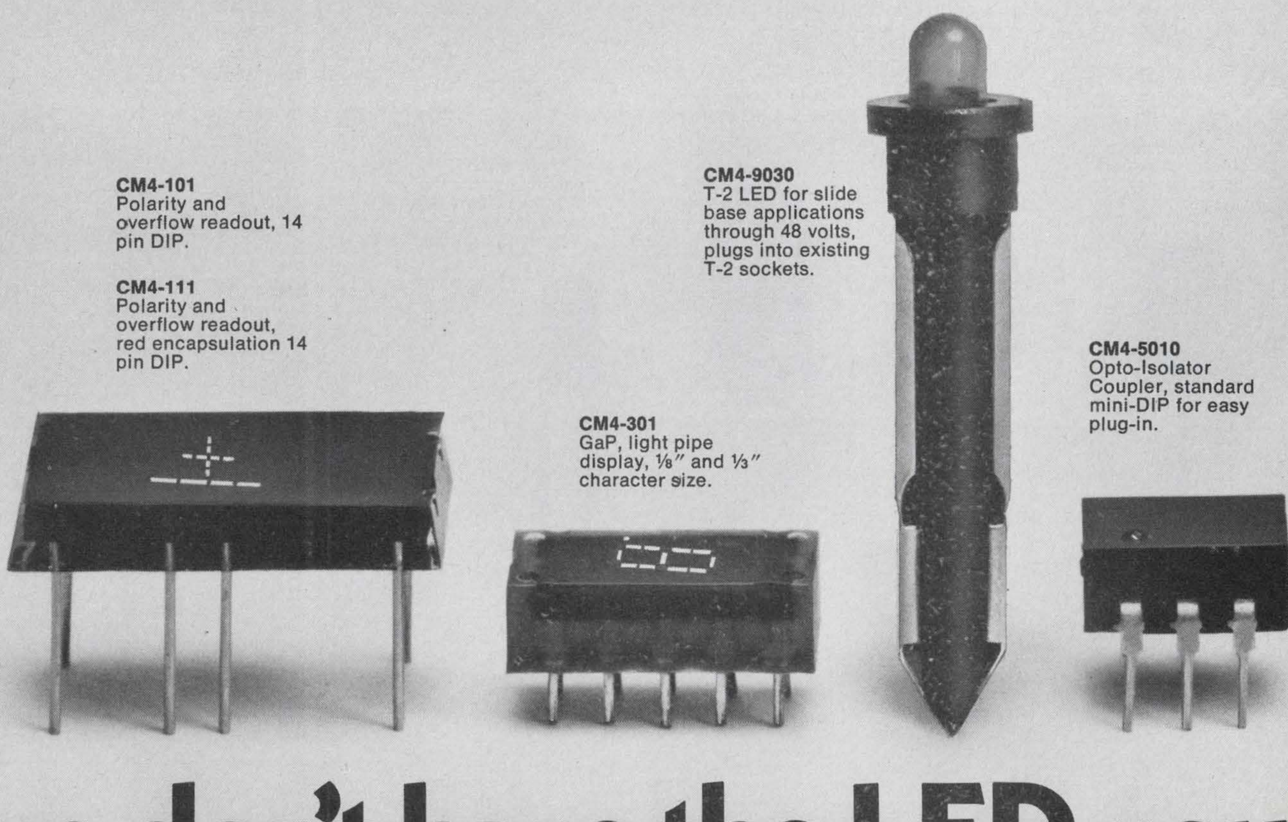
Descriptions, specifications and illustrations of over 50 electronic and electromechanical systems and devices are listed in a four-page selection guide. Eagle Signal Industrial Controls Div.

CHECK NO. 310

Switch selector

A switch selector-locator gives instant access to scores of the company's snap-action switches. Cherry Electrical Products Corp.

CHECK NO. 320



if we don't have the LED you

application notes

Silicone rubber

"Silicone Rubber Technical Information" provides data on the properties of silicone rubber. Characteristics of silicone rubber are discussed and illustrated with charts and photographs of relevant applications. General Electric, Waterford, N.Y.

CHECK NO. 321

Solid-state standard cell

A 12-page applications bulletin compares the accuracy and precision of Certa-Cell (solid-state standard cell) vs unsaturated standard cells of the mercury-cadmium type. The bulletin explains the improvements obtainable by using a solid-state standard cell. Codi Semiconductor, Fair Lawn, N.J.

CHECK NO. 322

Semi protective fuses

Characteristics of fuses used to protect semiconductors under "worst-case" conditions as well as under normal operating circumstances are defined, for the first time, the company says, in "Rectifier News." The article explains the principle of fast-acting fuses, what requirements have to be satisfied for the proper design of a semiconductor protective fuse and how to determine fuse coordination with semiconductors. International Rectifier Corp., El Segundo, Calif.

CHECK NO. 323

Software aids

"Microprogramming Software Aids" includes design automation techniques, charts and graphs. Details are provided on how a general-purpose microcode assembler speeds program development, betters documentation and eases future microcode modifications. Signetics Memory Systems, Mountain View, Calif.

