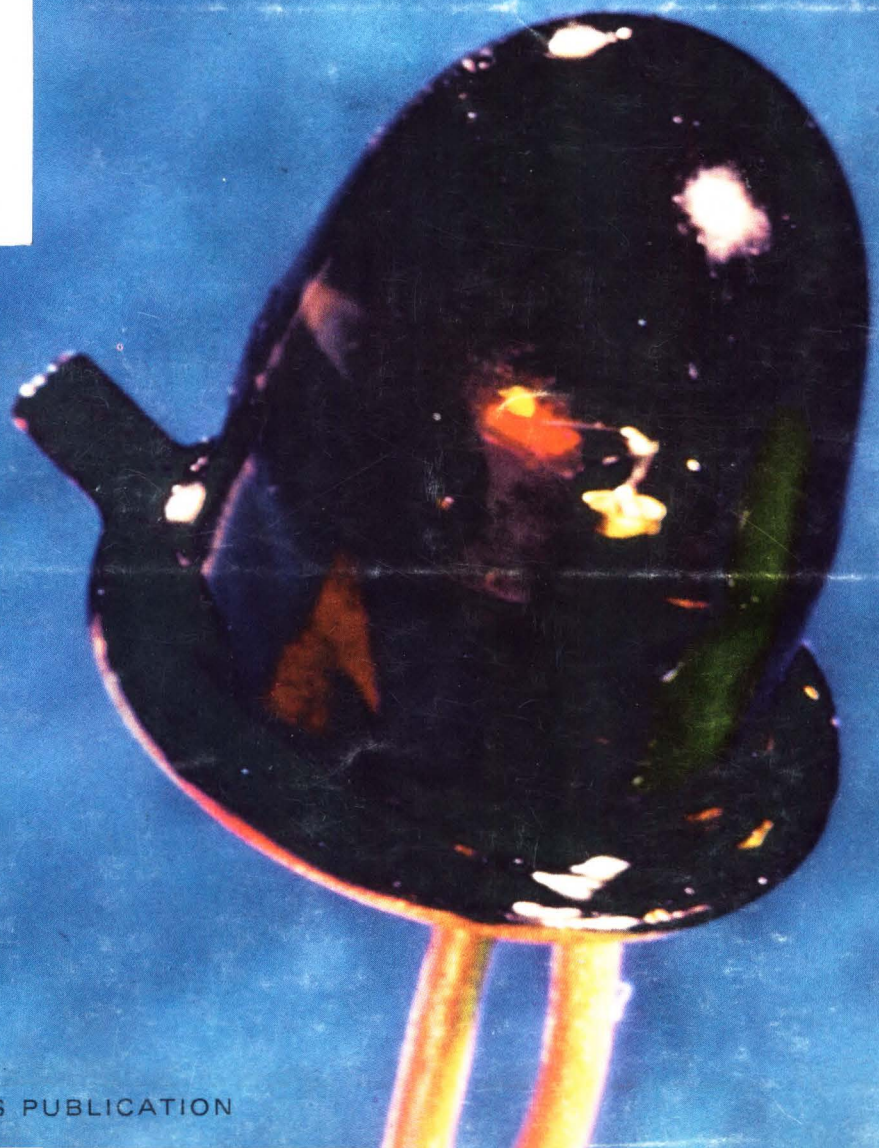
EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Solid-State Displays
Chips for Micropackaging
Digital Clock
Single-Shot Testing



A CAHNERS PUBLICATION

OCTOBER 1968

The counterpart.

Dale's new 8100 film T-Pots offer RJ-11 advantages at industrial prices

Dale's new 8100 Series makes it easy to approach RJ-11 performance at highly competitive industrial prices. Buy it sealed or unsealed—you're the boss. Get essentially infinite resolution...a broad 10 ohm to 2 Megohm resistance range...plus ability to dissipate ¾ watt at 70°C. The 8100 is part of a wide range of film element and wirewound T-Pots now available from Dale for industrial and commercial use. Common parameters: Low price, quick delivery. See your Dale distributor or call us at 402-564-3131 for complete details.

8100 FILM-T-POT SPECIFICATIONS

Standard Resistance Range: 10 ohms to 2 Megohms

Resistance Tolerance: ±10% 100 ohms through 500K ohms; ±20% all other values

Resolution: Essentially infinite

Power Rating: .75 watt at 70°C, derating to 0 at 125°C

Operating Temperature Range: −65°C to +125°C

Mechanical Adjustment: 25 ± 2 turns. Clutch prevents overtravel damage

Dimensions: .28" H x .31" W x 1.25" L

Models: 8187, printed circuit pins; 8188, stranded vinyl leads; 8189, solder hook; 8184, panel mount version of 8189; 8186, panel mount version of 8188

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

DALE®

DALE ELECTRONICS, INC.
1352 28th Avenue, Columbus, Nebr. 68601
In Canada: Dale Electronics Canada, Ltd.

CIRCLE NO. 1

By habit, loose jobs got carbon comps.

Until Corning.

Now, you have another choice.
Glass tin oxide film.
Corning makes them.
In the general purpose range.

Makes them with a base of pure optical glass. And a fully oxidized metal film. Environment can't degrade either. Film and substrate are molecularly bonded. Matching TC's do away with fatiguing stresses. Special silver-glass composition insures low termination noise. Press-fitted end caps mean mechanical integrity. Tailored tough insulations wrap them up. It all adds up to long-term dependability.

General purpose, precision, or special, CORNING® Glass Tin Oxide Film resistors are a better buy—by design. From 1/10 watt in .150″, up to 6000 watts in six feet, they're all shown in our new Resistor Design Guide.

Get your copy from: Corning Glass Works, Electronic Products Division, Corning, N.Y. 14830.

CORNING
ELECTRONICS

CIRCLE NO. 2

E-H 128 $980 Don't tell our new Model 128 it has a low price tag. Actually, the E-H 128 thinks, acts and talks like a much higher-priced box—gives you features never offered in a general purpose pulser at this price.

For instance? Risetime of < 3.5ns and < 4ns fall-time; rep rate to 50 MHz; dual outputs (positive and negative), 5v amplitude; independently controlled and continuously variable, attenuation ranges of 1, 2, 4, 8, 16; single and double pulses; single cycle pulses; external driving and external gating. All this and continuously variable trigger width (10ns to 50ns), plus pulse width and pulse delay continuously variable from 10ns to 10 milliseconds. What it adds up to, of course, is a pulser which gives you more discrete measurements and wider breadth of measurement than many pulsers costing hundreds of dollars more. Worth looking into.

E-H LEADS THE PULSER REVOLUTION
NEW LOW-PRICED GENERAL PURPOSE PULSER THAT ACTS LIKE A HIGH-PRICED BOX

E-H RESEARCH LABORATORIES, INC.

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In Europe: E-H Research Laboratories (Ned) N.V., Box 1018, Eindhoven, The Netherlands, Telex 51116
In Japan: Iwatsu Electric Co., Ltd., No. 710, 2-Chome Kugayama Suginami-Ku, Tokyo, Japan

Needles are for knitting—right?
Right.

...and Digits are for measuring—right?
Ri-i-ight!

Still using a moving-needle meter with: • parallax errors! • range selection errors! • interpolation errors • an unprotected movement that burns out on wrong polarity or high voltage!

Or are you using an NLS **X-3A** Digital Multimeter with:

- 0.1% accuracy
- Fully protected on all ranges
- Floating input
- Automatic polarity indicator
- Overload indicator
- 2000 digits per range
- 0.05% resolution
- Unique HI-MED-LO range selector
- Scaled analog output (drives strip chart recorder)
- Wide measurement capability

Measures:

DC Volts—10 μV to 1 KV in 6 ranges (to 30 KV with optional HV probe)

AC Volts—0.5V to 300V in 3 ranges

Ohms—10 mΩ to 2000 Meg Ω in 9 ranges

Current—10 pico amps to 200 mA in 8 ranges (to 2 amps with optional shunt)

VALUE THROUGH INNOVATION

Originator of the Digital Voltmeter

NON LINEAR SYSTEMS INC.

DEL MAR, CALIFORNIA

♦ CIRCLE NO. 3

CIRCLE NO. 4

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN is edited exclusively for designers of electronic products, equipment and systems. EDN presents news, methods, ideas and products only as they relate to the present and future job responsibilities of designers and design managers.

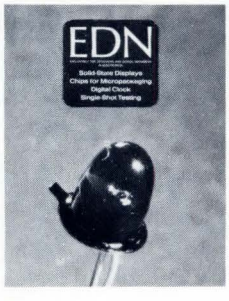
EDN DESIGN ACTIVITY FILING SYSTEM

This system uses three words to categorize all feature editorial. It is unique in that it is based on design "activity" rather than on "things" designed. The system consists of these words:

DESIGN ACTIVITY	"OF" or "WITH"	MODIFIER	FREQUENCY
DESIGN	MATERIALS	PASSIVE	(where applicable)
TEST	COMPONENTS	ACTIVE	
PACKAGE	CIRCUITS	LINEAR	
ANALYZE	FUNCTIONS	DIGITAL	
SURVEY	SYSTEMS	COMMUNICATION	LOG_{10} f (Hertz)
COMPARE		SERVO	
		RELIABILITY	
		HARDWARE	

TEST/SYSTEMS/COMM 8, for example, is the designation for filing an article under the Communications Systems Testing at 10^8 Hertz.

This system is compatible with most "personal" filing methods. Very few designers need to use all classifications, when their own individual requirements are overlaid on the system. In many cases two or even one level of classification is sufficient.



Tomorrow's circuits will have a fair sprinkling of semiconductors that also emit light. They'll be used for indicators, trouble-shooting aids and optical links. This happens to be an IR diode (by Monsanto) made visible by the film's response, but the visible-light versions look the same. See page 49.

Design News

Design Products 139

Design Departments

ABP CP MCB BPA

ibpa International Business Press Associates

DESIGN ELECTRONICS
ELECTRONICS WEEKLY
EDN
ELEKTRONIK
ELEKTRONIK-ZEITUNG
INTER ELECTRONIQUE

 Norman L. Cahners, Chairman of the Board; Saul Goldweitz, President. EDN (formerly Electrical Design News) is published monthly, except semi-monthly in June, September and November, by Rogers Publishing Co., Inc. E. S. Safford, President; G. F. Taylor, Vice President; T. F. McCormish, Vice President. Editorial, Advertising, Subscription Offices, 3375 S. Bannock St., Englewood, Colo. 80110. Telephone 303 789-0571. Printed at 85 W. Harrison St., Chicago, Ill. 60605. Controlled circulation postage paid at Chicago, Ill. Send form 3579 to subscription office. EDN is circulated to electronic design engineers and engineering managers in electronic original equipment manufacturing industries. Plants having more than twenty employees and manufacturing electronically operated or controlled equipment of their own design are considered part of this industry. Engineers in such plants responsible for specification of components, materials and test equipment for electronic application may receive EDN without charge. Completed qualification form and company letterhead required. Subscriptions to others in continental United States, $1 per copy, $20 per year. Send requests for qualification forms and change of address to subscription office in Englewood, Colo. 80110.

OCTOBER 1968, VOLUME 13, NUMBER 12

Design Features

Design Ideas

Design Predictions

Design Interface

270,000 µF

in a

3" x 5⅝" case

(This is a standard rating.
Even higher capacitance values
are possible on special order.)

POWERLYTIC® CAPACITORS ARE PACKED WITH CAPACITANCE!

Improved Capacitance Capability
Type 36D aluminum electrolytic capacitors now have as much as 60% more capacitance in a given case size than previously available.

Higher Operating Temperature
Improved Powerlytic capacitors may now be operated at 85 C.

High Ripple Current Capability
Ideal capacitors for use in "brute-force" filtering and pulse discharge applications. Single capacitors are capable of handling up to 20 or more amps rms at 25 C, 120 Hz.

Superior Seal and Safety Vent
Beaded aluminum can is crimped onto a rubber gasket recessed in a rigid molded cover, providing an expected operating life in excess of ten years. Pressure-type safety vent employs silicone rubber for reliable, predictable release of excess pressure.

Choice of Insulating Tubes, Terminal Styles
In addition to the standard bare case, Type 36D capacitors are available with a clear plastic tube or with a Kraftboard tube. Tapped terminals in two different heights, as well as solder lug terminals are available.

For complete technical data, write for Engineering Bulletin 3431B to Technical Literature Service, Sprague Electric Co., 491 Marshall Street, North Adams, Mass. 01247

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CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
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4SC-8130R1

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CIRCLE NO. 5

Editorial

Exclusively for Designers

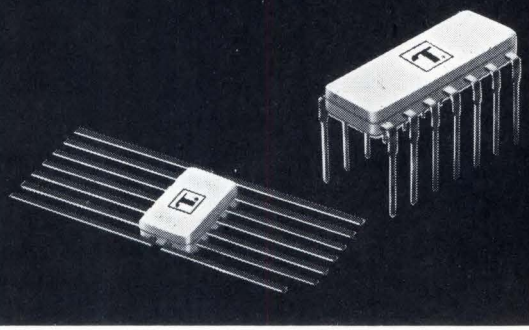
This is EDN as it will be from now on . . . repackaged in standard format. Even though EDN is now smaller on the outside, it is bigger on the inside! Our commitment is to designers and design managers. Here are some of the new things that will make significant contributions to fulfillment of that commitment:

- The design "activity" filing system is a new solution to a very real designer problem. It is explained on p. 10 and on the table of contents. Notice that, in addition to being categorized by this simple system on the table of contents, each technical article carries the listing at the bottom near the page number.
- Many writers wring their hands and chastise the designer for not solving all of our country's social problems. In our Design Interface for this issue, Glen Boe uncovers surprising facts about the genuine concern and action of designers throughout the industry. In future issues, articles will discuss the Design Interface with management, vendor salesmen, production, purchasing, engineering libraries, etc.
- Design Predictions (p. 47) is one man's opinion on the coming of LSI. In future columns we will air predictions and opinions from the industry's best designers. The column will be offered on an equal-time basis to those of opposing viewpoints.
- We have improved the graphics in EDN to communicate as fast as possible with the printed page. For example, note the tabs on pp. 27, 49, 93 and 139, indicating the beginning of new sections without taking a whole page to do it. Color is not used for "splash" but for organization and function as in the articles on pp. 84 and 93 and in the figure on p. 99.
- A few other touches have been added that we feel will make life a little easier for you, e.g., there will be no advertising in the middle of an article; also, no article ends on the back of another article.

The editors of EDN are quite proud of this issue. We feel we have been successful in blending good communication techniques with the best technical information available. We do know, however, that being the top magazine, like being a top designer, requires constant attention and improvement. We hope that you will let us know your thoughts, favorable or not, on the postcard provided just inside the front cover.

Editor

More MSI from Transitron



Now available for immediate shipment — 2 new complex circuits with industry's best performance

BCD-to-Decimal

DECODER-DRIVER

- High breakdown voltage — 70V min.
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- No background glow, no oscillation
- Low power consumption — typically 10mA @ 5V
- Compatible with TTL and DTL levels
- Only decoder-driver available in 16-pin hermetically-sealed ceramic dual in-line package
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Industry's Fastest (60 MHz)

4-BIT RIPPLE COUNTER

- High speed — typically 60 MHz
- Low power consumption — typically 180mW @ 5V
- High output current drive — typically 20mA
- Master-slave flip-flops provide application versatility
- Internal buffers provide low input current loading
- Buffered outputs prevent false output signals
- Full TTL compatibility (easily interfaces with other logic)
- Available for industrial or military temperature range operation
- Available in 14-lead flat package (suffix G) or 14-lead dual in-line package, ceramic (suffix P) and plastic for 0-75°C (suffix E)
- Both binary and BCD versions available in two pin configurations:
  - 4/10 { TRC 2511-14, Binary Ripple Counter / TRC 2515-18, BCD Ripple Counter
  - 7/14 { TRC 2521-24, Binary Ripple Counter / TRC 2525-28, BCD Ripple Counter

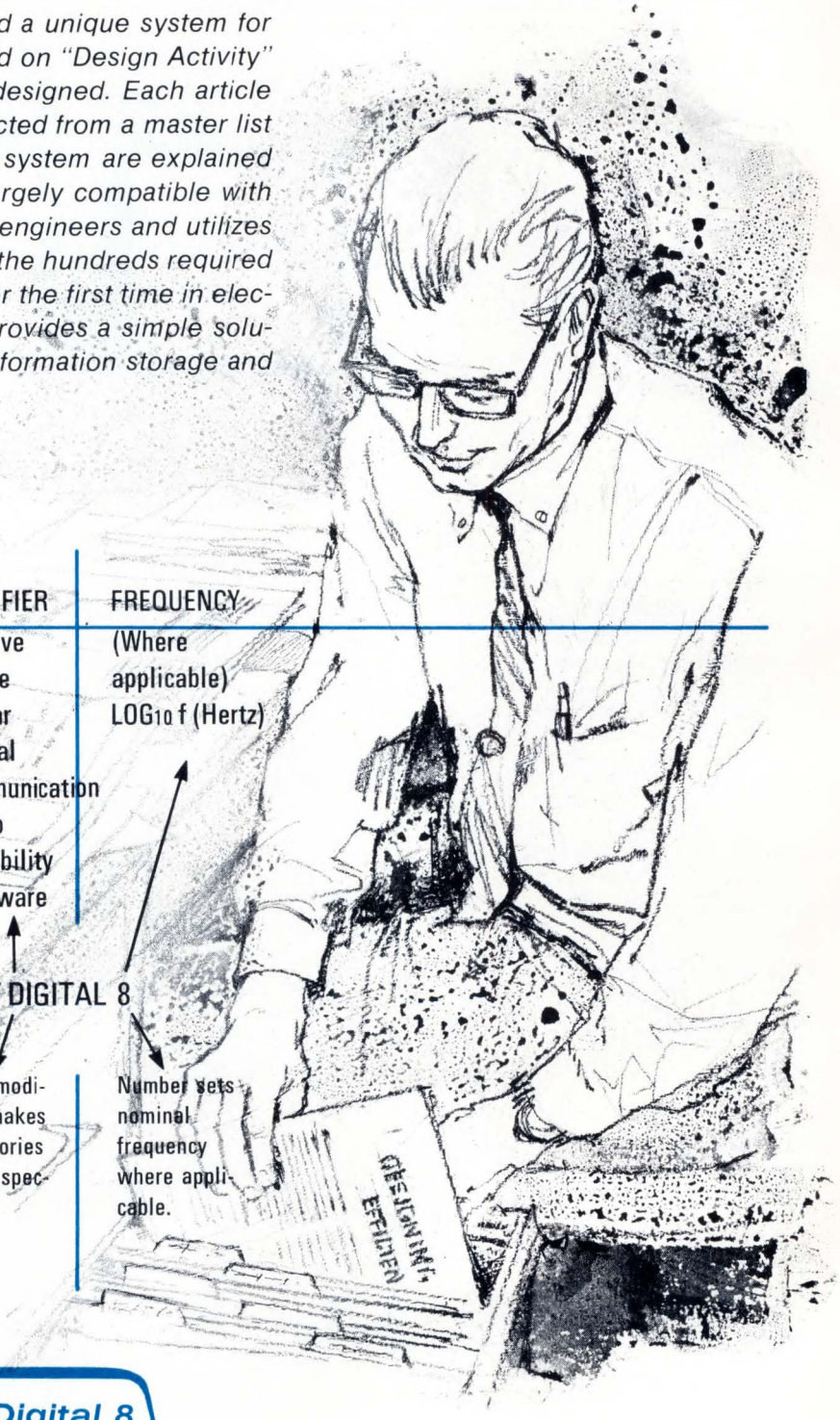
Send for complete data on these and other Transitron MSI functions. Available without charge.

Transitron electronic corporation
168 Albion Street Wakefield, Massachusetts 01880

CIRCLE NO. 6

EDN Activity Filing System

The EDN editors have developed a unique system for filing technical articles. It is based on "Design Activity" rather than on specific "things" designed. Each article is described by three words selected from a master list of nineteen. (The details of the system are explained on the table of contents.) It is largely compatible with the "personal" filing methods of engineers and utilizes just a few categories rather than the hundreds required for a product-oriented system. For the first time in electronics publishing, a magazine provides a simple solution to the reader's problem of information storage and classification.



DESIGN ACTIVITY	"OF" or "WITH"	MODIFIER	FREQUENCY
Design	Materials	Passive	(Where
Test	Components	Active	applicable)
Package	Circuits	Linear	LOG_{10} f (Hertz)
Analyze	Functions	Digital	
Survey	Systems	Communication	
Compare		Servo	
		Reliability	
		Hardware	

DESIGN / SYSTEMS / DIGITAL 8

This word designates the basic "activity" described in article.	Word from this column describes level at which activity takes place.	This modifier makes categories more specific.	Number sets nominal frequency where applicable.

Design / Systems / Digital 8

If you would like to try this new filing system, we will gladly send you a complete set of gummed labels for your file folders. From these you can choose those combinations which are useful to you.

CIRCLE NO. L63

new

~~old~~ reliable

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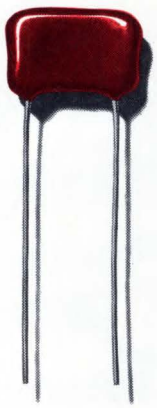
To: General Instrument Corporation, Capacitor Group
65 Gouverneur Street, Newark, NJ 07104



Send me a working sample of your dipped silver mica capacitor plus specifications.

Name_____

Title_____

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City_____ State_____ Zip_____

test it!

Test a General Instrument dipped silver mica capacitor yourself. Test it for temperature characteristics . . . For stability . . . For close tolerance . . . Resistance to humidity . . . Or anything else you can think of. There's no better dipped mica available.

Name your rating . . . 1pF to .03 μF. Name your voltage . . . 100 to 500. Name your tolerance . . . as close as $\pm 1\%$. Name your spec . . . commercial or MIL-C-5D. You'll get the exact capacitor you need from General Instrument Corporation, Capacitor Group, 65 Gouverneur St., Newark, NJ 07104. Fill out the coupon today.

capacitors

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TO ANY VTVM OR VOM

A NEW STANDARD OF THE INDUSTRY...

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- Less circuit loading than VTVM/obsoletes VOM
- Zero warm-up time — instant stability
- Complete circuit and meter protection
- Complete portability
- Greater frequency responses than most scopes

FE149 SENIOR FET METER

The only true Senior FET meter available today with outstanding accuracy and unbelievable ease of operation.

- **Unmatched Accuracy.** 1.5% on DC, 3% on AC, plus large 7-in. meter and mirrored scale, assure the most accurate tests possible.
- **Eight AC and DC ranges** .5V to 1500V full scale.
- **Zero center scale** with .25 v. either side assures measurements to less than .1 v. for transistor bias measurements.
- **AC peak to peak** readings to 4500V maximum with freq. response of 10HZ to 10MHZ ± 3DB.
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- **Nine DC and nine AC current ranges** 150ma to 5 amps.
- **Eight decibel ranges** for audio measurements.
- **Three HI-Voltage ranges,** 5 KV, 15 KV, 50KV with 39A21 high voltage probe. **$14.95**
- **Absolute meter and circuit protection** against circuit overload.
- Non-breakable, scuff-proof, vinyl-clad steel case.
- **Three-way power.** Operates on AC, on self-contained rechargeable batteries, or on AC with batteries plugged in. Same readings all three ways.

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Exclusive push-button design. Just push two buttons for any test — top row selects function, bottom row selects range. Action is instant and automatic.

$69.95

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ACCURACY DC ± 2.5% AC ± 4.5%

- 4½-inch meter, vinyl-clad steel case.

FE14 and FE16 popular 4 1/2 inch FET Meters

- **Hi Accuracy.** For unsurpassed measurements. Mirrored scales prevent parallax errors.
- **Minimum circuit loading.** 15 megohm input resistance on DC; 10 megohm on AC.
- **Zero center scale** ± 0.5 v. readings for transistor bias measurement.
- **Full meter & circuit protection** against possible circuit overload.
- **7 DC & AC voltage ranges** 1 to 1000 volts full scale.
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- **5 resistance ranges** to 1000 megohms.
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- **3 Hi-Voltage ranges,** 3 KV, 10 KV, 30 KV, extended with 39A19 ($9.95) high voltage probe.

$84.50

FE16 HI ACCURACY FET METER

ACCURACY DC ± 1.5% AC ± 3%

- 4½-inch high-styled meter, high-styled knobs, and special meter-tilting metal handle. Vinyl-clad steel case.

See your Sencore distributor today or write factory for complete line catalog.

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CIRCLE NO. 16

SYLVANIA'S DELAY RELAY.

It takes a hotfoot to make it work.

See the leg of the relay that has a resistance winding around it?

That leg is a bimetallic strip.

Send a jolt of electricity through the winding and the leg bends. And makes (or breaks) contact.

When the strip cools it unbends. And automatically breaks (or makes) contact.

Simple, isn't it?

Because it's so simple, the Sylvania thermal time-delay relay has some very sophisticated advantages.

First: Cost. A lot less than other relays.

Then: Reliability. Good for 100,000 operations.

Last but not least: we can make them by the million. We're aiming for the designer with big plans.

In cars, they can be used to light up the ignition key area when the door is opened. And turn on seat-belt warning lights.

They can be used in color TV sets for automatic degaussing. And in residential heating systems to assure proper ignition sequencing.

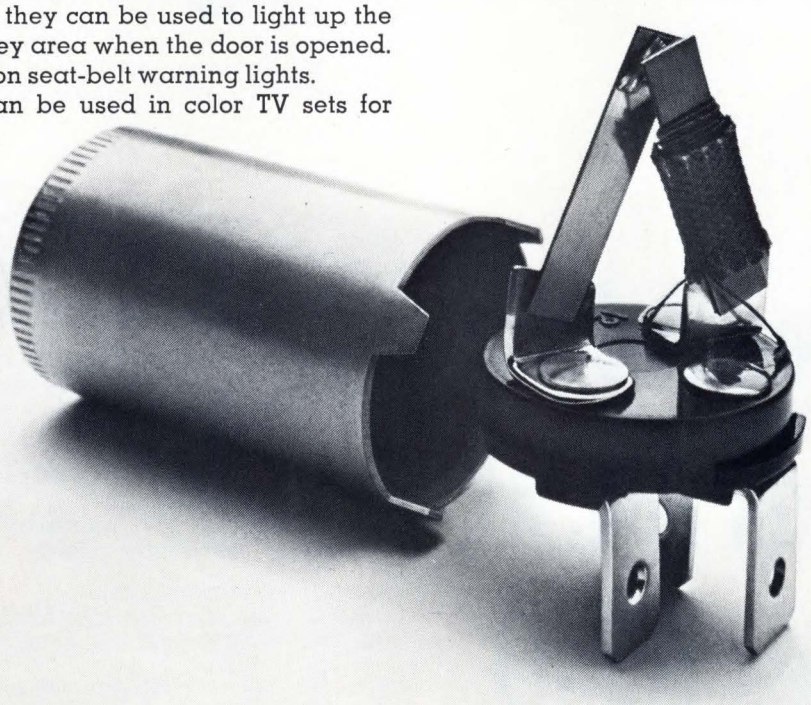
Plug one in wherever you want to delay a lamp or a small electrical load. Or need an automatic timer, alarm—or even limit switch.

We make the relay in 2-, 3- and 4-terminal versions. Normally open and closed. For AC and DC circuits.

A little gadget like this could help your design become a very hot item.

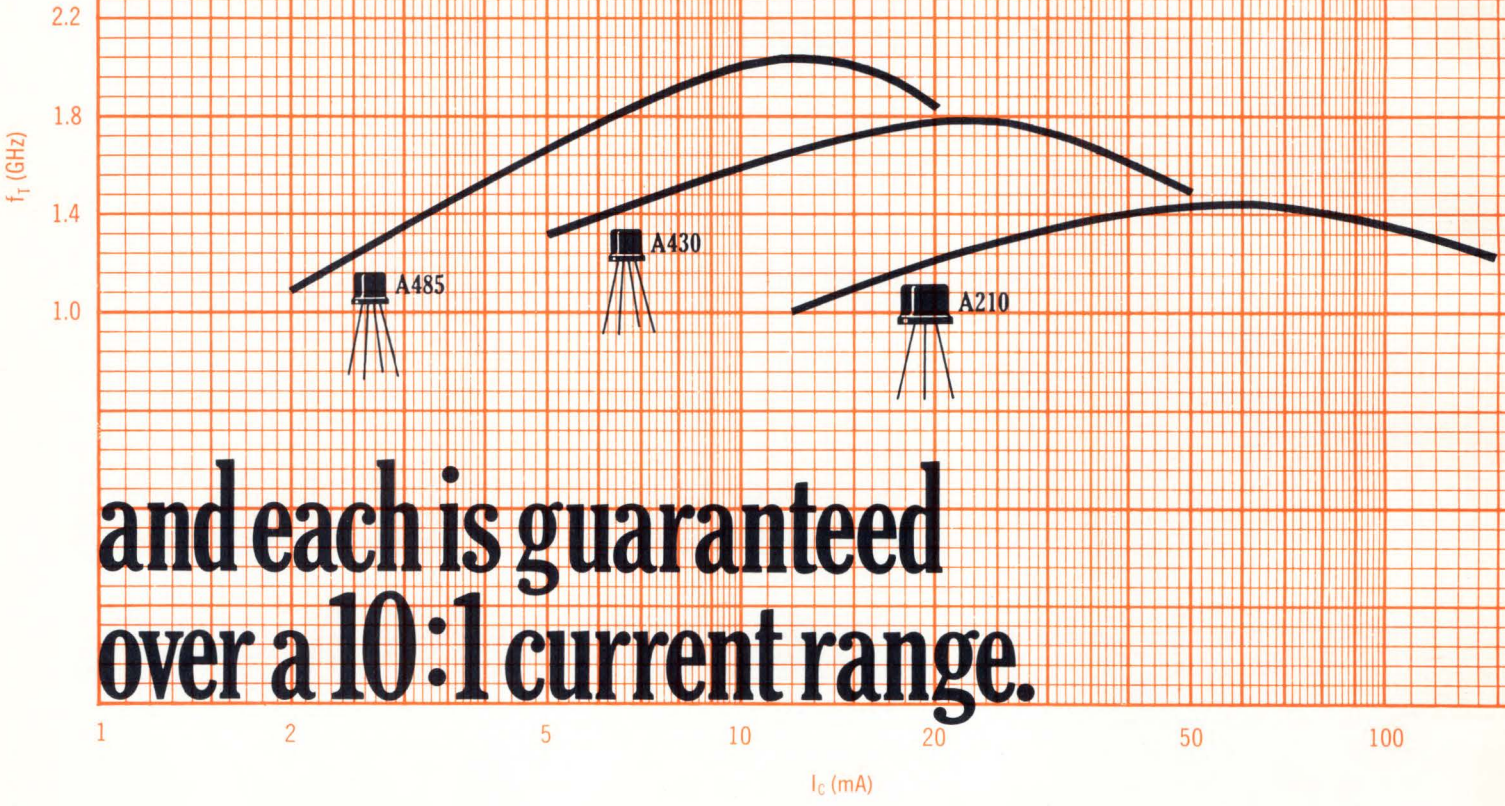
For details write to: Sylvania Special Products, Control Devices Div., Standish, Maine.

SYLVANIA
A SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS



CIRCLE NO. 10

Now there are 3 low-noise UHF transistors with f_T above 1GHz...



and each is guaranteed over a 10:1 current range.

Amperex A485, Amperex A430, Amperex A210.

The rousing success of our A485, which has linear f_T above 1GHz for collector currents from 2 to 25mA, has led us to develop the A430 (f_T above 1.2GHz from 5 to 50mA) and the A210 (f_T above 1GHz from 15 to 150mA). And now there are three Amperex low-noise UHF transistors with linear, high f_T and with overlapping collector current ranges in steps of 10:1.

With these transistors you can now optimize broadband, high gain UHF amplifiers to operate at any collector current from 2 to 75mA—with extremely low intermodulation distortion and low, low noise. Until now, it simply couldn't be done.

Typical applications include broadband test instruments, (e.g., RF oscilloscopes), telemetry equipment, antenna amplifiers (say, from 40 to 860MHz), CATV distribution amplifiers and high performance communications receivers.

If you need high gain, low noise and low intermodulation distortion anywhere in the UHF spectrum, the Amperex A485, A430 and A210 may be your answer.

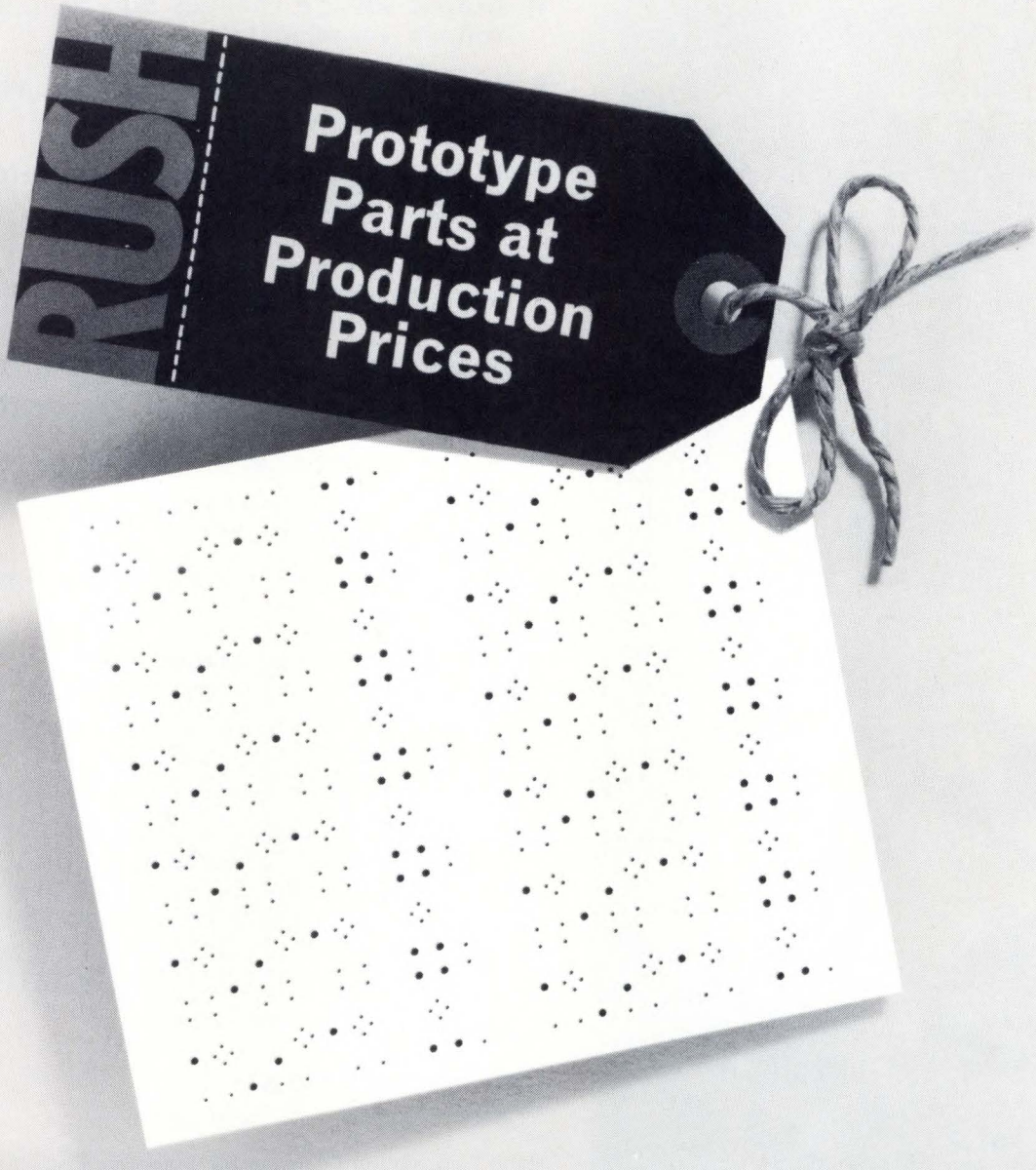
For data and applications information, write: Amperex Electronic Corporation, Semiconductor and Microcircuits Division, Slatersville, Rhode Island 02876.

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

CIRCLE NO. 11

Ceramic substrates in less time, for less money.



Hole-patterned ceramic substrates in quantities up to 250 are now available from Coors at *prices much lower* than ever before.

Parts shipments are faster too – *two weeks maximum* after receipt of order.

Substrates ¼ to 17 square inches in size, 10 to 35 mils thick, can be obtained with any practical number of holes in practically any pattern.

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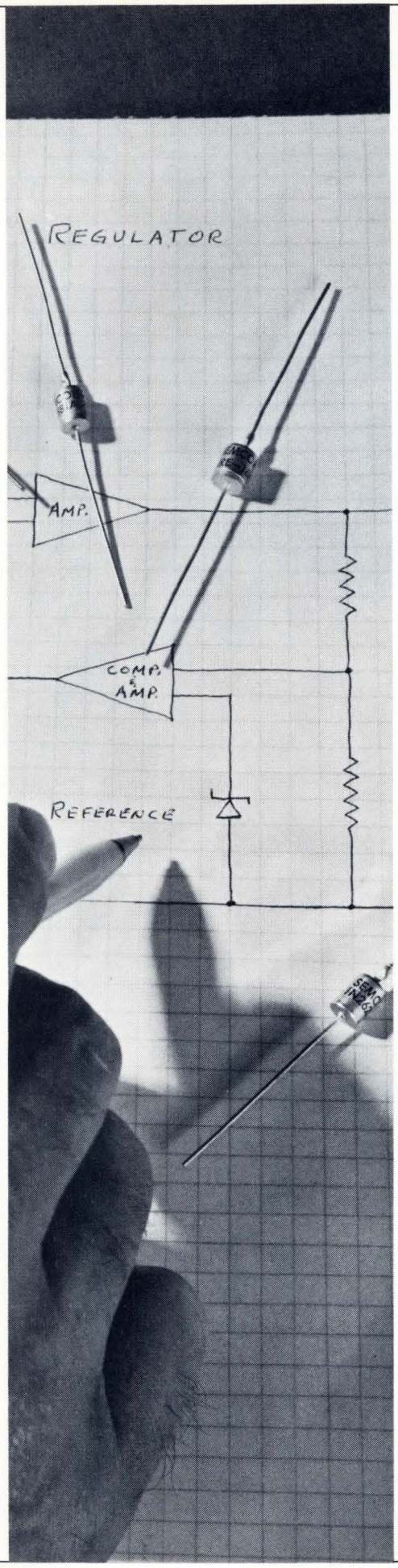
Materials are Coors famous-quality 96% and 99.5% alumina ceramics.

Turn breadboards into prototypes, prototypes into finished circuits quicker, cheaper.

Mail or phone your substrate specifications to Coors Custom Products Division – today. Coors Porcelain Company, 600 Ninth Street, Golden, Colorado 80401, (303) 279-6565.

Coors/CERAMICS

CIRCLE NO. 12



Voltage Regulator Problems?

- **Output voltage changes due to input voltage variations?**
- **Output voltage changes due to ambient temperature variations?**
- **Output voltage changes due to reference element voltage/time instability?**

Problems Solved!

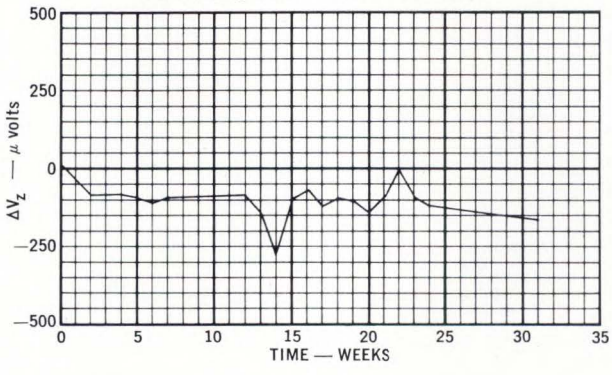
Use Semcor's Metal Temperature Compensated Reference Elements

Low dynamic impedance — as low as 15 ohms

Controlled temperature coefficient — as low as .0005 % / °C

Superior voltage/time stability — to .5mv per year

VOLTAGE/TIME STABILITY TEST



Call Semcor Now!

In stock and at the right price

Metal Temperature Compensated Reference Elements

1N2620 - 1N2624B .....9.3 Volts	1N3580 - 1N3584B .....11.7 Volts
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SRE Series .....9.4 Volts	

Also a complete line of Glass and Molded Temperature Compensated Reference Elements

COMPONENTS, INC.
SEMCOR DIVISION

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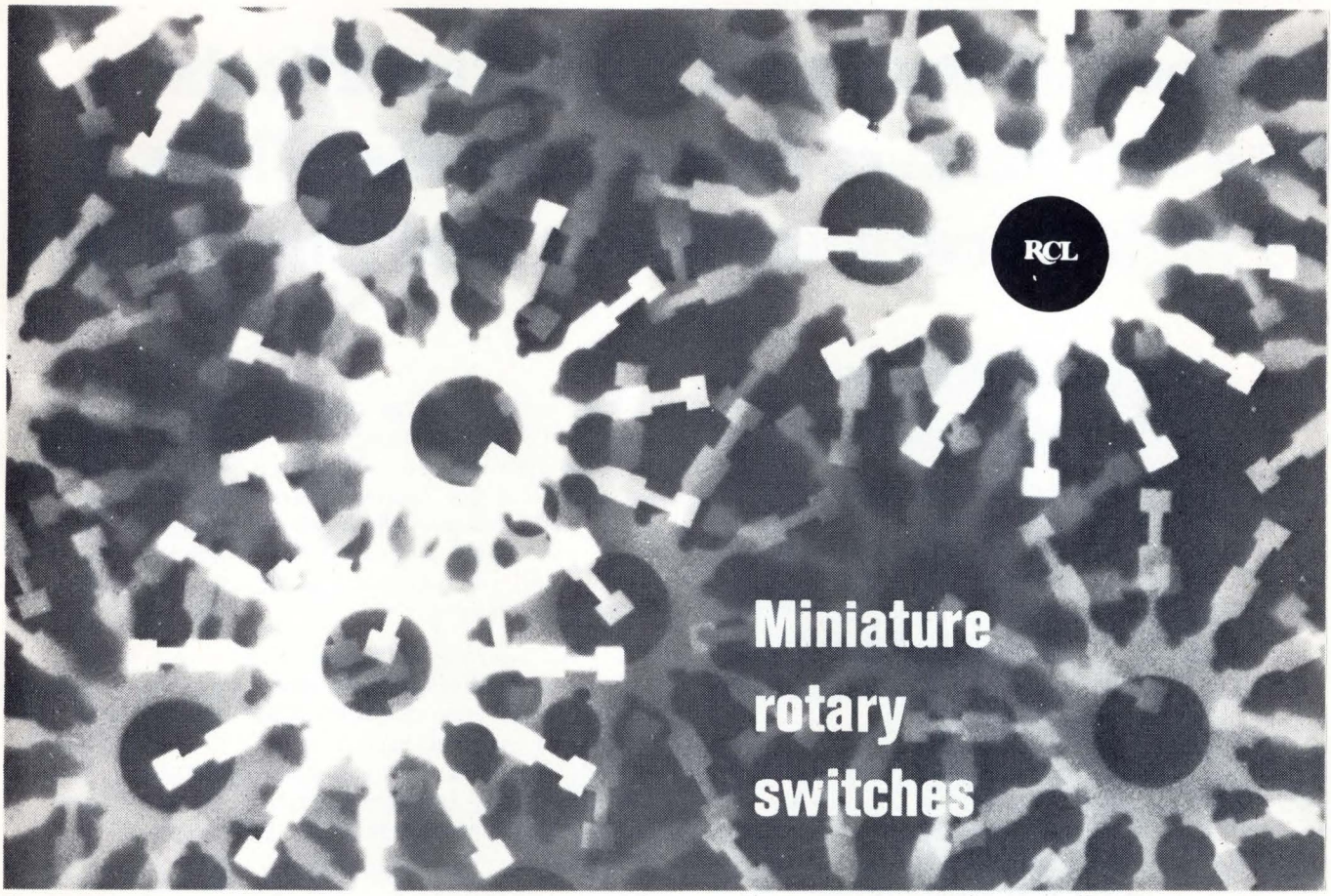
PHONE 602-272-7671 / TWX 910-951-1381

CIRCLE NO. 13



Industry's most complete selection

- Up to 12 positions per deck, shorting or non-shorting.
- Shorting AND non-shorting poles may be grouped on one deck in any combination.
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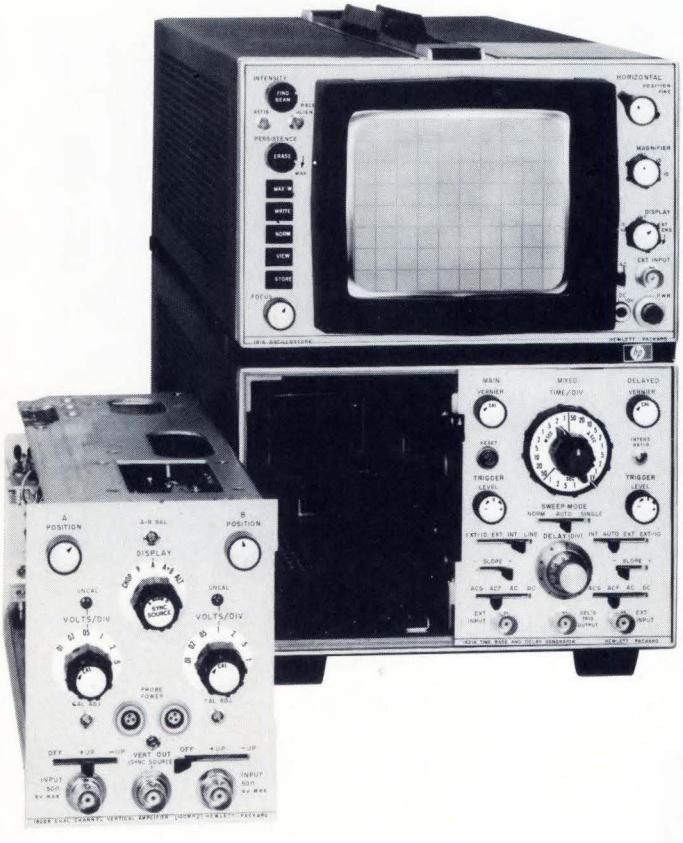
CIRCLE NO. 14

New hp 1802A 3.5 ns, 100 MHz Plug-in

Now You Can Disregard Capacitive Effects When You Measure Nanosecond Rise-Times And High Frequencies With a Real Time Scope!



The new hp 1802A Dual-Channel Vertical Amplifier plug-in used with any of the mainframes in the hp 180 scope system is designed *to eliminate the effect of input capacitance*—and its associated problems of signal attenuation and circuit loading. In fact, the input capacitance of the 180/1802A system is too low to be measured, so Hewlett-Packard now specifies the system as having a low reflection (<0.13) and an extremely low SWR of 1.35:1 at 100 MHz, 10 mV/cm sensitivity (1.1:1 at all other deflection factors).

For the first time you can forget about the influence of capacitance—the big problem in making high frequency real time measurements. You can measure nanosecond rise times and high frequencies over a wide range of source impedances—with 10 mV/cm sensitivity. You can look at your signal—without capacitive distortion of your display—and without capacitive disturbance of your circuit under test!

You have a near-perfect termination for your 50 Ω systems—regardless of your signal frequencies—with the 50 Ω impedance of the 180/1802A system. Optional resistive dividers increase resistance 5, 10, 50 or 100X with only 0.7 pF capacitance. You can make more than 90% of your high frequency real time measurements with these dividers and the 180/1802A system.

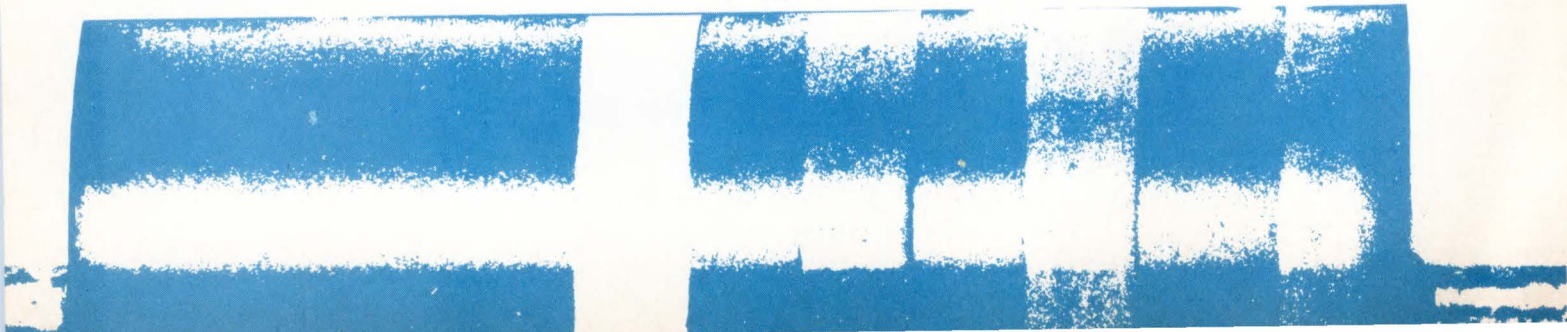
You can get higher resistances with the new hp 1123A 100 kΩ Active Probe which adds only 3.5 pF capacitance to your measurement system. Combine the active probe and its set of X10 or X100 matched resistive dividers and you've increased resistance greatly and *reduced* capacitance to only 3 pF!

Use the new 1802A Plug-in with the hp 181A Variable Persistence and Storage mainframe when you want to capture and hold high frequency single shot phenomena—or look at low rep rate fast rise time pulses.

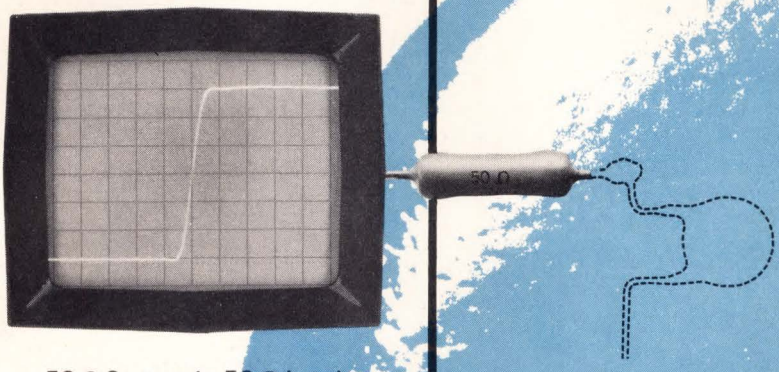
Get the full story on the new 1802A plug-in and your **free measurement error calculator** for calculating rise time accuracy of your measurement system from your nearest hp field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

Price: hp 180 Scope System with 100 MHz capability, $2500; with 100 MHz and variable persistence and storage, $3150; hp 1802A amplifier plug-in alone, $1200; hp 1123A Active Probe, $325.

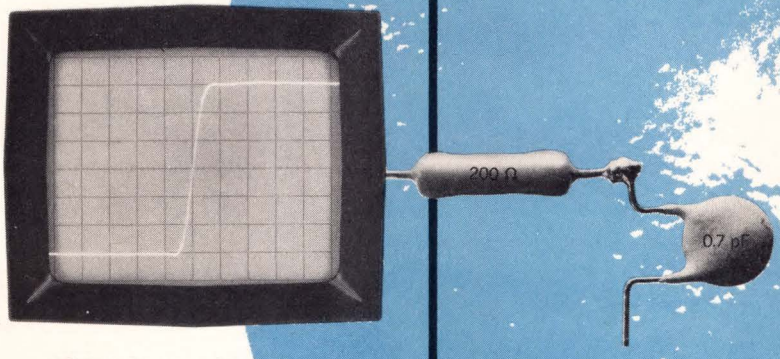
088/1



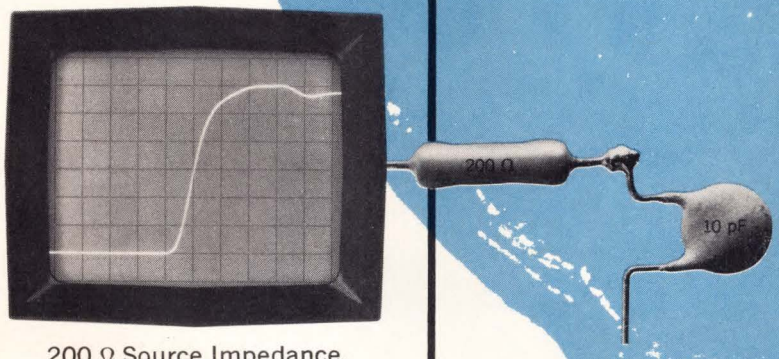
These are photographs of a 2 ns rise time signal—showing the effects of different probe capacitances.



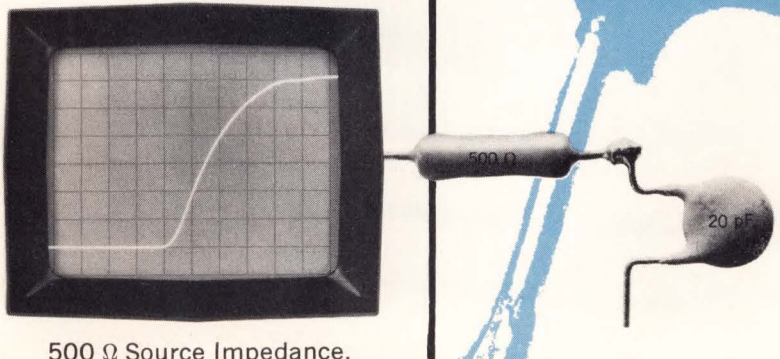
50 Ω Source to 50 Ω Load



200 Ω Source Impedance,
0.7 pF capacitance



200 Ω Source Impedance,
10 pF capacitance



500 Ω Source Impedance,
20 pF capacitance

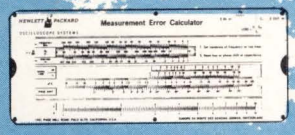
Capacitance and Fast Rise Time Measurements

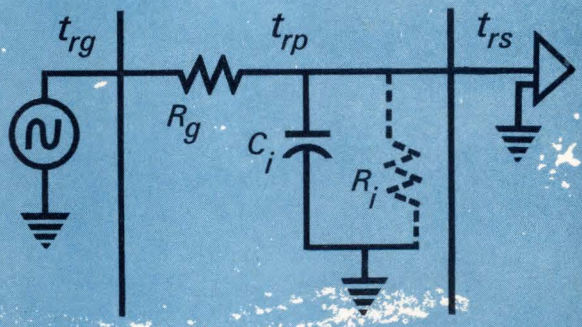
Rise time displayed on an oscilloscope is basically the result of the relationship of source impedance—**and** the capacitance of the **signal source,** the capacitance of the **probe,** and the capacitance of the **scope.**

The formula for calculating rise time—if you want to do things the hard way— is t_r observed $\approx \sqrt{t_{rg}^2 + t_{rp}^2 + t_{rs}^2}$ where t_{rg} is rise time of the signal source; t_{rp} is rise time of the probe ($t_{rp} = 2.2\ R_g C_i$); and t_{rs} is rise time of the scope.

To get an accurate rise time measurement of high frequency, fast rise time signals you need a measurement system with capacitance so low, it is essentially insensitive to a wide range of source impedances and frequencies. Otherwise you will have signal attenuation and capacitive loading of your circuit under test.

See for yourself what capacitance does to the rise time of your circuit under test. Use the t_r formula or calculate t_r using the new hp measurement error calculator—it's free on request!





HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

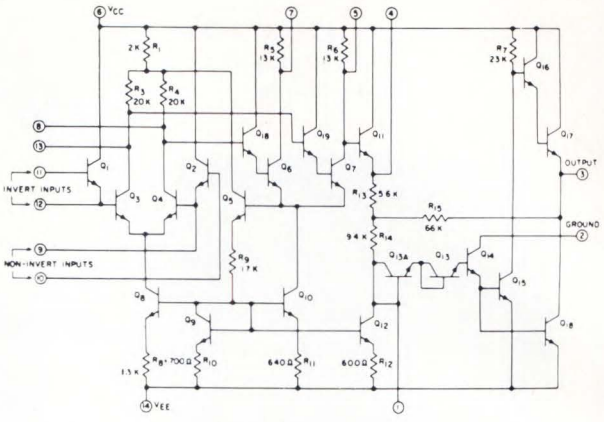
CIRCLE NO. 15

Check CA3047 Specs Against the Rest

Now there's a new industry standard for Op Amp performance/dollar—RCA-CA3047. Compare it with the rest for input and output specs and stability. Compare for gain and CMR, for output power and voltage swing... and price!

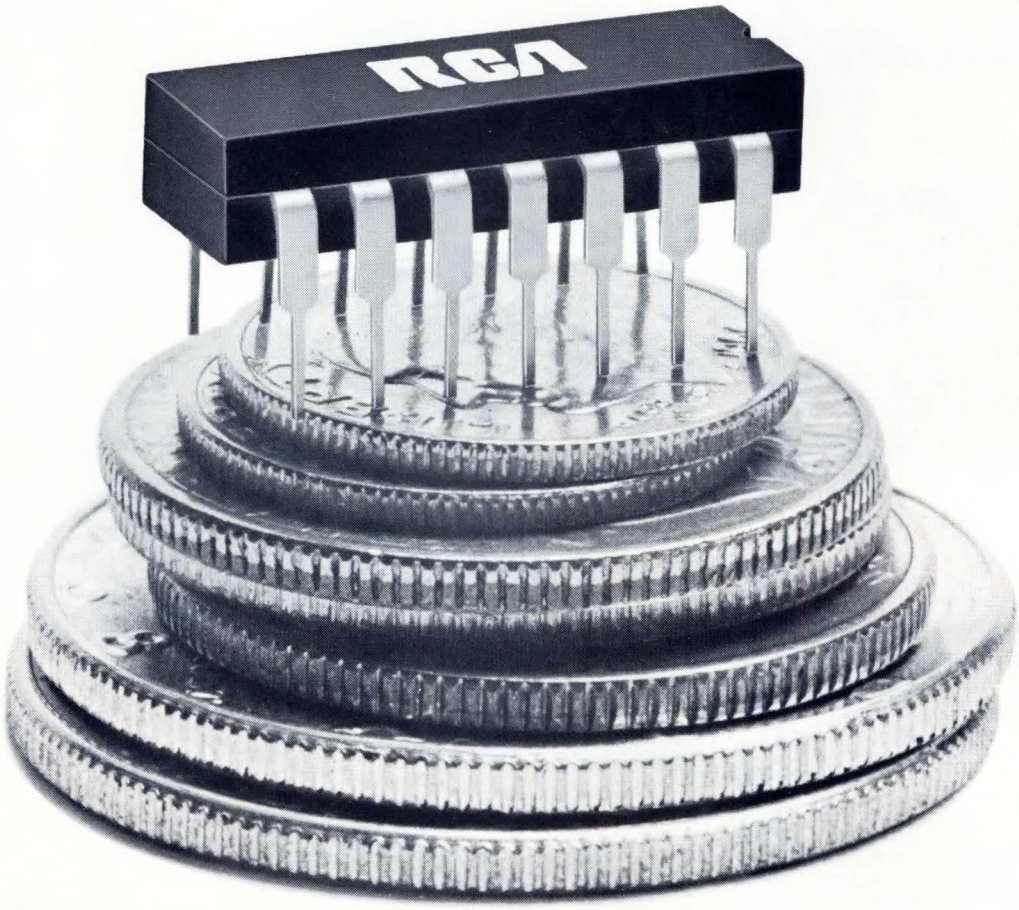
For more information, see your RCA Representative about CA3047 and the other Op Amps in RCA's economy/performance line. Or ask your RCA Distributor for his price and delivery. For data sheets on the RCA-CA3047, write RCA Electronic Components, Commercial Engineering, Section ICF-10, Harrison, N.J.07029.

Supply Voltage	**± 12 V max.**
Power Output (10% THD) (R_L = 500Ω)	**80 mW min.**
C-M Rejection Ratio	**84 dB min.**
Output Swing Voltage (P-P) (R_L = 500Ω)	**18 V min.**
Input Impedance	**150 KΩ min.**
Open-loop Voltage Gain	**84 dB min.**
Input Offset Voltage	**5 mV max.**
Input Offset Current	**35 nA max.**
Input Bias Current	**350 nA max.**
Slew Rate	**1.2 V/μs typ.**
Operating Temperature	**0° to + 70°C**



Look at how much Op Amp $1.95* can buy!

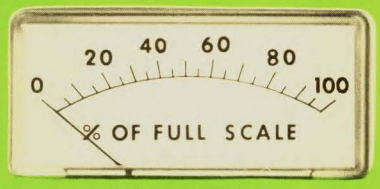
*per unit per 1,000



RCA Integrated Circuits

The Readable Little Meter

Hold the ad at arm's length and see just how readable it is.



(Actual size)

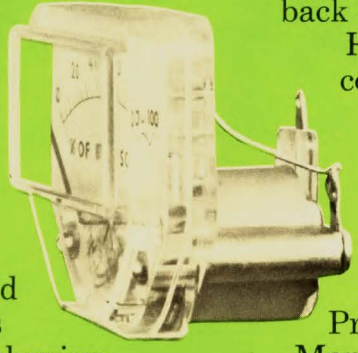
Put your left thumb here.

Put your right thumb here.

Honeywell's new 81T Panel Meter takes up about half the panel space of a full-scale meter.

But hold this ad out at arm's length and see how easy the meter is to read. (How we ever got such a large scale on such a small face without cluttering it, only our designers know.) And we've set the dial up front, so you can see it clearly, even from an oblique angle.

The small mechanism behind the small face is Honeywell's Auto-Torque taut-band mechanism.



It has about 50% fewer parts than a pivot-and-jewel.

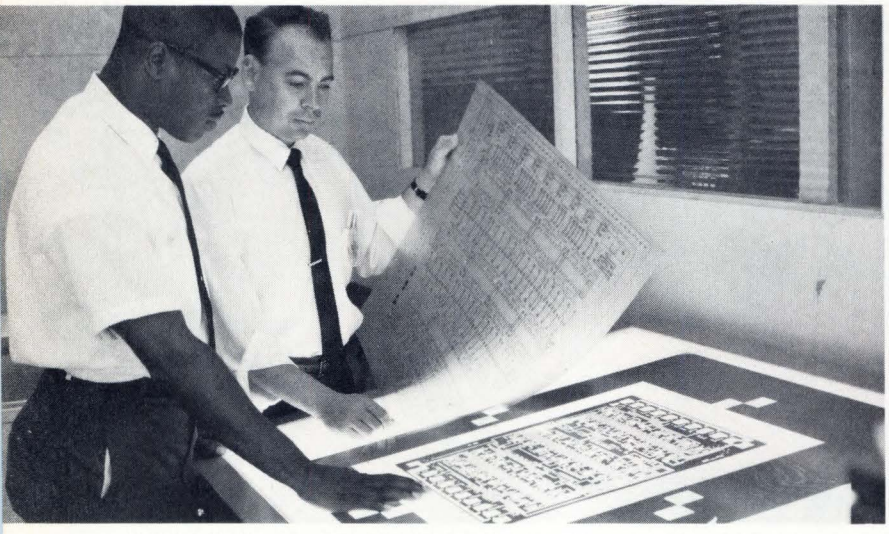
(One of the parts that's missing is the old space-consuming plastic barrel on the back of the meter.)

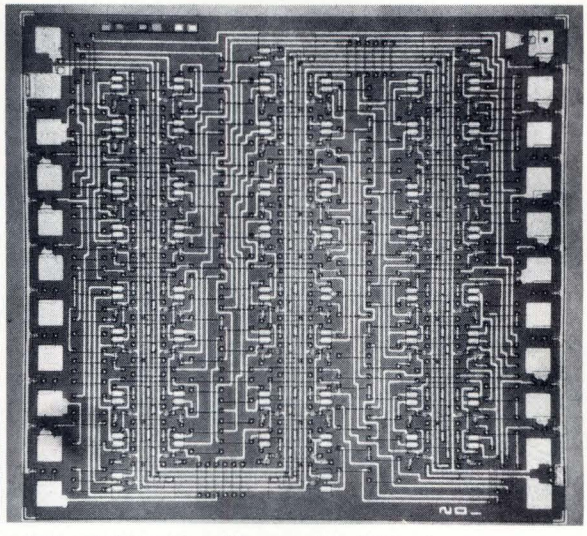
Honeywell 81T Panel Meters come in 33 standard ranges. And they cost no more than pivot-and-jewel meters. So you don't have to pay a lot to get a little.

(We'd like to send you a catalog. Write Honeywell Precision Meter Division, Manchester, N.H. 03105.)

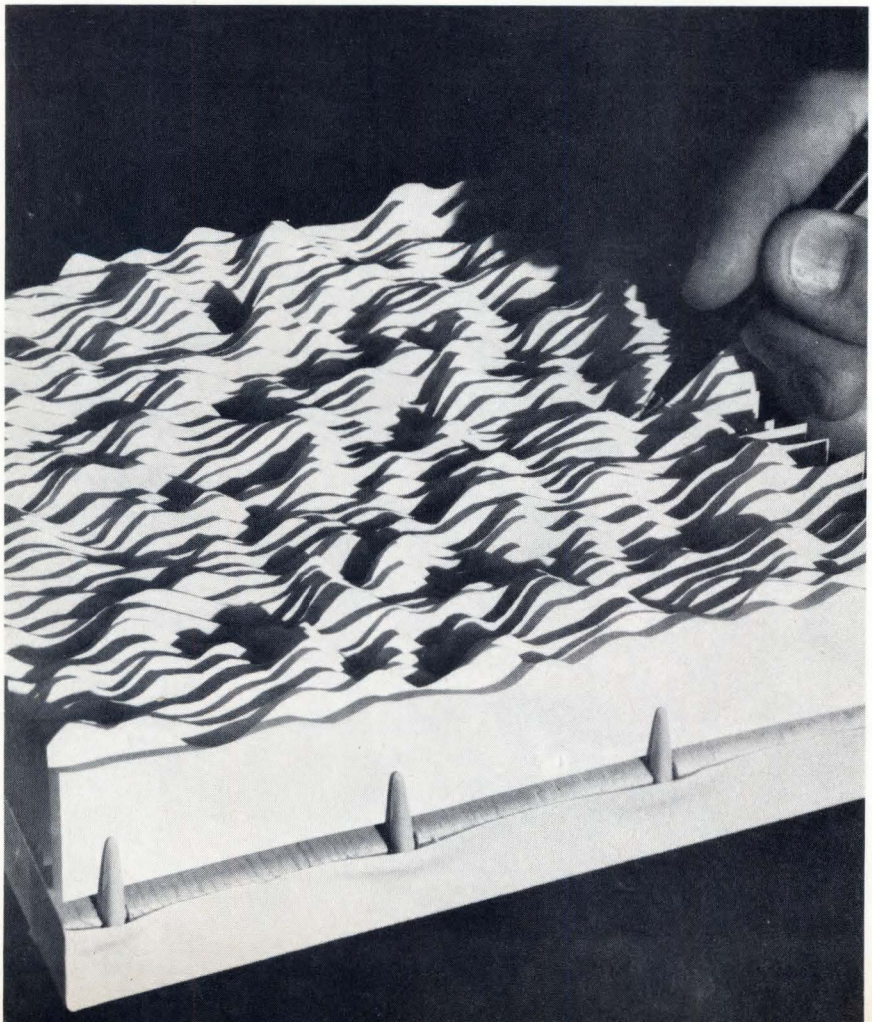
It takes all kinds of meters to make the Honeywell line.

Honeywell



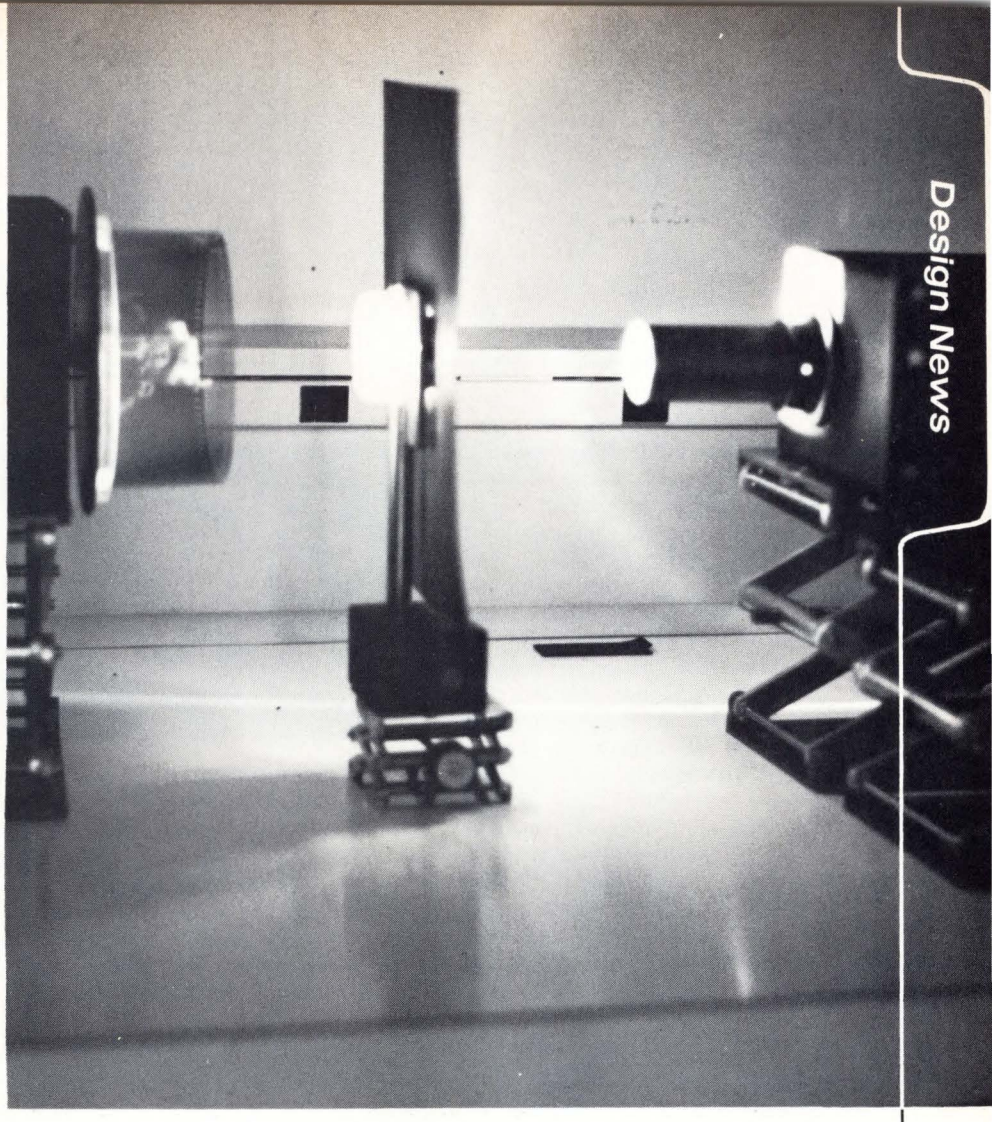


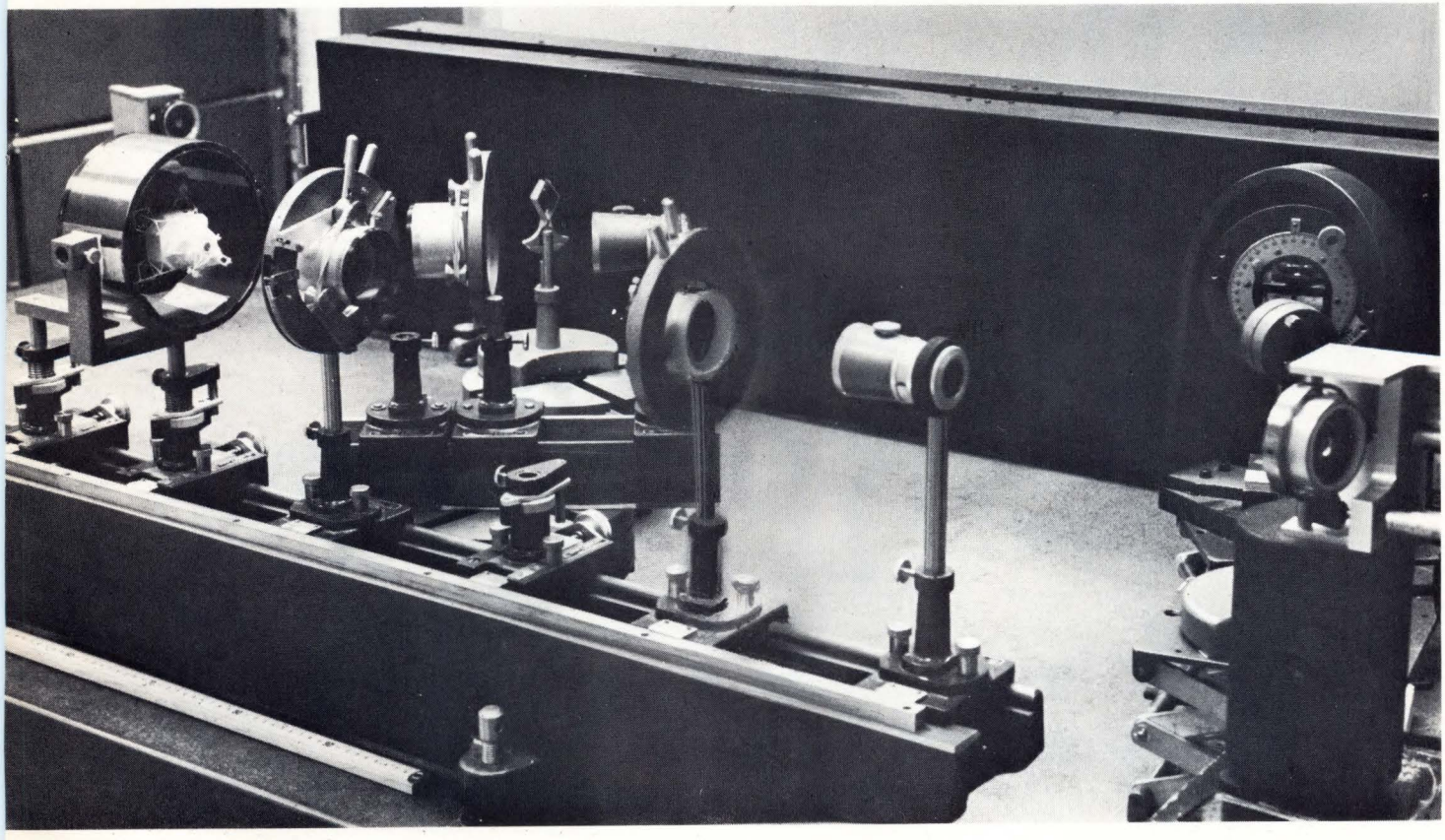
'UNIVERSAL' CIRCUIT PATENTED. RCA's entry into the LSI market, a one-layer metallized MOS chip with a possible 100 gates, was recently awarded a patent. The basic element is a variable-identity cell in which the transistors are not connected. The basic circuit operates as though it had two layers of metal, but only one is applied because RCA diffuses conductive paths in the silicon. Designers lay out the final interconnection for custom needs, making the cell into any kind of NAND or NOR gate. RCA states that all power bus structures are adjacent to cells via the meander line. All the engineer has to do is to connect from the proper bus line to the proper terminal of the cell to obtain proper loading of the cell. Array above is a completely processed customized chip for a binary-coded decimal up/down counter that uses 52 gates and 18 of the 22 bonding pads available. Final artwork at left is 200 times size of final chip.



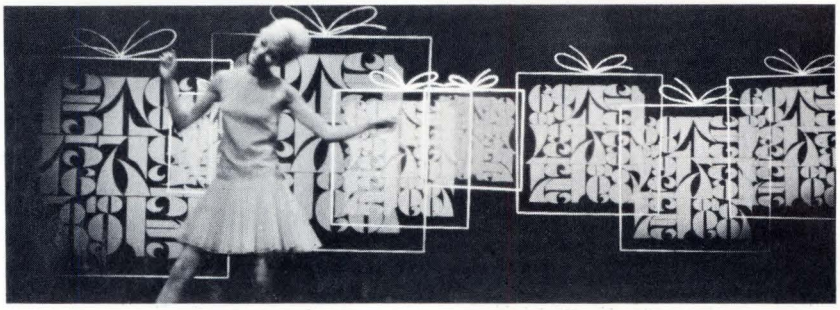
OCEAN ETCHED ON SILICON. Scientists at Lockheed's Research Lab. are reducing 1-sq mi of ocean to a 1-in silicon wafer to simulate the sea's wave patterns and then study scattering of microwave signals for various sea states – calm, moderately choppy, storm-tossed. The first step is the model shown at left that consists of cut-up computer readout derived from input of actual wave patterns into a computer. Wafers will be chemically etched, representing several sea conditions. The wafer then is placed at a precise distance from a laser source and its infrared beam duplicates, in miniature, the microwave radar beam from a satellite. It now is difficult for a satellite to interpret radar reflections, because of the constant shifting, rising and falling of the ocean. Such lab data could help future weather- and earth-resources satellites to make quick, remote analyses of conditions of the world's oceans, aiding in weather forecasting and navigation.

HOLOGRAMS IN THE ROUND. Researchers in the Optics Lab. at Martin Co., Denver, are perfecting a 360° hologram that differs from the one Bell Telephone Lab. is working on (EDN, May 1968, p. 33). The Martin hologram is made by illuminating the object (a model of Surveyor) that is placed inside a strip of film, which is taped in the cylinder at left of setup. A helium-neon laser takes 4 s to expose the film but a pulsed laser takes only 20 ns. For the reconstruction, Martin attaches the film to a revolving stand and uses any good light source. (The system reported from BTL exposed sequentially narrow parts of the film while rotating the object through 360°.) Applications of this type of hologram include a model with which astronauts can practice space docking. Martin is building an optics system that will blow up this 360° hologram to the size of the astronauts' window and then will maneuver the hologram to simulate actual docking procedures. Researchers also are working out a laser system that will use a pulsed laser to take holograms of rock samples from space, instead of the stereophotographs now taken. The pulsed laser exposes the holograms fast enough that the motion of the spaceship does not affect them.

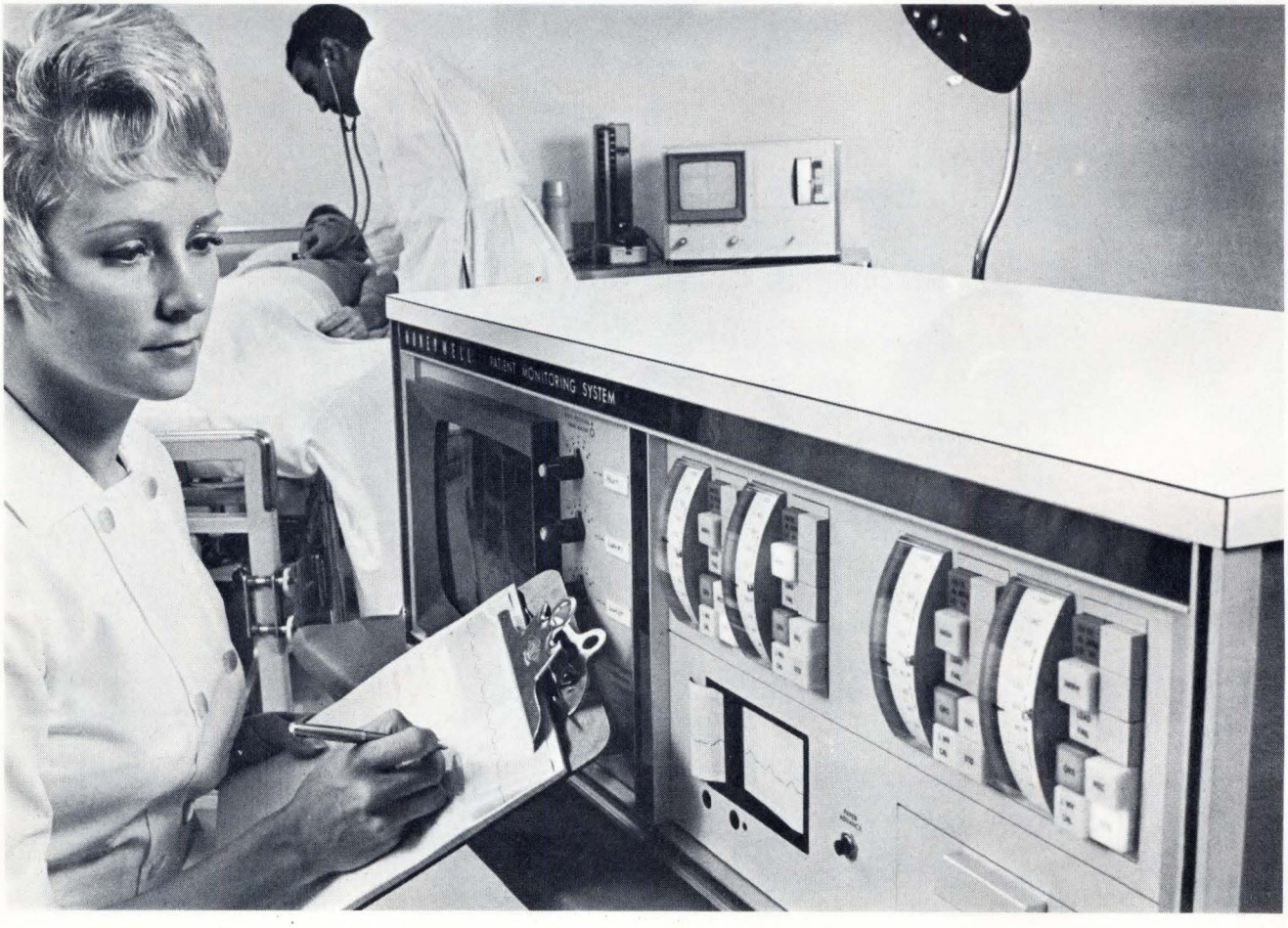




NEW DESIGN IN MEDICAL MONITORING. Reduction of false alarms and lead-failure detection are two of the benefits Honeywell's Test Instrument Div. promises with its new patient-monitoring system. "Most patient-monitoring systems cannot distinguish between alarms set off by true heartbeat activity and those generated by false information—noise interference, electrical or mechanical trouble," said the company. One of the design features is a highly sensitive beat-to-beat cardiotachometer that provides automatic control, high immunity from noise interference, baseline shift, and multiple counting of single heartbeats and artifacts. Another is the special lead-fail circuitry that detects the malfunctioning source and prevents the false alarm that otherwise occurs, affecting display of data recorded by the system.



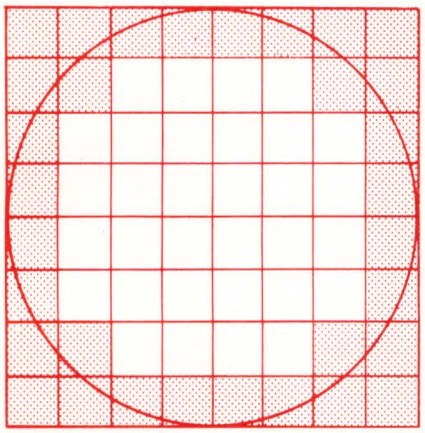
ACM COMES OF AGE. Braving Las Vegas' heat to attend the Association for Computing Machinery's 21st birthday party were 3000 computerites. Outstanding speaker was Nevada's Lt. Gov. Fike, who told the conference luncheon of the great strides that Nevada has taken in centralized data storage and processing. Highlight of the 50 exhibits at the August 27 to 29 show was the flamboyant Control Data display, featuring abstract light patterns and a dramatic young dancer (above). SIE Div. of Dresser International introduced a laser-activated incremental plotter of unique design, exceptional speed (p. 34). Copies of proceedings, largely software oriented, are available through Brandom Systems Press, New York, N.Y.



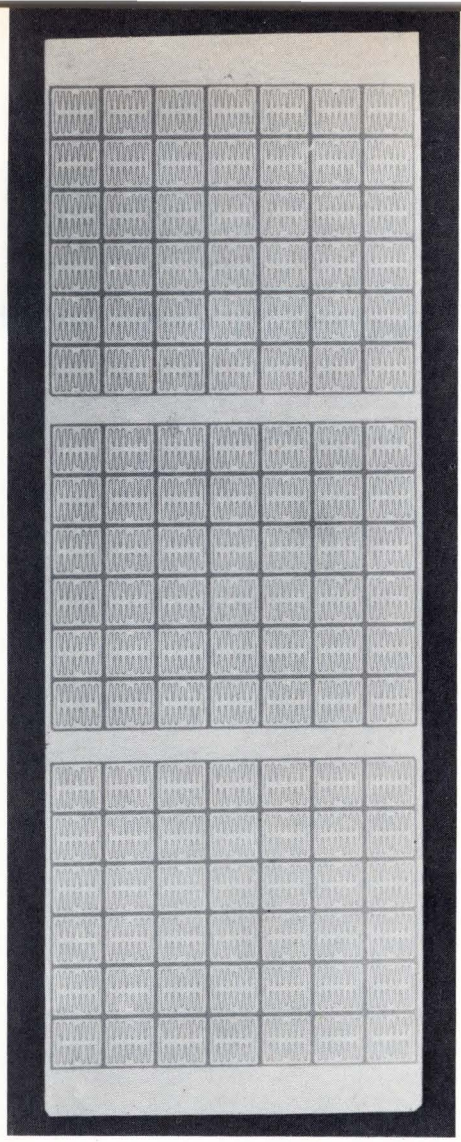
RECTANGLES IN, CIRCLES OUT Round wafers, sliced from silicon ingots, long have been the accepted form. But now comes the rectangular wafer! Circle-squarers' chips can be scribed on a square format and circles become inefficient (see comparison above).

Instead of slicing round chips off the crystals, designers at Motorola's Semiconductor Products Div. are cutting 2- by 2- by 6-in blocks of silicon from them. Ted Benedict, materials operations manager, says:

"Aside from the obvious efficiency advantages we obtain in space utilization in our diffusion and epitaxial deposition, a broken or damaged 2- by 6-in wafer usually can be two-thirds salvaged. A damaged 2-in round wafer is lost. The basic square-wafer format we are using allows processing of 2- by 2-, 2- by 4- or 2- by 6-in wafers and increases furnace capability."

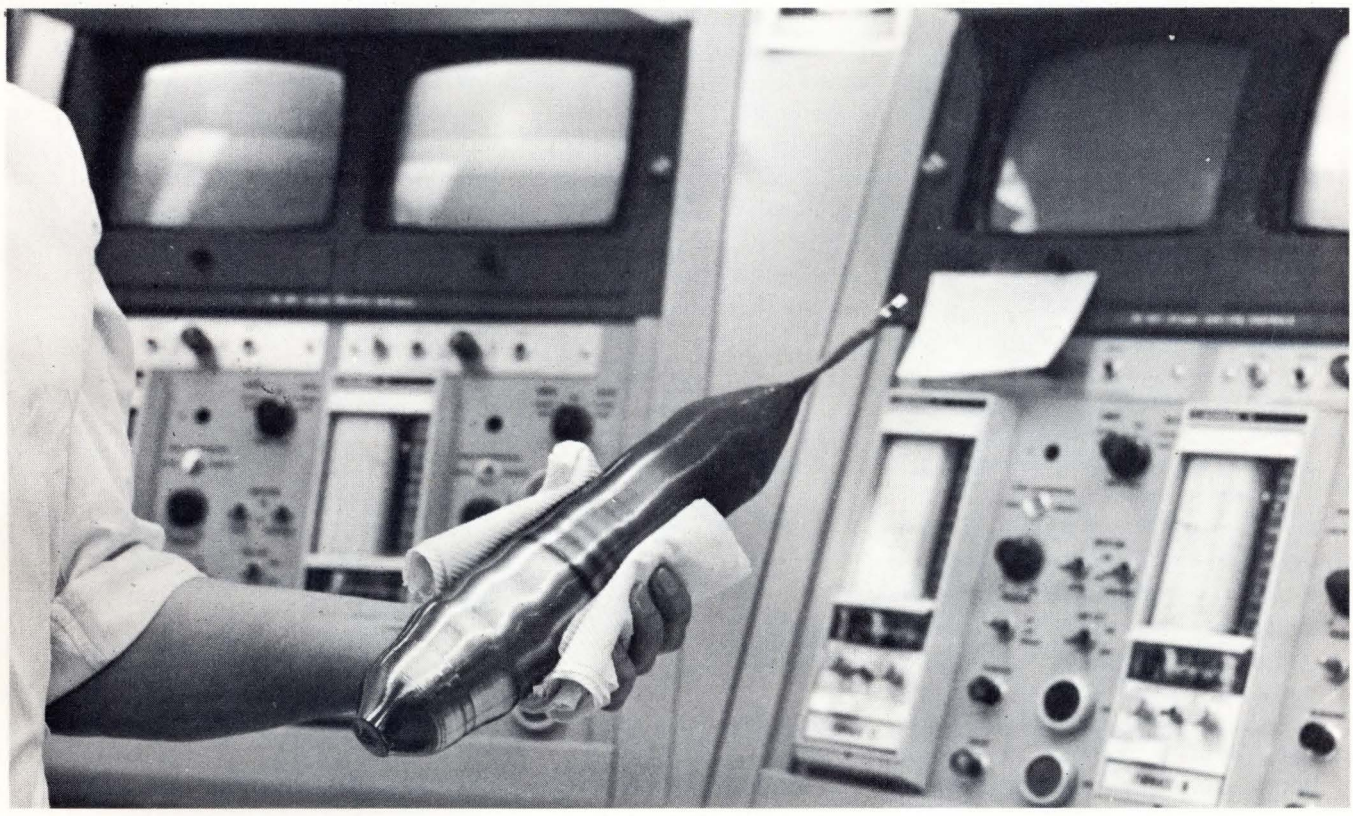


Two-inch circle (left) has 21 percent less area that 2 in^2.



Wafer (right) has 126 transistor chips, each 275 $mils^2$.

Crystal for "slab" wafers (below) is 2.8 in in diam when pulled. It is trimmed to a 2- by 2- by 6-in block and then sliced longitudinally with a diamond bandsaw. Waste is all recycled for further use.



Spatial Filtering Cleans up Deep-Space TV Noise

URBANA, ILL. – Researchers in Professor Poppelbaum's Computer Hardware Research Group at the University of Illinois have developed an on-line laser technique for eliminating noise that deteriorates space-generated TV signals. This real-time technique for cleaning up TV signals, based on spatial filtering, promises to be far more satisfactory than the time-consuming and expensive computer noise-elimination techniques now in use.

The basic technique is possible because most noise existing in space varies slowly, while the noise in consecutive TV-frame transmissions varies only in phase. This means that if one TV frame contains only noise and the next contains both signal and noise, the processing of both into a form in which one signal is subtracted from the other results in a noisefree signal.

The form that allows two TV signals to be combined mathematically is the Fourier transform. Subtracting one TV signal from another while in the transform plane actually removes a portion of the visible TV frame.

Spatial filtering helps to convert a TV picture into its Fourier transform. First, a complete TV picture is superimposed on a laser beam and the beam then is focused to a point. Instead of producing a perfect point of light, the coherency of the laser beam causes the elements of the picture to produce an interference pattern. This interference pattern, similar to a hologram, consists of a series of light and dark areas and is equivalent to the Fourier transform of the complete TV picture. This means that the light in any particular point is directly proportional to a Fourier coefficient.

Optically converting the television signal into its frequency domain is handy because mathematically any waveform can be modified by another simply by subtracting Fourier coefficients. Therefore, by freezing the Fourier-transform pattern of an all-noise TV frame for a short time and using it like a photographic negative, the noise is optically subtracted (spatially filtered) from the Fourier transform of the signal-plus-noise signal.

All laser light passing through the Fourier transform plane is reconstructed into a picture by reverse action of the interference patterns. Because the removed information exactly coincides with the noise that is superimposed on the desired signal, the resulting visible picture contains only signal information.

Modulating the laser beam with the entire TV picture was the major problem facing the developers, led by Prof. Michael Fairman. They solved it by using a modified version of the Ardenne tube, also called a solid-state light valve or a Pockels Effect Chamber. In the Ardenne tube, the entire TV frame is scanned onto an electro-optical crystal with a modulated electron beam.

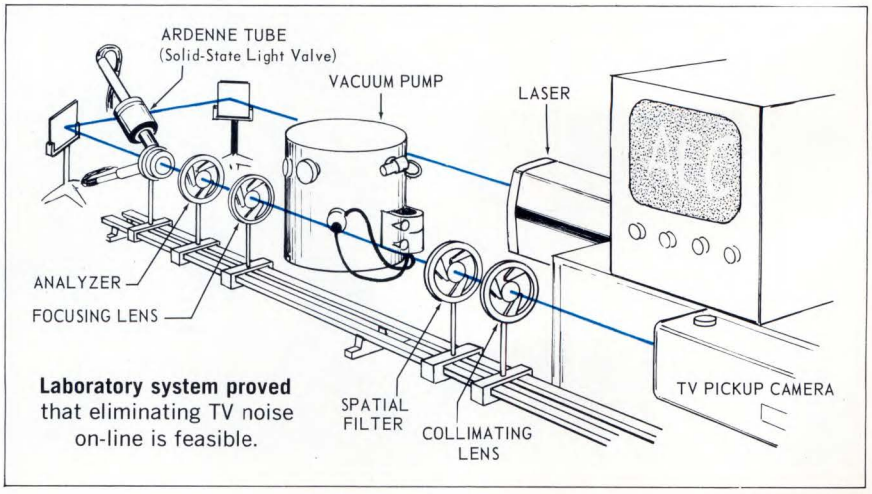
Normally, the KDP crystal does not affect the polarized laser light passing through it and this light is stopped by a cross-polarizing filter, which follows the crystal. However, when the scanning electron beam hits the crystal, an electrical field is developed that causes the light passing through that point to become elliptically polarized. A portion of this polarized light passes through the analyzer and appears as a light output. The amount of light is roughly proportional to the modulated intensity of the electron beam and the light passing through the analyzer is a true representation of the TV picture.

The fact that spatial filtering works and that noise is filtered out with this technique was proved at the University by using a steady-state source and a steady-state spatial filter. The filter consists of black spots drawn on a glass that exactly represents the Fourier transform of the steady-state noise.

However, in a dynamic system an active spatial-filtering technique must be developed. Two techniques have been considered. One workable technique employs two Ardenne tubes to produce a scan on a second tube, which is equivalent to the Fourier transform created by the noise-only TV signal. In this method, the KDP crystal of the second Ardenne tube acts as the electro-optical filter for masking noise out of the final TV picture.

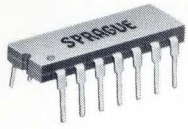
A more direct method provides a

(continued)



Laboratory system proved that eliminating TV noise on-line is feasible.

Add Sprague Series 7400A to your prints for Series 74N TTL circuits. They're pin-for-pin identical.



