

# Electronic Design 22

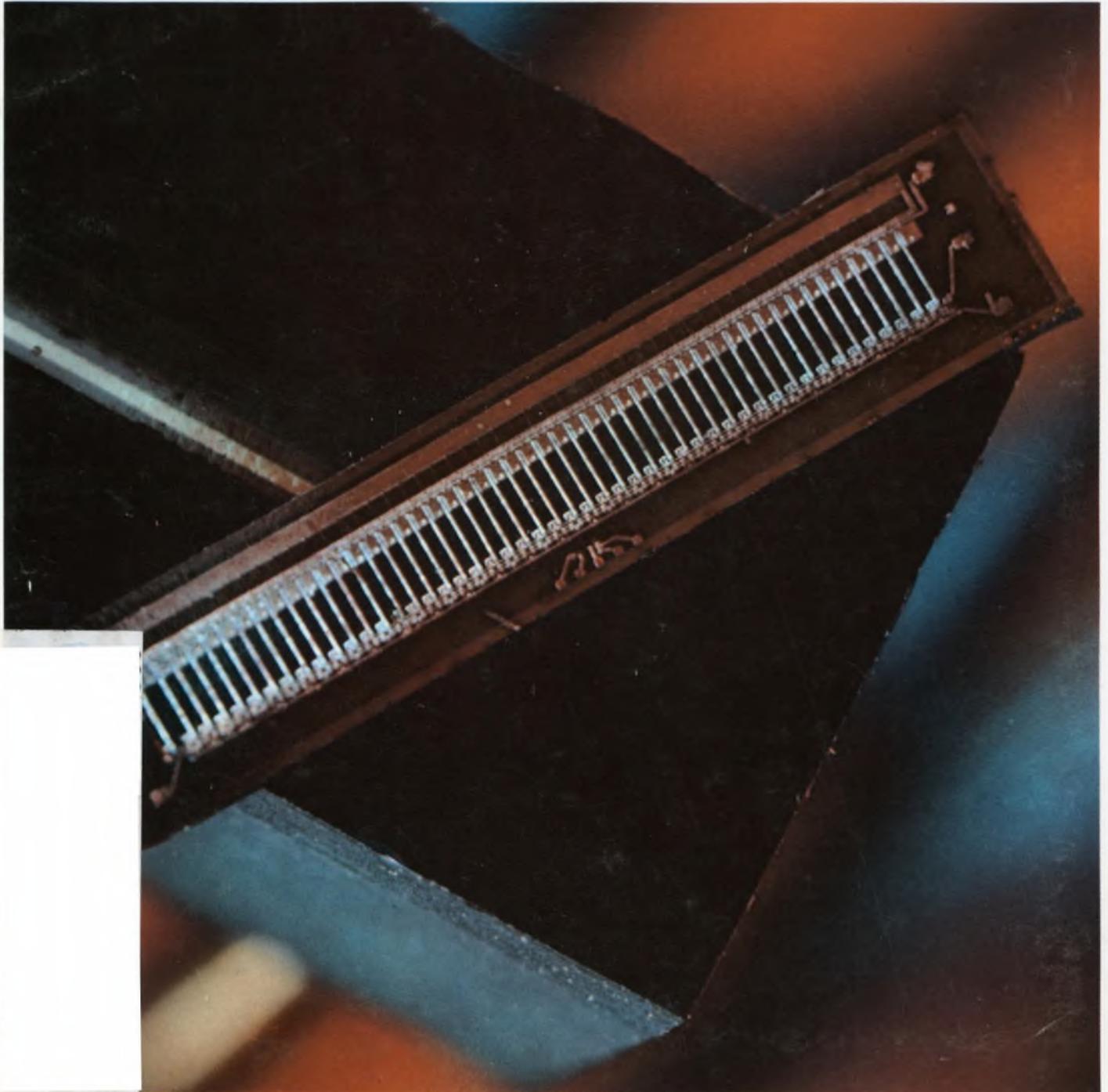
VOL. 18 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

OCT. 25, 1970

**Self-scanning photodiode array** promises low-noise video scanning applications. A single chip has 48 elements on 0.005-in. centers and only 6 output leads.