CHECK NO. 324

Memory systems

Memory systems configuration, design and operation using the AMS 6003 2-k MOS RAM are given in an application note. Advanced Memory Systems, Sunnyvale, Calif.

CHECK NO. 325

Low-resistance measurement

An application bulletin describes methods for making rapid measurements of resistance in the range from 0.001 to 1 Ω with accuracies of 0.06% or better. Both direct-ratio and comparative-ratio measurement methods are described. Hewlett-Packard Co., Palo Alto, Calif.

CHECK NO. 326

Electrolytic capacitors

A 24-page technical paper describes the manufacture of aluminum electrolytic capacitors and explains their areas of application. Sprague Electric, North Adams, Mass.

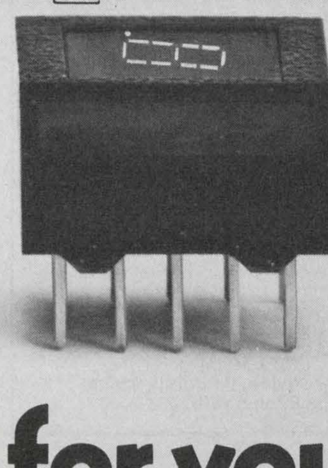
CHECK NO. 327

LED's are relatively simple. Some chips, some wire, some plastic. But making LED devices that work—that work exactly right for you—calls for a thorough appreciation of lighting technology, human engineering, even aesthetics.

Chicago Miniature is expert in miniature lighting of all kinds. We specialize in doing tiny things in a big way. And we've learned enough to know how varied your particular needs can be. That's why we provide more kinds of LED devices and packages than any other single source. Right off the shelf. And that's why we provide full support in application engineering.

Whether you're designing new panels, or modifying incandescent lighted panels for LED's, see if Chicago Miniature can help.

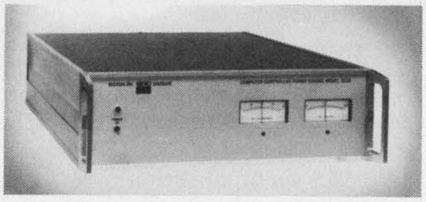
Chicago Miniature Lamp Works
4433 N. Ravenswood Ave.,
Chicago, Illinois 60640
a GENERAL INSTRUMENT company



CM4-170
Extremely visible ¼" character, extremely low power, small size.

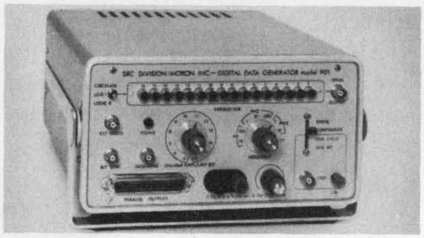
need, we'll make it for you.

Advertisement



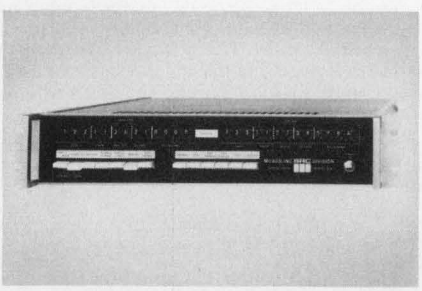
New Computer Compatible, Programmable DC Power Source. Automatic systems use. Output 100V @ 0.5A or 50V @ 1A. 16-bit binary or 8-4-2-1 BCD. Hi speed — over 10 kHz. Noise and ripple 800 uv p-p max. Load transient recovery 30 μsec. Data circuit interface selection, programmable current limiting. Hi AC/DC isolation w/guard shield. Data line isolation.

MOXON, SRC DIV. CIRCLE 101



New 16-BIT Digital Generator for Bread-Board Testing — Simple-to-operate Model 901 has three power supplies built-in for fast, easy broadboard testing (0 to 7 VDC, 0 to +15 VDC and 0 to −15 VDC). Latching pushbutton switches quickly program 16 digital bits in serial, dynamic parallel or "hard-wired" parallel form. Outputs offered are repetitive, non-repetitive and popular "walking" combinations. Rates to 15 MHz.

MOXON/SRC CIRCLE 102



New Search and Control Unit — Fully automatic, self-contained unit controls magnetic tape transport. It features multiple search modes for wider system applications plus adjustments for best search operation characteristics. Auxiliary outputs included for control of data reduction processes. Plug-in circuit boards replace difficult to service "mother boards."

MOXON/SRC CIRCLE 103

SRC

Moxon Inc/SRC Division
2222 Michelson Drive
Irvine, California 92664
Phone: (714) 833-2000

new literature

Connectors

TNC series connectors are highlighted in a 28-page, two-color book. Photographs and dimensional drawings of each type connector along with a quick-reference specification chart are included. Solitron/Microwave, Port Salerno, Fla.

CHECK NO. 328

Transportation switches

Marine, military, aerospace, commercial aircraft and general transportation switches are illustrated in a 36-page catalog. Tables offering quick-reference checks to appropriate military specifications, such as MIL-S-8805, are featured. Micro Switch, Freeport, Ill.