SERIES 74N	FUNCTION	SPRAGUE PART NO.
SN7400N	Quad 2-Input NAND	USN-7400A
SN7401N	Quad 2-Input NAND (No Collector Load)	USN-7401A
SN7402N	Quad 2-Input NOR	USN-7402A
SN7410N	Triple 3-Input NAND	USN-7410A
SN7420N	Dual 4-Input NAND	USN-7420A
SN7430N	Single 8-Input NAND	USN-7430A
SN7440N	Dual 4-Input NAND Buffer	USN-7440A
SN7450N	2-Wide 2-Input Expandable AND-OR-INVERT	USN-7450A
SN7451N	2-Wide 2-Input AND-OR-INVERT	USN-7451A
SN7453N	4-Wide 2-Input Expandable AND-OR-INVERT	USN-7453A
SN7454N	4-Wide 2-Input AND-OR-INVERT	USN-7454A
SN7460N	Dual 4-Input Expander	USN-7460A
SN7470N	D-C Clocked J-K Flip Flop	USN-7470A
SN7472N	J-K Master Slave Flip Flop	USN-7472A
	Dual J-K Master Slave Flip Flop:	
SN7473N	Single chip, pin 11 GND	USN-7473A
—	Single chip, pin 7 GND	USN-74107A
SN7474N	Dual D-Type Edge-Triggered Flip Flop	USN-7474A
—	Dual AC Clocked J-K Flip Flop	USN-7479A
	COMPLEX ARRAYS	
SN7441N	BCD-To-Decimal Decoder/Driver	USN-7441B
SN7475N	Quadruple Bistable Latch	USN-7475B
SN7480N	Gated Full Adder	USN-7480A
SN7482N	2-Bit Binary Adder	USN-7482A
SN7483N	4-Bit Binary Adder	USN-7483B
SN7490N	Decade Counter	USN-7490A
SN7491AN	8-Bit Shift Register	USN-7491A
SN7492N	Divide-By-Twelve Counter	USN-7492A
SN7493N	4-Bit Binary Counter	USN-7493A

For complete technical data on Series 5400 and 7400A circuits, write to Technical Literature Service, Sprague Electric Co., 491 Marshall St., North Adams, Mass. 01247

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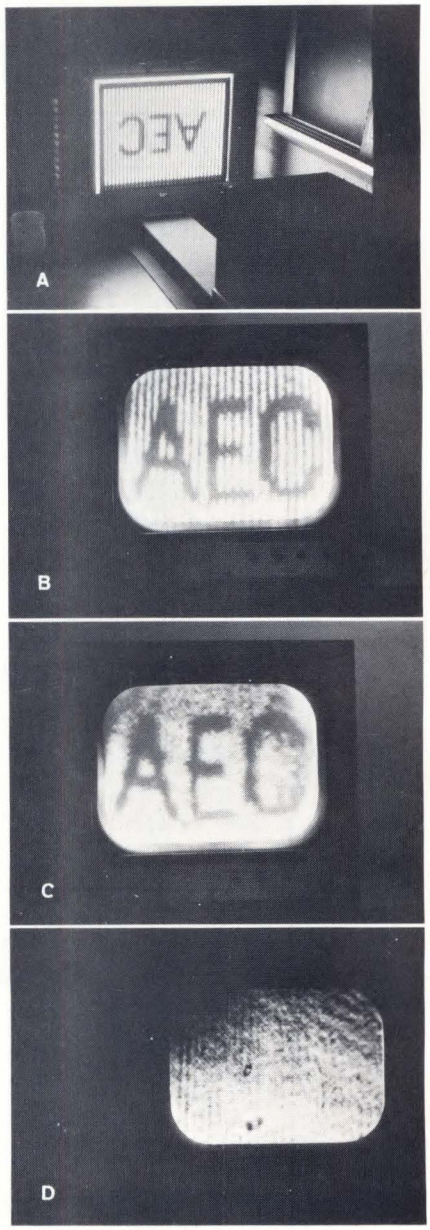
SPRAGUE WORCESTER...the world's finest microcircuit facility

4SS-7134R3

CIRCLE NO. 18

Spatial Filtering (Cont'd)

photochromic or F-center storage plate in the Fourier transform plane. However, considerable research is needed before proper device operation is perfected. (More information in Design Dataline, p. 220.)



Vertical black lines are superimposed for evaluation over desired signal, A. Without spatial filter, vertical lines appear in output, B. Adding appropriate spatial filter, C, to Fourier transform plane eliminates black lines. Inferior results are caused by inadequate system components. Blank screen, D, illustrates system operation with no video input.

These new SAMPLE/HOLD MODULES from BURR-BROWN

actual size

will help you build accurate A/D conversion systems in less time...at lower cost

Of the six Sample and Hold (or Track and Store) modules supplied by Burr-Brown, these two new units are proving to be the most popular. Why? Because they provide the type of precise, non-inverting performance that is ideally suited for highly-accurate A to D conversion systems. And, the price is reasonable. Only $110.00 for the 4034/25 . . . $125.00 for the 4035/15 . . . in single unit quantity.

Both units have excellent gain accuracy (±0.01%), low drift in the HOLD mode and a 10MΩ input impedance. Size is a convenient 1.80" x 2.40" x .60" for the Model 4034/25 . . . only 1.20" x 1.80" x .60" for the Model 4035/15. Rack mount versions are also available.

FOR DETAILED INFORMATION
on the complete line of Burr-Brown Sample/Hold Modules, simply contact your Burr-Brown Engineering Representative or use this publication's reader service card.

HIGHLIGHT SPECIFICATIONS

	4034/25	4035/15
Accuracy (0 to 60°C, 1% of f.s.)	±0.01%	±0.01%
Input Impedance	10 MΩ	10 MΩ
Aperture Time	0.05 μs	0.05 μs
Acquisition Time Settling to 0.01%	1000 μs	100 μs
HOLD Decay (at 25°C)	±0.1 mV/s	±0.25 mV/s
Power Requirements	±15V	±15V
Price, single unit quantity	$110.00	$125.00

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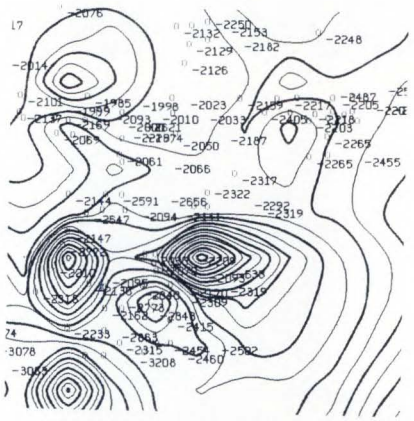
CIRCLE NO. 20

Laser-Plotting Graphics Take over

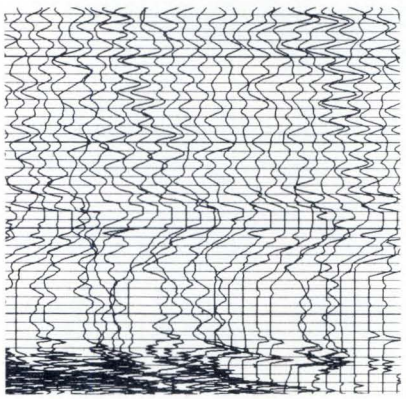
LAS VEGAS, NEV. – A new look in X-Y incremental plotters was unwrapped here at the recent ACM convention. Developed by SIE Div. of Dresser Systems, Inc., Houston, this digital plotter uses a modulated laser beam for selectively exposing conventional photographic film as instructed by an IMB Model 360 computer.

With a point-plot technique, the LGP-2000 graphic plotter prepares presentations up to 40 in wide and 100 ft long. Resolution is selectable, down to 0.005 in – a 40-in rotating mirror scan (divides) into 8000 tiny dots. These dots appear in as many as 14 shades of gray. Incremental film motion, again selective down to 0.005 in, provides the other plotting axis.

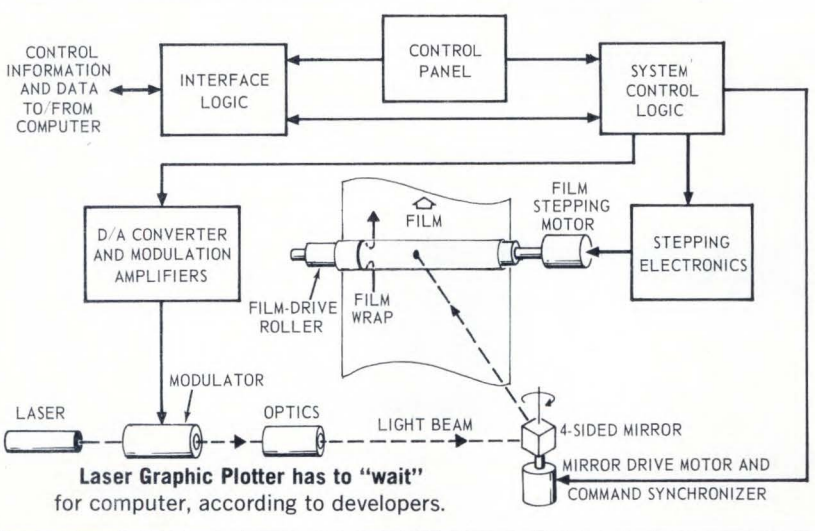
This plotter represents a major step forward in plotter speed, for example, with an IBM 360/40, a plot 40 in wide by 40.5 in long can be generated in 4 min, 10s. Electromechanical plotters are slower by at least an order of magnitude, but produce sharper, clearer images with better resolution. The new laser plotter is best (most advantageous) for such purposes as producing contour maps, irregular plots and varied-contrast plots. As with all such machines, it also can be adapted to polar plots.



Portion of contour map produced by plotter has resolution of 5 mils, lines are four dots wide and characters are two dots wide. Scale: 1 in = 8000 ft.



Portion of seismic wiggle trace has resolution of 5 mils, trace is one dot wide and timing lines are one, two and three dots wide. There are eight traces to an inch.



Laser Graphic Plotter has to "wait" for computer, according to developers.

Actual Size
Series 2500

TOTALLY ENCLOSED MICRO-MINIATURE ROTARY SWITCH WITH NEW

UNITIZED CONSTRUCTION 1/2 INCH DIAMETER...

Now that's a tiger, figuratively speaking, of course. But it does sum up the tiger-like performance of this new, totally-enclosed, micro-miniature rotary switch which exceeds the requirements of MIL-S-3786. Now briefly, because we want you to send for our complete specifications, let us take a look at what selective breeding and careful training have done for this tiger. Designed into a maximum overall dimension of .62 is a 30° indexed switch, giving you 2 to 12 positions with continuous rotation or with stops. You can even specify your own number of decks from 1 to 12. This tiger will perform at 70,000 feet and will stand its ground at temperature ranges of −55° C to +125° C. New unitized construction insures the highest level of reliability.

This is no paper tiger. It's off the boards and running, and your tiger-taming Janco representative holds the leash. Call him now! He's just back from safari with a great story.

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CIRCLE NO. 21

At ECI in St. Petersburg, Florida...
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- MODEM Technology
- Microelectronic Applications
- Error Control Coding
- Electronic Switching
- Time Division Multiplexing
- Reliability Techniques

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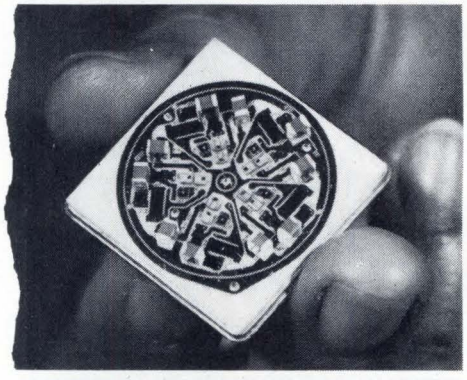
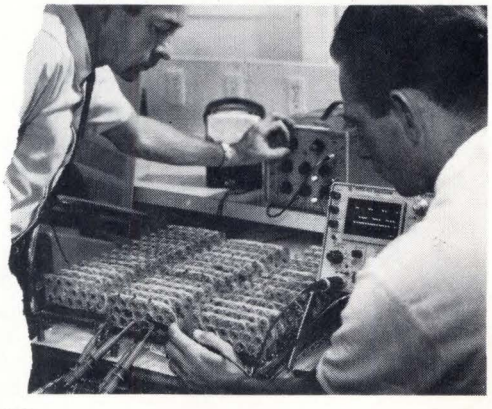




ELECTRONIC COMMUNICATIONS, INC.
ST. PETERSBURG DIVISION

CIRCLE NO. 721 ON ENGINEERING PLACEMENT CARD

SEMICONDUCTOR
newsbriefs
PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.

THE FIRST DOUBLE-REGULATED I/C VOLTAGE REGULATOR!

Here's a unique new monolithic I/C Voltage Regulator with an extra "built-in" reference-voltage regulator stage to provide regulating characteristics that are essentially independent of output voltage. No other I/C regulator available today offers this important advantage! So complete is this precision regulator that its 20 milliohm output impedance is independent of both output voltage and frequency up to 0.5 MHz. And, it can regulate loads **up to ½ Amp (without using external power transistors)!**

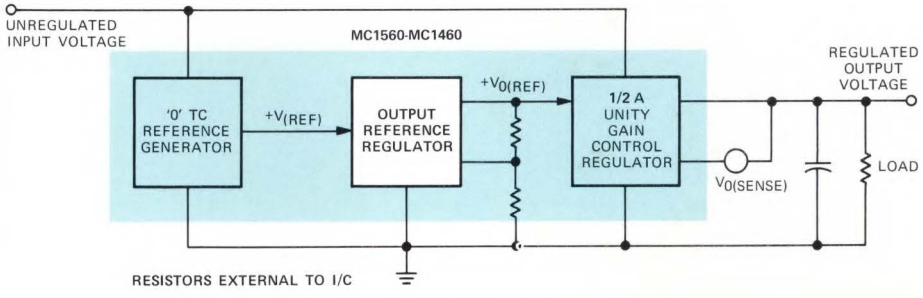
Available in two temperature ranges, the MC1560 (−55 to +125°C) and the MC1460 (0 to +75°C), also come in two different power handling packages – the new 9-pin TO-66 (suffix "R") which dissipates 10-Watts up to T_C = +65°C and the popular 10-pin, TO-5 ("G") for up to 1.80 W applications.

These remarkable I/C regulators also offer electronic "shutdown" control and short-circuit protection. The "shutdown" control can be actuated by an applied logic signal and can put loads in a "stand-by mode," or used as a dissipation control to protect the regulator under sustained output short-circuiting.

Other highlights include:

- Excellent transient response and temperature stability (0.003%/°C typ)
- High ripple rejection, 0.002%/V (typ)
- Single external transistor current boost to greater than 10 Amps

They're 100-up priced as low as $3.50 (MC1460G).



For details circle Reader Service No. **220**

Now "No Ringing" Series 54/74 T²L Circuits From Motorola!

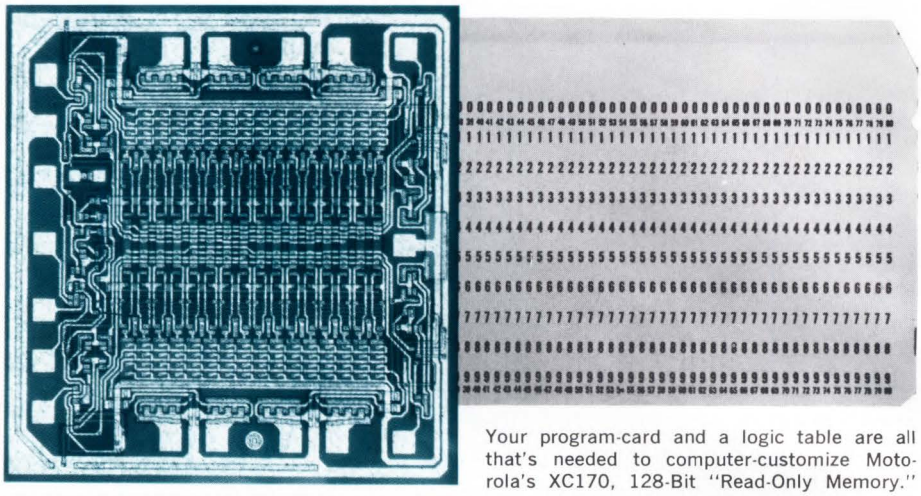
Motorola now supplies equivalents to the 54/74 T²L integrated circuit series – with an important added advantage – *diode clamped inputs!* So effective is this added circuitry that the "ringing" problem encountered with older T²L designs, is now virtually eliminated. In addition, the 3 J-K flip-flops in the line feature improved circuitry which offers greater protection against negative clock input transients.

The new MC7400P MTTL I/C line encompasses seventeen multi-function types including a full complement of gates (12 in all), covering NAND, NOR, AND-OR-INVERT functions and a gate expander. In addition to three J-K flip-flops, two of which are dual circuits, there is a Type "D" and a Quad Latch.

These integrated circuits are available in the 14-pin and 16-pin (MC7475P/MC7476P) dual in-line plastic packages.

FUNCTION	MOTOROLA	74N SERIES
Quad 2-Input NAND Gate	MC7400P	SN7400N
Quad 2-Input NAND Gate	MC7401P	SN7401N
Quad 2-Input NOR Gate	MC7402P	SN7402N
Triple 3-Input NAND Gate	MC7410P	SN7410N
Dual 4-Input NAND Gate	MC7420P	SN7420N
Single 8-Input NAND Gate	MC7430P	SN7430N
Dual 4-Input NAND Buffer	MC7440P	SN7440N
Expandable 2-Wide 2-Input AND-OR-INVERT Gate	MC7450P	SN7450N
Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC7451P	SN7451N
Expandable 4-Wide 2-Input AND-OR-INVERT Gate	MC7453P	SN7453N
Single 4-Wide 2-Input AND-OR-INVERT Gate	MC7454P	SN7454N
Dual 4-Input Expander	MC7460P	SN7460N
J-K Flip-Flop	MC7472P	SN7472N
Dual J-K Flip-Flop	MC7473P	SN7473N
Quad Latch	MC7475P	SN7475N
Dual J-K Flip-Flop	MC7476P	SN7476N
Dual Type "D" Flip-Flop	MC7479P	SN7474N

For details circle Reader Service No. **221**



Your program-card and a logic table are all that's needed to computer-customize Motorola's XC170, 128-Bit "Read-Only Memory."

ECONOMICAL CUSTOMIZED MSI VIA COMPUTER INTERFACING!

Let's let our computers "talk" to each other!

Objective: to establish a close-matching interface between Motorola and users of MSI circuits in order to customize standard circuitry to specific requirements – and to do it at a considerable savings in both time and money!

The XC170, forerunner in this unique scheme, is a monolithic "Read-Only" memory circuit whose basic structure consists of 16 eight-bit "words" (128-bits in all), with each bit initially in the logical "1" storage state. By removing appropriate metal links on its metalization pattern, these bits can be changed to the logical "0" state to meet your particular function requirements. Open collector outputs on each buffered line allow multiple "Wired ORing" for large memory arrays. (Incidentally, the logic levels of this circuit are compatible with both MDTL and MTTL families.) Address times are less than 45 ns.

All you need do to customize the XC170 is to supply a punched card that reflects the memory bit pattern that you have established, along with a table showing the R.O.M. contents. *Our computer does the rest!*

The customer's punched program-card provides the mask-making instructions for Motorola's computer-aided design facility. This card information also accompanies the processed parts through to final test where automatic equipment compares the results for compliance to the specified program.

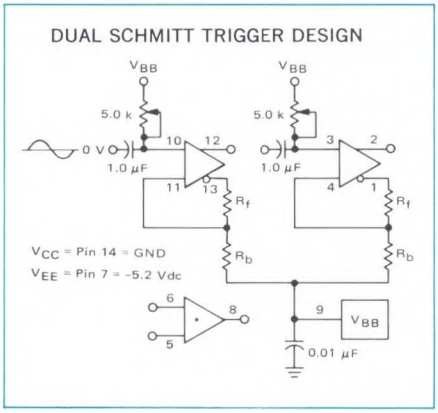
Pricing and scheduling can be easily worked out in consultation with your local Motorola representative. You'll be saving both time and money!

For details circle Reader Service No. **222**

"Step-Up" Saturated Logic To High-Speed MECL II With The New MC1035!

An exceptional new, multifunction circuit in the MECL II line, MC1035/1235, characterized as a dual Schmitt Trigger/Triple Differential Amplifier, now allows you to interface high-speed MECL systems with lower-speed saturated logic forms, while increasing low voltage swing signals to high MECL levels.

This versatile I/C consists of three differential amplifiers with emitter-follower outputs and a bias driver. It can also be used as a level translator (MOS to MECL), as well as in many linear applications. Examples include: an RF amplifier/FM amplifier-limiter; a wide-band video amplifier; an A/D comparator; a zero crossing detector; and, a V_{BB} buffered supply. All of these applications are illustrated and described in the comprehensive data sheet for this remarkable monolithic I/C.



For details circle Reader Service No. **223**

Each amplifier of the MC1035/1235 features:

- Voltage gain – 6.0 V/V (single-ended) or 12 V/V (differential)
- Bandwidth (at 3.0 dB point) – 45 to 50 MHz
- Useful gain – to 100 MHz
- Common mode rejection ratio – 80 dB
- Propagation delay – 3.5 ns (nom)

The MC1035 (0 to +75°C) is available in the ceramic 14-pin dual-in-line package while the full temperature range MC1235 comes in the 14-lead ceramic flat pack. And, it is low priced!

	Prices
MC1035L	$1.50 (1,000-up)
MC1235F	$3.00 (100-up)

The MJE3055 THERMOPAD plastic silicon power transistor performs like the TO-3 packaged 2N3055 still costs approximately a dollar!

90-Watt THERMOPAD Silicon Transistor Heralds New Low-Cost Power Designs!

A whole new era in economical, high-wattage power circuit design has been ushered in with the introduction of the Motorola MJE3055 THERMOPAD silicon power transistor – a "metal-spec'd" but plastic-packaged version of the popular TO-3 housed 2N3055. This 12 Amp, 60 volt, NPN unit dissipates a full 90 Watts, due to its unique direct chip-to-heat-sink thermal path design (only 0.030") – the first plastic power transistor to break the ultra-wattage barrier!

For the designer who is looking for an economical, yet speedy power switch, the MJE3055 offers both high frequency response and fast switching times. And, this universal transistor will also serve you well in series and shunt regulators and high fidelity power amplifiers. Its exceptional linear beta is spec'd at two I_C points to provide the circuit designer with a complete picture of its high gain capabilities over a wide current range.

Motorola THERMOPAD devices have proven their mettle in stringent no-failure tests such as: high humidity, reverse bias and 100,000 hours at 150°C storage temperature, as well as 42,000 hours of operating life under ambient conditions.

Type	h_{FE} @ I_C	$V_{CE(sat)}$ @ I_C (max)	f_T (min)	Price (100-up)
MJE3055	20-70 @ 4 A 5 min @ 10 A	1.1 V @ 4.0 A	2 MHz	$1.02

For details circle Reader Service No. **224**

Uniwatt plastic transistors now "fill-the-gap" between Unibloc and Thermopad power dissipation ratings.

Here's The "Uniwatt" – A Plastic Transistor That Fits Into The 1-To-6 W Power-Slot!

A new plastic transistor package – called the "Uniwatt" – now provides the designer with an economical device, capable of fulfilling medium power dissipation requirements to roughly six-watts. It fills the "thermal-gap" between the Unibloc plastic transistor case (310 mW) and the high power Thermopad plastic types (up to 90 Watts).

The Uniwatt package, about the size of a TO-5 metal-can device, has excellent thermal properties–being able to handle up to one-watt at T_A = 25°C, with no heat sinking and approximately six-watts when its integral heat-sink "tab" is chassis mounted.

The initial Uniwatt packaged introductions include both high-voltage NPN types and two NPN/PNP complementary series. The MPS-U01/U51 series features high, linear betas over a collector-current range of 1.0 mA to 1.0 Amp, while the MPS-U02/MPS-U52 series (designed for general purpose and driver applications) also offers low saturation voltages and a high f_T of 150 MHz at 20 mA. Two high voltage types, the NPN MPS-U03 and MPS-U04 provide V_{CEO} ratings of 120 and 180 volts, making possible the use of low-cost, medium-power plastic transistors in horizontal driver and video output applications.

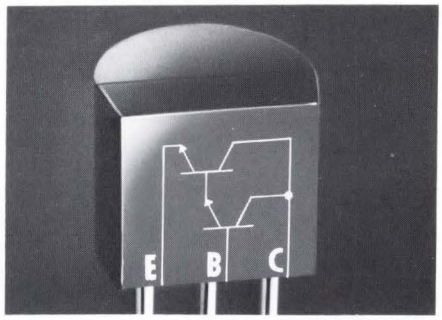
They are all silicon Annular transistors, famous for their high performance and reliability.

Type No.	Polarity	V_{CEO} Rating	P_D @ 25°C T_A	P_D @ 25°C T_C	h_{FE} @ I_C (min.)	$V_{CE(sat)}$ @ I_C (max.)	f_T @ I_C (min.)	Price (5,000-up)
MPS-U01 MPS-U51	NPN PNP	30 V	1.0 W	8.0 W	70 @ 150 mA	1.0 V @ 1.0 A	50 MHz @ 50 mA	54¢ 62¢
MPS-U02 MPS-U52	NPN PNP	40 V	1.0 W	6.0 W	50 @ 150 mA	0.4 V @ 150 mA	150 MHz @ 20 mA	46¢ 54¢
MPS-U03	NPN	120 V	1.0 W	5.0 W	40 @ 10 mA	0.5 V @ 200 mA	100 MHz @ 50 mA	66¢
MPS-U04		180 V						76¢

For details circle Reader Service No. **225**

Plastic Darlington Amplifier Saves Space, Saves Money!

Combining plastic encapsulation with closely matched transistor geometries on a single monolithic chip, Motorola has produced a peak-performance device for a "peanut" price. It's the NPN MPS-A12 Darlington amplifier. And, even though it offers betas in excess of 20,000, it comes for just 42¢ (1,000-up).



Monolithic Darlington amplifiers are now encapsulated in low-cost Unibloc plastic.

Its low cost, together with its high performance parameters and its 2-in-1 construction, make this Darlington applicable for a variety of compact economy designs. For example, it is ideal for pre-amp stages requiring high impedance inputs and as drivers in under 2-Watt amplifiers.

The unit displays excellent gain linearity from 1.0 mA to 100 mA. It also has a high f_T of 250 MHz @ 10 mA typ. Leakage current is only 100 nA at 15 volts.

For details circle Reader Service No. **226**

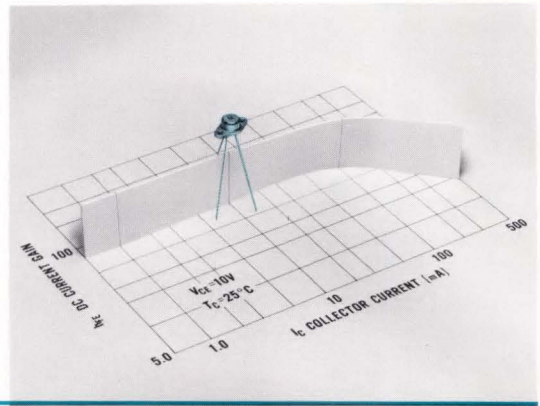
PRODUCT BRIEFS

SILICON PNP HIGH-VOLTAGE, MEDIUM CURRENT TRANSISTOR

— A Space-Saver That Can Switch 100-Watts At Nanosecond Speeds!

Small size vs. relatively high power handling and fast switching capabilities, makes the new PNP 2N5357 applicable for a variety of compact industrial and aerospace applications. It can switch up to 100-Watts at approximately 500 ns, as illustrated by its typical t_{on} = 60 ns and t_{off} = 280 ns values. And, it can handle 50 W (typ) at 1.0 ms pulse rates. $V_{CE(sat)}$ is a low 0.3 V @ 100 mA while $I_{C(sus)}$ is 3 Amps.

This 300 V (V_{CEO}) power switch achieves its size advantage through the use of the miniature TO-37 package, yet its power dissipation is a remarkable high 30 W @ T_C = 25°C. All this makes the 2N5357 a "letter-perfect" solution for miniaturized deflector circuits, inverters, servo-amplifiers, etc. operating from high-voltage power supplies.



For details circle Reader Service No. **227**

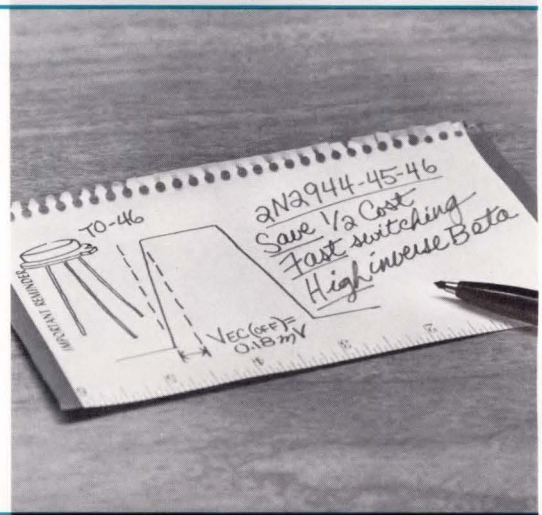
PNP HIGH-SPEED CHOPPER TRANSISTORS

—Save Space And Money In Low-Level Applications

Low offset voltage, low series resistance and new low prices (one-half the book prices for similar units), make Motorola's PNP 2N2944-46 series a prime candidate for most any low-level chopper application. And, because the units are packaged in low-profile, subminiature TO-46 cans, they are ideal for computer and instrumentation equipment where mounting space is a priority consideration.

Power dissipation is quite high for such a small package (500 mW @ T_A = 25°C). They exhibit both high inverse betas and high breakdown voltage. Their isolation-diffused, epitaxial-base Annular die structure assures long-term stable performance. Compare the prices for these high-performance choppers.

Type No.	$V_{EC(off)}$ @ I_B = 200 μA (typ)	r_{ec} (on) @ I_B = 1mA, f= 1 kHz I_C = 100 μA (typ)	V_{CBO}/V_{CEO}	I_{CBO} @ V_{CB} (max)	h_{FE} (inv) @ I_C = 200 μA (typ)	Prices (100-up)
2N2944	0.18 mV	4.0 ohms	15 V	100pA @ 15 V	20	$1.84
2N2945	0.23 mV	4.5 ohms	25 V	200pA @ 25 V	17	1.68
2N2946	0.27 mV	5.0 ohms	40 V	500pA @ 40 V	15	1.92



For details circle Reader Service No. **228**

NEW DIODE/TRANSISTOR OPTOELECTRONIC DEVICES

—Brighten The Low-Cost, High Density, Light-Activated Design Picture!

Two new photo-detectors (MRD210/250) and a photo-transistor (MRD-310) now broaden the opportunities to develop economical, light-activated designs requiring sensitive, yet low-cost units, with a high measure of reliability and mounting flexibility.

The MRD210 is housed in a sub-miniature "pill" package (only 0.06" dia.) which makes it ideal for closely-spaced matrix designs. The MRD250, only slightly longer, features a low-profile lens which minimizes "cross-talk." Both units lend themselves to automatic-insertion assembly techniques.

The TO-18 packaged MRD310 transistor utilizes an external "base" connection for added control. All three devices employ Annular structures and are sensitive over both the visible and infra-red spectral range.

Type	Radiation Sensitivity (min)	Illumination Sensitivity (typ)	Dark Current	Rise Time	Fall Time	Price (500-up)
MRD210	0.05 mA/mW/cm²	1.2 μA/lum/ft²	25 nA (max)	2.5 μs (max)	4.0 μs (max)	$6.10
MRD250	0.10 mA/mW/cm²	2.5 μA/lum/ft²				5.65
MRD310	0.20 mA/mW/cm²	2.5 μA/lum/ft²				5.65

For details circle Reader Service No. **229**

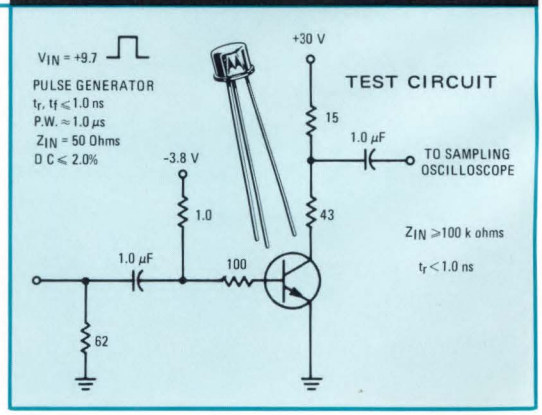
MEDIUM-CURRENT SILICON NPN CORE DRIVERS

—Provide Fast, Efficient, High-Voltage Switching Up To 500 mA

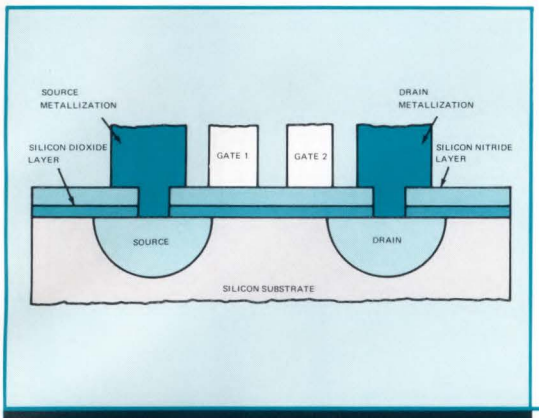
Designers of industrial and military computers: If you've been looking "high and low" for ultra-fast, high-voltage core drivers to operate at current levels of 0.5 Amp – your search has ended! Let Motorola's NPN 2N3722/23 do the job.

Maximum storage times as low as 85 ns, combined with fast turn-on of 50 ns and turn-off of 100 ns, at 30 Volts and 500 mA, are indicative of the speedy power handling capabilities of these TO-5 packaged devices. Efficient, low power loss operation is also assured by saturation voltages as low as 0.50 Volt at 500 mA.

Type No.	V_{CEO}	$V_{CE(sat)}$ @ 500 mA (max)	Switching Time (max)			h_{FE} @ 100 mA/1.0 V	P_D @ 25°C	
			t_{on}	t_s	t_{off}		T_A	T_C
2N3722	60 V	0.50 V	50 ns	85 ns	100 ns	40-150	0.8 W	4.0 W
2N3723	80 V	0.75 V	70 ns	110 ns	130 ns			



For details circle Reader Service No. **230**



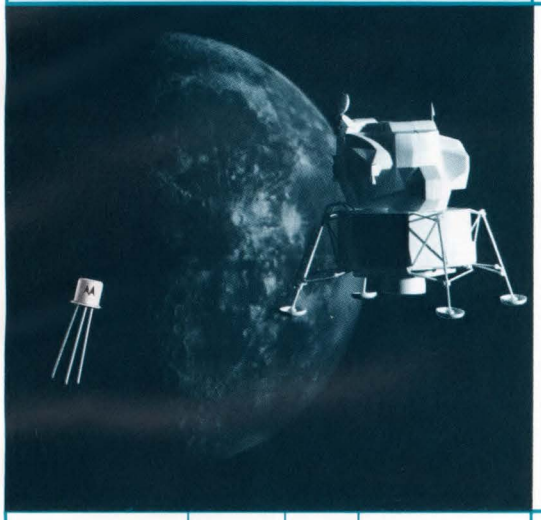
DUAL-GATE SILICON NITRIDE RF MOSFET

—Offers Cascode Performance Plus AGC Action . . . And It's Reliable!

RF circuit designers will appreciate the versatility and stable performance of the new MFE3006 dual-gate MOSFET. The series arrangement of two separate channels, each with an individual and independent control-gate, makes this MOSFET ideal for use in cascode configurations. In addition, this unit also provides excellent AGC action. Its application possibilities span a wide range of designs — from RF amplifiers and mixers up to 300 MHz, to gated amplifiers, choppers and DC amplifiers.

Typical highlight characteristics include a high power gain (G_{ps} of 24 dB; low noise figure (3.0 dB); and a reverse transfer capacitance (C_{rss}) of only 0.02 pF. The MFE3006 is fabricated using Motorola-developed Silicon Nitride passivation to assure long-term stability under both high temperature and reverse-bias conditions. All this, yet it's priced at just 90¢ (1,000-up).

For details circle Reader Service No. **231**



JAN2N4948/49 UNIJUNCTION TRANSISTORS

— Are First State-Of-The-Art UJTs To Be MIL-Qualified!

Motorola's JAN2N4948/49 all-diffused, Annular UJTs have been awarded MIL-qualification to MIL-S-19500/388 (USAF) — *the only up-to-date UJT devices to be so honored!* Unlike outmoded "bar-alloy" types, these UJTs excel in three vital parameters required by today's military requirements: (1) Low $V_{EB1(sat)}$ — 3.0 V max; (2) reverse-bias emitter current of 10 nA max; (3) and, a low maximum peak-point current of just 2 μA. And, though the MIL spec doesn't call for it, they easily operate in the 1 MHz region — making them ideal for stable, sensitive triggering and time-delay functions in virtually every military electronics system. Even with all these advantages they cost only ⅓ as much as previous MIL UJTs.

Type Numbers	I_p (max)	$V_{EB1(sat)}$ (max)	I_{EB20} (max)	Intrinsic Standoff Ratio (η)		Price (100-up)
				min	max	
JAN2N4948	2 μA	3 V	10 nA	0.55	0.82	$1.80
JAN2N4949	1 μA			0.74	0.86	2.60

For details circle Reader Service No. **232**

JFET Type Numbers		I_{DSS} (mA) Min / Max	Re (Y_{fs}) (μmhos) Min	Prices (100-up)	
N-Channel	P-Channel			N-Channel	P-Channel
2N5358	2N5265	0.5 - 1.0	800	$4.00	$5.40
2N5359	2N5266	0.8 - 1.6	900	3.60	5.10
2N5360	2N5267	1.5 - 3.0	1400	3.30	4.80
2N5361	2N5268	2.5 - 5.0	1700	3.00	4.50
2N5362	2N5269	4.0 - 8.0	1900	3.30	4.80
2N5363	2N5270	7.0 - 14	2100	3.60	5.10
2N5364	.....	9.0 - 18	2200	4.00	.....

N-CHANNEL AND P-CHANNEL JFETS

—Offer Tight I_{DSS} Ratios As Well As Low Noise Figures

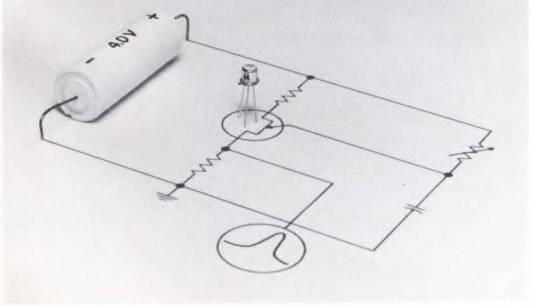
Motorola now provides an N-channel 2N5358-64 JFET series which is complementary to the P-channel 2N5265-70 line (introduced at the beginning of the year). In addition to their value in complementary circuit designs, these JFETs display performance characteristics that make them naturals for critical general purpose and military amplifier applications. Such highlight parameters as noise figures as low as 2.5 dB max @ 100 Hz make them prime choices for precision preamplifier applications.

Their I_{DSS} ratio is tightly specified at 2:1. Both series offer high minimum gate-source breakdown voltages ($V_{(BR)GSS}$). Motorola originated Designers data sheets, containing comprehensive min/max curves and detailed parameter specs, are available for both the 2N5358-64 and the 2N5265-70 series, permitting the design of most circuits entirely from the information presented.

Motorola also offers a 40-volt version of the 2N5265-70 — the MFE4007-12 series — which provides the same tight I_{DSS} ratios but at a substantial cost savings.

All three series — the 2N5358-64, the 2N5265-70 and the MFE4007-12 — are available for your immediate needs from your local Motorola distributor's warehouse. The units are packaged in four-leaded TO-72 metal-cans.

For details circle Reader Service No. **233**



ULTRA-LOW-VOLTAGE UNIJUNCTION TRANSISTOR

—First Advanced UJT To Operate From 4 Volt Sources!

Motorola's newest state-of-the-art UJT — the 2N5431 — now makes it possible to build industrial and military timing, triggering and sensing circuits which can operate from batteries or other low voltage sources.

Packaged in the TO-18 case, this new 4-volt UJT is fabricated using a process similar to that used for silicon Annular transistors, famous for their reliability and performance. The results: a UJT which exhibits no more than 10 nA emitter leakage-current (I_{EB20}) and peak-point currents of only 0.4 μA max, at 25 V, and 4.0 μA at 4 V (V_{B2B1}). It also has a tight eta range of 0.72-0.80 and a narrow base resistance spread of 6.0 kΩ to 8.5 kΩ.

All this and low prices, too! The 2N5431 lists for just $3.25 (1,000-up), with availability as near as your local distributor's warehouse.

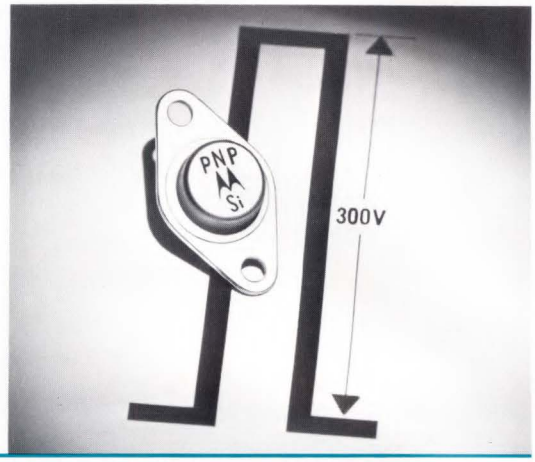
For details circle Reader Service No. **234**

HIGH-VOLTAGE PNP SILICON POWER TRANSISTORS

—Switch 250-300 Volts in Nanoseconds And, They're PNP Polarity!

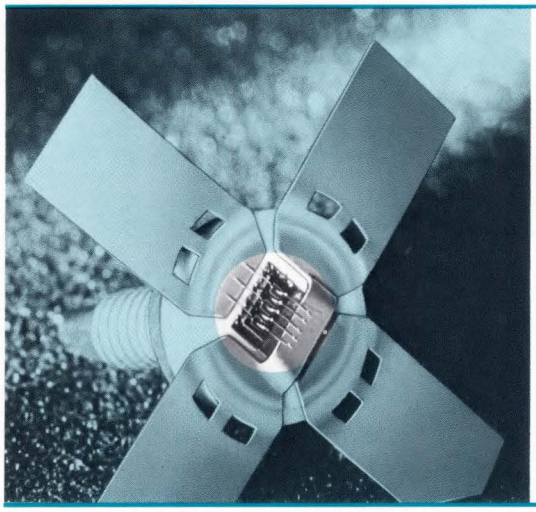
The design of direct line-operated switching circuits, thus eliminating the need for step-down componentry, is now possible using Motorola's new silicon PNP 2N5344/45, 250-300 volt power transistors. Their switching capability is ultra-nimble, too — less than 900 ns (max.) at 500 mA and 100 volts. And efficient, low-power-loss, low-distortion performance is ensured due to saturation voltages which are typically less than 0.38 V (also at 500 mA).

Packaged in the thermally-efficient TO-66, they offer high dc safe operating areas (up to 1 Amp). Their −65 to +200°C range makes them ideal replacements for germanium units in higher temperature designs.



PNP Type	V_{CEO}	P_D @ $T_C = 25°C$	Total Switching Time @ 500 mA/100 V (max)	h_{FE} @ 500 mA	$V_{CE(sat)}$ @ 500 mA (typ)	f_T @ 100 mA (min)	Prices (100-up)
2N5344	250 V	40 W	900 ns	25-100	0.38 V	60 MHz	$12.00
2N5345	300 V						15.00

For details circle Reader Service No. **235**



LOW-VOLTAGE "BET" SILICON RF POWER TRANSISTORS

—Protect Against Secondary Breakdown In Battery-Powered UHF Designs!

Motorola's new NPN MM1601/02/03 "BET" RF power transistors are standout performers for 12-Volt (nom) UHF power amplifier or oscillator applications in military and industrial equipment. They can be used in Class AB, B or C designs to provide dependable and efficient performance up to 240 MHz.

Their Balanced Emitter construction guards against secondary breakdown and prevents burn-out, even under "worst-case" mismatched load conditions. They are packaged in Motorola's stripline "opposed-emitter" case structure which provides low lead inductance and ease of tuning.

An Application Note describing procedures for systematic RF input-output network design as well as comprehensive device data sheets are available.

Type No.	Case Type	Power-In (Max)	Power-Out (Typ) @	Frequency	Power-Gain (Min)
MM1601	144	0.6 W	3 W @	175 MHz	7.0 dB
MM1602	145	2.5 W	10 W @	175 MHz	6.0 dB
MM1603	145	8.5 W	25 W @	175 MHz	4.7 dB

For details circle Reader Service No. **236**

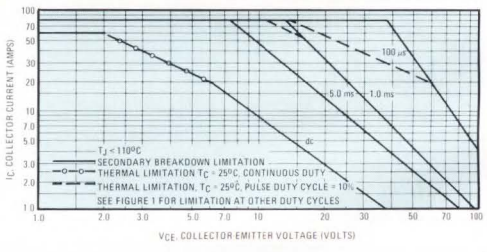
60-AMP 2N5435-40 "ADE" GERMANIUM TRANSISTORS

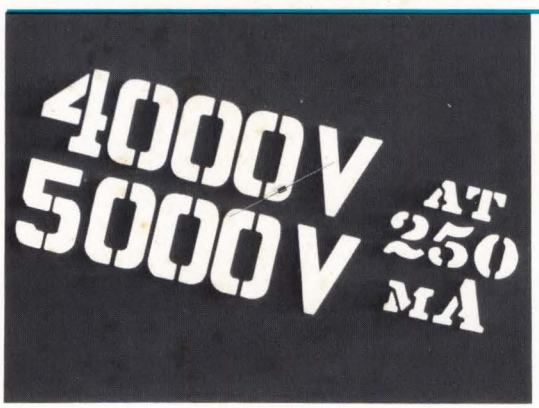
—Push Power Switching Performance To New Heights!

Motorola's continuing developments in ADE die technology (Alloy-Diffused-Epitaxial) now yields a line of germanium power transistors that can switch more power, faster . . . with higher betas and lower saturation voltages than ever before possible! The series is EIA-labeled 2N5435-40. And, like the rest of the ADE family, they provide double the power-handling capability of conventional units. Their high safe operating area limits and high, linear betas at high current levels qualify them for first consideration in critical, heavy-muscle designs. Cases: All-aluminum TO-3 (also available with flattened and pierced leads).

EIA Type No.	V_{CES}	h_{FE} @ I_C/V_{CE}	$V_{CE(sat)}$ @ I_C/I_B (max)	Switching Time @ I_C = 25A (max)			I_C (cont)
				t_r	t_s	t_f	
2N5435	60 V	20-60 @ 25A/2V 10 min @ 60A/2V	0.75 V @ 60 A/6 A	12 μs	10 μs	8 μs	60A
2N5436	90 V						
2N5437	120 V						
2N5438	60 V	40-120 @ 25A/2V 15 min @ 60A/2V	0.50 V @ 60 A/6 A				
2N5439	90 V						
2N5440	120 V						

For details circle Reader Service No. **237**





HIGH-VOLTAGE "SURMETIC" PLASTIC RECTIFIERS

—Protect Against Overloads To 5000 Volts, Cut Power Losses!

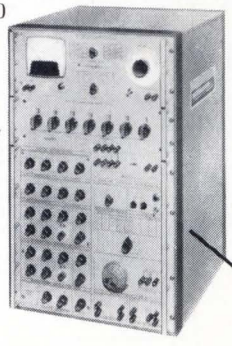
Surmetic rectifiers, long-time commercial/industrial standards in numerous low-cost, peak-performance applications — now wear higher-than-ever voltage designations . . . **4,000 and 5,000 V!** The MR995/6 can be designed right into high voltage B+ supplies in communications and electro-static equipment, high-energy capacitive discharge systems, CRT applications, X-ray, and other designs where severe voltage overloads may be encountered. High-temperature current handling and 15 Amp surge capability "above and beyond" safety factors. And, they shrug off tough 240-hour Mil-S-750 moisture-cycling tests.

Type	V_{RM}	I_o	$I_{FM(surge)}$	$V_{F(AV)}$	I_R	Price (100-up)
MR995	4,000 V	250 mA	15 A	1.7 V	10 μA	80¢
MR996	5,000 V					90¢

For details circle Reader Service No. **238**

Military and aerospace equipment demands proven reliability. That's why Dytronics specifies capacitors of MYLAR®

Dytronics Co., Inc., of Columbus, Ohio, makes Primary Phase Angle Standards that are used all over the world in all temperature extremes. Each precision unit uses 70 capacitors of MYLAR* polyester film. Why MYLAR? Here's what Paul Ryan, President, had to say: "Military and major aerospace facilities cannot afford equipment failure, and we must be sure of the components we select. Hundreds of our Primary Phase Angle Standards are in military usage, and we are not aware of a single failure of capacitors of MYLAR...we feel that this is evidence of both the reliability and performance of MYLAR and we find that capacitors of MYLAR cost about the same as those made of paper."



MYLAR offers thermal stability from −70° to +150° C., plus excellent resistance to most chemicals and moisture. MYLAR has high tensile and dielectric strength. Its unexcelled thinness has enabled manufacturers to reduce size and weight in capacitors.

Isn't that reason enough for you to consider capacitors of MYLAR in your designs? For additional information write to Du Pont, which offers the thinnest, most versatile range of capacitor dielectric materials available. Address: Du Pont Co., Room 5852, Wilmington, Delaware 19898.

*REG. U.S. PAT. OFF.

DU PONT MYLAR®

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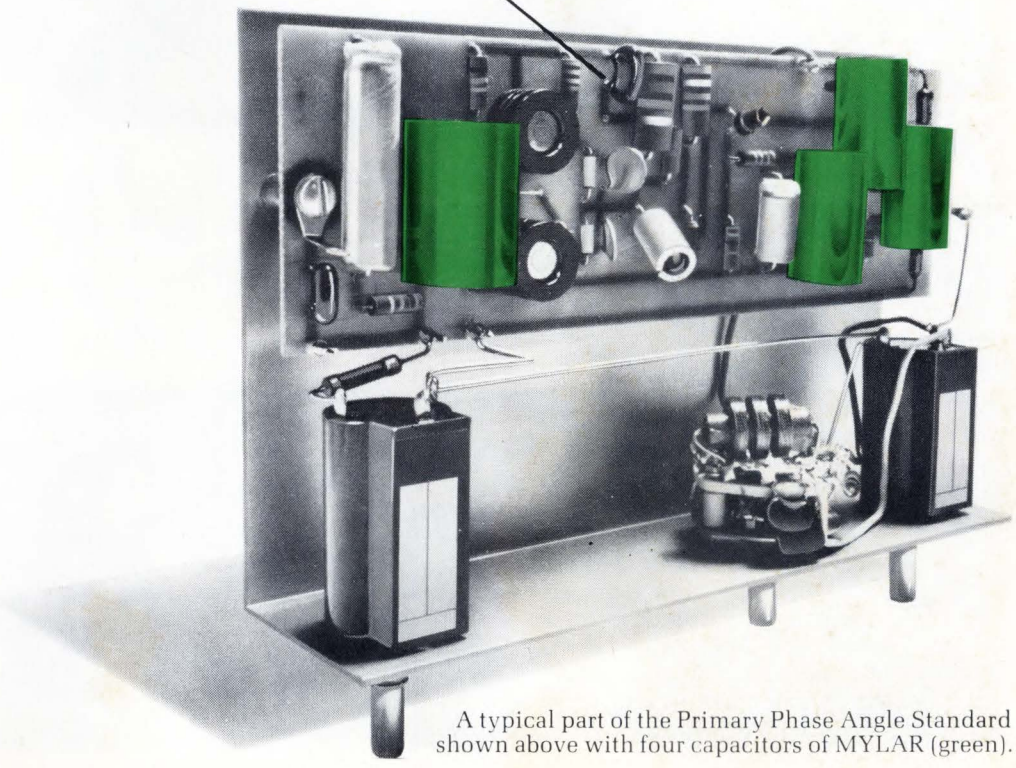


A typical part of the Primary Phase Angle Standard shown above with four capacitors of MYLAR (green).

CIRCLE NO. 22

'Picturephone' Tube Shows Live x-rays

X-ray diffraction pattern of a pentaerythritol crystal is produced "live" on TV monitor by a camera tube that is similar to the one used for "Picturephone" service.

MURRAY HILL, N. J.—"Live" X-ray images of a crystal are being produced as a by-product of BTL's development of a camera tube for its "Picturephone" service. Instantaneous studies of crystal orientation can be made with this technique.

The camera tube also has been used experimentally with X-rays to look at the internal structure of small electronic components for manufacturing defects. Bell feels it could be a valuable manufacturing technique also.

If an X-ray beam is passed through a crystal and the scattered radiation is allowed to fall directly onto the target of the camera tube, the resulting video signal shows a diffraction image of the crystal on the screen of a CRT. When the crystal is rotated, the pattern changes and the changes are seen "live".

For displaying X-ray diffraction patterns, both image-intensifier tubes and vidicon tubes are used. For a closed-circuit TV system, the new camera tube has about 20 times the spatial resolution available from X-ray image-intensifier tubes and is much lower in cost.

In this X-ray imaging application of the camera tube, the electron beam scans the photodiode array at the normal "Picturephone" rate. Video bandwidth is about 1 MHz and the picture is displayed on a standard TV screen. The tube also has been operated as slowly as one frame per second, which allows, in effect, a longer exposure time and results in a sharper picture.

Engineers' and Management Surveys indicate:

STARTING SALARIES OF ENGINEERS ARE DECEPTIVELY HIGH

By James M. Jenks

TWO SEPARATE STUDIES appear to contradict the commonly held belief that engineers today make out better financially than their colleagues who major in non-technical subjects.

The first survey polled graduate engineers; the second, company executives. The findings of these surveys indicate that the average engineer – despite a high starting salary – climbs fast but not far.

The need for technically trained men in recent years has exceeded the supply to such an extent that companies have been forced to bid for their services – to actually set-up "recruiting" offices on college campuses all over the country. Thus, starting salaries have gone up and up. But the income ceiling for these technically trained men is lower than for managerial personnel.

According to 1966 figures compiled by the Engineers Joint Council, the average engineer can only hope to earn about $13,500 a year. Even an engineer who is at the top of his profession (one whose salary is in the top ten per cent) earns only about $18,500 a year. In contrast, an American Management Association study shows that a middle management man can expect a maximum salary of between $20,000 and $30,000 a year in the larger companies. And, of course, a man who becomes a middle manager early in his career is still promotable. He still has the opportunity to reach the top executive level and earn much more.

This, of course, is not to say that engineering students would be wise to shift to the study of business administration – or that working engineers face a bleak future. Quite the contrary, the continuing growth of technology means that men with technical backgrounds are ideally qualified for the highest rewards industry has to offer – *if they also have a knowledge of the underlying principles of business.*

California Designs Mini-NBS

SACRAMENTO, CALIF.—Gov. Ronald Reagan recently took time out of a heavy schedule to sign into law California State Senate Bill No. 996. This little-publicized legislation was introduced by Senator Cologne, of Riverside. It authorizes the California Dept. of Agriculture's Bureau of Weights and Measures to ". . . upon request, certify and verify the various types of standards of weights and measures used by industry. . .", for a fee.

The National Bureau of Standards, under Dr. Aston, has been hinting rather broadly for several years that it would prefer to share the certification burden. Last fall, Dr. Aston became much more specific, stating that his objective was to have just 51 customers—50 states and the U.S. government. Taking the hint, a number of California-based industrial metrologists studied the proposal and concluded that it made good sense.

First, NBS certification is slow. An instrument may be out of the plant from 6 weeks to 6 months in the process. Backup standards, sometimes several sets, must be kept at hand. Shipping expenses are higher by far than is the case with in-state facilities. There is also less chance of damage during a shorter trip. Possibly the main benefit, however, is the opportunity such a facility would give to the metrology community to come together on a local, fraternal basis, working out its problems informally and personally.

The study group brought the proposal to the California Bureau of Weights and Measures, under Bill Kerlin. It was formalized into the Governor's Committee for Standards in Industry, and quickly went into action. Enabling legislation was prepared, and a Pert-like program developed. An industry-wide questionnaire now is being circulated to survey market potential. It already appears that approximately one-third of NBS's

Heading up California's Bureau of Standards are left to right, Richard Lyng, deputy director, California Dept. of Agriculture, Harry Spires, assistant director of the Center, and William Kerlin, chief, Bureau of Weights and Measures, Div. of Compliance, California Dept. of Agriculture.

certifications originate from the West Coast. Estimates are that a state or regional facility could save as much as half the present cost in fees, transportation and standbys.

A 15- to 20-acre site is being sought, probably in the Sacramento area, for a new CBS–California Bureau of Standards. The present plan is to start up with six of a contemplated 22 disciplines. Weight, length, volume, voltage, current and power certifications are starters, to be followed by time, frequency, optical standards, magnetics and, hopefully, nuclear standards.

Because the entire project is to be self-sustaining, it will be developed in Darwinian concept, from revenues to certification fees. Mr. Lyng, deputy director of California's Dept. of Agriculture, does not know where the money for the initial laboratory will come from. He is considering a lease-back arrangement, however, because public financing might have political complications–something California's present Governor really does not need.

Why state-run? Why not private-industry certification? Several reasons. First, CBS can work much more closely with another government agency than it could with a private company in establishing a new lab. Also, legal complications arise, as when my psychiatrist and yours do not agree in court. Without an impartial bureau to appeal to, we might end up with both Macy's and a Gimbels' volts. Could be a new, low-cost 0.98-one.

Technology Trips over Confused Democrats

CHICAGO, ILL. – To the cry of "the computer is a fraud", emotions rallied forth and the technical world was tried and hung in the last few hours of the Democratic National Convention last August.

TV viewers will recall that the chairman of the New Hampshire delegation, David Hoeh, managed to set back the state-of-the-acceptance-of-the-art considerably with his enraged reaction to what was actually a small spring-loaded switch that went bad in a magnetic card reader.

The pros and cons that led Mr. Hoeh to believe that all was not kosher on the convention floor will be argued long and loud. But the interesting part is that when Mr. Hoeh inserted his Dartmouth University identification card in the card reader that was to weed out those not qualified to enter and got the green light OK, he became convinced that it was a "computer" that was to blame.

(Mr. Hoeh maintained later that he felt that unauthorized people were being admitted to the floor with paper passes and he was only trying to prove that the highly touted security system was a fraud. In the melee that followed it has been alleged that Mr. Hoeh scuffled with police and pulled one officer's badge off. Mr. Hoeh alleged that when he tried to call his friends' attention to the "fraud", he was summarily hustled to the police station and sustained a head wound in the process.)

Spokesman for Card-Key Systems, Inc., general manager, Bruce Sedley, told EDN that overall the system worked very well. In 5 weeks the company designed the system and came up with 80 card readers and 11,000 cards. He reported that 30 people had been turned back trying to get in without credentials the night of the stormy Vietnam plank discussions. When the credentials' debate took place, Julian Bond's Georgia delegation tried to crash the floor, but could not get past the readers with phony cards. The company also pointed out that one of the security guards was the first one to observe the reader that went bad. While he was testing it, he maintained that Mr. Hoeh was watching and that he followed up by inserting his Dartmouth card.

This is not a computer. This is a simple card reader. Please post near politicians and/or people.

It's 10 to 1.

You don't have a control panel problem Master Specialties 10E lighted pushbuttons can't solve...in a snap.

WORD INDICATOR

4 COLOR FULL DISPLAY

2PDT 4PDT MOM. ALT.

HOLDING COIL INTERLOCK

LIGHTED CIRCUIT BREAKER

MASTER CONTROL CAPSULES

12 POSITION STEPPING SWITCH

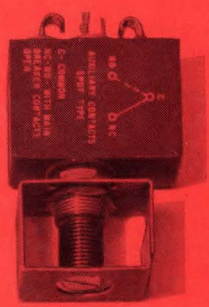
POSITIVE HARD MOUNT

RFI SHIELDING

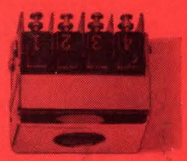
SWITCH GUARD

DRIP PROOF SEAL

Whatever your control panel problem, The MSC 10E can provide a ready-made answer...with snap-on versatility! One panel-front configuration, backed up by six snap-on control accessories and four environmental safeguards, offers you 138 optional ways to better design...better control. The illustrations speak for the 10E versatility. And eight years of field proven performance in equipment where comparative testing is the basis for selection speaks for its reliability. You won't find better value, it costs no more, and you can get it fast from the factory or from local stock of the distributors listed below. Contact us today. Enjoy more design freedom and reduce your procurement time and costs with the one pushbutton control that gives a 10 to 1 advantage. The MSC 10E!



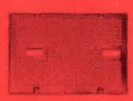
SNAP-ON CIRCUIT BREAKERS



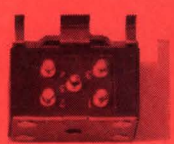
SNAP-ON SWITCH ASSEMBLIES

WRITE FOR LITERATURE on the MSC 10E and the control accessories shown.

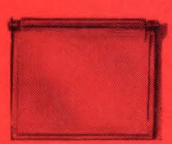
FOR MIL-SPEC APPLICATIONS, save time and costly testing by specifying companion Series 10H...the complete assemblies that meet all applicable requirements of MIL-S-22885.



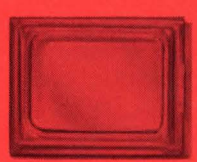
RFI SHIELD



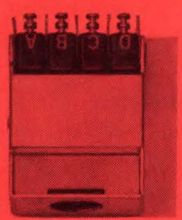
SNAP-ON CONTROL CAPSULES



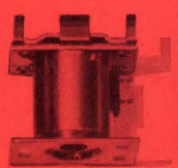
SWITCH GUARD



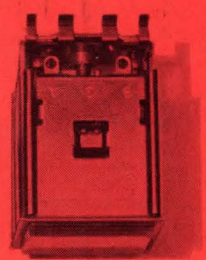
DRIP-PROOF SEAL



SNAP-ON STEPPING SWITCH



SNAP-ON HOLDING COILS



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CIRCLE NO. 27

Gunn Diodes Working in Series

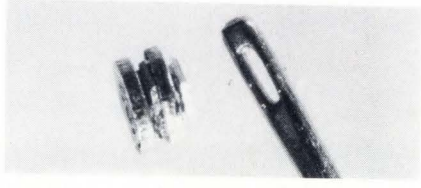
SCHENECTADY, N.Y.—Under certain conditions, physicists at GE's Research and Development Center have found that Gunn-effect diodes can be operated successfully in direct, diode-to-diode series electrical interconnection. In experiments, as many as four GaAs Gunn-effect diodes were successfully operated in direct series connection. GE claims that this is the first demonstration of series operation of Gunn diodes—an operation thought to be impossible until now.

Successful series operation of Gunn diodes may make possible the development of a high average power solid-state microwave source that can produce many watts in the 10-GHz range with the efficiency of a single diode. Such devices could power phased-array radar systems, hand-held radar equipment and microwave relay communication networks.

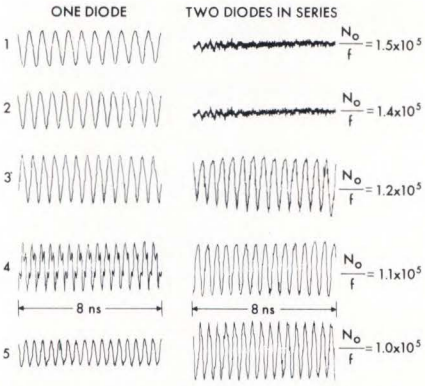
Important practical advantages of series operation include its ability to tailor net impedance of the series array to meet external circuit requirements and the availability of efficient heat sinking of the active volume of GaAs.

The impedance flexibility compares to the simple parallel operation of diodes, which always reduces net generator impedance. Heat sinking of series-parallel structures can be more efficient than the high power LSA (Limited Space-charge Accumulation) devices because the active volume of a series-parallel array can be filled largely with metal heat-sinking paths. Once the heat is conducted out of the cluster of diodes via these metallic paths, it can be conducted to cavity walls through an electrical insulator such as BeO.

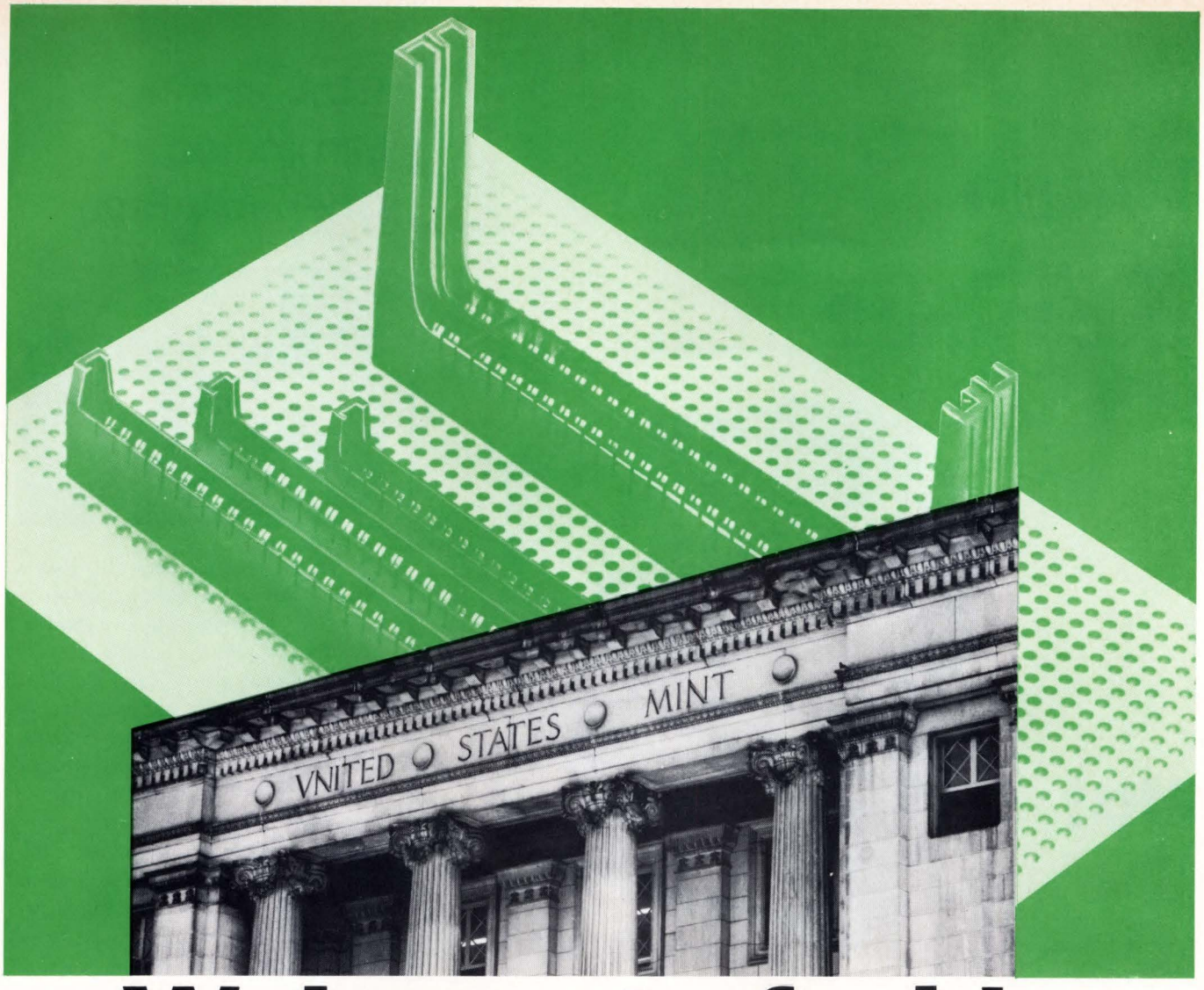
The key to successful series operation of critical diodes is the prevention of complete high field domain formation in any diode in the series string. This is done by operating series-connected diodes in a tuned circuit at a frequency higher than the transit time frequency. Conditions on the bias level, impedance presented to the series array by the tuned circuit and the degree of matching between individual diodes also must be met. Because the matching condition is broad, diodes that differ by as much as 20 percent in doping density can be operated in direct series connection.



Two Gunn diodes are mounted between metal wafers, which provide electrical contact points and act as heat sinks.



Sampling oscilloscope traces of diode RF currents compare operation of one Gunn-effect diode with two devices in direct series connection. A single diode and series-connected diodes operate under identical circuit conditions. Applied bias is six times threshold value for a single diode. Frequency of operation varies as a parameter over the range of 2.10 to 1.35 GHz. The single diode oscillates for all values of n_o/f in this frequency range—where n_o is the diode's equilibrium doping density. The two series-connected diodes cease coherent oscillation when n_o/f becomes too large. Lack of coherent oscillation indicates that one diode of the series pair has captured most of the applied bias voltage. The second diode acts as a positive resistor and reduces net circuit Q to the point where LSA operation of the overbiased diode is not possible. The overbiased diode generates noise.



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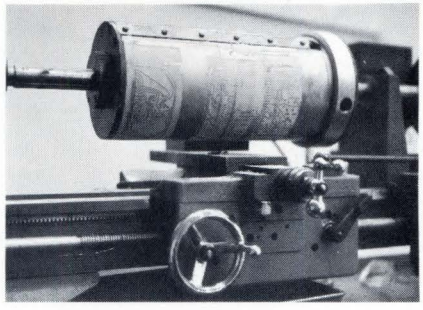
CIRCLE NO. 28

PC Engraver Eliminates Chemical Etch



LOS ANGELES—A sleeper at the recent WESCON exhibit was a photocell-controlled turning lathe designed to machine copper-clad circuit boards. Two identical drums are mounted between the lathe centers. One is scanned by a fine-beamed photocell. The other is exposed to a fine electromechanically driven cutting tool.

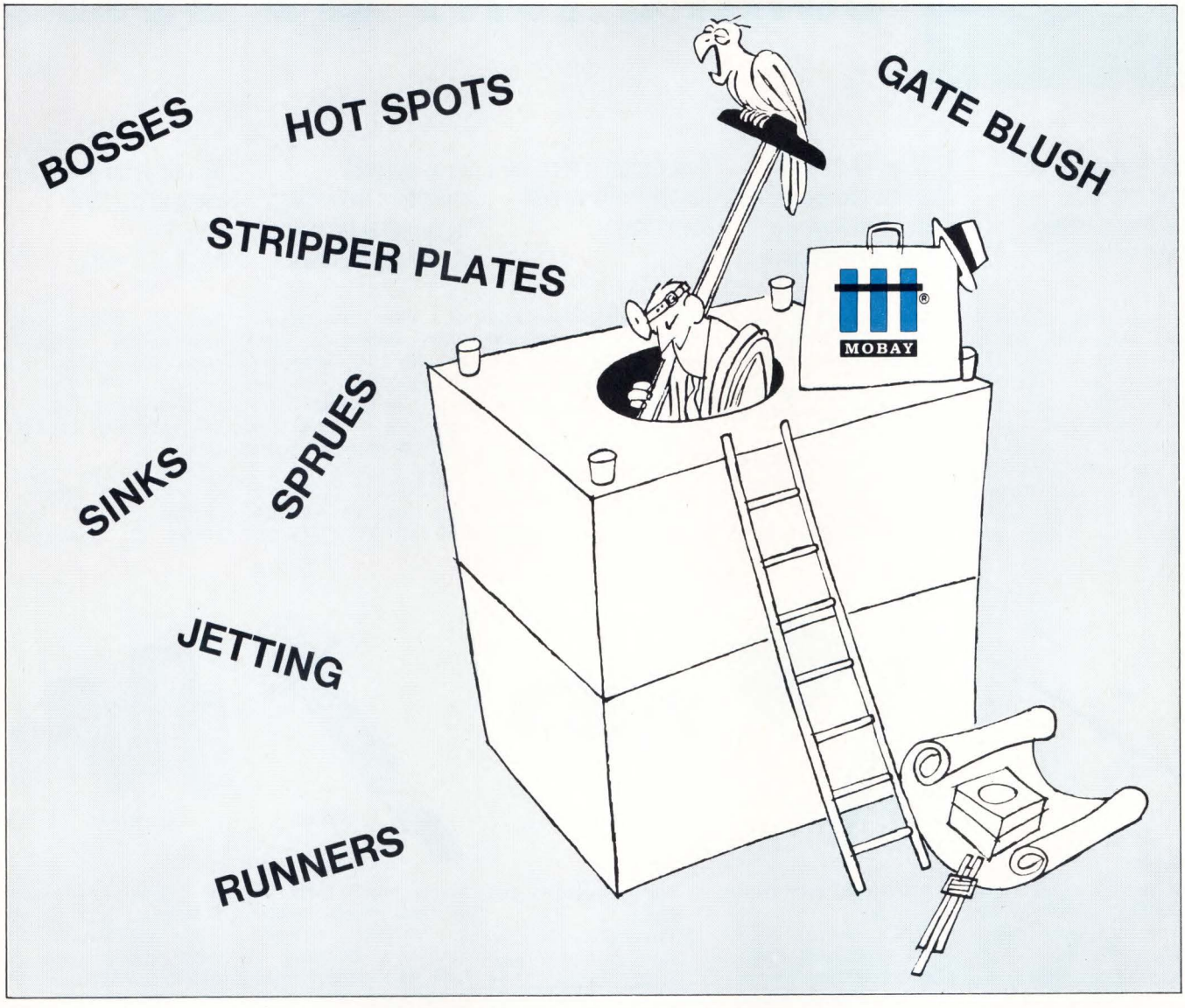
The desired pattern, drawn in pen or pencil, or printed, is attached to the scanning cylinder. A blank 1/16-in copper-clad epoxy or fiber-glass circuit board is mounted on the cutting drum. Both scanning and cutting heads traverse incrementally, moving on the axis approximately 3 mils with each turn. When the photocell sees white, the cutter advances, trimming the copper from the board. Black on the pattern causes the tool to retract, leaving copper on the board.

Advantages of the use of this machine, dubbed the Direction Circuit Engraver by the manufacturer, Graphic Electronics, Inc., of La Salle, Ill., are:

- No chemical etching required.
- No camera or darkroom needed.
- No special skills required.
- Operation is fully automatic once initial adjustments are made.

The machine will cover approximately 720 in^2/h—slow by etching standards—but the card is ready for use as it comes off the drum. For single cards, or small runs, cost is much lower than that for the photoetching techniques. With care, 5-mil line widths can be reproduced.

plastics mold design can be a dirty word...



If you are checking out engineering thermoplastics for a new job coming up, we can show you ways to save time, temper and tool-up costs. We'll show you evidence of how MERLON® polycarbonate or TEXIN® elastoplastics can give you a functional edge over just about any other thermoplastics you can name. ■ We'll talk to you about flow characteristics, melt viscosity, critical temperatures and a multitude of other processing variables that should be taken into account before production economics are pinned down or a material selected. ■ Any time you have a mold design problem is a good time to call us—before you have a problem is even better. 412 923-2700.

MOBAY CHEMICAL COMPANY

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CIRCLE NO. 30

MOBAY®

COMPONENT CAPSULES

New 3 amp hermetic A15 replaces costlier rectifier diodes

GE now offers a higher rated companion to its field-proved, 1 amp A14 rectifier at a significantly lower cost than other stud or lead mounted units (depending upon configuration). The A15 is rated 3 amps at 70°C and the 200 to 800 volt models are transient voltage protected up to 1000 W for 20 μS in reverse direction.

A15's dual heat sink design means low thermal impedance. Easy adaptation of axial leads to PC boards reduces installation cost below stud mounted units.

Both the A15/A14 are hermetically sealed in an all-diffused, glass passivated junction structure. No internal cavity means more resistance to environmental stresses . . . thus increased reliability.

High-power A15 is now available through GE distributors for applications including power supplies, battery chargers, TV damper diodes, communication equipment and small portable appliances. Circle **Number 281.**

Microwave Circuit Modules reduce design cycles and improve system performance

While producing lower overall costs, these design benefits result from:

- Optimum integration of active devices in package form
- Over two decades of microwave circuit development
- The industry's most advanced tube technology

MCM's used as: oscillators, amplifiers, multipliers, detectors, mixers, etc. Available in a variety of individually designed configurations.

Compare MCM features:

* Stable frequency performance in severe adverse environments
* Small size and lightweights—as low as 1 cubic inch and 2 ounces with high power to volume ratio
* Fast warm-up—3 seconds or less capability
* High performance from a single active device

GE is your one source for full R&D backup, critical testing experience and facilities and an unequalled output of highest performance active components including coaxial and planar gridded tubes. Circle **Number 282.**

New benefits from GE's hermetically sealed reed relays

Glass to metal seals and steel housing now provide true hermetic enclosure for reed relays. The GE 3SBN reed relay has:

- Increased sensitivity
- Immunity to magnetic interference effect
- Very low thermal emf's in contact circuits
- Protection of contact capsules and coils, because of rugged construction
- A lower weight than plastic encapsulation

This new relay comes in Form A, 1–6 poles and Form C, 1–5 poles and is only 0.350 inches high. The relay is available in a wide range of system voltages and is ideally suited for printed circuit board applications.

For more information Circle **Number 283.**

New low-cost miniature indicating lights ideal for limited space applications

GE's new, low-cost CR-103HE indicating lights are only 1 1/16 inches long and mount with a speed nut in a 5/16 inch diameter hole — perfect for applications where space is at a premium.

Flush and cylindrical lens types are available. The cylindrical lens protrudes only 7/16 inch, and is ultrasonically welded for maximum strength. Both are available in four lens colors: clear, amber, red and white. Four body colors are available: gray, white, beige and black.

The standard light has a 6 inch lead stripped 1/2 inch, but special lengths are available. Leads are staked into the body of the unit to insure that no movement takes place inside the light.

The CR103HE is UL listed for 120V, 240V, and 460V, and is ideally suited for applications where visual display and appearance is important. For more information Circle **Number 284.**

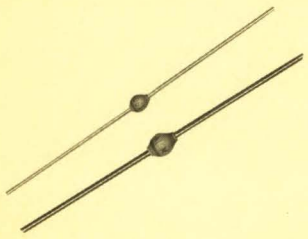
GE computer-grade capacitors offer over 1/2 farad at 5 volts

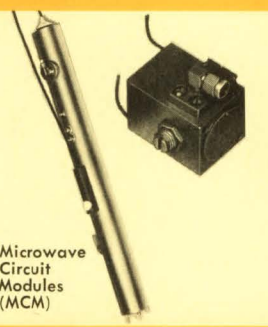
New GE 86F500 High-Capacitance computer-grade capacitors now provide up to 540,000 μf at five volts (34,000 μf at 100 volts) in a single case.

These enlarged-capacity units are excellent choices where large blocks of capacitance are required—as in power supply filters, for example. 86F500 units are rated for continuous operation at 65C or at 85C with proper voltage derating.

GE's new computer-grade capacitors provide highest capacitance per case size, high ripple current capability, low ESR, long shelf and operating life.

Units are available in nine case sizes—diameters 1 3/8" to 3", with lengths up to 8 5/8"—for operation up to 100 VDC. Circle **Number 285** on your reader service card.





Microwave Circuit Modules (MCM)

New 3S BN

CR103HE

86F500's

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Versatile GE meter relays are ideal for hundreds of applications

Including: temperature control, equipment overload protection, "go—no go" production line testing, and alarm sounding for a pre-selected value.

Accurate, repeatable control action over the entire scale is possible because there are no contacts on the unit's indicating pointer to cause mechanical interference. All units feature automatic ON-OFF reset control action. They easily adopt to manual reset.

No amplifier necessary. The unit's solid-state switch is connected in series with the coil of the load relay which operates it directly. Standard 120-volt a-c operation means no special power supply is needed.

The unit's "piggyback" control plug-in module design saves installation time, and eliminates the need for separate mounting.

For complete information about this meter relay and GE's full line of panel meters Circle **Number 286.**

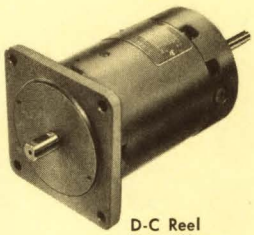
Big Look® Meter Relay

Computer tape reel drives—one of many applications for these motors

The excellent commutating ability, fast response, and long insulation life of GE 3 13/16, 4 5/8, and 6 5/16 diameter fhp motors meet computer tape reel demands for continuous duty, low maintenance, and reliability. And, applications don't end here.

Stall torque ratings from 3 to 120 ounce-feet and higher and various motor voltages span many application needs. This means these d-c motors can be custom tailored for almost all peripheral equipment needs.

Special mounting flanges, brake mounting arrangements on the commutator end, and shaft extensions can be furnished to your requirements. Also available: cooling air duct inlets at convenient locations. For more data, Circle **Number 287.**

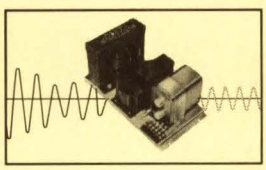


D-C Reel Drive Motor

Here's your key to low cost voltage stabilization

Every GE voltage stabilizer supplies constant output voltage to within ±1%, even with input fluctuations up to 15%. For special economy, core-and-coil units provide the lowest cost voltage regulation obtainable. They help meet tight space requirements, make wiring connections easier, and provide all the mounting flexibility you can ask for.

Voltage stabilizers are available in rating from 15 to 15000 volt-amperes in both standard and custom-designed models. Ask your GE sales engineer for publication GEA-7376 or circle magazine inquiry card **Number 288** for details.



AC Voltage Stabilizer

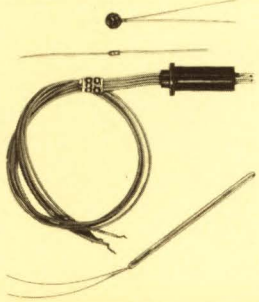
Fill your needs for sensitive temperature control with GE thermistors

Want extreme sensitivity to relatively minute temperature changes? You get it with GE thermistors (temperature-sensitive resistors). These devices also have temperature-compensating capability.

High sensitivity and small size make GE thermistors ideal sensors for SCR and transistorized controllers.

Operation over a wide temperature range permits thermistors to compensate the combined effects of copper windings and temperature-sensitive electromagnetic core materials.

GE thermistors are available as elements or in a wide variety of probe assemblies to suit your applications. Circle **Number 289** for more facts.

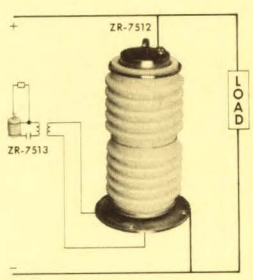


New circuitry combines TVG's in pairs for easy HV crowbarring

New developments in firing circuitry now make it convenient to crowbar high-voltage power supplies by utilizing GE's companion Triggered Vacuum Gaps in tandem.

And what's more—attaché-case size sensing and firing circuitry is now possible. A unique pulse transformer allows fault sensing at ground potential, even where the TVG trigger is at high negative voltage.

Use General Electric's ZR-7512/13 TVG combination shown in the sketch for protection at 45-KV, or other combinations covering from 300 volts to over 75 KV. For more information Circle **Number 290 .**



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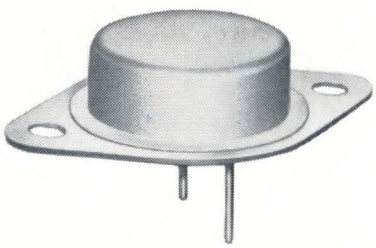

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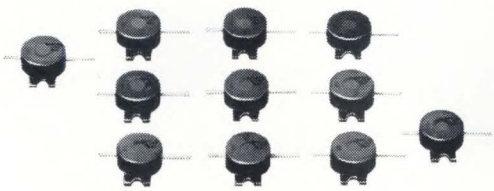

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B-5002 Series

For up-to-date techniques in fulfilling your silicon power transistor design needs, mesa construction still leads the way. That's right! The well-proven, well-accepted power mesa today fills more power sockets than any other approach.

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Bendix doesn't live by mesa alone. We also offer you: planar power devices, hybrid power circuits, state-of-the-art radiation-resistant devices and power rectifiers.

Whether your application is military, aerospace, commercial or otherwise, you can turn with confidence to Bendix for your silicon mesa transistor requirements.

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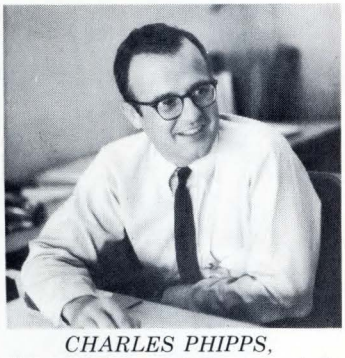
CIRCLE NO. 31

LOGIC ARRAYS SHOULD WAIT FOR LSI

At no time in the past has the semiconductor industry so uniformly described the products of 5 years hence, but offered such confusing directions on how to get there.



CHARLES PHIPPS,
Texas Instruments Incorporated

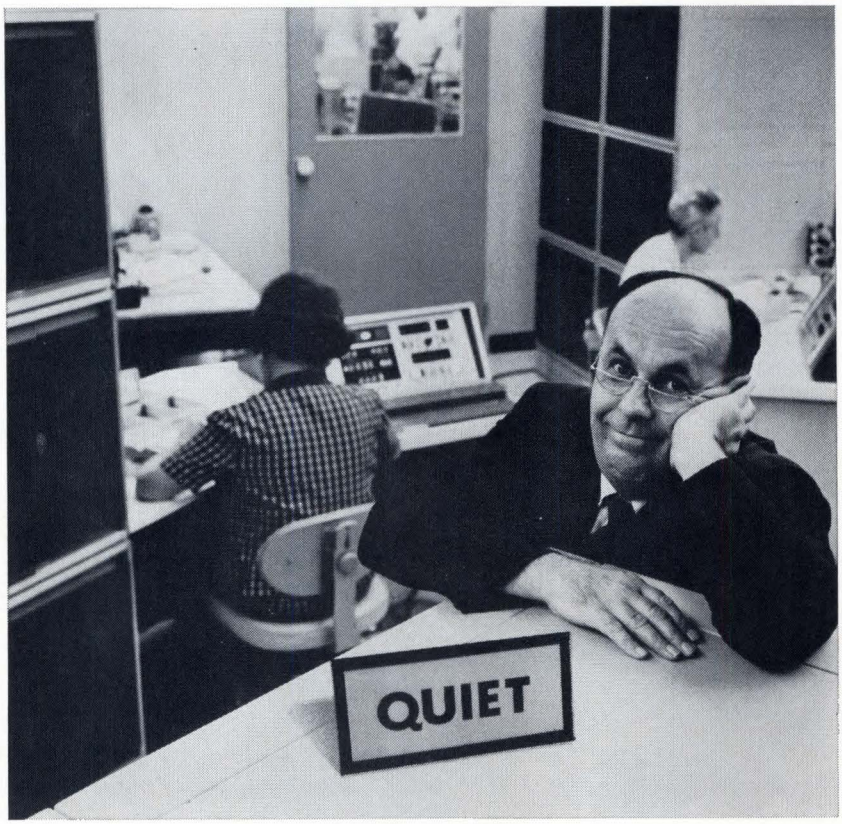
Within the past 15 years the electronics industry has witnessed the tremendous technical drive of the semiconductor manufacturers with the resultant obsolescence of technologies and products. Each significant advance in semiconductor technology has opened new opportunities for equipment manufacturers, particularly for those who made timely applications. Eager to apply this route to product success, they have become impatient with the progress of the semiconductor manufacturers. This is most evident for those products of the next generation of IC technology, designated by the widely accepted and ill-defined terminology of LSI (Large Scale Integration). The existing confusion regarding LSI applications is largely because of the need for decisions involving factors with very high uncertainties. Technologies, reliabilities, prices and equipment practices are all interrelated and subject to unforeseen change, making goals and timetables difficult to assess.

Thus, more and more equipment designers are pursuing evolutionary gains across the entire spectrum of semiconductor digital products. But success can be expected only from certain classes of digital products, i.e., storage, delay lines and input-output functions where product definition, packaging and testing do not differ substantially from standard IC practice. Evolution will not do for implementation of unique (every program different) logic arrays where the software content is so much greater. For logic arrays of 20 circuits and higher complexity, almost all will experience volumes that are comparable to the end equipment. For the majority of programs this requires annual production runs of only 100 to 1000 units of any array type. To amortize the software costs at an effective economic level, a large complexity per array will be necessary, i.e., 200 circuits or more per array. Thus, the only economical "near future" solutions are existing IC packages or real LSI, leapfrogging MSI. There can be exceptions: highly structured logic or high-volume requirements where either the adaptations to standard IC practice or the volume base will allow evolutionary product applications.

At this point in time there are only two methods with a "near future" chance of achieving LSI complexities economically; these are MOS logic arrays and bipolar discretionary wired arrays (although other techniques may also prove out in time).

The confusing directions facing the design engineer can be characterized as whether to pursue evolutionary gains or more bold advances in LSI. Although there are areas applicable to the evolutionary advances, it is the solution to the logic function that holds the key to the designer's decision. The evolutionary approach may involve least risk, but it will probably be the least satisfying in realizing the potential of LSI over the next few years.

The new E. Scrooge Memorial I-C Test Library.



(A TI Supply Philanthropy)

The new TI Supply Testing Service gives you immediate access to a large library of commonly used and standard test programs. And they're yours at little or no cost when you use the TI Supply Testing Service. These up-to-date, fully computerized programs can save you thousands of dollars in setting up your device tests.

(Your comptroller will tell you how the cost of software often exceeds the cost of the equipment when setting up your own in-house test facility.)

If you need special programs, TI's team of experienced test engineers can provide custom software economically. The Service is equipped to perform fully-computerized tests on integrated circuits, discrete components, circuit cards, LSI, and MSI. That includes not only dynamic, d-c, and linear tests, but also burn-in, extreme temperature and life tests, and environmental tests.

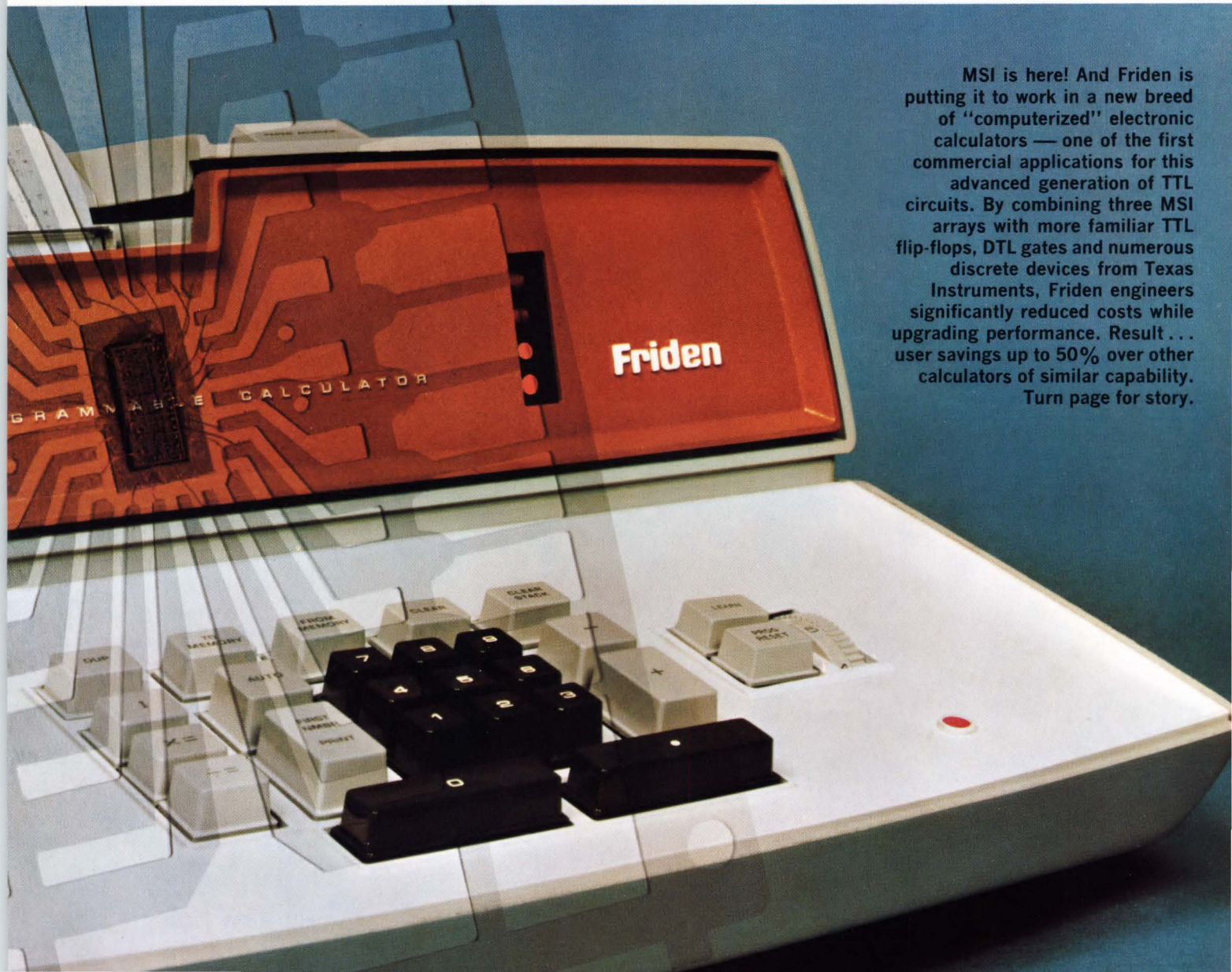
Call (713) CA 7-3611, (516) 488-1900, or write for our brochure to TI Supply Testing Service, 6000 Denton Dr., Dallas, Tex. 75235 and check into our test library. You'll discover software at costs even Scrooge would love.

TI SUPPLY

120

TTL Trends

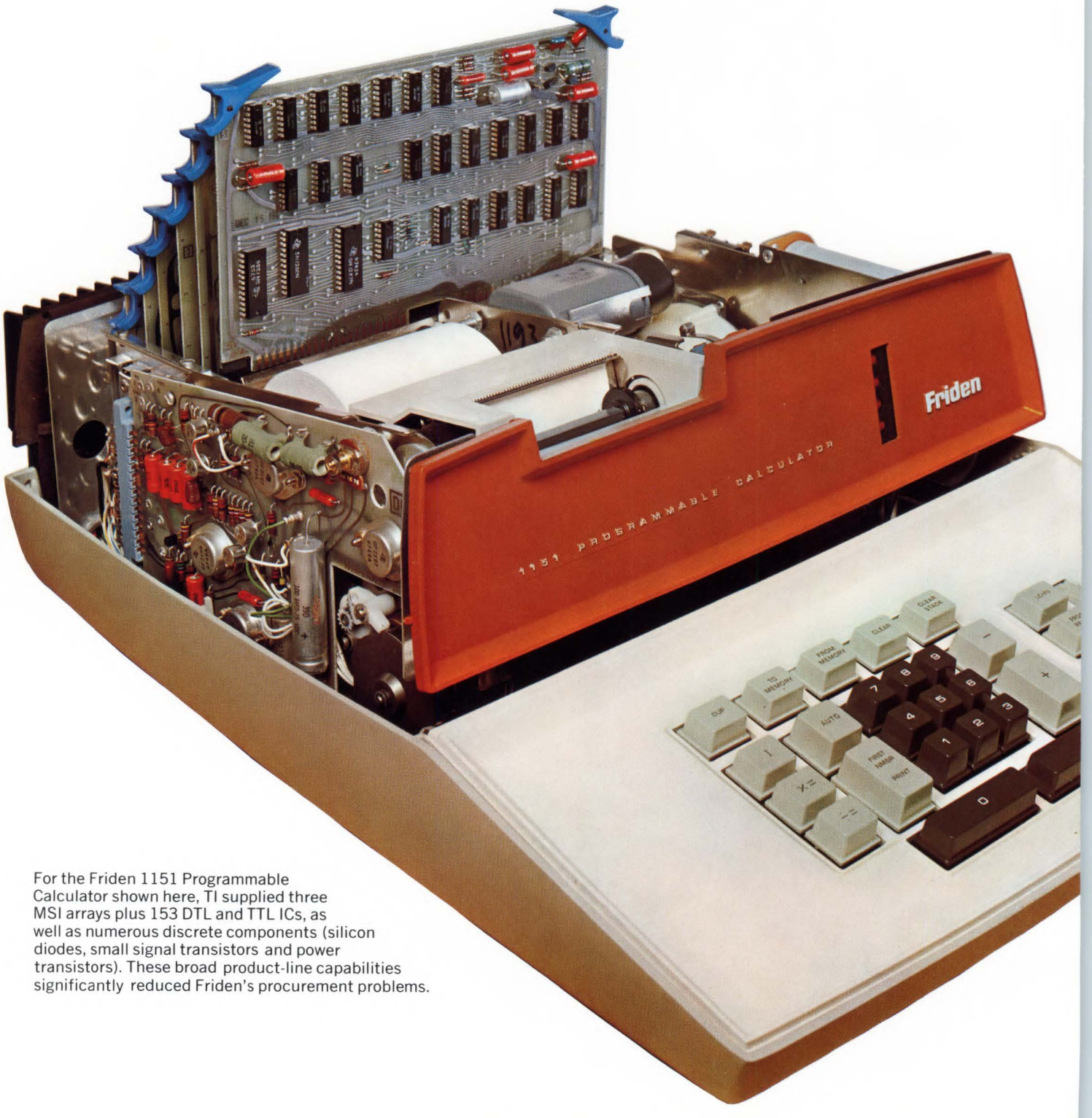
from Texas Instruments



MSI is here! And Friden is putting it to work in a new breed of "computerized" electronic calculators — one of the first commercial applications for this advanced generation of TTL circuits. By combining three MSI arrays with more familiar TTL flip-flops, DTL gates and numerous discrete devices from Texas Instruments, Friden engineers significantly reduced costs while upgrading performance. Result . . . user savings up to 50% over other calculators of similar capability.

Turn page for story.