Future arrays are expected to contain 64 and 128 elements. Applications to include optical character recognition as well as facsimile equipment. See p.101.



SAMPLING

REAL-TIME

STORAGE

ECONOMICAL

18 GHz  
250 MHz  
100 MHz  
500 kHz



HEWLETT **hp** PACKARD

OSCILLOSCOPE SYSTEMS

**What's new in HP Scopes?** 18 GHz, dual-channel sampling! New, faster HP diodes now extend sampling capability through 18 GHz. For the first time, you can directly view and measure 18 GHz CW signals (or 20 psec risetime pulses).

But there are more new scope innovations from HP. There's the new, easy-to-use, 250 MHz real-time scope... and new, direct read-out TDR with 1/4" resolution... and new variable persistence and storage scopes for measurements up to 100 MHz... and a whole new series of low-cost 500 kHz scopes.

AND, *there are more eye-popping*

*scope ideas just around the corner!*

Next time you see your HP field engineer, ask him what's new in scopes. You'll be surprised by all that's happening to give you better, more economical scope measurements. One thing, we bet you'll get a new (and better) answer, every time you ask!

Are you thinking about a new scope? Are you wondering whether you should continue down the same old road? Or is it time you took a look

at another manufacturer? The HP road means going with the demonstrated leader — maker of performance champs.

Call your HP field engineer, right now, if 18 GHz sampling is your interest. Complete 18 GHz sampling system available with delayed sweep, or w/o delayed sweep. If you already have an HP 12.4 GHz sampling system, add the new 18 GHz HP 1430B remote sampler. Write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

080/8



## THE 0.1% PORTABLE IMPEDANCE BRIDGE

# ...in the GR tradition of better measurements

GR's new 1656 Impedance Bridge rounds out the General Radio family of impedance bridges. Now there's a choice of three to suit your exact needs for accuracy and economy. All three measure broad ranges of C, L, R, G, D, and Q, while each has its own distinctions. The new portable 1656 offers 0.1% accuracy for only \$700 (price in the U.S.), the 1650 features 1% accuracy in a portable package for \$545, and the 1608 is a bench-type instrument with 0.05% accuracy for \$1675. All three are self-contained 1-kHz instruments; external oscillators and detectors will extend their ac testing capability to a 20 Hz-to-20 kHz range.

The 1656, like the other two bridges, measures C up to 1100  $\mu$ F, L up to 1100 H, and R to 1.1 M $\Omega$ . With the 1656, G can be measured up to 1.1 $\Omega$ ; D and Q cover over-all ranges of 0 to 50 and 0.02 to  $\infty$ , respectively. The 1656 resolves C down to 0.1 pF, L to 0.1  $\mu$ H, R to 0.1 m $\Omega$ , and G to 0.1 n $\Omega$ . Your best bet, anywhere, for dc measurements is the 1656: consider the 10- $\mu$ V/mm detector sensitivity and the wide resistance and conductance ranges.

Measurement of the new high-precision components demands an accurate bridge. With four-decade lever balancing, the 1656 achieves *true* 0.1% basic accuracy and a direct and easy readout of all four digits, without the need

for interpolation or vernier interpretation. A rack version of the 1656 is available for \$735; GR also makes an accessory \$45 test jig for connecting axial-lead components.

Know all the members of our impedance-bridge family by name:

1656—0.1% accuracy, portable, \$700.

1608—0.05% accuracy, bench, \$1675.

1650—1% accuracy, portable, \$545.