CHECK NO. 329

Photoelectric controls

Featured in a 32-page, photoillustrated brochure are the company's solid-state light sources—light emitting diodes. General Electric, Schenectady, N.Y.

CHECK NO. 330

Rf devices

Specifications, characteristics and options available for rf amplifiers, multicouplers, quadrature hybrids and directional couplers, frequency multiplexers and logarithmic video amplifiers are described in a catalog. Locus, State College, Pa.

CHECK NO. 331

Optical components

Information and prices on optical components for the ultraviolet, visible and infrared wavelength ranges; optical coatings for laser and commercial applications, as well as narrowband interference filters, are given in a 34-page catalog. Laser Optics, Danbury, Conn.

CHECK NO. 332

DTL, TTL micrologic cards

A designer's handbook and applications manual includes hundreds of DTL and TTL micrologic cards. The handbook provides specifications, packaging techniques and accessories, design data, test specifications and procedures, as well as pricing information. Control Logic, Natick, Mass.

CHECK NO. 333

Rf coils and chokes

Specifications and prices for rf coils, rf chokes, i-f transformers, relays, capacitors and related communications components are given in a 92-page catalog. To assist in selection, coils are categorized by frequency, from 0 to 40 MHz through 350 to 500 MHz, in the table of contents. Bell Industries, Compton, Calif.

CHECK NO. 334

Silicones

A wide variety of silicone materials for design needs are described in a full-color, 16-page catalog. Products detailed include those for potting, encapsulating, bonding, sealing, impregnating, coating, thermal coupling, vibration damping, lubricating and preventing corrosion. Dow Corning, Midland, Mich.

CHECK NO. 335

Wrapped-wire socket cards

Socket cards, universal cards, extender cards, card files and special hardware are featured in an eight-page catalog. Electronic Engineering Co. of California, Santa Ana, Calif.

CHECK NO. 336

FOR THE UTMOST IN RELIABILITY

INTERVAL TIMERS Series PAB.

This is an automatic reset interval timer with an extremely accurate timing mechanism built to stand up under hard usage in modern manufacturing processes. Due to the simplicity and reliability of its special clutch we can offer it in a range of time intervals from 1 second (1/60" dial divisions) to 3 hours (3' dial divisions), twelve in all. It is also available in a panel mount model PAF.

All of our timers are made to give you service far beyond what you'd reasonably expect. Our line consists of 17 basic types, each available in various mountings, voltages, cycles, circuits and load ratings . . . and with whatever special wrinkles you may need.

Bulletin #403 tells all about our line of reliable Interval Timers. Write for it or a catalogue of the entire line. If you have an immediate timer requirement, send us your specifications. Or for fastest service, give us a ring at (201) 887-2200.

INDUSTRIAL TIMER
A UNIT OF ESTERLINE CORPORATION

Industrial Timer Corporation, U.S. Highway 287, Parsippany, N.J. 07054

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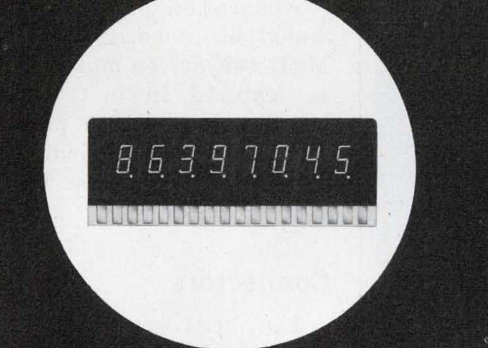

New NDP 1255-8
from NATIONAL ELECTRONICS
featuring

Gas Discharge Display Panel

- Large Character (.3")
- Edge Connector Plug In
- Multiplexed • Low Cost

NATIONAL ELECTRONICS
a varian division
geneva, illinois 60134 (312) 232-4300

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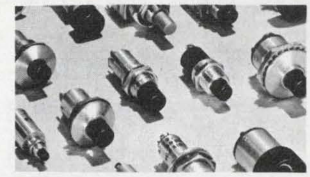
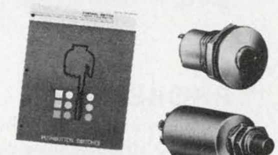
MEET OUR FAMILY OF AEROSPACE-RELIABILITY SWITCHES AT OEM PRICES



Send for these application bulletins

PUSHBUTTONS
Wide range of contact ratings and precision snap-actions with matching adapters



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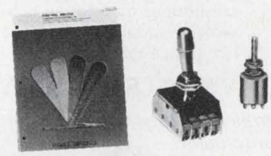
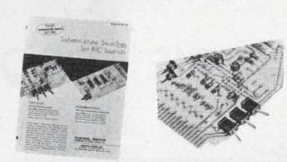
TOGGLES
Hundreds of types in all configurations.
1 to 8 poles.
1/10 amp to 40 amps.



circle no. 202

PCB SWITCHES
Two-circuit switches specifically miniaturized for PCB mounting. 2 or 3 position toggles. Momentary and latch-down pushbuttons.