MSI from TI helps Friden cut costs of "computerized" calculators

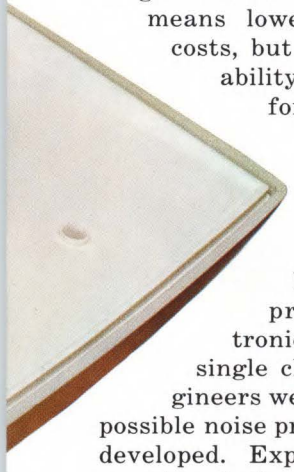


For the Friden 1151 Programmable Calculator shown here, TI supplied three MSI arrays plus 153 DTL and TTL ICs, as well as numerous discrete components (silicon diodes, small signal transistors and power transistors). These broad product-line capabilities significantly reduced Friden's procurement problems.

TI combined the equivalent of 93 gates in just three 24-lead MSI arrays to help Friden engineers reduce package count, circuit boards and overall costs of their new 1150 and 1151 electronic printing calculators.

Three custom TTL ring counters form the heart of Friden's sophisticated "computerized" calculators. These MSI units recirculate all arithmetic and memory information handled by the machines. Since June of 1966, they have been making possible substantial reductions in both costs and complexity.

Friden engineers took advantage of TI's broad IC capability to develop a low-cost, single-chassis design combining both electronics and printer in a single unit. They packed up to 662 gates on only six compact circuit boards by selecting optimum combinations of multiple-gate DTL and complex-function TTL integrated circuits. This single-chassis design not only means lower manufacturing costs, but also greater reliability and convenience for the user.



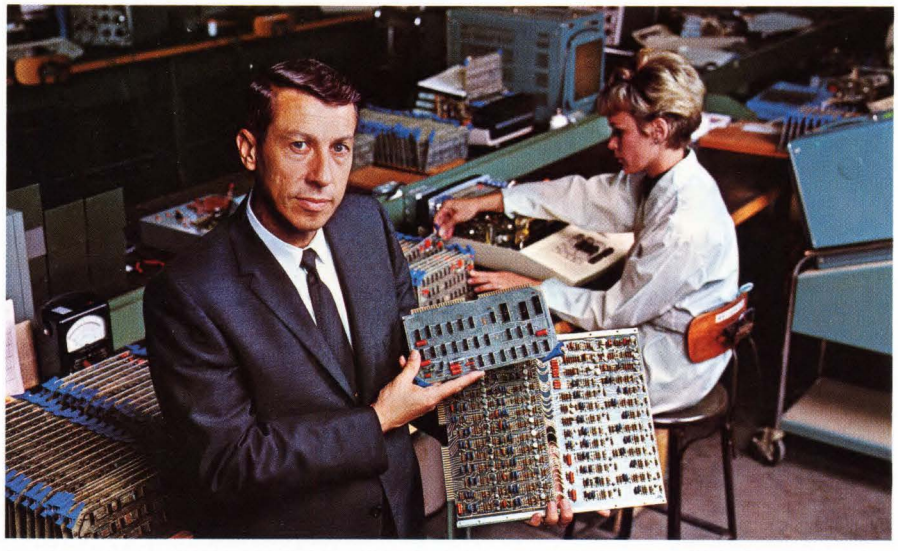
The high noise-immunity of TI circuits also provided an unexpected bonus. With both printer and electronics combined in a single chassis, Friden engineers were concerned with possible noise problems...but none developed. Expensive noise-suppressing design techniques were therefore unnecessary, and further cost reductions were realized.

As a result of these cost (and space) economies, Friden engineers were able to upgrade performance without corresponding price premiums. Here are two cases in point: The "stacking" feature, which allows retention of intermediate answers; and the floating decimal point, which permits the user to preselect desired accuracy. In addition, the 1151 is a programmable machine capable of "learning" up to 30 mathematical steps.

All this performance...at user savings up to 50 percent over machines of similar capability!

In these and other ways, Friden's new breed of calculators help close the gap between computers and office machines. They reduce the time required for complex calculations and minimize operator errors...yet they are priced far below today's least expensive computers.

Reliability is another bonus. The marriage of an all-IC logic design with a mechanical printer of unique simplicity dramatically reduces maintenance.



Smaller circuit boards, made possible by MSI and multiple-gate ICs, enabled Friden engineers to develop high-performance low-cost calculators, with both electronics and printer in a single chassis. Here, R. A. Ragen, Friden's Director of Engineering compares a new MSI/IC circuit board with one of the larger functional equivalents required in an earlier all-discrete-component model. In the pre-assembly checkout area (background), an 1151 Calculator performs final screening of hundreds of circuit boards each day.

Finally, broad total semiconductor availability—in volume—were key considerations in Friden's design and procurement decisions. For example, gates are Series 15 830 DTL and flip-flops are Series 74 because this combination promised optimum performance/cost ratios. And inspection of TI manufacturing facilities indicated capacity sufficient to meet Friden's high-volume production requirements.

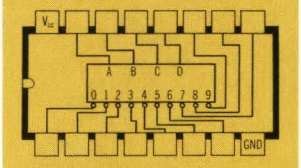
Cost...performance...size...availability...reliability...product saleability. These are some of the ways Friden benefited by using TI integrated circuits in their new computerized calculator line.

You can benefit, too. Join the growing list of OEMs that are improving their profits and building for the future. Include TI integrated circuits in your new equipment designs...today.

TEXAS INSTRUMENTS
INCORPORATED

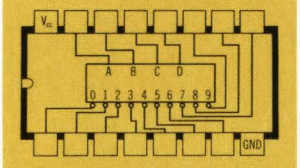
Nine new TTL decoders expand complex-function line

SN5442/SN7442
BCD-to-decimal decoder.



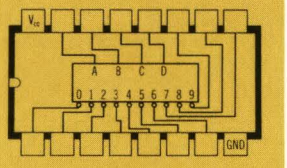
Active-low outputs. Fully compatible with all popular DTL and TTL logic.

SN5443/SN7443
Excess 3-to-decimal decoder.



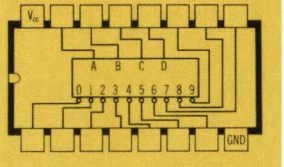
Active-low outputs. Fully compatible with all popular DTL and TTL logic.

SN5444/SN7444
Excess 3 gray-to-decimal decoder.



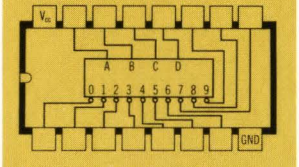
Active-low outputs. Fully compatible with all popular DTL and TTL logic.

SN5445/SN7445
BCD-to-decimal decoder-driver.



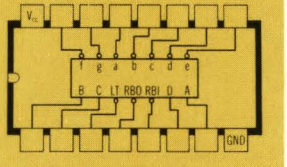
Active-low high-performance outputs. 30V breakdown, 80 mA sink-current capability for lamps, relays or memories.

SN54145/SN74145
BCD-to-decimal decoder-driver.



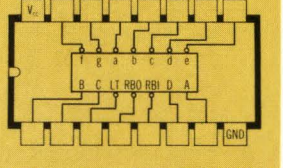
Active-low high-performance outputs. 15V breakdown, 80 mA sink-current capability for lamps, relays or memories.

SN5446/SN7446
BCD-to-seven segment decoder-driver.



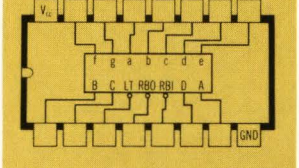
Active-low, open-collector outputs. 30V breakdown, 20 mA sink-current capability to drive indicator segments.

SN5447/SN7447
BCD-to-seven segment decoder-driver.



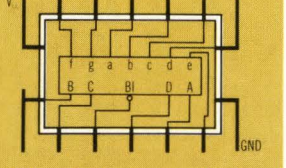
Active-low, open-collector outputs. 15V breakdown, 20 mA sink-current capability to drive indicator segments.

SN5448/SN7448
BCD-to-seven segment decoder-driver.



Active-high, passive pull-up outputs. For current-sourcing applications to drive logic circuits or power transistors.

SN5449/SN7449
BCD-to-seven segment decoder-driver.



Active-high, open-collector outputs. For current sourcing applications to drive logic circuits or power transistors.

These new monolithic decoders give design engineers new opportunities to reduce costs and improve performance of logic and display systems. They couple the high speed and high noise immunity of TTL with the overall economies of complex functions for a host of new applications.

Four basic logic forms are offered: BCD-to-decimal, excess 3-to-decimal, excess 3 gray-to-decimal, and BCD-to-seven segment. Active-high and active-low logic configurations are available.

All decoders have buffered inputs to reduce fan-in requirements to a standard TTL load.

A choice of output configurations are offered. Three of the decimal decoders (SN7442-44) employ familiar totem-pole outputs for high capacitive drive capability while two others (SN7445 and SN74145) have high-performance open-collector outputs to drive display lamps or relays. Two of the seven-segment decoders (SN7446-47) can drive display lamps directly while two others (SN7448-49) are designed to drive large displays through external power transistors.

Two temperature ranges are offered...full military (Series 54) and industrial (Series 74).

All decoders except the SN7449 are available in either of TI's 16-pin dual in-line packages...the low-cost plastic or the ceramic hermetic. For space-critical applications, the SN7449 is offered in the hermetic 14-lead flat package.

For data sheets on any or all these new decoders, write on your letterhead to Texas Instruments Incorporated, P.O. Box 5012, M.S. 980, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

LIGHT-EMITTING DIODES: KEY TO SOLID-STATE DISPLAYS

BOB CUSHMAN, Eastern Editor

SOLID-STATE DISPLAYS:

WHERE TO USE LED'S

Solid-state devices that turn electronic signals into visible outputs are now commercially available. The question is: where and how the designer should use them.

ROBERT CUSHMAN, Eastern Editor

If you start cautiously phasing solid-state display components into your designs right now, you'll be aboard what can't help but be one of the biggest things in our industry within 10 years. For electronics technology sorely needs displays to make all of the nanosecond gyrations of pennies-per-gate LSI logic mean something to the rest of the world.

The solid-state components you have to work with are principally LED's or light-emitting diodes. These now come in about every color but blue and can be bought from $25 to $4 in quantity. These LED's produce a "glow" of light by the same cold electroluminescene phenomenon that has become familiar in the older "pseudo-solid-state" EL panels. But, while the EL panels are excited to their luminescent state by an externally applied and relatively high-voltage field, the LED's are excited internally merely by the flow of tens of milliamperes through their junctions. This simplicity of operation is what makes them so useful.

It is not that these solid-state components will automatically guarantee better displays – for actually there is a number of nonsolid-state contenders such as gaseous matrices, liquid crystals, magnetic films and certain lasers that may deliver superior displays. It is rather that the growing dependency of our whole world upon computer-driven displays demands rugged, compact, fast-acting, highly fail-safe i.e., "solid-state", displays.

Right now the available LED's have glaring shortcomings. They don't emit much light (see box on brightness), they are still much too expensive (though prices should start dropping once the new plants under construction by Monsanto, HP and others get under way) and some of them gradually wear out.

But they have outstanding virtues, too. They respond at electronic speeds. They can be very small. They don't mind shock and vibration. Some can stand high temperatures.

Where to Start

Two places in displays where solid-state components can be used right away, and one place where they can't, are shown on the man-machine console on the opposite page. This is the typical computer-driven display that interfaces between the man and the machine in a sophisticated modern system. It is the cornerstone of many air-traffic, computer-aided design and process-control systems.

The two places where solid-state light-emitting components should be phased into this display either in the form of LED's or EL's are illustrated on the opposite page.

1. *Individual indicator lamps:* LED's are ideal for panel indicators. They can be driven directly from IC logic gates. They are less apt to fail without warning so don't necessarily need to be mounted in redundant pairs. They come complete with their built-in color filters.

2. *Area lighting on panels:* El's are ideal complements for LED's when it comes to providing area lighting. They are perfect for soft backlighting around control knobs and making annunciator nomenclature readable. (Their application will be covered more fully in a future issue of EDN.)

The one place on a display where an engineer should not spend too much energy trying to apply LED's at this time is the central CRT display.

3. *Central graphic display:* Neither LED technology nor any other technology is as yet anywhere close to replacing cathode-ray tubes. Eventually there will probably be a solid-state replacement for the CRT, but

(Continued)

Where Solid-State Display Components Can and Can't be Applied: In this typical man-machine console, we divide the lighted display elements into three classes: (1) the point-sources that are naturals for LED's, (2) the area sources that are naturals for EL's and (3) the central CRT display that cannot as yet be replaced with LED or EL techniques.

(Continued)

Understand LED limitations . . .

engineers working on systems with delivery dates in the next few years had best not wait for it. (A survey of the problems that prevent the early appearance of a solid-state CRT replacement will appear in a future issue of EDN.)

A lot of design work lies ahead in the display field. Often the display will be so alive with electronics and so intimately tied to the computer that it will become the focus of the whole system design.

Few of the displays shipped in the next few years will use may solid-state light sources, but eventually it's a good bet few displays will be shipped that won't be all solid-state, even down to the last flat screen graphics panel.

THE BRIGHTNESS PICTURE

Brightness can be the overriding factor in a decision of whether or not to use solid-state displays. Present LED's don't put out much light. Fortunately, many of the most important man-computer displays don't require much light.

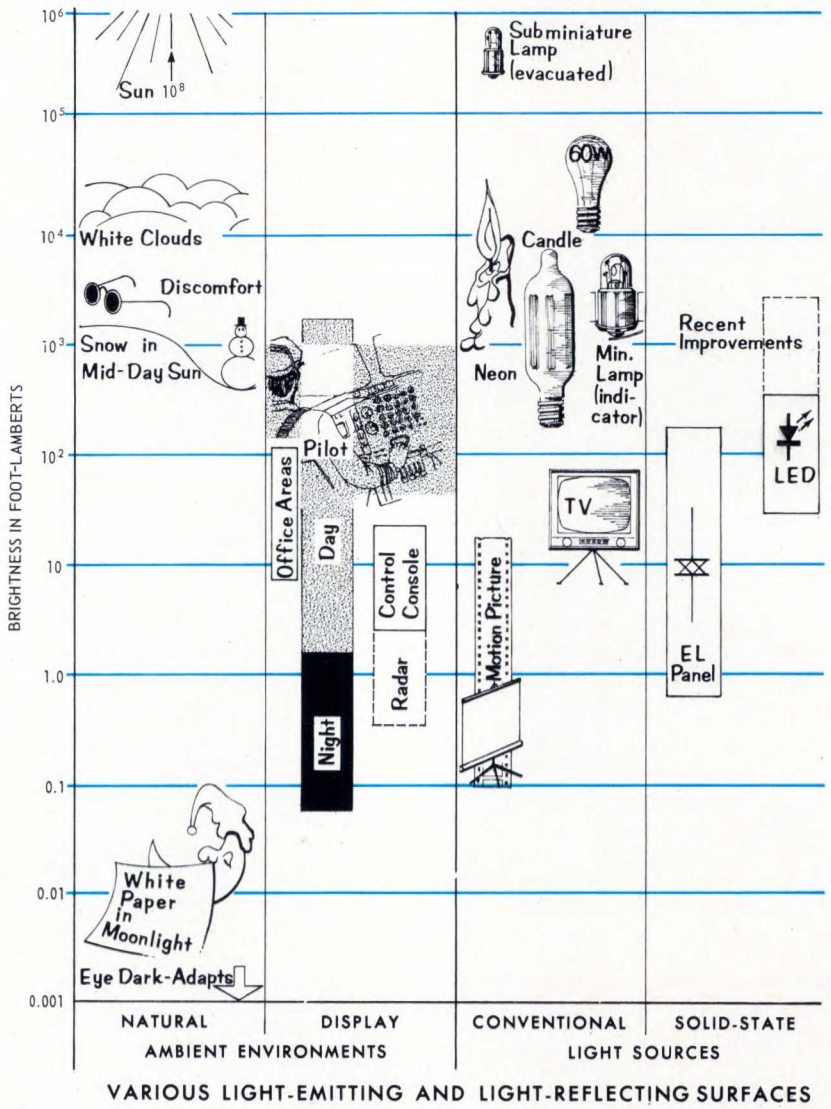
The picturegraph to the right stacks up the brightness levels of various environments against the brightness levels of various light sources. Up is bright; down is dark.

The brightness unit is the foot-lambert (fL), which measures how bright surfaces appear to humans. It is analogous to the decibel, which measures how loud sounds seem. Like human hearing, human vision takes in quite a dynamic range going from 10^{-6} at which surfaces are too dark to see up to 10^{+5} above which the eye may be harmed.

Most of the surfaces from which we gather visual intelligence have brightnesses in the 1 to 100 fL range. This page probably has a brightness somewhere between 10 and 40 fL. But, in the subdued light of a motion-picture theater or in your auto at night, the screen or dash can transmit intelligible symbols at brightnesses ranging from 0.01 to 5 fL.

LED's, it can be seen, are substantially less bright than most previous light sources. They have surface brightnesses in the 1 to 300 fL range as compared to neons midway between 100 and 1000 and small incandescents going from 1000 to 10,000. Some recent GaAsP LED's are showing brightnesses of 1800 fL but it must be remembered that the light is coming from a very small area. The 15-mil chips can be magnified to an apparent spot size of 30 mils by the lens without loss of brightness, but this is much less surface area than most competing light sources.

But this very low brightness makes LED's perfect to use as indicators that are viewed directly. There is no need to throw away light (and heat) in filters as the LED's emit in some of the standard display colors. Actually, the solid-state



VARIOUS LIGHT-EMITTING AND LIGHT-REFLECTING SURFACES

lamps are much superior at low lighting levels for they can be dimmed linearly and their very fast switching speed does not degenerate as they are dimmed (some incandescents are exasperatingly sluggish on turnon and turnoff when run at reduced levels).

This chart hints strongly at the most likely type of applications for solid-state light sources. It points toward those man-machine display consoles that would be used in an intentionally subdued ambient light level. Here, the lack of brute concentrated candlepower or brightness in present solid-state light sources is not so severe a limitation, for as one wag in the display field put it, "When operators get into intimate rapport with advanced graphic consoles, they tend to turn the lights down low."

SOLID-STATE DISPLAYS:

GETTING TO KNOW LED'S

LED's or light-emitting diodes are components that every designer should get familiar with right away. Overnight, it seems there are enough companies putting out LED's with reasonable light emissions and almost reasonable prices to make a number of premium display applications feasible.

Take a bare gallium-arsenide-phosphide diode chip. It looks much like any of the familiar silicon or germanium diode chips. It has the same dull metallic hue (depending on how the light strikes it). Attach some leads and put the gallium-arsenide-phosphide diode into a curve tracer and the trace will look like any germanium or silicon diode except the lift-off or knee voltage will be higher and the reverse voltage breakdown might, for some devices, be alarmingly low.

But then take a look at the GaAsP chip itself through a magnifying glass while applying a slowly rising dc forward bias. As the current starts to build up beyond the 1.4 knee voltage, you will see a faint reddish glow begin to appear on the sides of the chip at about where you'd expect the junction plane to be.

This is at about 1-mA current. Continue to raise the voltage and the glow will become brighter and spread all over the diode (typically a 20-mil chip). At about 10-30 mA, you'll want to dispense with the magnifying glass as the light from the chip will be quite bright. With the bare eye you no longer see a chip with a glowing surface but a tiny pinpoint source of light. At 100-200 mA the pinpoint will dazzle and become uncomfortably bright if viewed too closely. Raise chip beyond 200 mA forward current and it will heat up and destroy itself.

Do the same with a SiC chip and you'll see a yellow light. **Fig. 1** shows both SiC and GaAsP.

Fig. 1 – **LED light output.** The red Monsanto GaAsP (right) is operating at about 1.5V and 10mA. The yellow General Electric SiC (left) is operating at about 5V and 100 mA. The GaAsP is running cool but the SiC is running hot. The GaAsP is a passivated die covered by a dropped-on epoxy lens that magnifies its chip spot size. The SiC is just a bare, unpassivated chip on a header.

The characteristic curves for GaAsP and SiC LED's are shown along with typical germanium and silicon diodes in **Fig. 2**. The visible spectrum is also shown in **Fig. 2** with arrows to show where the light from GaAsP and SiC LED's falls. Remember that the visible spectrum means those frequencies seen by the human eye. The eye is like a detector preceded by a bandpass filter, the filter having the shape of a curve at the top of **Fig. 2**. This simple biological fact can cause a great deal of confusion when comparing LED's for display use. For example, GaAsP may put out more radiant energy at its red frequency than SiC, but SiC looks just as bright to a human observer because his eye favors yellow.

Observe that there is a relationship between the frequency of the light emitted by an LED and its knee voltage. The higher the knee voltage the higher the frequency of the emitted radiation. Ge and Si diodes emit radiations, but with their much lower knee voltages the frequency of any radiations would be way below the eye's spectral response. (And actually various internal physical problems in these familiar materials cause them to give off more wideband heat than useful near infrared emission.)

What happens inside an LED is that the forward current flow "pumps" electrons up to the conduction energy band and from this unstable state the electrons fall back, recombine with holes and emit light. (As will be remembered from elementary physics, falling electrons

Bandgap energy determines color . . .

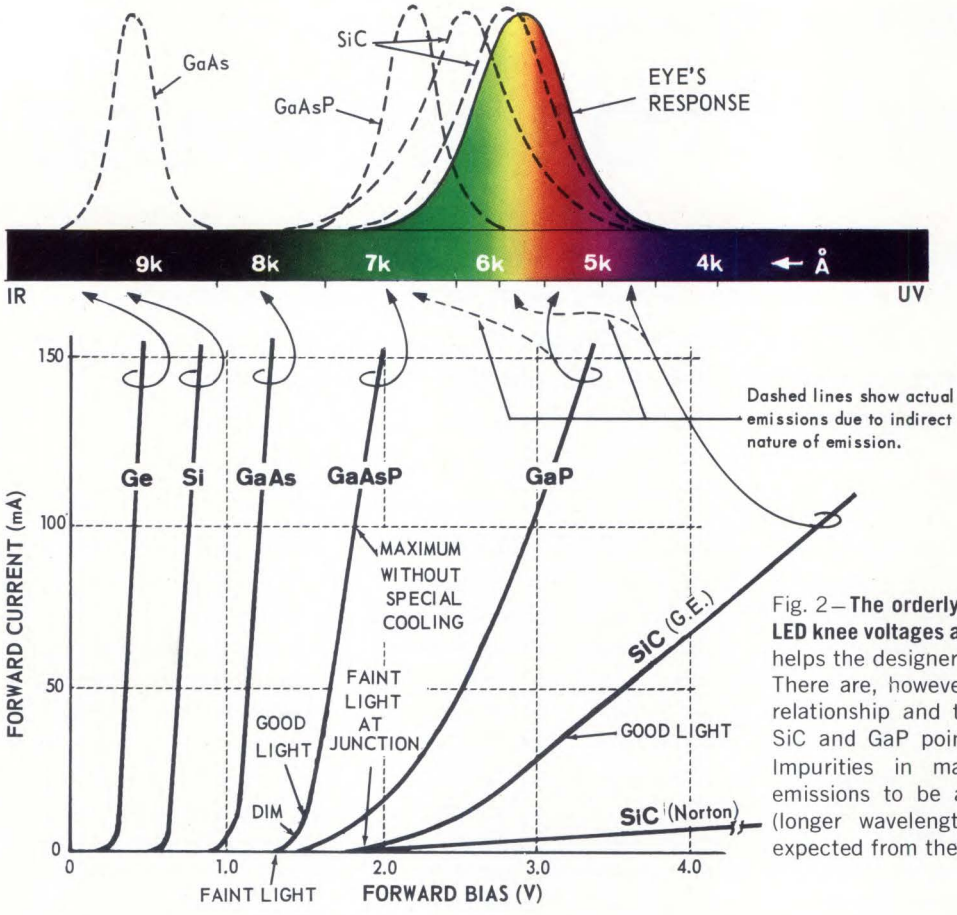


Fig. 2—**The orderly relationship between LED knee voltages and emitted color.** This helps the designer apply these devices. There are, however, exceptions to the relationship and the dashed lines for SiC and GaP point out two of these. Impurities in materials cause their emissions to be at lower frequencies (longer wavelengths) than would be expected from their knee voltages.

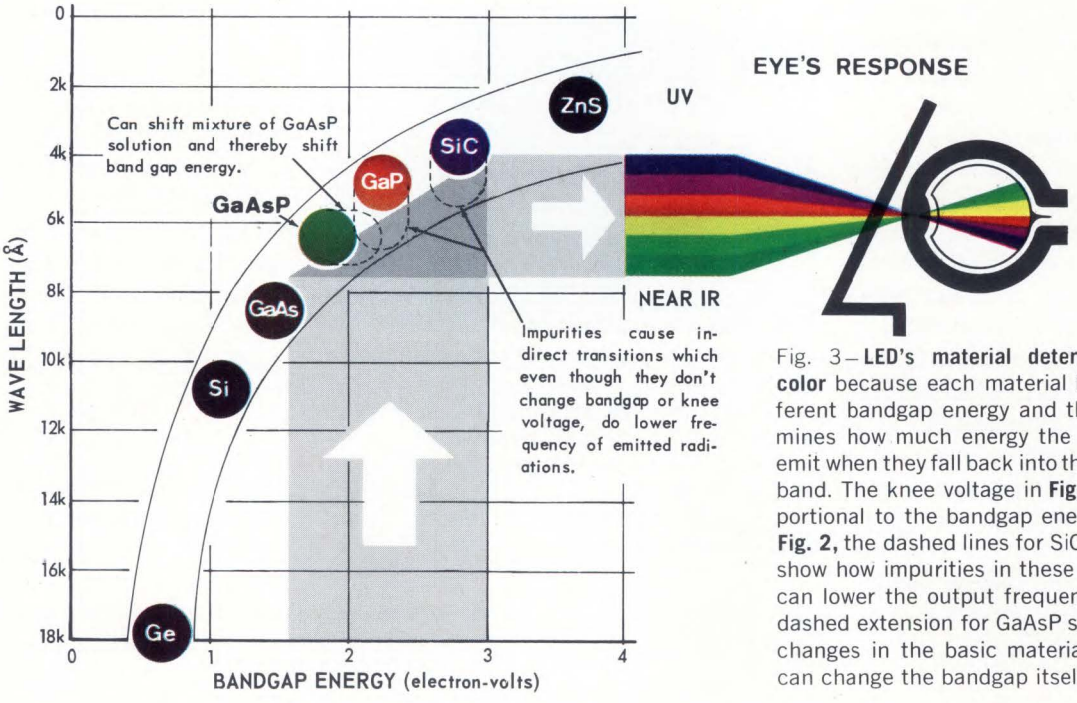


Fig. 3—**LED's material determines its color** because each material has a different bandgap energy and this determines how much energy the electrons emit when they fall back into the valance band. The knee voltage in **Fig. 2** is proportional to the bandgap energy. As in **Fig. 2,** the dashed lines for SiC and GaP show how impurities in these materials can lower the output frequencies. The dashed extension for GaAsP shows how changes in the basic material mixture can change the bandgap itself.

are the universal source of light, whether from hot sources such as fire, incandescent bulb filaments and the sun, or from these cold "luminescing" sources. The only thing that differs is the means for staging the electron's tumble.)

The particular light frequency or color emitted depends on how far the electrons fall. How far the electrons fall is determined by how far up they are raised by pumping. And, how far up they are raised depends on the bandgap energy level separating the valance band (where the electrons originally resided) and the conduction band. **Fig. 3** shows this relationship between emitted light frequency (in terms of wavelength) versus the basic bandgap electron volts of the various materials. The numerical value of the knee voltage in **Fig. 2** happens to be just a little lower than the numerical value of the bandgap energy in electron volts.

These simple relationships between LED knee voltages and the colors that they emit helps to organize the designer's approach to using these devices into circuits. It may, as will be shown later, lead to some interesting voltage-to-color schemes for future indicators.

Some Important Exceptions

Unfortunately, it isn't quite as simple as we have made out. The problem is that not all materials permit the electron to fall all the way across the forbidden gap region in one tumble. Impurities in the forbidden region give the electron stopping-off places and the resulting shorter tumbles of the electron cause the emissions to be of correspondingly lower frequencies (or longer wavelengths). Thus, the dashed lines in **Figs. 2** and **3** show that SiC, which should, by the size of its 3 eV band gap, emit blue, actually emits yellow and GaP, which, with its 2.3 eV bandgap, should emit green, also can be found emitting colors as low in frequency as reds.

The shortest wavelength the material (or mixture of materials in the case of GaAsP) could emit is given by its bandgap energy in eV and the knee voltage will always relate to this. However, various amounts of doping may shift the emission of certain materials to longer wavelengths. Researchers in the LED field generally prefer direct all-the-way action, as in GaAs and mixtures of GaAsP with lower than 44 percent P, as they think this gives the highest radiating efficiency. But the direct materials are hard to come by.

Right now the colors in which LED's are available are mainly red and orange (from GaAsP), green (from GaP) and yellow (from SiC). Monsanto, RCA, TI, GE and HP make various GaAs-based LED's. GE and Norton make SiC LED's. But many other companies, such as Sylvania and Sprague, are known to be interested in these light-emitting materials, so expect many newcomers to become LED sources. Also expect that LED's will be made from other material combinations and, so, will generate other colors.

There is, incidentally, one exception to the orderly relationship between output color and knee voltage. This is the green LED just introduced by General Electric. GE "cheats" and uses a GaAs infrared diode and coats this with a green phosphor. The invisible emission of the GaAs diode stimulates the phosphor coating to radiate the green.

How Much Light?

So much for LED physics. Despite the mind-boggling atomic phenomena going on inside, these little devices are exceptionally easy to use. Your first application question will probably be: how much light do they put out? The box on brightness on the previous page was a start but some more specific examples may help.

At 5 mA Monsanto MV10B3 GaAsP puts out enough light to be used as built-in circuit troubleshooting aid. At 10 mA, as when powered from a 1-1/2V cell, it puts out enough light to be at least marginally useful as an indicator outdoors as long as it is shaded from direct sunlight (see **Fig. 1**). If unshaded in the direct sun, the diode washes out and all you'll see, if you squint right at the die, is a dull red chip.

At night this LED powered by a 1-1/2V cell and running at about 10 mA can be seen for 500 ft. Here, the clear epoxy focusing lens produces an attention-getting sparkle. At 50 mA it would be five times brighter because the light output beyond the knee voltage varies linearly with current.

The point to understand, though, is that LED's, like the EL's to be discussed later, are really only suited where their light goes directly to the viewer and the viewer sees this light as standing out in a subdued surrounding. These solid-state sources are as yet not really suited for applications where their light reaches the viewer after reflecting off a secondary surface.

What Shape Beam?

A corollary to the question of how much light is the question of what shape or geometry is the LED's light. This depends on the chip configuration and mounting. **Fig. 4** shows several prevalent LED configurations. Configuration **4a** is the most common. Here, though the light is generated at the junction, it comes out all over the die surface. Often a bubble of clear epoxy is dropped on the die to adhere to it and harden into a spherical lens. This alters the index of refraction at the

Device geometry determines light geometry . . .

surface, lets more internal light get out and then focuses the light into a narrower beam.

In configuration **4b** the light only comes out at the junction. Norton's SiC is like this. Norton purposely grows a dark, thick P layer on top so the light emission is restricted to a narrow line at the junction. GE's SiC (shown in **Fig. 1**) emits all over because its more transparent N layer is on top. Norton's device is this way because it was originally intended for marking photographic film.

The SiC is so inert chemically that it can be brought right up to photographic emulsions for contact printing digital (or analog) data. Now it is found that the same fine line can be useful in visual displays.

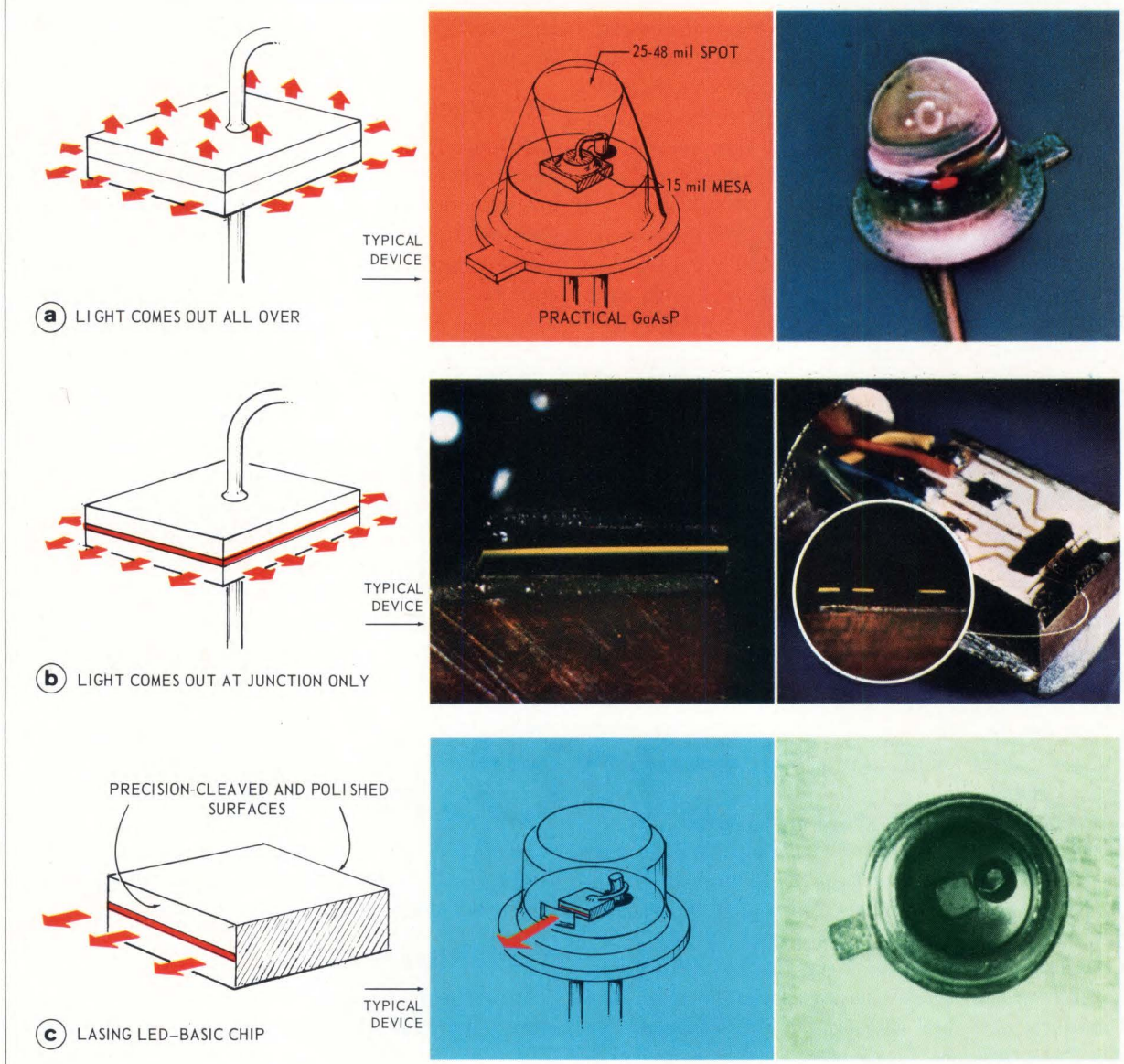


Fig. 4—**LED chip structure** determines the manner in which junction-generated light is radiated from diode. (a) Conventional LED's have flat chips. Junction light is emitted all over, through the thin translucent material (an epoxy lens can help get this light out and in usefully focused shape). (b) Thick SiC chips with dark P layers on top only allow the light to come out where the junction is exposed. (Fortunately, SiC LED's don't need the passivation protection so vital for lower bandgap materials.) (c) Laser LED's must have precise surfaces to reflect the light internally. They can be dangerous as display light sources.

The **4b** configuration is intended for lasing. Here the edges are cleaved to form precision reflecting surfaces. Then, if the junction current is driven to a sufficiently high level—say 5 to 100A—the initial LED light bounces back and forth between the mirror surfaces and stimulated or lasing emission occurs.

Lasing versions of infrared and visible spectrum LED's are beginning to appear. But, as might be expected, their need for precision shape makes them many times more expensive than ordinary LED's. Also, cooling becomes a major problem if they have anything but very short duty cycles, and there is always the very real danger of eye damage to the user. An example of an application where one might want to use a lasing LED in a display is where a light beam is to be scanned over a screen surface as in **Fig. 10**.

How Much Life?

The question of how long an LED will keep emitting at its original level of light is something that only time will tell. Early GaAsP devices were said to have decaying light outputs with time. Present devices are said to have more truly solid-state, unchanging characteristics, but still their makers mumble about half lives of 10,000h.

SiC devices show such remarkable inertness in face of temperatures and chemicals that makers such as Norton have their fingers crossed that their devices will not show any light decay. The problem is that, with devices as new as these and with only 8000h a year, it will be a few years before anybody really knows. Meanwhile, this lack of reliability documentation is sure to slow up the penetration of LED's into the one market they are seemingly best suited for—aerospace vehicles. (Monsanto tells EDN it is no longer mumbling about GaAsP lifetime, as its accelerated lifetime tests have by now shown a 100-years-to-half-brightness capability. Monsanto also expects its new planar process to eliminate the rapid decay of light output during the first few hours of device burn-in.)

Using LED's in Circuits

The simplest way to put LED's to work is just to connect them to existing circuits. Quite often an LED with a series resistor can be connected right across any logic gate or amplifier output that has the sufficient voltage swing and sufficiently low impedance to drive the LED. **Fig. 5** shows some arrangements EDN tried with familiar logic families. In the case of the T²L circuit, a test (see *Databank*, Ref. 1) was made to check if the LED capacitive and resistive loading affected the circuit speed. Loading was found to be negligible.

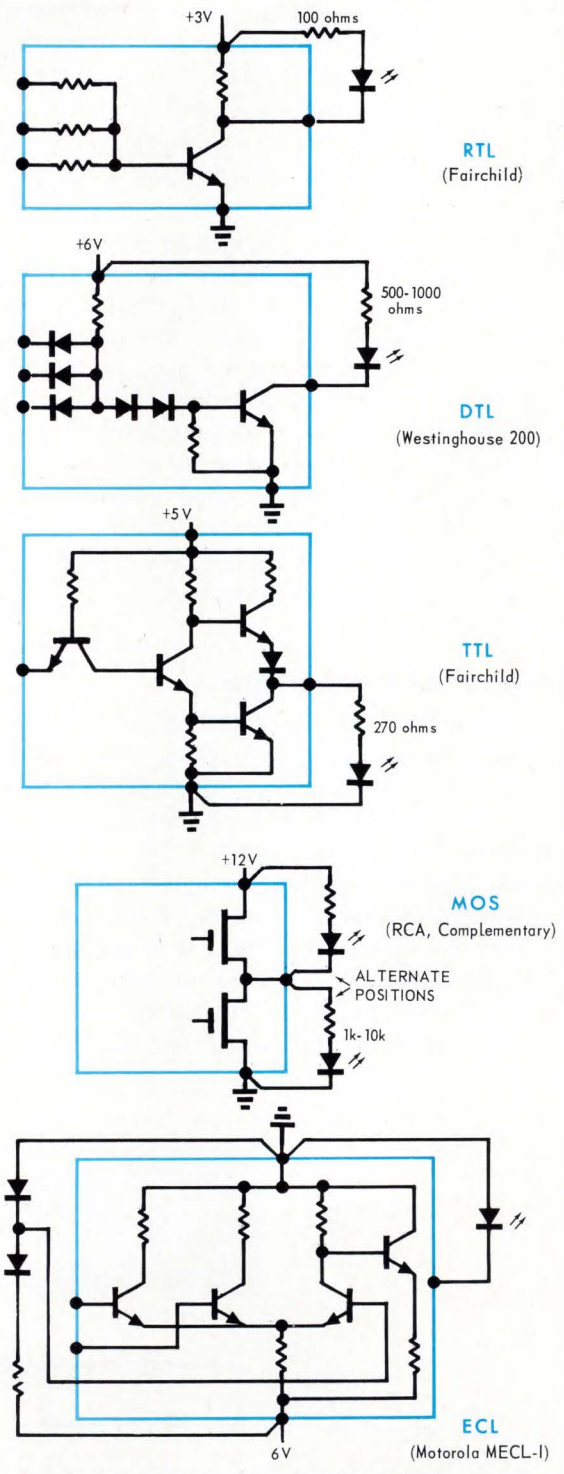


Fig. 5—**LED's driven directly by IC logic.** Many of the common IC logic family gates will drive LED's directly. Usually, it's just a matter of placing the LED across the gate output, with a series resistor to take up the voltage slack.

This suggests the use of the very fast, 10-ns response of GaAsP LED's for optoelectronic links as well as for indicators. GaAsP is not as good a match for the fast silicon photodiode pickups that would be needed at the other end of the link as GaAs IR diodes but they will work. Such optical links could be used to circumvent cabling delays, to provide isolation between subsystems or just to avoid having to connect some auxiliary indicating circuit into an important main system.

There will be many situations in which LED's will be used to complement existing display components, either as backups for critical signals or to provide greater depth of communication. For example, in **Fig. 6** the LED in the center of an EL-panel indicator gives a momentary flash whenever some transient event occurs while the EL panel gives an integrated indication of how frequently and how recently the LED flashed. This could help a traffic controller keep tabs on relative "busyness" of a number of streets at the same time.

Circuit Tricks with LED's

The fact that LED's are both semiconductor diodes and light sources suggests some novel circuits for these devices. For example, in **Fig. 7** two LED's are used at the input of the amplifier as combined signal limiters and indicators. At low signal levels the LED's properly present a high impedance to the signal and don't interfere. But, if the signal goes past the LED's knee voltage, they clip the signal by shunting it to ground. At the same time, they light up to warn the operator that he'd better attenuate the input. The LED's are purposely stuck through holes in the panel where they peep out in the center of their diode symbols.

Thus, the operator has a highly functional indication of system operation. He can see by the manner in which the LED's light up whether the peaks are continuous or transient and, according to which diode lights up, what the polarity of the transgression is. Many of the indicating tricks performed at high voltages by neons can be done at IC levels.

Two different types of LED's could be used together to indicate, by their different colors, whether a voltage was between proper limits. For example, in the bias input to the amplifier in the figure (say it was an instrumentation tape-recorder amplifier), a red GaAsP LED could be used to indicate when a lower 1.4V level had been reached and a yellow SiC LED could indicate when an upper 2V level had been reached.

To make things very easy for even the least skilled operator, the red GaAsP LED could be placed at approximately that point in the knob turn where it should light up and the yellow SeC LED could be placed where it should light up. Then it would be almost an unconscious procedure on the operator's part to turn the adjustment up until the red indicator lighted up, but not so far that the yellow lighted up.

A Natural Calibration

Simple as the adjustment would be, it would give the designer of the instrument an unusually high confidence that, as long as the LED's were operating, the operators would be keeping the bias adjustments within approximately correct bounds. Part of this confidence would be because of the fundamental relationship between the LED color and the voltage it indicated. In

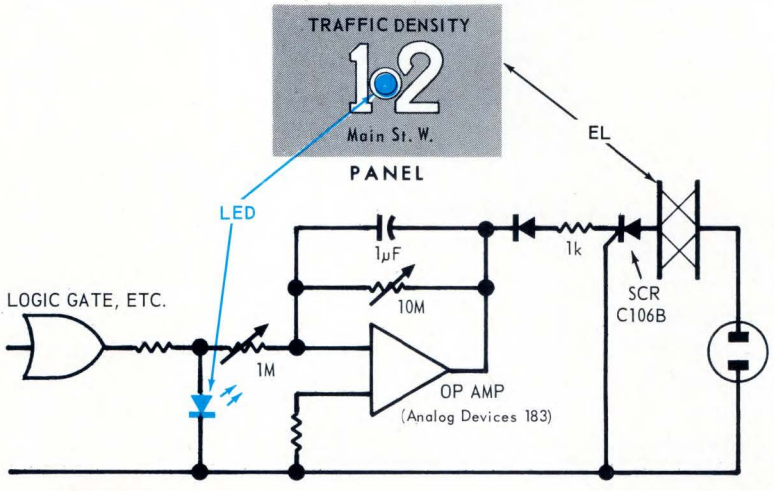
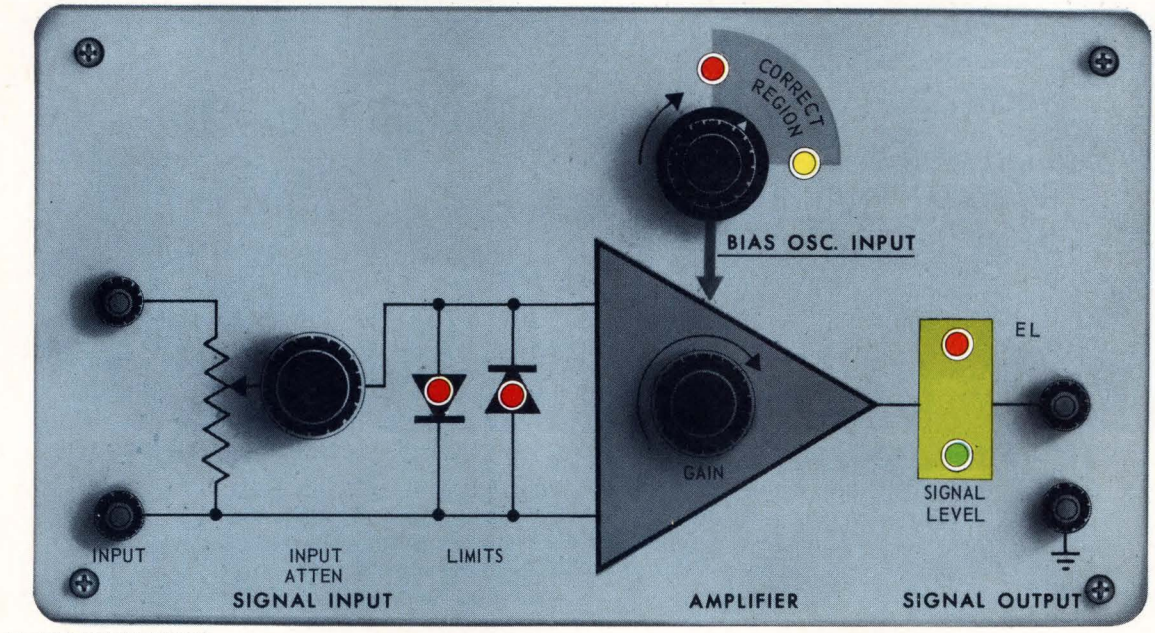
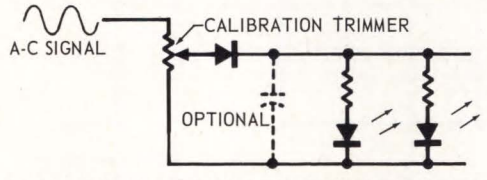


Fig. 6 — **LED's complement EL's.** These two solid-state display components are shown working together in a two-level traffic-density indicator. The LED flashes each time a transducer indicates a vehicle has passed, while the surrounding EL panel maintains (via the op-amp integrator) a trailing memory of how many times and how recently the LED was excited. The EL also backlights the nomenclature, telling what is being sensed. (Note the remote-base configuration for the SCR driving the EL in full-wave fashion.)



a –INSTRUMENT PANEL



b –POSSIBLE CIRCUIT FOR BIAS AND OUTPUT INDICATORS

Fig. 7–**LED's work well with analog.** Here, LED's are used to monitor three different signals. The amplifier would be close behind this instrument panel and the LED's placed in holes in the panel so the user would be actually "seeing the circuit in action". See text for explanations.

a crude sense it would represent a built-in lifetime calibration standard for the instrument (especially if the LED's were of the direct-transition types).

A final use of LED's in the instrumentation amplifier example of **Fig. 7** is shown at the output. Here a General Electric green unit is used for a green "GO" signal, and a red GaAsP unit is used for the "STOP" signal. In this case the green color is not fundamentally related to a knee voltage because the GE green LED is really (as was explained) a GaAs infrared emitter exciting a coating of green phosphor. Thus, this green LED would have a knee voltage of around 1V while the GaAsP red LED would have its customary 1.4V knee.

Naturally, by use of simple resistor divider networks, etc., the actual circuit voltages could be larger than the actual LED voltages.

If the designer wanted a red "STOP", an amber "CAUTION" and a green "GO" color combination that would go uniformly upward on the knee-voltage scale, he could use a low-mixture GaAsP for the red, a higher mixture (more phosphorous) for the orange-yellow of amber and GaP for the green.

Using LED's in Small Arrays

LED's can be quite effective when used together in small groups. Alphanumeric readouts are within grasp by this approach. The designer can mount many different combinations of LED's (mixing colors and device types if he chooses) to make up special arrays of LED dots or bar segments that he can selectively light up to form a wide variety of simple messages and picturegrams.

Fig. 8 shows a 5-character alphanumeric readout built as a feasibility demonstrator by Martin Marietta Corp.'s Denver Div. "It took us $1800 worth of LED's to get the display but, as anybody can see, it demonstrates that LED's can produce an entirely acceptable system from about every aspect except, as yet, the cost," said John Goodwin, Martin project engineer.

Martin used five 7 by 7 matrices, one for each of the letters displayed. Small 1/10-in-dia GaAsP diodes by Monsanto were used. They were inserted in holes drilled in a single-sided PC board and their cases, which carried their anode currents, conductive-epoxy-cemented to the foil side of the board. Their single

Make up your own displays . . .

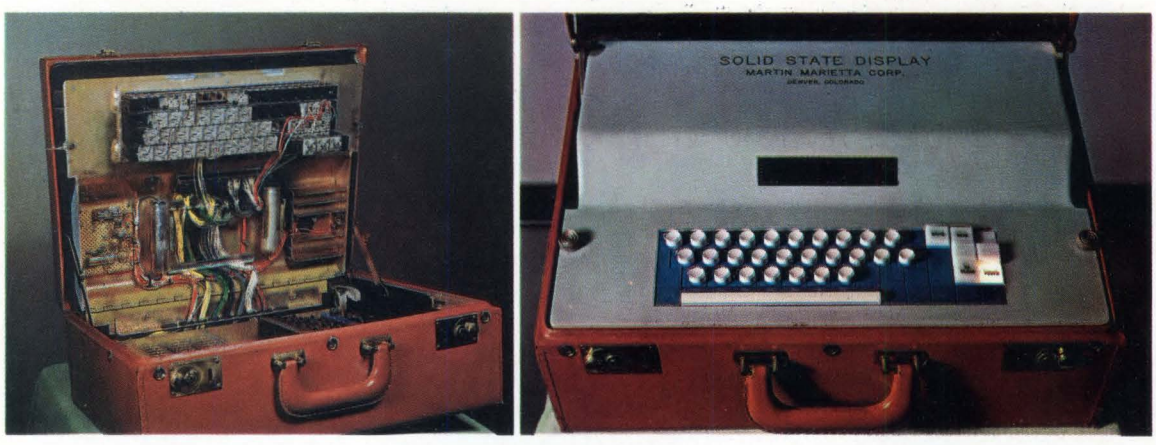
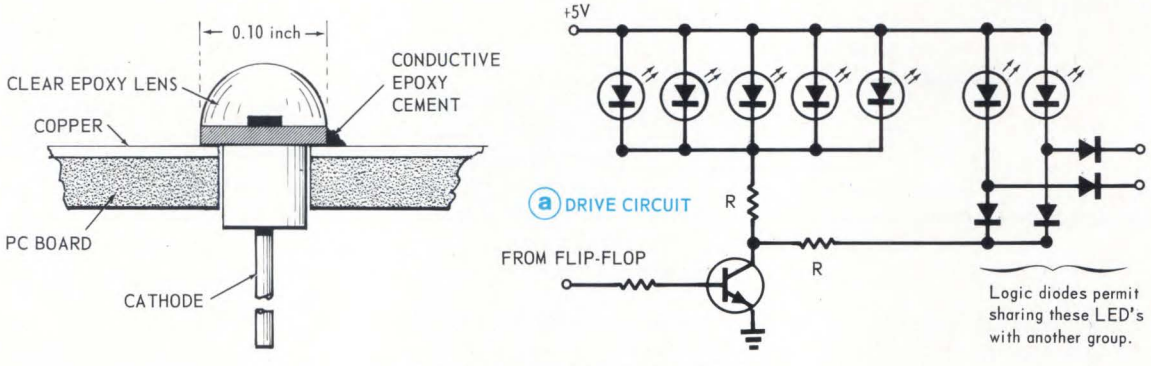
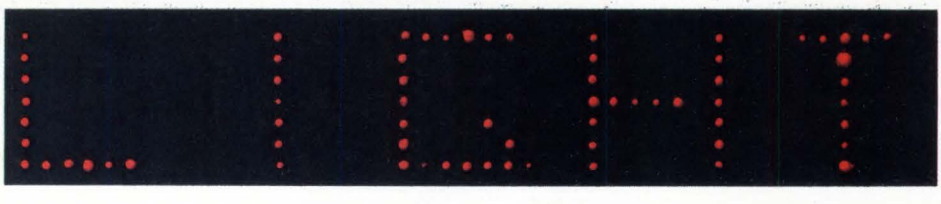
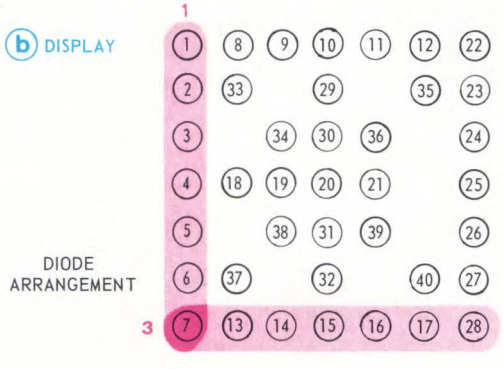


Fig. 8—**Martin's LED readout** gathered the LED's into groups of line segments and drove these with single transistors for each group. Diode logic in the driving circuit (a) enabled different groups to share the LED's they had in common. Photo of demonstrator with lid up shows surprising amount of circuitry that was needed as well as the size of the power supplies.



FIVE 3/32-inch ONE-SIDED PC BOARDS





Groups of diodes used to construct the "L" in above photo.

Diode Group	Diodes in Group						
1	1	2	3	4	5	6	7
2	1	8	9	10	11	12	22
3	7	13	14	15	16	17	28
4	4	18	19	20	21		
5	22	23	24	25	26	27	28
6	10	29	30	20	31	32	15
7	1	33	34	20			
8	20	36	35	22			
9	7	37	38	20			
10	20	39	40	28			

coaxial leads that carried their cathode currents protruded out from the back of the board.

Because this was to be primarily an alphabetical display, some of the 49 diodes of the matrix could be omitted. A second simplification was that groups of diodes were driven together. The segments Goodwin selected to form letters of the alphabet are shown in the illustration. For example, note that to form the letter "L", one would switch on group 1, which lights up diodes 1 to 7 on the left-hand column, and group 3, which lights up diodes 7 to 28 on the bottom row.

Each of the 10 groups has a circuit configuration like the one shown. A single transistor switches the group's diodes in parallel. A series resistor, R, adjusts the LED's to 1.6V, 10 mA, at which level they put out 50 fL of light.

Note, however, that most of the segments share diodes. For example, LED 7 is shared by groups 1 and 3. Ordinary signal diodes (in "OR" logic connections) permit either group to turn these shared LED's on.

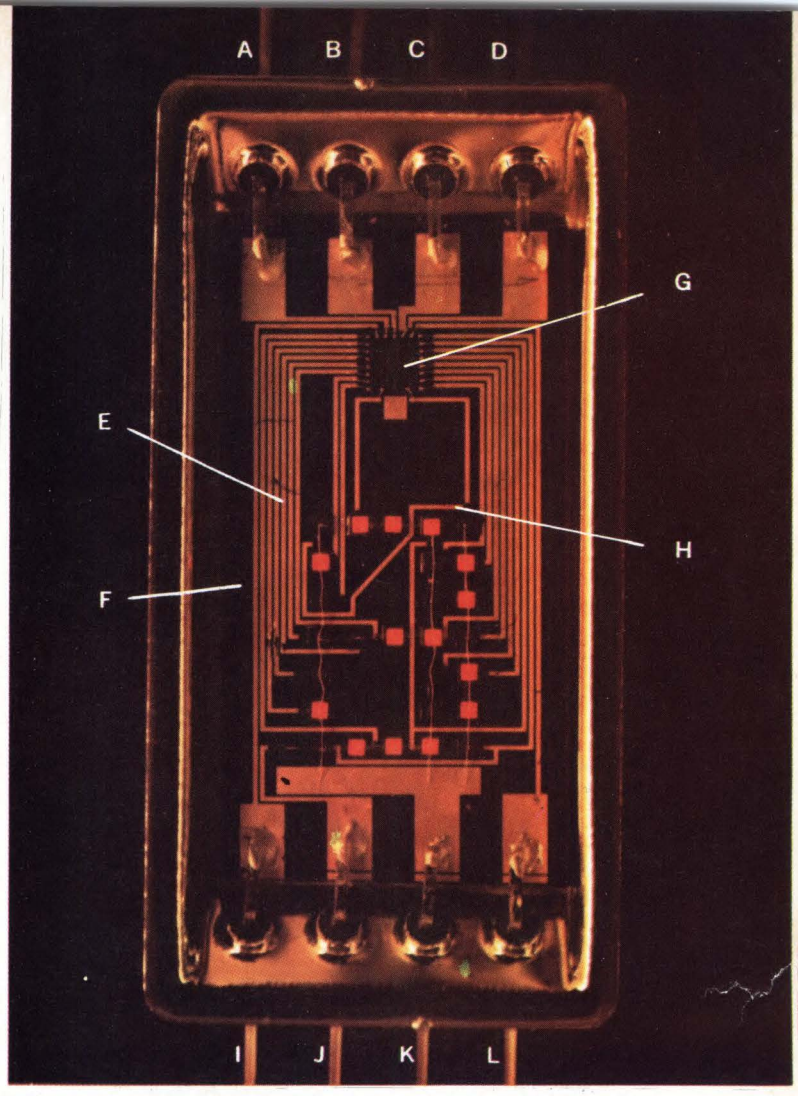
The rest of the Martin system includes a keyboard for word entry, three storage registers, and a clock and decoding system for automatically stepping each word into the display, holding it there for 3s, then putting in the next word. Such a display could be used to give an operator simple sentences and commands one word at a time. T^2L logic is used throughout. The LED drivers are discrete because by the time 7 LED's are paralleled, the current is up to 210 mA and it is just as easy to use a discrete device (though there are many IC drivers that could handle this).

The total system uses 20W. Though the individual diodes only require 30 mA when on, the 200 LED's, if all on, could use 6A and would account for even greater power. However, the normal combinations of diodes used to generate alphanumerics never draw more than a fraction of the total possible current.

Goodwin said the light output from diode to diode seemed quite evenly matched though he had not preselected diodes on this basis. But he believed, however, that when arrays of LED's are put into production, it will be necessary to demand LED's matched in both I-V characteristics and light output. Otherwise, the human eye, which is sensitive to brightness differences of 50 percent or more, might be able to detect hot spots in the display.

Buying LED's as Assemblies

Most of the companies selling LED's either have some sort of array assembly out as a product or are doing development work on one. They appreciate the market potential for the simple LED arrays that could be used for alphanumeric displays.



(A)Logic 2. (B)Logic + (5V dc). (C)Ground. (D)Logic 4. (E)Thin-film interconnections between LSI driver and LED's. (F)Dielectric Substrate. (G)LSI driver chip. (H)One of the 28 LED's. (I)Logic 1. (J)Decimal point. (K)LED +. (L) Logic 8.

Fig. 9—**HP's readout modules** use LED chips mounted on thin-film substrate. The discrete wiring forming the top connections to each chip can be faintly seen as it jumps from chip to chip. A single LSI driver IC (top) supplies the exciting currents to all of the LED's.

Hewlett-Packard makes a self-contained driver-LED array package and will sell it for $50 per position. HP lays down its discrete GaAsP chip on a substrate that also carries an IC decoder-driver and thin-film interconnections (see **Fig. 9**). Most use LED's in chip form at this point in LED evolution because most people don't want to squint at symbols as small as the chip areas found economical in IC processing. The separate LED chips can be spaced out to form popular-sized symbols. Actually, when the chips are running at 10-mA level and above and they have little magnifiers over them, they look much larger than they are.

Norton, however, makes some multiple LED's on a single chip. They put grooves down the length of their devices to separate them into a half-dozen or so separate LED's on one substrate. Because Norton's LED's are inert SiC, they offer some interesting possibilities to hybrid-circuit fabricators who wish to build their

Someday there will be an LED CRT . . .

own special-purpose displays.

The SiC devices, even though they have no passivation, can be handled quite freely. They can be left bare or potted directly into epoxy. It should be possible, for example, to line a number of these elements up on edge for a line segment display, holding them fixed in the desired configuration by epoxy. The main problem would be the electrical connection.

A Monsanto researcher, Stephen Fowler, believes that his company has found the answer to making practical XY addressable arrays on single wafer slices. From the few details he released it appeared that a planar process would be used and that possibly the viewing area problem would be solved by magnification.

One approach that does produce a CRT-like display with LED's is shown in **Fig. 10**. A rotating mirror sweeps the video-modulated beams from a row of LED's across a ground glass. These LED's could possibly be lasers. They might even be IR devices that would excite a phosphor on the screen. □

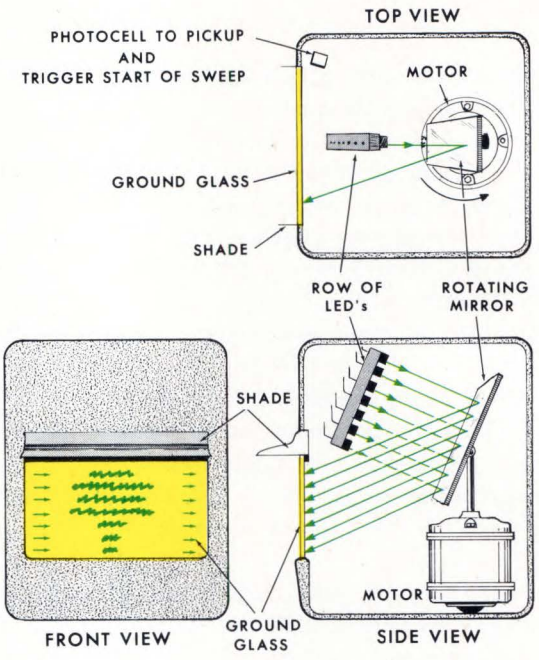


Fig. 10 – **Hybrid approach to solid-state TV** is to use a row of LED's and mechanically sweep this row across a ground-glass screen. Each LED would be fed the video modulation for its line during the scan.

Acknowledgments

The author wishes to thank the following sources for their help: C. Dougherty, GE; S. Fowler and L. Lutostanski, Monsanto; B. Howell and A. Robinson, Sylvania; R. Foley, Norton, and H. Luxenberg, consultant.

DATABANK

For general background on LED's, each of the following has has something to contribute:

1. "The High-Brightness LED", D. K. Hillman (Fairchild) and G. E. Smith (Monsanto), IEEE Spectrum, January 1968. A practical article that doesn't spend much time on basic physics of LED's but gets down to analysis of specific devices and their properties.
2. "Visible Light from Semiconductors", Max R. Lorenz (IBM), Science, March 29, 1968. Excellent – runs gamut from basic physics to device practicalities.
3. "Semiconductor-Diode Light Sources", M. R. Lorenz and M. H. Pilkuhn (IBM), IEEE Spectrum, April 1967. Basic.
4. "Semiconductor Light Emitters", F. Reid, Battelle Technical Review, March 1967, and reprinted in Solid State Technology, April 1968.
5. "Luminescence in Semiconductors", D. G. Thomas and K. Galt, Bell Laboratories Record, March 1968. Covers physical concepts.
6. "Light-Emitting Semiconductors", F. Morehead (IBM), Scientific American, March 1967. Slanted toward LED lasers.

For product information of LED's, write:

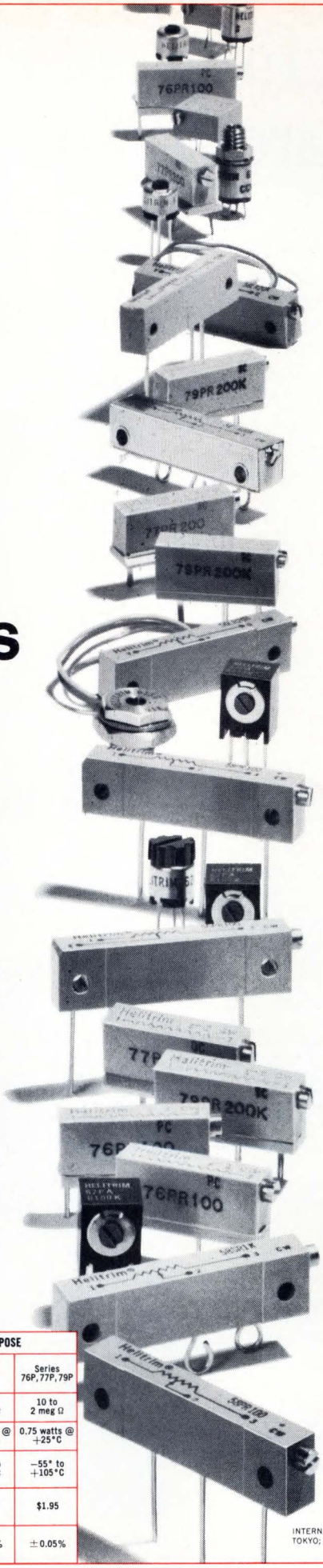
1. Monsanto, Electronic Special Products, 800 N. Lindberg Blvd., St. Louis, Mo. 63166.
2. Hewlett-Packard, 620 Page Mill Rd., Palo Alto, Calif. 94304.
3. General Electric, Miniature Lamp Dept., Nela Park, Cleveland, Ohio 44112.
4. Norton Research Corp., 70 Memorial Dr., Cambridge, Mass. 02142.
5. RCA Electronic Components, Harrison, N. J. 07029.
6. Texas Instruments Incorporated, Semiconductor Components Div., Box 5012, Dallas, Tex.

For general background on displays:

1. "Display Systems Engineering", H. Luxenberg and R. Kuehn (editors), McGraw-Hill Book Co., New York, 1968. One of the few comprehensive texts on displays.
2. "National Symposium on Information Displays", (9th annual volume published this year), Society of Information Display, 654 N. Sepulveda Blvd., Los Angeles, Calif. 90049. The proceedings of the meetings of SID, these volumes are probably the best single sources for determining the progress of the art. They lean toward computer-driven displays.
3. "The Scientific Basis of Illumination Engineering", Parry Moon (MIT), Dover Publications, 80 Varick St., New York, N.Y. 10014, 1961. At the Dover paperback price of $3.25, this makes a good "classical" reference work for anyone working with light. There is little to do with electronics, however.
4. "Biotechnology: Concepts and Applications", L. Fogel, Prentice Hall, Inc., Englewood Cliffs, N. J. 1963. Excellent general book on human factors in man-machine systems, with much useful quantitative data on human input channels.

In addition, the reader designing displays for military and space applications will find experts knowledgeable in the state-of-the-art in displays at the following government centers: NASA Electronics Research Center, Cambridge, Mass.; USAF Rome Air Development Center, Rome, N.Y.; U.S. Naval Research Laboratory, Washington, D. C., and U. S. Army Electronics Command, Ft. Monmouth, N. J.

The endless line



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Power Rating	1 watt @ +85°C	0.5 watts @ +85°C	0.5 watts @ +85°C	1.5 watts @ +125°C	0.5 watts @ +70°C	0.75 watts @ +70°C	0.75 watts @ +25°C
Operating Temperature Range	−65° to +175°C	−65° to +150°C	−65° to +150°C	−65° to +200°C	−25° to +125°C	−25° to +125°C	−55° to +105°C
Price (List 1 to 9)	$5.50	$5.50 (61P) $6.50 (all others)	$6.50	$8.00 (50) $7.50 (53, 54)	$1.75 (62P) $2.00 (62PF) $2.50 (all others)	$3.00	$1.95
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CIRCLE NO. 33

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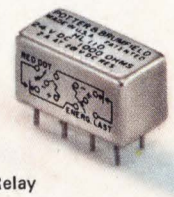

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This one is. Here's why.

First, the design. No other half crystal case latching relay, according to major users, can match its magnetic structure and its ability to meet the most stringent specifications.

Second, the meticulous production procedures we follow (our Intensified Control and Reliability Program) exceed industry standards. All assembly, adjusting and hermetic sealing are confined to our spacious clean room, replete with sophisticated air conditioning, laminar air flow work stations, ultrasonic cleaners, a Royco particle counter and a double air lock entrance.

Third, realistic verification of performance—including random vibration testing—is without duplication in the relay industry. For complete information, talk with your local P&B representative or call Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana.

HL SERIES ENGINEERING DATA

Description: Dual coil, polarized, magnetic latching (Single coil, polarized relays available on special order)
Contact Arrangement: DPDT (bifurcated, gold-plated silver-alloy)
Contact Rating: Dry circuit to 2 amperes @ 28V DC, resistive
Contact Resistance: 50 milliohms before life; 100 milliohms max. after 100,000 operations at maximum rated load
Expected life: 100,000 operations minimum at rated load
Pick-up: Dual coil—150 milliwatts (approx.)
Shock and vibration immunity:

Shock: 150g for 11 milliseconds
Vibration: .195" D.A. from 10 to 55 Hz. 30g, 55 to 3,000 Hz.
Random Vibration: In excess of .4g²/Hz. 20 to 2000 Hz.

No contact opening in either armature position

Partial view of clean room where HL relays are assembled, adjusted and sealed.

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Sealing in controlled atmosphere follows evacuation in vacuum ovens.

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CIRCLE NO. 34

AMF | POTTER & BRUMFIELD

Component and Circuit Design IDEAS FROM SYLVANIA

IDEAS /CRT Displays

New CRT family reduces computer readout cost.

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When it comes to matching the high speed of modern computers the CRT readout is king. Now, Sylvania's new family of computer readout CRTs gives you the best features of CRT readout at a price you can afford.

A typical application for these tubes is shown in the photograph. Here, Ultronic Systems Corp., a subsidiary of Sylvania Electric Products Inc., uses a 12-inch tube to display stock market information and business news reports in a revolutionary desk-top display system.

The Ultronic® Videomaster™ literally makes all other stock quotation machines obsolete. In its basic mode of operation, the machine's CRT displays seventeen separate items of information about the selected stock.

In the Marketminder mode, the Videomaster will keep track of the last selling price of eighteen selected stocks. A third mode, the Limit-minder, notifies the user when any of eighteen stocks reaches a preselected high or low limit. In a fourth mode, the CRT display shows the two exchange tickers most frequently used, plus news service reports. With this much data to handle, Ultronic needed a high-performance CRT.

Sylvania's needle-sharp electron gun maintains good edge resolution and provides a highly readable dis-

continued on next page

Videomaster stock market display system uses low-cost computer readout CRT to obtain crystal-clear display in a minimum of space.

This issue in capsule

play. The compact design of the 90°-deflection tube makes the all-solid-state system a real desk-top space saver. Both the 9″ and 12″ CRTs in the new line feature the new smaller neck diameter, reducing drive circuit requirements.

As can be seen from the table, the tubes in the new line feature either Kimcode or T-band implosion protection. For high-ambient light conditions, special optical panels can be bonded to the faceplate to improve readability. Although the table shows our standard line of computer readout tubes, keep in mind that Sylvania's extensive capabilities permit a wide range of modifications to be made at small additional cost.

In addition, we have a line of high-resolution tubes for more demanding applications.

These high-resolution tubes provide 0.003-in. line widths with center face resolution as high as 3000 lines. As with all Sylvania CRTs, variations from the specifications shown in the table are available at nominal extra cost.

CIRCLE NUMBER 300

Low cost computer readout tubes

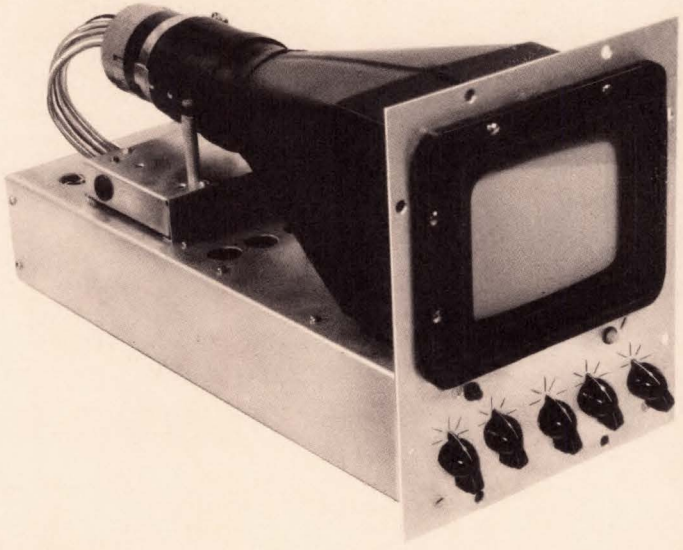
Size	Type No.	Defl. Angle (deg.)	Approx. Screen Area (Sq. In.)	Heater (V/mA)	G2 Voltage (V)	Neck Diam. (in.)	Overall Length (in.)	Safety Protection
9″	ST-4716A	85	42	6.3/0.450	100	20mm	8.44	T-Band
12″	ST-4729A	110	74	6.3/0.450	100	0.840	9.19	T-Band
15″	ST-4730A	110	100	6.3/0.450	300	1.13	10.75	T-Band
17″	ST-4549A	114	141	6.3/0.450	300	1.13	11.25	Kimcode
20″	ST-4542A	114	184	6.3/0.450	300	1.13	12.25	Kimcode w/mount. ears
20″	ST-4545A	114	184	6.3/0.450	300	1.13	12.25	Kimcode

High resolution computer readout tubes

Size	Type No./ Line Width	Defl. Angle (deg.)	Approx. Screen Area (sq. in.)	*Heater (V/mA)	G2 Voltage (V)	*Neck Diam. (in.)	Overall Length (in.)
8″	SC4859/ 0.003 in.	90	35.5	6.3/600	500	1.44	11.063
12″	SC4676/ 0.003 in.	70	67	6.3/600	500	1.44	16.60
14″	SC4860/ 0.003 in.	90	100	6.3/600	500	1.44	13.19
15″	SC5017/ 0.004 in.	70	102	6.3/600	500	1.44	17.5
17″	SC4836/ 0.003 in.	70	149	6.3/600	500	1.44	18.75
21″	SC4604/ 0.005 in.	70	262	6.3/600	700	1.44	22.59

*Variations available for most types per customer specification. Safety protection, AR treating and RFI coating as required.

IDEAS/*CRTs*



Complete CRT display modules can be designed to meet your space and input requirements.

Integrated display modules save you time and money.

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This modular approach can be a real time and money saver in the prototyping or breadboarding of proposed systems. In general, you'll find it less expensive to purchase the integrated modular package than to design and build the individual circuits.

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Pricing on the Sylvania modular CRT packages is based on a one-time engineering charge and a per piece price quotation. Sylvania's Industrial and Military CRT group can supply anything from prototypes to production quantities.

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Fast precision trimming of improved materials allows you to get high-precision networks at low cost.

New materials and improved process controls have enabled Sylvania to turn the manufacture of precision thick-film resistors into a routine affair. With the new techniques, resistor tolerances can be held to 0.05% to 1% with temperature coefficients extending down to as low as 20 parts per million. Tracking of several resistors on the same substrate can be held in the range from 5 to 20 parts per million per degree C.

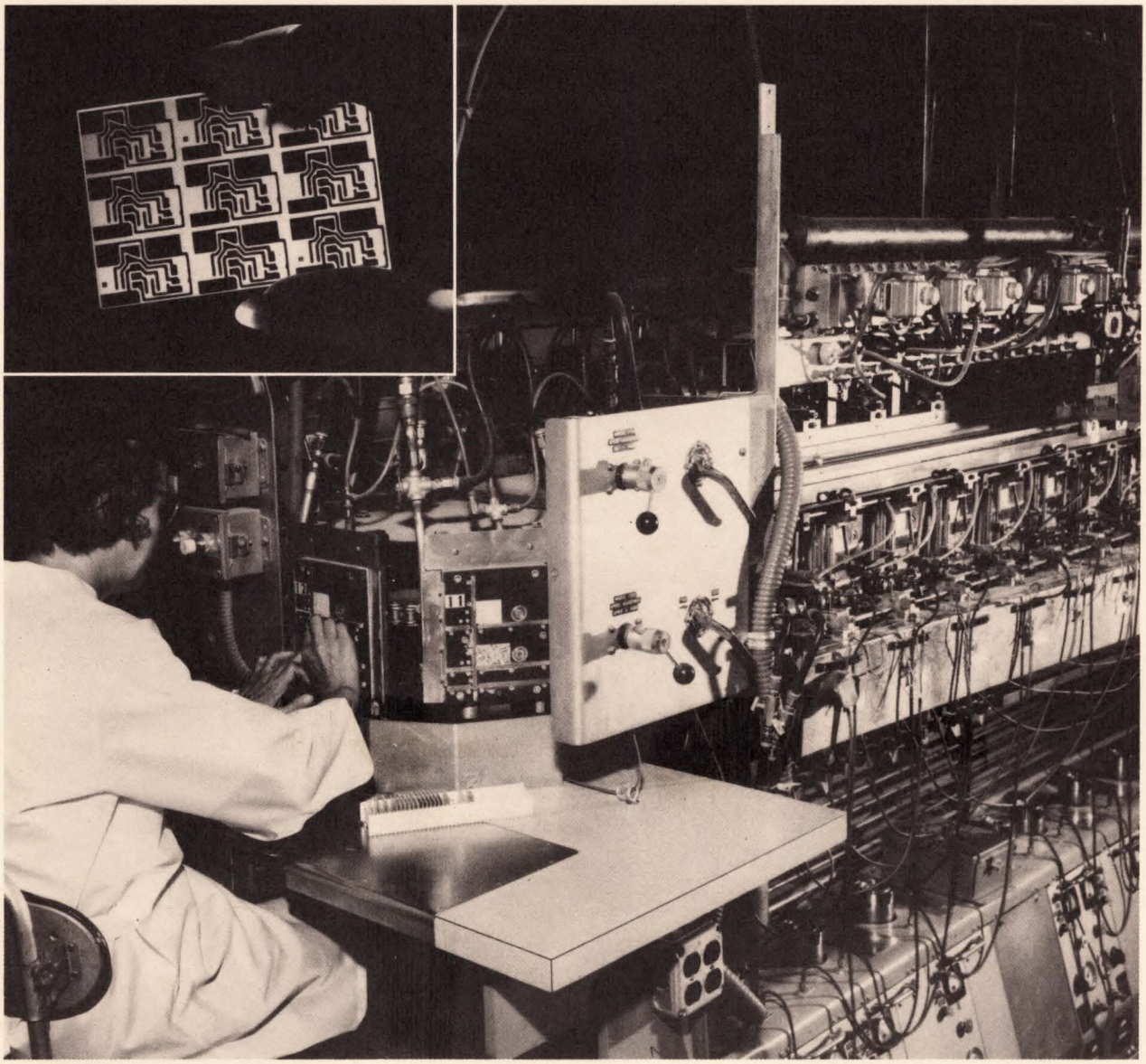
This means that ladder networks of ten to twelve bits can be made with accuracies better than the least significant bit. Similarly, step attenuators with precision of 0.1% can be obtained. R-C networks can be held to 0.25% over a broad temperature range.

And best of all, these devices can be made economically thanks to the Sylvania-developed forty-position trimming machine.

This machine incorporates precision bridges and fast-action abrasive shutoff devices to get high-speed, high-accuracy trimming. The forty-station capacity allows trimming of complex multi-resistor arrays at minimum cost.

Thick-film networks have many advantages over conventional discrete precision networks, including good thermal tracking, smaller size, lower cost, reduced weight and higher reliability. In addition, film networks can be hermetically sealed to eliminate the effects of humidity on the long-term stability of the network. This is difficult to do with discrete components of any reasonable size. Because these film networks are fabricated simultaneously from the same resistor and conductor inks, consistency of characteristics is improved. Reliability is improved by the elimination of many hand-wired connections.

CIRCLE NUMBER 302



Resistor trim machine with forty stations can trim resistors to tolerances as tight as 0.05%. Inset shows typical trimmed circuit.

Now we've boosted the Q of VVCs.

Sylvania's expanding family of voltage variable capacitor (VVC) diodes now includes units with Q's of 500 and better.

When they couldn't get the special VVCs they needed anywhere, a major manufacturer of communications equipment brought their problem to Sylvania.

They required very high-Q VVCs tightly matched into quads by capacitance change ratio for use as the tuning device in high-frequency amplifiers. Fast action was essential to meet the customer's production schedules.

A special team consisting of the customer engineers and Sylvania's engineering and production groups was rapidly formed to concentrate on a fast solution to the situation. By working closely with the user, and applying Sylvania's diode know-how, the required quantities were supplied on time. And the result is a new series of VVC diodes in the Sylvania line.

This high-Q series features typical Qs in excess of 600 and a choice of capacitance values from 4.0 pf to 33.0 pf, nominal. Tuning ratios are closely controlled to the typical values shown in the characteristics table.

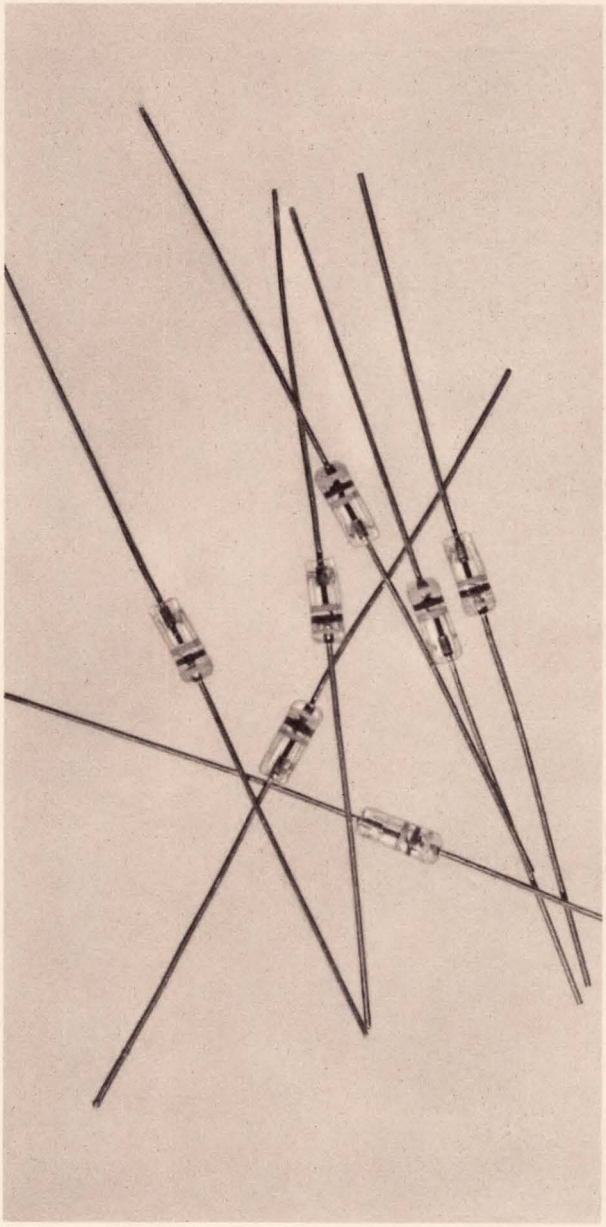
When it comes to packaging, you can write your own ticket because Sylvania has the flexibility to meet your needs.

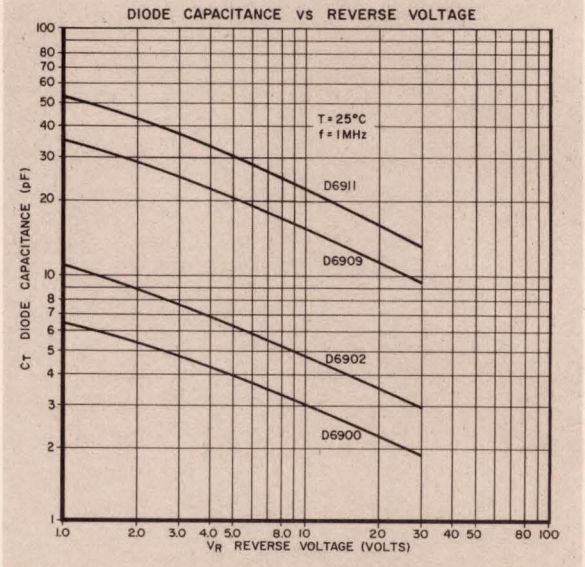
Whether you want your VVCs in chip form, DO-7 package or in any other form factor, Sylvania's VVCs offer a greater design margin.

The new series is also available in matched sets of two or more diodes with tightly controlled capacitance and change ratios between units.

When you need VVC diodes, take advantage of Sylvania's specialized design knowledge and our proven ability to deliver the goods.

CIRCLE NUMBER 303





Typical curve of capacitance versus reverse bias voltage for VVC diode.

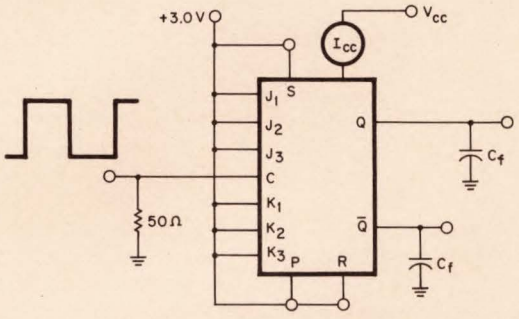
D6900 series high-Q voltage variable capacitors

TYPE	Capacitance (C_T) V_R=4VDC f=1 MHz pF (nom.)	Quality Factor (Q) V_R=4VDC f=50 MHz (min.)	Capacitance Ratio C_{2V}/C_{30V} f=1 MHz typical
D6900	4.0	600	2.8
D6901	5.4	600	2.8
D6902	6.8	600	2.9
D6903	8.2	600	2.9
D6904	10.0	600	2.9
D6905	12.0	600	2.9
D6906	15.0	500	2.9
D6907	18.0	500	3.0
D6908	20.0	500	3.0
D6909	22.0	500	3.0
D6910	27.0	500	3.0
D6911	33.0	500	3.1

Breakdown Voltage (I_R=10μA)=30VDC

Why you need SUHL J-K flip-flops for low power, high speed systems.

Current drain becomes a critical factor at extremely high computer logic switching speeds. The curves (right), applicable to all SUHL single and dual J-Ks, show that current-drain levels, even at high frequencies, are significantly better than those of conventional flip-flops.



Test set-up used to derive data presented in charts.

Recently we conducted a series of evaluation tests to establish typical distributions of current-drain levels for our SF-200 AND-input 50 MHz J-K flip-flops. The data we obtained applies also to other SUHL II single and dual J-Ks since all of them use the same basic circuit configuration.

For the SF-210, 50-MHz OR J-K flip-flop, current drain will typically be 2.2 mA higher across the test temperature range. This slightly higher drain is due to the added OR-gate stage.

As you can see from the curves, Sylvania's SUHL flip-flops are the way to go wherever low power and high speed are prime considerations.

The evaluation tests began with a lot of 100 units which were representative of product resistor value and Beta distributions. These units were then measured at frequencies of 1 MHz and 30 MHz with V_{cc} 5.0 V at 25°C and C_t 15 pF. Measurements were based on a 50% duty cycle using a Model 122 E.H. pulse generator. Units representing the minimum and maximum current drain observed in the distribution were then selected from the initial lot.

The selected units were measured for current drain at frequencies of 1, 20, 35, 40, and 50 MHz with an operating voltage 5.0V, and capacitive loads of 15, 50, and 100 pf. Measurements were taken at temperatures of −55°C, +25°C and +125°C.

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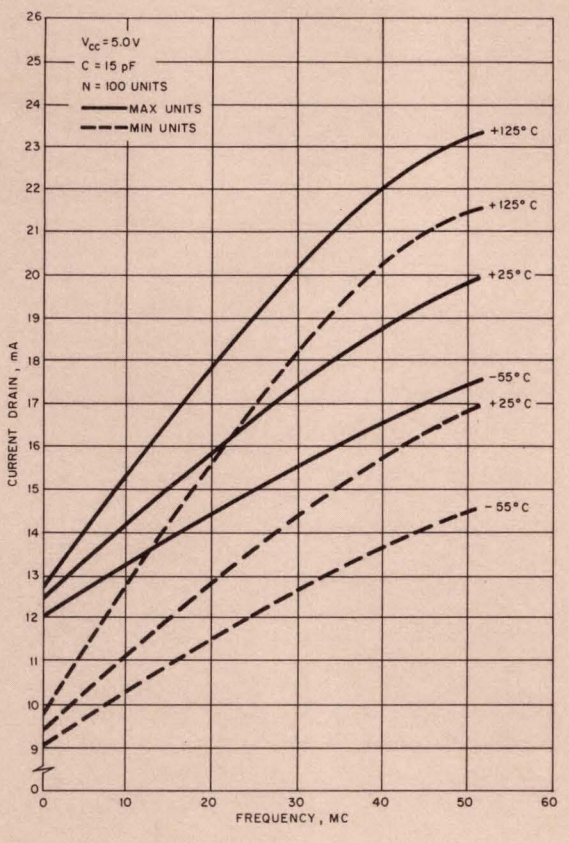
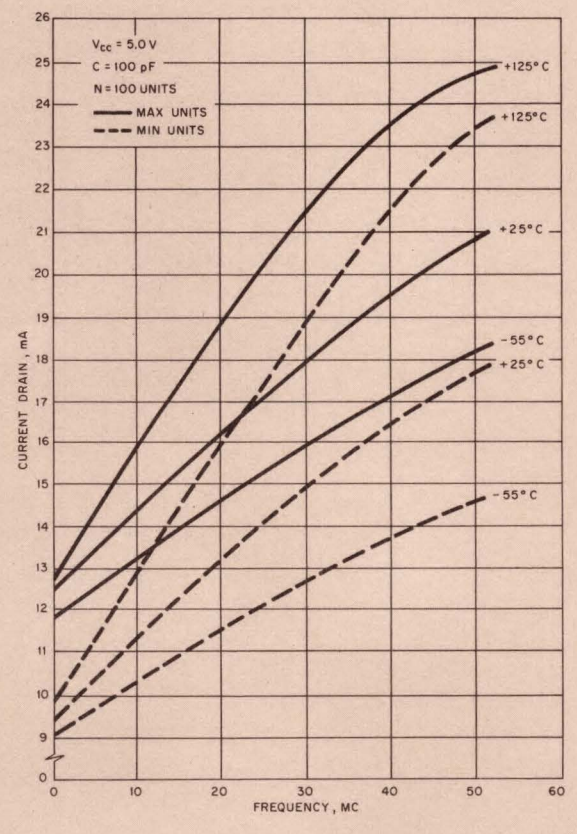




Operation at V_{cc} 5.0V with capacitive loads of C=15 pf and C=100 pf.

How EL devices can simplify photo-recording.

Electroluminescent panels make it easy to place supplementary data on films without complex optical systems.

If you have problems in placing identification marks or other types of data on films you may find your solutions in electroluminescent displays. EL has many advantages in this type of application. First of all, EL devices provide a planar display. The light source is almost in direct contact with the film, assuring a sharp image and minimum light spread. In Sylvania's electroluminescent devices, the use of a thin glass cover plate allows the film to be as close as 0.025 in. to the light source. Since the electroluminescent device is in direct contact with the film, there is no problem of designing or maintaining complex prism lenses and other optical components.

A second advantage of electroluminescent displays is low power consumption, therefore, less heat. This can be a real problem in incandescent lamp systems.

Another advantage is the very uniform light produced by electroluminescence over a given area, as compared to incandescent sources.

Probably the greatest advantage of EL in photographic applications, is the wide variety of display patterns you can obtain. Nearly any shape, symbol or group of symbols can be used. And they can be tailored to any format for a particular application. The ability of EL to display high-density patterns allows substantial amounts of data to be placed on each device (Fig. 1).

There are a number of ways that EL can be used to record information. A straightforward approach is to use a Sylvania ELX-4 numeric display like that shown in Fig. 2 for contact printing. Different combinations of digits can be obtained simply by energizing the appropriate segments.

Similar information can be obtained using an EL matrix (Fig. 3). A negative containing the desired information is placed over the matrix. The data to be recorded is transferred to the film by energizing selected elements of the EL device.

The graphs shown in Fig. 2 give typical exposure times for EL devices used with different types of film. Note that lamp is operated well below rated voltage, thus assuring long life.

It is also possible to use an EL binary dot matrix to place binary-coded information on the film. In this application, the high operating speed of Sylvania EL devices allows the display to keep up with rapidly changing data.

The ease with which EL displays can be modified to meet particular application needs means that Sylvania probably has the answer to your recording problems. Talk to our engineers and you'll find out.

CIRCLE NUMBER 305

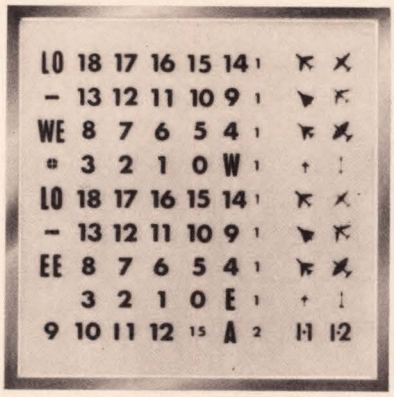


Fig. 1. High-density display using EL light with overlay.

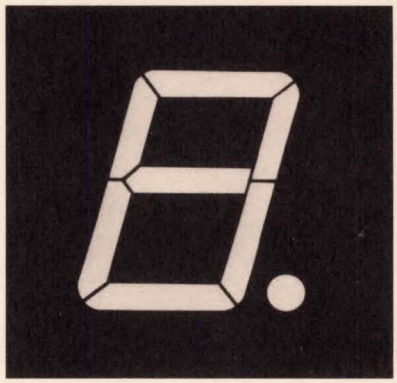


Fig. 2. Numeric EL display can be changed quickly for recording on film.

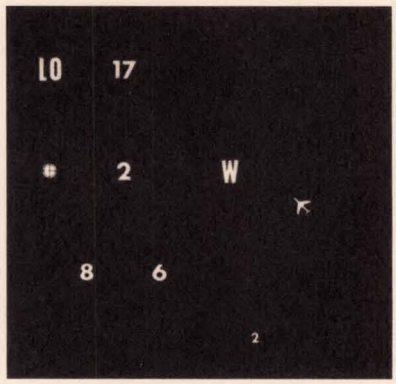


Fig. 3. X-Y matrix EL display can have selected segments illuminated.

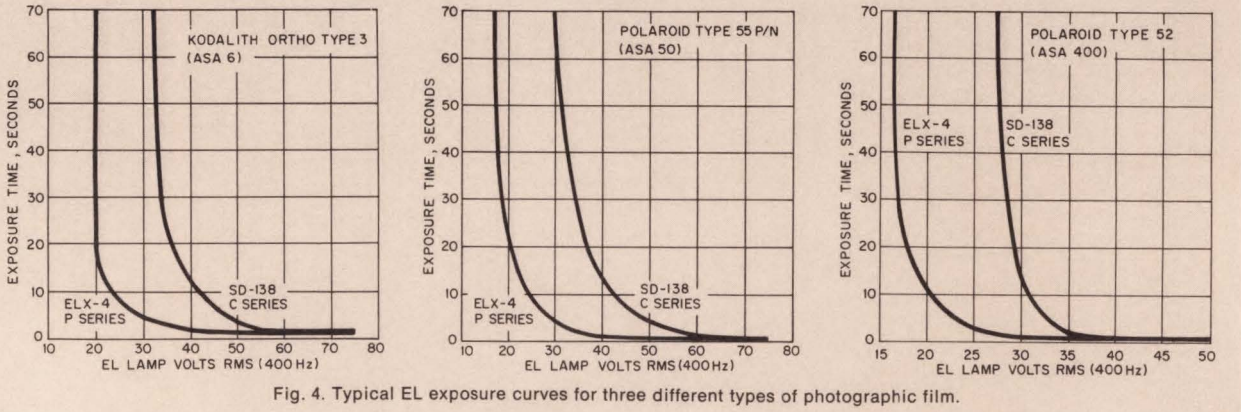


Fig. 4. Typical EL exposure curves for three different types of photographic film.

We've solved the noise problem in avalanche diode oscillators.

New Sylvania design combines the advantages of solid-state construction with noise levels of a klystron.