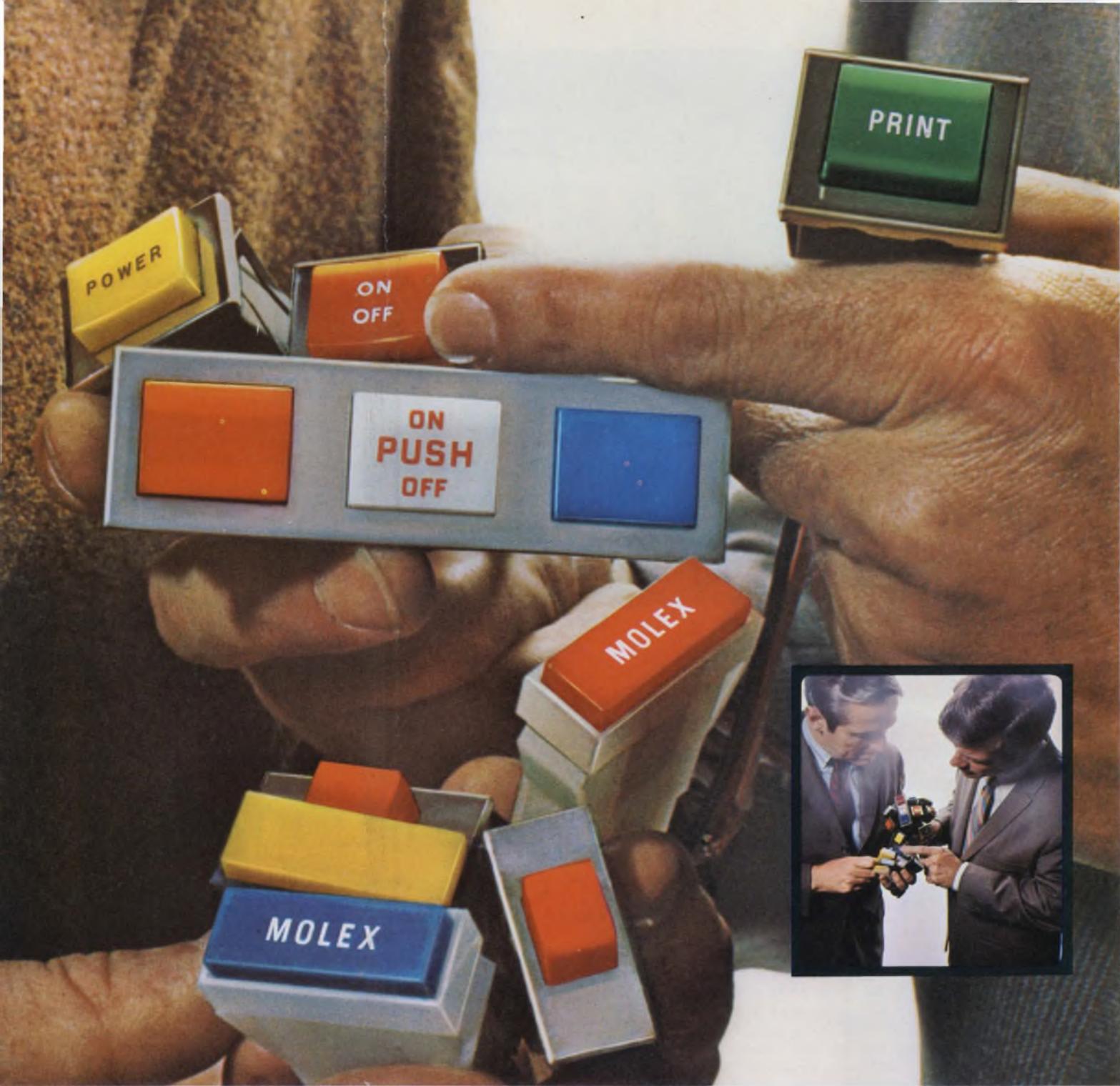
Whichever degree of measurement performance you require, you can get complete specifications from your nearest GR District Office or from 300 Baker Avenue, Concord, Massachusetts 01742. In Europe write to Postfach 124, CH 8034, Zurich, Switzerland.