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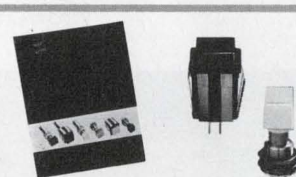
SWITCHLIGHTS
Illuminated pushbutton switches and matching indicators in a variety of colors. Bushing or snap-in mounting.



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EMI/RFI SHIELDED
Toggles, pushbuttons and indicator lights especially designed to minimize electro-magnetic interference.

circle no. 205

HERMETICS
Inert gas-filled and sealed. All exposed parts corrosion resistant.

circle no. 206

BASICS
Single to six pole. Wide range of standard to sub-miniature configurations.

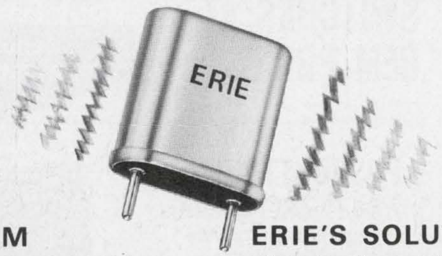
circle no. 207

CONTROL SWITCH INC.
A SUBSIDIARY OF CUTLER-HAMMER INC.
1420 Delmar Drive • Folcroft, Pa. 19032 • (215) LU-6-7500
Representatives and Stocking Distributors Throughout the United States, Canada, and Europe

ERIE FREQUENCY CONTROL

The Need:
A 1.22880 MHz CRYSTAL TO MEET
100 G SHOCK AND +50 G VIBRATION

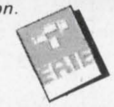
PROBLEM-
SOLUTION
#14



PROBLEM
The military demanded a miniature 1.22880 MHz crystal be designed to resist a shock of 100 G and 50 G vibration guaranteed through continuous monitoring during test, while maintaining all frequency and resistance tolerances.

ERIE'S SOLUTION
Erie designed a special welded mount which clamped the crystal without restricting the free vibration of the piezoelectric plate, enabling it to meet this rugged performance criteria.

CRYSTALS . . . CRYSTAL FILTERS . . . OSCILLATORS
Write for our fully illustrated catalog and send us your Frequency Control problem for solution.



ERIE
ERIE FREQUENCY CONTROL
453 LINCOLN ST., CARLISLE, PA. 17013 (717) 249-2232
DIVISION OF ERIE TECHNOLOGICAL PRODUCTS, INC.

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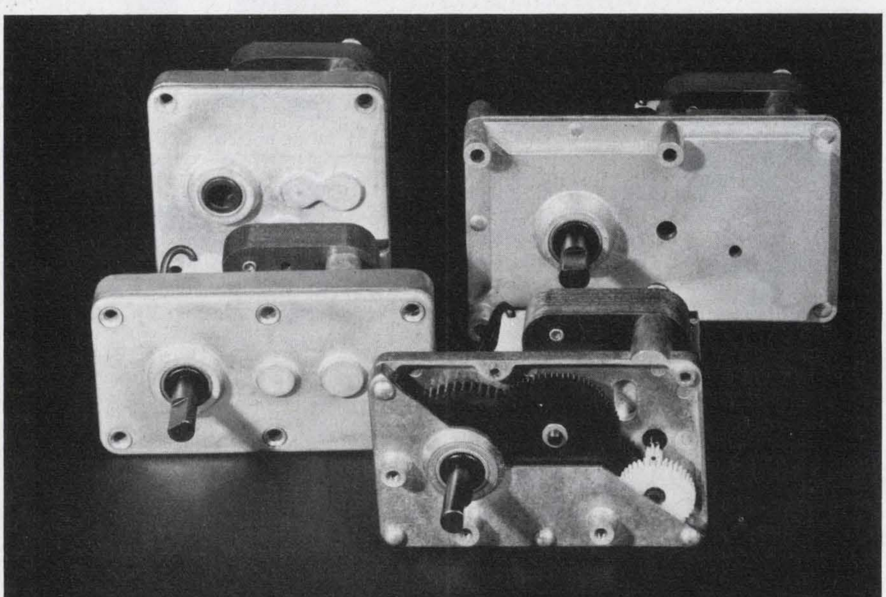

new a-c gearmotors
bring you Barber-Colman quality at competitive prices

These four new a-c gearmotors are engineered for products needing both a *compact* and a *low-cost* power package. Torque ratings to 150 lb-in. Speeds from 1 to 170 rpm. Mountings interchangeable with similar gearmotors now on the market. "Press-in" output shaft permits use of same motors with different shafts in multiple applications. Write for new SZ gearmotor details today.

BARBER COLMAN
BARBER-COLMAN COMPANY
Motor Division
Dept. T, 12117 Rock Street, Rockford, Illinois 61101

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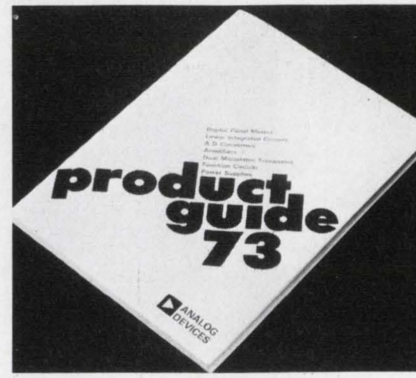


Product guide

Product descriptions and selection guides to digital panel meters, linear integrated circuits, a/d converters, amplifiers, function modules, power supplies and dual-monolithic transistors are given in a 208-page catalog. Analog Devices, Norwood, Mass.