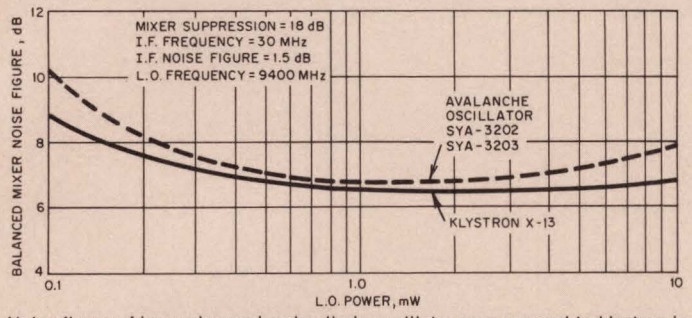
A combination of careful diode processing and improved circuit design has knocked 10 to 15 dB off the noise figure of typical avalanche diode oscillators. The measured noise figure of a balanced mixer using a Sylvania SYA-3202 local oscillator is within a fraction of a dB of that obtained with a klystron. (Fig. 1.) No filters, coupled cavities or other external circuits are used in the new design.

The SYA-3202 (waveguide) and SYA-3203 (coaxial) oscillators are designed for use as local oscillators, parametric amplifier pumps and other applications requiring low AM noise. The reduction in AM noise-to-carrier ratio is obtained over a broad range of frequencies away from the carrier.

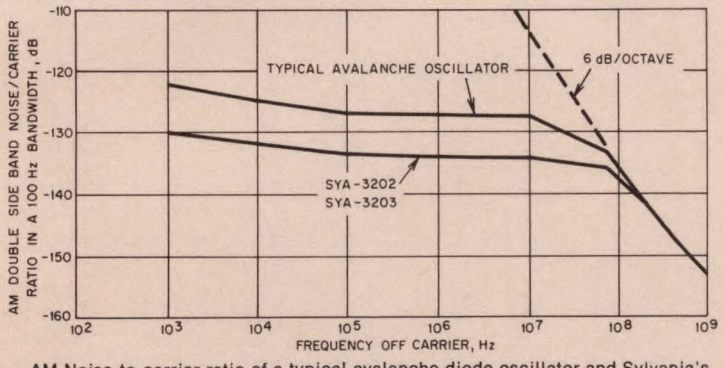
The AM noise-to-carrier curve for a typical avalanche diode oscillator and for a Sylvania low-noise oscillator are shown in Fig. 2.

The X-band oscillators are available in power outputs up to 50 mW, and can be used as a direct replacement for klystron oscillators in many systems.

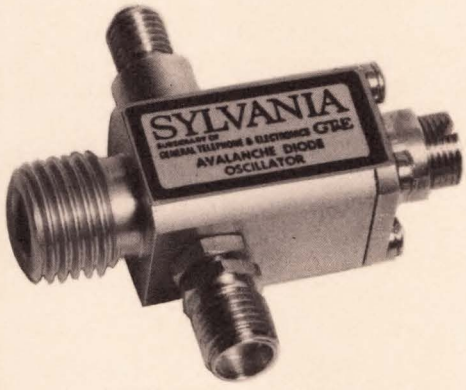
CIRCLE NUMBER 306



Noise figure of low-noise avalanche diode oscillator as compared to klystron in X-band local oscillator application.



AM Noise-to-carrier ratio of a typical avalanche diode oscillator and Sylvania's low-noise avalanche diode oscillator.



Avalanche diode oscillator is available in both coaxial and waveguide configurations.

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Meet tough TV set competition by standardizing.

Standardization is always a valuable tool in cutting production costs. It is especially valuable today where the pricing of black-and-white TV sets is an important marketing edge in meeting foreign competition.

Obviously, a key cost element in any black-and-white TV set is the picture tube. When you pick a standard tube for your design, you get the benefits of high-volume production and, as a result, lower cost. What is the lowest cost tube? In the 17″ to 23″ sizes, we recommend a tube with the following specifications:

Heater: 6.3 V, 450 mA.
Accelerator Grid (G2) voltage: 35 V.
Implosion protection: Kimcode with mounting ears.
Neck diameter (16″ and above): 1⅛″.
Anode rating: 12 kV min., 23 kV max.
Button location: short side.
Deflection angles: 16″ to 22″ —114°
23″ —110°

But keep in mind that locking into a standard tube does not have to mean a loss of flexibility in your designs. Because Sylvania is a high-volume producer of many tube types, modifications of standard tube lines can be made at slightly higher cost.

For example, do you need a low-drain filament for a battery portable? We'd suggest that you replace that 6.3 V heater with a 12.6 V, 72 mA, or 12.6 V, 150 mA unit. From Sylvania you can do it with off-the-shelf availability, and it'll cost only pennies more.

What about G2 voltage? For lowest cost and low B+ requirements you can't beat the tried and true 35 V variety. But again, for only pennies more you can select a unit tailored to meet your requirements from our library of electron guns. And again, this is an off-the-shelf delivery with no design or tooling time, or costs. Whether it be 35, 50, 100, or 300 volts, we have the gun ready to go.

For implosion protection we suggest Kimcode, with or without mounting ears. Because we manufacture a wide variety of implosion protection systems every day, we can also offer PPG bonded, T-band, and Shelbond systems at only slightly greater cost.

To sum up, you can meet foreign competition on an equal footing by standardizing your tube lineup. In addition, Sylvania's standard line of 12″, 15″, 17″, 20″, 22″ and 23″ B & W tube offer styling features not yet available in all foreign types. These features include the bold modern "flat-face, square-corner" look that spells the "in" styling of up-to-the-minute design.

J. L. Dangremond
Product Sales Manager

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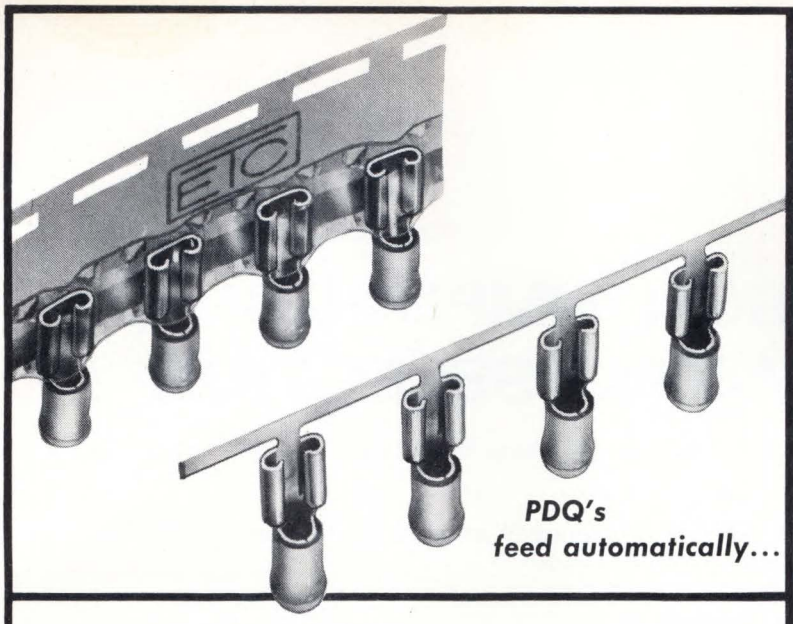

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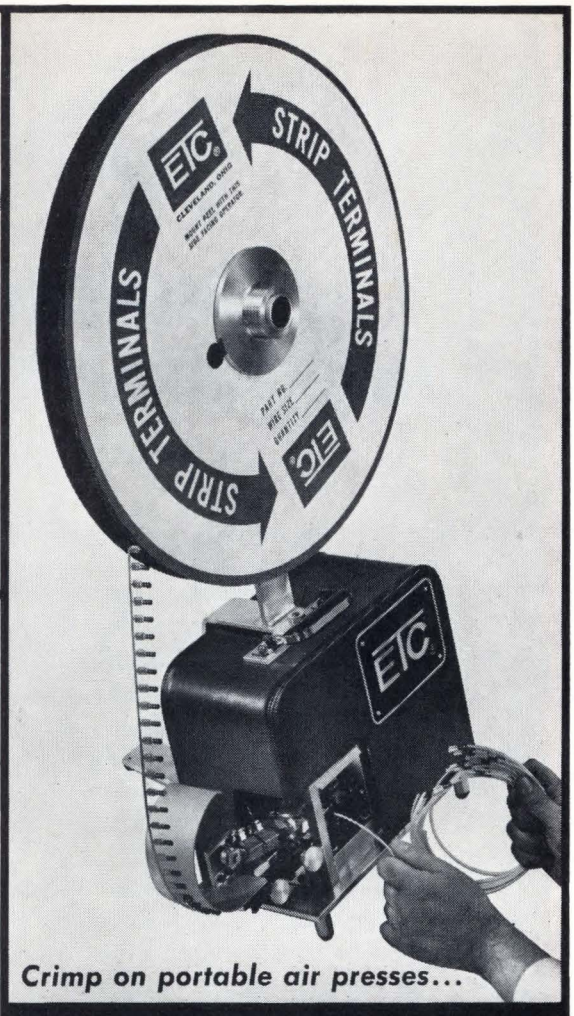

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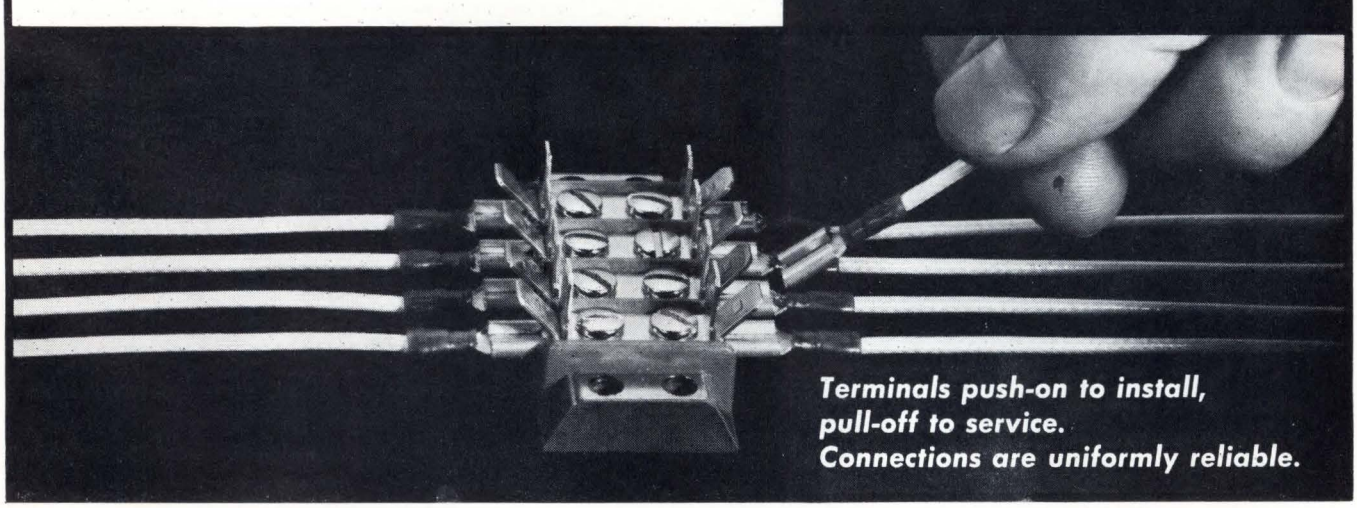


Terminals push-on to install, pull-off to service. Connections are uniformly reliable.

CIRCLE NO. 35

COMPARISON SIMPLIFIES MICROPACKAGING SELECTION

MICHAEL V. BOND, National Semiconductor Corp.

Many techniques are available to perform high-density packaging of semiconductor chips. The selection of which technique to use depends largely on environmental requirements and on available handling and mounting equipment. A survey of eight methods compared by performance capabilities, mounting and handling, relative size and relative cost, and availability provides the background needed to select the right technique for the next application.

SUMMARY

There are several major factors involved in deciding which micropackaging concept is best suited for a given application. Other factors need to be taken into account with regard to choice of substrate materials, metallization and passive components. What might not be quite so apparent is the effect of active device yield losses because of unsatisfactory mounting, lead bonding and mishandling on the eventual assembled substrate yield. Taking the example of a substrate having eight mounted active devices, the following will result:

Active Device Yield	Assembled Substrate Yield
90 percent	$(0.9)^8 \times 100 = 43$ percent
80 percent	$(0.8)^8 \times 100 = 17$ percent
70 percent	$(0.7)^8 \times 100 = 6.5$ percent

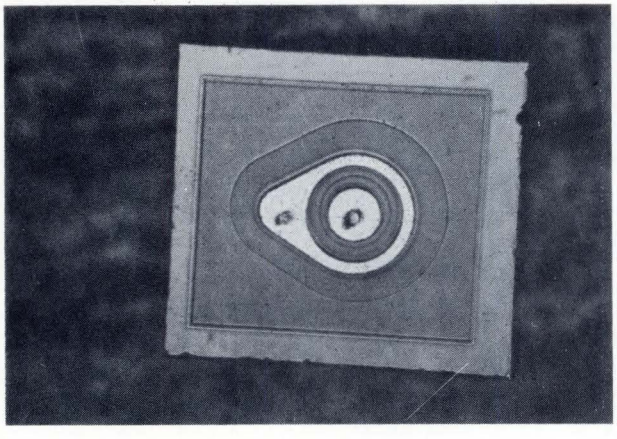
In some cases active devices can be replaced on the substrate but the rework cost may be prohibitive or reworking may endanger the stability of passive components on the substrate. Minimization of active device losses during assembly cannot be overemphasized as one of the most important economic factors controlling use of micropackaged semiconductors.

Michael V. Bond is a product marketing engineer with National Semiconductor Corp., giving technical backup to its field force in the introduction of new products. He has lived in the U.S. 1 year and was 3 years previously with Transitron in England. Bond was awarded a Higher National Certificate from Southeast London Technical College, England.

BASIC SEMICONDUCTOR DICE

These have the advantage of maximum packing density. Almost any passivated die can be used, allowing the complete spectrum of semiconductor devices to be included in hybrid circuits.

Except for power-dissipation considerations a die is capable of electrical performance equal to that of the same die in a conventional package. In fact high-frequency performance can be superior with the die because lead inductance is less and header capacitance is eliminated. However, electrical performance depends on the user's ability to perform die mounting and lead bonding.



Mounting and Handling

For die mounting a gold silicon eutectic bond normally is used, although conductive epoxies have been successful. Since fluxes are not used, the die must be "scrubbed", either manually or ultrasonically, on a preheated mounting surface to get a reliable ohmic die mount. The die mount has a finite resistance that can increase collector-emitter saturation voltage. Use of a solder preform during mounting minimizes the die mount resistance. The preform usually is gold or gold doped with arsenic or antimony. Die power dissipation also is dependent on the quality of the die mount.

Lead bonding is either by ultrasonic or thermal com-

Several major factors are involved in deciding which micropackaging technique is best for a given application. Most are evaluated and compared here to help simplify the selection.

pression techniques using gold or aluminum wire, the diameter of which depends mainly upon the size of the die metallization areas and technique used. For medium-power transistor dice the current-handling capacity of the lead wire is a controlling factor.

Both die mounting and lead bonding must be carried out in a carefully controlled, inert atmosphere, although this is not essential for ultrasonic lead bonding.

Vacuum probes are used for handling the dice, although this should be minimized and a cleaning operation should be performed as soon as possible prior to mounting.

Relative Size

Although dice are capable of the highest packing density, this density is dependent on the mounting and bonding techniques used; i.e., mounting pads must be large enough to allow for "scrubbing" and lead bonds must be "looped" from the die to substrate to eliminate chances of shorting. Dice vary in size according to function, but are typically 15 by 15 mils for a logic transistor to 30 by 30 mils for a medium-power type.

Relative Cost and Availability

Die cost is much lower than for other microsemiconductor packages, but in most cases this advantage is offset by relatively costly handling, mounting and bonding equipment in addition to the cost of training operators. Also, only certain dc parameters can be probed by the supplier and dynamic parameters are virtually impossible to test in slice form. However, these untested characteristics are guaranteed with some confidence by assembling and testing in conventional packages a sample of dice from the same process.

'FLIP CHIPS'

"Flip Chips"* were introduced to eliminate the problems of die mounting and lead bonding bare chips. They eliminate lead wire bonding with a face-bonding approach. Here all three (collector, base, emitter) contacts are bonded to the substrate simultaneously.

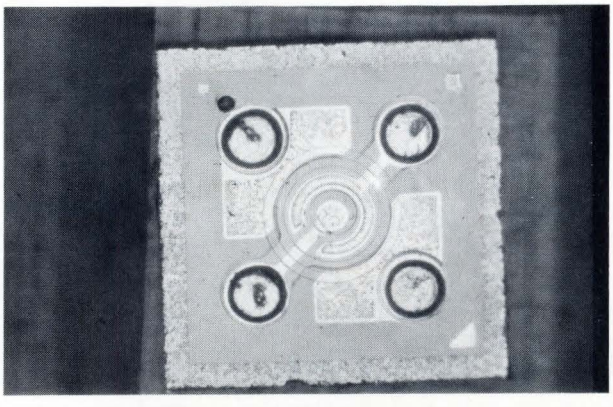
Performance Capabilities

Because of the added resistance that results when the collector contact is brought from the back to the face of the chip, the collector-emitter saturation voltage is higher than for a conventional die of similar size and geometry. The dissipation capability of the "Flip Chip" is lower than the conventional die because the contact areas are considerably smaller. If the chip uses over-oxide metallization to increase contact area, parasitic capacitances increase. In applications where the low thermal resistance of a substrate must be used to minimize local "hot spots", the "Flip Chip" is at a disadvantage when compared with a basic die.

Mounting and Handling

Either solder reflow or ultrasonic mounting is done,

INTERSIL SEMICONDUCTOR.



depending on the types of materials used for the "Flip Chip" contacts and on substrate metallization. The fact that all bonds are made simultaneously results in considerable simplification and reduction in mounting/bonding time compared with that for conventional dice. Unfortunately, the bond quality cannot be determined from a visual examination.

The choice of materials for substrate and/or metalli-

**Trademark of Digital Equipment Corp.*

(Continued)

Micropackaging *(Cont'd)*

zation is limited because coefficients of thermal expansion differ. This problem is accentuated for "Flip Chips" because of the rigid finished assembly.

Handling "Flip Chips" is not very different from handling conventional dice. Electrical testing of "Flip Chips" is easier since it is possible to test them without resorting to probing methods.

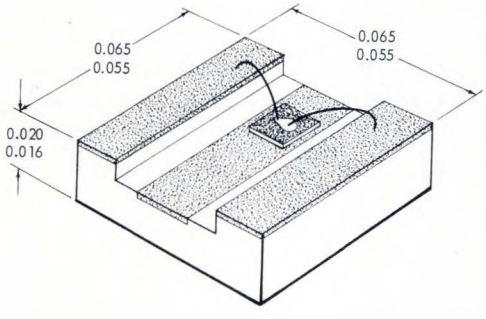
Relative Size

Generally, "Flip Chips" are no larger in area than basic semiconductor dice. Also, because bonding pads need not extend beyond the chip periphery, the substrate area can be used more efficiently, resulting in extremely high-density packaging. The thickness of a "Flip Chip" normally is greater than a conventional die, because of contact "bumps" that raise the bulk of the chip from the substrate. These bumps are necessary to align the "Flip Chip" on the substrate.

Relative Cost and Availability

There appears to be no reason why "Flip Chips" should cost more than basic dice. However, there are still very few semiconductor suppliers who offer "Flip Chips" as a micropackaging alternative. There are two basic problems, the first being the difficulty in maintaining the basic die performance combined with the need for the collector contact to be on the chip face. The second problem is that each "Flip Chip" must be designed for optimum performance. This means that considerable engineering effort is needed before a manufacturer can offer a reasonably broad range of devices. The first "Flip Chips" were made some 4 years ago, yet industry still cannot offer a broad product range of "Flip Chip" devices.

CERAMIC CHANNELS



The ceramic channel evolved as a result of attempts to completely eliminate the need for the user to perform bonding operation directly on the semiconductor die. The channel, a U-shaped piece of alumina ceramic, carries three gold stripes, about 0.2 mil thick. The die is mounted eutectically on the stripe in the bottom of the channel and the base and emitter connections are made, either by thermal compression or ultrasonic wire bonding, to two stripes on top of the channel.

Performance Capabilities

Since the dice used are standard geometries, electrical performance is comparable and is not in danger of degradation since the user is not required to bond directly to the die. Power-dissipation capabilities are excellent because of the high thermal conductance of the alumina ceramic.

Mounting and Handling

The channel normally is mounted by the use of thermally conductive, electrically isolating epoxy. This and the ceramic isolation allow the channel to be mounted across metallized conductors on the substrate. The thermally conductive epoxy results in efficient heat transfer from the channel to the substrate. Bonding from the emitter, base and collector of the channel is by thermal compression or ultrasonic wire-bond methods.

Because the channel is larger than the basic die and it is relatively immune to damage by mishandling, it can be handled with tweezers or a vacuum probe. Prior to incoming inspection and mounting, the channel should be washed to remove any contaminant that may have accumulated on the die surface. Location on the substrate is achieved by relatively simple jigging.

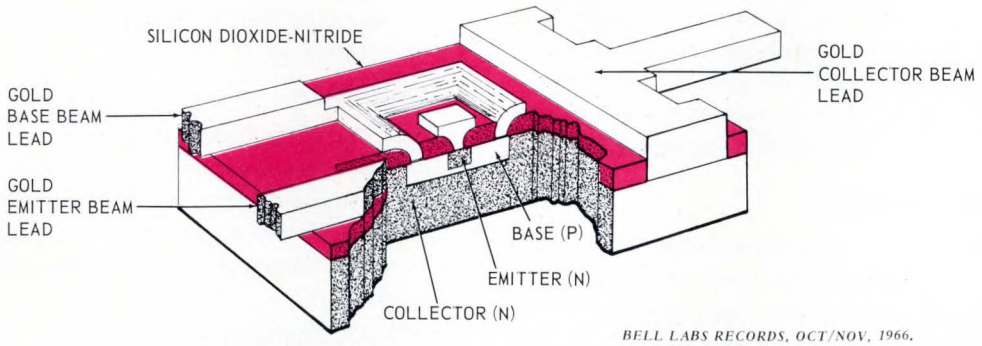
Relative Size

The size of the normal channel used for transistor die is 0.06 sq in, 0.018 inch high. Although this is somewhat larger than the basic die, its use results in considerable simplification of handling and bonding.

Relative Cost and Availability

Since both die mounting and lead bonding are performed by the supplier, the cost per channel approaches that of the JEDEC TO-18. However, this includes the protective package and guarantees of electrical performance on parameters that cannot be tested in dice form. Also, considerable cost savings are possible because of the ease of mounting and handling. Several manufacturers now supply channels using dice that cover a broad spectrum of semiconductor devices.

BEAM-LEADED CHIPS



BELL LABS RECORDS, OCT/NOV, 1966.

Chips with beam leads can be considered a variation of the "Flip Chip" in that they are also capable of being bonded face down. Essentially, they are manufactured in the same manner as "Flip Chips". However, instead of having contact "bumps", rectangular cross-section leads, usually of gold, are built up on the chip contact areas in the same plane as the surface of the chip.

Performance Capabilities

Here, as with the "Flip Chip", the collector contact must be brought to the chip face, resulting in the same type of performance limitations. However, since the beam-lead chip also can be mounted face up, it is capable of thermal characteristics similar to the basic semiconductor die. This is true if a suitable thermally conductive bonding agent is used between chip and substrate.

Mounting and Handling

Compared to the "Flip Chip", the beam-lead chip is more flexible since other bonding techniques can be used. Solder reflow is not recommended because gold is soluble in conventional solder. Thermal compression bonding, parallel gap welding and a technique known as thermal pulse bonding all have been used successfully. Thermal pulse bonding uses short-duration electrical energy as in welding except that welding current does not pass between the lead and substrate metallization. Handling is simpler than either conventional dice or "Flip Chips" because beam-lead chips can be supplied in strip form, which lends itself to automatic feed and bonding. However, extended beam leads, normally of the order of 1 mil in width, are fragile and are difficult to handle manually, even with vacuum probes.

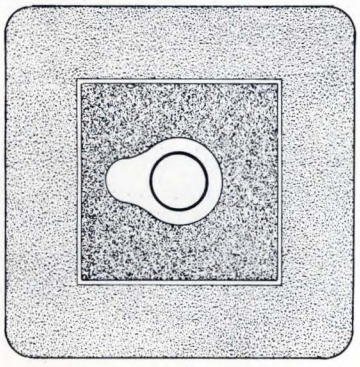
Relative Size

Because beam-lead chips are similar in size to conventional dice, they are capable of equal packing density. Since bonding is normally performed at the chip periphery, efficient use of substrate area is possible.

Relative Cost and Availability

As with "Flip Chips", ultimate cost should be little higher than for basic semiconductor dice. However, even fewer sources are available. Engineering problems necessitate complete redesign of existing dice, as with "Flip Chips", although problems with expansion coefficients should be less.

'KOVAR' OR MOLY-TABS



0.040 x 0.040

"Kovar"* of Moly-Tabs consist of a conventional die mounted on either a "Kovar" or molybdenum tab to eliminate the need for die mounting by the user. Earlier attempts to supply "Kovar" tabs with leads attached to base and emitter areas resulted in problems because of the extreme fragility of 1-mil-dia leads. Success would have given the user a micropackage without the need for any bonding at the chip.

Performance Capabilities

The use of a relatively large (approximately 40 by

Trademark of Westinghouse.

(Continued)

Micropackaging *(Cont'd)*

40 mils) electrically and thermally conductive tab enables the basic die to dissipate heat efficiently by heat conduction to the substrate. Electrical characteristics are similar to the basic die and the elimination of die mounting by the user considerably reduces the chance of electrical characteristics degradation.

Mounting and Handling

Reflow soldering of the tab to the substrate is feasible and can be performed at lower temperatures (220°C) than conventional die mounting (370°C). Mounting with conductive epoxies also has been used successfully. Either method results in low-resistance bonds that do not cause any appreciable increase in collector-emitter saturation voltages. Lead bonding from the base and emitter areas to the substrate metallization is done by either thermal compression or ultrasonic techniques. However, excess pressure or excess heat (in the case of TC bonding) can damage the active regions of the die. Handling normally is done by vacuum probes.

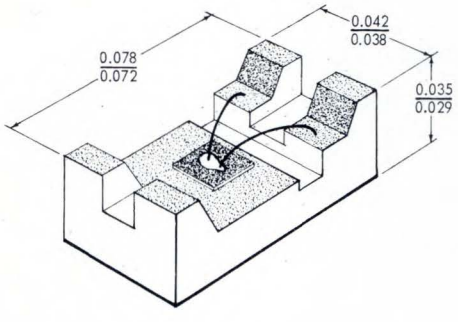
Relative Size

"Kovar" or Moly-Tabs generally are larger (40 by 40 mils) than the dice mounted on them and therefore do not use substrate area as efficiently as dice or face-bonded chips. However, the ease of mounting should offset this disadvantage except where packing density is critical.

Relative Cost and Availability

"Kovar" or Moly-Tabs are somewhat higher in cost than basic dice. Their availability is good since several semiconductor manufacturers are prepared to extend their die-mount facilities from conventional headers to tabs. Therefore, complete coverage of the semiconductor spectrum is available.

'LIDS'



The "LID"*, or Leadless Inverted Device, evolved as a modified version of the ceramic channel. Basically, instead of the base and emitter leads being bonded to the tops of the lands, the lands are stepped; the steps carry the lead bonds and the tops of the lands are used for mounting on the substrate. The third land, which is split for convenience of manufacture, carries gold metallization, which is an extension of that on which the die is mounted. Thus, all connections are brought to one face of the package and it may be mounted "face down", eliminating the need for lead bonding by the user. The inside of the channel is normally filled with epoxy to protect the die and lead bonds.

A recently introduced variation of the "LID"—the PILL package, is larger and circular in shape. It is more easily aligned and should lend itself to use in consumer applications because of lower projected cost.

Performance and Capabilities

As with the basic channel, standard dice are used. Therefore, electrical performance of conventionally packaged devices is available. The standard "LID" allows use of dice up to 28 mils square, although packages are available that are large enough in area to allow the mounting of integrated-circuit chips. Dual "LIDS" are available for mounting dual transistor dice. Because of the excellent thermal properties of the alumina ceramic used for the package, thermal tracking is equal to or better than that achieved in many conventionally packaged dual transistors.

Since the "LID" can be bonded to the substrate by using relatively low-temperature methods, risks of parameter degradation during bonding are virtually eliminated. The lands are approximately 12 by 15 mils in area, insuring efficient heat transfer to the substrate. Tests have indicated that the substrate is the limiting factor when considering power-dissipation capability of the "LID".

Mounting and Handling

The "LID" normally is mounted by solder reflow methods that only require temperatures of around 220°C. For highest-reliability bonds both the substrate pads and "LID" should be pretinned prior to heating the substrate pads for reflow. Fluxing is mandatory. Bond quality can readily be determined by

**Trademark of Amperex Electronic Corp.*

visual examination of the solder fillet between "LID" and substrate after reflow. Another somewhat simpler mounting method is to cover the substrate pads with flux-loaded solder paste. The "LIDS" then are aligned in a jig and pressed down on the solder paste. No pretinning is necessary and the bonds are made merely by heating the substrate to 220°C.

All of the active devices on a substrate can be bonded simultaneously after the "LIDS" have been positioned. Any slight misplacement is corrected during reflow since the surface tension of the solder tends to pull the "LIDS" into alignment on the substrate mounting pads. The process is so simple that in most cases it has been possible to eliminate optical aids for the operator during mounting. To reduce the time needed for pretinning "LIDS", conventional wave soldering can be used.

Relative Size

The "LID" now accepted as an industry standard measures 0.075 by 0.04 by 0.032 inch high. In the majority of cases the reduction in packing density, compared with that for conventional dice, is more than offset by the extreme ease with which handling and mounting operations are performed. The multiple "LID" used for more than one dice at a time maintains the 0.075- and 0.032-inch dimensions, has the 0.40-inch dimension extended and has more mounting feet.

Relative Cost and Availability

The "LID" costs approximately the same as a channel of similar electrical performance that approaches the price of the TO-18. Since all die and lead bonding is performed by the supplier, the "LID" offers excellent value. Price projections indicate that the "LID" should cost little more than a conventional TO-18 or TO-5 packaged device of identical electrical performance. This projection is accurate only if "LIDS" are made in sufficient quantity to enable mechanized manufacturing techniques. Electrical performance can be guaranteed as for conventionally packaged devices. Several semiconductor manufacturers now offer "LIDS" containing dice from the same generic families as supplied in conventional packages.

MICRO-TABS

The micro-tab is also known by other names, but in all cases is basically a ceramic channel with external wire leads and epoxy protection added.

Performance Capabilities

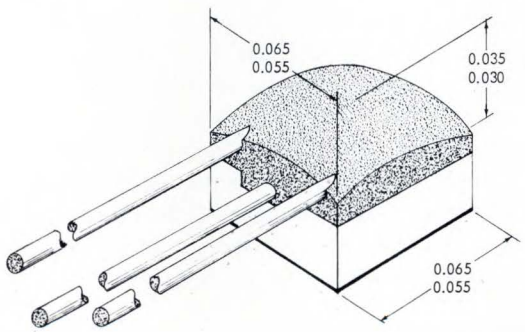
As with the basic channel, electrical performance of the micro-tab is equal to that of the conventionally packaged die. Power dissipation in free air is generally 150 Mw maximum, although it can be considerably improved by bonding the ceramic face of the package to the substrate with a thermally conductive epoxy. If the epoxy is electrically insulating, the package can be mounted across substrate conductors.

Mounting and Handling

The normal version of the micro-tab has 5-mil-dia wire leads of gold-plated "Kulgrid"*—a nickel-clad copper wire of exceptional strength for its small size. This wire is ideally suited for bonding by regular lead/-tin soldering techniques. It also is magnetic, which allows magnetic handling tools to be used.

Some manufacturers supply gold-leaded micro-tabs. These are not suitable for soldering by normal methods, since gold is soluble in lead/tin solder. These leads normally are mounted by welding to the substrate.

*Trademark of Hillcross Co., Inc.



Regardless of the lead material, the leads normally are welded to the metallized lands of the ceramic prior to epoxy coating by the manufacturer.

Relative Size

The micro-tab usually is 60 mils square by 32 mils thick with all three external leads extending from one side of the package. Substrate area utilization can be as efficient as for the ceramic channel, depending on how the user mounts the package.

Relative Cost and Availability

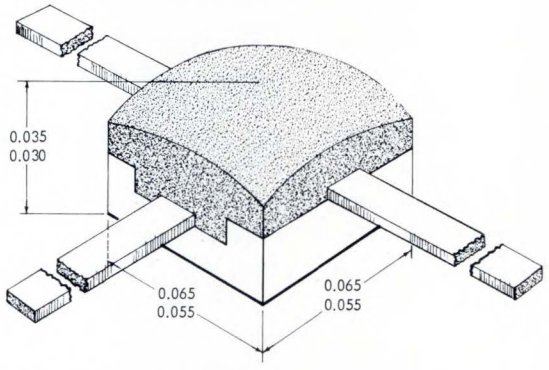
Cost of the micro-tab is somewhat higher than the channel because of epoxy encapsulation and provision

(Continued)

Micropackaging *(Cont'd)*

of external leads. However, since conventional soldering methods can be used for mounting, the micro-tab is well suited for use in consumer applications where existing soldering facilities can readily be adapted. Also, epoxy encapsulation allows handling precautions to be minimized. Several manufacturers supply micro-tab transistors, usually containing dice for use in low-level amplifiers. However, there is no reason why dice up to 30 by 30 mils cannot be supplied if the application and demand warrant.

'MICRO-T-TABS'



There are several versions of "Micro-T-Tabs"** available. All consist basically of a body from which ribbon leads extend in a T-configuration. There have been attempts to supply hermetically sealed packages by the use of ceramic, glass or glass-frit cases. None of these has been completely successful and no supplier presently guarantees his "Micro-T-Tab" to be fully hermetic. The idea behind the "Micro-T-Tab" originated with the registration of the JEDEC TO-50 and TO-51 packages. There are several sources for packages similar to the TO-51 outline, some being molded and some consisting of epoxy-filled cases. "Micro-T-Tabs" of smaller size are available, some of which make use of the ceramic used for the channel package. Ribbon leads are welded to the metallized areas of the ceramic and epoxy covers the entire unit similar to the micro-tab.

Performance Capabilities

Electrical performance is similar to that obtained from conventionally packaged devices. Power dissipation is from 150 to 225 Mw in free air, according to the size and type of Micro-T-Tab. The ceramic-based version can be epoxy-bonded to the substrate, which increases heat transfer and permits a more uniform temperature distribution across the substrate.

Mounting and Handling

The gold-plated "Kovar" ribbon leads to the Micro-T-Tab allow either conventional or reflow soldering or welding techniques to be used for bonding to the substrate. Alignment of the package on the substrate is relatively simple, stemming from the T-configuration lead layout. The ceramic-based version has the added advantage that the top and bottom of the package are easily identified (one being epoxy and the other being ceramic), thereby eliminating any ambiguity in lead connection. Handling is straightforward as the ribbon leads are robust and suitable for magnetic handling if required.

Relative Size

Micropackages, having T-configuration leads, vary in size, depending on the type of construction, from 60 mils square by 32 mils thick for the ceramic-based version to 150 mils in dia by 60 mils thick for the TO-51. Lead thickness is normally about 5 mils with close tolerance control to permit consistent welds where this mounting method is used. Lead width varies between suppliers from about 35 mils to 60 mils.

Packing density is necessarily dependent on the type of Micro-T-Tab used, but it can be equal to that of the channel.

Relative Cost and Availability

Cost is similar to that for the micro-tab and is somewhat higher than for conventional devices in large quantities. Availability is good since several manufacturers now offer a Micro-T-Tab package containing dice from most generic families of conventional TO-18 devices. Package sizes differ from one supplier to another as do the positions of collector, base and emitter connections, although the T-lead configuration is a common factor. □

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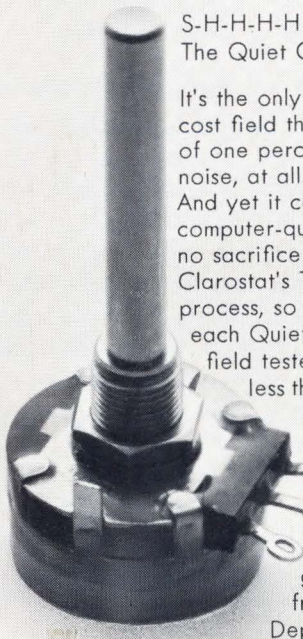


CLAROSTAT

INSTRUMENTING FOR AUTOMATED SINGLE-SHOT MEASUREMENT

What sort of circuit blocks are needed to set up a useful single-shot measuring system? The relative simplicity of a practical setup may surprise you.

THAD DREHER, E-H Research Labs.

As might be expected, single-shot automated measurements require completely new instrumentation approaches. Once the human operator is out of the loop, there is no longer a need to expand the time scale of events to suit the range of human perception. The basic idea of conventional oscilloscope techniques—that of translating very fast transients to a time scale the eye can use—becomes largely outmoded. Gone with it is the need for iterated excitation response cycles at high repetition rates.

Taking, to a large extent, the place of previous approaches is the single-shot sample-and-hold technique discussed in the preceding article "Why Single-Shot Measurements in the Time Domain?" (August 1968 EDN, p. 76). It is now fitting that we look into the functional blocks of instrumentation that go to make up a single-shot test system.

Instrumentation for single-shot measurements falls naturally into three functional classifications: a wideband sample-and-hold sensor for voltage, another similar sensor for time and a data-handling unit that converts the pulse-height analog from the sensors into a form suitable for storage or display.

Strobed Sample-and-Hold Voltmeter

Functioning of this voltmeter is shown by the waveforms of **Fig. 1a**. At some time in the excitation-response cycle, usually at the midpoint or other specified level of the driving step, a sync pulse is generated, defining T_o. The voltmeter accepts the sync pulse as a START command, and after a programmed delay, generates a strobe pulse during which it samples the signal present at its input. Stretching and amplifying the sample yields a pulse-height analog proportional to the instantaneous voltage V_n. This analog output is held for a period suitable for the data-handling equipment receiving the information; then the instrument is made ready for a new measurement cycle.

Measurement Cycle. As blocked out in **Fig. 2**, the voltmeter is composed of a control section and a signal channel. The control section performs the relatively

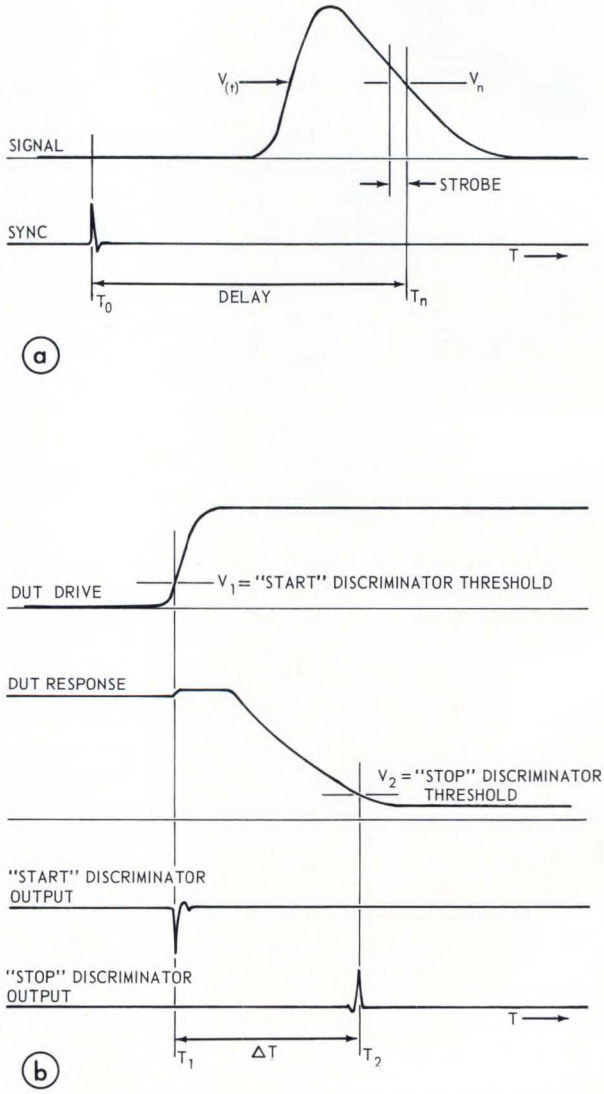


Fig. 1—**Two basic measurement problems:** (a) Measurement of instantaneous voltage V_n at time T_n after sync. (b) Measurement of time difference, ΔT, between T_1, T_2, defined in terms of discrete voltage levels V_1, V_2, on the signal waveform (or on two time-related waveforms as shown).

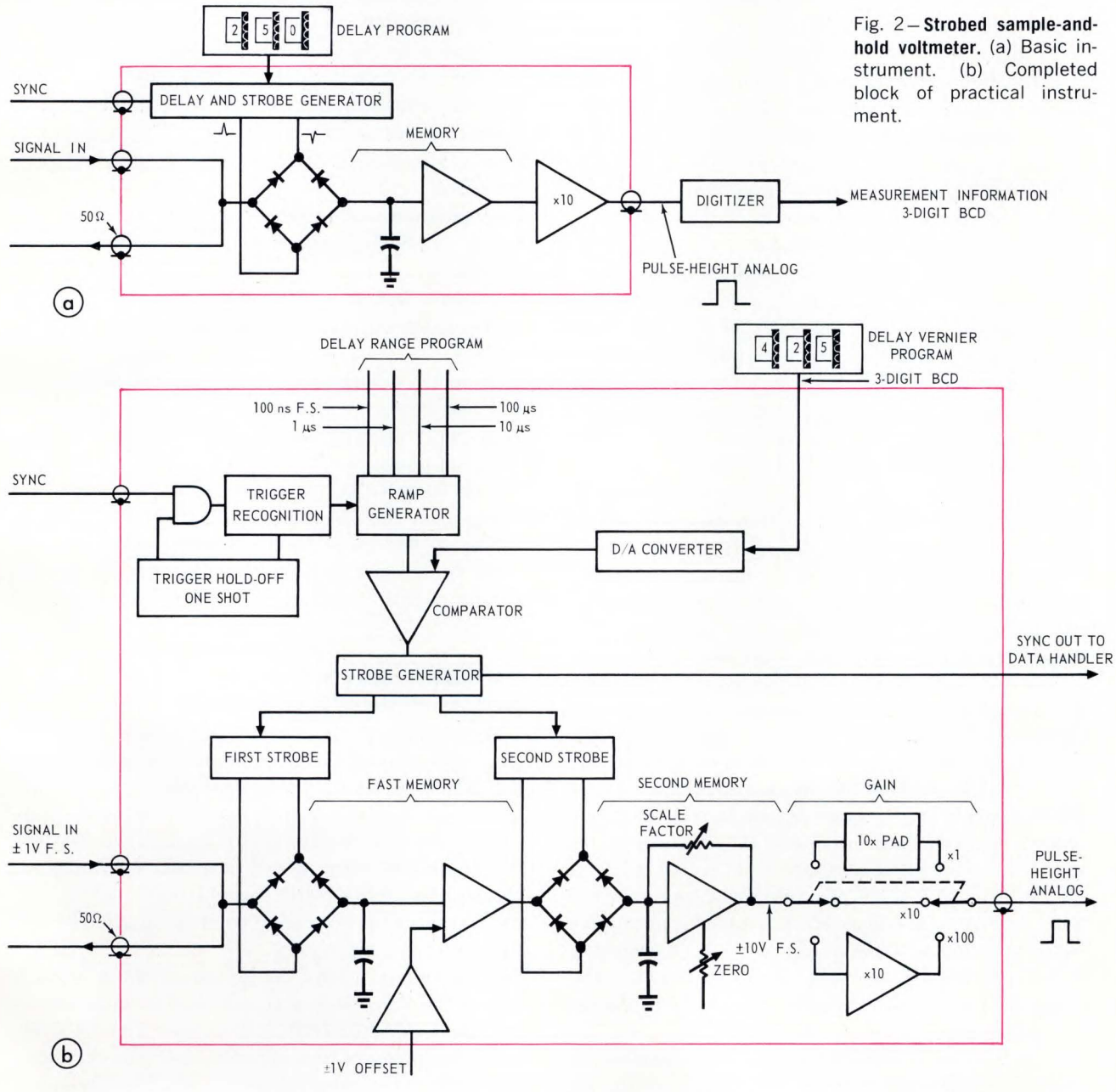


Fig. 2—**Strobed sample-and-hold voltmeter.** (a) Basic instrument. (b) Completed block of practical instrument.

Instrumenting *(Cont'd)*

simple functions of trigger recognition, converting the program information into a time delay and generating the strobe pulse at the end of the delay period. Measurement begins with a trigger command that is shaped, then used to key the delay ramp generator and the trigger hold-off one-shot. The input trigger signal must pass an AND-gate that serves to lock out the trigger channel for the period of the measurement cycle. This period, determined by the fixed constants of the hold-off one-shot, may be selected to give the data handler ample time to perform its function.

The delay generator is a ramp-generator/comparator. In it the decade ranges switch the ramp rate and the vernier program changes the comparator threshold. When the ramp reaches the comparator setting at the end of the programmed time interval, the comparator switches and triggers the strobe generator. The strobe opens the sampling gate and the signal voltage is delivered to the first memory input.

To take as little energy as possible from the input signal, the time constant of the first memory is reduced to a minimum (on the order of 0.5 ns). Output of this fast memory is stretched to the required period by a second memory, giving a duration on the order of tens of microseconds to tens of milliseconds. Zero and scale-factor adjustments are accomplished in this stage. The system gain up to this point is ten.

Output of the second memory may be switched to the output jack directly or sent through a 10X pad or X10 amplifier to give X1, X10 and X100 scale factors. At the same time that the second memory is gated, a sync pulse is delivered to the outside world, indicating that measurement information is now available.

Signal-Handling, Strobing. "Nature loves 50Ω" is the first commandment of fast-pulse engineering. To achieve bandwidths on the order of hundreds of megahertz the input section of the voltmeter is in a 50Ω feedthrough configuration. A balanced diode-bridge gate effectively isolates the signal line from the signal channel except for the strobe period. During the strobe enough energy must be extracted from the signal line to charge up the input capacitance of the first memory, on the order of 2 to 10 pF. This input time constant must be kept as low as possible, because it ultimately determines the transient response of the instrument. For this reason a second stretcher is used after the first memory, which cannot hold for the required number of milliseconds.

In any sampling system the design is a compromise between input time constant and strobe width. Together they determine sampling efficiency, which can be described as that percentage of the actual signal voltage that is held on the first memory capacitance at the end of the strobe. In low-efficiency systems (those in which the strobe is made extremely narrow) the sample is brought up to 100 percent by positive feedback that is predicated on a fixed value of input time constant. Dot-transient response in low-efficiency sampling thus becomes source-dependent because any change in effective source impedance during the strobe period is reflected as a measurement error. By reducing the input time constant to something around 0.5 ns, a strobe 4 ns wide is still eight time constants long so sampling efficiency is near 100 percent. The system in **Fig. 2** needs no positive feedback. With a relatively broad strobe of 4 ns the effective bandpass is well over 100 MHz.

Performance. An instrument using the scheme of **Fig. 2** can be designed to have the following characteristics:

- Dynamic Range: −1V to +1V.
- Measurement Accuracy: Around 0.1 percent, plus noise.
- Noise: 0.5 mV pk-pk, 95 percent of distribution.
- Strobe Positioning Range: 10 ns to 100 μs.
- Strobe Positioning Accuracy: On the order of 1 percent of program.
- Data Rate: To 1000 measurements per second with negligible baseline shift or other anomaly. Operation at 100 kHz is entirely feasible, but at this rate the limitations of diode gates begin to show in the form of base-line creep and anomalies in transient response.

Voltage-Triggered Sample-and-Hold Time-Meter

Functioning of the time-meter is shown is **Fig. 1b**. Two voltage-sensitive discriminators generate START and STOP pulses that define the time interval to be measured. In the example one discriminator is assigned to the drive pulse and triggers when the drive step reaches its programmed threshold V_1. The second observes the device response and triggers at V_2, which in this case is the 90-percent point defining TURN-ON time of an npn transistor.

Measurement Cycle. As shown in block form in **Fig. 3**, the time-meter is composed of a control section and dual START/STOP discriminator channels. The control section performs the functions of trigger recognition and hold-off, plus memory-erase. This amounts to

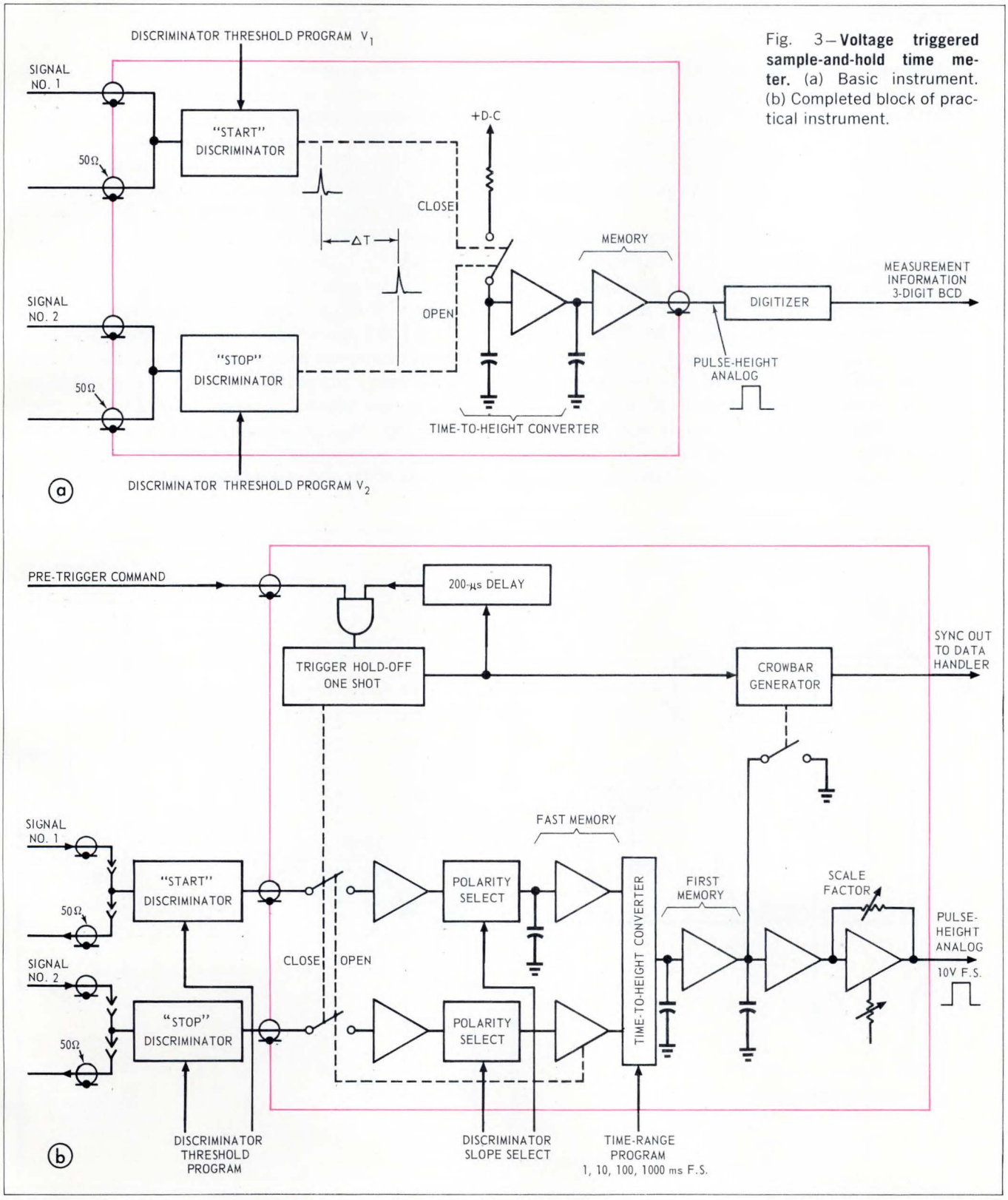


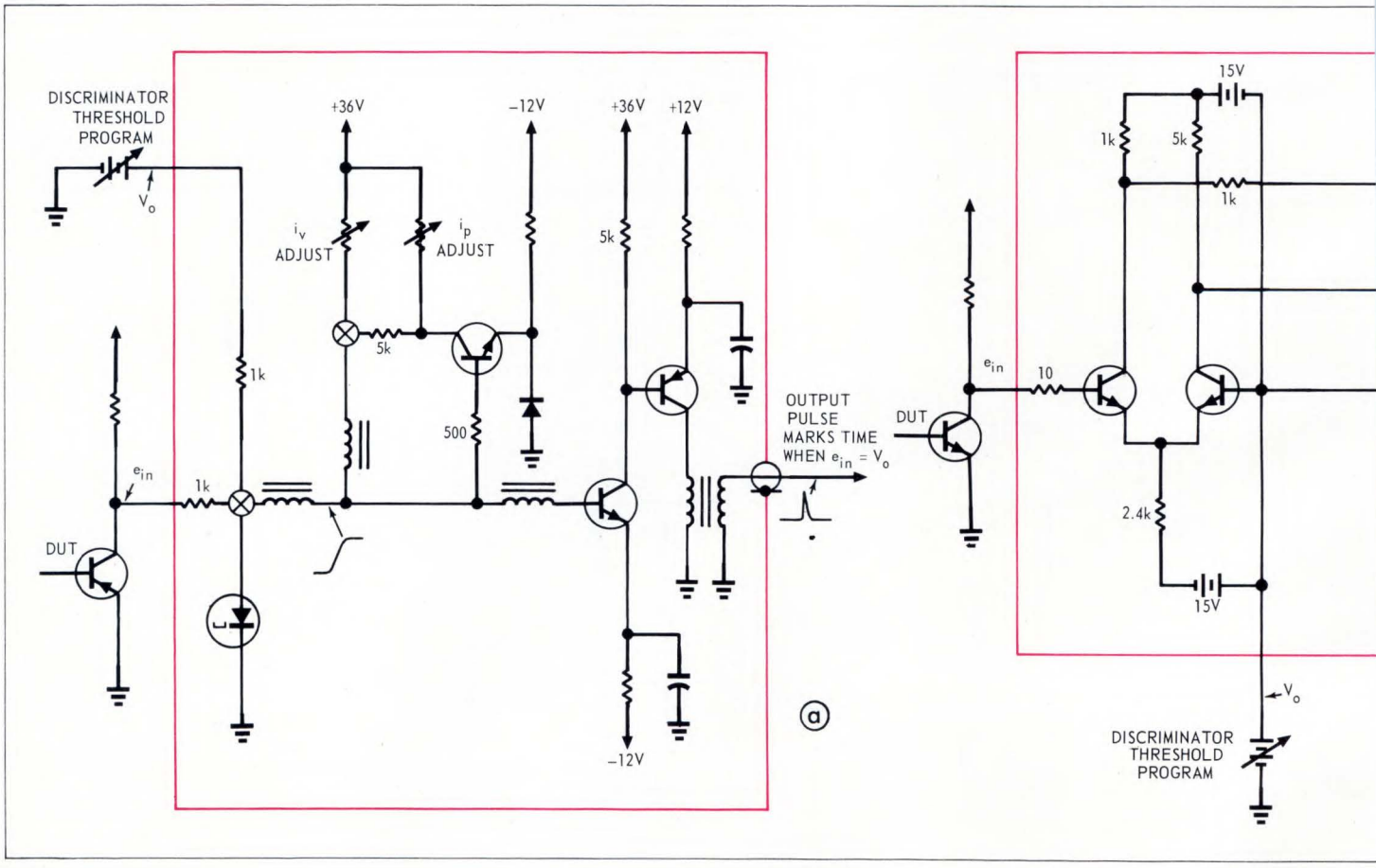
Fig. 3—**Voltage triggered sample-and-hold time meter.** (a) Basic instrument. (b) Completed block of practical instrument.

Instrumenting *(Cont'd)*

applying a shorting bar across the second memory at the end of each measurement cycle. A fundamental difference from the strobed voltmeter concept lies in the use of separate miniature sensing heads containing the two discriminators. Gating is not performed between signal line and sensor but between sensor output and the rack-mounted data converter.

Measurement begins with a pretrigger command that opens fast gates in the START/STOP pulse lines. The trigger must pass an AND-gate that locks out the trigger channel for the period of the measurement cycle, about 1.2 ms. This period is determined by a 1-ms one-shot, keyed by the trigger at the same time the fast gates are opened. When the one-shot reverts to its normal state at the end of its 1-ms period, it operates the crowbar, grounding the second memory. An additional delay of 200 μs is added in the clearing line back to the trigger AND-gate so that all circuitry has ample settling time before the next measurement is begun.

Signal waveforms passing through the discriminator trip-points generate positive polarity START pulses if the waveform is negative-going or negative polarity ones if the slope is positive. The fast memory will accept START pulses of negative polarity only. Therefore, the DISCRIMINATOR SLOPE program selects the desired START pulse by switching from straight-through to inverting operation. The first START pulse of the selected polarity is stretched by the fast memory, which controls the time-to-height converter. The START pulse begins constant-current flow into a capacitor and the associated STOP pulse shuts it off. Total charge dumped into the capacitor is determined by the time interval between the START and STOP commands. Voltage developed at the output of the first memory is therefore proportional to the time interval marked off by the discriminator output pulses.



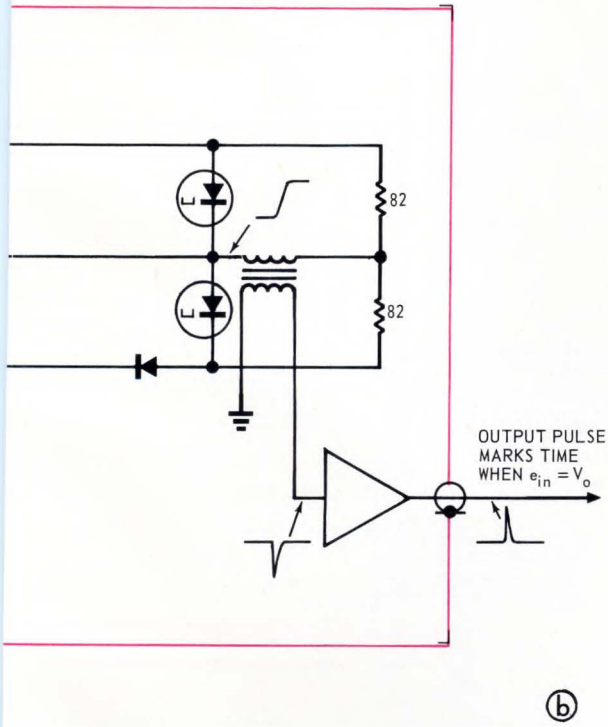
The first memory is designed to clear during the measurement cycle. To hold the measurement analog essentially constant for 1 ms, a second memory, which looks into the high impedance of an FET amplifier, is used. At this point the crowbar, (essentially a shorting switch that clears the second memory) is applied to return the output to zero.

An IC amplifier, adjusted for zero, offset and scale-factor calibration, makes up the output section. The measurement is delivered in the form of a pulse-height analog, held for 1 ms.

Discriminators. The vital element in the time-meter is obviously the discriminator that interfaces between the signal source and the measuring instrument. An ideal discriminator would present high impedance and low shunt capacitance to the signal source. It would also have a bandpass on the order of hundreds of megahertz. The design should minimize lead and lag firing, hysteresis and duty-cycle effects. It should allow quick, easy programming. It should be bipolar. That is, it should produce a marker of one polarity when the signal moves through the trip-point in one direction, and an opposite polarity marker when the signal moves in the opposite direction. There should be very little disturbance fed back to the signal line.

Two typical discriminator approaches are given in **Fig. 4**. In the first (**Fig. 4a**), a biased tunnel diode acts as the sensing element. The circuitry shows the summing of signal current and bias current at the diode, the effective translation of the diode switching point to i_o by i_p, i_v adjustment and the translation of the very fast diode-generated step to a marker pulse by means of a differentiating transformer.

Somewhat more sophisticated is the approach in **Fig. 4b**, where a long-tail-pair comparator of high-performance npn transistors serves as the recognition



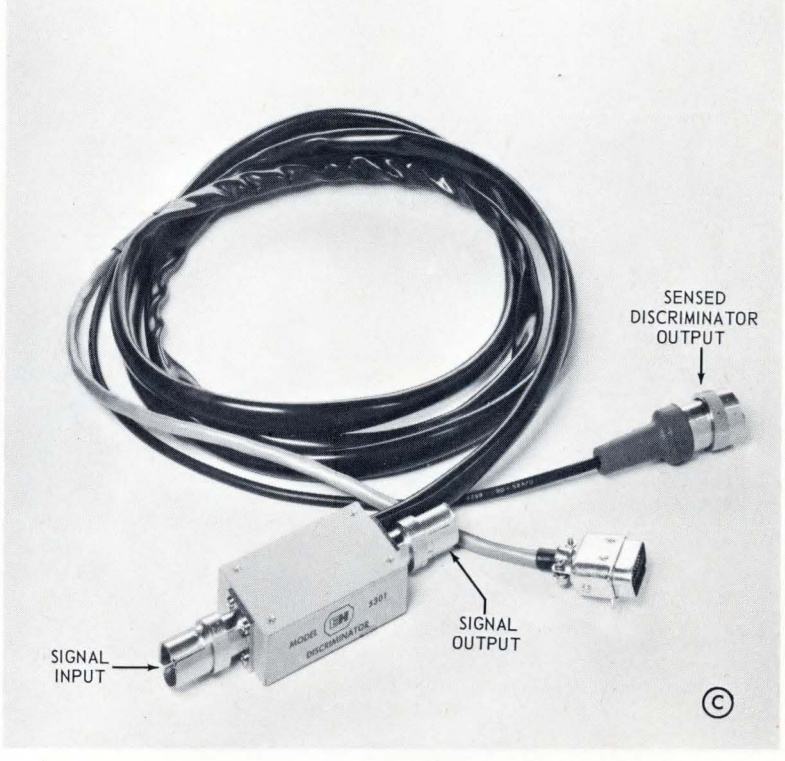


Fig. 4 – **Typical voltage-sensitive discriminators:** (a) Biased tunnel diode. (b) Emitter-coupled comparator. (c) 50Ω feedthrough packaging.

Instrumenting *(Cont'd)*

circuit. Output of the comparator is sharpened by a Goto-pair configuration of tunnel diodes, with a differentiating transformer that converts the step into a marker. The performance of this circuit is remarkable in view of its simplicity. Lead, lag and hysteresis effects are reduced to the point where measurement accuracy can be specified at better than 3 percent on waveforms moving 2V at 1V/ns. At 2V/ns the deficiencies of available measuring equipment introduce some ambiguity. The question then becomes: which is better, the single-shot discriminator or the read-off of 90 percent on a sampling scope, with its questionable dot-transient response and line structure?

Packaging. The discriminators shown in **Fig. 4** are inherently high-impedance devices with respect to 50Ω for they may be made to show 10 kΩ or more input impedance. Two basic approaches are possible: either the discriminator is placed in shunt with 50Ω transmission lines in the same manner as the voltmeter, or it is mounted on a PC card or plug-in carrier designed to be built directly into test fixture circuitry. One convenient package (**Fig. 4c**) has the sensing circuitry mounted in a 50Ω feedthrough head measuring about 1 by 2 by 5 inches. This sensing head may be plugged in in series with signal lines directly at input/output ports of test jigs and fixtures. The START/STOP pulse recognition circuitry in the mother instrument may be made relatively insensitive to cable distortion, so that remote operation at distances of 100 ft or more is feasible.

Performance. An instrument using the approaches of **Figs. 3 and 4b** can be designed to have the following performance:

- Dynamic Range: −5V to +5V.
- Bandpass: On the order of 1 GHz.
- Measurement Range: 1 ns to 1 μs full scale.
- Time-to-Voltage Conversion Accuracy: In the order of 3 percent of reading, plus jitter.
- Jitter (Noise on time axis): About 15 ps pk-pk.
- Data Rate: To 700 measurements per second.

Data-Handling

Fundamentally a data system working from either of the two sensors described must be able to accept a pulse-height analog and convert it to a form suitable for display, storage and limits comparison. One of

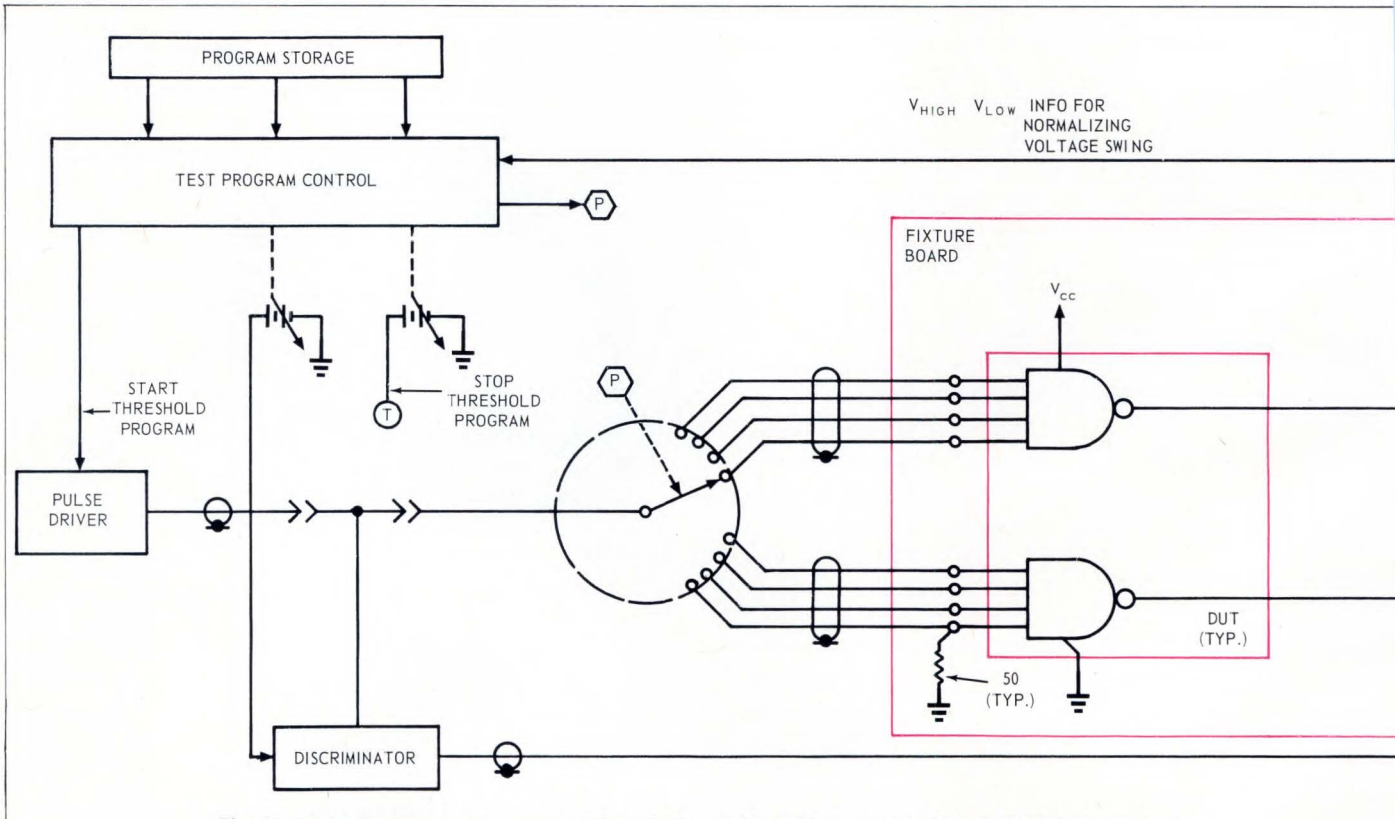


Fig. 6—**Typical system arrangement** using single-shot sample-and-hold time and voltage sensors.

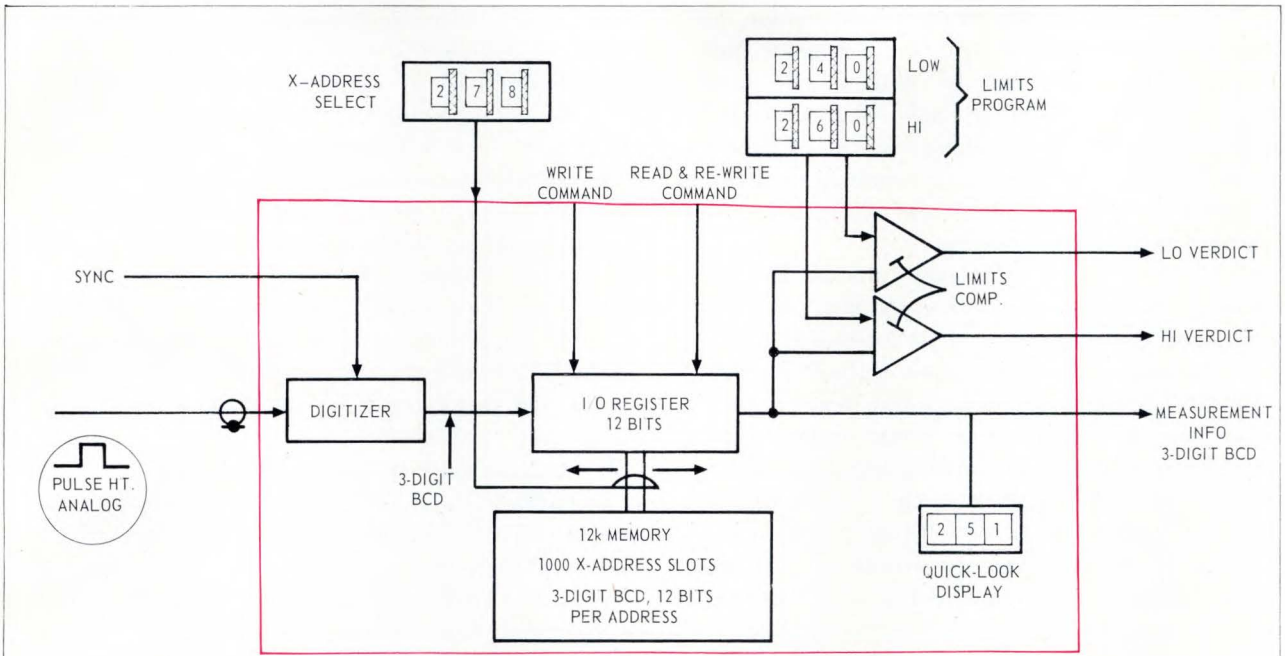
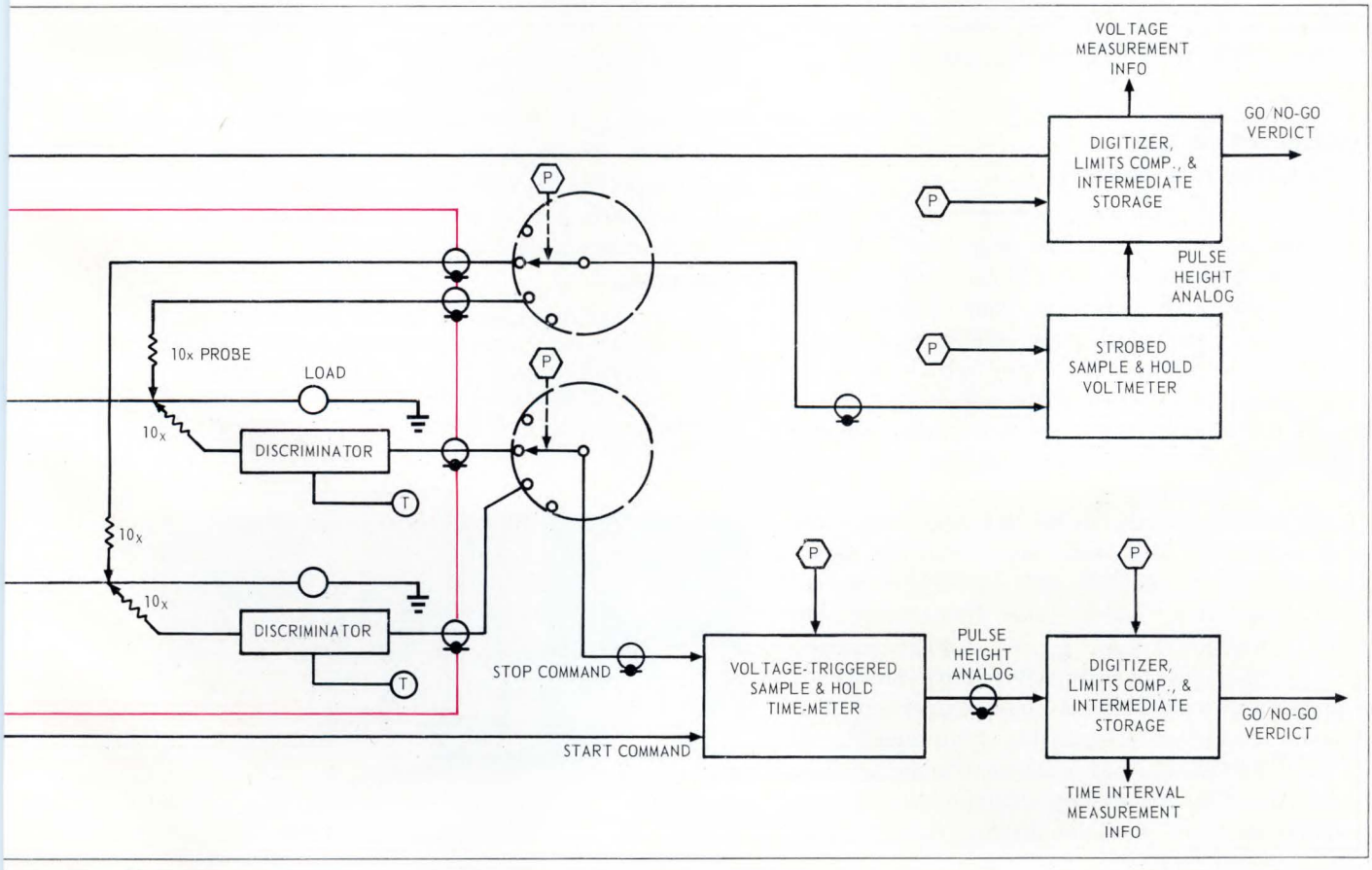


Fig. 5—**Functional block diagram** of intermediate storage system.



many possible data-handling schemes is given in **Fig. 5**. Here a fast digitizer converts the analog into 3-digit BCD that is held in a 12-bit I/O register. Measurement information can be written into intermediate storage as shown or displayed on quick-look 3-digit glow tubes. Limits comparison can be done on the WRITE cycle (within microseconds of digitizing) for automated sorters, or at any convenient time after the actual measurement process.

One of the virtues of intermediate storage with nondestructive readout is that a measurement series may be sectioned for histogram presentation by any number of run-throughs with varied limits. If the GO window is moved systematically across the distribution, a counter applied to either of the limits verdict outputs gives the information necessary for plotting histograms.

It is not immediately obvious why the 12k memory (**Fig. 5**) is arranged in the form of 1000 x-address slots with a single 3-digit y-number recorded in each slot. For the limited function described here, any standard random-access scheme of organization is suitable. But with the addition of a time-base generator, applied to step the x-address scanner at regular intervals from slot to slot, the 1000 by 1000 digital grid concept discussed in the August article becomes a reality. The instrument becomes a recorder of arbitrary waveforms of voltage as a function of time, limited only by the mechanics of the DIGITIZE/WRITE cycle.

Typical Single-Shot Measurement System

Voltmeter and time-meter sensors are shown incorporated in a simple system (**Fig. 6**) designed to make dynamic pulse tests on IC logic—in this case a dual four-input gate. The device under test is worked into specified loads, which may either be passive networks or active devices simulating actual-use conditions. Both voltmeter probe and time-meter STOP discriminator are effectively in shunt with this load and must present relatively high impedance if excessive loading is to be avoided.

A coaxial reed switch in the 50Ω input line of the voltmeter transfers it to each load in turn. The signal is probed down to the 50Ω level by built-in passive probes with 10X (or higher) ratio. This arrangement makes it possible to make V_{high}, V_{low} voltage measurements defining voltage swing for each individual gate, for purposes of normalizing or limits comparison. Measurement is digitized, compared to programmed limits and the GO/NO-GO verdict is delivered to the handling mechanism. The actual measurement is, of course, available in digital form for display, recording and normalizing purposes.

The time-meter is connected so that all START commands are derived from a single discriminator monitoring the drive pulse line, while individual high-impedance discriminators generate STOP pulses at each device output port. The input drive line is switched, in turn, to each device input port by a coaxial commutator, so that the active drive line is at 50Ω impedance right up to the test socket where it is terminated. (For purposes of clarity, no dc biasing is shown.) This configuration, which allows one discriminator to service any number of input ports, is not practical on the load side unless the coaxial lines leading out to the commutator can be made part of the load. It is generally better to use one discriminator per output port as shown, and switch the STOP command lines between sensor and "mother" unit.

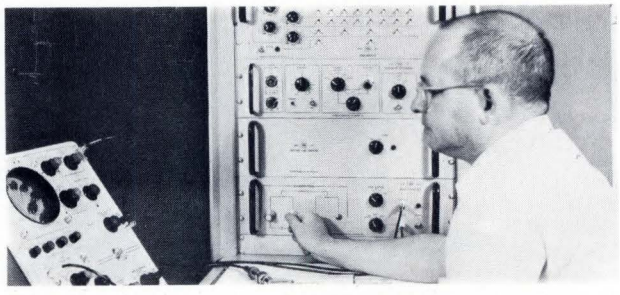
It should be noted that a fixed delay time is inserted between START and STOP pulses by the length of line between START discriminator and test socket. This is easily compensated by inserting an extra length of coax in the START command line, to delay the START pulse and zero the measurement. Also worth noting is that when one discriminator is assigned permanently to the input port, rise times of the DUT are not directly measurable on a single pass, but must be taken as the difference between propagation delays up to 90- and 10-percent levels on successive passes. This makes it important to design differential mode capability into the data handler, so that it can compute the difference between two successive measurements. □

The first of this series of three articles "Why Single-Shot Measurements in the Time Domain?" appeared in the August 1968 EDN on p. 76. A coming issue will contain the concluding section entitled "Applying Single-Shot Time-Domain Measurements".

Databank

References suggested by author, Thad Dreher, include:

1. "Nanosecond Pulse Measurements", by Winningstad, IRE WESCON Record, August 1961.
2. "Nanosecond Measurements with Sampling Oscilloscopes", by Zimmerman. Electro-Technology, January 1965, pp. 69-72.
3. "Fast Pulse Techniques", by Dreher, E-H Research Labs., 1967.



Thad Dreher is a consultant doing technical writing for E-H Research Labs. He received a B.A. in 1950 and a B.S.E.E. in 1959, both from the University of South Carolina. He previously worked at RCA and at Du Pont.

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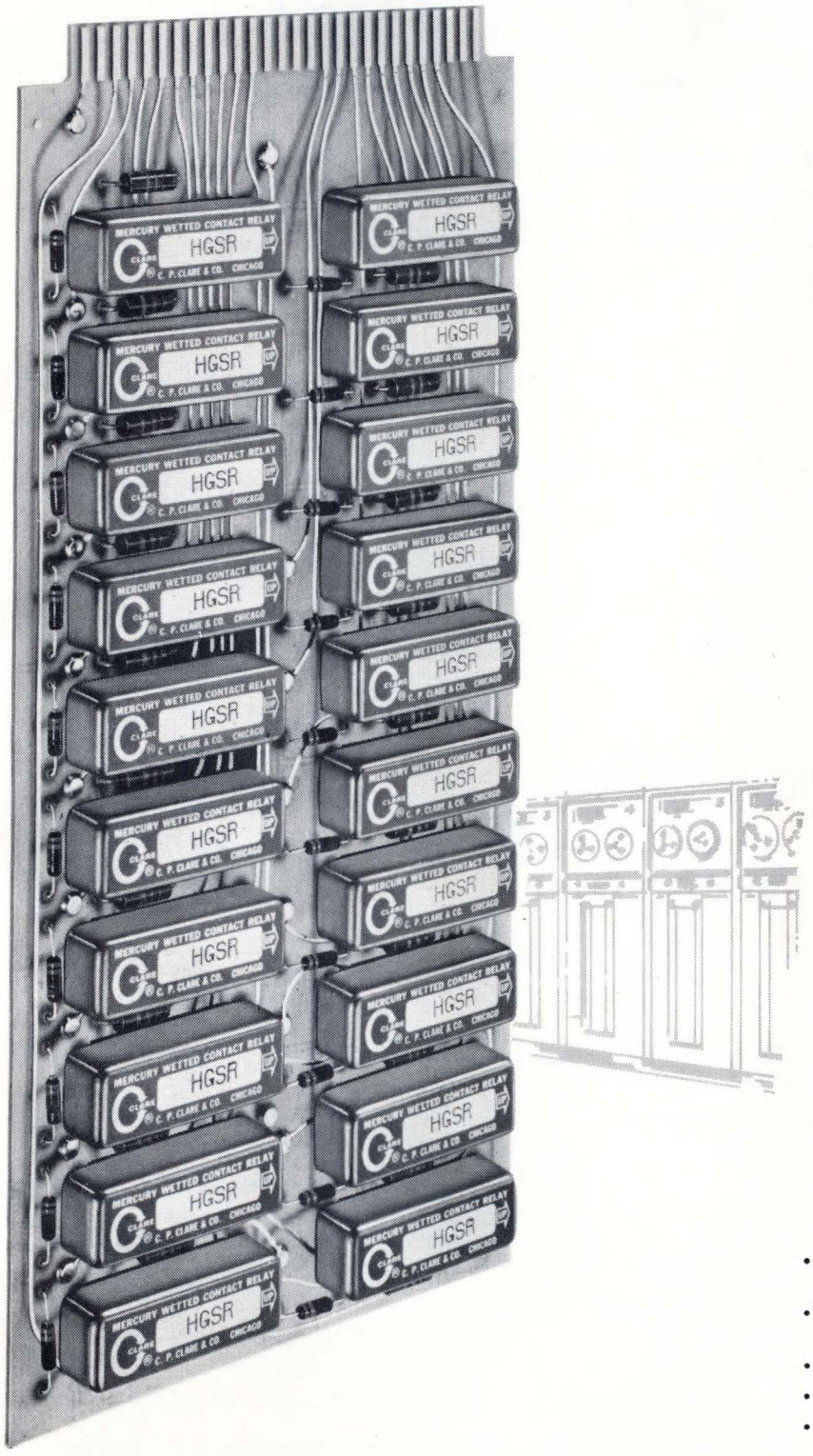

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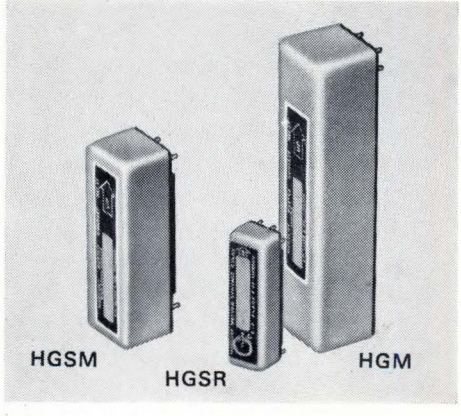

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CIRCLE NO. 37

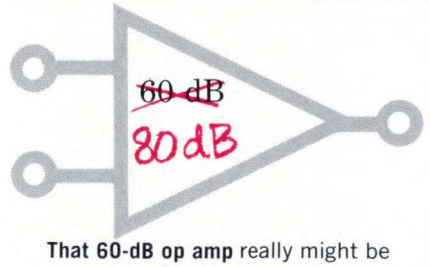
DB OR NOT DB?
(That Is the Question)

IC op-amp spec sheets hardly ever use the term dB correctly. The same goes for most engineers. Going back to basics shows why and "DB or Not DB?" proposes a way to clear up the confusion.

ROBERT C. SANFORD, Babcock Electronics

When is a dB not a dB? Most of the time, if you listen to today's crop of engineers or read linear-IC data sheets.

Let's take a typical listing. We need an IC operational amplifier, and we find one that has a unity-gain bandwidth of more than 10 MHz that looks good. The open-loop voltage gain is listed as 60 dB with a recommended load impedance of 2 kΩ. The input impedance is not listed (it rarely, if ever, is). Anyway, this is of no concern as long as it is reasonably high and the gain is high, because we expect to use it in an operational configuration.



That 60-dB op amp really might be an 80-dB op amp.

Just to check the amplifier against the specs, to be sure that it is good and that they are not kidding about the gain, we measure it. We use the recommended 2k load and connect a good generator to the input, at a frequency well down from 10 MHz, say 100 kHz. We measure the output with a good VTVM and adjust the generator until the output is 5V rms. We then switch the VTVM to the input and get a reading of 5 mV rms. Of course, with a real IC, we should read less input since the 60 dB was specified as a minimum, but we are trying to make a point.

Now we do a little math. Dividing the output by the input, we have 5V over 5 mV, or 1000. This is the same as 10^3 and the exponent is 3. Or, take the log to base 10 and the log is 3. Now, we take $20 \times \log_{10}$ 100 or 20×3 and get 60 dB, just as the spec sheet said. Right?

Wrong.

Following this procedure, we get the number 60 all right, but—it is not dB! Call it anything you wish, but *don't* call it dB. The IC maker calls it "voltage gain" in "dB" but he is just as wrong as you are. Your fellow engineers talk of "voltage gain", or more likely just "gain", in terms of dB. Ask them if the terminal impedances are included in the figure and chances are that they won't know what you are talking about.

Here's the Glitch

What's so wrong about it? And, what do impedances have to do with it?

A decibel, or dB, is 1/10 of a bel (named after Alexander Graham Bell), and is a unit of *relative power*. Today, it is difficult, if not impossible, to find a textbook or handbook that correctly defines a dB. Even the "Green Book"—*Reference Data for Radio Engineers* by ITT—which is considered by many engineers as the "bible" for designers, leaves the subject up in the air. It defines a dB as a measure of relative power measured at two points, shows the equations for power ratio and either voltage or current ratio as we all know them (one of which we used before), and provides listings of dB values for various ratios to illustrate the equations.

True, the "Green Book" adds a disclaimer to say that dB can be used with voltages or currents only when they are measured across *identical* impedances. *But*—it doesn't *stress* the point, and it doesn't give the *correct* equation for use with voltages or currents.

The correct equations are:

$$\mathrm{dB} = \log_{10} \frac{P_2}{P_1}$$

$$\mathrm{dB} = 20 \log_{10} \frac{V_2}{V_1} + 10 \log_{10} \frac{Z_1}{Z_2}$$

where the subscript 1 represents input and the subscript 2 represents output. The second equation can be used for currents instead of voltages. The important point to remember is that the second term of the equation *must* be included. If two voltages are measured at the same point (or two currents through the same

impedance) or at different points across (through) identical impedances, then, *and then only*, can we drop the second term.

Quite obviously, when the spec sheet on our IC amplifier lists a "voltage gain" of 60 dB, the statement is meaningless because the input impedance is not specified. Let's assume that we measure the input impedance in the particular open-loop circuit we used before and it turns out to be 200 kΩ. This is 100 times the load impedance. Since the log of 100 is 2, the second term of our equation becomes 20, and the IC's real gain is 60 + 20 or 80 dB, *not* the listed 60 dB. If you are lucky—and a very few spec sheets do list a "power gain"—you also may find a listing for your IC of 80-dB *power gain.*

$$dB = 20 \log_{10} \frac{V_2}{V_1}$$

$$dB = 20 \log_{10} \frac{V_2}{V_1} + 10 \log_{10} \frac{Z_1}{Z_2}$$

A dB is not a dB if it does not include impedance.

Fact: Spec sheets and most engineers today prattle about voltage gain in dB.

Fact: These engineers either don't know or, if they ever learned, have forgotten the correct definition of dB.

Fact: Engineers and technicians who deal with telephone, broadcast or RF circuits and systems usually handle dB's correctly because they always measure across equivalent impedances, even though they may not realize that they are correct only by accident. However, some *do* realize that they are dealing with power ratios.

Fact: Engineers and technicians who measure only voltages or currents can successfully operate on the foregoing systems only because the systems maintain a constant impedance, *not* because they know what they are talking about.

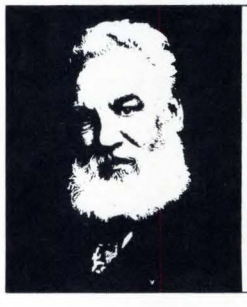
Fact: Engineers accustomed to the foregoing systems who read IC spec sheets will either be at a complete loss or will misinterpret the spec sheets and come up with wrong answers.

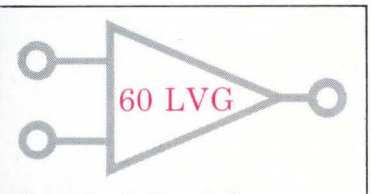
In the Beginning

How did such a mess ever get started? Well, back approximately 20 years ago, when "hi-fi" was just becoming a part of our language, almost no technicians and very few engineers knew anything about dB (this includes most of those in the special fields mentioned, even though they used the term). Many manufacturers of "hi-fi" and the PA amplifiers decided that defining their equipment in dB would "snow" the prospective buyers and bury the amplifiers' deficiencies in double-talk, so amplifiers of that era often were rated in "dB", even though the term was meaningless.

A few complaints about the practice were voiced in letters to the editor in some magazines, but the general hope was that the practice simply would fade away. Unfortunately, it didn't. Today, a very large proportion of otherwise reputable amplifier manufacturers incorrectly rate their amplifiers in "dB voltage gain"; engineers use the term dB promiscuously and incorrectly, and supposedly authoritative writers do the same in print.

What can be done to correct this situation? I suggest a new term for voltage gain—LVG, for log voltage gain—to be used instead of dB for those measurements dealing only with voltage. Thus, the IC amplifier would have been listed as 60 LVG, *not* 60 dB as it was. The transition from cps to Hz—in all its forms—was accomplished quickly and with relatively little mental anguish. Why not the transition from dB to LVG for voltage gain? □





Alexander Graham Bell probably would prefer LVG. (Pach Bros., New York, N.Y.)

Databank

Author Robert Sanford discovered two references that include the correct equations. They are:

1. "Mathematics for Electricians and Radiomen", First Edition, by Nelso M. Cooke, McGraw-Hill, Chapter XXI, Sections 21-1 to 21-3, p. 309, 1942.

2. "Radiotron Designer's Handbook", Fourth Edition, by F. Langford-Smith, Radio Corp. of America, Chapter 19, p. 806, 1952, gives the most complete discussion of all aspects of the problem and its solutions.

Author Robert C. Sanford, an E.E. from the University of Missouri, has been awarded two patents and has applied for a third. His years of experience include design work for several leading electronics firms. One of Bob's pet peeves is sloppy or incorrect measurement terminology, which he squarely attacks in this article.

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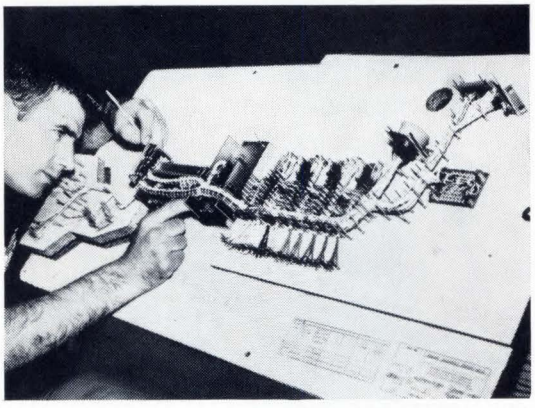

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						@ I_C = 0.5A V_{CE} = 5.0V		@ I_C = 0.5A I_B = .05A	@ I_C = 0.5A I_B = .05A	μA		MHz
			Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	@ V_{CB}	Typ.
2N4862	2N4863	2N4864	140	120	8	50*	150*	0.20	1.2	0.1	60	85
SDT5001	SDT5501	SDT5901	60	40	8	50	150	0.35	1.2	0.1	30	85
SDT5002	SDT5502	SDT5902	80	60	8	50	150	0.35	1.2	0.1	30	85
SDT5003	SDT5503	SDT5903	100	80	8	50	150	0.35	1.2	0.1	60	85
SDT5004	SDT5504	SDT5904	140	100	8	50	150	0.35	1.2	0.1	60	85
SDT5005	SDT5505	SDT5905	180	120	8	50	150	0.35	1.2	0.1	60	85
SDT5011	SDT5511	SDT5911	60	40	8	120	—	0.35	1.2	0.1	30	85
SDT5012	SDT5512	SDT5912	80	60	8	120	—	0.35	1.2	0.1	30	85
SDT5013	SDT5513	SDT5913	100	80	8	120	—	0.35	1.2	0.1	60	85
SDT5014	SDT5514	SDT5914	140	100	8	120	—	0.35	1.2	0.1	60	85
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CIRCLE NO. 39

TIME-MULTIPLEXED ELECTRONICS

BOB KOEPER, Senior Editor

Device improvements, coupled with across-the-board price reductions for semiconductors, has helped multiplexing invade the tape-recorder business.

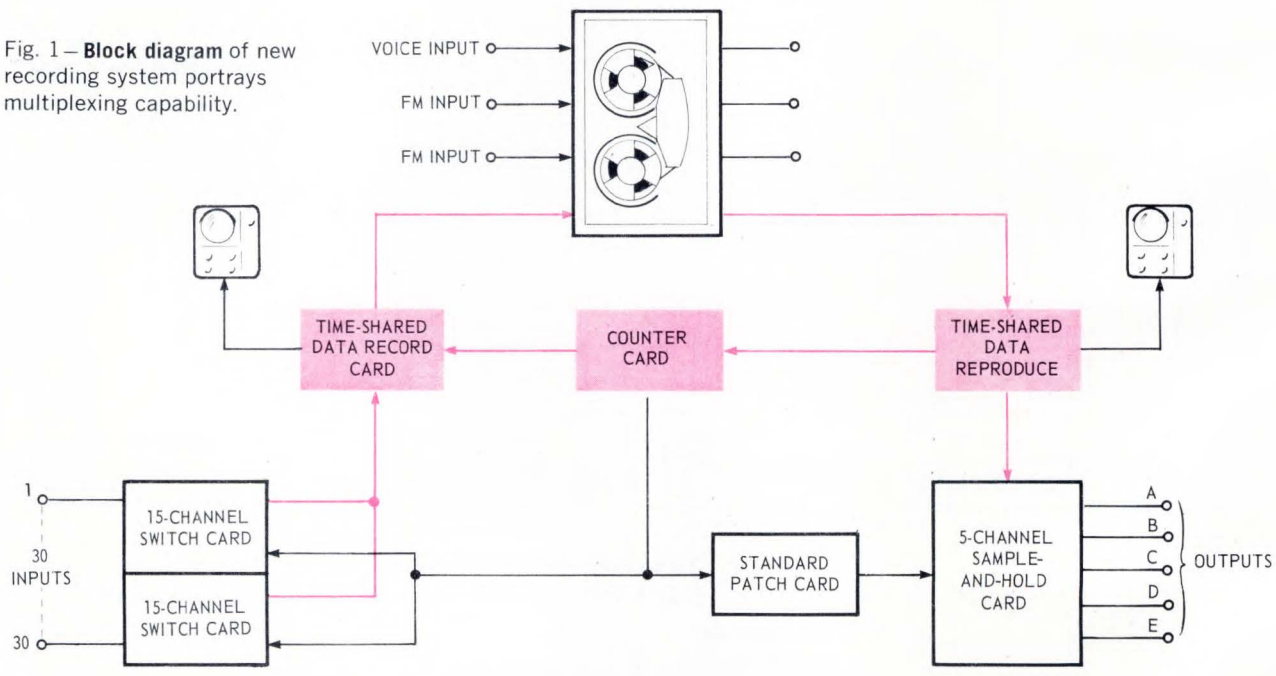
Historically, to commutate, store and decommutate a number of slowly changing data channels have meant large dollar investments and racks of equipment. With the strides made in semiconductor technology (including integrated circuits), equipment size was reduced, but not the cost. Now, the marriage of familiar tape-recording techniques and time-shared multiplexing has resulted in a 75-percent cost reduction with no performance degradation, and total system size is no larger than a tape recorder (see photo).