**General Radio**

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INFORMATION RETRIEVAL NUMBER 2



**HERE ARE TWO EASY WAYS TO SOLVE LIGHTED PUSH BUTTON SWITCH PROBLEMS. Economically. Reliably. Fast. The Molex 1175 snap mounts. Offers spade or wire terminals for fast, easy assembly. A choice of nine colors, 500 variations. And look at the Molex 1820. You can use one, or a gang of them, for an infinite variety of applications. Lighted push button can be wired to light independently of the switch. And it's available in colors galore. Best of all . . . both switches are priced considerably under one**

**dollar in quantity. ■ These components are good examples of the Molex creative approach to design problems. And we have the ability to design reliability and ease of assembly into a product without letting costs run wild due to over-engineering. ■ If this makes sense, and you would like a *free sample* of either the 1175 or 1820 switch, write: Molex Incorporated, Downers Grove, Illinois 60515. Or phone (312) 969-4550.**

*...creating components that simplify circuitry*



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## NEWS

- 29 **News Scope**
- 32 **Cassette TV players face 'war' on five fronts.** Lack of standardization seems destined to spur fierce competition for sale and buyer confusion
- 34 **Diode laser array offers 30-to-40-W power.** RCA infrared source, developed for military, has possibilities for police applications
- 36 **Measuring motion with 0.0001-inch accuracy**
- 38 **Direct numerical control: The new assembly-line boss**
- 41 **Technology Abroad**
- 43 **Washington Report**

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## TECHNOLOGY

- 57 **Cut production costs with this technique** for ordering and bunching capacitors. Faster assembly and lowered inventories provide savings.
- 66 **Versatile table simplifies convolution.** It allows you to look up this operation on two exponential functions as easily as a logarithm.
- 70 **Reduce motor/tachometer coupling** and improve servo-system performance. It's essential to the design of stable, compact control systems.
- 76 **Want a bandpass filter?** You can build one by commutating simple low-pass filters, and easily vary bandwidth and resonant frequency.
- 80 **Pasture or production? What'll it be** for the older engineer? This one parlayed ambition, ability and a few ideas into a paying business.
- 82 **Ideas for Design**
- 91 **Product Source Directory: IC and Semiconductor Testers**

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## PRODUCTS

- 101 **Microwaves & Lasers:** Photodiode-array chip has own scan generator.
- 106 **ICs & Semiconductors:** 300-ns, 2048-bit MOS ROM dissipates only 20 mW.
- 110 **Components:** Solid-state relays have \$5.80 price tags.
- 104 **Modules & Subassemblies**                      117 **Tools & Engineering Aids**
- 113 **Instrumentation**                                      119 **Packaging & Materials**
- 115 **Data Processing**                                      132 **Product Index**

---

## Departments

- 55 **Editorial:** Whatever happened to our space program?
- 13 **Designer's Calendar**                                      124 **Application Notes**
- 46 **Sidelights**    126 **New Literature**
- 121 **Evaluation Samples**                                      127 **Bulletin Board**
- 122 **Design Aids**    130 **Advertisers' Index**