CHECK NO. 342

Transformers

Specifications and data on precision torodial transformers are given in an eight-page catalog. Perkin-Elmer Corp., Norwalk, Conn.

CHECK NO. 343

Multistage blowers

Application, performance and installation information on the model M357 belt-driven multistage blower is featured in a two-page data sheet. Bulletin M357 presents performance curves showing air flow vs pressure or vacuum. Rotron Inc., Woodstock, N.Y.

CHECK NO. 344

Connectors

The PGB series of connectors that enable packaging designers to make interconnections virtually anywhere on a back panel without interfering with the Z_2 level of the wrap post is described in a 12-page catalog. Winchester Electronics, Oakville, Conn.

CHECK NO. 345

Test equipment

A full-line catalog on test equipment covers products ranging from service monitors to tone generators and wattmeters. The 36-page, color catalog includes photographs and listings of features, specifications and model nomenclatures. Motorola, Schaumburg, Ill.

CHECK NO. 346

bulletin board

Allied Control Co., Inc., has acquired the rights to manufacture and sell **solid-state relays** previously manufactured by Jewell Electrical Instruments, Inc.

CHECK NO. 347

Monsanto Co. has announced price reductions for four **solid-state display products.** The MAN 5, a green seven-segment numeric, and the MAN 8, a yellow numeric, are reduced to $7.50 from $17 (1-9); $6.75 from $14 (10-99); $5.60 from $11.25 (100-999); $5 from $10 (1000 up). The MAN 7, a red numeric, is reduced to $5 from $6 (1-9); $4.60 from $6 (10-99); $3 from $4.95 (100-999); $2.70 from $4.60 (1000 up). The MAN 64A, a 0.4-in. high numeric, is reduced to $8 from $11.50 (1-9); $7.25 from $9.20 (10-99); $6 from $8 (100-999); $5.50 from $7 (1000 up).

CHECK NO. 348

An agreement whereby **Arco Electronics** will serve as master distributor for **relays** marketed for Siemens has been announced by both companies.

CHECK NO. 349

Price reductions

Simpson Electric Co. has reduced the price of its **Model 150 Amp-Clamp** to $25 from $30.

CHECK NO. 350

Statek Corp. has announced price reductions of 20% to 85% on low-frequency (10 to 250 kHz) **quartz crystals packaged in TO-5s.** The reduction covers series-resonant crystals in two types and calibrations. Typical price reductions are from $30 (1-9) to $4.30 (1-24) and prices are reduced from $2.50 to $2 (1000-up). Wider calibration-tolerance crystals are $1.70 (1000-up).

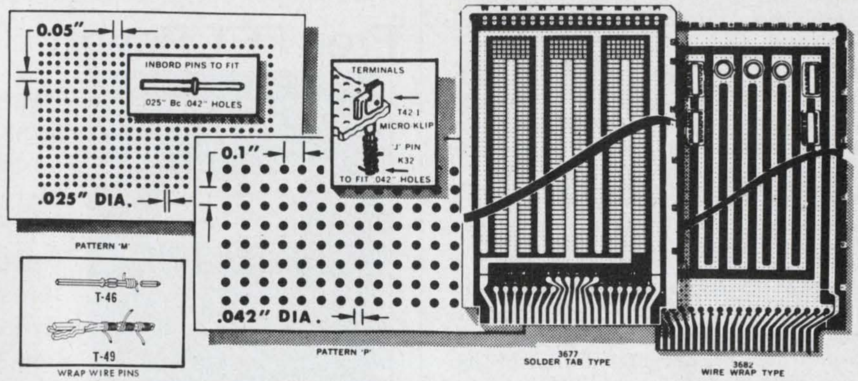
CHECK NO. 351

Ailtech has announced a price reduction on all instruments in its **F200 series of function generators** by $100.

CHECK NO. 352

New **MICRO-VECTORBORD AND D.I.P. PLUGBORDS ARE HERE!**

Save time — Save work — Save money



WIDE SELECTION OF SIZES AND MATERIALS

MICRO-VECTORBORD "P" .042" holes match D.I.P. leads. Epoxy glass or paper, cop. cld. also 1/64" to 1/16" thk.

MICRO-VECTORBORD "M" .025" holes match Flat-Paks, 1/32" Epoxy glass, cop. cld. also or .007" Mylar.

NEW SOLDER-PAD D.I.P. PLUGBORDS — 3677 Series Epoxy glass, "P" pat., 1/16" thick with 44 etched plug contacts (2 side total) power, ground busses, pads for up to 24 D.I.P.'s (14's). Also 21 units 16-leads D.I.P.'s, T-O's and discretes.

NEW WRAP WIRE D.I.P. PLUGBORDS — 3682 Series Similar to above but closely spaced bus lines for higher density. Up to 48 D.I.P. 14 lead wrap wire sockets mountable or T-O's and discretes.