A block diagram of the system (**Fig. 1**) portrays the addition of time multiplexing to an otherwise standard four-channel recorder. With multiplexing, the unit has 33-channel capability—30 time-shared channels each with response from dc to 5 Hz and three channels of dc to 2.5 kHz each for FM.

Input Circuit

MOSFET's are used in the input circuit (**Fig. 2**) with 15 of the 30 input channels contained on one plug-in board. Each MOSFET circuit is controlled by a counter that causes the MOSFET to turn on 30 times a second with an aperture time of 50 μs. The ON-time duration is sufficiently long to permit the recorder to sample, record and reproduce input changes up to 5 Hz. With a sampling rate per second of 30 this amounts to six samples per cycle. Channels may be cross-connected to increase response at the expense ot total channels.

Fig. 1—**Block diagram** of new recording system portrays multiplexing capability.



EXTEND RECORDING CAPABILITIES

Amplitude to Time Conversion

To make a system of this type work properly, the voltage amplitude of the input signal must be converted to a proportional time increment for recording, and reconverted from pulse-width to pulse-amplitude information for reproducing.

The conversion from amplitude to time duration is performed on a separate plug-in card. The diagram (**Fig. 3**) illustrates how the conversion is made. Heart of the conversion scheme is a patented circuit that not

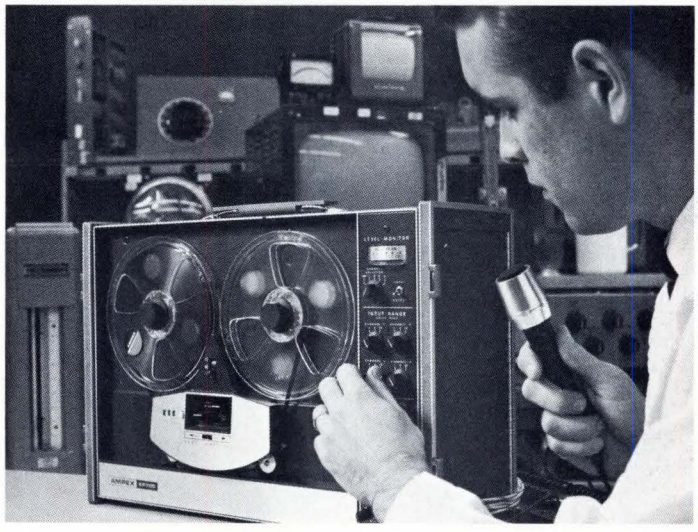


Photo of SP700 tape system depicts small size of multiplexed system. It is a modular system with plug-in boards determining system capabilities. Price, depending on capabilities, ranges from $2700 to $4800. This compares with as much as $20,000 for competitive systems made up of separate components that perform the identical functions.

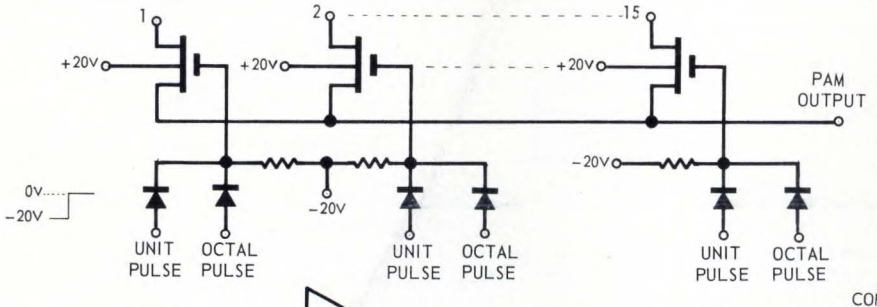


Fig. 2 – **Schematic diagram of input circuits.** Each input board handles 15 inputs with all pulse-amplitude-modulated (PAM) outputs time shared on single output line.

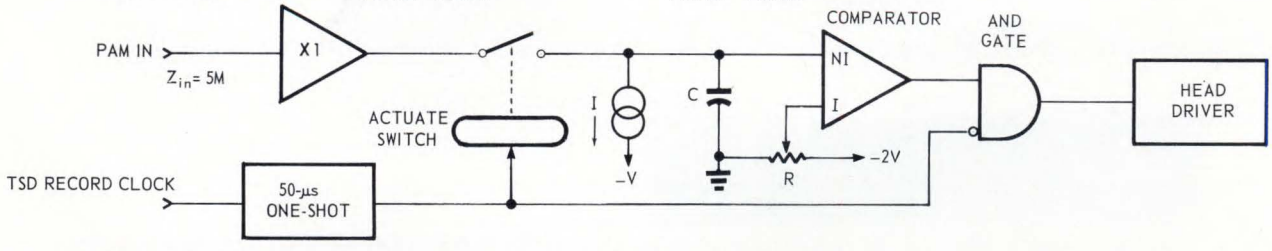


Fig. 3 – **Patented principle** of linear voltage to time conversion illustrated in block diagram. PAM pulses from multiplexer are connceted to capacitor C for 50 μs, the period when the actuate switch is closed. During this time, C charges to full value of input signal and when switch opens, C is linearly discharged with time. At the time switch opens, gate conditions are satisfied, forming the leading edge of the data pulse. C discharges until it reaches the switching level set into the comparator by the potentiometer R, which adjusts minimum duration of the pulse. Comparator output forms the trailing edge of the data pulse. Conversion scale factor is determined by the value of 1.

Time-Multiplexed Electronics (Cont'd)

only stores the sample but provides the linear system base as well.

Time Back to Amplitude

A reproduce card accepts differentiated inputs from the recorder reproduce head via a preamp, reconstructs the time-modulated signals, then demodulates them into amplitude-modulated pulses. **Fig. 4** shows how this is accomplished.

Outputs Available

Two types of outputs are made available from the unit. The first is the complete 30-channel PAM signal accessible for connection to a lab scope for bargraph display. With this output, all 30 channels can be viewed simultaneously. The second output makes available any five channels via sample-and-hold amplifiers. An appropriate filter smooths out the abrupt changes observed from the sample-and-hold circuit (**Fig. 5**).

The new system, first conceived and developed by Kauke & Co., has been acquired by the Ampex Corp. John Kauke is now with Ampex as manager of the Industrial Products Dept. The recording system is expected to find wide application in biological and chemical measurements, petrochemical technical measurements, automotive diagnostic testing and medical data acquisition.

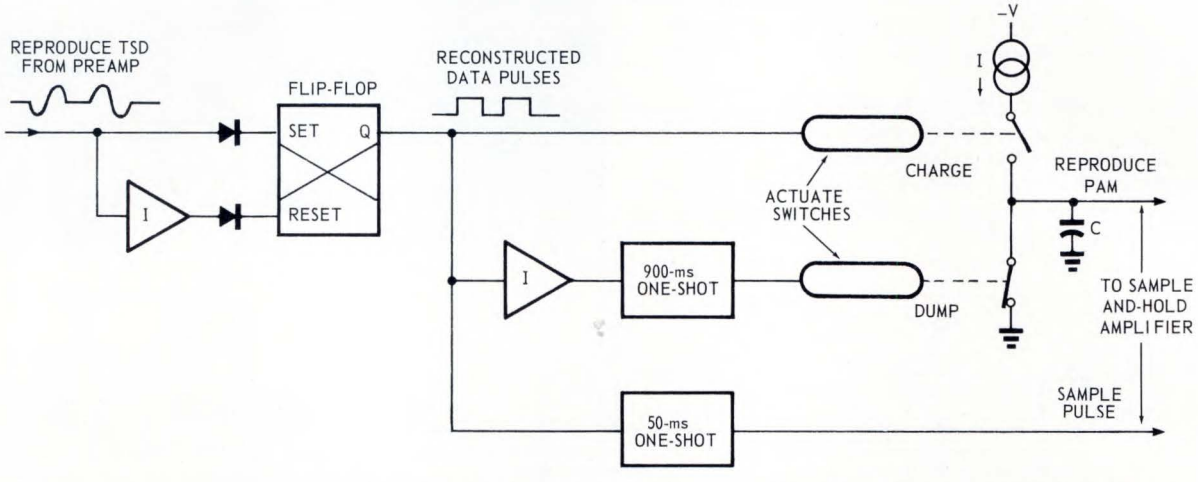
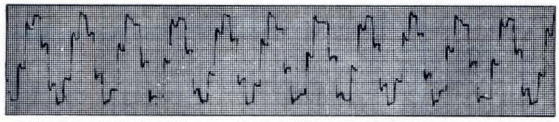
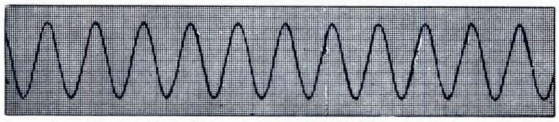


Fig. 4—**Conversion of time duration** to voltage is illustrated by block diagram. Signals from tape are amplified and then used to reconstruct the original data pulses by means of the flip-flop. Charge-actuate switch closes for duration of the data pulse and the dump-actuate switch opens for 900 μs, allowing capacitor C to linearly charge at a rate determined by current 1. C holds the charge until the 900-μs one-shot allows the dump-actuate switch to close, at which time C discharges and is ready for the next data pulse. A sample pulse is initiated by trailing edge of the data pulse, actuating the sample-and-hold amplifier while C retains its charge.



5-Hz SINE-WAVE DATA, SAMPLE-AND-HOLD OUTPUT, UNFILTERED



SAME AS ABOVE, BUT FOLLOWING 5-Hz CUTOFF FILTER

Fig. 5—**With as few as 6 samples/cycle,** sample-and-hold output appears meaningless. After suitable filtering, data are restored to original shape and amplitude.

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CIRCLE NO. 41

Heated Substrate Controls Drift in Monolithic Amplifier

A heated substrate included in the design of a monolithic IC preamp results in a circuit with drift characteristics equal to or superior to amplifiers with FET inputs or chopper stabilization.

J. D. LIEUX, Fairchild Semiconductor

A temperature-stabilized substrate technique has produced a linear integrated circuit with very stable characteristics. The design uses the unique advantages of monolithic integrated circuits to give a versatile preamplifier that operates over a wide range of power-supply voltages. Its performance equals or surpasses existing approaches such as FET inputs or chopper stabilization with the added advantages of small size, simple construction, good reliability and low cost.

Existing circuits use closely matched bipolar transistor pairs or rely upon the inherent matching and close thermal coupling of monolithic IC's to obtain drifts on the order of 5 to 10 μV/°C. FET input stages are employed when input currents in the hundred-picoamp range are needed, but at the sacrifice of offset voltage drift.

The most common method for lowest drift is chopper stabilization, which, if properly designed, can give excellent stability. In many applications, however, the size, expense and performance drawbacks such as poor overload recovery, large shot noise and poor reliability restrict their use.

Regulated Substrate

With the new technique (a temperature-stabilized substrate) all components of the circuit are kept at constant temperature by an active regulator included on the chip. This approach gives drift performance approaching that of the best chopper-stabilized amplifiers, with small size, low cost, moderate power consumption and excellent reliability. A circuit design using this principle is a complete preamplifier on a temperature-stabilized substrate. The circuit consists of a two-stage differential input, differential output amplifier, plus a temperature regulator, with a voltage gain of 100. Compared to a single high-gain amplifier, this circuit in combination with a second amplifier reduces the effect of drift in the second amplifier to a negligible value. At the same time its gain of 100 is not so high as to make frequency compensa-

(Continued)

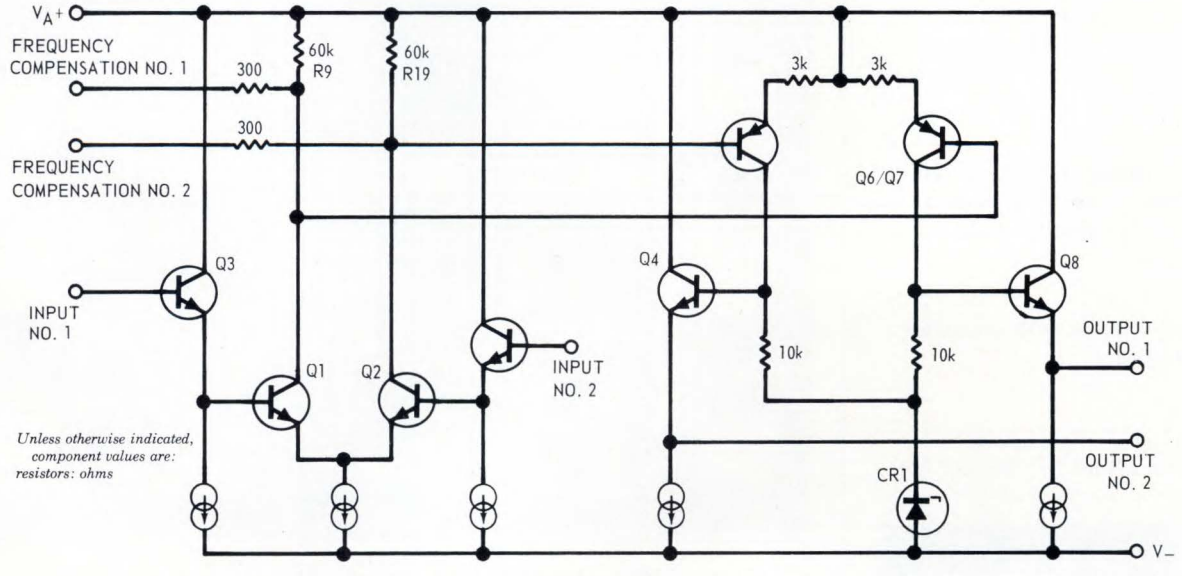


Fig. 1 – **Simplified schematic** of two-stage differential input, differential output amplifier.

(Continued)

Heated Substrate (Cont'd)

tion difficult in operational-amplifier applications.

A simplified schematic of the amplifier section (**Fig. 1**) shows the differential input pair, Q1 and Q2, buffered with emitter followers Q3 and Q4 to obtain an input resistance of 300 MΩ and low offset and bias currents. Current source biasing of the emitter followers results in an input offset voltage relatively independent of the base and leakage currents of the differential pair.

Most important in low-drift amplifiers is to maintain the input circuit transistors at exactly the same temperature. The regulator circuit greatly reduces temperature changes seen by the chip, but slight thermal gradients across the chip may be present, resulting from uneven heating, uneven die attach and edge effects. Even a 0.01°C temperature difference between the transistors in a pair will produce 20 μV of offset drift. With two pairs of input transistors, chip layout is enhanced, which cancels the effects of thermal gradients. The emitter followers (**Fig. 2**) are on opposite sides of the chip centerline from their corresponding amplifier transistors. If gradients are present across the chip, equal offsets produced in each half of the input stage pro-

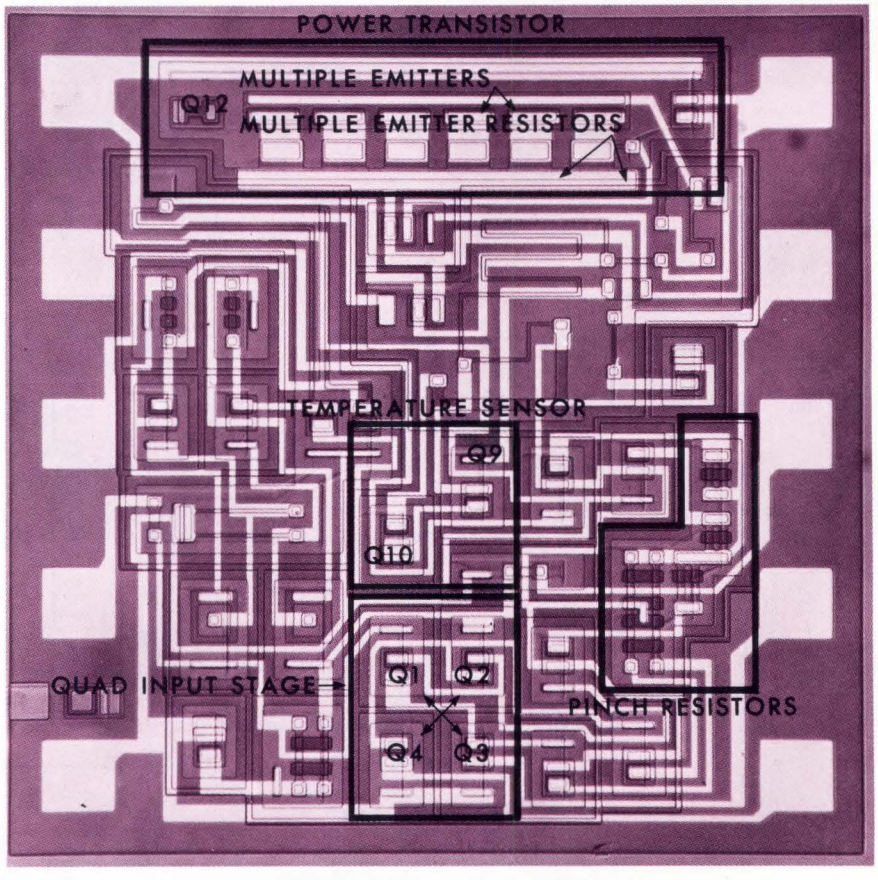


Fig. 2—**Photomicrograph of layout** depicts how attention to component placement leads to best temperature gradient control.

duce a net drift of zero.

A second stage employs compound pairs of pnp and npn transistors for level shifting and some additional gain. The circuit uses lateral pnp's with current gains of about 1 to 3 connected in a feedback arrangement with npn's to form high beta compound transistors. This minimizes first-stage loading. Current source biased output emitter followers provide low output resistance, reducing subsequent circuitry loading. Zener diode CR1 and the voltage drop across the 10k second-stage collector resistors determine output common-mode voltage.

Temperature Regulator

The basic regulator circuit (**Fig. 3**) consists of a pair of temperature sensors, Q9 and Q10, and a large power transistor Q12. Changes in chip temperature are sensed by Q9 and Q10, which develop a temperature-dependent voltage across the external temperature adjust resistor, R_{adj}. This control voltage is applied to the base of the power transistor via Q11 and CR2. The control voltage changes Q12 collector current (and hence power dissipation) to keep chip temperature constant. The photomicrograph (**Fig. 2**) illustrates the central location of the temperature sensors

(Continued)

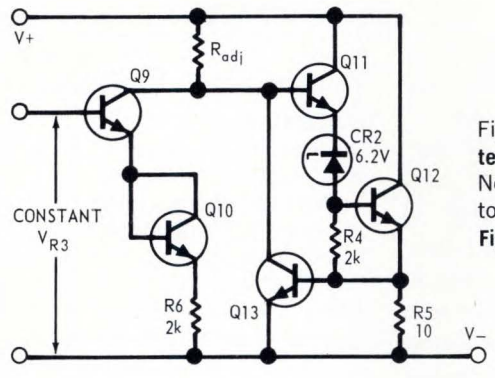


Fig. 3—**Simplified schematic of temperature control circuit.** Note physical size of transistor Q12 on photomicrograph **Fig. 2**.

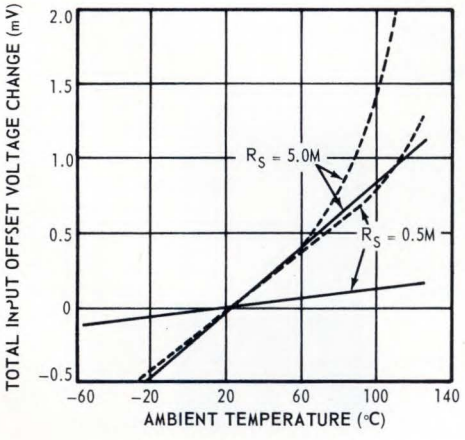


Fig. 4—**Comparison of new circuit design performance** and standard amplifier with FET input circuit. Plot shows input offset voltage change versus ambient temperature.

(Continued)

Heated Substrate (Cont'd)

and the opposing location of amplifier input stages and the heater transistor. The use of multiple emitters and multiple emitter resistors on the power transistor prevents current hogging, spreads power dissipation evenly across the chip and reduces thermal gradients. Transistor Q13 limits the initial turn-on current of the device, preventing possible damage to the power transistor. Stabilization after turn-on is rapid, with the chip temperature reaching 1°C of final value in 1 sec. The R_{adj} resistor was made external to the chip to allow a wide selection of supply voltages, ambient temperature ranges and power consumption.

Performance

The final design (which has been turned over to production) has 2-mV and 2-na input offset voltage and current, input offset voltage and current drifts of 0.6μV/°C and 2 pa/°C and input bias current drift of 15 pa/°C. A comparison with amplifiers having FET input stages (**Fig. 4**) shows that the heated substrate unit exhibits better offset drift for source resistances below 5 MΩ. It also has better drift performance for any source resistance for ambient temperature above 45°C. This occurs because of the exponential behavior of the FET's leakage current.

Because of temperature stabilization, there is almost no change in any operating characteristic of the circuit over the full temperature range. The only exception is power dissipation, which varies inversely with temperature.

A factor that can affect drift performance of the circuit is physical layout. Since the circuit must regulate its power dissipation to maintain constant chip temperature, best control is obtained if the case-to-ambient thermal resistance is kept as high as possible. Therefore, heat sinking of the can should be avoided and moving air over the circuit should be minimized. Precautions also should be taken to eliminate thermal-electric voltages produced by dissimilar metals in contact. This can occur when component leads are soldered to a copper circuit board. Normally, the thermoelectric voltage at one junction is canceled by another; however, if the junctions are at different temperatures because of unequal air movement or heat sinking, an appreciable offset drift can result. Therefore, the number of such junctions should be kept to a minimum and should be placed as close together as possible to minimize temperature differences. □

Databank

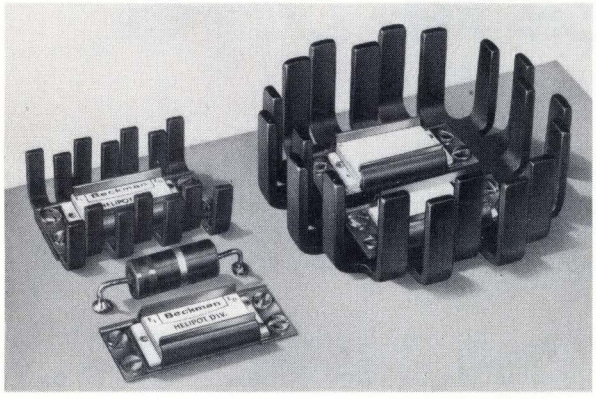
For background information, Mr. Lieux advises readers to try these sources:

1. "Fairchild Semiconductor Linear Integrated Circuits Applications Handbook", Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif., edited by James N. Giles. Good reference on fabrication and application of LIC's.
2. "Applying a Temperature-Stabilized Monolithic Transistor Pair", by J. Carryl Lieux, Electronic Products, May 1967, pp. 84-87. A good explanation of temperature-stabilizing circuitry.

J. D. Lieux is a senior engineer with Fairchild Semiconductor where his duties include circuit design of linear integrated circuits. He received the B.S.E.E. from Louisiana State University and is a member of Tau Beta Pi, Eta Kappa Nu and IEEE.

Tips on cooling off hot semiconductors and microcircuits

Read on. Find out how circuit designers use IERC heat dissipators to protect and improve circuit performance of semiconductors and microcircuits.



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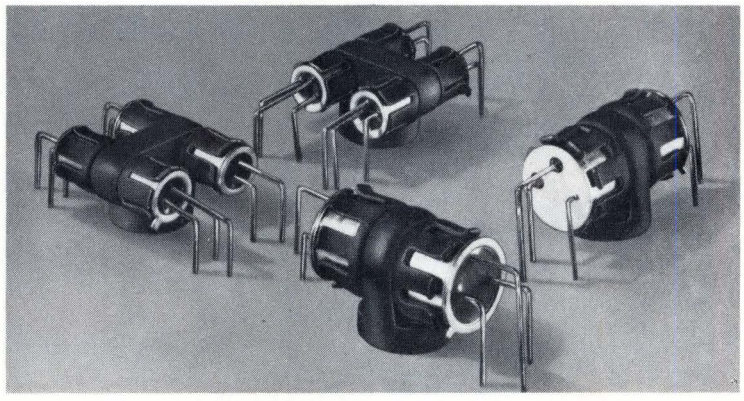
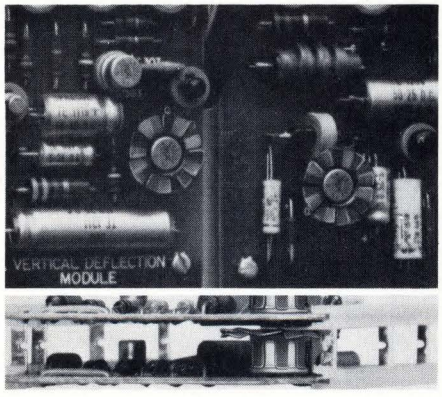


These special dual and quad Therma-Link dissipators permit thermal mating of matched transistors. Therma-Link retainers do exactly as their name says: They provide a thermal link between transistors and the chassis or heat sinks. They are also available with beryllium oxide washers which have the excellent thermal conductivity of aluminum, are electrically insulative and reduce normal mounting capacitance by ½ to ⅓. The washer is brazed to a brass slug or hex stud for mounting.



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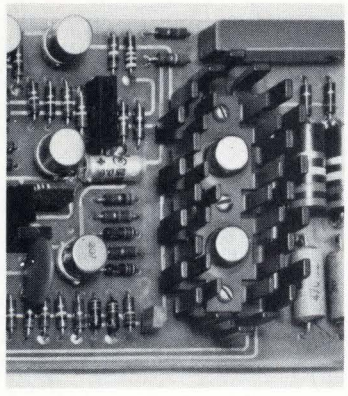

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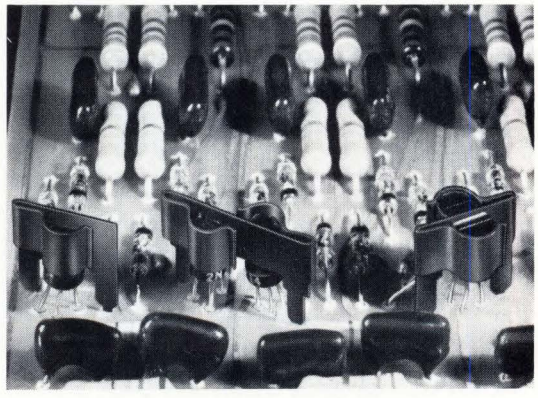

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CIRCLE NO. 47

Design Ideas

PIN Diodes Stabilize RF Level

JIM KLUGE, Senior Editor

Connected externally to the output of an RF signal generator, this regulating circuit maintains a constant voltage level for precise RF measurements.

A high degree of RF signal-generator output stability is commonly achieved through the use of an expensive special RF signal generator or a "bench full" of auxiliary electronic gear in combination with an ordinary RF generator. Either of these two approaches involves an expenditure of both time and money. NBS Boulder Laboratories has resolved this problem by designing a small, low-cost ($80 of parts) device capable of automatically stabilizing the output voltage level of ordinary RF signal generators.

Two pin diodes connected in shunt with the signal path are the regulating elements. They are connected to the center conductor of a 50 Ω air line and are spaced 1/4 wavelength apart when optimized at 1 GHz. The signal is detected, filtered and compared to a dc reference voltage. A dc error voltage, proportional to the difference between the reference and the peak signal level, is applied to a feedback amplifier. The amplifier biases the pin diodes to adjust the signal level for a null in the error voltage.

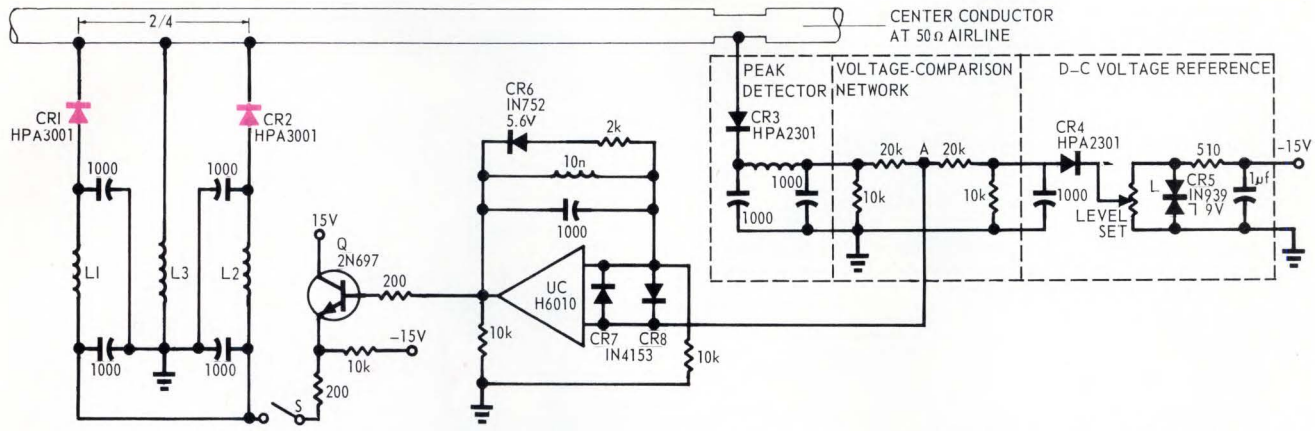
The stabilizing factor of the regulator at 1 GHz is 1000; that is, voltage variations in the RF input are reduced by a factor of 1000 (60 dB). The insertion loss is less than 2 dB and the regulator has a dynamic range of approximately 10 dB.

Although other methods for stabilizing generator-signal level have been available, this device is small and requires no modification or internal connections to the RF signal source. □

Databank

L. D. Driver recommends these references for further information:

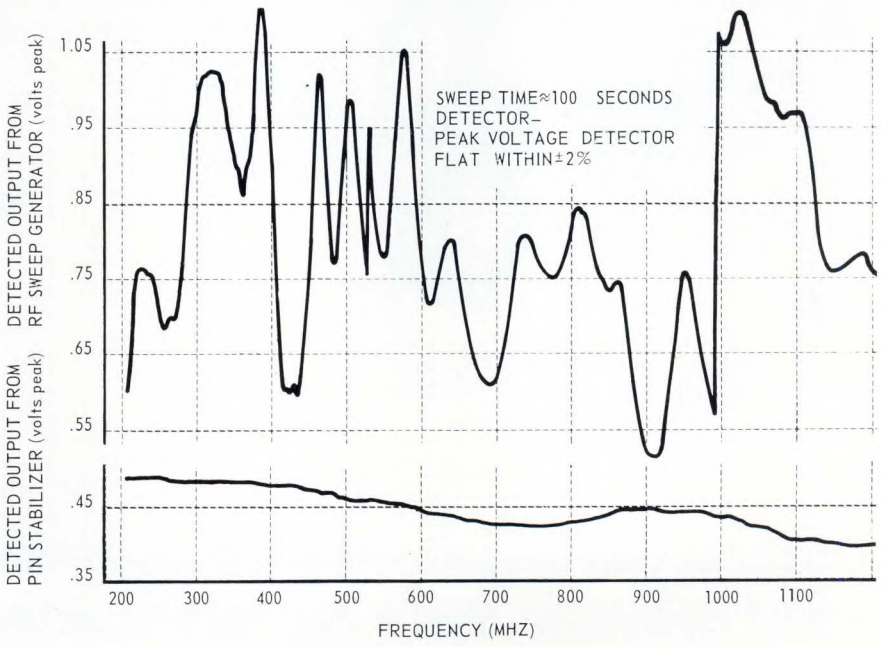
1. "The Pin Diode", HPA Application Note No. 4, Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Basically describes the pin diode—how it works, its equivalent circuit and some application considerations.
2. "Biasing and Driving Considerations for Pin Diode RF Switches and Modulators", HP Application Note No. 914. Discusses practical driving considerations for pin diodes.
3. "An Attenuator Design Using Pin Diodes", HP Application Note No. 912. Covers wideband attenuator design.
4. "Constant Impedance Pin Diode Attenuators", by C. A. Prufer, Microwaves, August 1967, pp. 46-49. Also deals with wideband attenuator design.
5. "Wideband RF Voltmeter Comparator", by L. D. Driver and M. G. Arthur, IEEE Trans. on Instrumentation & Measurement, IM-17, No. 2, June 1968, pp. 146-150. Explains in detail the operation of voltage comparison circuit used in the stabilizer. Also describes measures that can be taken to frequency-compensate the RF detector for appropriate applications such as swept-frequency leveling.

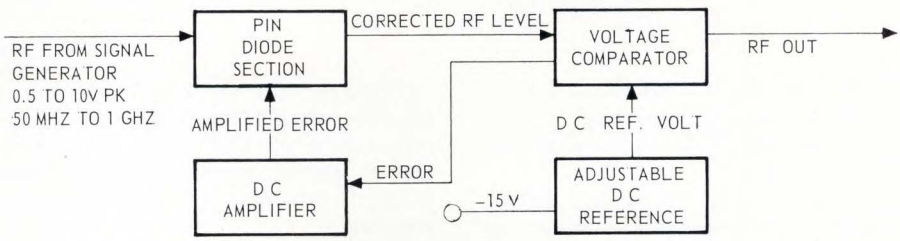


RF-voltage-level stabilizer biases a pair of pin diodes, CR1 and CR2, which shunt the RF signal path to act as a voltage-dependent attenuator. Biasing current is applied through switch S from emitter-follower Q. Voltage-comparison network compares dc levels from peak-signal detector and dc voltage reference. When levels are equal, zero null occurs at point (a) to set proper diode bias as determined by op amp. CR4 is included for temperature compensation of CR3. CR7 and CR8 protect op-amp input from transients. L1 and L2 are series elements of pi-section low-pass filter. L3 provides dc path for pin-diode bias currents. Coil inductance of L3 and 1/4-wavelength spacing of diodes are optimized for a minimum VSWR at 1 GHz, typically 1.02. For applications requiring minimum VSWR over a wide frequency range, typically a sweep generator, a more complicated diode configuration, such as a bridged-T, would be appropriate.

Although optimized at 1 GHz, stabilizer is useful at other frequencies (right). Recordings of generator output versus frequency, both with and without leveling, show improvement in output stability of a swept-frequency generator. Although adequate, performance of stabilizer (for swept-frequency leveling) can be improved by frequency compensation of its internal RF detector.

L. D. Driver *of NBS adjusts internal reference of RF signal stabilizer he developed. An electronics engineer at NBS Boulder Labs. for 6 years, he has a B.S.E.E. from Kansas University and has done graduate work at Kansas University and the University of Colorado.*





RF signal stabilizer detects RF signal supplied by an ordinary RF generator and compares it with a dc reference voltage. Error signal is amplified and applied as bias to pin diodes to correct for variations of RF input level.

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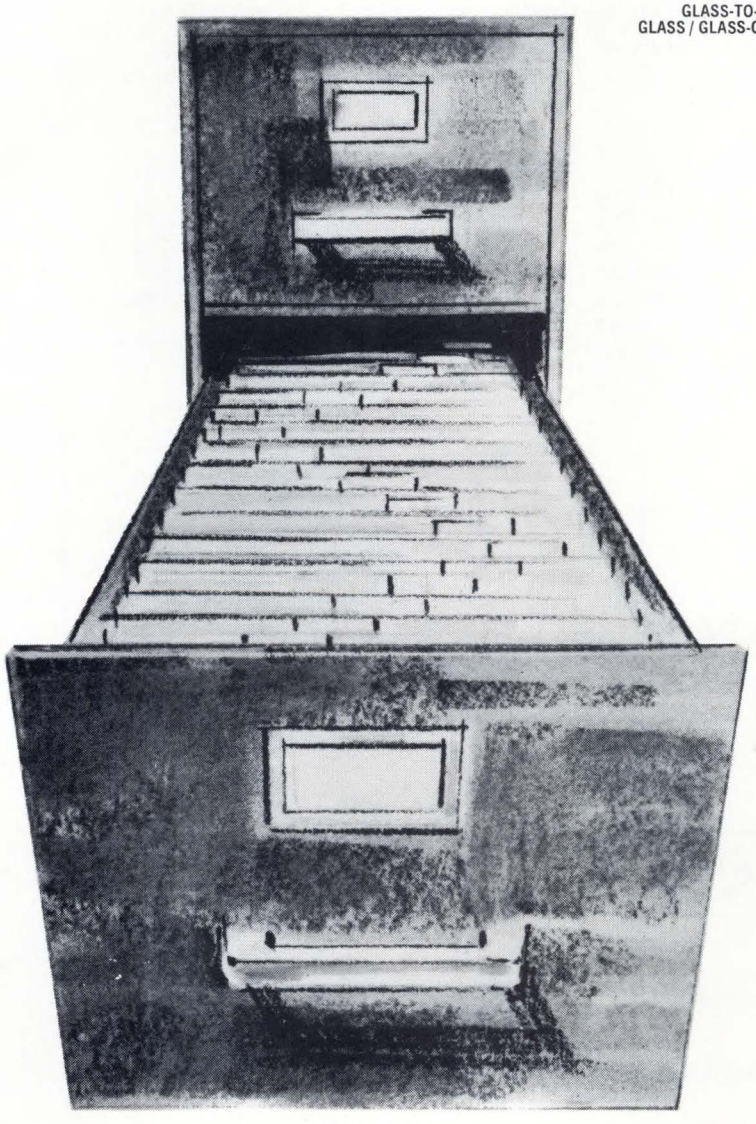


CIRCLE NO. 49

Audio IC Doubles As Regulated Power Supply

SZABOLCS WALKO, Raytheon, Canada

A standard IC 2W audio amplifer, plus a few discrete components, forms a compact regulated power source.

As integrated-circuit use increases, the need arises for regulated power supplies for these circuits, preferably IC types. With the addition of a few external components, a standard PA237 audio amplifier integrated circuit can be converted to either a series or shunt voltage regulator with medium power capabilities.

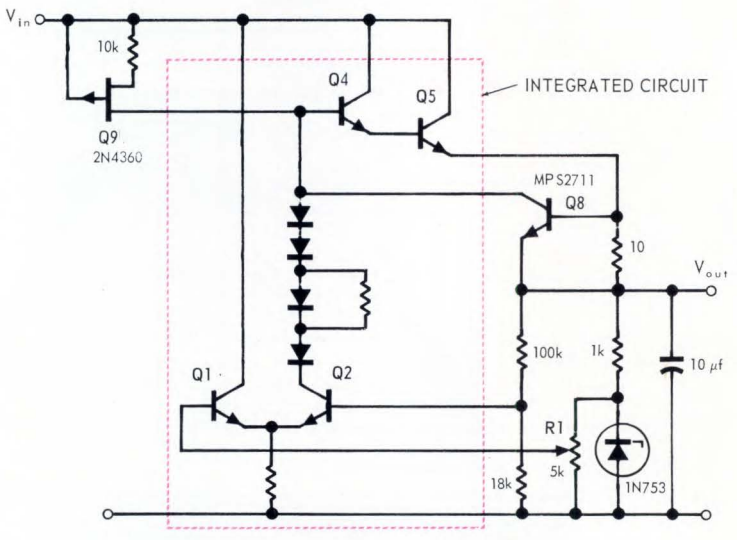
Schematics of the General Electric PA237 IC and its application as series and shunt regulators are given below. Performance of the regulator is limited by the maximum ratings of the integrated circuit. Maximum unregulated input voltage is 27V and peak currents up to 225 mA can be tolerated. With the regulator output short-circuited at maximum input voltage (27V), output current limit can be set as high as 83 mA before the package rating of 2.25W is exceeded. However, in view of secondary breakdown and reliability considerations, it is advisable to adjust the current limiting to 50 mA.

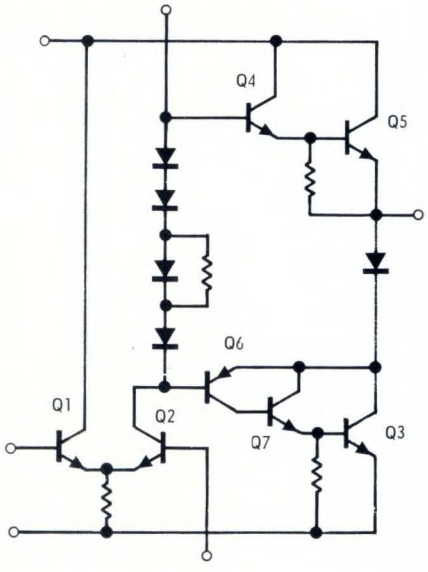
Under normal operating conditions the circuit will dissipate a maximum of 600 mW with a 27V input and 50-mA load. The performance of the circuit is as follows for input voltages between 17 and 27V:

$$\text{Line regulation } \frac{dV_o}{dV_{in}} = 0.4 \text{ percent}$$

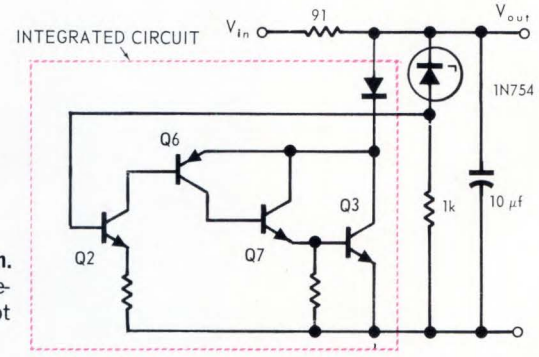
$$\text{Load regulation } \frac{dV_o}{dI_o} = 0.6 \text{ ohm}$$

Series regulator configuration (right). A small amount of quiescent current (about 3mA) flows through transistor Q3, but since this transistor, as well as Q6 and Q7, does not participate in the regulator action, they are not shown. Transistor Q9 is a P-channel junction FET that serves as a constant current source. Transistor Q8 acts as a current limiter and potentiometer R1 sets the output voltage level.





Basic diagram of PA237 integrated circuit.



Shunt regulator diagram. Unused portions of integrated circuit are not shown.

Output voltage (adjustable)
= 15V (nominal)

In the shunt regulator diagram the unused part of the circuit comprising transistors Q1, Q4 and Q5 is not shown. The advantages of this circuit are its inherent current limiting as well as its simplicity. The disadvantage is the fixed output voltage that is determined by the zener diode.

Minimum obtainable output voltage is about 3V. In the integrated circuit the worst dissipation occurs without a load. The maximum output current changes between 110 and 220 mA, depending on the input voltage (17 up to 27V). In order to maintain constant output voltage with temperature change, the temperature coefficient of the zener diode should be opposite that of the base-emitter diode of Q2. The temperature dependence of the transistor's h_{FE} also contributes to the output voltage drift. Together, they result in a drift of approximately 0.5 mV/°C. A better thermal match is difficult to achieve because of the spread in the temperature coefficient of the zener diode. Performance of the shunt regulator for input voltages between 17 and 27V is:

Line regulation $\frac{dV_o}{dV_{in}}$ = 0.25 percent

Load regulation $\frac{dV_o}{dI_o}$ = 0.13 Ω

Maximum output current
= 110-220 mA
Output voltage = 6.6V (nominal)

The primary goal of this article is to illustrate two basic power supply designs. The reader can use his imag-

(Continued)

Audio IC Doubles (Cont'd)

ination in developing applications based on the ideas presented here. For example, the output power capabilities of both regulators could be increased quite easily by using an additional external power transistor and the regulator as a driver. The circuit also could be used to build a switching-type regulator or to control a thyristor. □

Databank

For more detailed information the author advises readers to check these references:

1. "D-C Regulated Power Supply Design", by E. C. Wilson and R. T. Windecker, Texas Instruments, Dallas, application report, 1960. Detailed discussion and design of a voltage regulator.
2. "Power Supply Handbook", by P. Birman, Kepco, Flushing, N.Y., 1965. Deals with all aspects of power supplies.
3. "D-C Power Supply Handbook", Hewlett-Packard, 1967. Extensive coverage of circuitry, features, specifications and measurement methods.
4. "A Versatile, Monolithic Voltage Regulator", by R. J. Widlar, National Semiconductor, Santa Clara, Calif., 1967, Application Note No. 1. Integrated circuit controls series pass transistor.
5. "Power Regulation and Control Using Multifunctional Integrated Circuits", by Embree, Fisher and Hamilton, Proc. IEEE, August 1967, pp. 1466-1476. In-depth discussion of temperature compensation, stability, noise and close tolerance on output voltage.

Szabolcs Walko is a circuit design engineer at Raytheon, Canada. He currently is working on secondary radar equipment. He received his engineering degree in 1961 at the Technical University of Budapest.

2 new INDUSTRIAL CERMETS

MODEL 3069

MODEL 3009

...with BOURNS Reliability Sealed in!

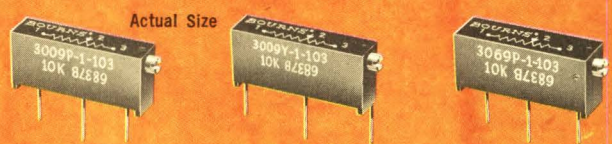
Let's talk some straight cermet potentiometer facts about Bourns new cermet Models 3069 and 3009. They're just $1.45*. Both feature Mil-Spec immersion seals for trouble-free operation after being subjected to printed circuit board processing. And there's the ±0.05% settability. Bourns cermets have tinned pins for compatability with both automated and hand soldering methods. They're round .021 diameter pins which alleviate complicated printed circuit board fabrication. Bourns cermet potentiometer's space-saving size is complemented by an RJ11 pin configuration if you want it. Bourns new cermets have two more exceptional features: Date Code Traceability and Temperature Coefficient maximum of 150 ppm/°C over the entire temperature range.

These, then, are the facts. No embellishments, no frills. Bourns tells it straight because it best explains what the Models 3069 and 3009 do — and why. Electrically, they're identical. Physically, they differ slightly, but for a good reason. Those last four words say a lot about these two new Bourns cermets and the versatile Bourns line. It's really why we design a product in the first place.

Complete data on the new Bourns cermet potentiometers — Models 3069 and 3009 — is available upon request to the factory, your local Bourns Sales Office, or representative.

*500-piece unit price

Actual Size



3009 P | 3009 Y (RJ11 Pin Configuration) | 3069 P

SPECIFICATION TABLE

Standard Resistance Range	10 ohms to 1 megohm
Resistance Tolerance	±10%
Power Rating	0.75 watt
Operating Temperature Range	−55 to +125°C
Temperature Coefficient	150ppm/°C**
Immersion	MIL-R-22097
Dimensions	3009 - .75 x .19 x .35; 3069 - .75 x .25 x .35
Terminals	Printed Circuit Pins—RJ11 configuration available on 3009

**100 ppm/°C available

BOURNS

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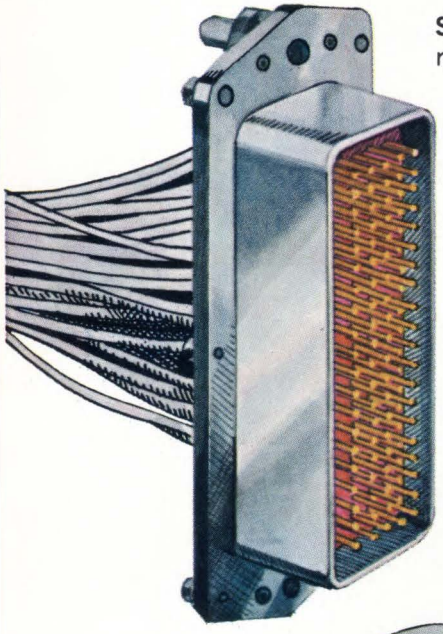
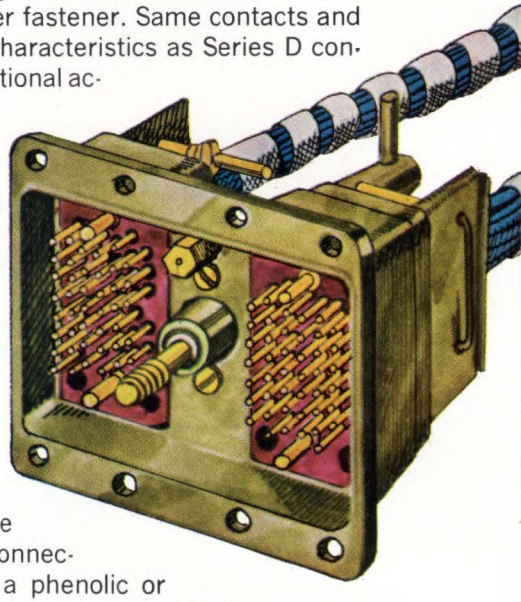
CIRCLE NO. 52

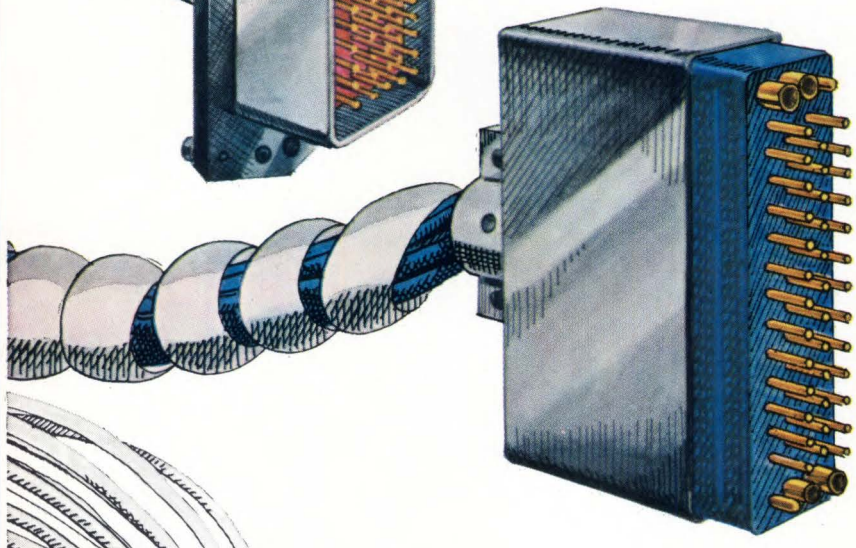
Design engineers' favorite



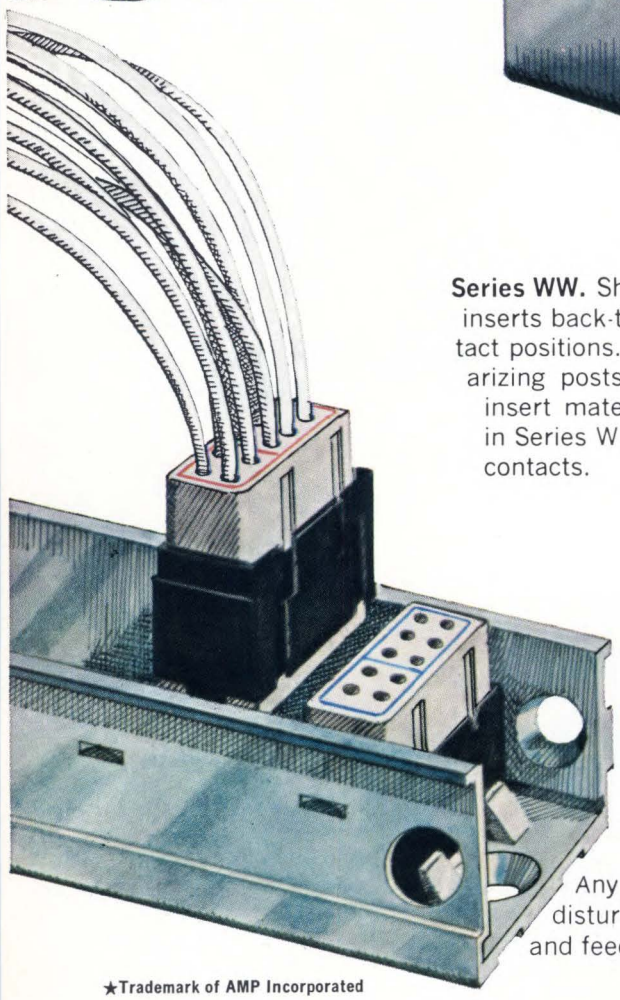
Series A. Fully sealed high reliability connector. Machined pins and sockets, reliable gold over nickel plate. Precision crimped. Available in 50 and 100 contact versions with .100" center spacing.

Series DD. Shell takes two Series D inserts, providing up to 156 contact positions. Cavity identification front and rear. Quick center fastener. Same contacts and operating characteristics as Series D connectors. Optional accessories include straight or 90° shields and cable clamps.

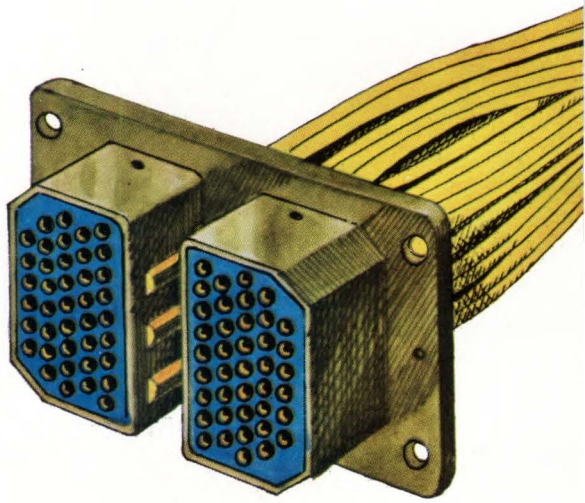




Series M. Least complicated of all, these pin and socket connectors consist of a phenolic or diallyl phthalate block and snap-in contacts. They accept a number of contact types, including subminiature COAXICON* coax contacts. Available with pin hoods, cable clamps, polarizing pins. From 14 to 104 positions per connector. Meets MIL-C-8384.



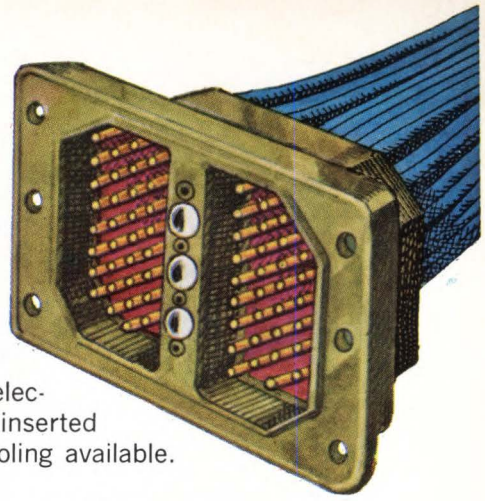
Series WW. Shells incorporate two Series W inserts back-to-back, provide up to 90 contact positions. Center fastener. Three polarizing posts prevent mismating. Same insert materials and contacts as used in Series W connectors. Accepts coaxial contacts.

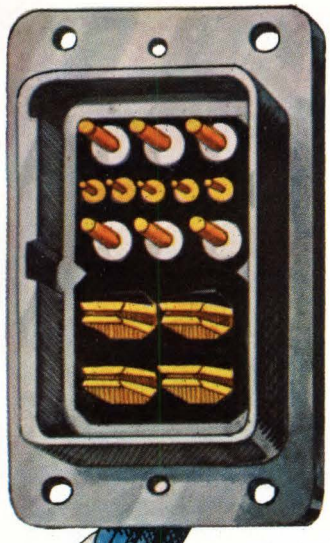


TERMI-BLOK* terminal junction modules. Revolutionary sealed modular commoning system for flexible wiring in airframe, aerospace, and ground support equipment. Vibration-proof modules. Triple-sealed. Positive contact retention. Three module sizes accept wire sizes 24 thru 12 AWG. Up to 400°F continuous operating temperature. Any module removable without electrically or mechanically disturbing other modules. High density, weight-saving feed-to and feed-thru bussing and splicing.

★Trademark of AMP Incorporated

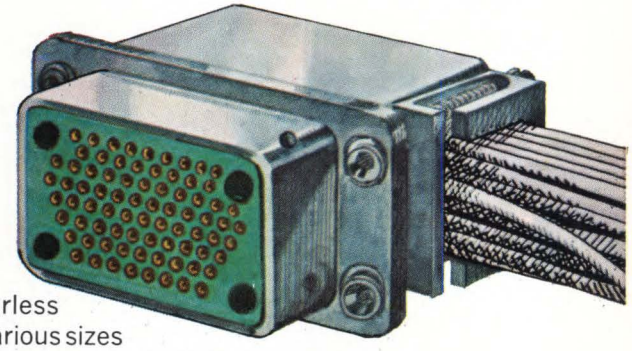
connectors



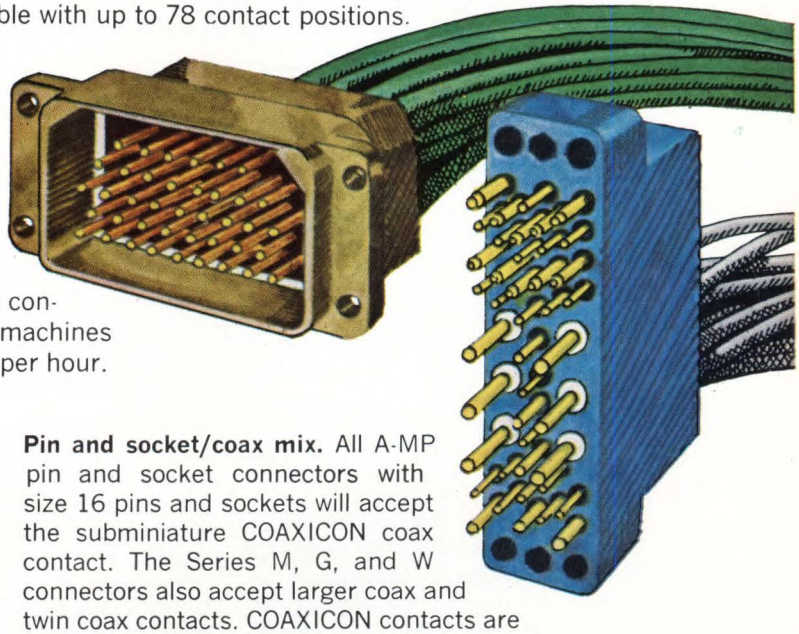


ARINC type. Fully environmental rack and panel connector with crimp, snap-in, front-extractible contacts. Intermateable with present ARINC connectors. Dual-spring socket contact assures consistently reliable performance under vibration and overload conditions. Silicone sealed front and rear. Hard dielectric clip and contact retainer. Contacts crimped, inserted and extracted with MS tooling. Automated tooling available. For any plane that flies.

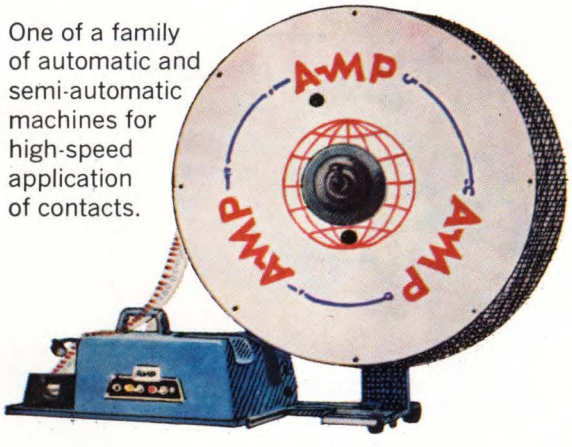
Series G. Versatile modular connector. Various module styles accept several types and sizes of pins and sockets. Snap one, two, or three module inserts into the die-cast aluminum housing. Snap in dependable crimp type contacts. High-speed assembly tooling assures lowest installed costs. Mix power contacts and coaxial circuits. For 32 thru 8 AWG wire sizes.



Series D. Rectangular pin-and-socket connector with glass-filled diallyl phthalate inserts in aluminum shells. Accepts five types of solderless snap-in contacts in various sizes from 10 thru 20, including subminiature coax contacts. Gold over nickel plating on contacts. Raised cavity identification. All parts made of non-magnetic materials. Maximum operating temperature +150°C, minimum -65°C. Meets MIL-C-21617 specifications. Available with up to 78 contact positions.



Series W. High reliability aircraft and military connector. Polarized shell of die-cast aluminum. Diallyl phthalate inserts provide excellent mechanical and electrical properties. Crimped pin and socket contacts of various types and sizes 20 thru 16 snap into housings from rear, are easily removed. Cantilever contact in each socket provides constant contact pressure. AMP's automatic crimping machines permit application rates of more than 2,000 contacts per hour.



One of a family of automatic and semi-automatic machines for high-speed application of contacts.

Pin and socket/coax mix. All A-MP pin and socket connectors with size 16 pins and sockets will accept the subminiature COAXICON coax contact. The Series M, G, and W connectors also accept larger coax and twin coax contacts. COAXICON contacts are applied with a single stroke, fit most types of miniature RG/U and shielded cable. As many as 156 coaxial and pin or socket contacts may be mixed in any pattern. For more information, write **AMP Incorporated, Harrisburg, Pa. 17105.**

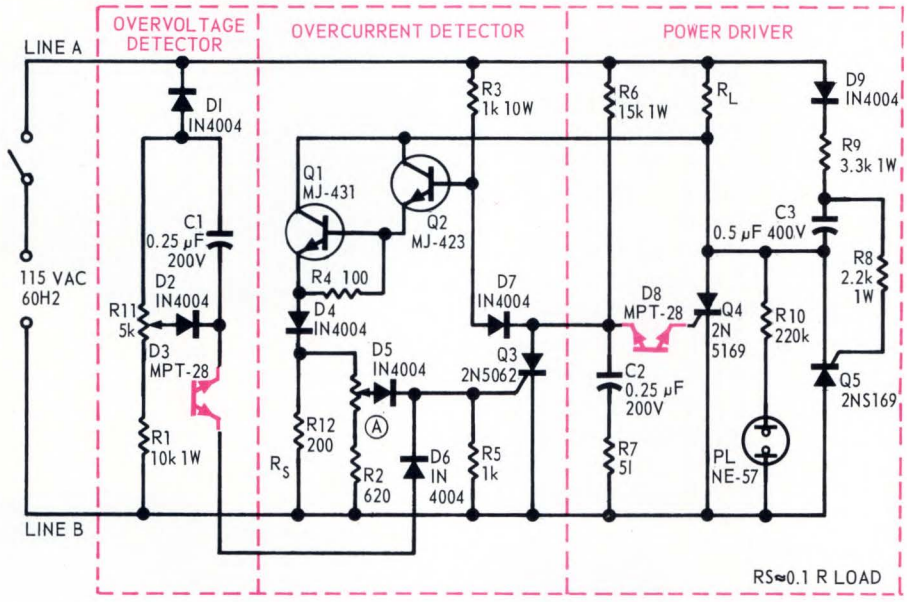
...all from AMP

CIRCLE NO. 53

Three-Layer Triggers Control Load Protector

THOMAS B. STEPHENSON, Western Editor

AN OVERVOLTAGE, OVERCURRENT PROTECTOR FOR 20A LOAD



Three basic sections comprise protector.

Power Driver

When Line A goes positive with respect to Line B, capacitor C2 charges through resistors R6 and R7. When breakover voltage across three-layer diode CR8 (about 28V) is reached, CR8 turns on, causing SCR Q4 to conduct. Full line voltage, less forward voltage drop of Q4 (about 1V), appears across R_L. Same voltage is applied across CR9, R9 and C3 in series. C3 charges until line voltage reaches peak.

When line voltage falls off from peak value, CR9 becomes reverse-biased, C3 discharges through R8 and gate of Q5. Values of R8, R9 and C3 are selected such that, as line voltage goes through zero, ample charge remains in C3 to gate on Q5. Thus, Q5 is slave-fired by Q4, but both SCR's switch off automatically as line voltage reverses.

Overcurrent Detector

This circuit is designed to prevent CR8 from firing Q4, thus keeping load R_L off-line. It must act before voltage across C2 and R7 reaches breakover voltage of CR8.

When Line A goes positive with respect to Line B, Q1 and Q2 are biased on through R3, allowing load current prior to breakover of CR8 to flow through sense resistor R_s. If $R_L >> R_s$, R_L acts as current source, voltage across R_s is proportional to load current. If voltage across R_s is sufficient to forward-bias CR5 and gate of Q3, then Q3 turns on, clamping voltage across C2 and R7 to about 1V. CR8 is locked off, Q1 and Q2 turn off for lack of base drive by CR7. Load current now limited to leakage currents of Q1, Q2, Q4 and Q5, and supply to fault indicator lamp PL.

Constants as given handle up to 20A continuously. R_s must be held to about 1/10 R_L. Voltage divider R12 and R2 allows adjustable trip-point. R12 is set such that voltage at point A fires Q3 before collector current of Q1 reaches 3.5A, the design limit. CR4 protects Q1 and Q2 from reverse line voltage. R4 compensates for leakage current through Q1. CR5 and CR6 form "OR" gate, tying both overcurrent and overvoltage circuits to Q3. R7 limits discharge current of C2 through Q3.

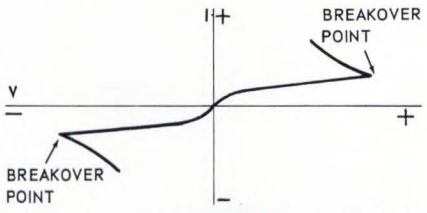
Maximum forward surge current of Q4 and Q5 is 240A. Should load short-circuit at peak line voltage (168V), circuit will not be damaged if total source impedance of supply line is greater than 0.7 Ω. Q4 and Q5 will be switched out within 1/2 cycle of a fault. If a worst-case fault is anticipated, 5-μh of choke in series with R_L will amply protect the SCR's from excessive short-circuit current. Circuit is automatically restored when fault is removed.

Overvoltage Detector

Shown is peak-voltage detector, which senses excess voltage on negative half-cycle (Line B positive with respect to Line A). It locks out Q4 and Q5 as long as overvoltage persists. C1 charges through CR1 and CR2 to level set by voltage divider R11 and R1. D2 prevents C1 from discharging through R11. R11 is set so that C1 charges to less than breakover voltage of CR3, plus sum of forward voltage across CR6 and gate drop through Q3 under normal line voltage conditions. When this voltage is exceeded, CR3 breaks over, discharging C1 through CR6, into gate of Q3.

Time constant of R11, R1, C1 combination must be long enough to assure adequate gate current to fire Q3 when line goes positive. Circuit restores automatically when overvoltage is removed.

VOLT-AMPERE CHARACTERISTIC OF THREE-LAYER DIODE



These are silicon annular three-layer bilateral triggers. They exhibit symmetrical negative resistance switching characteristics. Inexpensive and durable, they are useful in thyristor triggering circuits such as shown.

Design Ideas

Overvoltage and overcurrent protection reacts within a half-cycle, resets automatically.

Voltage-breakover characteristics of three-layer diodes offer protection to excess load voltages or currents. Their unique volt-ampere response is used to trigger a lock-out circuit that disables a pair of power thyristors (SCR's) when load rating is exceeded. The protector reacts within a half-cycle to lock out or reset automatically.

The design is noteworthy because no current-sensing element is required in series with the load as is the case in most circuits of this gender. ▭

This article is one of a series of six articles prepared by the Industrial Applications Group, Motorola Semiconductor Products Div. Circuits presented were developed to meet specific customer problems in medium-power conversion, switching and motor control applications. These six designs are selected from the Motorola Handbook, "Semiconductor Power Circuits", *published in October 1968.*

Bob Gregson, of Motorola Semiconductor Products Div. Industrial Applications Group during the past 4 years, attended Northeastern University, and worked at the Instrumentation Lab of MIT prior to Motorola. He has six patents pending.

Timer Design With Programmable UJT's

CARL BROGADO, E. Bollay Associates

A new semiconductor device, the programmable UJT, teams well with the FET in designing stable timers.

Semiconductor timers have found a new friend in the programmable UJT. When coupled with an FET constant-current source and a high-quality capacitor, a highly versatile, adjustable and stable delay circuit can be constructed. The key to this high performance is the programmable unijunction transistor, designated PUT.

PUTs offer very high sensitivity along with low peak-point current and low leakage.

Other more obvious advantages of the PUT are the programmability of η, I_P, I_V and R_{BB}; ability to generate fast, high-energy pulses; selection of firing voltage, and low cost.

The author designed a 6-sec timer Selected for low I_P and high I_V. A low-leakage diode provided temperature compensation of the anode-to-gate voltage V_{ag}. An FET constant-current source permits a linear and adjustable charging characteristic. Frequency stability is excellent over a wide temperature range. □

Databank

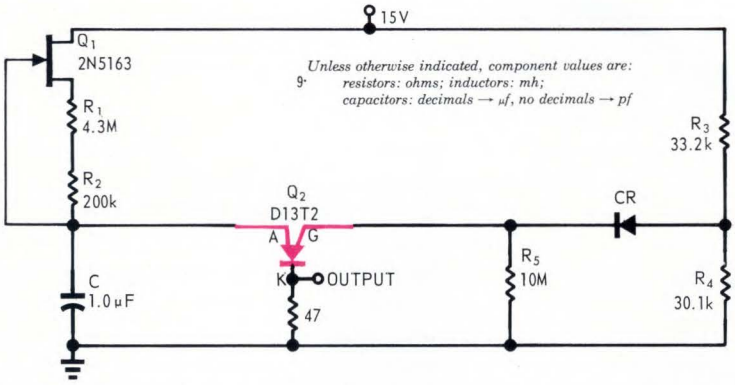
Interested in some references? Carl Brogado suggests these:

1. "Unijunction Transistor Timers and Oscillators", Application Note No. AN-294, Motorola Semiconductor, Scottsdale, Ariz. Gives detailed advantages of using a constant-current source to charge timing capacitor.

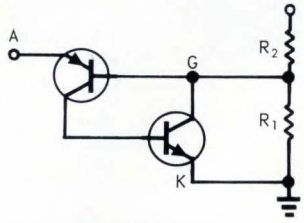
2. "The Field-Effect Transistor Constant-Current Source", application note, Siliconix, Inc., Sunnyvale, Calif. Shows typical designs using FET as a constant-current source.

3. "General Electric Transistor Manual", Seventh Edition, Syracuse, N.Y. Chapter 16, p. 391, "Understanding PNPN Devices", fully explains a two-transistor amplifier with regenerative feedback as applied to an SCS switch, which is in proximity to a programmable unijunction.

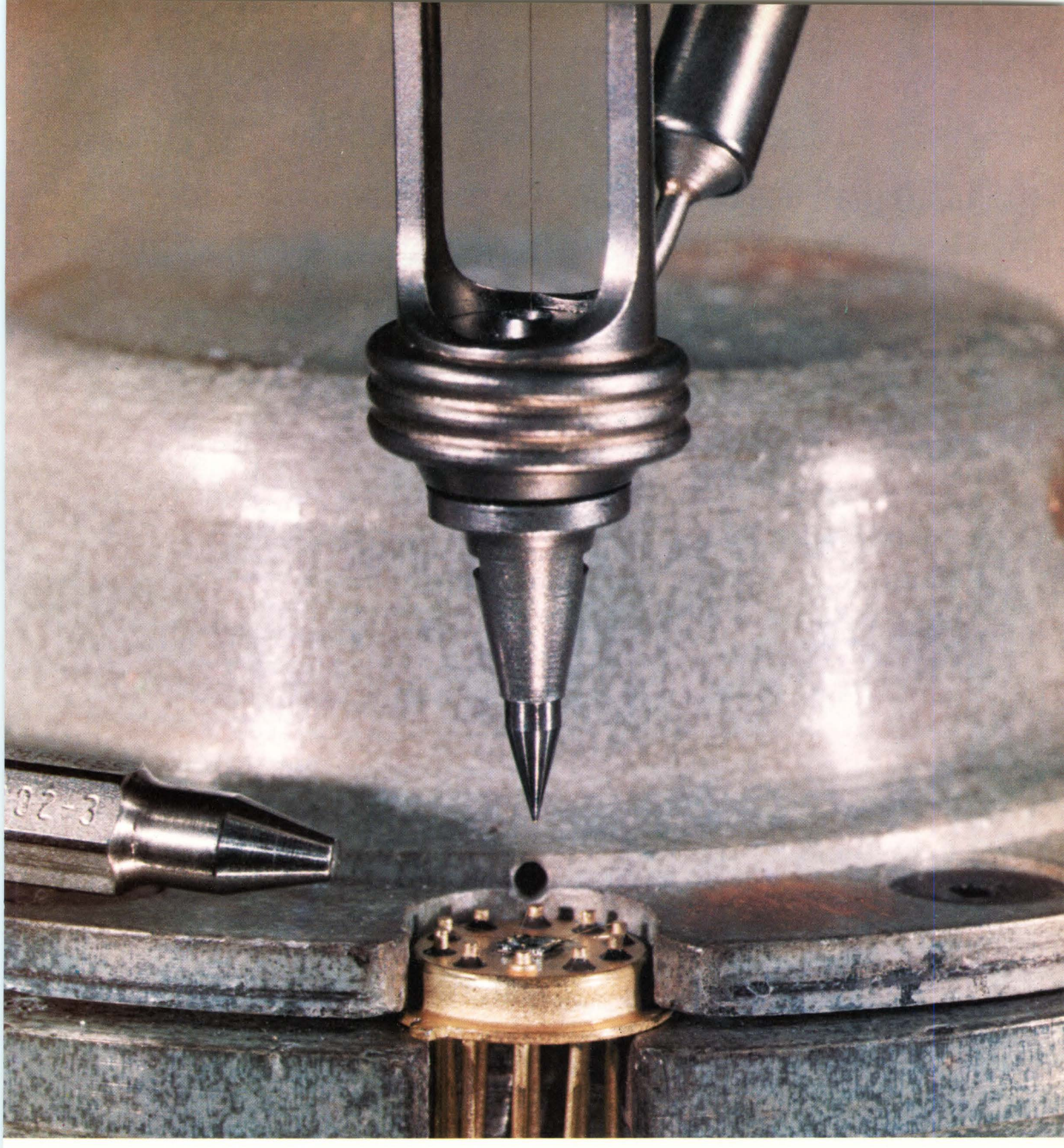
Carl Brogado is now employed at Transformer Electronics Co., Boulder, Colo. He did circuit and systems design at E. Bollay Assoc., Inc., Boulder, Colo. Prior to 1-1/2 years at Bollay, he did research at General Precision Corp. Education includes Glendale Junior College, San Jose State College and University of Colorado Extension Center in Denver.



PUT timer design benefits from FET constant-current source to provide 6-sec linear charging characteristic. PUT was selected for low I_P, high I_V. Timing capacitor C is low-leakage metallized polycarbonate that is charged from constant-current source Q1, R1 and R2 to generate linear ramp. Voltage on C increases linearly with time until PUT conducts. Firing voltage is determined by voltage divider R3, R4. R5 forward-biases CR. CR compensates for negative temperature coefficient of PUT anode-to-gate voltage, V_{ag}. Changing value of capacitor C varies timer delay over range of 1 sec to 5 minutes. Frequency stability is better than 1.5 percent from −25°C to +75°C.



Programmable UJT (PUT) is equivalent to pnp-npn cascaded configuration with three external connections. Gate voltage determines triggering level. Conduction of pnp supplies base current to npn. Collector current of npn turns on pnp harder, providing a regenerative switching effect and in turn fast, high-energy trigger pulses.



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TEMPRESS

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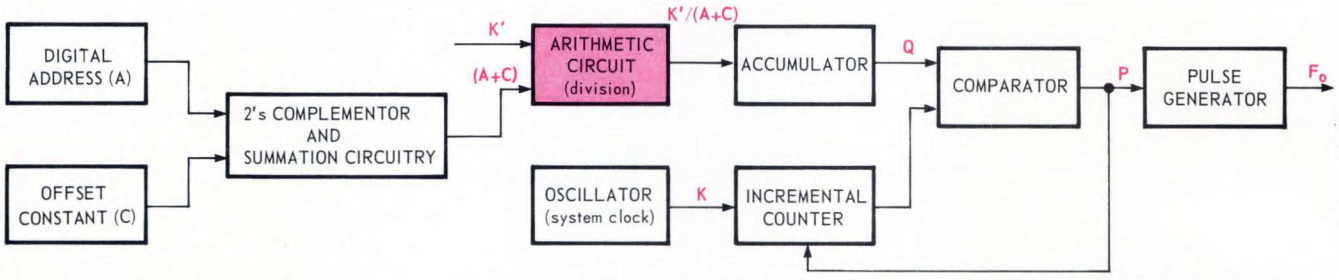
CIRCLE NO. 55

Unique Technique Expands Programmable Digital Clock Capabilities

Programmed digital clock continuously compares the derived period of the desired frequency to the pulse count of a master clock.

NEAL WALTERS and JACK DICKERSON, IBM Corp.



The programmed digital clock system continuously compares the derived period of the desired frequency to the pulse count of a master clock. An offset constant C is added to each new address (A + C) to establish lowest selectable output frequency. Two's complement of the sum is digitally divided into a second constant K′ (review on next page). At the end of a division cycle, quotient Q stored in accumulator register is compared continuously with the increment counter output at master-clock frequency K. When equality is sensed, output pulse P is generated. If a symmetrical square wave (F_0) is required, equality is sensed at one-half of quotient value and the output pulse toggles a flip-flop. Shorter pulses are derived by the output pulse triggering a one shot at various duty cycles.

The programmable digital clock (PDC) produces a given frequency from a corresponding address that is used to derive the period. Clock frequencies can be changed as fast as the PDC system delays will allow. This approach yields a high-resolution clock that is more flexible than the selective clocks developed by a scalar technique.

The lowest selectable output frequency (offset constant) is determined and added to the address corresponding to the required frequency. Through digital division, PDC creates and stores a number equal to the period. By appropriately counting the master clock pulses and continuously comparing the count to the stored period, the desired frequency will be produced.

The high resolution of PDC is achieved by either increasing the frequency of the master clock or decreasing the binary constant K′ used as the dividend in the digital division. Increasing the frequency of the master clock will increase the incremental counter size. A wider range of frequencies can be obtained by decreasing K′ for a given number of consecutive addresses. However, decreasing K′ will also increase the size of the arithmetic and accumulator registers.

Accuracy, an important item, depends upon the quotient (period) that is determined by the accumulator size. The better the accuracy the larger the number of accumulator stages. The accumulator size in turn will influence the number of comparison stages and the incremental counter size.

The concept of PDC can be used in data handling, radar and telemetry applications. It is ideal for automatic testing and measuring in either a factory or a laboratory. The PDC concept presently is being used for a digitally controlled "buzz" source in an experimental terminal analog speech synthesizer.

Acknowledgments

The authors wish to express their appreciation to four associates in IBM: H. Deutsch and D. S. Garris for their many suggestions during the idea design phase; J. S. Sikora for his assistance during implementation, and H. D. Maxey. □

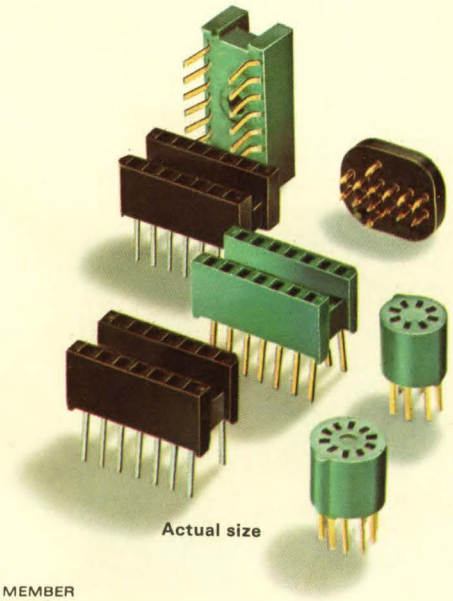
Databank

The authors who collaborated on this story also collaborated on references. They recommend:

1. "Digital Computer Design Fundamentals", by Yaohan Chu, McGraw-Hill, New York, 1962. Good reference for understanding operations (complementing, adding, dividing) in binary.
2. "Perform Binary Division Fast", by Martin S. Schmooker, Electronic Design, July 12, 1966, pp. 61-65. Presents a good review of several ways that binary division can be performed.

CINCH PRECISION MINIATURE SOCKETS

INSURE EQUIPMENT DEPENDABILITY



Actual size

Equipment design frequently involves problems of field maintenance or circuit updating. Cinch component sockets provide inexpensive and effective solutions without compromising reliability.

DIP sockets for 14 and 16 lead DIP's are typical of Cinch specialized miniature sockets. Available in GP black phenolic or SDGF diallyl phthalate, they have extremely high resistance to shock, vibration, humidity and corrosive atmospheres. Contacts are gold or cadmium plated beryllium copper with low contact resistance.

IC sockets for 6, 8 and 10 pin TO-5 cased devices, miniature *NIXIE Tube* sockets and *Subminiature relay* sockets are just a few of the other component sockets Cinch manufactures.

For information on DIP sockets and other Cinch interconnection devices, write to Cinch Manufacturing Company, 1501 Morse Avenue, Elk Grove Village, Illinois 60007. C-6818

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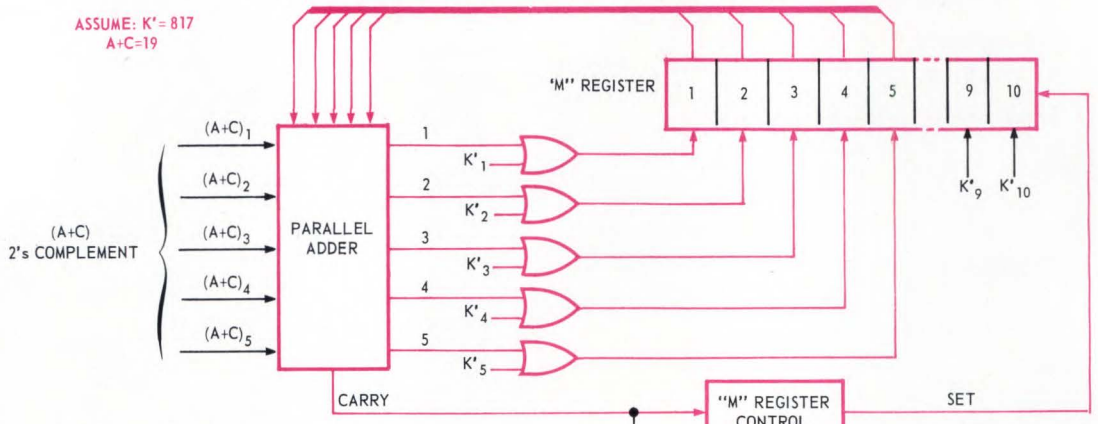
CIRCLE NO. 56

Digital Clock (Cont'd)



Brief Review of Two's Complement Division

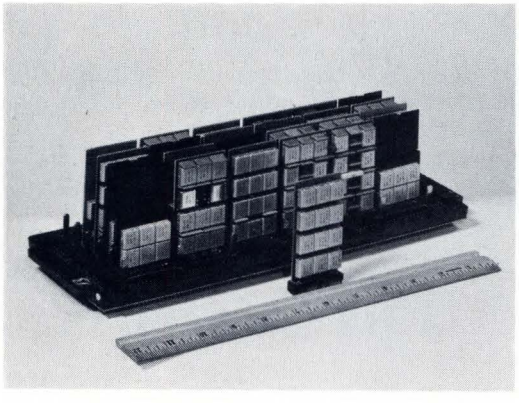
1. Generate the 2's complement of the divisor and keep the dividend in true binary.
2. Logically add the divisor to the MSD of the dividend.
3. If the addition produces a carry (positive remainder), enter a "one" in the quotient. Save the sum and bring down the next bit of the dividend. Shift the divisor and add.
4. If there is no carry (negative remainder), enter a "zero" in the quotient. Discard the logical sum, shift the divisor and add again.
5. Repeat the process until all bits of the dividend have been brought down.

EXAMPLE: 817÷19 = 43

				Quotient
817	1100110001 in binary		1100110001	
19	10011 in binary		01101	
19	01101 in 2's complement	Sum	10011010001	1
43	101011 in binary		0011010001	
		Shift	01101	
		Sum	0110100001	0
		Restore	11010001	
		Shift	01101	
		Sum	100111001	1
			00111001	
		Shift	01101	
		Sum	01101101	0
		Restore	0111001	
		Shift	01101	
		Sum	101001	1
			010011	
		Shift	01101	
		Sum	100000	1

CYCLE	OPERATIONAL STEP	CARRY	ADDER OUTPUT	M REGISTER CONTENT	ACCUMULATOR CONTENTS
INITIAL CONDITION	– – –	0	00000	1100110001	000000
1	Add	1	00110	1100110001	000000
	Set Acc.	1	00110	1100110001	000001
	Set M	1	00110	0011010001	000001
	Shift M and Acc.	1	00110	0110100010	000010
2	Add	0	11010	0110100010	000010
	Set Acc.	0	11010	0110100010	000010
	Set M	0	11010	0110100010	000010
	Shift M and Acc.	0	11010	1101000100	000100
3	Add	1	00111	1101000100	000100
	Set Acc.	1	00111	1101000100	000101
	Set M	1	00111	0011100100	000101
	Shift M and Acc.	1	00111	0111001000	001010
4	Add	0	11011	0111001000	001010
	Set Acc.	0	11011	0111001000	001010
	Set M	0	11011	0111001000	001010
	Shift M and Acc.	0	11011	1110010000	010100
5	Add	1	01001	1110010000	010100
	Set Acc.	1	01001	1110010000	010101
	Set M	1	01001	0100110000	010101
	Shift M and Acc.	1	01001	1001100000	101010
6	Add	1	00000	1001100000	101010
	Set Acc.	1	00000	1001100000	101011
	Set M	1	00000	0000000000	101011
STOP: Answer is in the Accumulator; Remainder in M.					

Basic block diagram of two's complement division circuit. Division timing is controlled by a counter synchronized with master clock. Each division cycle produces *one bit* of quotient and subdivides into the following steps: (1) Add MSB of "M" register to the input. (2) Place the carry bit into the LSB of the accumulator. (3) If carry is "one", enter adder output into MSB of "M" register. (4) Shift "M" register and accumulator left one bit. Assume initial conditions of "M" register is binary number K'. Chart illustrates the contents of each register after the operational step has been carried out.



Buzz generator designed to cover male range of intonation in a terminal analog speech synthesizer. Utilizing a 65.536-kHz crystal oscillator and seven-bit address provides frequencies from 64 to 192 Hz in 1-cycle increments.

Jack Dickerson is a 12-year veteran of IBM Corp., Research Triangle Park, N.C. At present he is a staff engineer in the Multiplexor Products Group, Systems Development Div., and has been granted two patents. This is his third article published in EDN (May 1962, December 1962).

Neal Walters is a Senior Associate Engineer and his duties involve logic and circuit design for the system development group of Research Triangle Park, N.C. He has been with IBM for 2-1/2 years.

CIRCLE NO. 57

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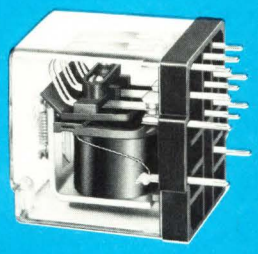

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CIRCLE NO. 58

CUSTOMER ENGINEERING CLINIC—

Triac Blows When Operated Within Specified Power Limits

THOMAS A. PENKALSKI, General Electric Co.

Problem: The customer is driving a transformer primary with a triac. He complains that, even though the transformer is unloaded, the 6A, 400V triac is being destroyed. He argues that the PA424 integrated zero-voltage switch (**Fig. 1**) will always energize the triac and transformer at zero instantaneous line voltage and in so doing will hold the steady-state value of magnetizing current (I_{mag}) well within the limits of the triac.

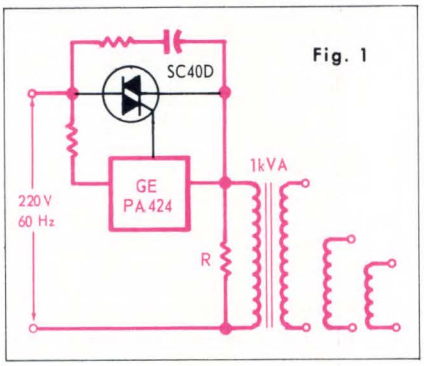
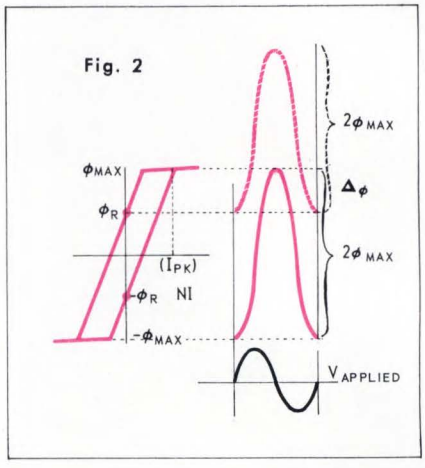


Fig. 1

Discussion: The customer is almost correct. The PA424 will apply line voltage to the transformer primary at zero instantaneous line voltage, and the steady-state I_{mag} will be within the capability of a 6A triac. However, after once being energized and then de-energized, the core exhibits residual magnetism. When energized again at zero voltage, the core quickly saturates and a very high transient I_{mag} results. Current is limited only by line impedance and primary resistance. In fact, the first pulse of this transient —as high as 90A for some 1-kVA transformers can certainly be detrimental to a 6A triac.

A simplified BH curve for a fixed core dimension and applied frequency, along with its applied voltage and some possible resulting flux curves, all in their proper phase relationship, are shown in **Fig. 2**. In this figure, it is assumed that the voltage applied will allow complete utilization of the core but will not result in steady-state saturation. The voltage and flux curves show that when line voltage is applied at its zero crossing, the core flux traverses $2\phi_{max}$ during that voltage cycle. When this flux excursion is within the unsaturated limits of the BH curve, as it would be in steady-state (shown by the solid flux line), a tolerable peak I_{mag} will be realized. However, when the triac gate signal in **Fig. 1** is removed, the triac will turn off when the circuit current drops below triac holding current. The remaining energy will be dissipated in resistor R and ultimately the core will come to rest at or between either residual flux point, ϕ_R or $-\phi_R$.

Let us assume that the transformer core has been previously magnetized and rests at ϕ_R. The PA424 then



energizes the triac at zero instantaneous line voltage as shown in **Fig. 2**. The resulting flux is shown by the dotted curve starting at ϕ_R, increasing to a magnitude of $2\phi_{max} + \phi_R$. Unfortunately, this flux drives the core well into saturation, resulting in a high transient I_{mag}. If the core were preset at the other extreme ($-\phi_R$), the flux would reach a magnitude of $2\phi_{max} - \phi_R$, with the resulting I_{mag} being somewhat less than before but still possibly detrimental to the triac. Intermediate values of residual flux would result in inter-

CUSTOMER ENGINEERING CLINIC

Customer engineers are continually called upon to solve problems arising from application of their companies' products. Because many of these problems arise repeatedly, they indicate a general electronic application problem area. In each issue, this section will present such a problem and, in the following issue, will reveal the solution to that problem.

EDN will pay $25 for any published problem-solution set contributed by a customer engineer. To get this department off to a good start, EDN this month presents one problem-solution set plus a second problem. The second problem will be solved in the next issue.

(Continued)

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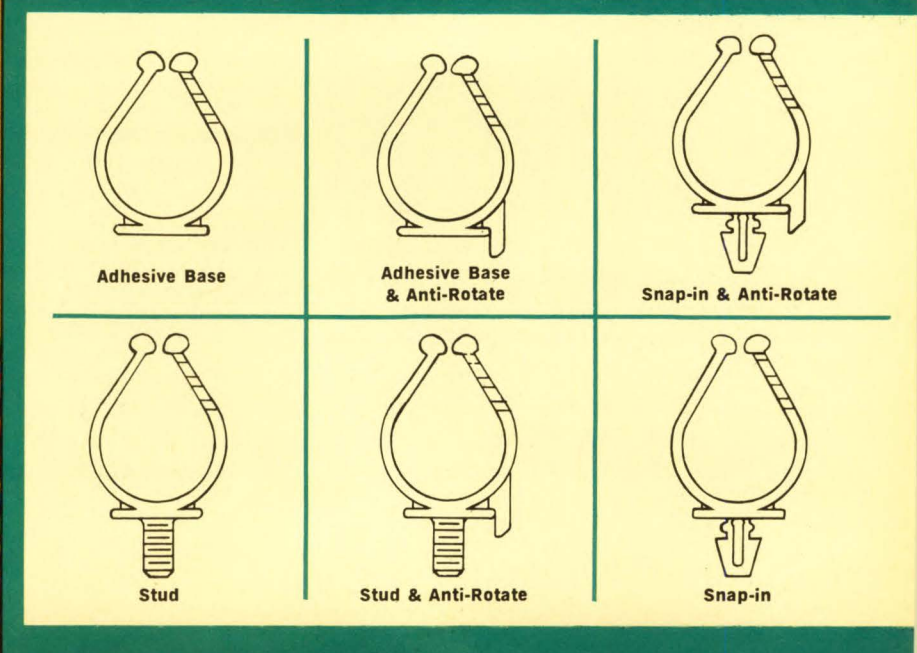

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CIRCLE NO. 59

mediate transient values of I_{mag}.

Because of the primary resistance voltage drop during saturation, the high saturation current decays as a dc component, as shown in **Fig. 3**. The primary resistance and leakage reactance exert a considerable limiting effect on maximum peak current.

Solution: For possible solutions to this problem consider **Fig. 4**. If the customer knew the residual flux level and was able to distinguish the proper half-cycle of applied voltage, then the triac could be turned on at the phase angle α (assuming the core were preset at ϕ_R). The core flux would then start essentially where it had previously come to rest and would not increase enough to cause saturation, resulting in the elimination of high magnetizing transient current. Or, as an alternative, if he knew only the relationship of ϕ_R to ϕ_{max}, but not the residual flux level, and did not distinguish between half-cycles of applied voltage, he could safely turn the triac on at phase angle α corresponding to ϕ_R, on either half-cycle, decreasing α on each succeeding half-cycle until full voltage is realized.

Unfortunately, knowing the residual flux level and proper half-cycle is inconvenient and the relationship of ϕ_R to ϕ_{max} is seldom known. Further, for some cores, ϕ_R may be almost equal to ϕ_{max}, requiring α to be very large. Therefore, one of the most general and practical solutions is to "soft start" or phase control the applied voltage starting from a very large triggering angle, α, on either half-cycle and decreasing α slowly on each succeeding half-cycle. For some applications, such as welding controls, it is advantageous to know the residual flux level and the proper half-cycle and energize the transformer at zero instantaneous voltage of the proper half-cycle. This will decrease startup time and reduce RF interference.

Fig. 3

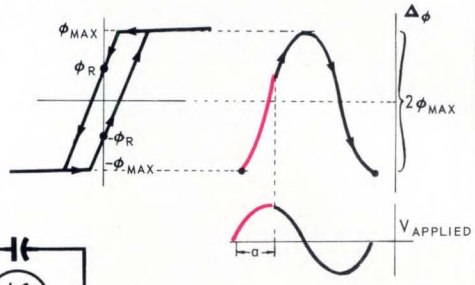


Fig. 4

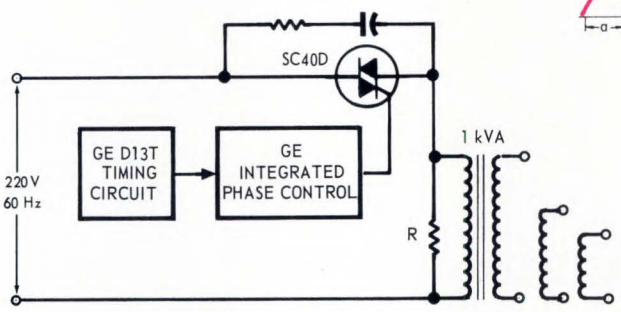


Fig. 5

Other solutions are:

a. Size triac to withstand worst-case inrush current. This may not be practical for large transformers but may be reasonable for smaller VA ratings.

b. Use a transformer with twice the ϕ_{max} capability, i.e., double the voltage rating. This may not be economical for large VA ratings.

c. Introduce a current-limiting impedance. This is a good solution if line regulation is not important.

The suggested solution to the problem is shown in **Fig. 5**. The GE PA424 zero-voltage switch should be replaced with the new GE integrated phase control for inductive and resistive loads. A GE D13T, programmable unijunction timing circuit, or the equivalent, also should be incorporated as a means of slowly decreasing a large angle α. □

Databank

For more information, try these references.

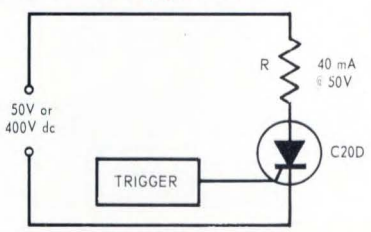
1. Puchstein, A. F., Lloyd, T. C., and Conrad, A. G.; "Alternating-Current Machines", Third Edition; John Wiley & Sons, Inc.

2. "SCR Manual", Fourth Edition; General Electric Co., Semiconductor Products Dept., Auburn, N.Y.

NEXT MONTH's PROBLEM – SCR rated at 400V blows when 400V is applied.