Information Retrieval Service Card inside back cover

**Cover:** Photodiode-array photo by Fairchild Microwave and Optoelectronics, Mountain View, Calif.

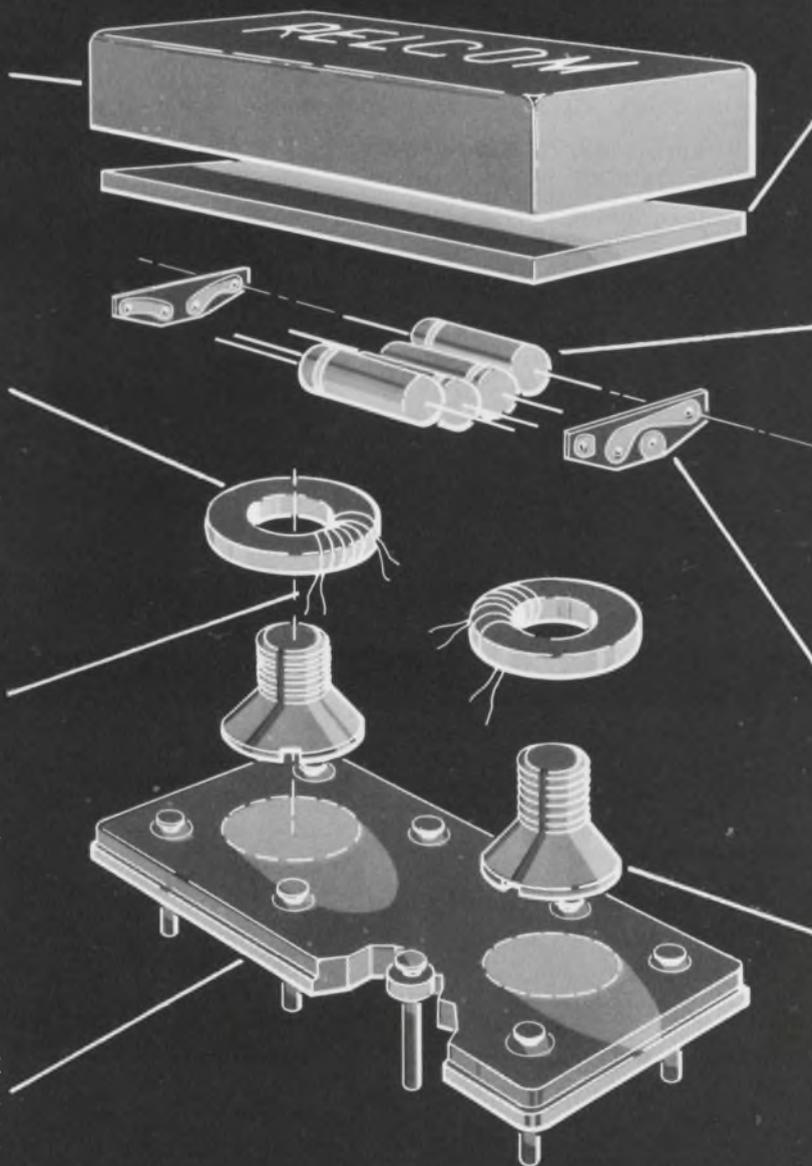
# THE THINGS WE DO FOR OUR CUSTOMERS... START RIGHT UNDER OUR NAME.

Custom cans are put thru a proprietary burr removal and a polishing process; checked for size to assure proper fit, legibility and permanence of printing, and solderability before being placed in stock.

Core material is selected as optimum for the specified frequency range. Cores are checked for dimensions, physical imperfections, and electrical performance. Relcom processing then brings them to optimum shape and a permanent insulative coating is applied to identify type and process completion. After electrical test and a permanence of coating test, cores are ready for parts stock.

Specially made wire is inspected upon receipt for geometry, wire size, insulation type and thickness and bonding physical strength. Insulation is stripped and wires cleaned before soldering for reliability of solder joints. Wires are additionally bonded to prevent excessive splitting which would degrade performance.

This header has been designed with a can-mounting flange and nail-head pins for reliability of solder joints. Inspectors check glass-to-metal seals, plating, and dimensions.



A cushion provides added insurance against electrical shorts to the can and extra protection against damage in a severe shock environment. Protective spraying of circuitry provides additional protection against electrical shorts.

Diode type has been carefully selected and specified to provide high reliability and a broad frequency range with low noise figure. As with other parts, vendors have been carefully qualified. Incoming diodes are temperature cycled to assure stability, checked for physical and electrical characteristics, and precisely matched to provide excellent mixer isolation and IMD performance.

For an extra measure of reliability, two circuit boards are used to interconnect the diode ring. These plated-thru boards are designed and inspected to avoid possible electrical shorts.

Plastic supports provide winding insulation from the header, maximum support for the transformers, and a means of holding the windings in place under any shock or vibration condition.

Bonding materials and application methods have been selected to provide reliable attachment of components without suffering electrical degradation or component damage.



Now, here's how all this attention to detail can benefit you —

**RELIABILITY:** Relcom's mixers, transformers, reactive hybrids and switches are produced in accordance with MIL-I-45208A performance standards. They're GUARANTEED to meet our published specifications from  $-54^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ , AFTER exposure to MIL-STD-202D environments. This is an unmatched reliability guarantee! And it's why you can use standard Relcom products, right off the shelf, in nearly any high-rel application.