TERMINALS — Micro-Klips, Mini-Wire-Wraps, Rd. Pins, Patch Cords, etc., available.

Send for complete literature

Vector ELECTRONIC CO., INC.
12460 Gladstone Ave., Sylmar, California 91342
Phone (213) 365-9661 • TWX (910) 496-1539

28-73-3

"SEE US AT WESCON BOOTH 1708"

INFORMATION RETRIEVAL NUMBER 80

Fight Brownouts
with TOPAZ LINE REGULATORS

• No Distortion • Most Efficient
• Lowest Cost • Smallest Size

SPECIFICATIONS:

Input: 85 to 125V sine wave
Output: 117 V sine wave
Operating Frequency: 47 to 63 Hz
Response: Less than 1 cycle
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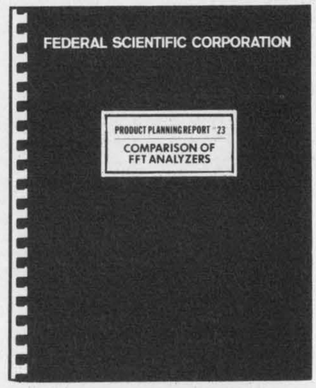

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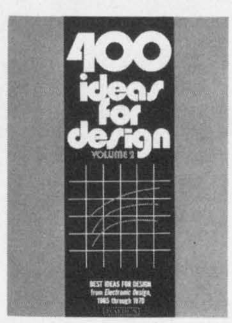

A unique sourcebook of practical design techniques and approaches using the latest components, representing the best contributions to *Electronic Design's* "Ideas for Design" column. All selected for their practical value in solving the design engineer's most common, everyday problems. They have proved useful as parts of larger designs or as aids in measuring the parameters and testing the effectiveness of existing designs. 288 pp., 7⅛ x 9¾, illus., cloth, $11.95. **Circle the reader-service number to order a 15-day examination copy.**

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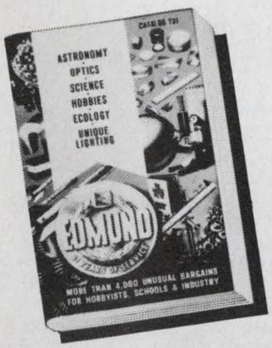

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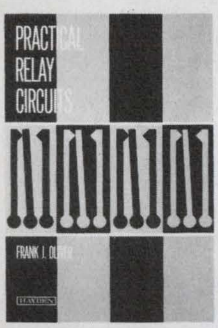
By Frank J. Oliver



Uniquely groups various relay circuits according to the functions they perform, enabling the systems designer to quickly select the best circuit for his specific purposes. Includes arc and RFI suppression systems; time delay function; audio tone control and resonant-reed relays; sequential relays; protective functions of relays against overload overvoltage, and overcurrent, pulse generation and detection; logic circuits; and more. Particularly important is coverage of pulse-operated relay systems now extensively used with automated control systems. Illustrated with many circuit diagrams using the latest American National Standard graphical symbols. 363 pp., 6 x 9¼, illus., cloth, $14.95. **Circle the reader-service number to order a 15-day examination copy.**

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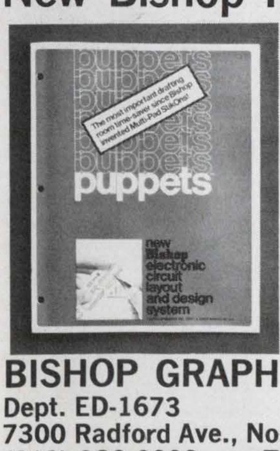

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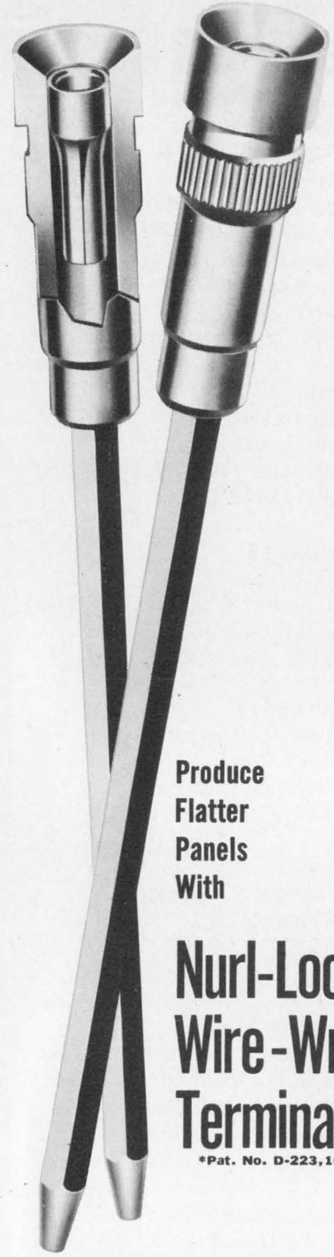