Problem: A customer comments that even though a 400V SCR passes only a small forward current, it is being destroyed when the dc supply voltage is increased to 400V. He also mentions that the SCR is bolted directly to a PC board and is operating in 75°C ambient air.

Solution: Next issue of EDN.



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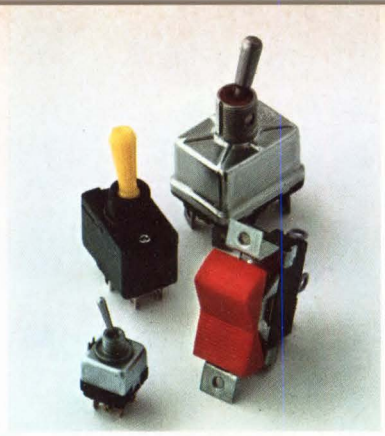

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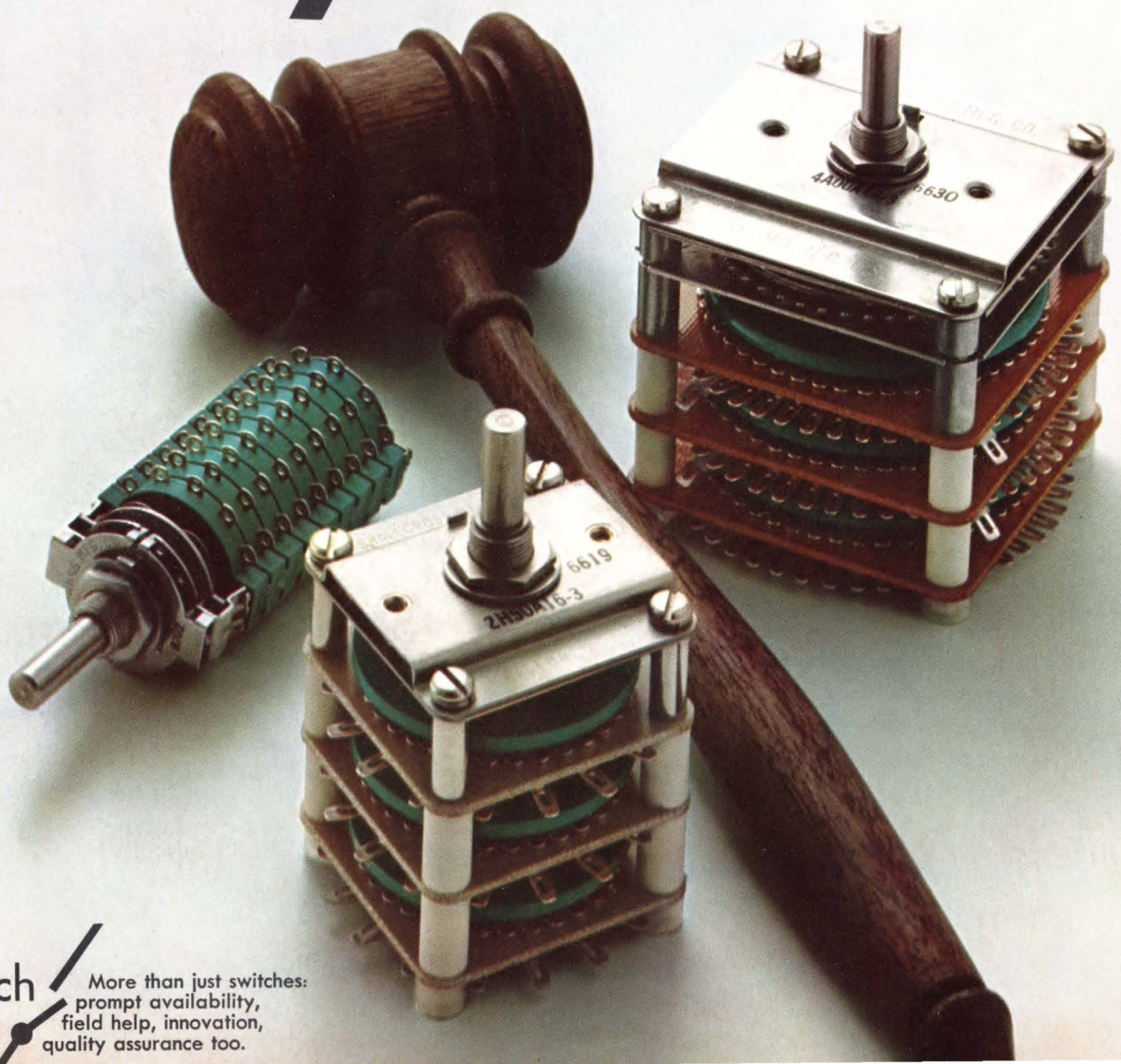

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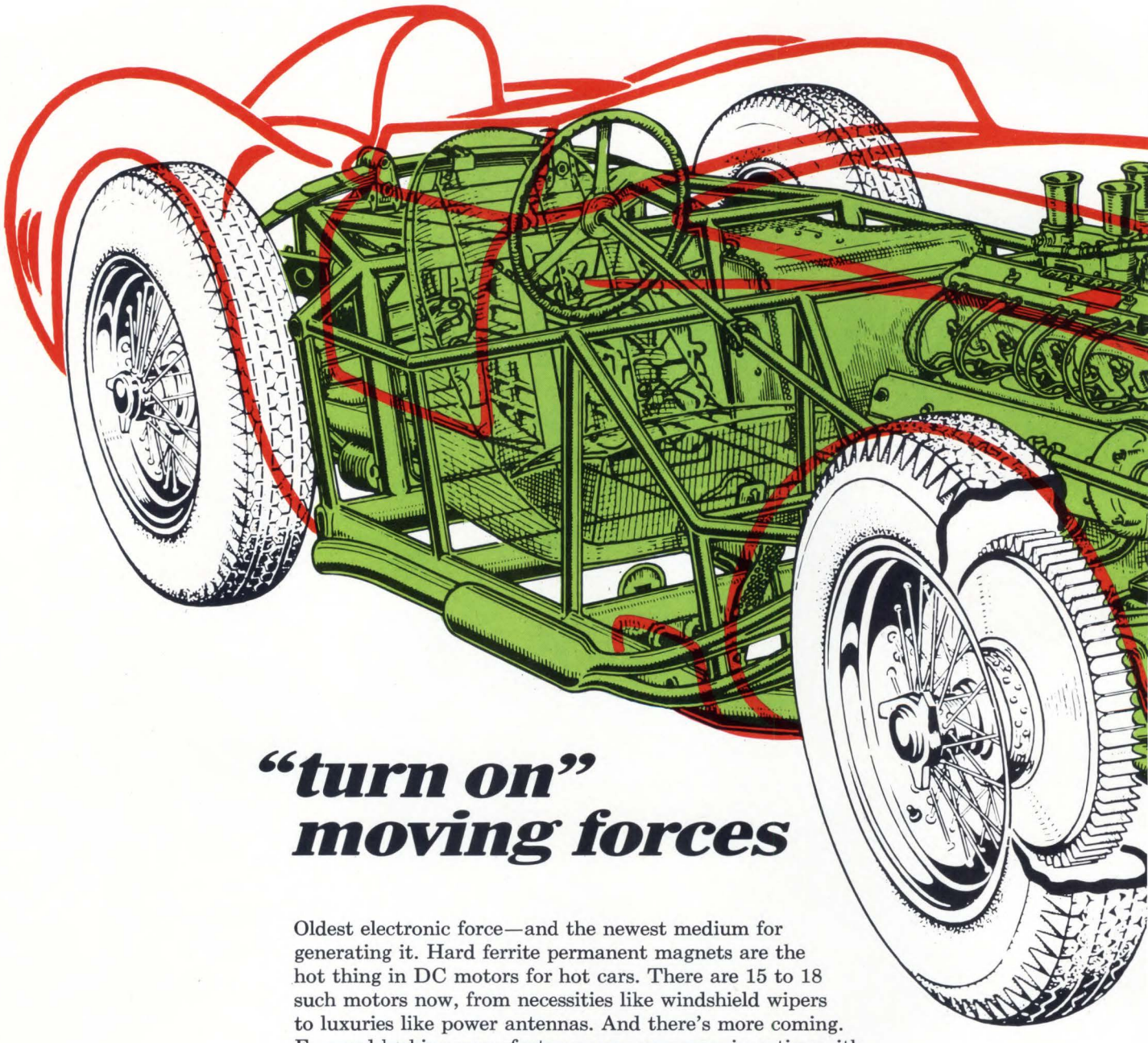

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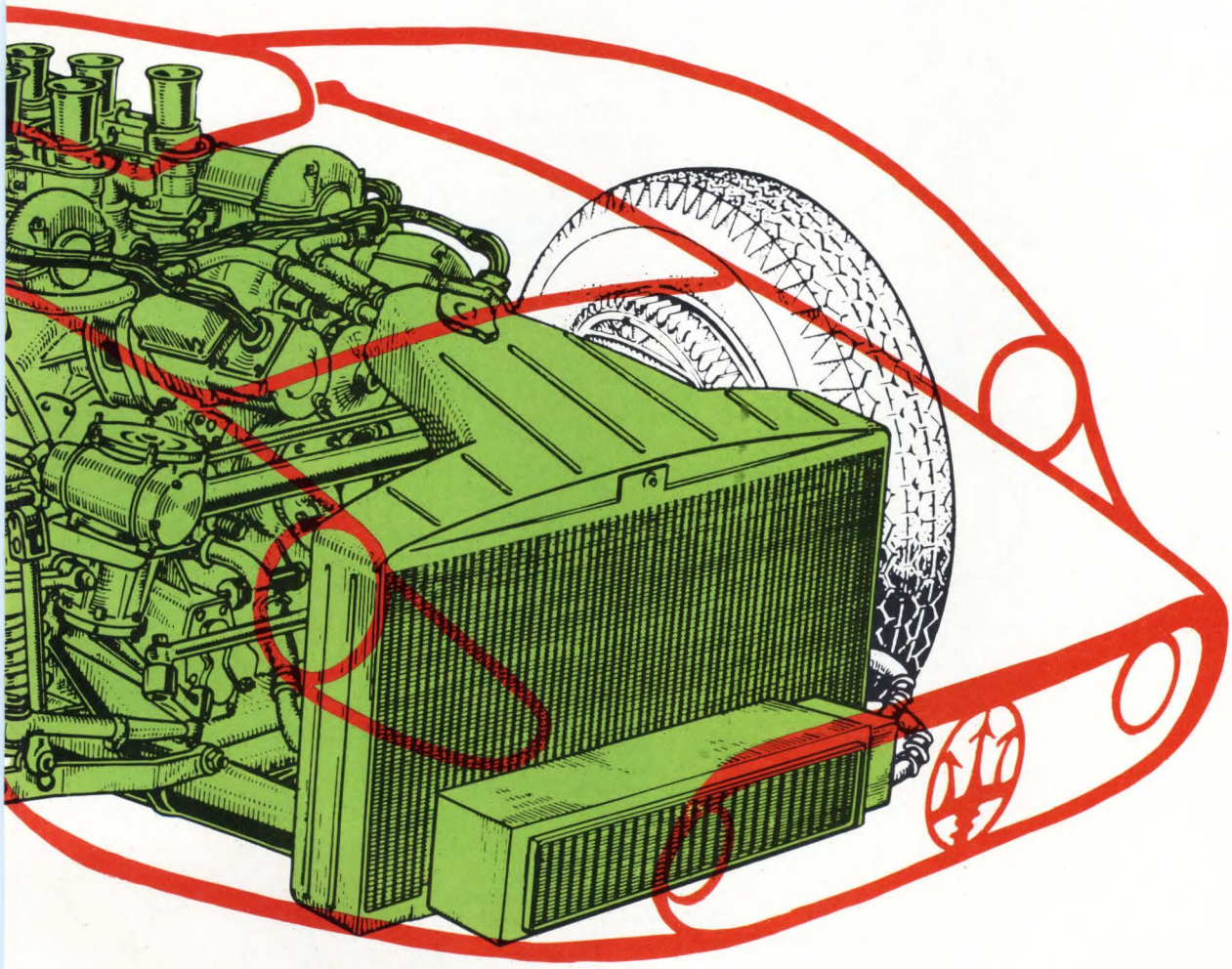

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CIRCLE NO. 61

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CIRCLE NO. 62

Design Interface

Hard-Core Unemployment

Designers Do Give a Damn

GLEN BOE, Executive Editor

There is no doubt that the U.S. is plagued with domestic problems. They are big today and are fully capable of growing to proportions that will strangle American society as we know it.

Pollution, transportation and housing are problems that can be solved to some degree by technology. They are problems that engineers and other technical people, in cooperation with professional planners, can analyze and respond to in terms of proposed legislation and hardware. The ghetto is different. No amount of crime-fighting equipment or riot-control hardware will ever *solve* the ghetto problem. It is a people problem—not a hardware problem.

How Serious Is the Ghetto Problem?

Anyone who reads the papers knows that the ghetto problem is serious. But so are lots of other problems—both domestic and foreign. In an address before the Business-Civic Leadership Conference on Employment Problems, Richard C. Cornuelle, Executive Vice President of the National Association of Manufacturers, put the priority in perspective.

"We have a remarkable unanimity among our members that the greatest . . . most important piece of

(Continued)

Editor's Note: *The engineering department is more than circuit diagrams, Boolean algebra, test fixtures, the latest integrated circuits and unfinished chess games. It also is PEOPLE—people who must interface with other people. Productive relationships with people are indispensable if the designer expects to realize his professional goals—whether they be design achievement, engineering management or both.*

Although most "Design Interface" articles will be dealing with the problems of communicating with people in marketing, purchasing, production and management, we believe that an interface with far broader implications is that between the mainstream of middle-class society and the "unemployable" ghetto dweller. More specifically, we would like to explore this problem in the context of the designer and his on-the-job activities.

business on the agenda of American business today is to . . . find out exactly what its total capabilities to solve community problems are . . . and to get busy and put them to work."

Another renowned spokesman for business, Robert W. Sarnoff, told RCA stockholders last May 7, "To me, it is very plain that a publicly held enterprise cannot ignore social problems that can engulf or even destroy it. No problem, in my view, is more critical and urgent than the social crisis in the cities—and, in particular, the problem of the hard-core unemployed."

These sentiments have been restated hundreds of times in public and thousands of times in print. It is impossible to deny that hard-core unemployment is at or near the top of the list of problems that must be solved.

Group from Youth Opportunity Corps and Upward Bound tours Motorola Semiconductor Products Div. assembly line.

What Really *Is* the Problem?

Most people who have ever tried to break into the job market have run into frustration. "I can't get that job because they want someone who is experienced. But how can I get experience if no one will hire me?" Eventually, most people get a foot in the door and the cycle is broken. Conversely, many black job seekers are never able to crack the cycle because racially discriminatory hiring practices are heaped on top of normal experience requirements. Compound that with a police record, poor references and deviations from WASP "norms" in appearance, education, speech and values (all understandable, but none "acceptable") and it all adds up to unemployment and an overwhelming sense of frustration.

Trainees at NARTRANS, recruited from ranks of disadvantaged youth and hard-core unemployed, receive instruction in terms, signs and general shop language.

When a black "employable" does crack the cycle and land a job, he faces a different sort of frustration. It takes about 1 week on the job to realize that the bottom rung is about as high as he will ever climb on the ladder to professional and financial success. It's obvious, because his black coworkers with years of service are still on the bottom rung. He concludes that training for the next step up the ladder is little more than a futile exercise. This is confirmed when he finally meets a black production foreman who has a Bachelor's degree in engineering and two Master's degrees—one in psychology and one in business administration. Result? Frustration and its consequences.

Expanding this simplistic description of the problem would require a volume or two. It boils down to the fact that the socially deprived also are economically deprived. The causes and effects become indistinguishable, but the end result is a disheartening self-perpetuating waste of human resources.

None of the foregoing has mentioned the migration of "unemployables" to urban areas and the flight of industry to the suburbs. This combination has served to concentrate the problem into an awesome powder keg called the ghetto.

What's the Solution?

Although the solution to the problem is at least as complicated as the problem itself, meaningful jobs for the chronically unemployed must be a part of that solution. Since private industry provides such jobs, then that part of the solution is largely in the hands of private industry. President Johnson has passed the ball to industry by requesting that 500,000 jobs be

(Continued)

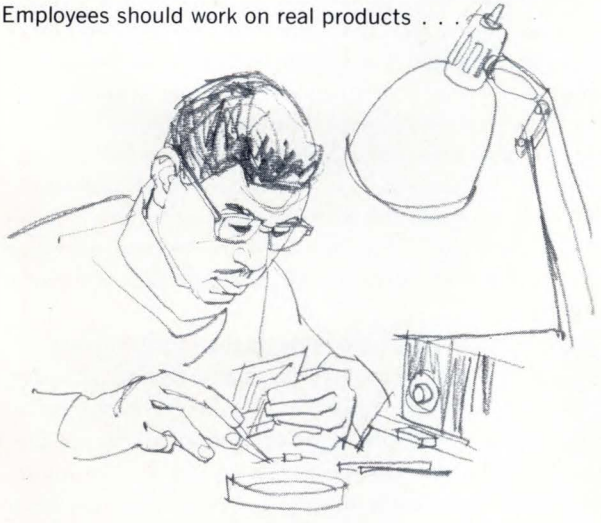
Engineer Runs Equal Employment Opportunity Program

When Honeywell top management committed itself to doing something about the hard-core unemployed, that commitment was followed up by action. For Honeywell-Denver, the first step in the plan of action was to appoint a coordinator to organize and run the program. Interestingly enough, an E.E., Mel Johnson, was elected. Johnson was formerly Manager of Technical Services for Honeywell-Denver. In this capacity he was responsible for the engineering lab, standards lab, model shop, and the design and construction of test equipment. More recently he was Production Manager for Laboratory Standards. His new responsibility is to hire and train "unemployables" for permanent jobs at Honeywell.

Where Do You Begin?

Because the goal is permanent jobs, the first order of business was to survey the Denver operation for anticipated entry-level job openings. These turned out to be in cable and harness fabrication, circuit-board assembly and mechanical assembly. Next, a tentative training schedule, calculated to bring skills up to factory standards, had to be formulated. Then came the task of acquiring and equipping a training site. Finally, candidates referred by the Denver Work Opportunity Center were interviewed and hired. The stage was set for the real work to begin.

Employees should work on real products . . .

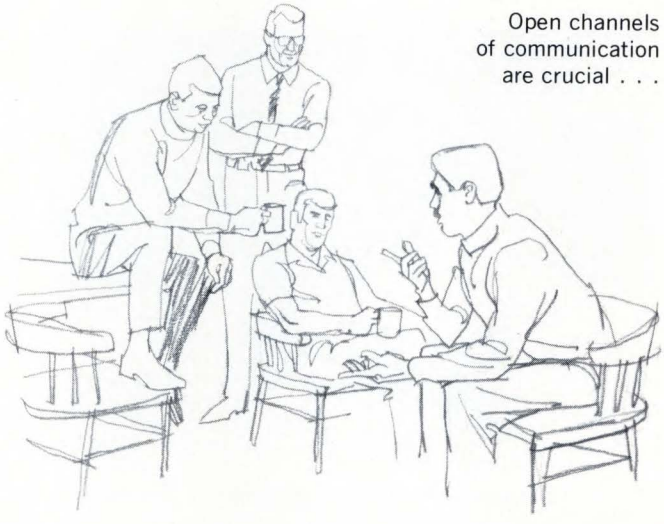


Decisions for Progress

In the chronicle of events that followed, certain salient points stand out that any EEO coordinator should note and apply:

The job's the thing. Employees should be hired immediately, then trained so that they are able to perform up to job standards. When hard-core unemployed are offered only training, they often are unable to see the connection between the schooling they receive and the job they are supposed to go out and find when they finish a course. Further, a course diploma rarely cuts through the barriers of discrimination, past job failures and the host of other factors that tend to keep the hard-core unemployed out of work.

Open channels of communication are crucial . . .



Employees should work on assemblies that actually end up in marketed products. These assemblies are not make-work projects or training kits, but real production subassemblies. Plant inspectors visit the training center regularly to inspect and accept or reject the center's output. This not only reinforces the fact that employees have jobs (versus being in school), but also gives employees first-hand feedback on required

(Continued)

made available to hard-core unemployed by June 1971.

Recruiting, training and holding hard-core unemployed is no easy task, but industry's response and methods are paying off. The approach is to hire a man first, train him to do a meaningful job, then place him in that job and require him to produce. This is quite different from the conventional approach – screening applicants for intelligence and skills, then placing a qualified applicant on the job and providing a minimum amount of OJT. Industry's new approach is to place almost no screen between an applicant and a job.

The U.S. government and industry are teaming up in their attack on hard-core unemployment. Industry is doing what it does best – employing people to produce goods. The government is doing what it does best – providing money. The new twist is that the traditional interface between a human resource and a job is being customized to fit the hard-core unemployed rather than making the applicant conform to established criteria.

Foothill Industries Rehabilitation Workshop in Pasadena is typical of sheltered workshops that provide jobs and training for both physically and socially disadvantaged. Foothill's end products include electronic subassemblies and skilled workers for the electronics industry. There are an estimated 1400 such workshops in the U.S.

A typical trainee is most likely negro, has a sixth-grade education, has been unemployed for 18 months, never received intensive skill training, had unskilled parents, lives with more than one family, needs eye glasses and dental work, has seen a physician once in his life, is married with three children, has no transportation, can afford to eat only twice a day and has had enough contact with the law to have spent at least 30 days in jail. Industry is facing up to the task of taking this kind of raw material and drawing upon its latent talent to serve both industry and society.

IBM provides jobs in this building in the Bedford-Stuyvesant section of Brooklyn. For the time being the plan is only to have manufacturing operations – assembly of computer cables – in this building. However, one negro executive at the plant speculated that it would be a wonderful example to the youth of the predominantly colored Bedford-Stuyvesant area if they could see negro engineers and managers tackling more sophisticated computer developmental tasks.

Designers *Are* Involved

You might ask, "What does this have to do with designers?" True, the first steps must be taken by management. But the framework within which management can operate to initiate hiring and training programs is well established. Contacting the local Chamber of Commerce or the National Alliance of Businessmen will unleash a flood of practical and immediate help. A firm commitment first must come from a company's chief executive, but making the program work requires sincere and active participation by every employee.

If you are an engineer working for a large electronics firm, your firm probably has some formal program going to hire and train the hard-core unemployed. Since many of the jobs being opened up are on the production line, you may be barely aware of the "unemployables" now contributing to the success of your company. But as training methods are improved, you

(Continued)

Opportunity Program (Continued)

quality of workmanship. The scrap rate has been surprisingly low.

Open channels of communication are crucial to the success of the program. For example, a Friday afternoon review of the week's activities where employees comment about what they learned—or failed to learn—during the week has provided insight into things to stress the following week. Even more important is rapid response to all problems and questions as they come up. This means personal problems as well as on-the-job problems.

Absolute candor in all aspects of training is a must. The people involved here can spot a phony reason (or person) faster than it can be heard or seen. And that goes for everything from explaining errors or omissions on engineering drawings to the departing visitor who left an unmistakable trail of bigotry behind.

Managing such a program is a job for a technical man— not a personnel man. Put yourself in the position of having an order for 100 PC-board assemblies. Your raw material is a set of engineering drawings, production parts, a small but well-equipped production facility and a handful of newly hired unemployables. The problem becomes one of being a small subcontractor producing a technical product with an untrained work force. It requires detailed knowledge of engineering and production practices, an ability to manage and the skill to quickly and creatively solve an unbelievable spectrum of both technical and personal problems.

Factory personnel should work with trainees. . .

Trainees should be given the "big picture". . .

Factory personnel should work with trainees frequently to smooth the transition from training center to factory. This allows the trainee to get to know people he will be working with and also introduces him to helpful shortcuts and special skills used in factory assembly. Volunteer coaches from the prospective factory department are expected to spend 2 hours per day with the trainee during the trainee's last week at the training center.

Trainees should be given the "big picture" about how their company operates. They should be told the functions of engineering, sales, production and management, and significance of their work. They must know that their contribution is essential to the success of the company.

Proof of the Pudding

In a status report dated August 5, Johnson states, "Barring unforeseen events, all trainees from the initial class should be successfully assigned in their factory roles by August 23, 1968."

Successes such as this are being multiplied hundreds of times by electronics firms from coast to coast. Although programs differ in detail, there is no doubt that our industry has the ability to provide meaningful jobs for hard-core unemployed.

may find increasing numbers of these employees in the engineering department.

For example, Texas Instruments has a Department of Labor contract to hire and train 150 draftsmen. In addition, they are seeking approval on a proposal to hire and train 100 technicians. These contracts specify that employees must be recruited from among the disadvantaged. Engineers will necessarily be involved in training and working with such employees. Crucial to the success of every such program is interest, understanding and commitment on the part of every person who contacts the new employee.

What Can I Expect?

Depending on what phase of the program you get involved with you can expect some degree of unfamiliar and disquieting behavior by new disadvantaged employees. They may not be able to get along with fellow employees. They may not be able to get along with supervisors. They may have a chip-on-the-shoulder attitude. They may dress, act and speak differently. They may be late. They may be absent. They may not be able to communicate effectively because of limited vocabulary. They may lack proficiency in the basic three R's.

Under normal circumstances, one of these traits could be sufficient cause to give up on an employee. But if the ghetto problem is ever to be solved, individual problems must be solved. And as engineers who are, or shortly will be, interfacing with employees from the ranks of the hard-core unemployed, we must face and solve each individual problem as it arises.

Courtland S. Gross, retired Lockheed Chairman of the Board, in a speech last year before the National Urban League, admirably summed up our responsibility in this regard:

"We must not forget that for many disadvantaged people, getting used to what are to us the familiar ways of corporate life is a devastating and psychologically disturbing experience . . . I think it is clear that we must help the underprivileged get used to it – with tact, with understanding, with counseling, with patience, with encouragement."

ENGINEERS AND ELECTRONICS FIRMS IN ACTION

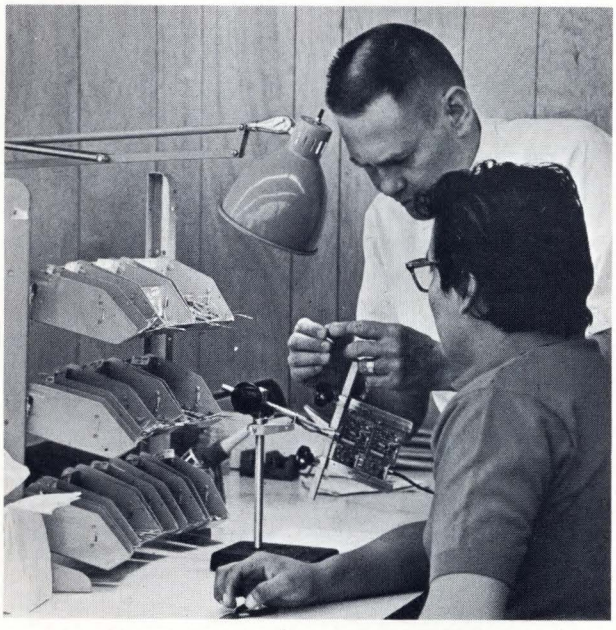
In a recent survey, EDN asked readers if they thought engineers should become involved in social problems. Many readers expressed a desire to become involved but didn't know how to go about it. "Yes, but I'm still trying to figure out how", is typical of many answers. EDN research has turned up many examples of how engineers and their companies *are* involved with one social problem – the hard-core unemployed.

Manpower Administration MA-3 Contracts

One of the most effective ways business is going about providing jobs is through MA-3 contracts awarded by the Department of Labor. Under these contracts, the Department reimburses the employer for a portion of the cost of training a hard-core unemployed person. Complete information on the requirements for government assistance through an MA-3 contract is

Urban labor can match the skill of any other area's labor, says Loebe Julie of Julie Research Labs. Julie has always (since 1954) been located in New York's Manhattan and in low-income areas. Yet, with New York labor, he has produced precision standards that have won him recognition with the National Bureau of Standards. Because his field – precision analog measurements – demands the most careful workmanship, his faith in urban labor has meaning.

Although Julie is known to be an impatient and demanding perfectionist, he apparently has patience and a gift for educating when it comes to training people. He has hired workers, many of whom could hardly speak a word of English – who would not be able on that score to get past the usual large company's employment form – and turned them into highly competent workers in production and testing. Many larger companies in the electronic industry base their precision upon Julie instruments.



Teaching fabrication techniques is only a small part of Mel Johnson's job. Johnson, EEO Coordinator for Honeywell, and an engineer, is involved in everything from motivational psychology to quality control.

available from the National Alliance of Businessmen.

Bay Area Consortium

There are three types of MA-3 contracts: individual, consortium (or pool) and national. One of the most impressive examples of a consortium-type program can be found in the San Francisco Bay Area. Here 41 firms have banded together and pledged 481 jobs. Lockheed Missiles and Space Co. is handling the training phase for all member firms as subcontractor to the Management Council for Bay Area Employment Opportunity. The Council itself is direct contractor to the Labor Dept. Included in the consortium are companies familiar to EDN readers: Alfred Electronics, Ampex, Beckman Instruments, Data Technology, Electroglas, Farinon Electric, General Electric, General Precision-Link, Hewlett-Packard, Optics Technology, Spectra Physics, Ultek and Watkins-Johnson.

Factories in the City

Many electronics firms are investing heavily in building production facilities near centers of hard-core unemployment. AVCO in Roxbury (Boston), Control Data in Minneapolis, Western Electric in Newark and IBM in Brooklyn's Bedford-Stuyvesant section are four well-publicized examples. Locating plants in ghetto areas provides badly needed jobs and, in addition, skirts the transportation problem that continually crops up when core-city residents must commute to jobs in suburban plants.

Forming Subsidiaries

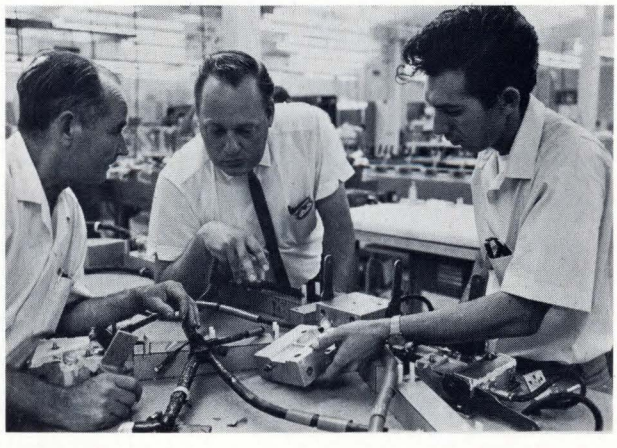
NARTRANS, a newly formed subsidiary of North American Rockwell, will concentrate on hiring and training the hard-core unemployed. Formally opened on July 16 with 65 permanent staff members and 125 production employees, the firm performs machine-shop operations, drafting, typing and keypunching. In addition, NARTRANS produces plastic bags, shipping pallets and crates. Work is being performed on a subcontract basis for the five North American Rockwell divisions located in Southern California.

The subsidiary's general manager, Robert C. Robinson, is a negro space engineer who worked on the Saturn V launch vehicle. Employment at NARTRANS is expected to more than double during the first year of operation. When the subsidiary becomes profitable, it expects to expand its activities to subcontract work for firms other than North American Rockwell.

Backing New Companies

For many reasons, black entrepreneurs find it difficult or impossible to obtain financial backing from traditional lending institutions. Typical of the action attitude of industrial leaders, several electronics firms

(Continued)



In addition to handling training duties for the Bay Area Consortium, Lockheed Missiles and Space Co. has been very active in-house in hiring and training workers from among the socially disadvantaged. Typical of engineer involvement at LMSC is E.E. Carl S. Birge (center), shown working with Isaac Guerrero (right) and Louis A. Torres (left) on a component molding problem.

have provided substantial loans to help such entrepreneurs get off the ground.

For example, EPA Electronics assembles several different Hewlett-Packard instruments. A subcontractor to HP, EPA is financially independent, plans to do subcontract work for other electronics firms and is looking forward to introducing its own proprietary line of instruments. Industry involvement here consisted of HP's response to a sound business proposal with arrangements for a loan, assembly contracts and advice.

Other Programs

Literally hundreds of company-funded, company-staffed programs for hiring and training the disadvantaged exist. Community job programs run by employer councils, rehabilitation centers, workshops, educational programs and other projects are all contributing toward making job holders out of job seekers.

Although there is still a big job to be done, the involvement of the business community is not only sincere, practical and effective, but is indispensable to the eradication of hard-core unemployment.

Another answer to the EDN survey mentioned earlier expresses the attitude that must prevail if we are to progress toward a solution:

"Contrary to popular belief, E.E.'s are people. As people we have the same responsibility to society as do businessmen or ministers . . . We must live as responsible citizens of our street, community, city and nation. Possessing a good technical education, we have the added responsibility of helping those less fortunate by doing what must be done rather than dreaming of doing it."

Databank

Want to increase your knowledge level on this problem even more? These sources will help.

Information About JOBS

1. "Supplemental Information for the Preparation of JOBS/MA-3 Proposals", prepared by the U.S. Dept. of Labor, April 1968. To find out more about the JOBS program and about this report, write to the National Alliance of Businessmen, 726 Jackson Pl. N.W., Washington, D. C. 20506.
2. "New Job Drive Turns to an Old Twist", Business Week, March 2, 1968, p. 24. Explains NAB's "Community Chest" drive for jobs. Specifies goals and names the business leaders involved.
3. "A Business Attack on Poverty—Training the 'Untrainable' ", U.S. News & World Report, March 18, 1968, p. 61. More on JOBS—with sidebar information on "why it costs so much to train the 'hard core' ".

Other Employment Programs—and Problems

1. "Putting the Hard-Core Unemployed into Jobs", Community Relations Service, U.S. Dept. of Justice. Copies available from the Supt. of Documents, U.S. Govt. Printing Office, Washington, D. C. 20402; $0.35. Part I summarizes the Business-Civic Leadership Conference on Employment Problems. Part II presents case studies with emphasis on company programs, employer-community job programs and special tools and techniques. Includes listings of pertinent resources, programs and federal agencies.
2. "The WEMA Perspective", Summer 1968, Western Electronic Manufacturers Assn., 2600 El Camino Real, Palo Alto, Calif. 94306. Excellent overview of the electronics industry's involvement in urban problems. Shows how such companies as Raychem, Honeywell and Lockheed are helping.
3. "Business and the Urban Crisis", McGraw-Hill, Box 756, Times Square Station, New York, N.Y. 10036. Reprints available; less than 100 copies, $0.25 each. Focuses on the problem in all its facets—jobs, housing and education.
4. "A New Business for Business: Reclaiming Human Resources", by Gilbert Burck, Fortune, January 1968, p. 158. Part of a special issue on the urban crisis, this article relates the story of the Watts Manufacturing Co., established by Aerojet-General, and other corporate programs and training systems.
5. "Business Wrestles with Its Social Conscience", by Robert C. Albrook, Fortune, August 1968, p. 88. Tackles the problem of the role profit-seeking companies should play in the urban crisis. Capsulizes the facts about business's efforts and the organizations involved.

General References

1. "Report of the National Advisory Commission on Civil Disorders", Bantam Books, $1.25. Tells it as it is, in summary and in depth. A must for every personal library.
2. "A Sharper Look at Unemployment in U.S. Cities and Slums", U.S. Dept. of Labor, Office of Information, Publications and Reports, Washington, D. C. 20210. Gives facts and figures about who is unemployed, where they are and why they are.

The Engineer and Society

1. "Whose Crisis?", Institute of Life Insurance, 277 Park Ave., New York, N.Y. 10017. Points out that it is "your" crisis, too, and suggests ways "you" can get involved.
2. "Should Engineers Get Involved?", American Engineer, March 1968, p. 45. Agrees that to get involved can be frustrating, but it is still necessary. Advises how an engineer can attack the problem.

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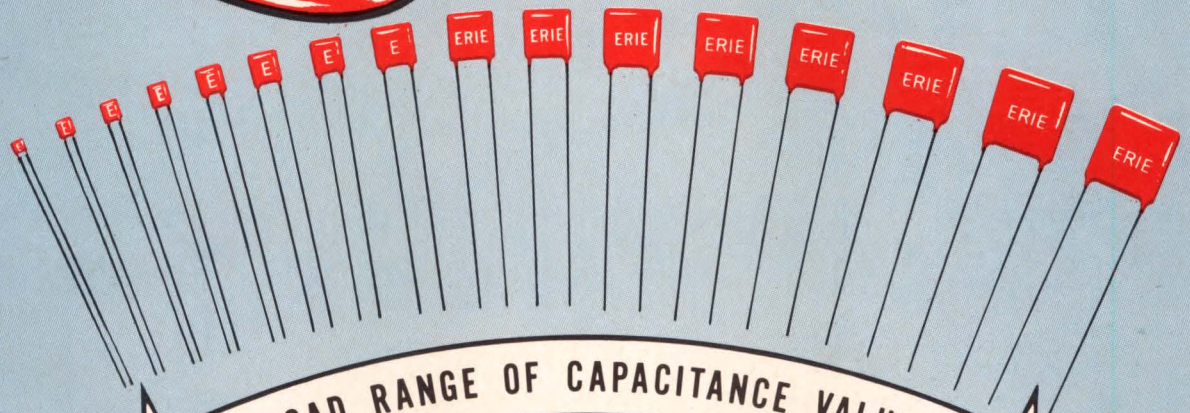

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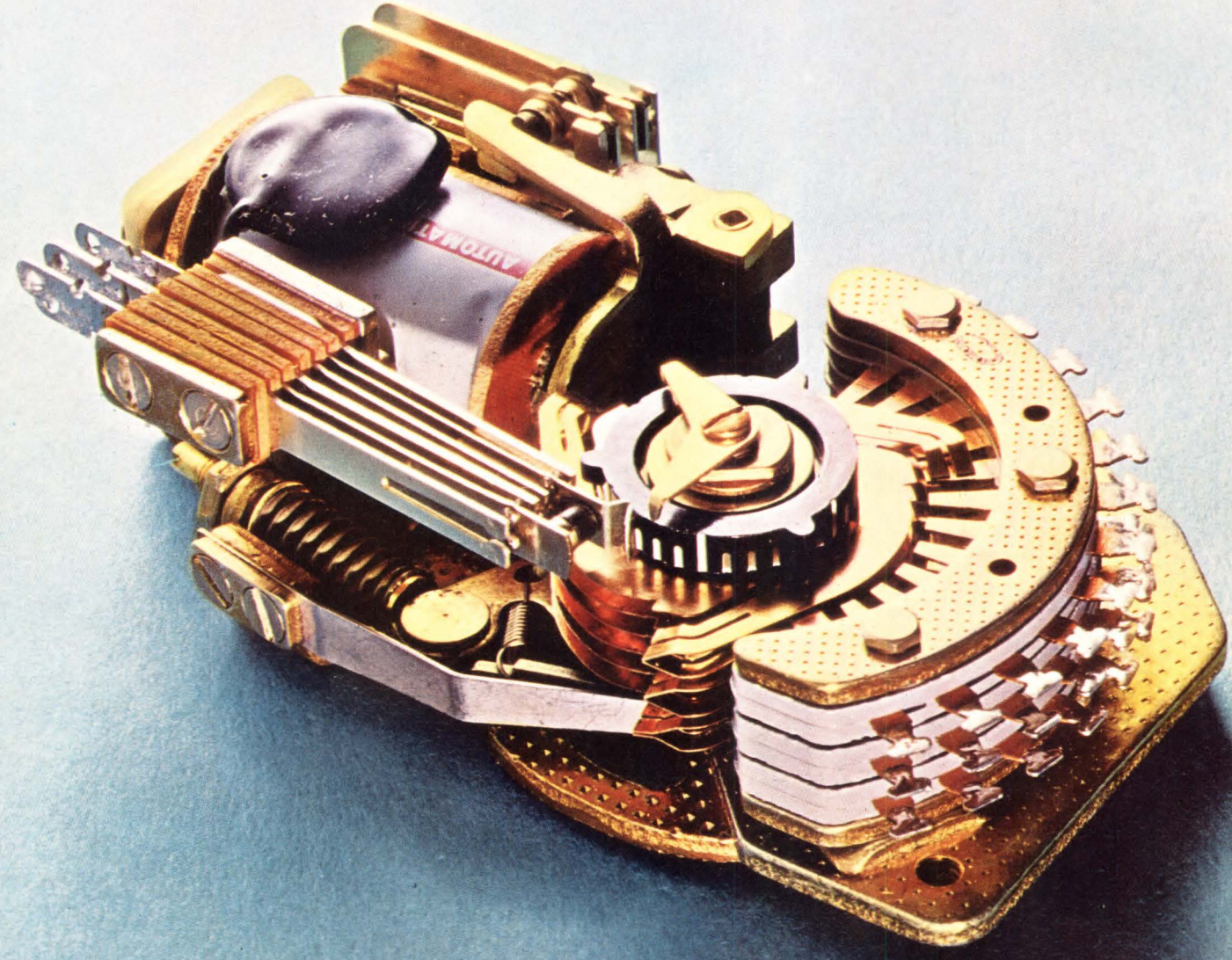
CIRCLE NO. 63

Reliability is a spring, a wheel and two thingamajigs.



Every AE Type 44 stepping switch comes with them.

One-spring power.

The drive spring is a coil. What it does is store up power. When it comes time to switch, the spring lets loose and moves the wiper assembly forward. Each time using precisely the same pressure.

Notice our spring is tapered at one end. It's designed to perfectly match the power input. That's why you always get the best possible transfer of energy.

At one end of the drive spring is an adjusting screw. We turn it a little this way or a little that way and the tension is always perfect.

Try that with a flat spring.

We re-invented the wheel.

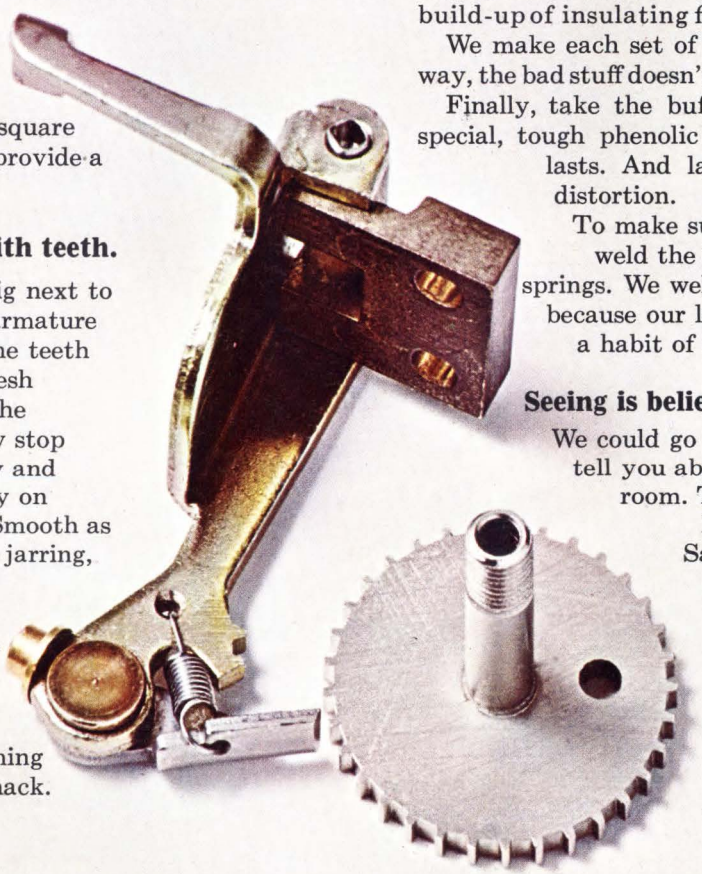
The ratchet wheel is a little different. The way it's made, for one thing. First, we blank it. Next, shave it. And finally, case-harden it. Then it's super strong.

Notice the big, square teeth that always provide a sure bite.

A thingamajig with teeth.

That thingamajig next to the wheel is the armature assembly. When the teeth on the end of it mesh with the teeth on the ratchet wheel, they stop the wiper assembly and position it precisely on the contact bank. Smooth as silk, every time. No jarring, no jamming, no banging.

No adjustments, either. As the teeth wear, they just drop further into the wheel. So nothing ever gets out of whack.



A pawl that floats.

On the end of the armature is the pawl. We made it "free floating" to eliminate the jamming and binding that go with the old style pawl stop block. And while we were at it, we stopped pawl breakage and put an end to double-stepping or overthrow.

Don't bother looking for this special set-up anywhere else. It's patented.

The other thingamajig.

It's called a contact spring. We've got some strong feelings as to what makes a contact spring strong.

In the first place, we believe there's strength in numbers. So we put two sets of contacts on each spring. This means you get a completed circuit every time. Without fail.

But some of the credit for this has to go to our solving the most common cause of contact failure—the build-up of insulating films on the contact points.

We make each set of points self-cleaning. That way, the bad stuff doesn't have a chance to build up.

Finally, take the buffers. We make ours of a special, tough phenolic material that lasts. And lasts. And lasts. All without wear or distortion.

To make sure they stay in place, we weld the buffer cups to the contact springs. We weld, rather than use rivets, because our lab found that rivets have a habit of falling off or wearing out.

Seeing is believing.

We could go on talking reliability and tell you about our testing and run-in room. There's a lot more to tell. But we'd rather have our Sales Representative show you. And let you see first hand the reliability that's built into every AE stepping switch. Just call or write. Automatic Electric Company, Northlake, Illinois 60164.

AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

CIRCLE NO. 64


MOTOR 4
START
RESET

Pushbuttons? Why not go where you have the whole spectrum to choose from!

With panel design continually increasing in sophistication, pushbutton specifications are becoming more and more exacting. Whatever the case—whether your needs call for the simple or the complex—your best bet is to call MICRO SWITCH. The reason is plain. No one can match our pushbutton line in breadth of selection.

What's more, your MICRO SWITCH Distributor can offer you literally thousands of pushbutton varieties *right off the shelf.* For example, he stocks hundreds of interchangeable operator and switch modules that combine into thousands of different assemblies—allowing you to economically customize your panel with unlimited design freedom.

Special problems? MICRO SWITCH also puts the broadest field engineering service at your beck and call. These pushbutton specialists, backed up by the largest manufacturing and design facilities in the industry, can come up with the right solutions fast.

Just a sampling from our spectrum of pushbuttons is shown at left and described below. For more details, call a Branch Office or an Authorized Distributor (Yellow Pages, "Switches, Electric"). Ask for Catalog 51.

1. Unlighted Pushbutton Switches. Bushing or bracket mounted. Available in 1-, 2-, 3- or 4-pole double-throw circuitry, momentary or alternate action. Black, red and green buttons in various diameters. Sealed designs available. Wide range of electrical power-handling capabilities.

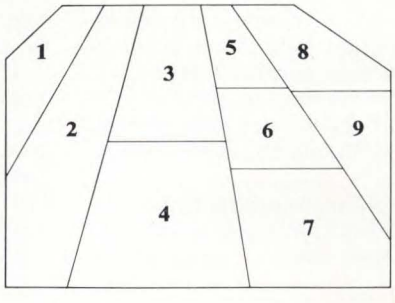
2. Series 2C200 Modular Lighted Pushbutton Switches. Rectangular display lighted by projected or transmitted 4-lamp color. Can be relamped without tools. 1, 2, 3 and 4 section split-display screens. Maintained, momentary or magnetic hold-in operation. Switch modules with silver or gold contacts, multiple circuits and broad choice of contact arrangements and electrical capacities. Also reed switch module.

3. PT Heavy-duty and CMC Pilot-duty Industrial Manual Controls. Oiltight pushbuttons, selectors and indicators with the modern square look. Lighted or unlighted. Large easy-reading legends. Multi-circuit control with up to 32 circuits per unit.

4. KB Switch/Display Matrix. New keyboard building block concept consisting of pushbuttons and pushbars (lighted and unlighted), switches, indicators, mechanical interlock units, and modular hardware for mounting and wiring. Entire KB matrix can be bench assembled. Switches can be pre-wired and plugged in like a radio tube. Milliamp-rated "encoding" switch produces a coded output for data entry, exclusive of separate circuit packages. "Power" switch with 5 amp. 115 vac rating has lighted display option.

5. 50PB Bushing Mounted Pushbutton Switches. One-lamp indication. Choice of button sizes, shape and colors. Long- and short-stroke and turn-to-hold momentary action; one- and two-level alternate-action. 1-4 pole double-throw and two-circuit double-break contact arrangement.

6. DM Pushbutton Switches: Attractive, rugged snap-in panel mount. SPDT or DPDT circuitry. Three snap-on button styles, ½" to 1" diameter, red or black. Also $^{11}/_{32}$" diameter integral momentary-action and push-pull alternate action buttons. Rating: 10 amps, 125 or 250 vac; ⅓ hp, 125 or 250 vac.



7. 302PB Miniature Pushbutton Switches. One- or two-section two-lamp display. Momentary and alternate-action operation of two SPDT switches. Spacing barriers and panel seals available.

8. Series 2N Modular Lighted Pushbutton Switches. Relampable without tools, these switches feature spring-lock mounting. Molded color housings, in gray, white or black, can be supplied with terminals for two or four lamps. Modularity provides a number of circuit, operation and display possibilities paralleling the 2C200 options. Spacing barriers and hold-in coil modules are available.

9. Series 2M Round Display Modular Lighted Pushbutton Switches. Colored guard rings encircle display screen, prevent accidental operation, code control function. Broad choice of circuitry through switch modules used with Series 2N. Many choices of transmitted and projected display colors. Panel mount in $^{1}/_{16}$" to $^{5}/_{16}$" thick panels.

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FREEPORT, ILLINOIS 61032
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CIRCLE NO. 42

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We make a reflector precise enough to light a football field

Chicago Aerial Industries didn't ask us to invent a better way to illuminate football games. What they wanted was a three-dimensional, electroformed reflector head formed to incredibly precise specifications for a military contract. They decided we were the only people with the capabilities to produce what they needed.

They were right. No one can match Buckbee-Mears in the field of two or three dimensional precision electro-forming. Our mesh screens, for example, go down to four million holes per square inch with perfect accuracy. Line width tolerances of ±.0001 are common.

A few of our standard products include evaporation masks, pin hole apertures, micro-mesh sieves, electron microscope grids, optical wedges, zone plates and a variety of micro-miniature parts.

We're equally adept at electroforming gold, silver, copper and nickel. Any shape you want. Besides the reflector, we produce seamless tubing to a thickness of .005 inches for housing intricate electronic packages used in space vehicles. We make the carefully angled exhaust pipes for aircraft jet engines.

If it requires an intricate two or three dimensional shape with precision tolerances, just ask us. Call Bill Amundson, our Industrial Sales Manager, and tell him what you need.

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CIRCLE NO. 65

Multiplexer Extends Solid-State Tester Capabilities

A multiplexer has been developed to interface with the four input leads of any standard transistor or diode tester. Once interfaced, the basic four-lead tester becomes a 16-lead tester with capability of reducing test time by as much as 50 percent.

With a waferprobe, multiple devices can be tested during a single head-down cycle, resulting in test rates up to 10,000 devices per hour.

Basic matrix (below) depicts how up to five programmable power supplies can be added and multiplexed to the 16-device input leads.

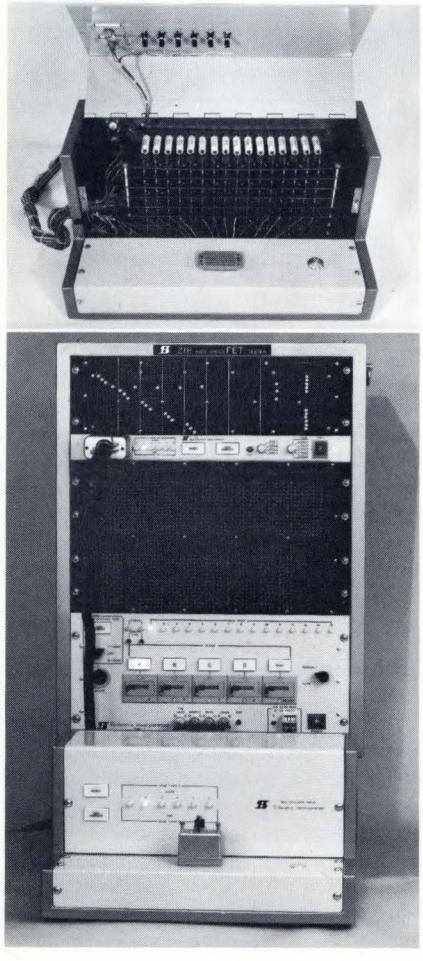
One critical problem in designing a multiplexer of this type is found in the matrix design. Both low leakage current and fast settling time are essential in this type of system. Each reed relay (top right) is especially treated to minimize leakage from contamination and to repel moisture. Each is fitted with a guard band to shunt off any remaining leakage to ground. With this design, less than 20 pA of dc leakage is added between any two leads of the basic system.

The multiplexer has a control panel (lower right) that selects both mode of operation and number of cycles (up to 6), depending on the device to be tested. The multiplexer is mated to a "ZIP" high-speed FET tester. Pinboard programming and prepunched "Mylar" sheets are used for reliability, low cost and reprogramming ease.

The basic multiplexer has all of the necessary controls for interfacing with virtually any transistor test system, automatic waferprober, automatic handlers, classification and data-logging systems. Four basic operating modes provide test flexibility to accommodate single-chip arrays and discrete devices for go/no-go testing or data accumulation. The four operational modes are shown in Table I.

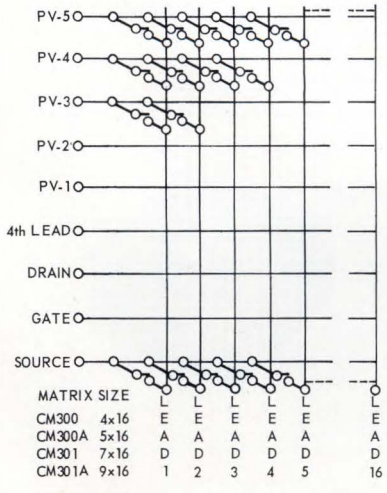
Siliconix, Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif., 94086.

CIRCLE NO. 426



With top opened, (upper photo) banks of especially treated reed relays are shown, which add less then 20 pA between any two leads of a basic tester.

Control of multiplexer is by way of control panel shown just below top patch panel. Both mode and number of cycles are selected here.

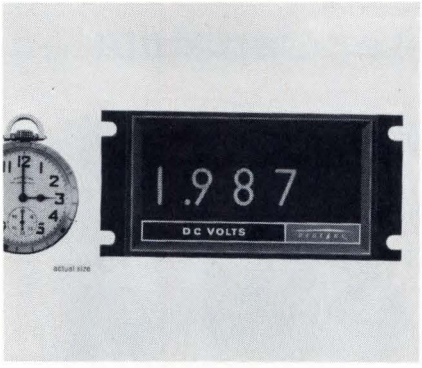


	MODE I	MODE II	MODE III	MODE IV
TYPE OF TESTING	GO/NO-GO	DATA COLLECTION	GO/NO-GO	DATA COLLECTION
NUMBER OF DEVICES TESTED PER MULTIPLEXER PASS	1*	1*	1 TO 6**	1 TO 6**
TYPE OF DEVICES	ARRAYS	ARRAYS	DISCRETE DEVICES	DISCRETE DEVICES
USED WITH	MONITOR II, ZIP, ANY OTHER GO/NO-GO TESTER, CLASSIFICATION SYSTEM	MONITOR II, ANY OTHER DATA COLLECTOR, CLASSIFICATION SYSTEM	MONITOR II, ZIP, ANY OTHER GO/NO-GO TESTER	MONITOR II, ANY OTHER DATA COLLECTOR

* CIRCUIT WITH A REPETITIVE FET OR ANALOG GATE PATTERNS IN A SINGLE CHIP OR PACKAGE.
**SINGLE FET OR ANALOG GATE.

Table I operating modes.

Basic switch matrix depicts choice of four different multiplexers for adding up to five programmable power supplies.

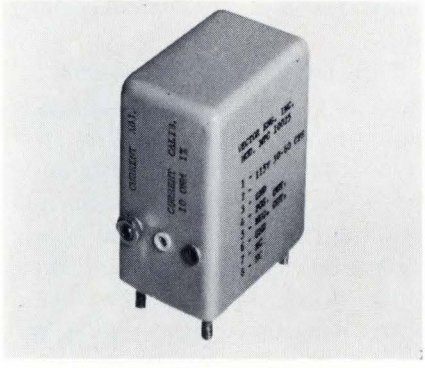


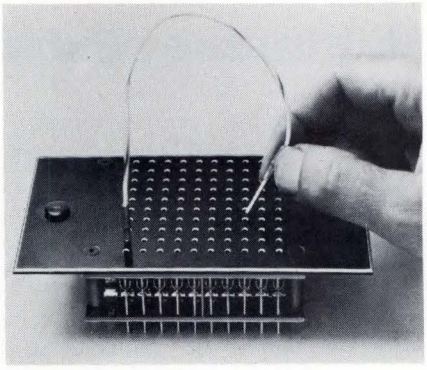
Small, Low-Cost Digital Panel Meter, Series 270, measures 2-1/16 by 4-1/2 by 7-7/8 in and features a 0.1-percent accuracy. Covering dc ranges from 200 mV and 20 μA, the Series 270 has an input impedance from 100 MΩ with resolution of 100 μV/-digit. The instrument is completely self-contained and provides a nonblinking display. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403.

CIRCLE NO. 427

Miniaturized Power Supplies designed for avalanche diode oscillators are available in five models covering current ranges from 8 to 200 mA. Input is 115V ac, 50 to 420 Hz, 0.01-percent regulation, 3-mV pk-pk ripple. There are no turn-on or turn-off transients. Average size 2-3/4 in high by 1-7/16 in thick by 2-5/16 in wide. Vector Engineering, Inc., 58 Brown Ave., Springfield, N. J. 07081.

CIRCLE NO. 429

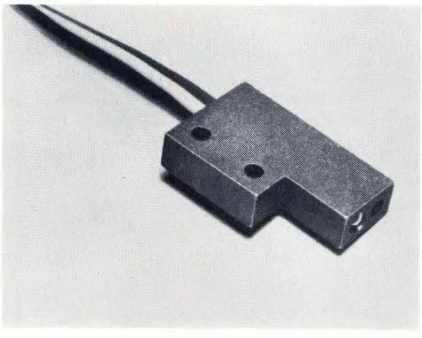


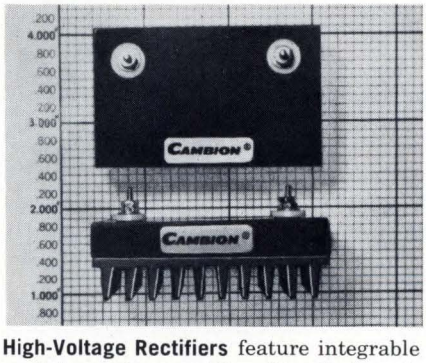


"Sealectroboards" have 10- by 10-hole format and single-deck design with individual gold-plated contacts. Low-investment programming is possible through a new low-cost patchcord that uses No. 24 AWG stranded wire with colored shrink-tube insulation. The pin on the cord is gold-plated for extended life over thousands of insertions. Programming Devices Div., Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. **CIRCLE NO. 431**

Subminiature Photocells, Light Sources and Scanner, Model PL-8S4, were designed for high-speed detection of small objects at rates above 50,000/s. The Model PL-8S4 can accurately pick up code-mark registration on printed film or paper webs while ignoring unrelated printed marks. These new units all are waterproof and are provided with 6-ft PVC-covered leads with spade lugs. Lamp bulbs in these heads are rated at 40,000+ h for years of trouble-free service. The photodiodes have a rise time of 1-1/2 μs, with stable operation all the way to 225°F. Solid-state control amplifiers are available in a wide variety to complement these subminiature units. Frost Electronics Corp., 1 Goddard Dr., Rockaway, N. J. 07866.

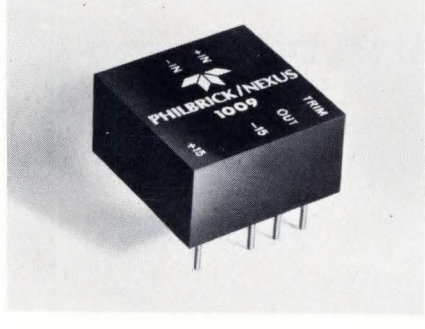
CIRCLE NO. 428





High-Voltage Rectifiers feature integrable modules and assemblies. Standard modules range from 5 to 40 kV and 0.25 to 4A, including center-tap and bridge full-wave rectifiers. These units incorporate integral resistor-capacitor shunting components across each diode to assure stable, uniform voltage division and transient protection. Hybrid construction utilizes printed and fired resistors and capacitors on a ceramic substrate for minimized high-voltage and heat-dissipation problems. Versatile modular packaging permits simplified installation in a variety of rectifier circuits. Cascaded modules provide extremely high-voltage capabilities. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138. **CIRCLE NO. 430**

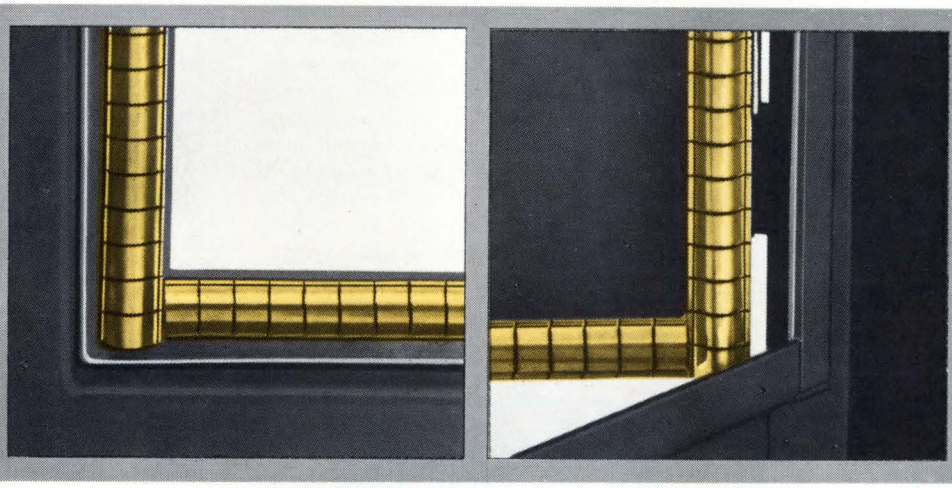
Operational Amplifiers, Type 1009, are general-purpose units recommended for applications where the high input impedance and low bias currents of an FET input are required. The 1009 Series is rated at normal ±15V supply voltages and the design allows normal, stable operation over the ±10 to ±18V range. The output voltage is developed at a low impedance level to permit driving loads with resistance as low as 2000Ω. Attractive features of this unit are its low noise characteristics, moderate full-output frequency, good open-loop gain and gain-bandwidth specifications and a 6 dB/octave roll-off with large tolerances to capacitive loading. Philbrick/Nexus Research, Allied Dr., Dedham, Mass. 02026. **CIRCLE NO. 432**



Sticky RFI problems?

sticky fingers®

attach with self-adhesive, shield RFI better than anything else!



Panel-type enclosure openings can be shielded quickly using STICKY FINGERS strip. Strip forms own corner.

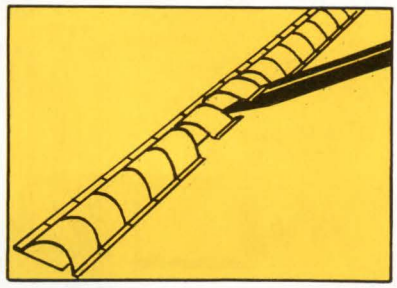
STICKY FINGERS adhere firmly to door flanges, sealing against RFI/EMI on closing.

At last you can get superior RFI/EMI shielding with a beryllium copper finger strip that requires no soldering, screws, clips, or other fasteners. A unique adhesive, developed especially for new STICKY FINGERS, provides an extremely tight instant bond that "cures" and strengthens with age . . . won't creep or crawl even with thousands of closings. And new STICKY FINGERS meet MIL Specs on salt spray, shock and humidity cycle tests and is unaffected by temperatures from —65°F to 160°F!

What's more, shielding effectiveness is greater than 108 dB at 10 GHz, and 70 dB at 200 kHz magnetic!

New STICKY FINGERS are available in a variety of surface finishes. Write today for complete information plus a free sample.
Address: Dept. EDN-53

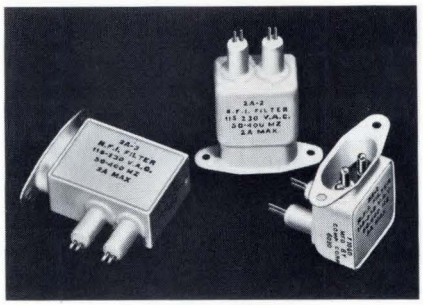
Easy to install!



Simply remove adhesive backing and rub a pen or small screwdriver under the fingers, assuring complete contact.

INSTRUMENT SPECIALTIES CO., INC.
Little Falls, New Jersey
Phone 201-256-3500

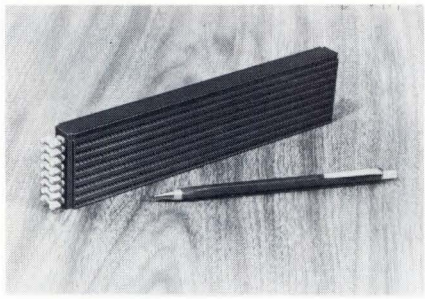
CIRCLE NO. 66



Filters, Series 2A, are designed to provide good RFI rejection in a miniature package and can handle a maximum operating line current of 2A. The series operates from ac line sources of 115 or 230V at frequencies of 50 to 400 Hz. They have extremely low capacitance of 5000 pF between line and ground. Three different output locations afford complete versatility of mounting. Input accepts a standard three-conductor line cord. Ratings of the series include a high pot test of 2000V dc to assure trouble-free operation on power lines subject to high-voltage transients. Line resistance: in to out, 0.03Ω. Leakage current of each line to ground: at 230V, 50 Hz, 0.4 mA; at 115V, 400 Hz, 1.5 mA. Components Corp., 2857 N. Halsted St., Chicago, Ill. 60657. **CIRCLE NO. 433**

Solid-State Cavity Oscillator, Model 7981, covers the 0.95- to 2.05-GHz range. Signal source can be operated either in CW or pulse mode with pulse rise and fall time of 100 ns max. Pulse voltage ON is −12V; OFF is 0V. Input voltage is ±12V dc (±10 percent) with current drain of 60 mA max. Nominal power output is 40 mW min (25 mW min for frequencies other than 1 to 2 GHz). Typical power output variation is ±2 dB over an octave frequency range. Frequency stability is typically 50 ppm/°C over a temperature range of 0 to 50°C. Units come equipped with OSM female output connector, but others can be supplied upon request. Polarad Electronic Instruments, Long Island City, N.Y.
CIRCLE NO. 434

High-Density Connector, called "Berg Zero Force Connector", is designed so that multiple leads from components, jumper wires, computer memory planes and printed-circuit connectors can be inserted and withdrawn with minimum push-pull forces. The connector matrix is 0.1 by 0.2 in with an average density of 80 contacts/sq in. As many as 1280 contacts have been designed into a single unit. The connector contains a gold-plated leaf spring and contact plate at each matrix location. After leads are positioned, a nylon rod is inserted through each of the eight rows of contacts. The rod consecutively lifts and flexes the springs, locking the leads in place and completing the circuit. Berg Electronics, Inc., York Expwy., New Cumberland, Pa. 17070. **CIRCLE NO. 435**



Microminiature Potentiometer is available for optimum efficiency in the design of high-frequency printed circuits and is ideal for use where space is limited. It is a 1/4-in trimmer microminiature metallic-film potentiometer that incorporates infinite resolution, low temperature coefficient and a full range of resistance values from 10Ω through 100kΩ. The trimmer is a single-turn unit, housed in a molded diallyl phthalate case and O-ring sealed. It is available in two models, the MF2 without stops and the MF2S with stops. It can withstand military environmental specifications such as MIL-STD-202B. Minelco, 600 South St., Holbrook, Mass. 02343.
CIRCLE NO. 436

This 40 Amp TRIAC really controls power

2N5441 and 2N5442 press-fit types give you:

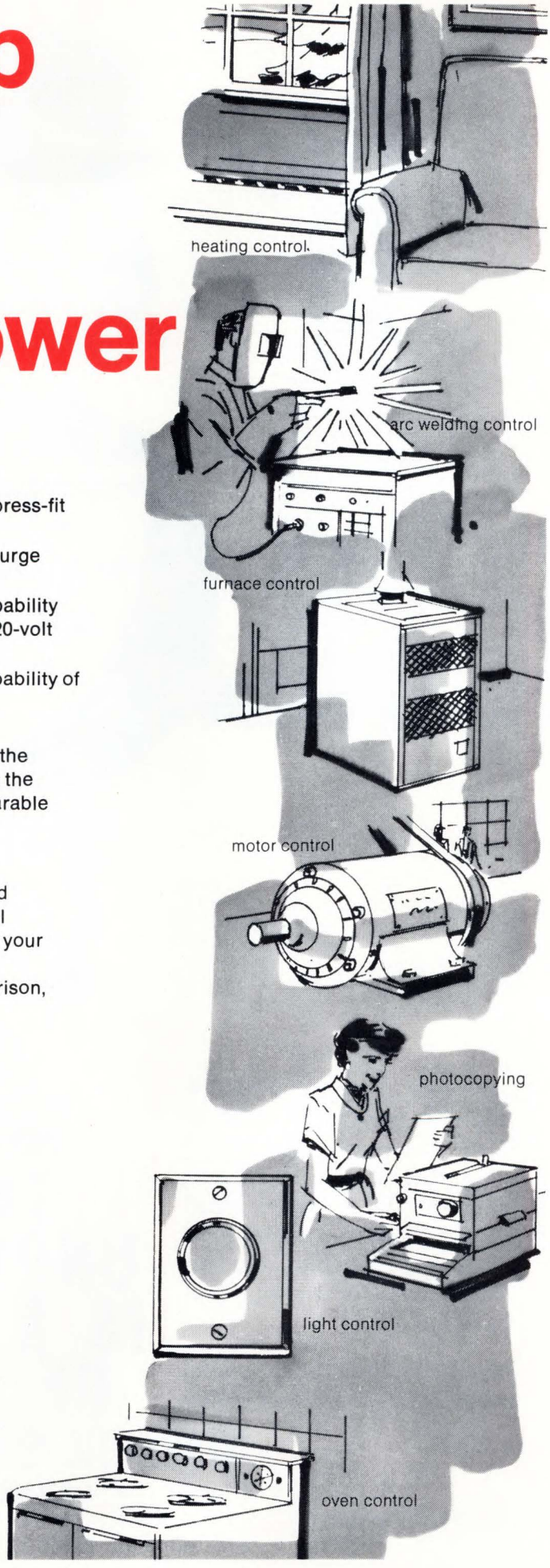
- 300 amp full cycle surge capability
- power handling capability of 5,000 watts for 120-volt operation
- power handling capability of 10,000 watts for 240-volt operation

Because a Triac can do the job of two SCR's back-to-back, the 2N5441 or the 2N5442 can virtually replace any two types in the 2N690-series or the 2N3873-series in circuits having comparable voltage and current ratings—and with fewer components.

2N5444 and 2N5445 stud types also available.

Please give your RCA Field Representative a call if you need application assistance in applying Thyristors to your control problems. Ask him, too, for pricing information—or contact your RCA Distributor. For technical data, write RCA Electronic Components, Commercial Engineering, Section RF-10, Harrison, N. J. 07029.

RCA



CIRCLE NO. 68

Over 80% of current magnetic shield designs originated at MSD. Some were pretty simple . . . and some were pretty complicated. Each was so successful that they have made MSD the world recognized standard in magnetic shield design and fabricating.

Whether your specific shield problem requires a complicated or simple solution, MSD's vast design, engineering and fabricating experience is available to you.

Write for EMC Engineering and Procurement Catalog.

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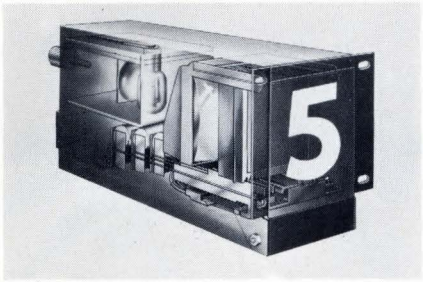
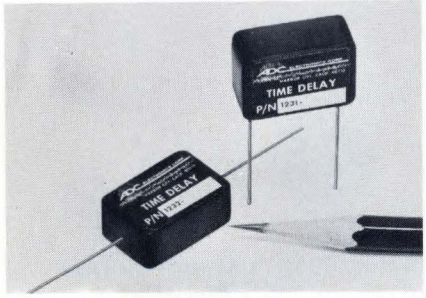
CIRCLE NO. 69

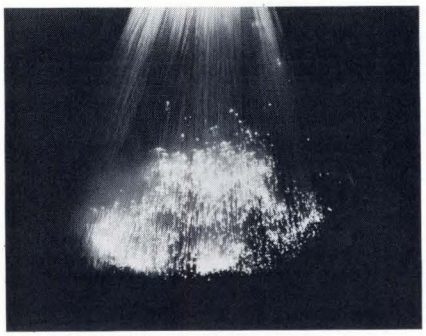
Components



Message Readout accepts any binary or teletype code up to 6 bits, does its own decoding and displays as many as 38 different characters or messages, with a standard character height of 1-3/8 in. Called the "Bina-View", the unit may be driven directly from computers or other electronic equipment, and will operate on as little as 128 mW per bit and 4W per set pulse. The readout incorporates built-in memory and will continue to display messages when all bit and set pulse power has been removed. Options include the ability to display as many as four colors, a check-back feature that will verify input signals and an additional floating decimal point that will display with any character on command. Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, Calif. 91405. **CIRCLE NO. 437**

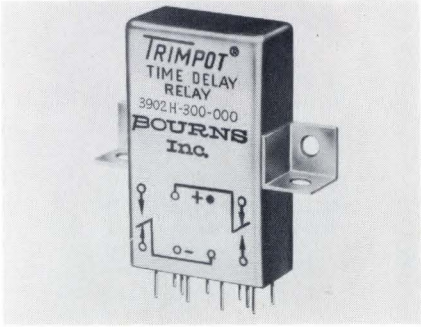


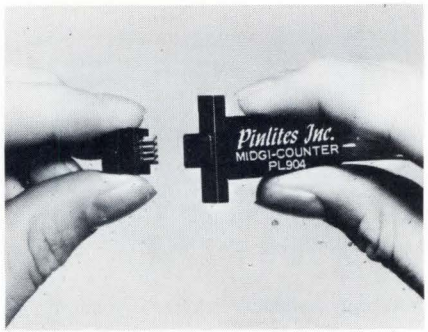
Solid-State Time-Delay Relays offer fixed time delays ranging from 0.1 to 15s with accuracies of ±5 and ±10 percent. Designed for circuit-board or chassis mounting, the units have an output rating of 0.7A and a size volume of no more than 0.25 in^3. The Series 1231 has both leads extending from the bottom and the Series 1232 has one lead extending from each side. Input voltage range is from 14-35V dc and minimum holding current is 10 mA. Reset time is 20 ms max. ADC Electronics Corp., 1227 W. 254th St., Harbor City, Calif. 90710. **CIRCLE NO. 438**



High-Quality Fiber-Optic Bundles produced at extremely low cost are available in standard bundle diameters from 1/16 to 1/2 in and lengths to 12 ft. Specifications: fiber diam, 0.003 in standard (larger diameters available); band radius, 1/4 in; spectral transmission, essentially flat from 4250 to 20,000 Å. Also available are splayed bundles bound in PVC, encapsulated and optically polished at one end. Fiber Photics, 2557 Soquel Dr., Santa Cruz, Calif. 95060. **CIRCLE NO. 439**

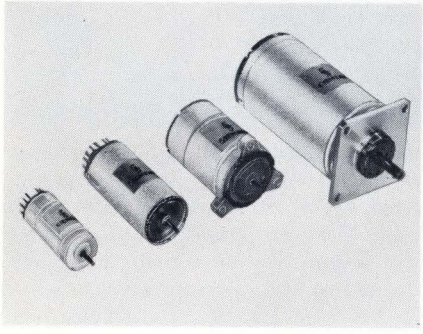
Time-Delay Relay, Model 3902, has a 1A, dpdt contact arrangement. Time delays from 0.1 to 15s are available. Less than 0.05A is required for continuous operation from an input operating range of 20 to 30V dc. The Model 3902 meets or exceeds all applicable electrical and environmental requirements of MIL-R-5757D. Also, special designs are available for custom specification. Bourns, Inc., Trimpot Products Div., 1200 Columbia Ave., Riverside, Calif. 92507. **CIRCLE NO. 440**

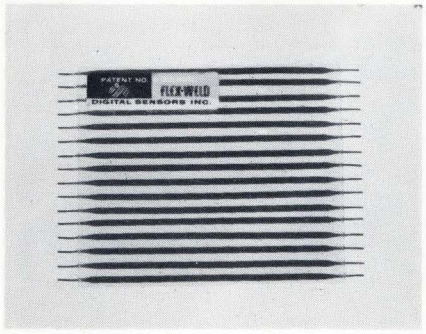




Decade Counter, called "Midgi-Counter", can count up to a 10-MHz rate's TTL data pulses and convert to seven-segment code. Some features of this unit are IC compatibility, smallest size available—1/6 in^3, blanking and lamp test inputs, brightness control and weight of 14g. This unit is capable of driving any of the "Midgi-Lites". Both military and commercial versions are available and are designed for 5V operation. Pinlites, Inc., 1275 Bloomfield Ave., Fairfield, N. J. 07007. **CIRCLE NO. 441**

Miniature Brushless DC Motors offer improved reliability. The motors operate without certain troublesome components found in conventional motors—brushes, commutators and rotor windings. They are available now in fractional-horsepower sizes to meet most applications. The dc motors are competitively priced, and offer extended service life for most high-reliability, low-maintenance applications. Siemens America, Inc., Power Equipment Div., 350 Fifth Ave., New York, N.Y. 10001. **CIRCLE NO. 442**

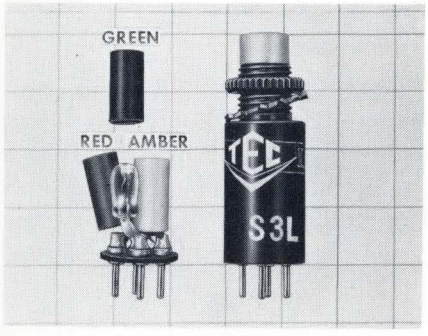


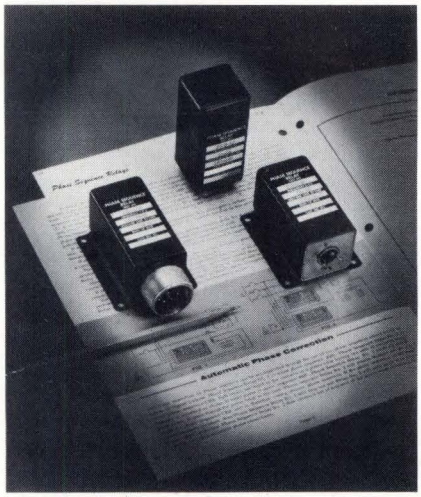


Flexible Jumpers, designated "Flex-Strips", provide printed-circuit interconnections where flexing, hinging, weight and space savings are desired. The tin-plated copper conductors, bonded between two layers of "Teflon", are a continuous strip, which is flat in the bonded area and round where it projects from the insulation. The round pins are soldered into holes in the circuit board. Digital Sensors, Inc., 4127 N. Figueroa St., Los Angeles, Calif. 90065. **CIRCLE NO. 443**

Subminiature Indicator, S3L Series, offers three separate color indications in an extremely small package. Three T-1 incandescent lamps with red, green and amber lamp filters are permanently wired in a 0.360-in-diam by a 0.600-in-long body. The S3L Series mounts in a 1/4-in hole on 3/8-in centers. It is designed for aircraft applications requiring a large number of indications in a limited amount of space. Transistor Electronics Corp., Box 6191, Minneapolis, Minn. 55424.

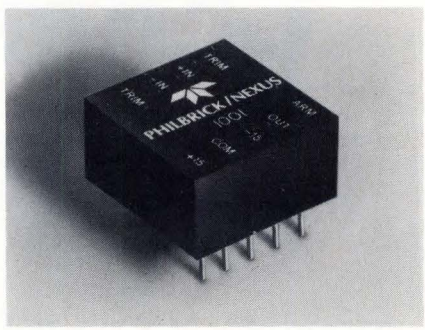
CIRCLE NO. 444





Phase-Sequence Relay protects 3-phase equipment against phase reversal, grounded phase leads or open phase leads. The 2000 Series units are available with operating voltages from 120 to 480V line-to-line and operating frequencies of 60 or 400 Hz. Hi-Tek Corp., 2220 S. Anne St., Santa Ana, Calif. 92704.

CIRCLE NO. 445



Multiduty Op Amp, Model 1001, is designed for use in portable instruments or remote instrumentation. Intended for general-purpose applications, the unit operates on a supply voltage ranging from ±1.85 to ±15V. Output range is larger than the usual fraction of supply voltage, making it an excellent unit for ±10V output with ±12V supplies. Built-in bias-current compensation, preset at the time of manufacture, reduces dc errors caused by bias currents over a wide range of operating temperatures. Philbrick/Nexus Research, Allied Dr., Dedham, Mass. 02026.

CIRCLE NO. 446

The Plaisted Polar Expedition needed a battery that could come on strong at 20° below.

Mallory made it.

What can we do for you?

The arctic explorers of the Plaisted Expedition needed a battery. A battery reliable enough for their "diaries" — the portable tape recorders they used to record important events. A battery that could put out strong, steady power at –20° F. A battery that wouldn't crumble when the temperature reached –63° F.

Mallory made it. The battery—a Mallory alkaline battery. Its ability to work when ordinary batteries are frozen is only one of its superior qualities. Some others: extraordinary shelf life—over 80% of original capacity after 2 years; exceptional performance under high current drains; low impedance—in standard sizes as low as 0.1 ohm per cell. And, of course, the Mallory alkaline battery has a very high energy density, up to 35 watt-hours per pound.

POWER PER POUND

The word "heavy" in "heavy-duty" batteries often throws people off. Because heavy-duty alkaline batteries often weigh a bit more than the same size ordinary battery, people feel they must be sacrificing lightness to gain power. Nothing could be further from the truth. Alkaline batteries actually enjoy quite an advantage over ordinary batteries when it comes to weight. The secret is size. Because Mallory alkaline batteries pack so much power in such a small space, the size of a battery needed for a given application can often be reduced. Pound for pound—size for size—Mallory alkaline batteries provide more capacity—more power than any ordinary battery.

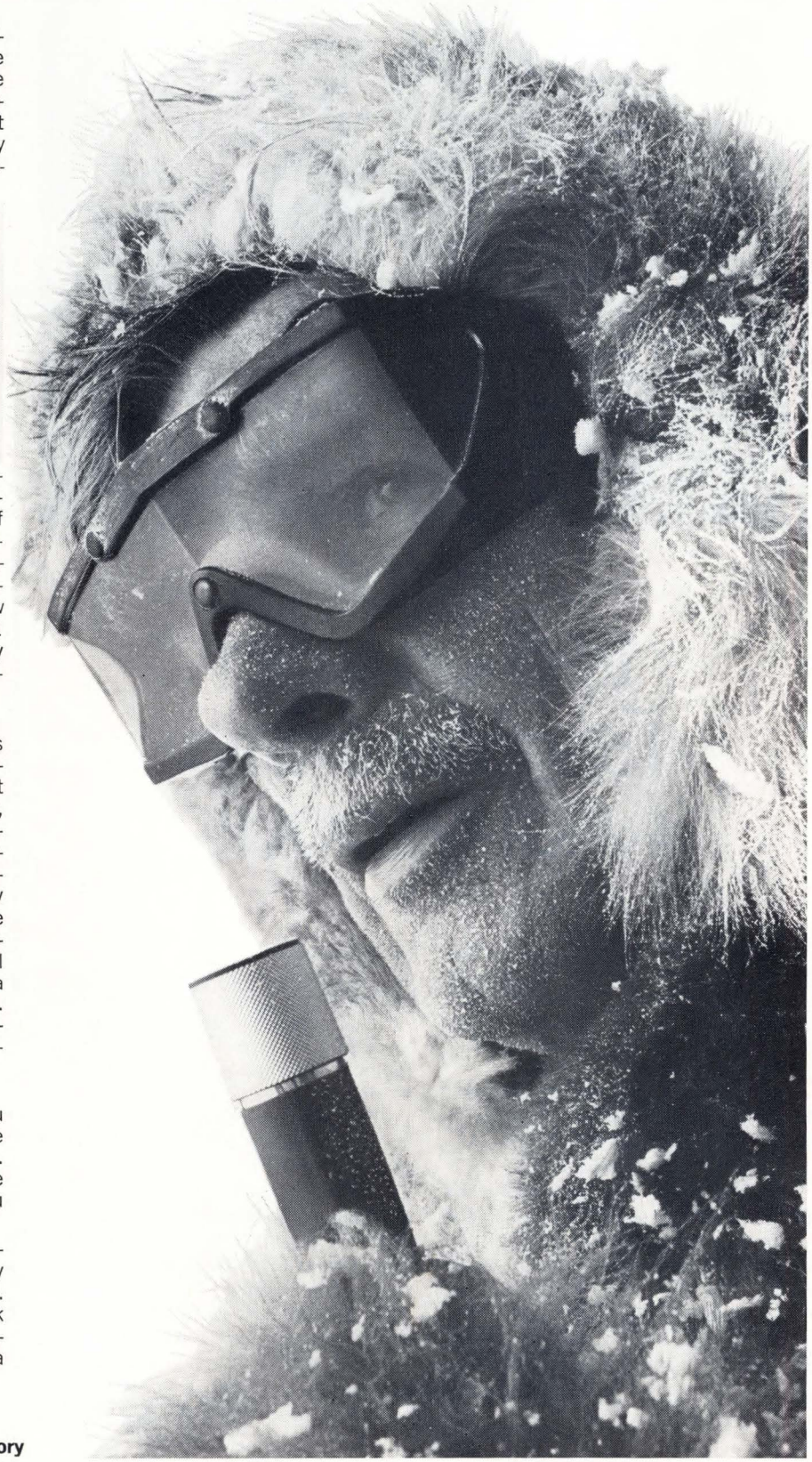
OVER 1000 DIFFERENT TYPES

Chances are Mallory has the battery you need already in production. Right now we're making over 1000 different types and sizes. And if we're not actually producing the one you need, we'll be glad to sit down with you to design one to your specifications.

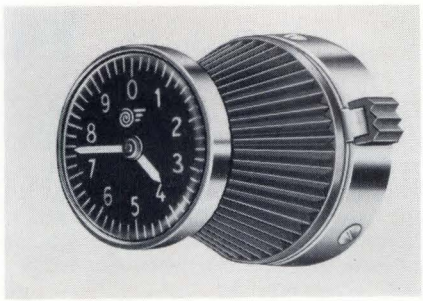
For more information, please write Technical Sales Department, Mallory Battery Company, a division of P. R. Mallory & Co. Inc., South Broadway, Tarrytown, New York 10591. Telephone: 914-591-7000. (In Canada: Mallory Battery Company of Canada Limited, Sheridan Park, Ontario.)

MALLORY

It's good business to do business with Mallory



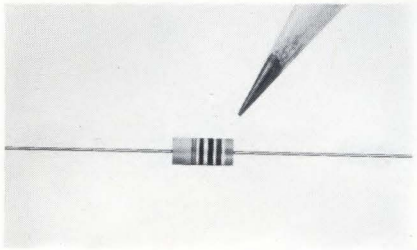
CIRCLE NO. 76



Clock-Face Turns-Counting Dial, Model 76, offers accurate positioning for multiturn devices and is ideally suited to minimum-space precision applications. Despite its small size (7/8 in in diam), readability is possible at a glance from any angle and is of the highest order to fiftieths of a turn. Model 76 features positive-action lock and is available with standard 1/4-in shafts. The block hands and integers are finished with a glow-orange enamel. Duncan Electronics, Inc., 2865 Fairview Rd., Costa Mesa, Calif. 92626. **CIRCLE NO. 447**

Pushbutton Switches with Matching Indicator Lights are available with snap-in mounting feature. Illumination is by one T-1-3/4 incandescent bulb in the 6 to 28V range. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. **CIRCLE NO. 448**

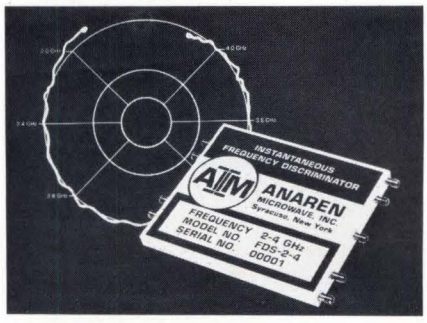
High-Speed Rotary Switch can withstand temperatures of up to 1650°F for extended periods of time without distortion or failure. It has functioned at operating velocities of 4.4 surface ft/s under a single-point-contact brush load of 10g. The switch element is 0.335 in in diam and 0.160 in thick and contains two rows of four-contact segments. The entire switch is a glass-ceramic material, with hard 24-carat gold firmly adhered to glass-ceramic as the contact segment. Poly-Scientific Corp., Blacksburg, Va. 24060. **CIRCLE NO. 449**



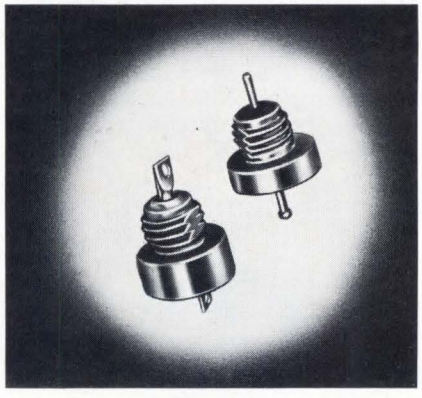
Subminiature Inductor, called "Super Wee-Wee-Ductor", offers the design engineer a molded, shielded unit with unprecedented inductance-to-size ratio. It incorporates a unique T-lead construction on all values from 0.10 to 10,000 μH, providing excellent reliability where fine wire sizes are used. The "Super Wee-Wee-Ductor" meets the stringent requirements of MIL-C-15305C, Grade 1, Class B, and MS90537. Nytronics, Inc., Essex Electronics Div., 550 Springfield Ave., Berkeley Heights, N. J. 07922. **CIRCLE NO. 450**

Miniature X-Band Coaxial Isolator with 400-MHz bandwidth and VSWR of 1.30 features isolation of 80 dB min (70 dB from −55 to 95°C) and insertion loss of 0.7 dB max (0.8 dB from −55 to 95°C). It measures 3 by 13/16 by 1 in, weighs 4 oz and has OSM connectors. Micromega, 4134 Del Rey Ave., Venice Calif. 90291. **CIRCLE NO. 451**

Shaft Encoder, called "Decitrak", converts mechanical motion into digital electrical data for numerical display, computer input, automatic card punching and set-point control. The encoder with its associated electronic modules automatically performs many data-taking tasks and directly generates digital tapes and punched cards from instrument outputs. The accuracy is 1 part in 10,000; the size, 2-1/2 in in diam, and power required, 115 or 220V. Theta Instrument Corp., 22 Spielman Rd., Fairfield, N. J. 07006. **CIRCLE NO. 452**

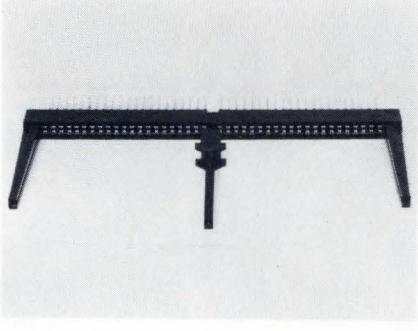


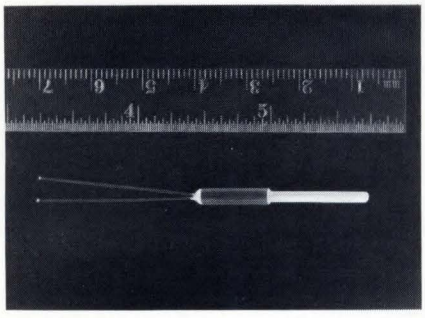
Instantaneous Frequency Discriminator converts a single RF input signal to sine and cosine outputs for polar display or frequency. It is available in frequencies ranging from 0.25 to 18 GHz. Advanced printed stripline techniques and rugged construction assure reliability even in the most adverse environments. This complex signal-processing network is contained in a very compact package providing orders-of-magnitude size reduction over conventional constructions. Anaren Microwave, Inc., 478 E. Brighton Ave., Syracuse, N.Y. 13210. **CIRCLE NO. 454**



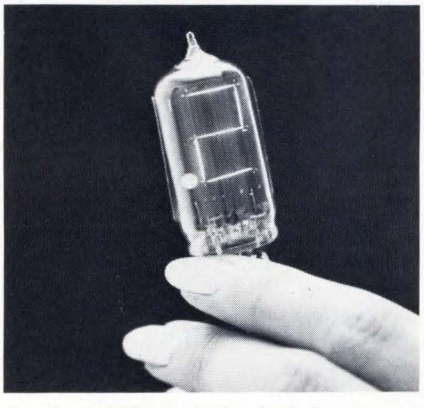
Broadband, Low-Pass Filter, called "Little Button", is designed to meet the demands for subminiaturization of EMI suppression devices. The filter occupies less than 20 percent of the volume compared to the current line of miniature broadband filters. It is obtainable in hermetically sealed or epoxy-potted versions. The epoxy-potted version is 0.287 in long; the hermetically sealed button uses glass-to-metal sealed terminals and is 0.357 in long. Both versions are 0.405 in in diam. These filters utilize an L-type network and have a 15A rating. Gulton Industries, Metuchen, N. J. **CIRCLE NO. 455**

Card-Edge Receptacle for PC boards offers 84 dual-readout contacts spaced on 0.200-in centers. The connector features 4-in-long card guides and an optional snap-in center guide, thereby accommodating one or two 1/16-in-thick PC cards. The insulator is glass-filled nylon and the contacts are made of gold-plated phosphor bronze, rated at 5A and designed for wire-wrap terminating. Elco Corp., Willow Grove, Pa., 19090. **CIRCLE NO. 453**



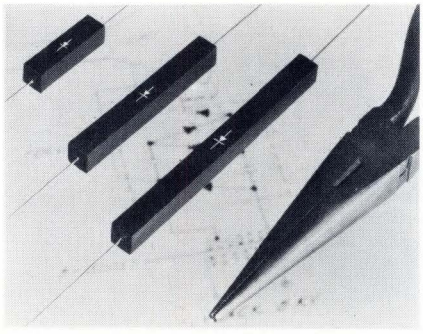


Miniature Resistance Temperature Detector is used where space and response requirements are critical. Its minimal time lag insures fast reaction to load changes with minimum overshoot. Sensitivity and repeatability are superior. The sensitive length is 0.35 in and diam is 0.075 in. The total sensor length is 1.25 in and the diameter of the stainless-steel mounting sleeve, 0.125 in. Maximum operating temperature is 1100°F. It also is available as a dual signal sensor. Electric Thermometers, Inc., 10 Glover Ave., Norwalk, Conn. 06850. **CIRCLE NO. 456**



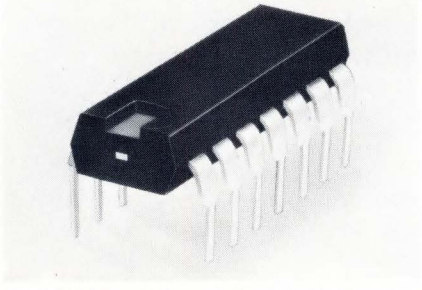
Illuminated-Filament Readout Lamp permits daylight and wide-angle viewing. Low-voltage, long-life "Numeralamp" produces numbers from 0 through 9, plus optional decimal point. Design voltage is 4V ac/dc, with 200,000h average life at this voltage. Brightness is rated at 4000 fL. Design filament temperature is approximately 1800°K. Sealed in standard vacuum tube with nine-pin miniature base, lamps are mounted on 1-in centers. They measure 2.1 in high and 0.83 in wide. Character size is 0.4 by 0.7 in. Los Angeles Miniature Products, 17000 S. Western Ave., Gardena, Calif. 90247.