**CONFIDENCE:** Relcom's products are 100% tested to electrical specifications (with guard-bands and recorded data). Units are serialized for performance and material traceability. Our one-year warranty experience shows less than 0.2% of units shipped need be replaced.

**VALUE:** Product losses, resulting from defective production parts, are unusually low. That's why our prices can match your in-house costs, and stay competitive with other outside sources.

**DELIVERY:** Our near absence of production problems means on-time delivery. During the past year, 95% of Relcom's shipments were made by the scheduled shipping date, and 97% were made within three days of that date.



Another big factor in Relcom quality is our people, with their training, experience and dedication. Relcom engineers, for example, do nothing else but design signal-processing components. Their combined experience totals more than 56 years. You benefit by coming to experts who've designed a wide variety of signal-processing devices for a broad series of applications.

Relcom's production staff is another big contributor to product quality and reliability. Again, experience is a good part of it. Our assemblers average more than two years with the company. New personnel are trained in-house by production managers who've worked in several facets of the business. Turnover is low. Craftsmanship continuity is maintained from product to product.

Relcom's Quality Assurance Department combines a 25-year electronics industry background with 11 years in quality control. Personnel update their skills in QA methodology with formal classwork. During product design, inspection procedures and production documentation are reviewed. From receiving and assembly inspection plans to final inspection audit, customers are assured of detail conformity on every aspect of the product they buy.



Put all the elements of our QA program together — our people, procedures, and procurement techniques — you'll find you buy much more than a product when you buy from Relcom. Ask any of our 400 customers; instrument manufacturers, receiver designers, large-scale military and commercial systems producers, and builders of satellite transponders.

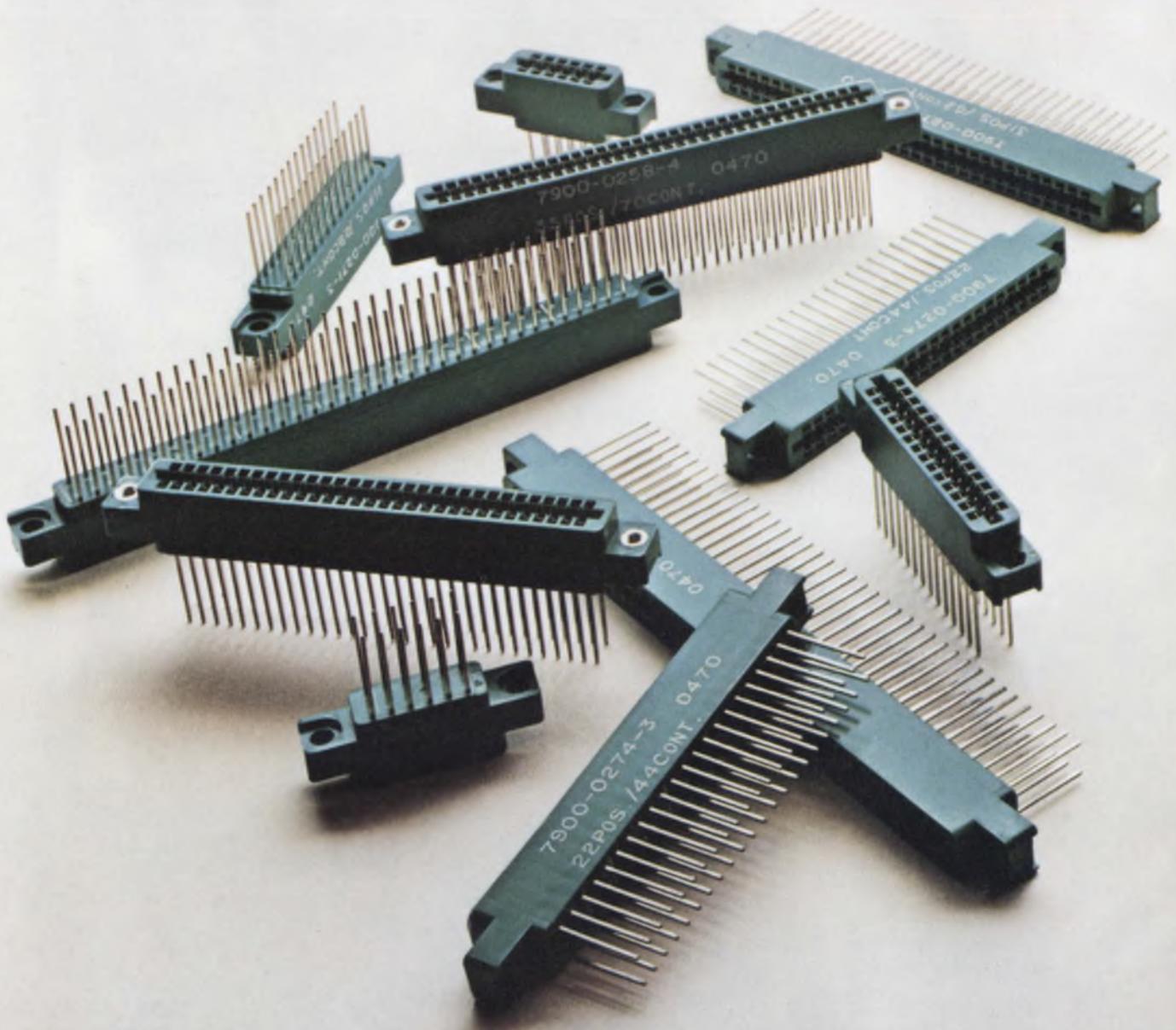
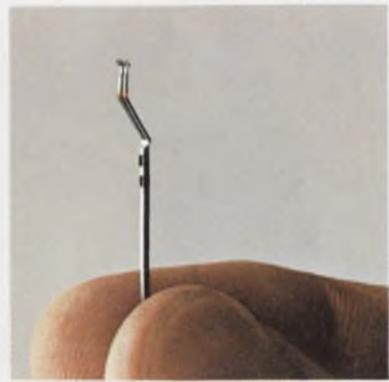
After all, when you make signal-processing components with the care we do, and make them for the customers we have, you have to provide the best product available.