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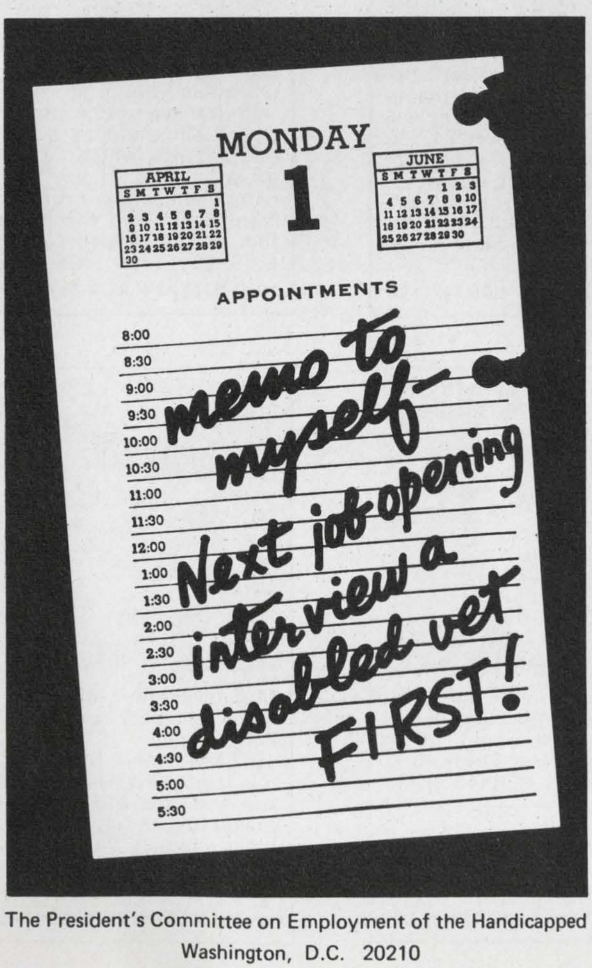

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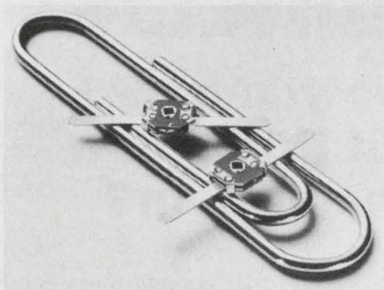

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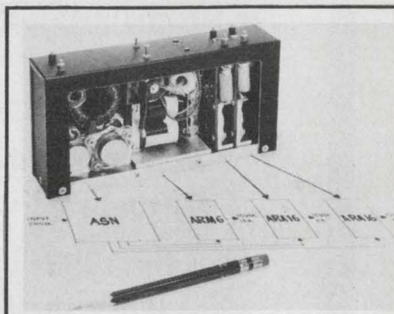

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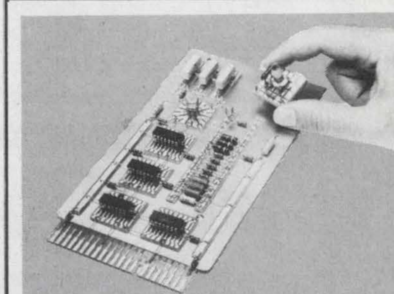

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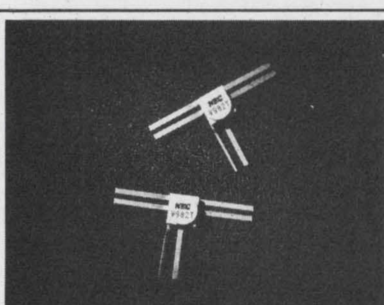

The V981 and V982 very high speed switching transistors have FT of 8 GHz and 6.5 GHz respectively. These NEC Transistors are for fast switching in an ECL configuration for systems operating at speeds in the hundreds of megabits per second. California Eastern Laboratories, One Edwards Court, Burlingame, Calif., 94010. (415) 342-7744.

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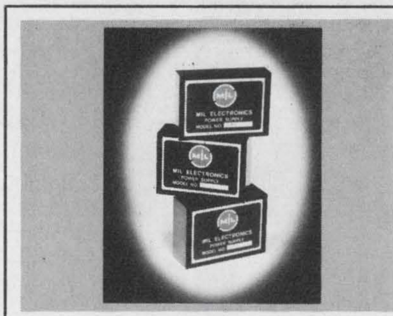

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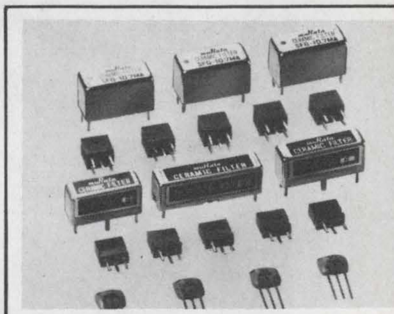

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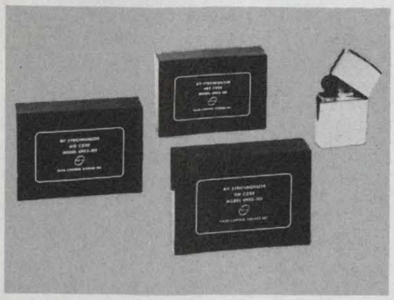