CIRCLE NO. 457



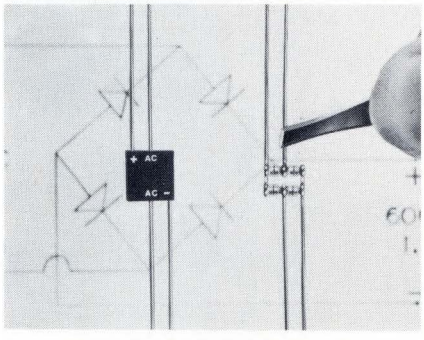
High-voltage rectifier and rectifier assemblies feature PIV's from 5000 to 45,000V, output current capability from 1 to 10 mA at 65°C ambient and an operating frequency of 100 kHz with a 300-ns recovery time. Dimensions are 0.25 in sq and 1 in long. Varo, Inc., Semiconductor Div., Box 1437, Garland, Tex. **CIRCLE NO. 458**

HRN8348D is a MOSFET designed for use in high-speed multiplexing and as a replacement for some types of mechanical relays. Typical channel resistance is 25Ω when biased with −10V gate bias. Breakdown voltages exceed −20V and the gate terminal is diode protected. Gate-to-drain and gate-to-source capacitances are typically 7 pF. Packaged in TO-72 containers, units are priced at $6.75 in quantities of 1000. Hughes MOSFET's, 500 Superior Ave., Newport Beach, Calif. 92663.
CIRCLE NO. 459

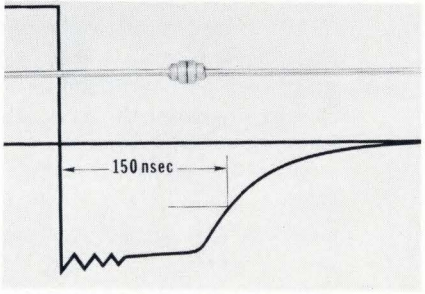


Model 830 is industry's first fully compensated FET operational amplifier in a dual in-line epoxy package. Key specifications include short circuitproof, voltage gain of 300,000, 20 μV/°C drift, input bias current of 15 pA, 6V/μs slew rate, 10V common-mode voltage and output of 10V at 5 mA. Zeltex, Inc., 1000 Chalomar Rd., Concord, Calif. 94520. **CIRCLE NO. 460**

Single-phase power bridges are rated to 1.5A with surge rating capability to 25A. PIV ranges from 50 to 600V and recovery times of 2 μs, 500 ns and 50 ns typical are available. In 100 pieces, price for the transfer-molded units is $4.70 each. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. **CIRCLE NO. 461**

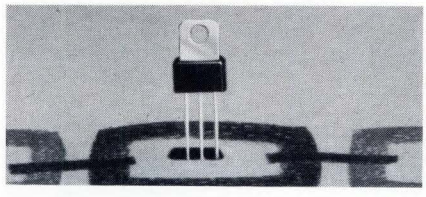


2N5452-54 dual-junction FET's feature an output admittance guaranteed to be below 1 μmho. The 52 unit has a tight match in output admittance of 0.05 μmho typically at a frequency of 1 kHz. Offset voltage is 5, 15 and 25 mV max, respectively, and leakage is 100 pA max. The 52 unit also is characterized by a drift spec of 5 μV/°C over the range of −55 to 125°C. Union Carbide Electronics, Semiconductor Dept., 8888 Balboa Ave., San Diego, Calif. 92123.
CIRCLE NO. 462



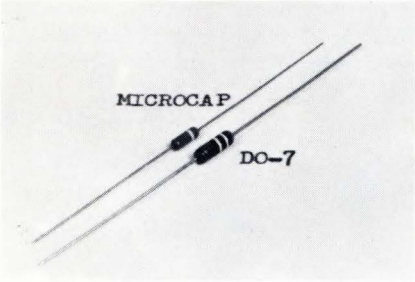
1N4942, 44 and 46, 1A fast-recovery rectifiers feature 200, 400 and 600V PIV and 150-ns recovery time. Units handle surges to 15A for 8.3 μs and body size is 0.16 in long by 0.085 in in diam. The series meets all requirements of MIL-S-19500/359A. Prices in 100 pieces start at $2.75. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. **CIRCLE NO. 463**

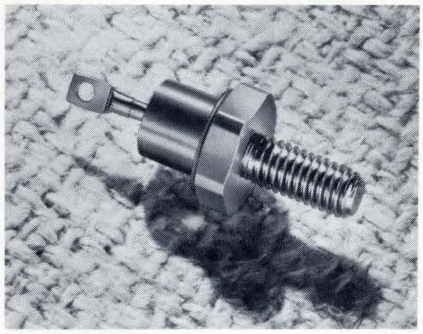
T2-1 and T2-2 are npn transistor pairs available in die form, wafer form or packaged in a 10-pin TO-5 or dual in-line container. Characteristics that are similar for both units include an f_T of 450 MHz, BV_{CBO} of 20V and P_D of 100 mW. Typical saturation voltage at an I_C of 5 mA is 0.3 and 0.25V, respectively, and the electrical substrate breakdown voltage is 35 and 15V min, respectively. A third unit, T3-1, is a multidevice unit for designing silicon monolithic IC's and for evaluating process sequences. Each transistor die measures 50 mils on a side and contains the following matched pairs: one medium geometry, two small geometry and two laterial pnp configurations. This unit also is available in a die form, wafer form or the 10-pin TO-5 or dual in-line container. In 100-499 units, prices are $2.75 (T2-1), $3.25 (T2-2) and $4.50 (T3-1). Integrated Circuit Engrg. Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018. **CIRCLE NO. 465**



MPSU01 and MPSU51 are npn and pnp complementary transistors designed for use in audio amplifiers delivering up to 5W output. $V_{CE(sat)}$ is 1V at 1A, max V_{CEO} is 30V and max I_C is 1.5A with a device dissipation rating of 8W and a case temperature of 25°C. In quantities of 100 units, prices are $0.77 and $0.89, respectively. MPSU02 and MPSU52 are npn and pnp transistors intended for general-purpose amplifier and driver applications. These units have an f_T of 150 MHz, V_{CEO} max of 40V, I_C max of 800 mA and a dissipation of 6W at a case temperature of 25°C. The 100-quantity price is $0.66 and $0.77, respectively. MPSU03 and MPSU04 are 1A silicon transistors designed for video output circuits. These units feature high collector-emitter breakdown voltages of 120 and 180V, respectively, minimum gain is 40 at an I_C of 10 mA, V_{CEO} is 0.5V max at 200 mA collector current and dissipation at 25°C case temperature is 8W. In 100 quantities, prices are $0.94 and $1.08, respectively. Motorola Semiconductor Products, Inc., Box 20924, Phoenix, Ariz. 85036.
CIRCLE NO. 464

"Microcap" voltage-variable capacitors are available from 1 to 22 pF (at 4V bias) in a package only 45 percent of the standard DO-7 size. The units make electronic tuning practical in the 200- to 1500-MHz region. Application notes for linear operation are available. Eastron Corp., 25 Locust St., Haverhill, Mass. 01830.
CIRCLE NO. 466

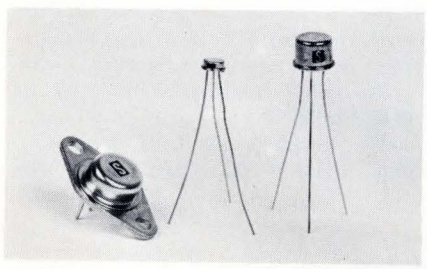




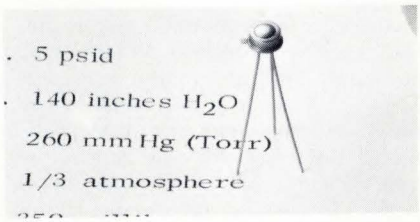
1N1199A, RA-1N4506, R comprise a line of 12A silicon power rectifiers with PIV from 50 to 1200V. Units have surge-overload current ratings to 240A and prices range from $0.99 to $3.45 in single-unit quantities. Tung-Sol Div., Wagner Electric Corp., 1 Summer Ave., Newark, N. J. 07104. **CIRCLE NO. 469**

C1160 426-bit MOS dynamic serial-shift register contains 2567 devices on a 105- by 106-mil chip. The unit requires half the voltage and less than one-fourth the power of comparable circuits. It operates with a 2-phase clock at shift data frequencies from 50 kHz to 5 MHz. Maximum power dissipation is 400 mW. Available in the TO-87 and TO-5 packages, units are priced from $87 each. American Micro-Systems, Inc., 3800 Homestead Rd., Santa Clara, Calif. 95051. **CIRCLE NO. 467**

K4044-46 are dual npn silicon transistors contained on a single 20- by 20-mil chip. Not only are both transistors completely isolated from each other, but the collectors also are isolated from the bottom of the chip, allowing the use of an epoxy adhesive for mounting chips to a substrate. V_{CBO} is rated 60, 45 and 30V, respectively; $V_{CE\ (Sat)}$ is 0.35V for all units and h_{FE} is 225 min for the 44 unit and 150 min for the 45 and 46 units. Prices start at $1. Industro Transistor Corp., 35-10 36th Ave., Long Island City, N.Y. 11106.
CIRCLE NO. 470

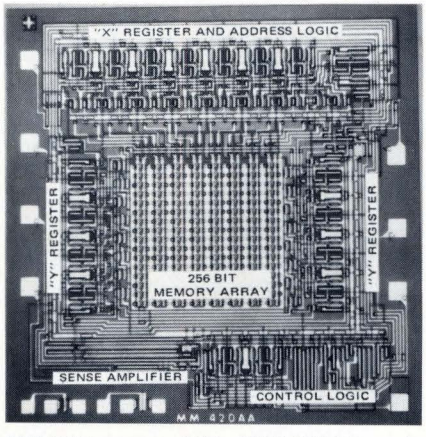


2N4862-64 are 2A npn silicon power transistors designed to fill the void between small-signal and high-power device applications. Units have voltages to 300V, leakages of 0.5 nA, saturation voltages less than 0.1V and uniform current gain from 10 to 500 mA. Typical f_T is 85 MHz. Units are available in the TO-46, TO-5 and TO-66 packages. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. **CIRCLE NO. 468**



"PITRAN" pressure-sensitive transistor transducers now are available for bidirectional ranges of 2 and 5 psid. Linear outputs of more than 20 percent of the supply voltage can be obtained without amplification. Supply voltage can range from 1 to 50V. The device is a silicon planar npn transistor with emitter-base junction mechanically coupled to a diaphragm located in the top of a TO-46 can. Price in prototype quantities is $85. Stow Labs., Inc., 110 Barton Rd., Stow, Mass. 01775.
CIRCLE NO. 471

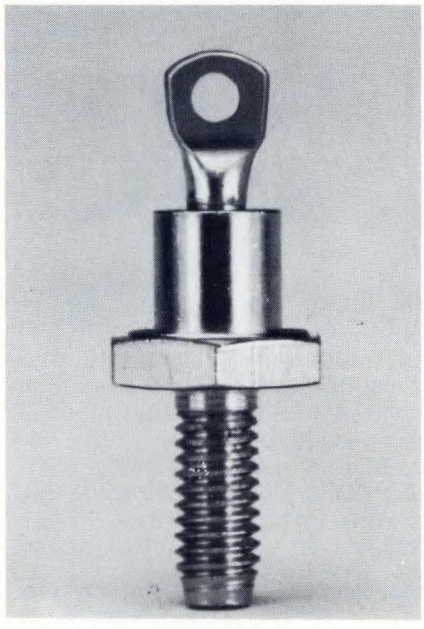
LM170 is a monolithic AGC/squelch amplifier. It contains the preamplifier, variable gain circuit and sensitive squelch threshold detection on the same chip. It features a large gain control of 80 dB, differential inputs with common-mode input range and dissipates only 18 mW from 4.5V supply. For 100-999 units, a −55 to 125°C price is $12.95 or $4.95 for a −25 to 75°C unit. **CIRCLE NO. 472**



MM420 is a monolithic MOS 256-bit read-only memory that contains all the control logic and memory on the same chip packaged in an eight-lead TO-5 container. Included on the chip are the counter decoder, address logic and sense amplifier. An end-of-sequence output is provided to allow expanding of the serial bit length without using external components. Programming the metallization pattern during fabrication sets up the read-only characteristics of the memory. In 1-24 quantities, a −55 to 125°C unit is $90 and a 0 to 70°C unit is $37, with the price for each metal-mask option $800. **CIRCLE NO. 473**

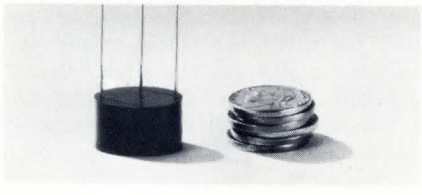
National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051.

Model 5500 monolithic analog multiplier is packaged in a TO-5 low-profile can, features ±1 percent max error, ±5 to ±20V supply operation, complete temperature compensation with a full operating temperature range from −55 to 125°C, and no external compensation is needed. The 1-9 price range is $17 each. Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. **CIRCLE NO. 475**

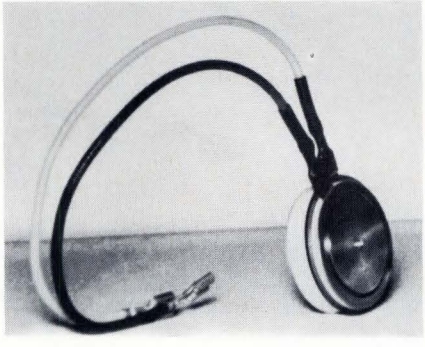


Series E4 power rectifiers have PIV ratings from 50 to 1000V, 6A max forward current (single-phase), surge current of 250A, 1.1V max forward voltage drop at 6A, maximum reverse current at 150°C at 1 mA and an operating temperature from −65 to 175°C. Edal Industries, Inc., 4 Short Beach Rd., East Haven, Conn. 06512. **CIRCLE NO. 476**

"Phasistors" are designed for use as a phase-control device in applications such as light dimmers, ac-dc motor controls, temperature controls, constant-light photoelectric controls and variable supplies. They have excellent stability, superior surge capability, control grid sensitivity in the range of microamperes and are virtually free from any injurious RFI effects. Units are available in blocking-state voltages to 500V and current ratings to 15A with resistive, inductive and incandescent loads. Typical prices on 6.5A units with 220V blocking voltages start at $6 in quantities of 1-24 units. Hybrinetics, Inc., 14630 Wicks Blvd., San Leandro, Calif. 94579. **CIRCLE NO. 477**



Type 272 "Pow-R-Disc" is a full-capacity thyristor mounted in a new flat-pack container. It is rated at 300A half-wave average, with forward blocking voltage to 1500V. Package size is approximately 1/2 inch thick and 1-1/2 inches in diam. In this package, the silicon wafer is cooled from both sides with an equal thermal impedance from the junction to either face of the heat sink. This results in a forward- or reverse-polarity mounting capability. Price for 25 to 99 pieces is $150 for the 600V model. Westinghouse Semiconductor Div., Youngwood, Pa. 15697.
CIRCLE NO. 478



BHA-0001 is a 2W Class A audio amplifier that features an audio output power at a frequency of 1 kHz equal to 2W, response from 40 to 10,000 Hz, input impedance of 300Ω, input voltage of 5 mV, power dissipation of 12W max at a T_c of 100°C, operating case temperature of −30 to 100°C and noise output relative to 1W of −50 dB. The thick-film unit has been optimized for marine and automotive applications with battery voltages of 14V. In such applications, rated output can be sustained with power-supply voltages from 11 to 16V. In 100-999 quantities, price is $4.90 each. Bendix Semiconductor Div., South St., Holmdel, N.J. 07733. **CIRCLE NO. 479**

5A SCR's can handle 5A at 100°C, feature low thermal resistance of 3.3°C/W, a low holding current less than 3mA, fast recovery time of 50 μs, a maximum gate-trigger current of 200 μA and a high-voltage rating from 60 to 400V. The unit is mounted in a stud-mounted package with anode internally connected to the case. Solid State Products, Inc., 1 Pingree St., Salem, Mass. 01970.
CIRCLE NO. 480

4 breakthroughs: new NIXIE® tube

size

.530″ dia. x 1.5″ for IC compatibility — largest numeral height provides best readability.

anode strobing

new design permits all like-numerals to be driven in parallel for time sharing operation with improved brightness.

pin spacer

simplifies both PC board layout and tube insertion.

price

in quantities of 1,000 — only **$3.95** each.

ACTUAL SIZE

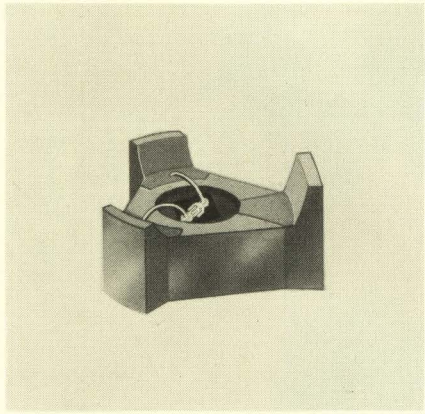
This new tube, type B-5750, has been engineered to achieve all these outstanding breakthroughs in a single design. The new slim-line tube not only has two internal decimal points but also has an "in-line" lead arrangement which is compatible with dual in-line IC's. In addition, the numeral aspect ratio has been designed to provide the optimum in readability and viewing distance.

The movable pin spacer – standoff, which is used to align the tube pins for ease of PC layout and insertion, is part of the tube assembly. The anode strobing/time sharing operation permits substantial reduction in driver costs for many multi-digit display applications. For more information on these and other features contact your nearest Burroughs representative or sales engineer, or write: *Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Department N6, Plainfield, New Jersey 07061 TEL: (201) 757-5000.*

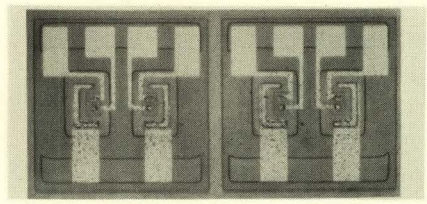
CIRCLE NO. 83

Burroughs

New SC's



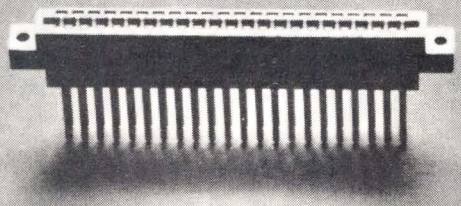
TDA420 is an npn transistor with characteristics that include an I_C range from 25-100 mA, V_{CE} of 25V, h_{FE} min is 40 at an I_C of 75 mA and f_T is 1000 MHz. The chip is mounted in a new "Tri-LID" package that offers all of the advantages of the conventional four-legged "LID", plus greater power because of its slightly larger dimension and triangular shape. A new brochure entitled "LID'S—Leadless Inverted Devices" describes this package in more detail. Also included are five new semiconductors in the conventional "LID" package that includes three N-channel FET's, an npn medium-current switch and core driver and an npn low ON-resistance switch. Amperex Electronic Corp., Semiconductor & Microcircuits Div., Slatersville, R.I. 02876. **CIRCLE NO. 481**



Oxide-isolated transistor chips for hybrid-circuit application are available in clusters. In addition to each transistor's being oxide-isolated from each other, the bottom of the chip also is oxide-isolated, so that the unit cannot short out with anything else. To reduce the number of wire bonds necessary between units on any chip, interconnection patterns also are available. Typical frequency of any individual transistor is 200 MHz. Voltages over 100V are possible and a saturation of less than 0.5V at 50 mils is available. Industro Transistor Corp., 35-10 36th Ave., Long Island City, N.Y. 11106.

CIRCLE NO. 482

CIRCLE NO. 85 ▸



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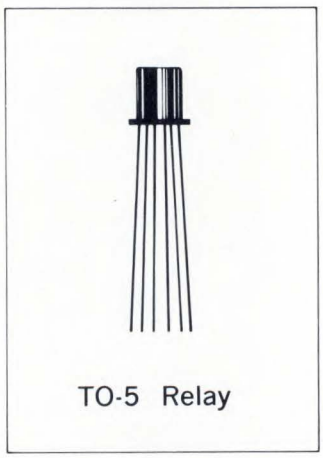

TO-5 Relay

Teledyne Relays has put the Driver where it belongs — in the Driver's Seat. Neatly enclosed in the relay package, it: • suppresses coil transients • increases reliability • reduces design time • reduces relay package size more than 50% • cuts production costs.

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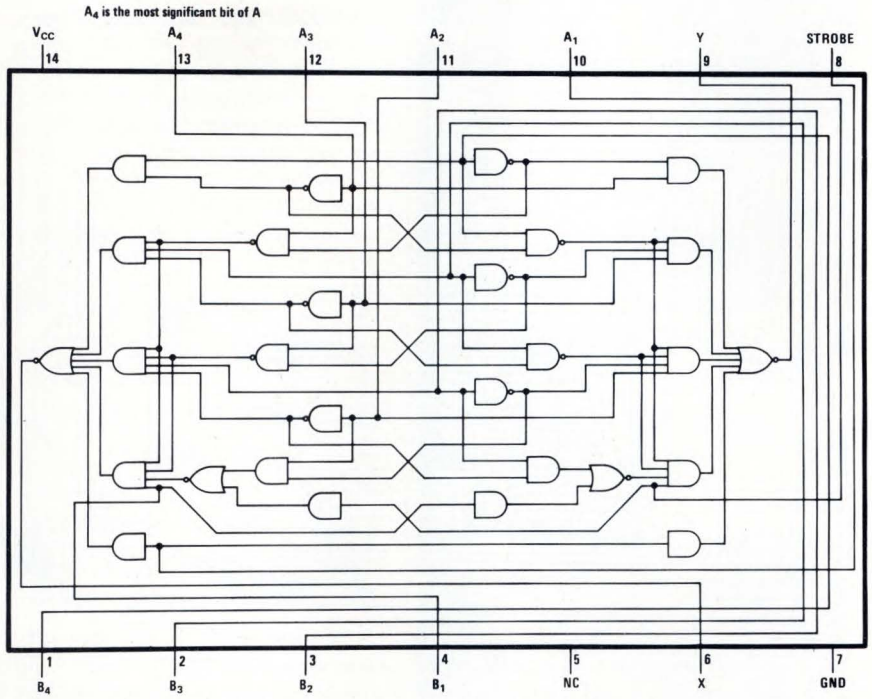
CIRCLE NO. 86



DM7200/DM8200 monolithic four-bit comparator is used to compare the numerical values of 2 four-bit binary numbers. Outputs indicate number A greater than number B, number B greater than number A or both numbers equal. A strobe input overrides all other inputs and places the outputs in a definite state. Characteristics include a 1V typical noise immunity, 20-ns typical propagation delay and 175-mW typical power dissipation. Available in 0 to 70°C and −55 to 125°C versions, the 1-24 prices start at $14.40.

CIRCLE NO. 483

NH0006C is an integrated relay lamp driver designed to accept DTL or TTL logic levels and drive a load up to 300 mA at 28V. Dual AND inputs are provided along with an expander connection. External control of rise and fall times is provided to decrease cold lamp surges or to minimize EMI if long lines are to be driven. Operating temperature is from 0 to 70°C and the 1-24 price is $18.

CIRCLE NO. 484

National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051.

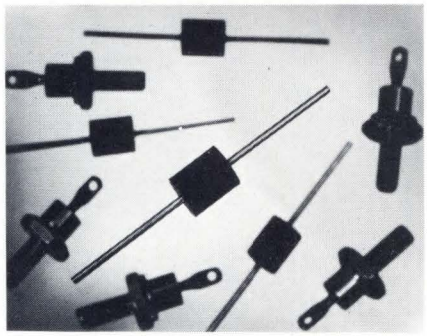
CDA1 series of D/A ladder switches features a typical transistor ON resistance of 5Ω. Used with a ladder network of 20 and 10-kΩ resistors, the standard CDA1 matched units will build a 10-bit system accurate to 1/2 bit. For a 12-bit system, the CDA1-3S12 consists of 10 standard CDA1-3 units, plus two CDA1-3 units with ON resistance of 5Ω ± 1Ω. For a 14-bit system, the CDA1-3S14 set consists of the above set, plus two CDA1-3 circuits with ON resistance of 5Ω ± 0.5Ω. In small quantities, prices start at $528. Crystalonics, A Teledyne Co., 147 Sherman St., Cambridge, Mass. 02139.

CIRCLE NO. 485

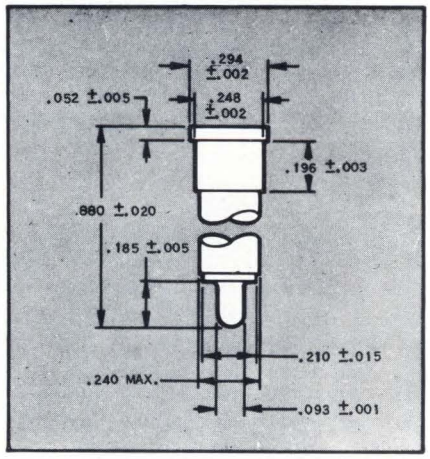
D5109 diodes are contained in a new package for multithrow broadband PIN and varactor diodes. Called "spider" diodes, the new sealed packages offer up to eight ribbon radial leads with a common-center lead. Typical characteristics include a 200V breakdown at 10 μA, 0.2 pF at −50V junction capacitance, series resistance of 2.5Ω at 100 mA and 1 kHz, 20-ns switching time and 0.25W dissipation at 25°C, with a peak power-handling capability of 700W and an operating junction temperature of 150°C. Microwave Group, Semiconductor Div., Sylvania Electric Products, Inc., 100 Sylvan Rd., Woburn, Mass. 01801.

CIRCLE NO. 486

SDP1040, 50, 60 (eight-diode) and SDP1070, 80, 90 (16-diode) arrays are available with switching speeds in the range of 50 ns or less and are packaged in hermetically sealed containers for military as well as commercial use. Typical applications include core driving, magnetic cores, memory drums and tapes. Prices in quantities from 1 to 99 range from $14.50 to $22.50. **CIRCLE NO. 487**



3VR6-3VR150 3W zener diodes are packaged in a new axial-lead epoxy package that is easier to mount and costs less than the standard DO-4 stud-mounted metal case. Units are available from 6.8 to 150V, and at the 1000-piece-level price is $0.70 each. **CIRCLE NO. 488**
Transitron Electronic Corp., 168 Albion St., Wakefield, Mass.



CA4L2-E bulk gallium-arsenide diode can furnish 100W pulses at operating frequencies from 1 to 1.5 GHz. It is designed to handle pulse lengths up to 250 ns with average powers up to 25 mW. Cayuga Assoc., Inc., Parker Rd., Long Valley, N. J. 07853. **CIRCLE NO. 489**

SE517J dual operational amplifier features a typical channel separation of 90 dB from dc to 200 kHz, a unity-gain frequency response of 15 MHz, input impedance of 25 kΩ and a typical gain of 20,000. Available in both a military and commercial/industrial version, the latter is priced at $5 in 100-up quantities. **CIRCLE NO. 490**

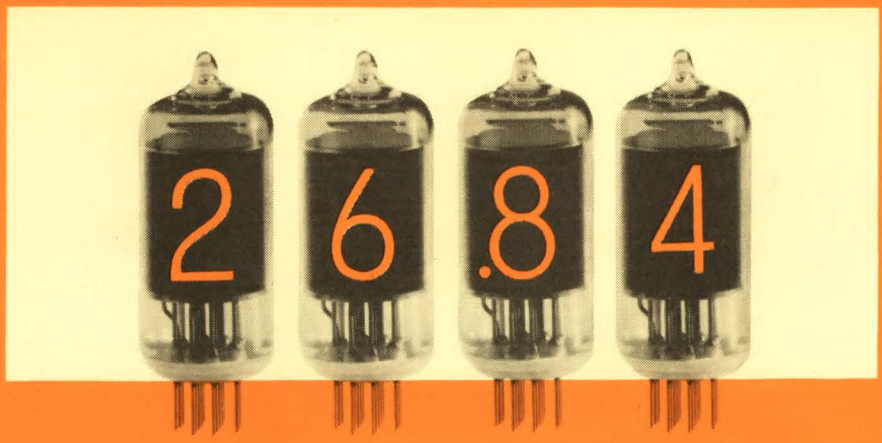
Four new multiple OR gates have been added to the "Utilogic II" commercial/industrial IC family. New units include a quad two-input OR gate (384), a dual four-input expandable OR gate (334), a triple three-input OR gate (374) and a triple two-input expandable OR gate (375). In the 10 to 55°C range, prices for each, in 100-up quantities, are $1.03, and in the 0 to 75°C range, price is $1.11 in 100-up quantities. **CIRCLE NO. 491**

Twenty high-speed TTL circuits in the 5400/7400 series are available. The 20 circuits are direct pin-for-pin replacements for the original line of 54/7400 circuits. However, the new units are offered in a 14-lead silicone DIP that is reported to be superior to the original circuits' epoxy packaging. The new package is superior in moisture resistance, thermal stability and radiation resistance. **CIRCLE NO. 492**
Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086.

RM4101 is a monolithic general-purpose operational amplifier that is internally compensated by addition of a 30-pF MOS capacitor to the chip. The unit operates over a ±5 to ±20V supply range while operating at a nearly constant current independent of supply voltage. This is accomplished with a buried FET resistor. Input voltage range is ±12V, increasing to ±15V for supplies ranging from ±15 to ±20V. "Latch-up" has been eliminated in the design of the 4101 circuit. **CIRCLE NO. 493**

RM-80 is a 16-bit integrated circuit "scratch pad" memory, arranged in a 4 by 4 matrix, and has nondestructive readout. Typical characteristics include turn-on and turn-off times of 13 ns, T_{wr} of 28 ns, V_{sat} at the output of 0.2V at 40-mA load at 25°C, and operation from −55 to 125°C. **CIRCLE NO. 494**

Raytheon Co., Semiconductor Operation, 350 Ellis St., Mountain View, Calif. 94040.



ZM1000 readout tube made for high-volume applications...

...and priced accordingly!

The Amperex ZM1000 is the first digital numerical indicator tube, designed from the ground up, to provide big economies both in initial cost and in application. It sells at more than a dollar below competitive types, and the price-break grows with the volume.

We scrapped every notion about how to make numerical indicator tubes and developed a completely new design that offers unsurpassed performance and reliability at mass-production prices.

Every ZM1000 has a built-in decimal-point indicator. Use it if you wish—or ignore it... in either case, there's no additional cost for the decimal. The ZM1000's large numerals are clearly legible at 35 feet, yet an 8-digit readout can be installed in only 6 inches of panel.

Superior design makes the ZM1000 more economical to use, too; its high-temperature base is designed to plug directly into a printed circuit board or an inexpensive, readily available socket.

IMPORTANT FEATURES

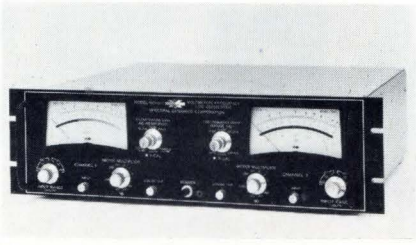
- Dynamic life expectancy: 200,000 hrs.
- Height of numeral.....0.6"
- Tube diameter.....0.75"
- Height of Tube.....1.67"

For complete data and comprehensive application bulletin on indicator-driver circuits for the ZM1000, write: Amperex Electronic Corporation, Semiconductor and Microcircuits Division, Slatersville, Rhode Island 02876.

Amperex®

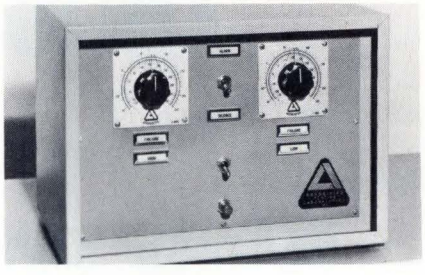
TOMORROW'S THINKING IN TODAY'S PRODUCTS

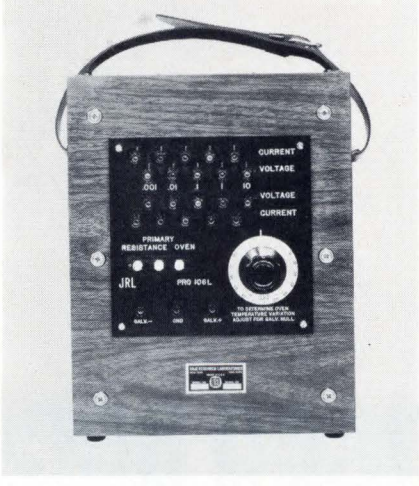
CIRCLE NO. 88



Voltmeter/Log Converter converts two channels of either ac or dc inputs to their corresponding dc logarithms and provides a true rms meter display for each channel calibrated in volts and dB. The Model SC112-1 is intended for direct X-Y plotting of test data from magnetic tape, or in real time, and for log-log response plotting. The amplitude-to-log dc portion of the instrument has 80-dB dynamic range and ±0.5-dB accuracy. Spectral Dynamics Corp., Box 670, San Diego, Calif. 92112. **CIRCLE NO. 495**

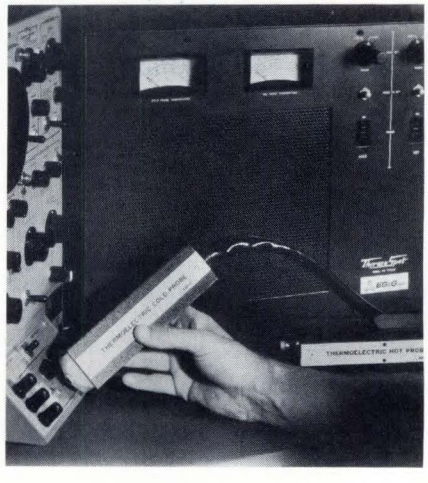
Temperature-Safety Shut-Down Control gives adjustable high-temperature fail-safe capability to all chambers intended for high-temperature operation. The Model ETL-C can be programmed to shut down or assume control of the chamber in the event of primary control failure. Control range is from −125 to 450°F and failure is signaled either by audible or visual alarms. Unit price for the ETL-C is $395. Associated Testing Labs., Inc., 200 Rte. 46, Wayne, N. J. 07470. **CIRCLE NO. 497**





Low-Range Resistance Reference Standard, Model PRO-106L, includes five Julie-Type NB-1 resistors with values of 0.001, 0.01, 0.1, 1 and 10Ω packaged in a constant-temperature oven. Standard accuracies are ±0.0008 percent and stability varies from 5 ppm to 1 ppm/year, depending upon the resistance value. Oven temperature stays constant within 0.03°C, which never allows a deviation in standard resistance of greater than 0.1 ppm for temperature effects between 0 and 28°C oven ambient. Julie Research Labs., Inc., 211 W. 61st St., New York, N.Y. 10023. **CIRCLE NO. 496**

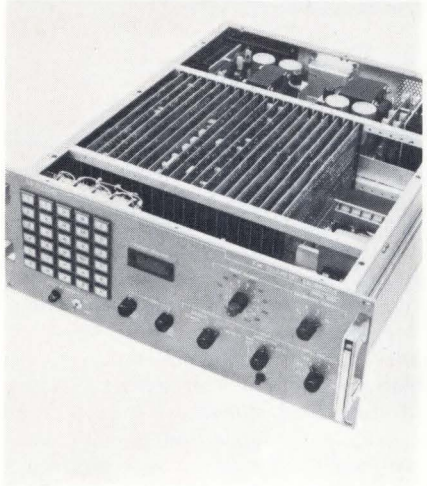
Thermal Stabilizer, the "ThermoSpot", uses thermoelectric cold and hot probes to allow stabilizing of small components and samples at temperatures between −55 and 180°C with ±0.5°C stability. Cooling capacity is approximately 2W at −55°C. Consisting of a controller-heat exchanger and two probes, the multistage system uses thermoelectric modules and is self-contained. Probes can be mounted anywhere within 5 ft of the controller and can accommodate exchangeable electrically "floating" tips, platforms and miniature enclosures. EG&G, Inc., Electronic Products Div., 160 Brookline Ave., Boston, Mass. 02215. **CIRCLE NO. 498**



Equipment

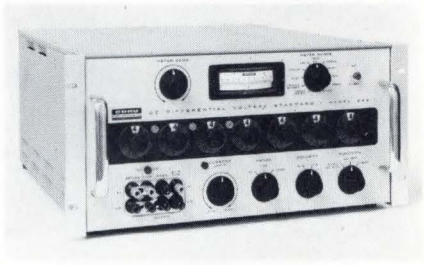
Fifty-MHz Counter-Timer, Model 110A, has a full range of functions and BCD output. Applications of this fully programmable instrument include measurement of frequency, period, period average, time interval and totalization. Monsanto Electronics Technical Center, 620 Passaic Ave., West Caldwell, N.J. 07006.

CIRCLE NO. 499

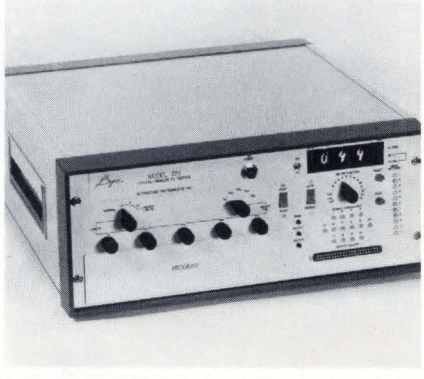


FM Discriminator Calibrator, Model 838A, provides rapid and accurate calibration of telemetry FM subcarrier discriminators. Internally generated are all 21 of the 7-1/2-percent narrowband and all eight of the 15-percent wideband proportional IRIG FM subcarrier channels as well as four selectable tape-speed reference frequencies. A single crystal-controlled frequency is used as a reference for all frequency outputs. Digital multiplying and dividing techniques allow output frequencies within 0.001 percent of intended values. Monitor Systems, Inc., 401 Commerce Dr., Ft. Washington, Pa. 19034.

CIRCLE NO. 500

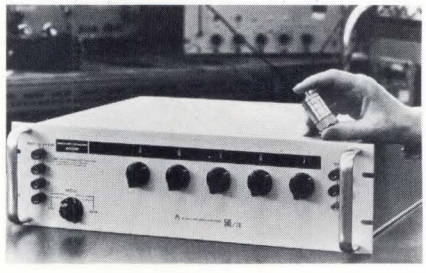


DC Voltage Standard/Voltmeter is a differential or direct-reading dc voltmeter plus a precision dc voltage standard. Potentiometric measurements can be made to 0.001-percent accuracy. Output current capability as a dc standard is 50 mA. Features of the Model 365 include a polarity-reversal control, a no-parallax meter, overcurrent and overvoltage protection and self-checking of linearity. Cohu Electronics, Inc., Box 623, San Diego, Calif. 92112. **CIRCLE NO. 501**

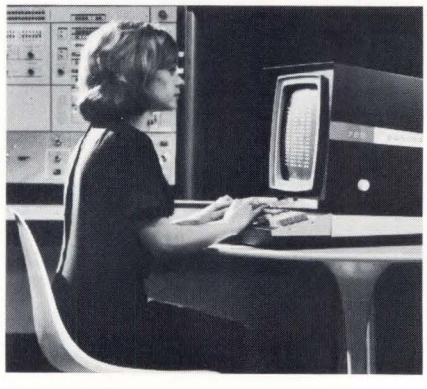


Automatic Testers for IC's, Models 720 and 721, are fully automatic, easily programmed with a single plug-in circuit card and require no operator skills. Digital integrated circuits with up to 16 leads in any standard configuration can be tested. Readout consists of go/no-go lamps and a three-decimal digit volt/current readout for any failed parameter. Testing rate can be in excess of 5000 devices an hour and both dc and functional measurements are performed simultaneously. Models are identical except that Model 721 includes a three-decimal digit volt/current meter. Microdyne Instruments, Inc., Waltham Engrg. Center, 225 Crescent St., Waltham, Mass. 02154. **CIRCLE NO. 502**

Resolver/Synchro Bridge and Resolver/Synchro Simulator, Models 540/20 and 530/20, respectively, are wideband units that operate from 50 Hz to 10 kHz and that feature 0.001° resolution. Uses for the bridges and simulators include not only evaluation of resolver and synchro subsystems and components, but also the test and calibration of complete control systems. North Atlantic Industries, Inc., Terminal Dr., Plainview, N.Y. 11803.
CIRCLE NO. 504



Data-Display System, Model 720, lets users add, edit, delete and update computerized data while viewing it on a TV-like screen. The system can be located remotely from the computer and sends and receives data at high speeds over telephone lines. There are two edit modes. In one, line operators are held to specified areas of the screen, preventing accidental destruction of basic formats and computer-generated forms. In the second, supervisory personnel can modify or generate the formats themselves. A unique display logic compresses all messages into the most compact form before communication with the computer. Sanders Assoc., Inc., 95 Canal St., Nashua, N. H. 03060. **CIRCLE NO. 503**



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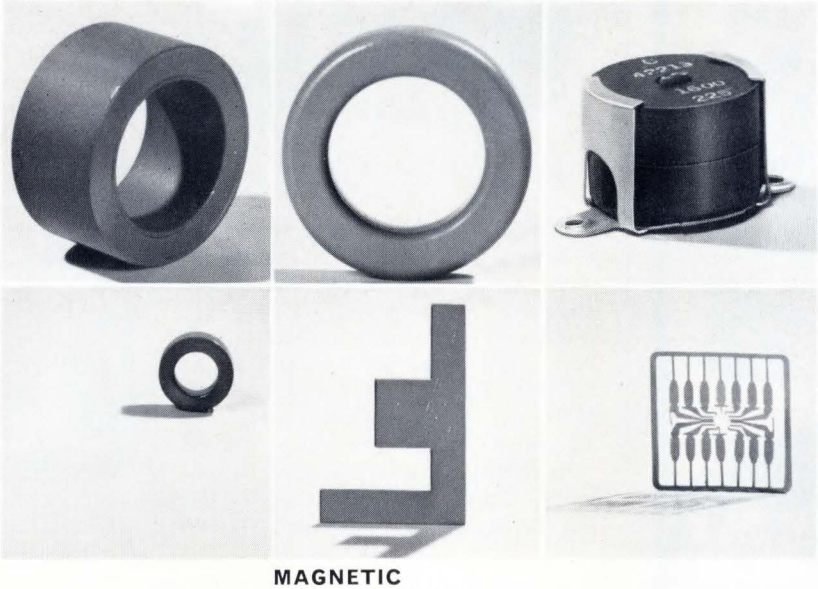
Made from nickel, silicon, or cobalt irons. We supply all AIEE standards plus special sizes in thicknesses from ½ through 14 mils. All sizes boxed in phenolic or plastic, aluminum or GVB-coated aluminum boxes.



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Nickel-iron materials in thicknesses of .004″, .006″ and .014″. 38 standard shapes in sizes from DU-87 and EI-12 down to EI-093, EE-30-31 and F-094.

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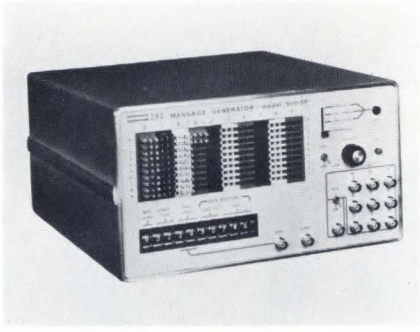
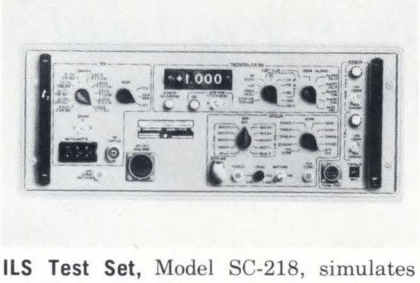
CIRCLE NO. 92



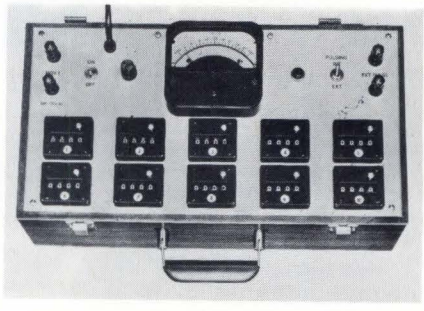
Digital Data Simulator programs 960 bits of binary information at the front panel, using 320 octal-weighted programming pins. 960 serial bits can be clocked out at rates to 10 MHz, and in the parallel mode up to eighty 12-bit parallel words can be delivered at clock rates up to 5 MHz. When simulating computer words, up to 12 parallel outputs can be generated with a single instrument. Moxon Electronics Corp., 2309 Pontius Ave., Los Angeles, Calif. 90064. **CIRCLE NO. 505**

Low-Cost Computer, Model PDP-8/L, has basic core memory of 4K words expandable to 8K. Cycle time is 1.6 μs and the price of $8500 is low for a full-scale, 12-bit computer. Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754.
CIRCLE NO. 506



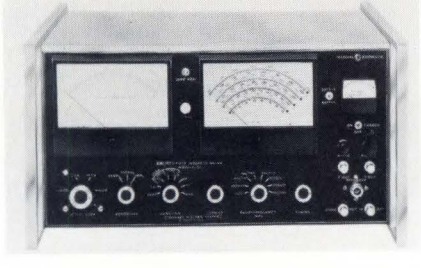
ILS Test Set, Model SC-218, simulates localizer, glide-slope and marker-beacon signals for a variety of aircraft positions during the approach pattern to a runway. Tests performed with the set include deviation, balance, sensitivity, linearity and flag outputs. Output frequencies are controlled within ±0.005 percent. The SC-218 is suited for both flight-line and maintenance-shop usage, General Dynamics, Electronics Div., 1400 N. Goodman St., Rochester, N.Y. 14601.
CIRCLE NO. 507

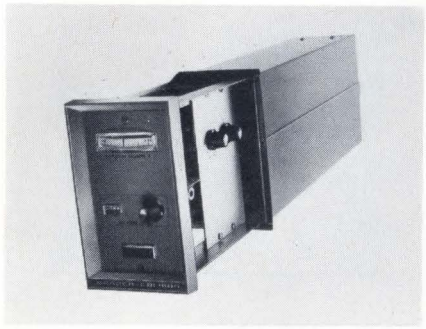
Statistical Counter, Model 2660, contains an electrical measuring instrument, a 10-segment contact-making relay and 10 four-digit electromechanical counters with reset buttons, plus related timing and actuation circuitry. The standard model is equipped for evaluation of line voltage between 95 and 135V in 4V increments and has internal reading rate of 1/s. By external timing signals, the readings may be as frequent as 5/s or as slow as desired. Simpson Electric Co., 5200 W. Kinzie St., Chicago, Ill. 60644. **CIRCLE NO. 508**



Sound-Level Meter, battery-operated and hand-held, covers the dynamic range from −5 to +10 dB. The Model 2205 uses a pistol-grip handle and need only be aimed at the noise source. B & K Instruments, Inc., 5111 W. 164th St., Cleveland, Ohio 44142. **CIRCLE NO. 509**

RFI/EMI Data-Acquisition System is fully automated. The Series 7 consists of four electronically programmable RFI/EMI receivers, a companion programmer and a digital readout panel. Ultimate receiver coverage will be from 20 Hz to 10 GHz. Receiver, Model NM-37/57, will have programmability of tuning, band switching, detector mode and bandwidth changing. It will cover the frequency span from 30 MHz to 1 GHz. Stoddart Electro Systems, 2045 W. Rosecrans Ave., Gardena, Calif. 90249. **CIRCLE NO. 510**



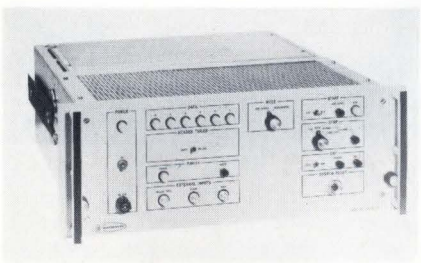


Solid-State Controllers, 540 Series, accept thermocouple output and have control sensitivity of ±5 μV. Set point resolution is 0.2°C. Featured are illuminated digital display of the set point and a calibrated deviation meter. The meter is independent of the control circuitry and indicates if the process is under set point (for continuous indication of process condition in relation to set point). Models are available with single or dual outputs. Barber-Colman Co., Industrial Instruments Div., 1300 Rock St., Rockford, Ill. 61101.

CIRCLE NO. 511

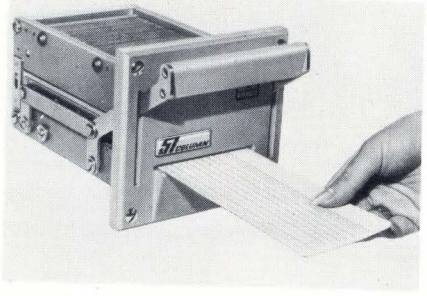
Pulse Generator, Model 137, has repetition rate from 10 Hz to 100 MHz with variable rise-and-fall times from 2 ns to 2 μs. Also featured are ±5V amplitude, inverting logic and single- and double-pulse output. E-H Research Labs., Inc., Box 1289, Oakland, Calif. 94604.

CIRCLE NO. 512



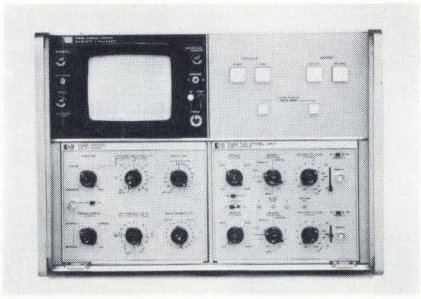
Data Coupler, Model 1000, contains necessary timing, control and interface logic for direct entry into a customer-specified tape recorder, plus a power supply sufficient to drive a full contingent of options. When equipped with options, the Model 1000 links any digital tape recorder in record or play-back mode with multichannel analog or digital sources, computers, telephone data sets and teletype equipment. Datatron, Inc., 1636 E. Edinger Ave., Santa Ana, Calif. 92705.

CIRCLE NO. 513



Tab Reader, a 51 by 12 unit that supplies 612 bits of information from a standard 80 by 12 IBM punched card, uses a contact design that eliminates through-card contacts and prevents lint and dirt from impairing reliability. An electrical lockout prevents closure of the contacts before a card is fully inserted and properly oriented, assuring accurate readings. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. **CIRCLE NO. 514**

Equipment



Digital Signal Analyzer offers a broad range of signal-averaging capabilities. It can operate as a "calibrated" or "weighted" averager and has flickerless display. The Model 5480A has both analog and digital outputs. An X-Y recorder can be connected directly to the analog output for permanent recording of stored or averaged signals. Plug-ins now available equip the analyzer for digital signal averaging. With these, two signal inputs may be processed in the same combinations provided by a conventional dual-trace oscilloscope. Coverage is from dc to 50 kHz with input sensitivity from 5 mV to 20V/cm adjustable in 12 steps. Sweep time ranges from 10 ms to 200s, calibrated in seconds/centimeter of display. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. **CIRCLE NO. 515**

D/A Converter, Model HS-2810, decodes eight-bit words at a word rate of 10 MHz to an accuracy of 0.1 percent. The desired minimum and maximum analog output is adjustable by two 10-turn potentiometers. The D/A converter automatically divides this range into 256 levels. Range and bias of the analog output may be controlled by an external source having bandwidth up to 25 MHz. This allows the instrument to be used as a high-frequency function generator, programmable attenuator or modulator, as well as a D/A converter. Computer Labs, 1109 Valley Park Dr., Greensboro, N.C. 27403.
CIRCLE NO. 516

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New technological dimensions mean growth, expansion...and outstanding career opportunities.

All of this is going on at LTV Electrosystems.

One new dimension was added last year when we acquired our Memcor Division – tactical communications. Memcor Division produces the PRC-25 and the VRC-12 for the U.S. Army. It also does exciting work in TACAN/DME test equipment, development of man-portable TACAN, nuclear instrumentation and control systems, and in production of a host of other components and products.

And Memcor Division is just one of four Electrosystems operating units, which utilize 14 plants in six states. Greenville Division, Garland Division and Continental Electronics have impressive dimensions in a variety of electronic systems fields: special purpose systems with air, sea and land applications in surveillance and reconnaissance, command and control, tracking, digital communications systems, display systems, guidance and control systems, specialized antennas, the world's most powerful RF transmitters, particle accelerators, to list a few.

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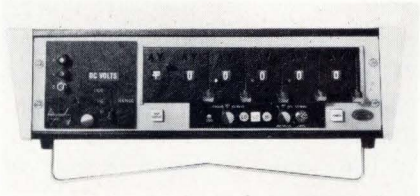
T. L. Norton,
Vice President,
LTV Electrosystems, Inc.;
General Manager,
Memcor Division

Equipment



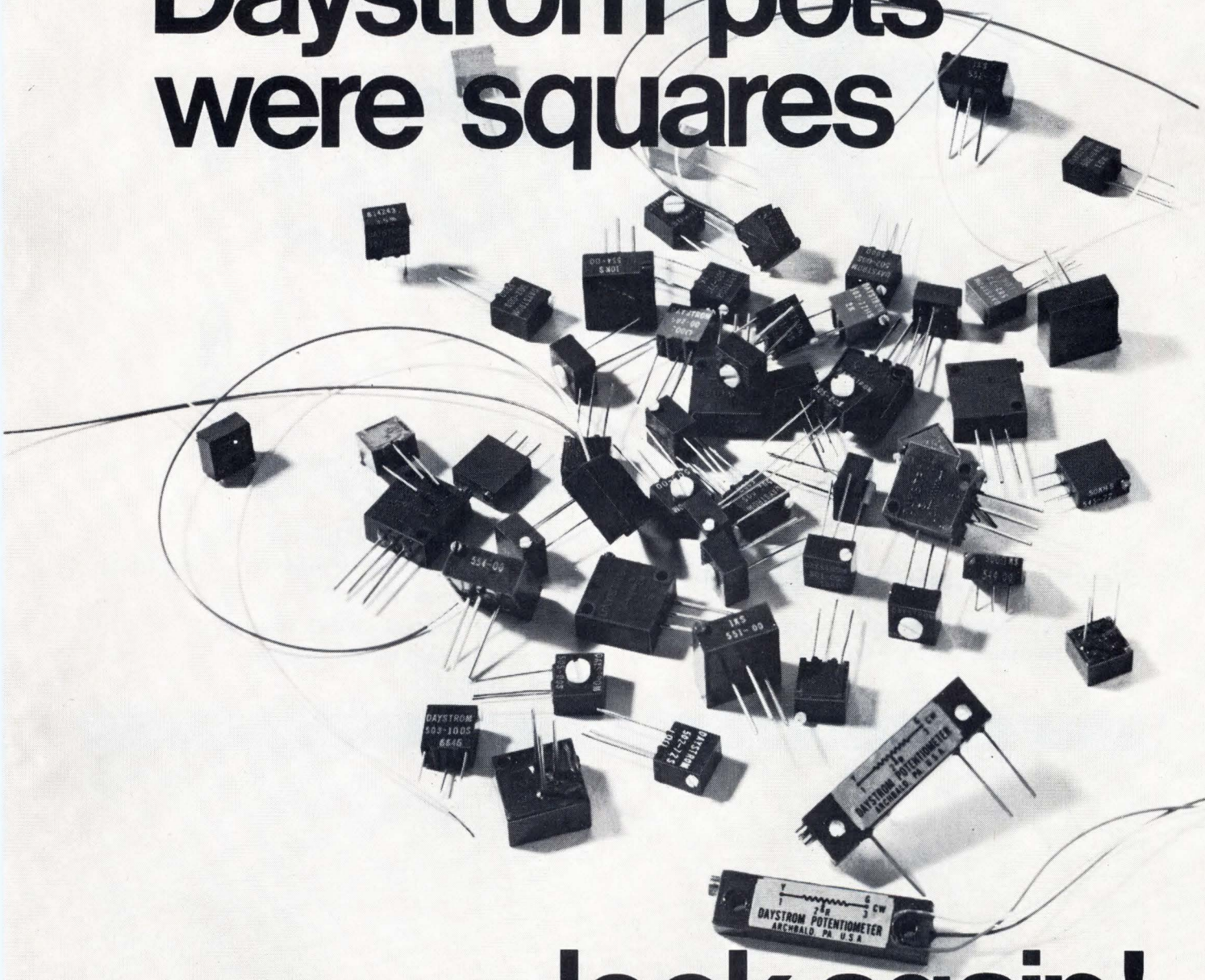
Multipurpose Instrument serves as "logic assisted" potentiometer, limit tester and comparator. Basic accuracy for dc voltages is 0.002 percent of reading. Four models are available: Model 804 for dc voltage tests, Model 805 for dc volts and millivolts/ohms/ratio, Model 904 for ac/dc volts and Model 905 that combines all features of the other three models. James G. Biddle Co., Plymouth Meeting, Pa. 19462. **CIRCLE NO. 517**

Light-Beam Oscillograph, Model LCR, is low cost and provides a complete analog-recording system with built-in signal conditioning. Eight recording speeds from 0.2 to 80 in/s are provided by the unit's servo-drive system. Frequency response is 2 kHz ±5 percent at full scale of ±2 in without signal conditioning. Features include 3, 8 or 14 channels; 6-in by 150-ft thin-base chart; 12-in optical arm and 35W xenon lamp. Midwestern Instruments, Inc., 6422 E. 41st St., Tulsa, Okla. 74135. **CIRCLE NO. 518**

Four- and Five-Digit IC Frequency Counters measure average frequency to 20 MHz, time interval and periods from 300 μs to 0.2s. They also will total pulses over a selected time period. Model 2724 has four digits and Model 2725 has five. Rated accuracy, maintained over a temperature range of +15 to +55°C, is ±0.01 percent of reading ±1 in the least significant position. Simpson Electric Co., 5200 W. Kinzie St., Chicago, Ill. 60644.
CIRCLE NO. 519

CIRCLE NO. 101 ▸

If you thought all Daystrom pots were squares



...look again!

Rectilinear components are still a necessary requirement in many circuit applications. That's why Weston has rounded out its high-performance potentiometer line with two new rectilinear models. RT-12 styles 534 and 535 are designed for both general-purpose and military applications. They feature the same ±5% tolerance, 10 ohm to 50K range, and slip clutch stop protection that are standard with Daystrom Squaretrim® units, plus 24-turn adjustability and humidity proofing. Also new this year . . . models 553 half-inch and 543 three-eighth-inch Squaretrim potentiometers in military and commercial versions. Save board space as well as money with our field proven 501 Series multi-turn and 504 Series single-turn 5/16" Squaretrims offering values to 20K in a 0.02 cubic inch case. All Squaretrim Diallyl-Phthalate cased pots give you Weston's patented "wire in the groove" construction and your choice of flexible leads, pin and screw configurations. Whether your trimmer needs are military, industrial or commercial, you'll find the answer in this complete new low-cost line. Write today for data sheets and evaluation samples. DAYSTROM potentiometers are another product of WESTON COMPONENTS DIV., Archbald, Pennsylvania 18403, Weston Instruments, Inc., a Schlumberger company

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- life greater than 20,000 hours
- stacking capability for higher voltage regulation

VOLTAGE REGULATOR AND REFERENCE TUBES

SIGNALITE TYPE	BREAKDOWN VOLTAGE vdc max.	REFERENCE VOLTAGE MEAS. AT		CURRENT RANGE* FOR REGULATOR	OPERATING CURRENT ma		
		vdc	ma	ma	MAX.**	MIN. AS SHUNT REG.	MIN. IN PARALLEL WITH A CAPACITOR
V83R4	115	83±2	1.5	0.25 — 4.0	6.0	0.25	0.4
V84R2	115	84±2	1.0	0.15 — 2.0	3.0	0.15	0.35
V91R2	125	91±2	1.0	0.1 — 2.0	3.0	0.1	0.3
V103R2	135	103±2	0.8	0.2 — 2.0	3.0	0.2	0.25
V110R4	170	110±2	1.5	0.5 — 4.0	6.0	0.5	0.95
V115R4	155	115±2	0.8	0.15 — 4.0	6.0	0.15	0.3
V116R2	150	116±2	0.6	0.12 — 2.0	3.0	0.15	0.3
V139R1.9	190	139±4	0.5	0.3 — 1.9	3.0	0.3	0.6
V143R1.9	225	143±4	0.5	0.3 — 1.9	3.0	0.3	0.6

NOTES:
*Limits for less than two volt variation.
**Maximum continuous current without permanent damage to tube.
Equilibrium condition reached within 2 minutes after ignition.

302

APPLICATION NEWS LETTER

The Signalite News Letter fully illustrates how voltage regulating tubes are used as reference voltage sources, and in: regulated power supplies, oscilloscope calibrators, photo multipliers, zener diode type voltage sources, digital voltmeters, timing circuits, over voltage protection, suppressed 0 voltmeters, frequency dividers, indicating voltmeters . . . and many other applications. Copies are available from your Signalite representative or contact Signalite.

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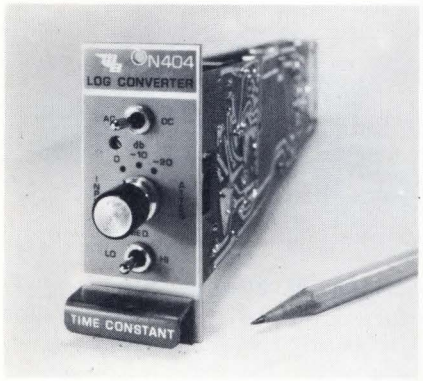
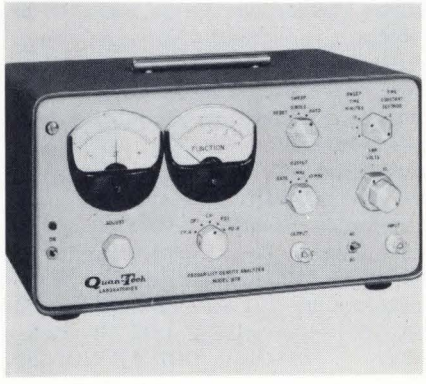
CIRCLE NO. 102

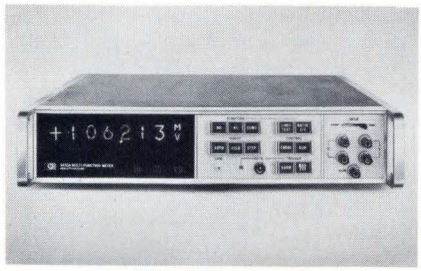
Equipment



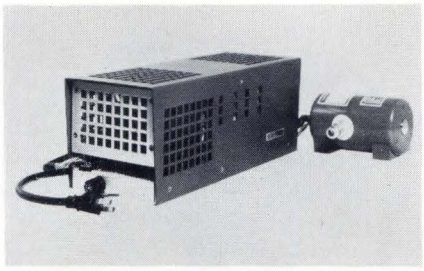
Log Converter has frequency range of dc to 10 kHz and allows direct linear dB plotting of signals with up to 50-dB variations. The Model N404 has self-contained power supply and isolated input/output signal path. Accuracy is ±0.5 dB, input impedance less than 600Ω and output impedance 100,000Ω. MB Electronics, 781 Whalley Ave., New Haven, Conn. 06508. **CIRCLE NO. 520**

Probability Density Analyzer, Model 317B, will measure manually or plot automatically either probability density or cumulative probability functions. Frequency range is from dc to 1.75 MHz, and two Model 317B's may be used together with a counter to perform joint probability analysis. Quan-Tech Labs., Inc., 43 S. Jefferson Rd., Whippany, N. J. 07981. **CIRCLE NO. 521**





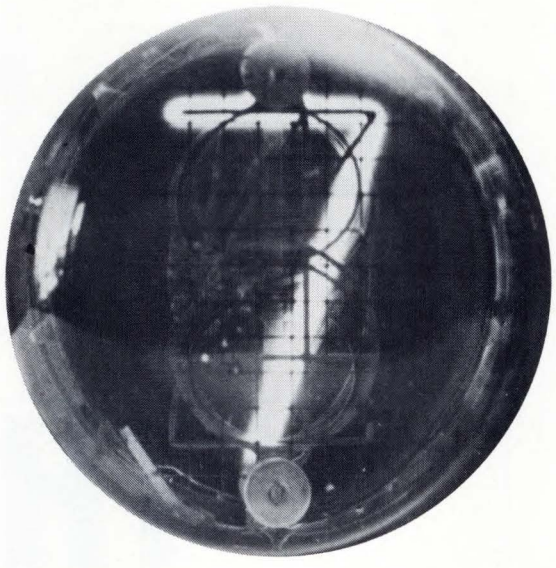
Digital Multifunction Meter, basically an integrating voltmeter with five dc ranges, performs up to 12 different measurements. The Model 3450A has isolated inputs and the basic instrument measures both dc voltage and dc-voltage ratios. Optional plug-in modules allow measurement of true rms to 1 MHz, resistance and resistance ratios. Readout is five digit with a sixth added for 20-percent overranging on all ranges. Maximum sensitivity on the lowest range is 1 μV. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. **CIRCLE NO. 522**



Programmable Microwave Source can be voltage or resistance controlled to provide 1- to 40-GHz output in octave or waveguide ranges. The Model 101 consists of power supplies, a shaping network and a backward-wave oscillator (BWO). Tuning linearity is ±0.5 percent between the program input and the RF output. Frequency stability is 2 ppm and line regulation is 20 ppm for a ±10-percent change in line voltage. The source can be tuned over its full frequency range in less than 1 ms. Micro-Power, Inc., 25-14 Broadway, Long Island City, N.Y. 11106.

CIRCLE NO. 523

nimo™
10-Gun CRT Display
unretouched



Gas Discharge Tube
unretouched

The difference is clear.

Until now, tube readouts left something to be desired. The multi-plane gas discharge display tube is a real eye-strainer, particularly under high ambient light or at a wide viewing angle.

Now we have the **nimo**™ 10-gun CRT display. Now, every character or message can be displayed on the same sharp, clear plane. No feedback ... no image ambiguity ... no external focusing ... no ambient light worries.

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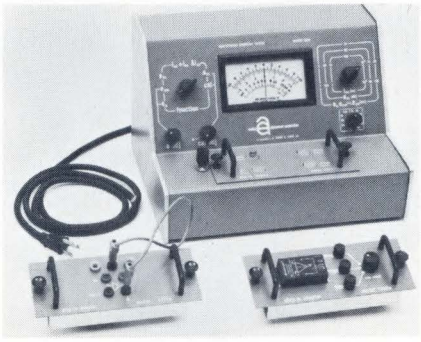
In all, there are 12 clear advantages to the new **nimo**™ 10-gun CRT.

Why not arrange with IEE for an eye-opening comparison? Phone ... or drop us a line; you'll get an immediate response. Industrial Electronic Engineers, Inc., 7720 Lemona Avenue, Van Nuys, Calif. (213) 787-0311.

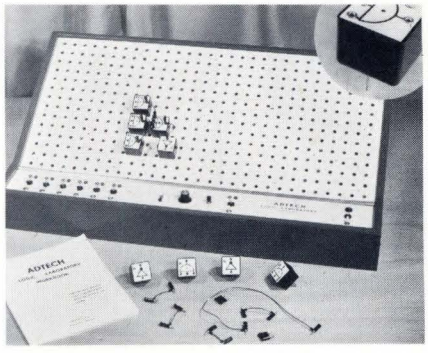
The uncommon readout.

CIRCLE NO. 107



Operational-Amplifier Tester can handle types ranging from FET-input to integrated circuit, hybrid and discrete-component types. The Model 131 uses interfacing modules to provide socket and electrical accommodation for most types currently available. Burns & Towne, Inc., 18-36 Granite St., Haverhill, Mass. 01830.
CIRCLE NO. 524

Logic Breadboarding System, Model 401B, consists of a 32- by 18-in logic board, a set of 60 "Logicubes" and 150 patchcords. Twenty-five types of cubes are available. These use TTL IC's throughout and have a replaceable indicator lamp for each output. Adtech, Inc., Box 10415, Honolulu, Hawaii. **CIRCLE NO. 525**



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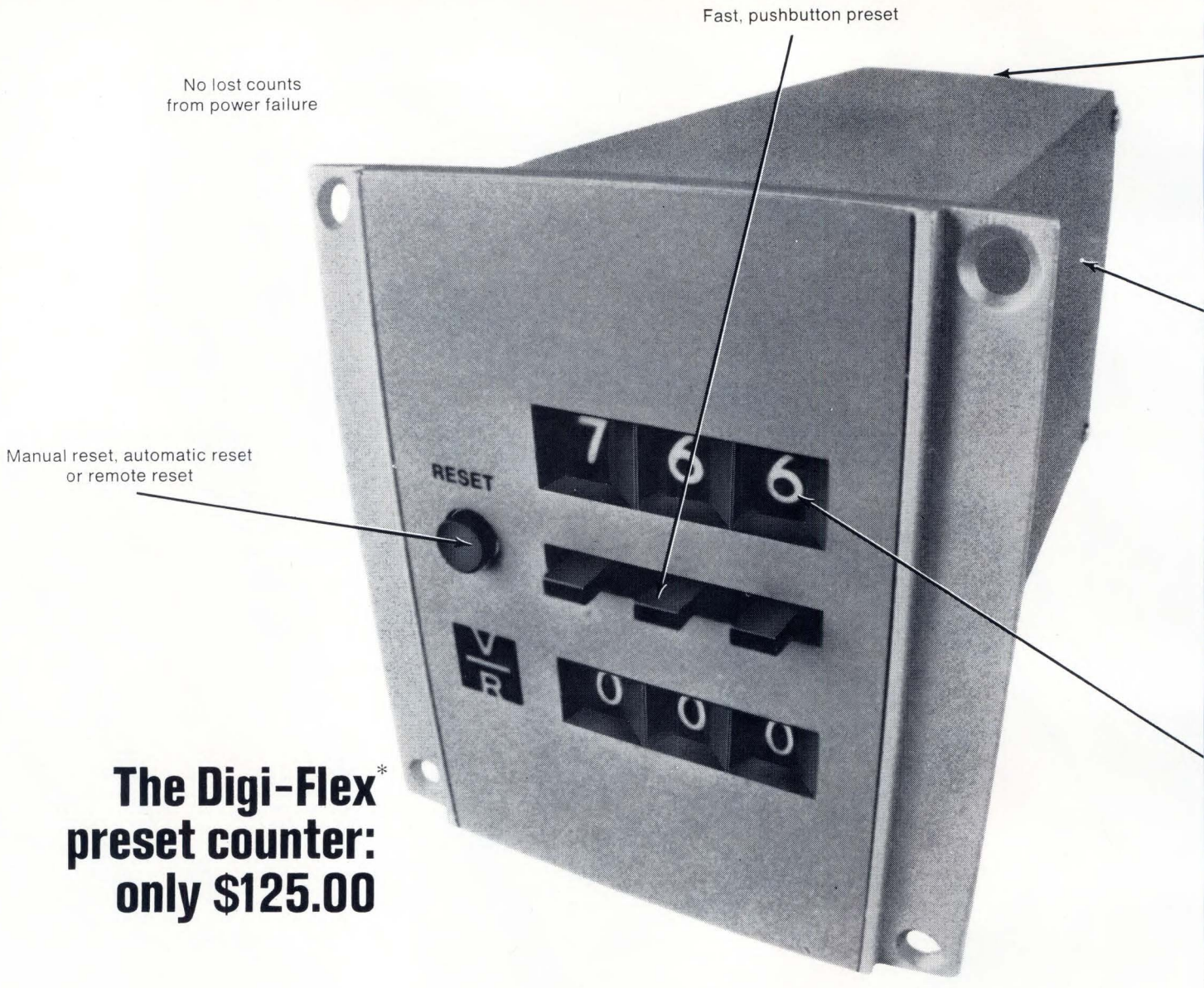
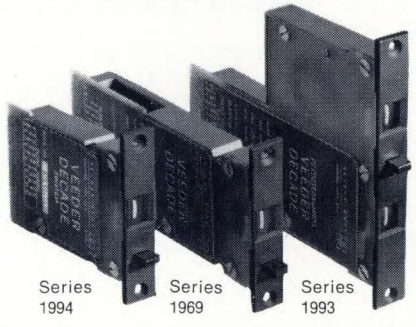


The Digi-Flex* preset counter: only $125.00

The versatile, economical Digi-Flex* counter is a predetermining control designed to solve application problems involving high-speed data processing systems, electronic controls, machine tools and similar equipment. Unlike competitors, the Series 7102 clearly displays both preset number and count total. It operates at speeds up to 2400 cpm, ideal for replacement of timers to control machine cycles precisely. The rugged panel face and steel enclosure make it well suited to most industrial environments.

The Digi-Flex is available at the low price of $125.00. Or, if you want to

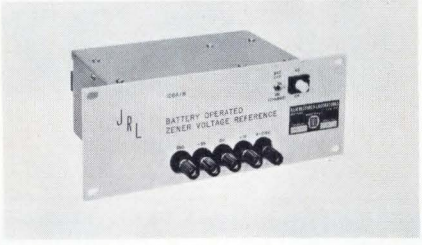


construct your own units, we've got the components to do it. For example, these new low priced models: The Series 1969 Veeder Decade* has two basic readout models – decimal or BCD; the Series 1994 Veeder Decade switch also has two models – decimal output or BCD output. And the Series 1993 predetermining Veeder Decade has predetermining switch output and optional decimal readout. For information about our complete line of counters, switches, predetermining modules, control packages and totalizers, write for Design Kit: Veeder-Root, Hartford, Conn. 06102.

*Trademark of Veeder-Root

CIRCLE NO. 94

Optical Telemeter, Model DOT-100, gives complete electrical isolation between data-acquisition instrumentation and data-processing, storage or display facilities. Modulation bandwidth is from dc to 100 kHz, linearity is 0.2 percent, output SNR is 50 dB and the system rejects radio-frequency interference. Dacom, Inc., 3946 Fabian Way, Palo Alto, Calif. 94303. **CIRCLE NO. 526**

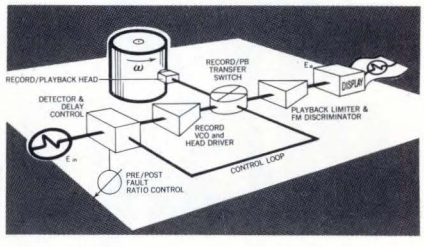


Ovenless Zener Voltage Reference has output stability of 10 ppm/month and warms up to within 1 ppm of final value in less than 15 min from initial turn-on. Overall temperature coefficient is less than 0.3 ppm/°C from 20 to 30°C. Operation is either from line or batteries. Julie Research Labs., Inc., 211 W. 61st St., New York, N.Y. 10023. **CIRCLE NO. 527**

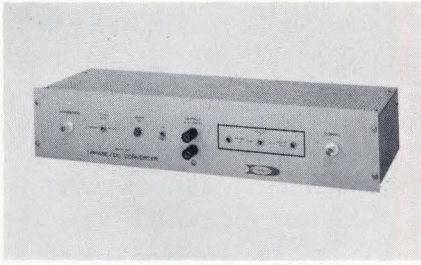
DC Microvoltmeter/Nanoammeter has 500-MΩ input impedance and offers greater than 160-dB common-mode rejection and recovery time for a 10^6 overload is 3s. Nine voltage ranges from 15 μV to 1500V full-scale plus current ranges from 15 pA to 10 mA full-scale allow measurements to an accuracy of ±0.2 percent. General Radio Co., West Concord, Mass. 01781. **CIRCLE NO. 528**

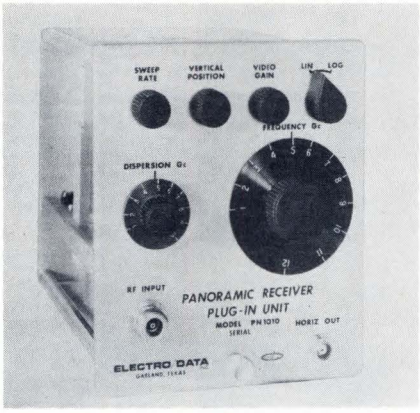
Universal Counter-Timer is a seven-digit instrument with two input channels. The Model 300 offers ac-dc coupling, memory, reset, short or long adjustable display time, self-test and ± slope triggering. Both inputs measure from 0 to 20 MHz with 10-mV rms sensitivity for sine waves. Time Systems Corp., 2239 E. Middlefield Rd., Mountain View, Calif. 94040. **CIRCLE NO. 529**

Transient Recorder continuously monitors electrical data and automatically captures 1s of fault data, with the ratio of prefault to postfault display adjustable within the 1s period. Up to 32 channels of data can be monitored simultaneously. Clevite Corp., Brush Instrument Div., 37th and Perkins, Cleveland, Ohio 44114. **CIRCLE NO. 530**



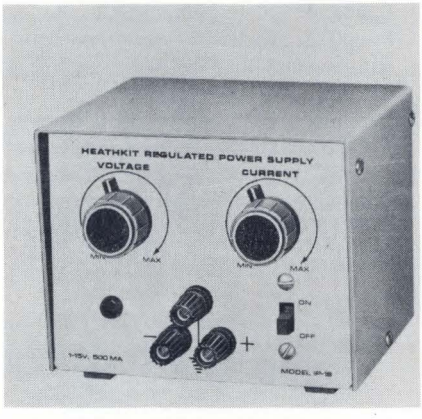
Phase-to-DC Converter, Model 222, generates a precise dc voltage proportional to the phase difference between the two input signals. No adjustment is required for amplitude or frequency over the frequency range from 20 Hz to 500 kHz. Accuracy is ±0.1° below 20 kHz and sensitivity is 10 mV/deg. Dytronics Co., Inc., 4800 Evanswood Dr., Columbus, Ohio 43224. **CIRCLE NO. 531**

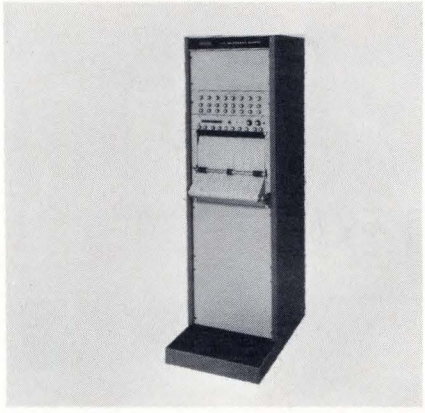




Panoramic Receiver Plug-In Module is YIG-tuned over the 120- to 1200-MHz range. The Model PN1010 is available for plug-in use with Tektronix 560 Series or Tektronix Letter Series scopes. Use of the YIG bandpass filter tuning eliminates images and spurious responses. Electro/Data, Inc., 3121 Benton St., Garland, Tex. 75040. **CIRCLE NO. 533**

Low-Cost Regulated Power Supply, Model IP-18, delivers 1-15V dc at from 10 to 500 mA. This all-silicon transistor supply has current limiting, 40-mV full-load to no-load regulation, 0.1-mV maximum of ripple and noise and transient response time of 25 μs. Price of the IP-18 kit is $19.95. Heath Co., Benton Harbor, Mich. 49022. **CIRCLE NO. 534**





Direct-Writing Recorder offers true thermal rectilinear recording with dc to 175-Hz frequency response. Type RD-III is a medium-sensitivity eight-channel unit suitable for accurate long-term unattended recording. Beckman Instructments, Inc., Electronic Instruments Div., 2500 Harbor Blvd., Fullerton, Calif. 92634. **CIRCLE NO. 535**

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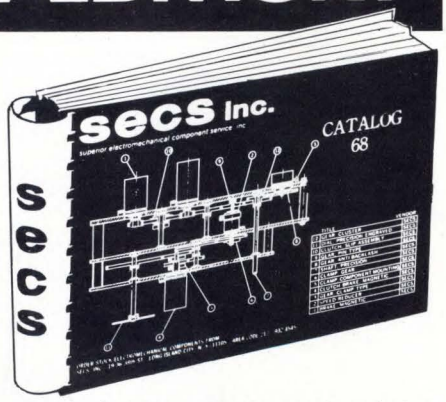

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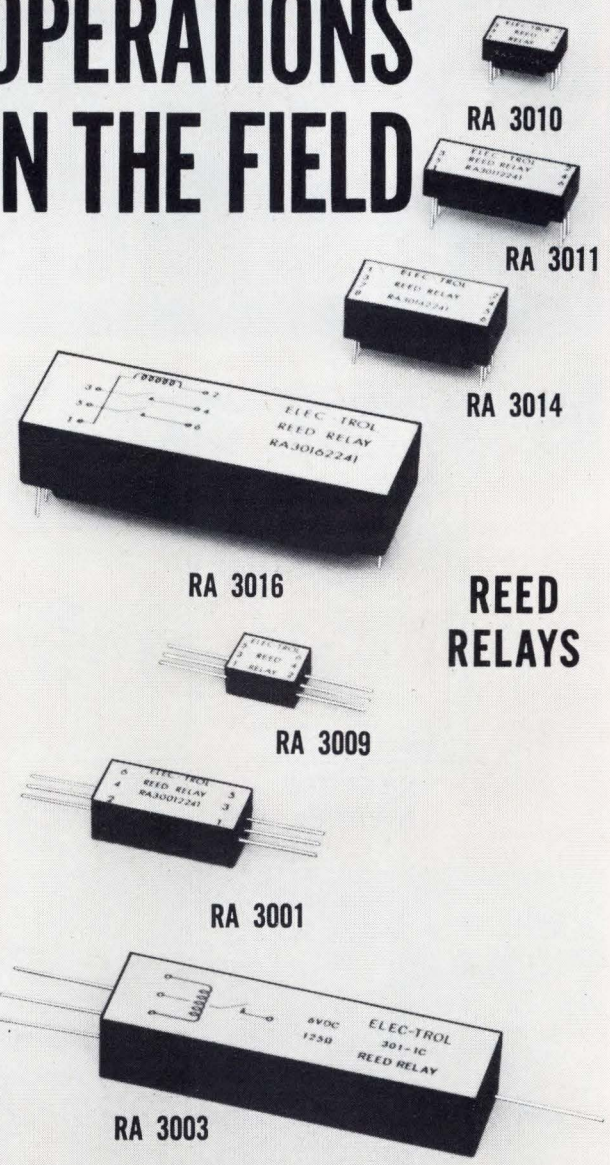

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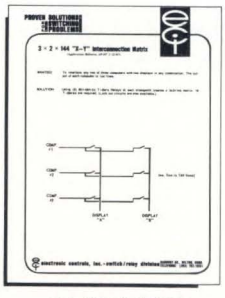
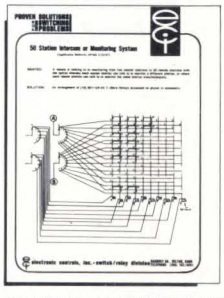
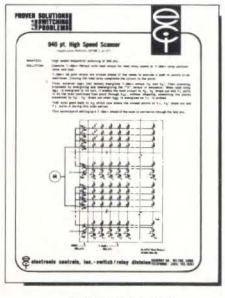


COMPUTER INTERFACE



COMMUNICATIONS CROSS-POINT SWITCHING



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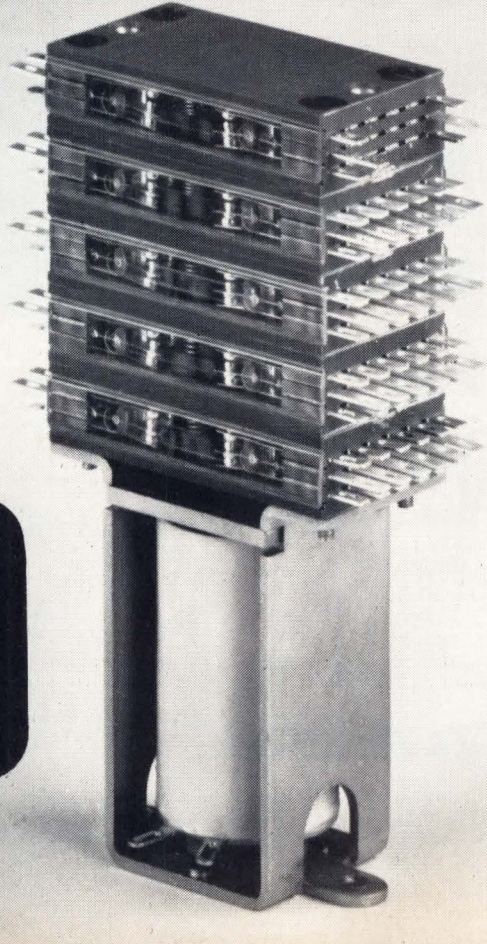

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See Product Preview #2 on the following page

EDN CARAVAN ROUTE

October 14 – November 14, 1968

DAY / DATE / TIME	AREA	SITE
Monday, October 14		
9:00 - 12 noon	Dallas, Texas	LTV Electrosystems (Garland)
1:30 - 4:30 p.m.	Dallas	Geotech, Div. of Teledyne (Garland)
Tuesday, October 15		
9:00 - 12 noon	Dallas	LTV Aerospace
1:30 - 4:30 p.m.	Dallas	Texas Instruments
Wednesday, October 16		
9:00 - 12 noon	Dallas / Ft. Worth	Bell Helicopter (Ft. Worth)
1:30 - 4:30 p.m.	Dallas / Ft. Worth	General Dynamics (Ft. Worth)
Friday, October 18		
1:30 - 4:30 p.m.	Albuquerque, N.M.	Sandia Corp.
Monday, October 21		
9:00 - 12 noon	Phoenix, Arizona	Motorola Aerospace
1:30 - 4:30 p.m.	Phoenix	General Electric
Tuesday, October 22		
9:00 - 12 noon	Phoenix	Sperry Flight Systems
1:30 - 4:30 p.m.	Phoenix	Goodyear Aircraft (Litchfield Park)
Thursday, October 24		
9:00 - 12 noon	San Diego, Calif.	General Dynamics (Lindbergh Field)
1:30 - 4:30 p.m.	San Diego	General Dynamics (Kearny Mesa)
Friday, October 25		
9:00 - 12 noon	San Diego	Ryan Aeronautical
1:30 - 4:30 p.m.	San Diego	Stromberg Data Graphics
Monday, October 28		
9:00 - 12 noon	Los Angeles	ITT Gilfillan
1:30 - 4:30 p.m.	Los Angeles	Teledyne Systems (Northridge)
Tuesday, October 29		
9:00 - 12 noon	Los Angeles / Orange Co.	Beckman Instrs. (Fullerton)
1:30 - 4:30 p.m.	Los Angeles / Orange Co	Hughes Aircraft (Fullerton)
Wednesday, October 30		
9:00 - 12 noon	Los Angeles / Orange Co	Aeronutronic (Newport Beach)
1:30 - 4:30 p.m.	Los Angeles / Orange Co.	McDonnell Douglas (Huntington Beach)
Thursday, October 31		
9:00 - 12 noon	Los Angeles	Northrup Corp. Norair / Nortronics (Hawthorne)
1:30 - 4:30 p.m.	Los Angeles	Scientific Data Systems (El Segundo)
Friday, November 1		
9:00 - 12 noon	Los Angeles	McDonnell Douglas (Long Beach)
1:30 - 4:30 p.m.	Los Angeles	Garrett AiResearch (Torrance)
Monday, November 4		
9:00 - 12 noon	San Francisco Bay	Sylvania Elec. Prods. (Mountain View)
1:30 - 4:30 p.m.	San Francisco Bay	Ampex (Redwood City)
Tuesday, November 5		
9:00 - 12 noon	San Francisco Bay	Applied Technology
1:30 - 4:30 p.m.	San Francisco Bay	Varian Associates (Palo Alto)
Wednesday, November 6		
9:00 - 12 noon	San Francisco Bay	Philco-Ford Corp. (Palo Alto)
1:30 - 4:30 p.m.	San Francisco Bay	Westinghouse Elec. (Sunnyvale)
Thursday, November 7		
9:00 - 12 noon	San Francisco Bay	Lockheed Missiles & Space (Sunnyvale)
1:30 - 4:30 p.m.	San Francisco Bay	Lockheed Satellite (Sunnyvale)
Friday, November 8		
9:00 - 12 noon	San Francisco Bay	Fairchild Instrumentation (Sunnyvale)
1:30 - 4:30 p.m.	San Francisco Bay	IBM Corporation (San Jose)
Monday, November 11		
9:00 - 12 noon	Los Angeles	Litton Industries (Woodland Hills)
1:30 - 4:30 p.m.	Los Angeles	Litton Industries (Van Nuys)
Tuesday, November 12		
9:00 - 12 noon	Los Angeles	TRW Systems (Redondo Beach)
1:30 - 4:30 p.m.	Los Angeles	Hughes Aircraft (El Segundo)
Wednesday, November 13		
9:00 - 12 noon	Los Angeles	McDonnell Douglas (Culver City)
1:30 - 4:30 p.m.	Los Angeles	Lockheed California (Burbank)
Thursday, November 14		
9:00 - 12 noon	Los Angeles	General Dynamics (Pomona)
1:30 - 4:30 p.m.	Los Angeles	Aerojet General Corp. (Azusa)

Cermet

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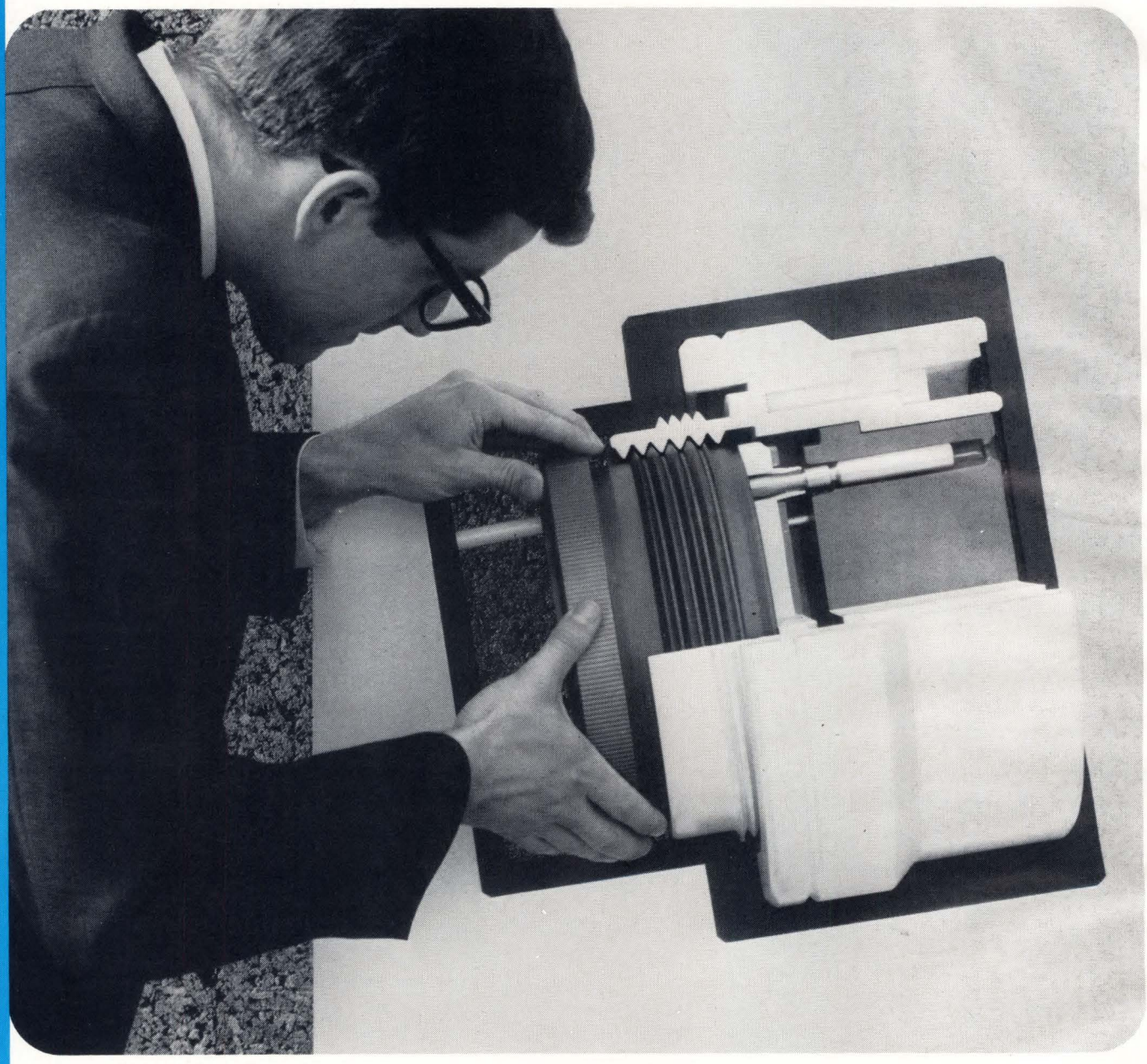

Catch the full story on MIL-C-81511 Astro/348® at the Amphenol exhibit in the EDN Caravan.

A working model shows how Amphenol's design simply and effectively meets subminiature, environmental requirements. And the Amphenol MIL-C-81511 family is growing. Additional contact sizes and insert arrangements are now on the way. A complete display including accessories will be a part of the EDN Caravan.

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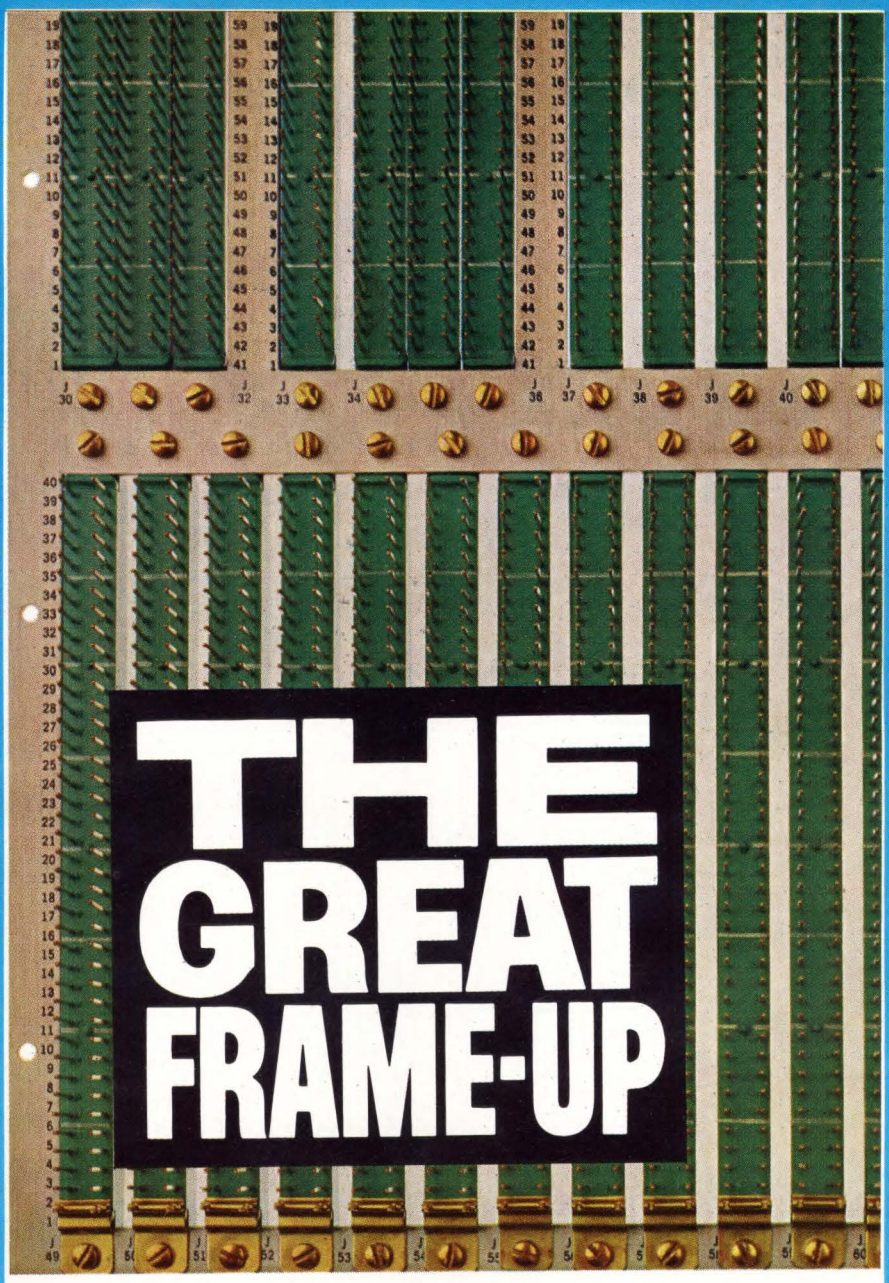

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Our new AccurFrame takes the fuss and bother out of wire-wrapping. It's easy, fast and error-free. And very simple to use.