Relcom products cover a frequency range from DC to 2.5 GHz. You can find out more about Relcom reliable signal-processing components and their applications by circling our reader service number. We'll send you detailed short-form catalogs describing our complete line of mixers, transformers, reactive hybrids and RF switches in coaxial connector models, or P.C. packages. Or better still, call a Relcom sales engineer at our Mountain View office for your own evaluation unit. The call's on us.

# RELCOM

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Sylvania gives you a choice of either gold-dot contacts or gold-plated bellows contacts in any of our new P-101 PC-card edge connectors.

Our gold dots are just as reliable as conventional bellows contacts, and they save you money because they use less gold.

There are other ways we save you money.

For instance, you don't have to pay tooling costs for any P-101 connector you buy from us. We're using new expandable molds, so there's no need to

tool up for each connector.

The molds allow us to change over from one connector to another fast, so we can give you quick delivery.

And they let us make connectors with a small or large number of contacts. (Even the oddballs are now conventional.)

For connectors with .125" contact spacing, you can specify anything from 12 to 100 contacts.

For connectors with .100" contact spacing, you can get 36 to 100 contacts.

# What a line.



All these connectors are designed to meet Mil Spec C21097B—which requires 500 or more trouble-free insertions.

We hold the locus point on contact tails within .010" radius of true position, so that your programmed wiring machines can work without interruption.