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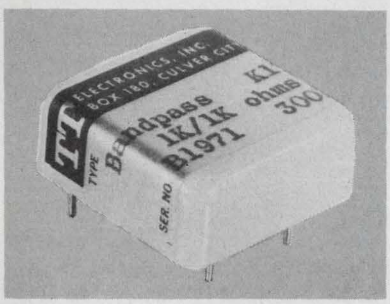

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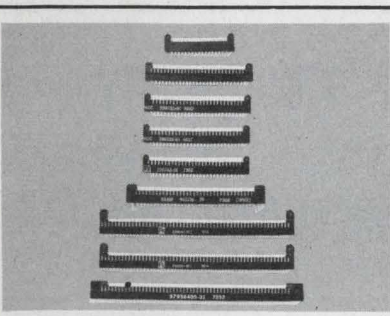

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product index

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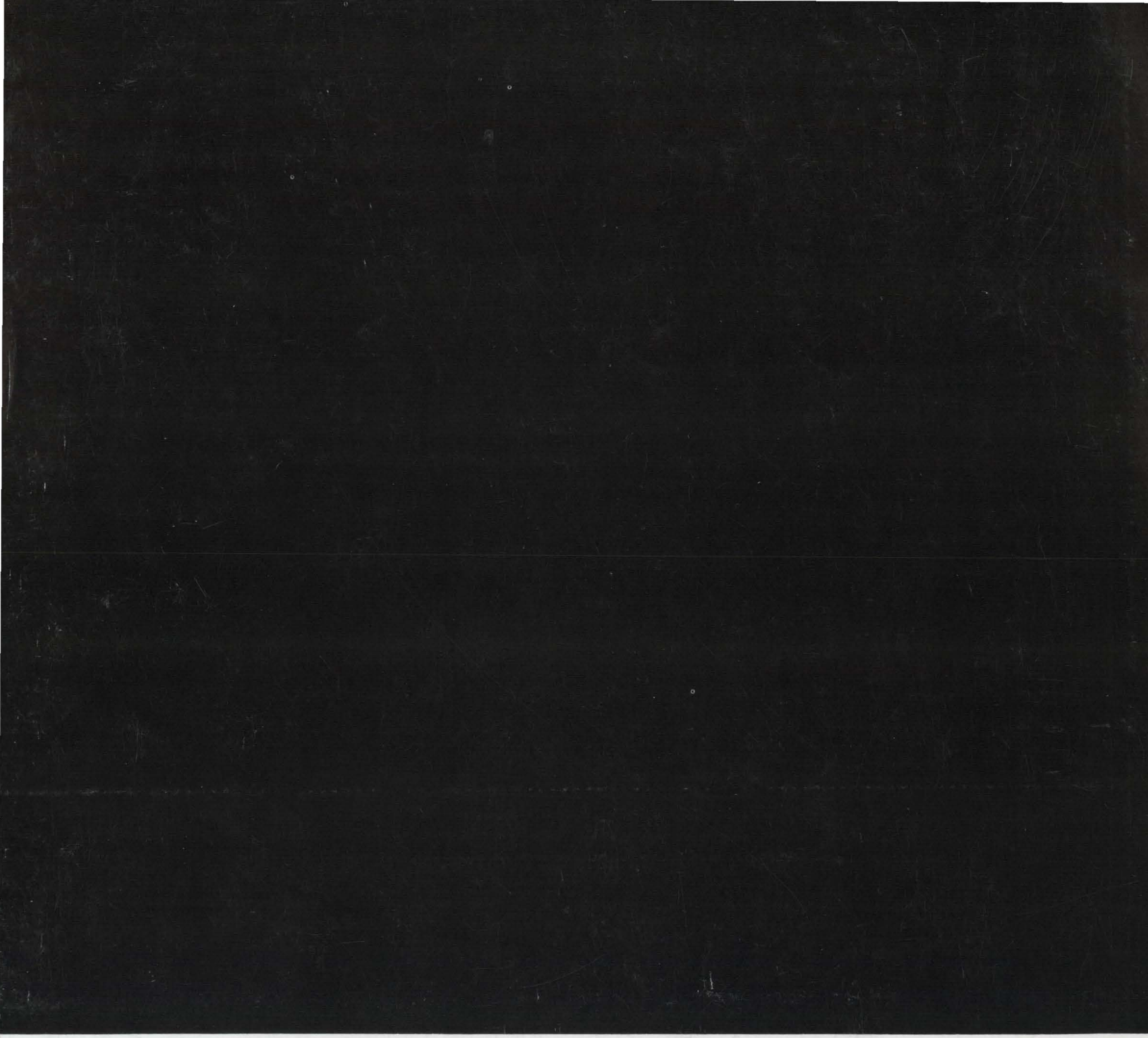
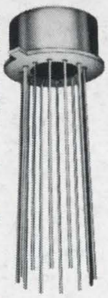


RCA's new amplifier may turn you off!



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*These three types are also available in formed-lead TO-5 for dual-in-line socket configuration, as CA3094S, CA3094AS, and CA3094BS.

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