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You'll like our Wire-Wrap connectors, too. They're available in sizes ranging from 22 to 50 contact positions. Designed for automatic equipment, high-strip force retention, bifurcated spring contacts for superior interfacing. We integral-mold them in diallyl phthalate SDG-F. Contacts are easily removed. Retained by a 90° twist.

Get all the profitable facts about the Great Frame-Up from your District Sales Office. Or from Winchester Electronics, Main Street & Hillside Avenue, Oakville, Connecticut 06779.

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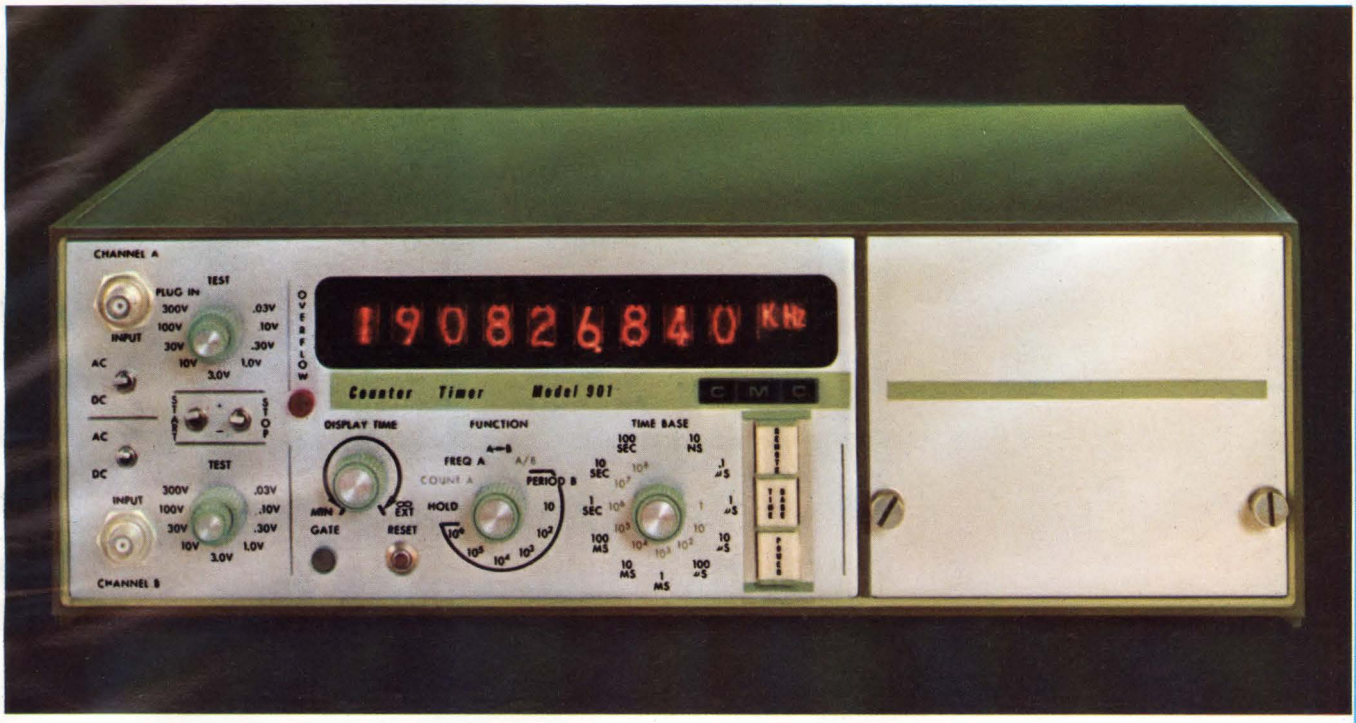
When will someone introduce a true 200-MHz counter-timer?



NOW!

And it's yours for less than $2500!

Imagine a universal counter-timer that offers 200-MHz direct counting instead of 100 or 125... that provides nine-decade readout instead of eight...that offers gate times from 1 microsecond to 100 seconds instead of to only 10 seconds ... that provides time-interval resolution of 10 nanoseconds instead of 100... that has an input sensitivity of 10 mV instead of 100... and that can be operated completely by remote control, including attenuator and trigger levels.

Imagine all that in a new state-of-the-art IC counter-timer. Then decide how much more you would be willing to pay. Brace yourself: *This unique CMC Model 901 actually costs from $250 to $1000 less than the closest competitive models, which still fall far short of 901 performance!*

But that's not all. The CMC 901 achieves its 200-MHz range without prescaling, heterodyning, or requiring plug-ins. And it offers time-interval measurement as an integral function of the basic counter at no extra cost. Also, the unique CMC design and the use of advanced IC's throughout the main circuitry greatly enhances reliability and reduces heat dissipation and maintenance problems.

And here's more. Two optional heterodyne converters are also being introduced with the 901 – the Model 931 for a range to 1.2 GHz, and the Model 935 for 3.2-GHz operation.

For complete specs on this first, true, 200-MHz universal counter-timer – circle the reader service card.

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A Division of Pacific Industries

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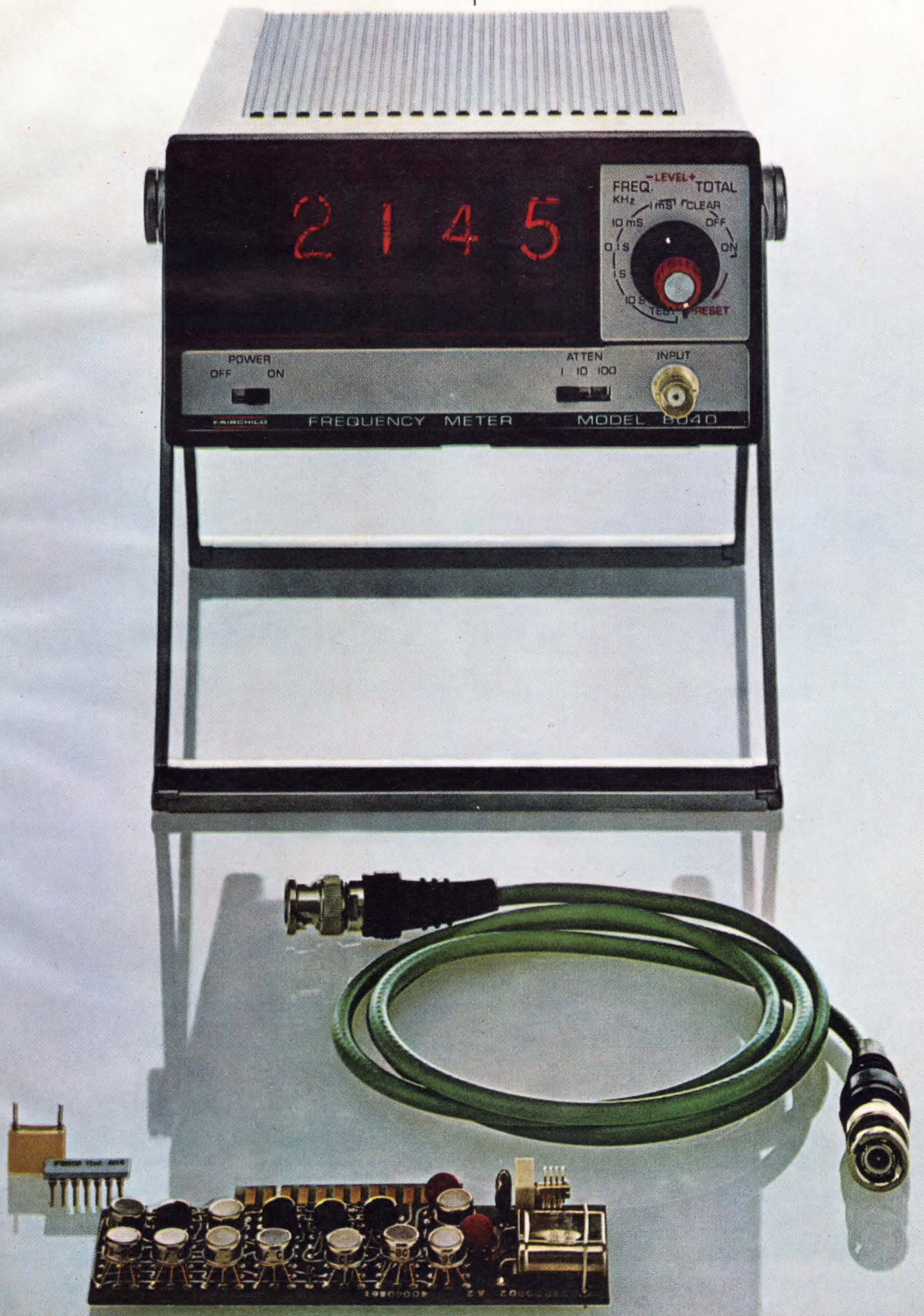
Fairchild's 8040 counter provides a unique time base with five gate times in the frequency mode: 1msec through 10 sec. It's the only instrument in its price range that allows you to display the most significant digit for any frequency without buying extra digits. The 8040 time base is 60Hz line frequency with 0.1% stability. It offers 1 Megohm input. Its range is 10Hz to 2MHz. A fifth digit is optional. If you need a more sophisticated counter, we also have a five-digit, 30MHz instrument. It's called the 8050. It costs $695. It does a lot more than the 8040. Call for specs on both. Dial (408) 735-5201. Ask for Don Greening.

FAIRCHILD
INSTRUMENTATION



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- Bringing to company doorsteps the latest products and technology from 15 companies.[1]
- All products displayed under operating conditions with factory trained representatives in attendance.[2]
- All booth displays fully air conditioned[3] for comfortable, at ease inspection and discussions.
- All Caravan visitors eligible to win a Grand Prize;[4] drawing at end of of tour.
- Watch this space for exact date, time and place, when the 1968 EDN New Products Caravan will visit your plant.[5]

EDN NEW PRODUCTS CARAVAN

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1. See Caravan Roster.

2. They also write sales orders.

3. Seven tons per vehicle; we were comfortable even in Dallas and St. Louis.

4. Last year's prize was a Muntz Stereo System.

5. Or a plant near you.

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product report
digital instruments

Automate Your Measurements . . .

. . . with these NEW Tektronix products.

Digital Oscilloscope

The Type 568/230 Digital Oscilloscope System provides digital readout of measurements that are displayed in analog form on the CRT. They enable the engineer, technician or production worker to make dynamic switching-time measurements with greater speed, convenience and repeatability than is possible by making measurements directly from the cathode-ray oscilloscope display. Typical measurements include pulse voltages, risetime, falltime, delay time, storage time, pulse width and many other specific measurements.

With the NEW programmable plug-in units and Sampling Heads, all of the measurement functions of the Type 568/230 can be externally programmed for use in high-speed automated measurement systems. The Type 568/230 can make more than 100 dynamic measurements per second, and data output connectors provide measurement results in convenient BCD code. Programming is easily accomplished with the use of new Tektronix Program Units.

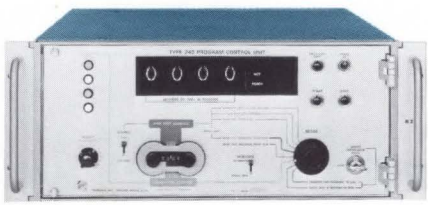
Type 568/230/3T6/3S6/S-1/S-1 ..... $7340

Automatic Measurements

NEW Type 241

Add the NEW Type 241 Programmer to the Type 568/230 Digital Oscilloscope and obtain up to 15 automatic measurements. The Type 241 will automatically sequence through 15 programs, stopping on out-of-limit measurements. Programs are easy to setup and change, enabling a person having minimum training to program the Type 241.

Type 241 ..... $1950



NEW Type 240

The NEW Type 240 Program Control Unit and NEW Disc Memory program the Type 568/230 at speeds up to 100 measurements per second and provide local storage of 1600 independent measurements. Sorting, classifying and diagnostic test routines are also obtained using the Disc Memory. A Punched Tape Reader is used with the Type 240 in low-speed systems, providing a maximum of 6 measurements per second.

Type R240 ..... $3800
Disc Memory $6600
Punched Tape Reader $1250

NEW Type R250

The NEW Type R250 Auxiliary Program Unit adds additional programming capabilities to the Type 240 and provides programming and buffering for pulse generators, power supplies and other equipment. System engineering and design is required with the Type R250. The NEW Type R116 MOD 703L and Type R293 MOD 703M Programmable Pulse Generators are designed specifically for use with the Type R250 in automated systems.

Type R250 ..... $1400
6 Shift-Register Cards ..... $ 420
Type R116 MOD 703L $2775
Type R293 MOD 703M $1300

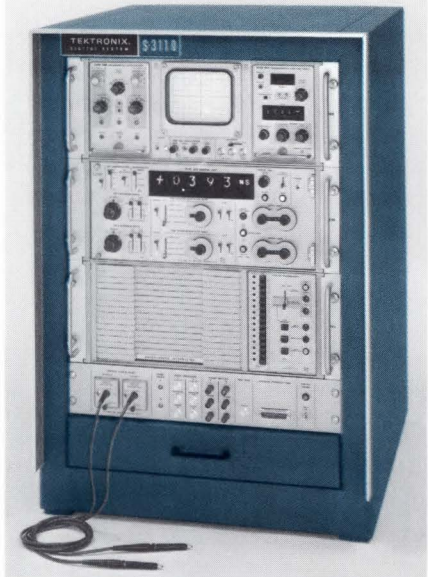
U.S. Sales Prices FOB Beaverton, Oregon

NEW Tektronix Measurement Systems

Making the Measurement . . . . Tektronix Measurement Systems

Tektronix Measurement Systems use Tektronix Catalog products and additional equipment such as programmable power supplies, test stations, equipment racks and other equipment. Tektronix does the systems engineering and supplies a digital measurement system ready to do your measurement job. Your requirements to test integrated circuits, transistors, circuit boards and subassemblies can be met with a Tektronix dynamic measurement system.

NEW

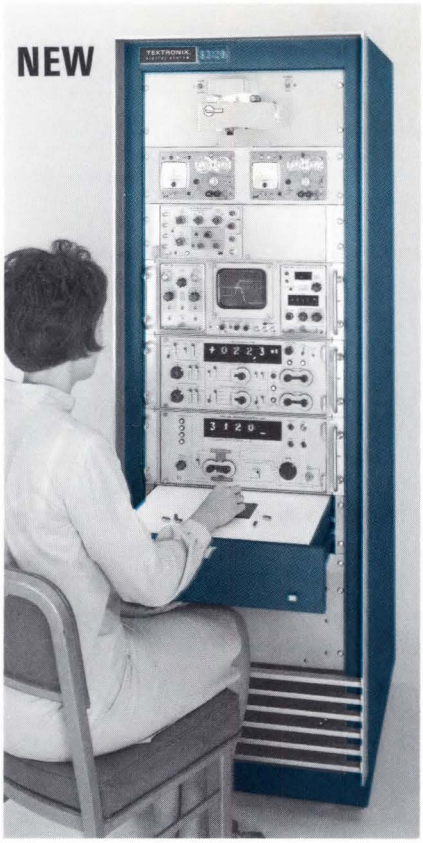


Type S-3110 Pulse Testing

The Type S-3110 provides up to 15 measurement programs and eliminates operator interpretation and error when testing pulse generators and other pulse sources. Programmable measurements provide consistent GO, NO-GO readings with the speed and repeatability required for production testing and QC. Measure pulse period, pulse width, risetime, falltime, pulse amplitude, overshoot, DC offset and many other specific pulse parameters. Sampling Heads provide a choice of system measurement capabilities. Select the measurement performance you need today and update your performance with future Sampling Heads.

Type S-3110 ..... $11,500

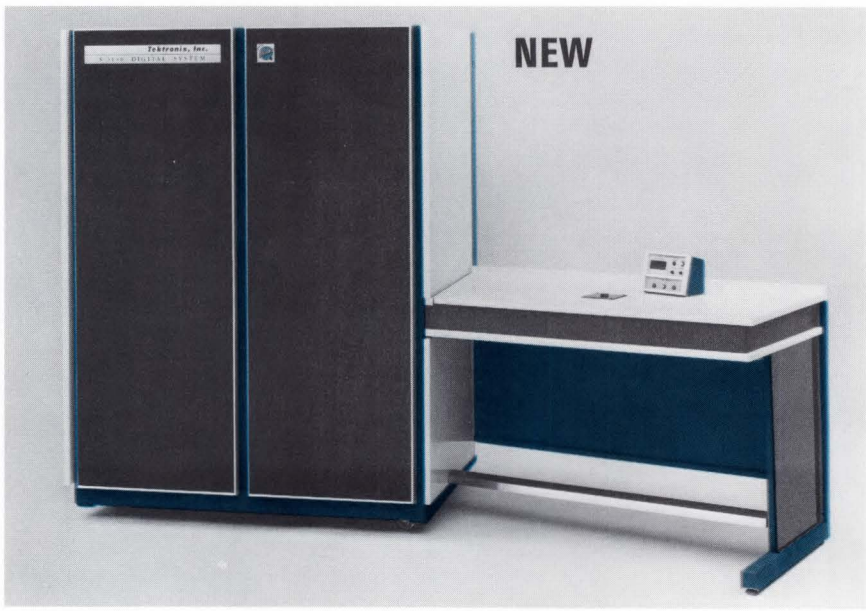
NEW



Type S-3120
Switching-Time Measurements

The Type S-3120 is designed to verify the switching-time performance of transistors, diodes and IC's. The Type S-3120 is intended for use where power supply voltages and pulse parameters do not require programming. Program branching with the Type S-3120 permits sorting and classifying of semi-conductors. For example, when making a rise-time measurement, a within - limits measurement will continue the normal measurement sequence; an above-limit measurement (slow risetime) can stop the sequence to reject the component; and a below-limit measurement (fast risetime) can branch to a new measurement sequence for reclassifying the transistor.

Type S-3120 ..... $28,000



Type S-3130 Integrated Circuit Testing

Tektronix Type S-3130 Digital Measurement System makes 100% dynamic testing feasible for incoming inspection of IC's. Dynamic testing now can check the performance of your IC's under simulated operating conditions at a low cost per unit tested. Measurement speeds of 100 measurements per second with local storage of 1600 independent measurements provides the flexibility and versatility required of a dynamic IC tester. Measurement programs change power supply and pulse generator parameters over a wide range; extra program lines from the Type R250 can be used to switch test point and operating and load conditions.

Type S-3130 ..... $41,000

U.S. Sales Prices FOB Beaverton, Oregon

For a demonstration, call your local Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

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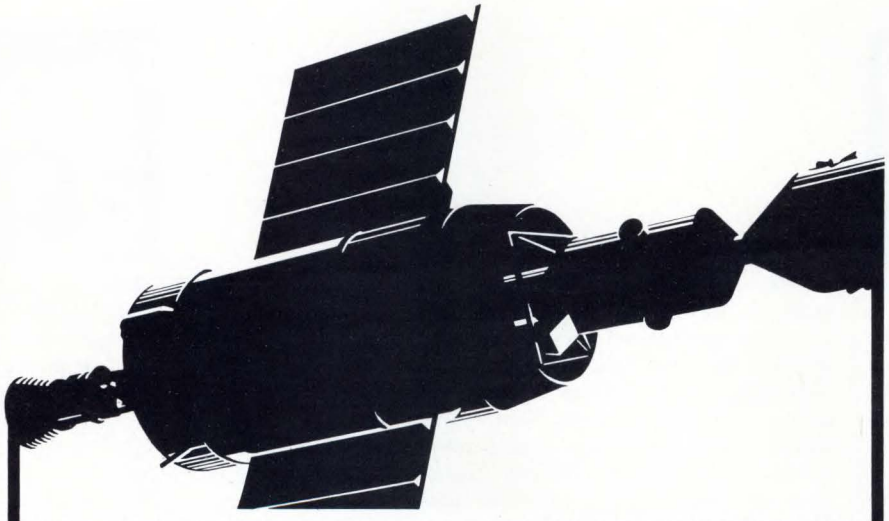

Mail to: Mr. W. R. Wardle, Professional Employment, Box 14308, St. Louis, Mo., 63178
or: Mr. N. R. Kilgore, Professional Employment, 3000 Ocean Park Blvd., Santa Monica, Calif. 90406

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EDN-10

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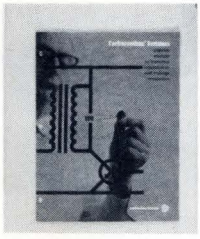
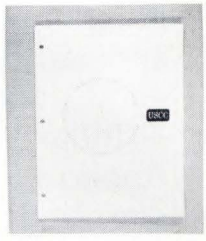
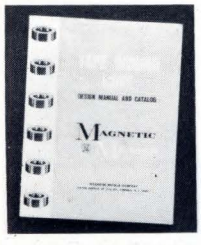


Varistors. A technical bulletin on varistors (voltage-dependent resistors) describes characteristics and applications for these nonlinear resistors with large negative voltage coefficients. The bulletin offers complete product information, including electrical specifications, physical specifications and characteristic curves. It also contains a thorough treatment of varistor applications, including typical circuit diagrams. The Carborundum Co., Electronics Plant, Box 339, Niagara Falls, N.Y. 14302. **CIRCLE NO. 541**

Instrumentation. This 48-page catalog supplement contains information on the new instruments introduced by Tektronix, Inc., at the WESCON Show. Included in the supplement is a description of a portable oscilloscope, a TV waveform monitor, an engine analyzer, a swept-frequency converter for spectrum analyzers, a series of digital instrumentation and much more. Each item is illustrated and thoroughly described with waveforms, performance specifications and ordering information. Tektronix, Inc., Box 500, Beaverton, Ore. **CIRCLE NO. 543**



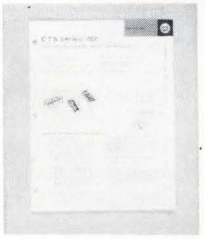
Ceramic Capacitors. This 12-page catalog describes miniature high-stability ceramic capacitors. Included are complete specifications, physical drawings, part numbers and ordering information for capacitor styles with axial or radial leads, tubular or rectangular configurations and precision epoxy or resin-coated cases. Also included are typical characteristic curves and detailed test procedures used during manufacture. U.S. Capacitor Corp., 2151 N. Lincoln St., Burbank, Calif. 91504. **CIRCLE NO. 545**



Tape-Wound Cores. Complete technical information for the engineer concerned with the design of components involving the use of tape-wound cores is contained in a "Tape Wound Core Manual and Catalog". Divided into three major parts, the manual presents core size and material identification, and curves illustrating important properties associated with the materials. Also included are design formulas and information for the application of tape-wound cores. Included with the manual is a concise lift-out section that provides a quick reference to all pertinent information for the specification and use of tape-wound cores. Magnetic Metals Co., Hayes Ave. at 21st St., Camden, N.J. 08101. **CIRCLE NO. 542**

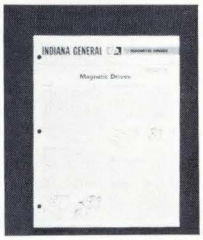
Adjustment Potentiometers. An eight-page brochure features the nomenclature, dimensions, specifications, price listings and detailed photos of more than 50 adjustment potentiometers. Types listed include cermet, high-performance wirewound, special-purpose and general-purpose wirewound, and general-purpose and special-purpose carbon-element potentiometers. The specifications include resistance tolerance, power rating, maximum temperature, adjustment turns, standard resistance and humidity. Also included are dimensions and specifications for adjustment potentiometer mounting hardware. Bourns, Inc., Electronic Components Operations, Trimpot Products Div., 1200 Columbia Ave., Riverside, Calif. 92507. **CIRCLE NO. 544**

Multilayer PC Boards. Entitled "A Designer's Guide to Multilayer", this booklet is intended to assist the engineer in designing multilayer printed-circuit boards that are highly producible, reliable and economical. The information presented will serve both as a guide for the engineer/designer who is relatively unfamiliar with the requirements for multilayer PC design and as a ready source of reference material for those persons actively engaged in the field. Subjects covered include multilayer artwork, hole sizes and shapes, materials, laminating, drilling, plating, conductor characteristics and etching. Lockheed Electronics Co., 6201 E. Randolph St., Los Angeles, Calif. 90022. **CIRCLE NO. 546**



Resistor Modules. Data Sheet 3760 contains illustrations, dimensioned drawings, electrical specifications, mechanical specifications and environmental performance characteristics on the Series 760 dual in-line cermet resistor module. This network is mechanically compatible with standard monolithic 14-lead dual in-line packages. The networks are available with up to 13 resistors screened on both sides of the substrate or a resistor network plus chip capacitors and/or active devices. CTS of Berne, Inc., Berne, Ind. 46711.

CIRCLE NO. 547

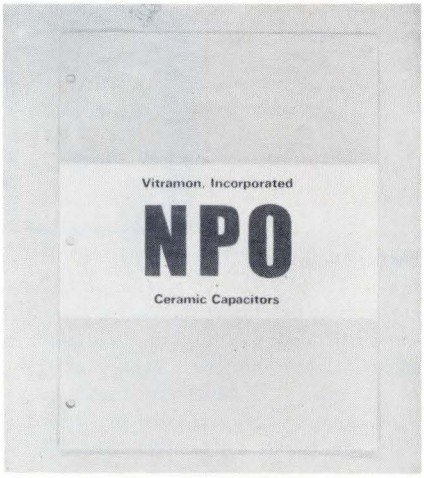


Magnetic Drives. Magnetic drives, which make it possible to transmit torque through a barrier without the use of a mechanical connection, are discussed in a technical data bulletin. Drive characteristics, general considerations and design requirements are given for synchronous axial and radial, eddy-current and hysteresis drives. Line drawings of each type illustrate drive configurations and proper positioning of component parts. Engrg. Data Form 382. Magnet Div., Indiana General Corp., 405 Elm St., Valparaiso, Ind. 46383. **CIRCLE NO. 548**

Soldering Problems. A six-page bulletin entitled "What Can Go Wrong with Printed-Circuit Soldering" describes 17 common soldering faults and their remedies. Problems covered include such faults as dewetting, excess solder, icicling, webbing, white residues and blow holes. Eleven detailed photographs illustrate some typical defects caused by such factors as chlorine contamination, entrapped gas pockets and improper laminate curing. Bulletin TR-1020. Alpha Metals, Inc., 56 Water St., Jersey City, N. J. 07374.

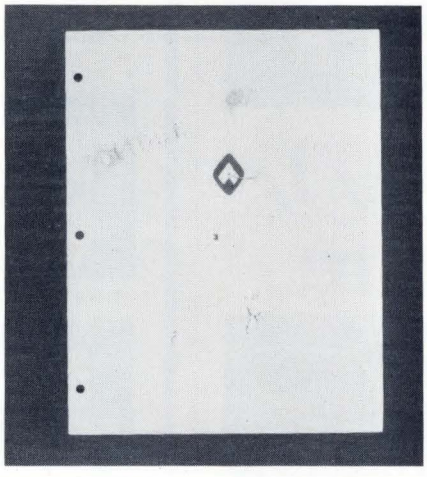
CIRCLE NO. 549

Literature



Ceramic Capacitors. A four-page catalog describes a series of NPO ceramic capacitors. The units listed are offered in four styles—with axial and radial leads and in chip form. Capacitance values range from 10 to 2700 pF. The catalog includes general, electrical and mechanical specifications, dimensional drawings, ordering information and typical curves. Vitramon, Inc., Box 544, Bridgeport, Conn. 06601.

CIRCLE NO. 550

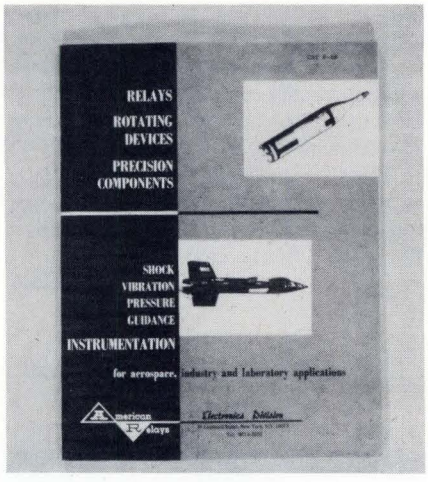


Trimming Potentiometers. Miniature wirewound potentiometers are featured in a four-page short-form catalog. The booklet gives complete specifications for 3/8- and 1/4-in-sq wirewound and special-purpose trimmers. Information includes resistance ranges, terminals, tolerances, temperature ranges and many other details. Techno-Components Corp., 7803 Lemona Ave., Van Nuys, Calif. 91405

CIRCLE NO. 551

Electromechanical Components. Catalog 8-68, 100 pages, lists electromechanical components and equipment from all major manufacturers. It features such items as accelerometers, counters, meters, motors, precision potentiometers, selsyns, servomotors, test equipment and timers. Special complete sections are included on relays, pressure transducers and gyros. Electronics Div., American Relays, 39 Lispenard St., New York, N.Y. 10013.

CIRCLE NO. 552



Wire, Cable and Tubing. This easy-reference guide is designed to provide basic wire, cable and tubing specification data in a simple-to-use format that includes charts, diagrams and illustrations. Included is a guide to military specifications for hookup wire requirements for MIL-W-76-B and MIL-W-16878D, a wire-sizes and resistance chart and a wire-stranding chart. Alpha Wire Mfg. Co., 711 Lidgerwood Ave., Elizabeth, N. J. 07207.

CIRCLE NO. 553

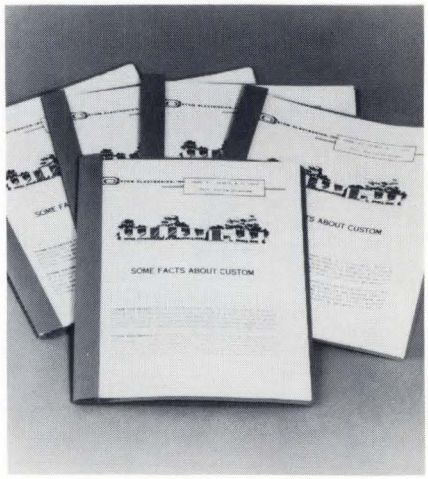
Literature

Power Supplies. "Power Supplies Unlimited" is the name of an illustrated catalog that provides complete specifications in tables for any laboratory or sophisticated system requiring solid-state dc power-supply equipment. Page references and convenient charts make it easy to cross-index the appropriate power-supply models for specific needs. NJE Corp., 20 Boright Ave., Kenilworth, N. J. 07033.

CIRCLE NO. 554

Capacitors. Standard types and sizes of impregnated reconstituted-mica-paper capacitors are listed in a 13-page catalog. Included are specifications on "Mylar"-wrap, axial-lead, epoxy-molded and cylindrical epoxy-tube capacitors, ranging in size from 50 pF to 10 μF, 1000 to 30,000 Vdcw. Temperature ratings range from −65 to 125°C. Custom Electronics, Inc., Browne St., Oneonta, N.Y. 13820.

CIRCLE NO. 557



Zener and Reference Diodes. A selection guide for users of zener and reference diodes covers zener application requirements from 2.4 to 200V and includes 10 device families with power ratings from 125 mW to 50W. The section on temperature-compensated reference diodes includes six families with voltage ratings from 6.2 to 19.0V at maximum temperature coefficients of 0.001 percent °C. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. **CIRCLE NO. 555**

Analog Function Modules. Descriptions and worst-case specifications for a line of analog function modules and operational amplifiers are offered in a 12-page product catalog. Contents include operational amplifiers, power supplies, linear amplifiers, logarithmic amplifiers, analog multipliers and dividers, analog memory modules, telemetry modules and nonlinear function modules. Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706.

CIRCLE NO. 558

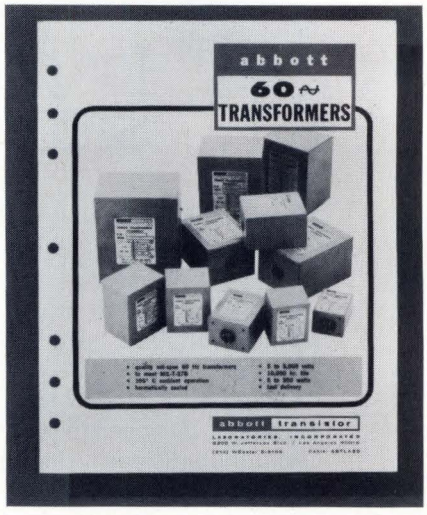
Rectifiers. A series of silicon and selenium rectifiers, including fast-recovery, high-voltage, power and JAN types, are described in a short-form product review. The catalog covers silicon rectifiers, bridges, plug-in tube replacements, oil cans, 20 types of JAN rectifiers and high-voltage selenium rectifiers. Shown are appropriate forward currents, peak inverse voltages and recovery times, plus outline drawings and dimensions. Electronic Devices, Inc., 21 Gray Oaks Ave., Yonkers, N.Y. 10710. **CIRCLE NO. 556**

Transistor Substitution Chart. A dual and Darlington transistor substitution chart has a cross-reference list intended to serve as a guide in selecting items from the Raytheon line to replace other types having similar electrical characteristics. Direct interchangeability will depend on physical dimensions and variations in package that may fall within EIA TO-71, TO-77, TO-78 or TO-89 dimensions, but are not standard among manufacturers. Raytheon Co., Semiconductor Operation, 350 Ellis St., Mountain View, Calif. 94040. **CIRCLE NO. 559**

Literature

Pushbutton Switches. A 12-page brochure describes Class 9001 Type K heavy-duty, oiltight pushbutton switches. The publication includes details of the complete line of Square D pushbutton and selector-switch operators, special operators, pilot lights, contact blocks, legend plates, accessories and enclosures. Featured are illuminated mushroom pushbuttons, illuminated selector switches and interchangeable light modules. Bulletin SM-353. Square D Co., Dept. SA, Milwaukee, Wis. 53201.

CIRCLE NO. 560



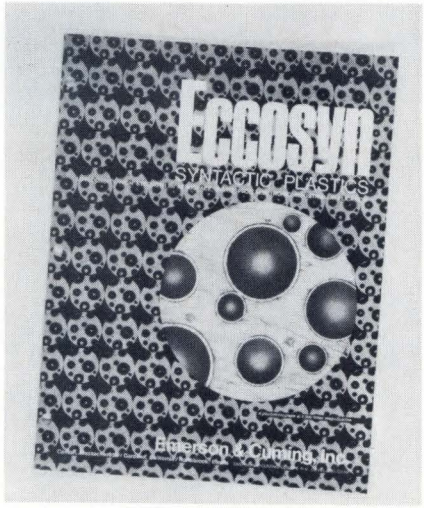
Power Transformers. A complete line of MIL-Spec 60-Hz power transformers is described in a six-page brochure. These standard transformers are available in a variety of power levels from 5 to 300W at almost any output voltage between 5 and 5000V ac. All secondary voltages are center topped. Complete electrical specifications, mounting details and prices are given in the brochure. Abbott Transistor Labs., Inc., 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. **CIRCLE NO. 562**

Computer-Aided Design. Entitled "Gleam/1130—A Production System Base for Computer-Aided Design", this publication is a reprint of a technical paper that was presented at the Fifth Annual Design Workshop. Authored by W. H. Sass, staff engineer, IBM Systems Development Div., the paper describes an experimental program for concurrent operation of several graphic production jobs—including design and artwork generation. Called "Graphic Layout and Engineering Aid Method", the program is designed for circuit design work, network analysis, simulation control, printed-circuit layout, component placement, flow analysis, logic drawings and for the processing of schematic diagrams. IBM Corp., Systems Development Div., Neighborhood Rd., Kingston, N.Y. 12401.

CIRCLE NO. 561

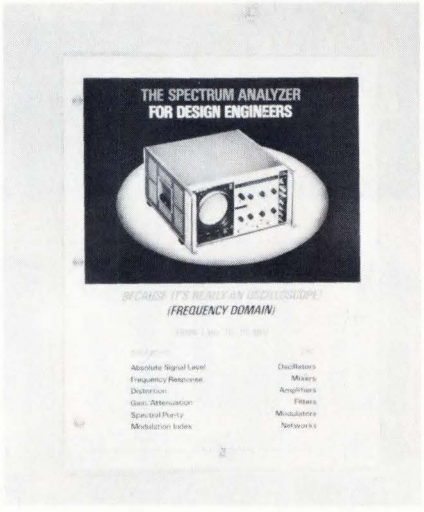
Vidicon Camera Tubes. Bulletin TD-86-855 provides application information and operating characteristics for Westinghouse slow-scan vidicon-camera tubes. Capable of storage, delayed readout or frame times of several minutes, the tubes operate by the mechanism of true-charge storage, which eliminates the "sticking" and "lagging" found in other slow-scan vidicons. The bulletin describes vidicons for industrial and military applications. After giving general technical information on sensitivity, resolution, dark current leakage, residual signal, target voltage and scanning, the bulletin shows response curves and schematics for vidicons with magnetic, electrostatic and hybrid guns. Westinghouse Electronic Tube Div., Box 284, Elmira, N.Y. 14902.

CIRCLE NO. 563



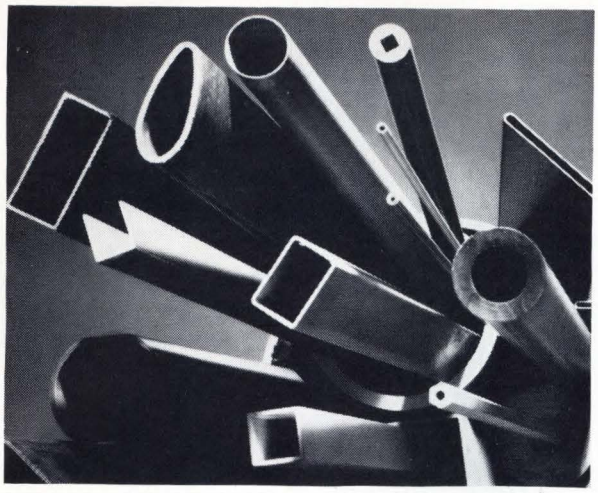
Syntactic Foams. This brochure briefly discusses the important features of 14 "Eccosyn" syntactic foams. Each is composed of small hollow glass, ceramic or plastic spheres in a plastic matrix. In form, these products may be pourable liquids, free-flowing powders or moldable compositions with densities varying from 14 to 56 lb/cu ft. Syntactic foams have exceedingly high strength-to-weight ratios and can be used in electronics for potting, in aerospace for structural components and in hydrospace for deep-water flotation. A table lists the most important characteristics or use for each of the materials, together with some of the physical and electrical characteristics of the system after curing. Emerson & Cuming, Inc., Canton, Mass. 02021. **CIRCLE NO. 564**

Frequency-Domain Measurement. A 16-page booklet sets forth the benefits that the design engineer can realize if he has access to a stable, fully calibrated modern spectrum analyzer. Measuring in the same domain in which he is thinking, with a single such instrument he can see signal level, frequency response, harmonic and intermodulation distortion, spurious content, frequency stability and spectral purity, modulation index, gain and attenuation. The booklet contains 37 oscilloscope photographs that demonstrate how each of these measurements is made on oscillators, mixers, amplifiers, filters, modulators and networks. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. **CIRCLE NO. 566**



Filters and Attenuators. An 80-page catalog contains illustrations, diagrams and specifications for a broad line of fixed attenuators, variable attenuators terminations, low-pass filters, high-pass filters, band-pass filters, band reject filters, diplexers, manual coaxial switches, remote coaxial switches, transfer switches and other similar devices. The catalog outlines standard models that include the specification combinations most widely used by the microwave industry. Catalog No. 686. RLC Electronics, Inc., 25 Martin Pl., Port Chester, N.Y. 10573. **CIRCLE NO. 565**

Marketing Reports. Called "Mainly Marketing", a monthly report to technical managements is devoted solely to the problems of marketing in, to and by the electronics industry. On alternate months, exclusive surveys report on some aspect of current marketing practices in the industry. The second cycle of alternate months presents practical tutorial articles on some phase of marketing pertinent to the industry. An information package includes a sample copy, an index of previous issues and a descriptive flyer. Schoonmaker Assoc., Box 35, Larchmont, N.Y. 10538. **CIRCLE NO. 567**



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Why be restricted to the use of round laminated plastic tubes? We make them in a wide variety of inside and outside contours—square, oval, hex, rectangular, and in angles and channels, even multi-cavity tubes. Wide range of grades, diameters and lengths. Complete fabrication facilities. Write for further information. Synthane Corporation, 53 River Road, Oaks, Pa. 19456—or call (215) 666-5011.

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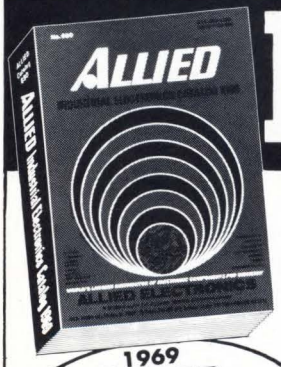

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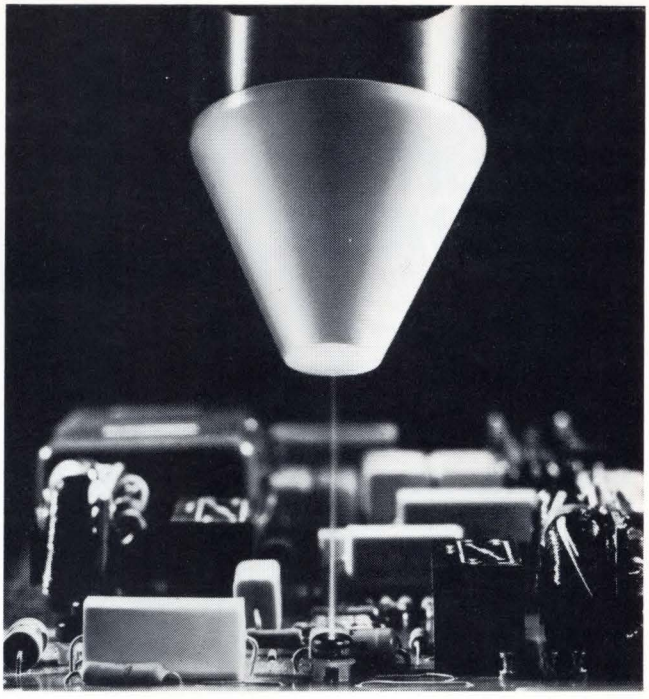

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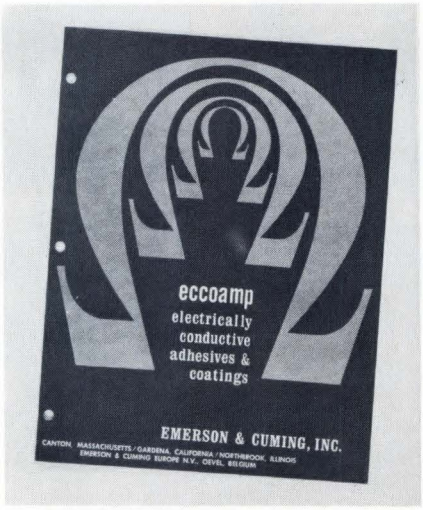
RAYTEK

Circuit Ryder® Infrared Thermometer

A basic tool for electronic engineers

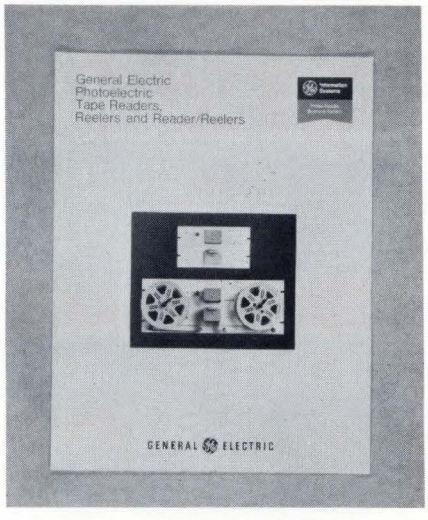
CIRCLE NO. 140

Literature



Conductive Adhesives and Coatings. A four-page brochure describes the "Eccobond" line of conductive adhesives and a second line of conductive coatings. Listed in tabular form are the important handling features of the materials such as mix preparation, consistency and curing conditions. Also detailed are certain of the cured properties, such as volume resistivity, maximum service temperature, bond strength and thermal coefficient of expansion. The text gives a concise description of each product with emphasis on the type of application each is designed for. Photographs illustrate some of the many uses of these materials. Emerson & Cuming, Inc., Canton, Mass. 02021. **CIRCLE NO. 568**

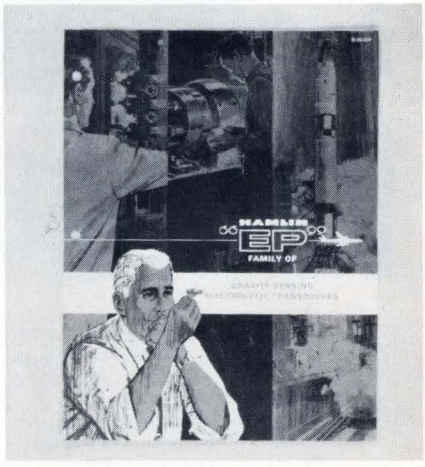
Photoelectric Tape Readers. Bulletin GEA-8492 describes a line of photoelectric tape readers, reelers and reader/reeler combinations. The brochure illustrates "through-the-tape" and reflected light readers and associated tape-handling equipment. Products are designed for use in digital data handling, communications, numerical control, photo-typesetting, ground support and other tape-programmed systems. Specification and application information, such as capability, size and special features, appears on the same page as each product illustration. Printer-Reader Business Section, General Electric Co., 511 N. Broad St., Philadelphia, Pa. 19123. **CIRCLE NO. 570**



Receivers and Comparators. A line of time and frequency receivers and comparators designed to perform a specific function in utilizing any of the transmissions of the National Bureau of Standards is described in this catalog. Also listed are antennas, antenna kits, antenna couplers and a time-base calibrator. A large part of the catalog is devoted to information pertaining to the services available from WWV, WWVH and WWVB. Included in this section are great circle maps of the northern portion of the Western Hemisphere and a great circle map of the world, both centered upon Ft. Collins, Colo. Specific Products, Box 425, Woodland Hills, Calif. 91364. **CIRCLE NO. 569**

Computer Workbook. A 200-page Computer Lab Workbook contains a complete course in digital logic. Designed for use with the "Computer Lab" digital logic teaching device, the workbook contains 46 experiments and more than 160 illustrations, tables and diagrams explaining and illustrating the text. Material in the workbook's 10 chapters ranges from an introduction to the binary concept through Boolean algebra and serial adders to digital system design and techniques. Each chapter includes a main theme experiment and additional subexperiments to supplement the basic concept of the chapter. Dept. P, Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754.
CIRCLE NO. 571

Literature



Gravity-Sensing Transducers. A complete EP family of gravity-sensing electrolytic transducers is described in a four-page bulletin. Along with application information, 10 standard models are pictured and described. Dimensional drawings, circuit diagrams and performance charts are included on each model. Devices are ideal for monitoring or controlling systems requiring a gravity reference. Hamlin, Inc., Lake and Grove Sts., Lake Mills, Wis. 53551. **CIRCLE NO. 572**

Heat Sinks. A complete line of natural convection heat sinks, including 21 different models ranging from miniature milliwatt transistor and diode coolers to king-sized, high-power radial-fin heat sinks, is described in an illustrated technical bulletin. Fin sizes and configurations to meet a wide variety of cooling situations are described, together with complete dimensional information and free convection-thermal characteristics. The publication includes a section on heat-sink application, explaining the general principles of heat transfer applied to semiconductor cooling. George Risk Industries, 672 15th Ave., Columbus, Neb. 68601.
CIRCLE NO. 573

Repeat-Cycle Timers. A four-page bulletin provides complete information on a line of basic repeat-cycle timers. Included are operating specifications, mounting dimensions and outline drawing characteristics for timers with one to 10 switches. The units described can be provided with open construction, dust covered or hermetically sealed to withstand severe environmental requirements. The A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720.
CIRCLE NO. 574

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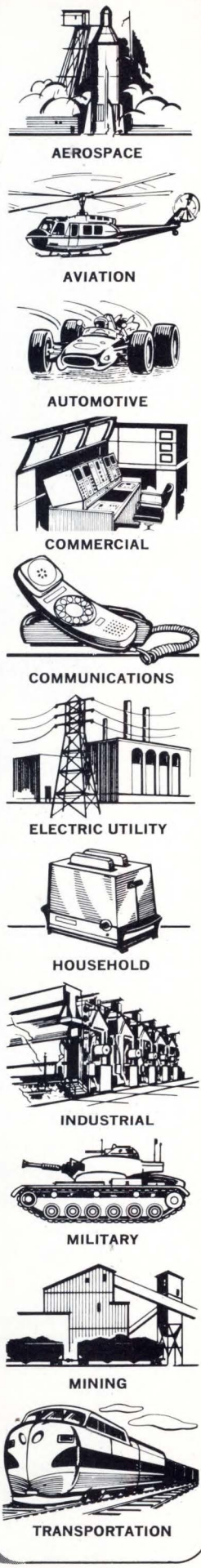
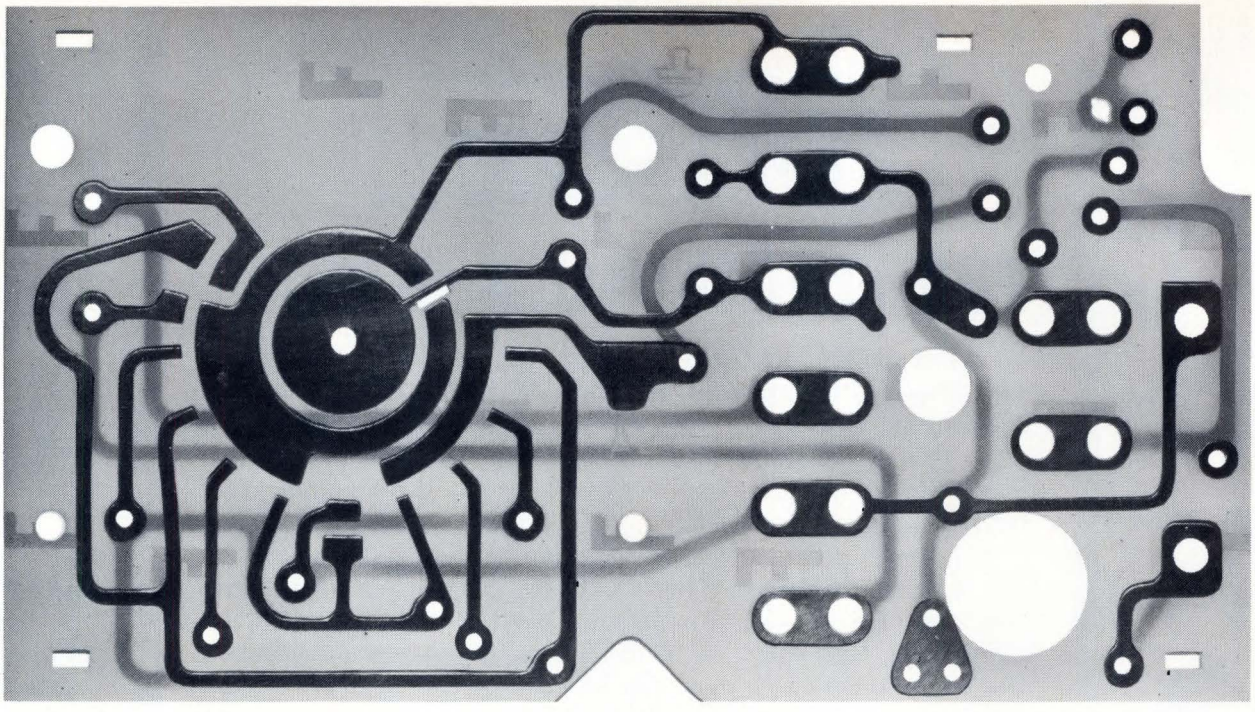


CIRCLE NO. 146



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Please send my free Pencil Test Kit containing one piece of die-stamped circuitry, one pencil (unsharpened), die-stamped vs etched comparison chart and a stabilization of heat rise chart.

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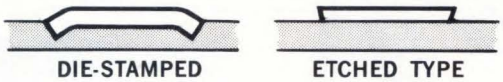
CIRCLE NO. 147

CROSS SECTION VIEW OF DIE-STAMPED AND ETCHED CONDUCTORS SHOWS GREATER THICKNESS AND RAMP EDGE OF DIE-STAMPED.

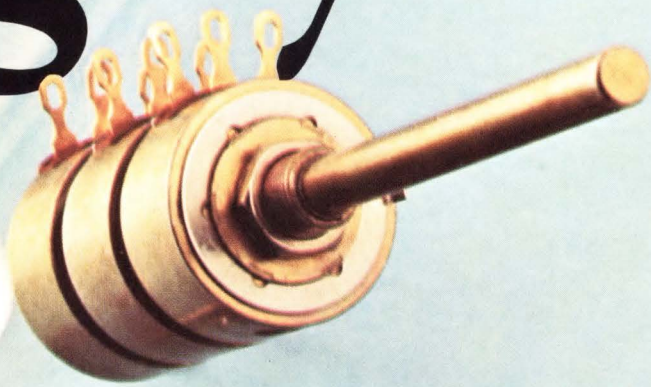


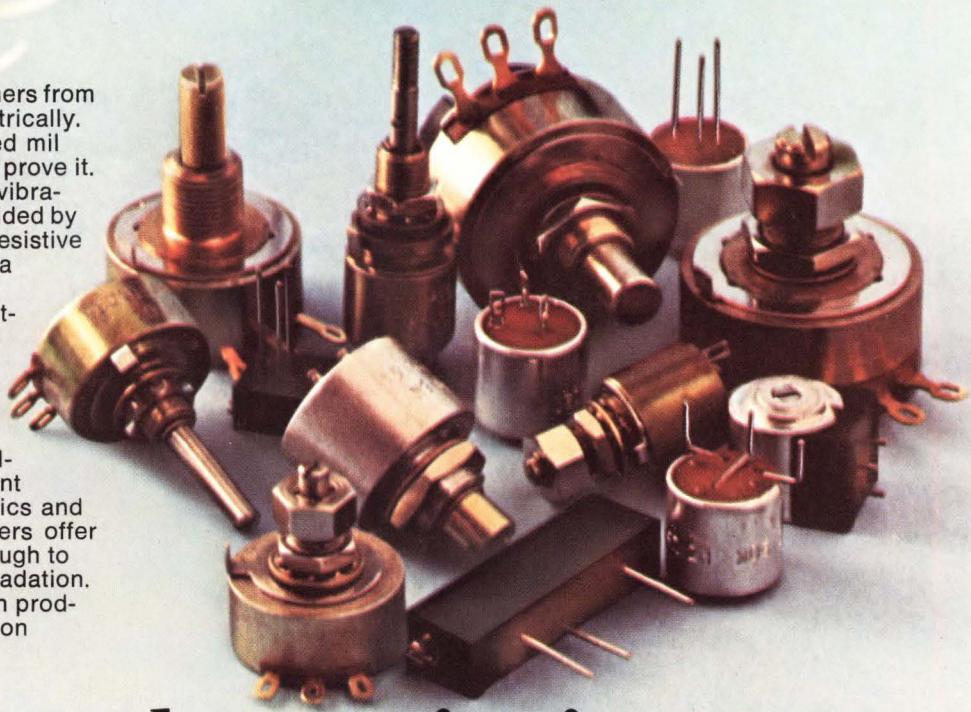
DIE-STAMPED ETCHED TYPE

GTI® CORPORATION

CIRCLE NO. 148

Tough guys





These variable resistors and trimmers from PEC are the tough guys. Tough electrically. Tough mechanically. Actually exceed mil specs. Designed to take it. Tested to prove it.

Insensitive to thermal shock and vibration. PEC potentiometers are hot-molded by an exclusive process incorporating resistive element, insulator, and collector in a rugged integral unit.

Heavy terminals, insulated supporting base and a bridging contact brush of honed carbon resist mechanical damage, thus assuring circuit integrity.

PEC's new metal ceramic trimmers are made from a specially developed material guaranteeing excellent temperature coefficient characteristics and resetability. These multi-turn trimmers offer infinite resolution and are tough enough to stand extended cycling without degradation.

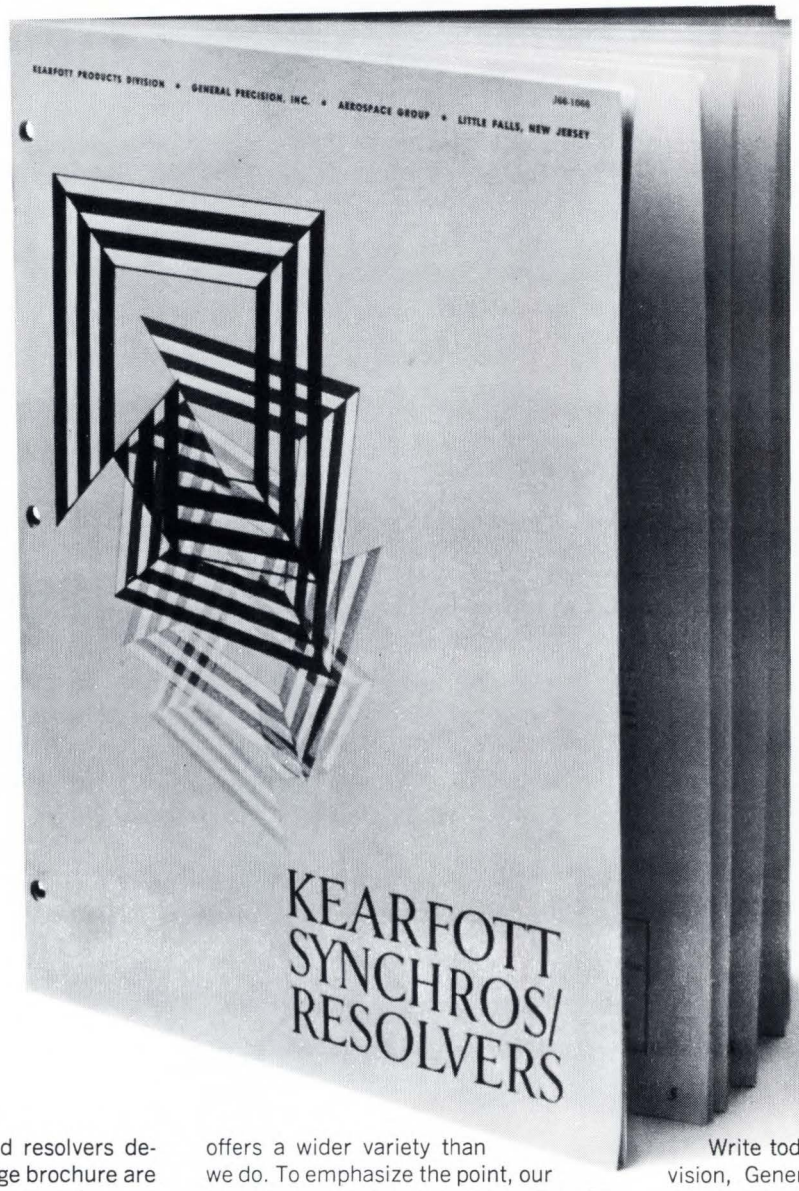
If you're meeting tough specs with products destined for a tough life... call on PEC for tough guys to help.

From the passive innovators at PEC Ltd.

AN AFFILIATE OF AIRCO Speer Electronic Components

PRECISION ELECTRONIC COMPONENTS LTD., manufacturers of variable resistors and trimmer potentiometers.
Bradford, Pa. 16701 (814) 362-5536; 19 Hafis Road, Toronto, Ontario (416) 241-4491

Resolve to get it.



Most of the synchros and resolvers described in this new 32-page brochure are standard only in the sense that they are readily available at competitive prices. Any of the "standard" units can be quickly modified to suit your particular needs, providing thousands of opportunities for *you* to resolve *your* problems.

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Order the catalog. It's loaded with diagrams, dimensional data, electrical characteristics and application data. There's even a section on design basics.

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GENERAL PRECISION SYSTEMS INC.

KEARFOTT PRODUCTS DIVISION

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* Events Counter
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* Time Interval Meter
* Period Meter
* Ratio Meter
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all for only $1250

Heath Universal Digital Instrument

Now you need only one instrument, the Heath EU-805A to make any digital measurement you want. The UDI will measure all these functions: Frequency, Period, Ratio, Time-Interval, Events Count, Integrating DVM and Voltage Integrator. Combining in one standard rack package a DC-12.5 MHz Multi-Purpose Counter/Timer with a 0.05% accuracy Digital Voltmeter, the new Heath/Malmstadt-Enke EU-805A offers compactness on your bench and unmatched versatility. An original modular design based on plug-in cards with TTL IC's — cards stay in place for all 7 functions. And you can add new cards for other functions and protect the instrument from obsolescence.

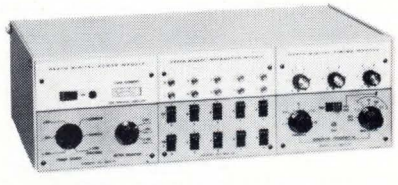
The UDI features convenient fast cycling on slow time bases, unique summing function for continuous summation without display reset, memory starts new count scaling before previous count has cleared, variable display time from 0.1 s to 30 s, 6 digit read-out plus over-range.

The two identical high-sensitivity (10 mV) input comparators provide 1 MΩ impedance, complete range of trigger controls (including Automatic Mode), oscilloscope monitoring of triggering point and four levels of input attentuation to accept up to 500 V. Input pulse resolution is better than 50 ns. Time base stability is better than 5 in 10^9 (short term) & 1 ppm (long term). Time bases range from 1 us to 10 s. Accuracy is ±1 count.

DVM section has Automatic Polarity Indication, 5 x 10^9 ohm input impedance on separate 1 V range (10 MΩ on the others) four ranges from 1 to 1000 V, 10 uV resolution, 0.1 second to 10 second integrating time and V-F output available at rear panel.

The EU-805A is obviously the instrument you need . . . and it is obviously priced right: $1250. Less DVM order EU-805D at $940. DVM conversion pack costs $340.

The UDI is part of the Heath Modular Digital System. Many of its cards may be used in the Heath /Malmstadt-Enke Analog Digital Designer EU-801:



The ADD permits investigation and design of various analog and digital circuits and instruments, by plugging-in circuit cards to its power, binary and timing modules. Connections are made with ordinary wire and component leads.

For more information send for the NEW HEATH Scientific Instrumentation Catalog

HEATH

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(prices & specifications subject to change without notice) EK-260

CIRCLE NO. 150

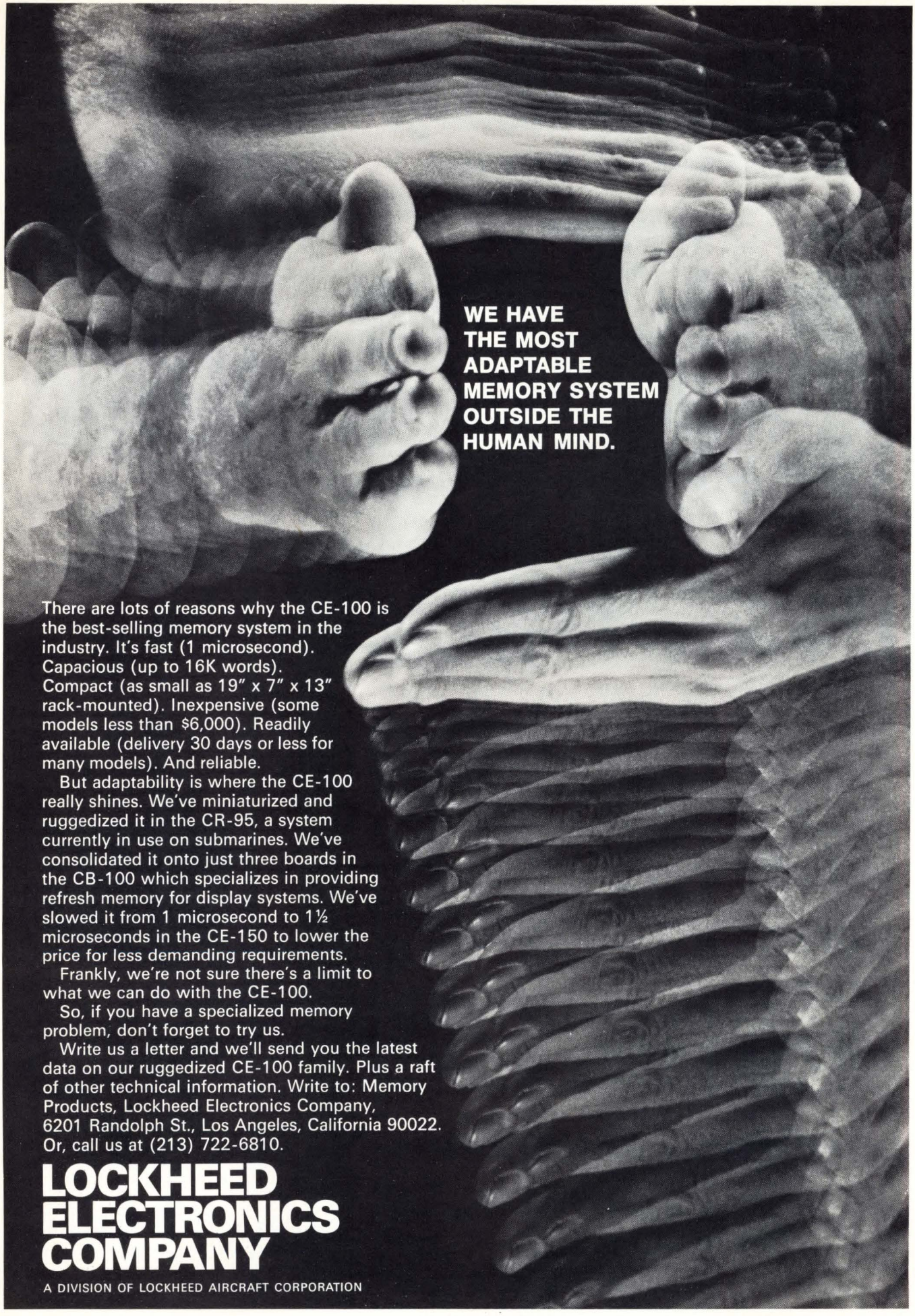
Literature

Sweep Generators. A complete line of sweep generators for testing TV tuners and circuits in the IF, VHF and UHF regions is described in a 28-page catalog. Designated No. 82, the catalog contains complete descriptions and specifications on three basic sweep-generator series and 39 various functions that are, or may be, included with the sweepers to enhance their operation. Charts are included in the catalog to simplify selection of the proper sweep generator and functions to obtain an optimum instrument for every application. Telonic Instruments, 60 N. First Ave., Beech Grove, Ind. 46107.

CIRCLE NO. 575

Power Conversion. Entitled "The Wanlass Paraformer", a 20-page booklet describes the principles of operation of parametric equipment. It provides a description of this passive power-conversion device and includes a description of its filtering and regulating qualities. Also included are illustrations of waveforms, pictorial views and curves covering the device's operation and construction. Products manufactured with parametric power-conversion techniques are illustrated, and applicable specifications are given for the devices. Wanlass Electric Co., 1540 E. Edinger Ave., Santa Ana, Calif. 92707.

CIRCLE NO. 576



There are lots of reasons why the CE-100 is the best-selling memory system in the industry. It's fast (1 microsecond). Capacious (up to 16K words). Compact (as small as 19" x 7" x 13" rack-mounted). Inexpensive (some models less than $6,000). Readily available (delivery 30 days or less for many models). And reliable.

But adaptability is where the CE-100 really shines. We've miniaturized and ruggedized it in the CR-95, a system currently in use on submarines. We've consolidated it onto just three boards in the CB-100 which specializes in providing refresh memory for display systems. We've slowed it from 1 microsecond to 1½ microseconds in the CE-150 to lower the price for less demanding requirements.

Frankly, we're not sure there's a limit to what we can do with the CE-100.

So, if you have a specialized memory problem, don't forget to try us.

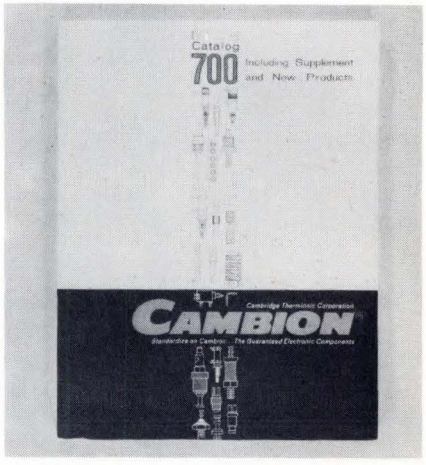
Write us a letter and we'll send you the latest data on our ruggedized CE-100 family. Plus a raft of other technical information. Write to: Memory Products, Lockheed Electronics Company, 6201 Randolph St., Los Angeles, California 90022. Or, call us at (213) 722-6810.

LOCKHEED ELECTRONICS COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

CIRCLE NO. 153

Literature



Electronic Components. Highlighted in this 220-page catalog is a rapidly expanding line of miniature connectors, including sockets, patch cords, plugs and jacks. These items are particularly useful in the electronic and data-processing fields where pluggability of printed-circuit cards and other components is becoming the standard assembly procedure. In addition, the catalog contains major sections on terminals, terminal boards, insulated terminals, coil forms, coils and similar products. Catalog No. 700. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138.

CIRCLE NO. 577

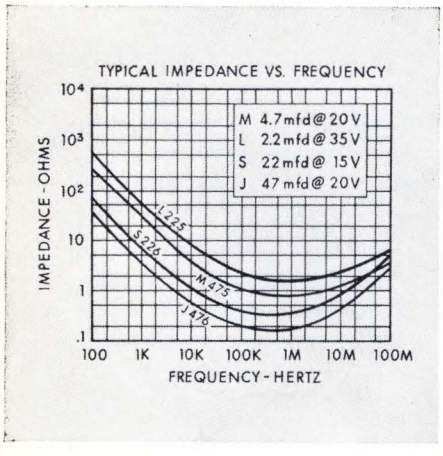
Electronic Counters. A wall chart measuring nearly 2 by 3 ft contains complete specifications on a line of solid-state counters, including bidirectional counters, variable time-base counters, preset counters, counter-timers and strain-gage digitizers. More than 30 standard and special-application counters are described. Included in the chart is an actual-sized photograph showing the interior of a typical counter with callouts showing the use of TTL integrated circuits and removable printed-circuit boards, as well as other features. Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. 91406.

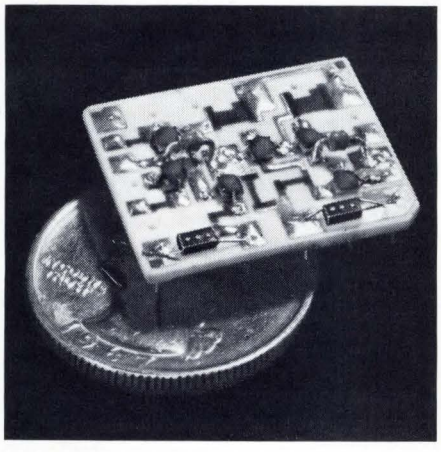
CIRCLE NO. 578

Bypass your problems

or...how Components, Inc. can help clean up digital pulses in a small way

The problem of unpremeditated switching noise is apt to crop up in even the best of IC and hybrid logic arrays, once they are plugged into the system. When it does, the designer has the option of redesigning the circuitry or simply filtering out the spurious noise at appropriate stages. The second approach, although less heroic, is often more practicable if filter components can be found which are sufficiently economical of both space and cost.





C.I.'s Minitan® Series, world's smallest electrolytic capacitors, are a natural solution here, just as they are wherever size and performance are critical.

These micro-miniature, solid-tantalum electrolytics provide ideal physical and electrical properties for computer bypass and filtering applications. They are compatible with thick-film and integrated circuitry in both size and reliability, and present extremely low impedance and excellent temperature stability. Rated for use from —55°C to 125°C, they are available in values from .001 to 220 mfd., with axial or radial leads.

Need a Two-Way Street? . . .

C.I.'s Non-Polar Minitan capacitors are available for use where ac or occasional voltage reversals are present. Unlike other non-polar solid-tantalums, these little capacitors were designed as non-polars from the ground up. Result: 1) they are available in standard, rather than off-beat capacitance ratings; 2) they are ½ to ¼ the size of other units; 3) they are extremely reliable, even with frequent voltage reversals.

When the squeeze is on . . . call Components, Inc. If you have a space problem, C.I. has the capacity to solve it. We offer more subminiature case styles and ratings than anyone else in the business. We welcome requests for samples, performance and reliability data, and application assistance. Standard prototypes normally shipped within 24 hours. Write or call today for data or samples.

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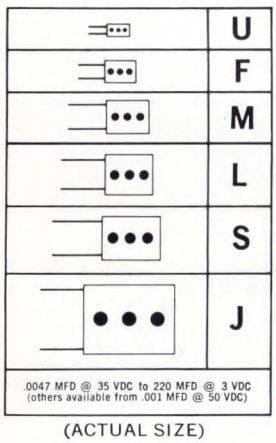
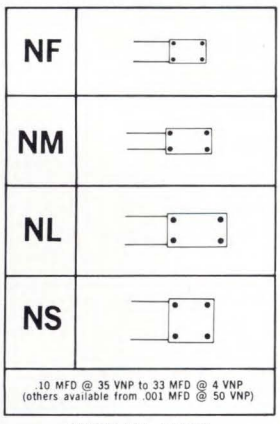


(ACTUAL SIZE)

MINITAN NON-POLAR
(Also available with axial leads)



(ACTUAL SIZE)

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CIRCLE NO. 154

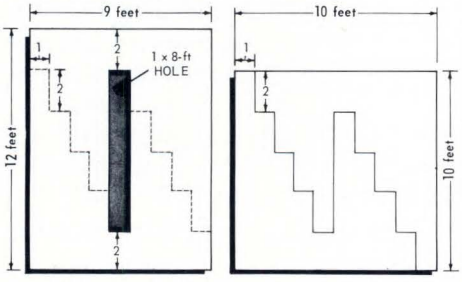
The Carpet Challenge

Intrigued by Herbert Whitman's "Cut a Rug" puzzle (EDN, Sept. 2, 1968, p. 20) 200 readers took scissors in hand and cut right to the heart of the problem. Result: bits of paper snowed EDN's mail desk this month —paper that had been cut into exact dimensions to form the "10- by 10-ft" rug requested in the puzzle. (Solution shown below.)

Many problem-solvers wanted to know how long it took others to cut a rug. Answers ranged from: "Time to solve = time to draw" to "Now we have a problem! To whom do we charge the 17 man-hours of engineering effort required for the solution?"

J. D. Morseman, Huntsville, Ala., commented, "The most challenging part of Mr. Whitman's problem was how he managed to wear a perfectly rectangular hole. I suspect he is hiding a severe infestation problem, i.e., an advanced case of neurotic rug moths with unsuppressed geometric tendencies."

EDN thanks Mr. Whitman for sending in the puzzle and wishes him luck with his moths.



Problem: Cut the rug into two pieces, such that when the two pieces are placed together, they will form a 10- by 10-ft rug.
Solution: Make a series of 1- by 2-ft cuts, leaving two pieces, with one being shifted one over and two down.

More Than Just Class C

Reader Harry Hyder asks if the amplifier described in "Overdrive Boosts UHF Amplifier Efficiency and Power" (EDN, June 1968, p. 38) is "just another overdriven Class C amplifier"? Dave Snider, developer of the circuit, comments on technical aspects of the question:

"Output power and collector efficiency of a tuned RF amplifier can be increased beyond maximum theoretical limitations set by conventional Class B or Class C operation by simply controlling load impedance presented to a device at the harmonic frequencies of the RF drive signal. If only the load impedances are controlled, 100-percent collector efficiency is possible with greater output power than either Class B or Class C operation. This defines the 'Optimum Efficiency Class B' mode.

"If the RF drive also is increased such that the output voltage and current waveforms are symmetrically clipped, even more output power can be developed but at only 90-percent collector efficiency. However, this approach results in an amplifier that is rather insensitive to variations in RF drive. This defines the 'Overdriven Class B' mode. The reader should note that with either the Overdriven or the Optimum Efficiency mode of operation, both the output power and the collector efficiency are, at the same time, greater than with Class C operation."

Credit Due Teradyne

Kemon P. Taschioglou, of Teradyne, has pointed out that in the article, "Trends in Computer-Aided Testing" (EDN, Sept. 2, 1968), Teradyne was incorrectly identified as Teledyne in the photo caption on p. 22 and in the acknowledgments.

Robert Compton, EDN Midwest Editor and author of this story, asks Teradyne to "please accept my apologies" for the misspelling.

An Inch Is an Inch Is an Inch

Dear Mr. Wiesner:

Re: Your editorial in the August 1968 issue.

While I agree that the SI System (referred to as the metric system in the editorial) should receive serious consideration for adoption in this country (and without going into the details of what that really means), I wish to point out what is apparently an error in the editorial. Some years ago (in the late 1940's I believe), the American, British and Canadians got together and produced what is called the ABC Inch, defined as 2.54 centimeters exactly. For 10 or 20 years the three countries, America, Britain and Canada, have been using this same inch.

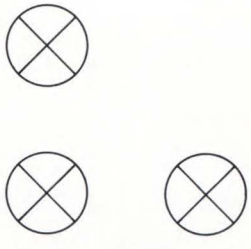
A more realistic problem to discuss is whether you would like a 1/4-20 bolt to be labeled 6.35 × 7.874 or whether you wish to have the bolt modified to a 6 × 8. In the first case you haven't changed the bolt, just the language used to describe it. In the second case you actually have changed the bolt's size and the next time you need to fix your car, which is 10 years old (and still has the English bolts on it), you will swear at somebody. You will need to have two sets of wrenches on hand. I do not say the change should not be made. I do say, however, that we should be more explicit about what we mean by changing to the SI (metric) system and that we should anticipate our own personal costs, depending on which one of the changes we mean.

Ralph A. Evans, Physicist
Research Triangle Institute

Can You Solve This One?

Albert A. Sorensen, Palos Verdes Peninsula, Calif., challenges EDN's readers with this "hard" puzzle. Shown are three views of a solid object. All rules of orthographic drawing projection apply; that is, lines are formed by edges or surfaces meeting, etc.

Problem: Describe the object.



Send solution to EDN, Design Noise Dept., 3375 S. Bannock, Englewood, Colo. 80110.

New, true dual-beam oscilloscope.

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And only $995*

True dual-beam, portable oscilloscope features line or battery operation. Choice of 15 or 30 MHz bandwidth plug-in Y-amplifiers (23 and 12 nsec rise times).** Solid state unit provides differential input, internal voltage calibrator, and both signal and time delay.

For complete data, write for Bulletin TIC 3318A to Motorola Communications & Electronics Inc., 4501 W. Augusta Blvd., Chicago, Ill. 60651.

*Exclusive of options. **15 MHz amplifier, $395; 30 MHz amplifier, $595.

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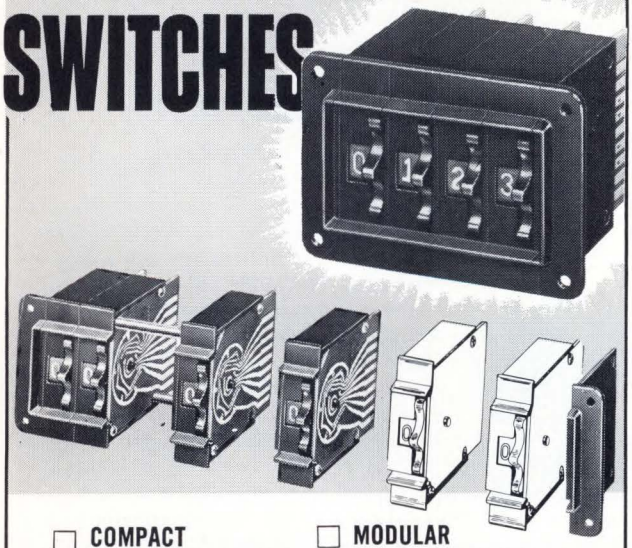
THUMBWHEEL SWITCHES



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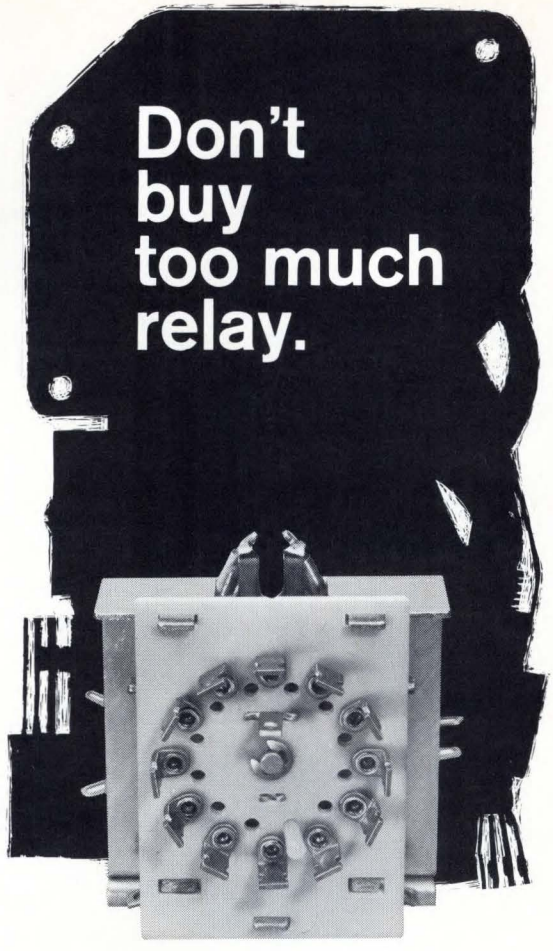

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CIRCLE NO. 157

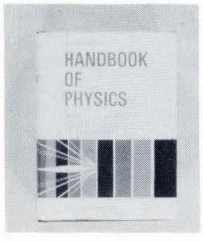
Broadcast over Design Dataline—suggestions and information from EDN's editors and authors about new books, government reports and other references.

More on Spatial Filtering

If you would like additional information on the spatial filtering technique discussed on p. 30, first refer to the book, "Pictorial Pattern Recognition", Thompson Book Co., 14th & F Sts. N.W., Washington, D.C. 20005, 1968. W. J. Poppelbaum describes the technique quite thoroughly in the chapter entitled "Adaptive On-Line Fourier Transform".

Then, check another direct reference, the paper Mr. Poppelbaum and Mr. Faiman gave at WESCON '68, entitled "Unusual Electro-Optics for Display and Processing".

Handbook Of Physics



Edited by E. U. Condon and Hugh Odishaw; Second Edition; McGraw-Hill Book Co., New York, N.Y.; December 1967; 1680 pages; $32.50.

The engineer's interdisciplinary bridge is usually physics. Most of us have one or more such texts on our bookshelves. We are well aware of the rapid advances taking place in our own technology, but are apt to consider physical concepts as fixed.

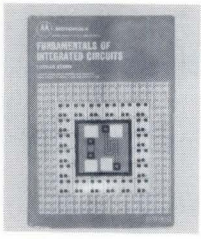
That such is not the case is evidenced in the preface to this second edition of the handbook by Drs. Condon and Odishaw. In the mere 9 years that have passed since the first edition was produced, the world of physics has changed markedly. One-third of this edition is made up either of new or totally revised material. Another third consists of material that has had from a fair to a considerable amount of revision. The final third alone appears substantially unchanged.

This handbook holds some surprises. First, it seems to contain an inordinate amount of mathematics. Yet, when one gets into this section he gradually realizes that it is treating the mathematics peculiar to physics rather than the classic.

Ninety-two chapters and an appendix later, the diligent find an index, considerably expanded over that in the first edition, containing approximately 12,000 entries. This, with an excellent running bibliography, makes "Handbook of Physics" invaluable for reference. Trouble is, it is as exciting as a novel, and when merely looking up a constant, one easily is caught up into reading whole chapters. Yash Pal's treatment of the mysterious and elusive cosmic ray is a particular case in point. For more information about this book, Circle No. **401**.

Tom Stephenson

Fundamentals Of Integrated Circuits



By Lothar Stern; Hayden Book Co., Inc., 116 W. 14th St., New York, N.Y. 10011; 198 pages; $8.95.

Here is a book that begins with an introduction to the integrated circuit and its different forms and continues with semiconductor physics through transistor action. It details with excellent photographic support the techniques of IC fabrication, including monolithic, thin-film and hybrid circuitry.

It also discusses the techniques of IC packaging; provides a comparison of today's standard circuit logic forms; relates the circuit-design aspects of IC's; devotes a chapter to layout, and concludes with a look at large-scale integration.

The book should prove a valuable asset, both to the novice and to the seasoned designer who has used the IC in design, but who is not familiar with the construction and cost trade-offs. For more information about this book, Circle No. **402**.

Bob Koeper

Computer Selection

By Edward O. Joslin; Addison-Wesley Publishing Co., Reading, Mass.; 172 pages; $7.95.

Much literature either explains or tells how to build a computer, but few present the purchasing aspect. This book is strictly for the users.

The author provides, by means of examples and detailed case history, a few important guides for the reader on how to make the wisest computer-system investment through system analysis. Also, he develops many concepts equally helpful in making any capital-equipment investment where competing sources of off-the-shelf products are involved.

One subject of dispute is whether to lease, purchase or lease with option to buy. The book clearly reveals all pros and cons of various acquisition plans. Both users and manufacturers of computers should find the book valuable in helping them to avoid many of the common mistakes in the process of computer selection. For more information about this book, Circle No. **403**.

Harry Howard

Dataline—Relay Info

E. U. Thomas recently sent in a reference suggestion. Mr. Thomas, who is chairman of the Society of Automotive Engineers' Aerospace Electrical Equipment Subcommittee A-2R for Relays, advises that Section XI of NAVAIR 01-1A-514 of the "Technical Manual on the Design of Electric Systems for Naval Aircraft and Missiles" is an excellent relay reference. This report is based in part on some of the work done by the A-2R subcommittee.

For more information, he suggests that interested readers contact L. W. Wendling, Code AIR-533-52A, Naval Air Systems Command, Washington, D.C. 20360.

Do you have a reference clue that might aid other designers? Send information to EDN Design Dataline.

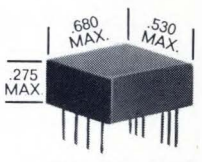
Clearinghouse Report

"Operational Amplifiers for Use in Nuclear Spectroscopy"; NASA TND-4349 (N68-18254); by Theodore E. Fessler, Lewis Research Center; March 1968. Fast operational amplifiers are well suited for designing electronic pulse amplifiers for nuclear physics research. Unlike most commonly available op amps, these must have excellent high-frequency response, so are constructed with new fast transistors and circuits tailored to that need.

The report treats the design and use of op amps in circuits with rise times as low as 10 ns. A specific amplifier is used to illustrate real amplifier performance, and phase-compensation methods and their relation to open-loop amplifier properties are described. Finally, some closed-loop amplifier circuits are used to demonstrate practical phase compensation.

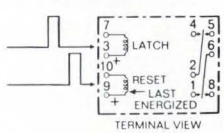
Report may be ordered, by number, from the Clearinghouse, U.S. Dept. of Commerce, Springfield, Va. 22151. Price: $3.

Deutsch/Filtors latching flat pack relay. Address it and forget it.



Talk about good things coming in small packages.
The Deutsch-Filtors flat pack latching relay is the ultimate.

Called the ML, it's designed to do a big job in a small space. That makes it a flat pack.
For applications where contamination and power are critical, such as space systems, time-sharing lines and matrixing, ML has all the advantages.



Advantages like: design for easy application to printed circuit boards; fastest latching relay in the industry (2.5 milliseconds max.); and 100 grid spacing. It also features Deutsch-Filtors' unique sealed contact chamber design, which eliminates contamination—forever. Add to that, low price in lots of 1000 or more, and you've got the whole story. For aerospace, military, and commercial applications.

Interested? Write for full information and a design sample of the ML latching relay.
And remember, Deutsch-Filtors guarantees the highest quality relays money can buy. It's the only way we know how to make them.

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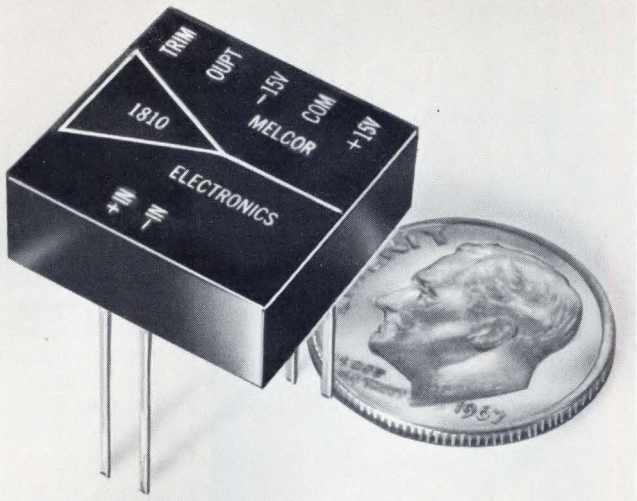

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OCTOBER 1968

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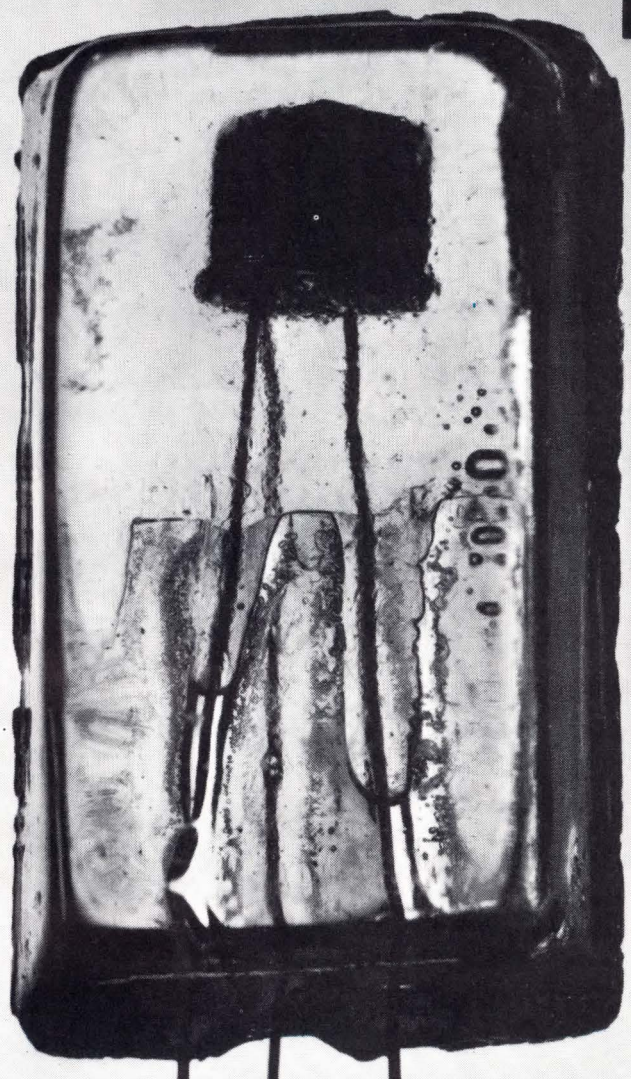
Index to Ads, New Products, and New Literature

Index to Ads, New Products, and New Literature

Don't buy a transistor, buy a speedy, three-legged ice cube.



Now that's a switch — namely, SSPI's 2N5552 10 ampere switching transistor. But a speedy ice cube? You really need one when you're looking for efficiency. With a saturation voltage of under one volt at 10 amperes, power loss is reduced. The speed? Saturated turn-off time is less than 700 nanoseconds at 5 amperes. This means smaller parts and a cool running system. And the minimum beta of 30 @ 10 amperes means a low supply current. So why would you want your system getting all heated up over a transistor when you can cool it with the coldest 10 amp transistor available? Incidentally, we also make a stud-mounted ice cube, too. For more information, call or write Peter Jenner at:

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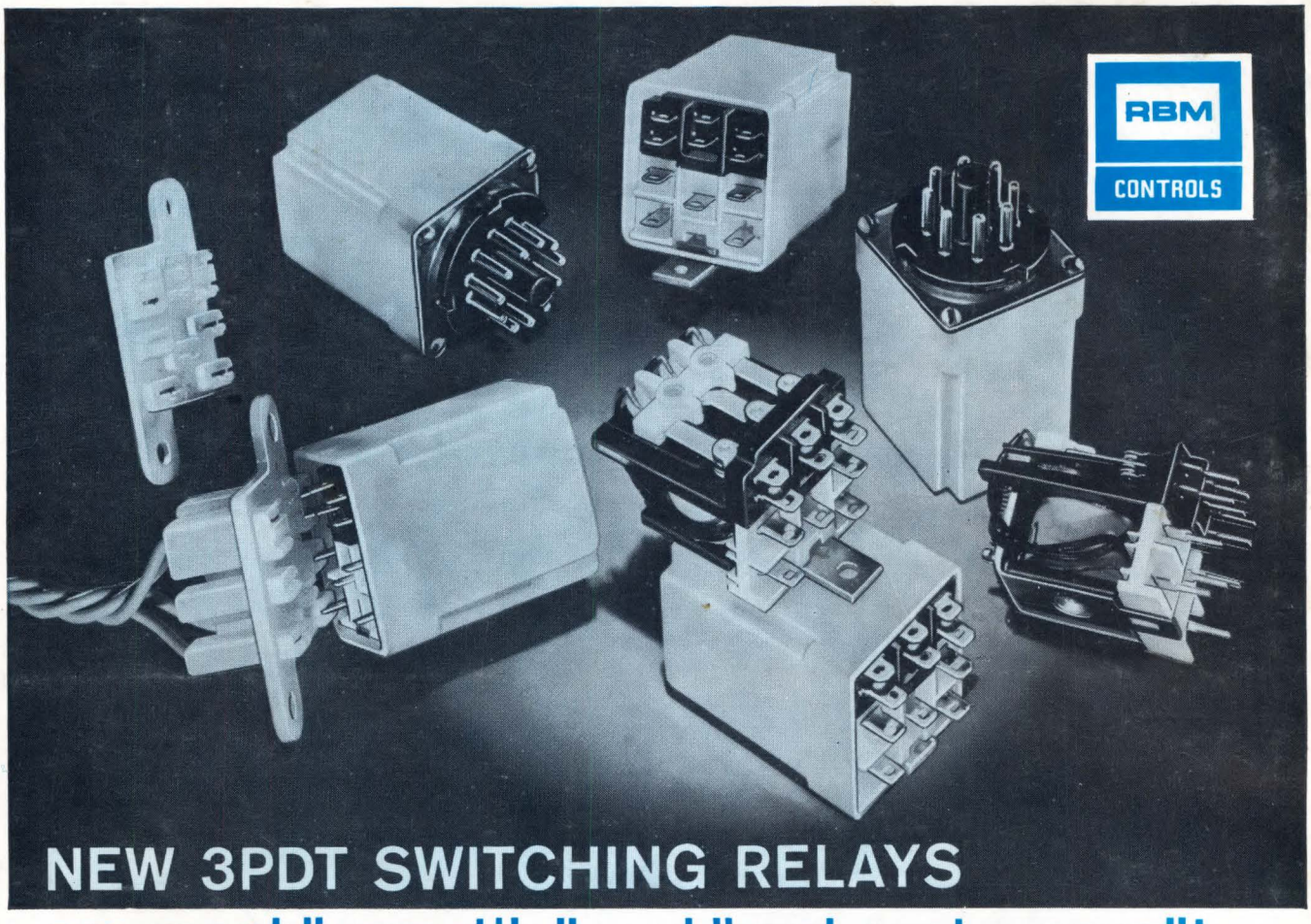

NEW 3PDT SWITCHING RELAYS

are most "versatile" and "real cost savers"!

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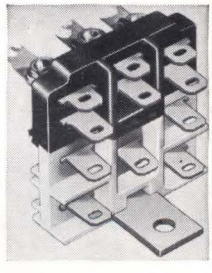
Another cost-reducing feature is the one-screw, single-hole front mounting standard, which cuts both mounting and assembly time.

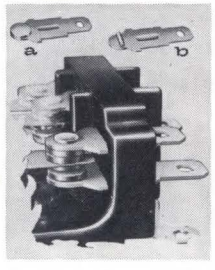
MOLDED PLUG

For 3/16" quick connect plug-in enclosed relay provides protection in handling and servicing.



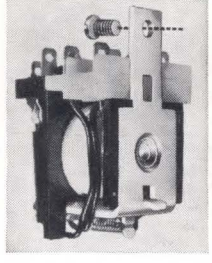
WIRING FLEXIBILITY

Both coil and contact terminals are out front for ease of wiring and low cost assembly.



CONTACT FLEXIBILITY

Button type (a) and crossbar (b) power contacts available on same relay for multiple switching operations.



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One screw, single hole standard **front** mounting reduces assembly time.

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