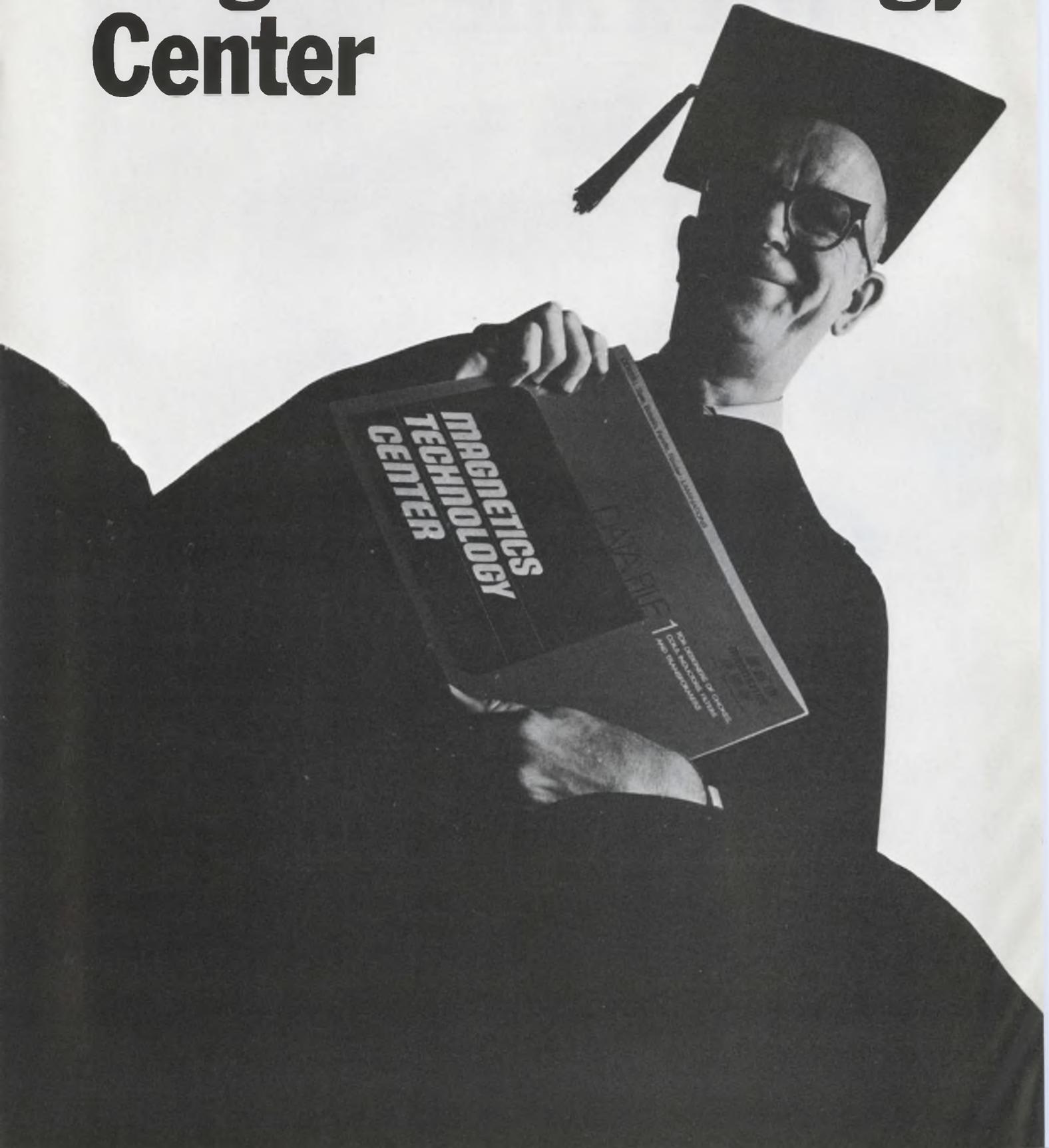
But the main thing is, you can now get custom connectors "off the shelf" from us at reasonable cost.

Two complete lines of them.  
And that's not just a line.

*For details, write to: Sylvania Precision Materials,  
Parts Division, Warren, Pennsylvania 16365.*

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# Magnetics introduces a post-grad center that keeps you up to date on the state of the art in magnetic materials. No campus; no fee; texts free. You learn on your own time.

We don't pretend to be scholars behind ivy-covered walls. We are a group of inquisitive specialists with interests in electronics, electrical engineering, physics, metallurgy and related fields. We work with low and high permeability magnetics, ferrites and photo-chemically machined metals. Some of us have spent over 20 years here at Magnetics developing theories and putting them to practical use.

Now we'd like to share with you what we've learned—through a curriculum that no undergraduate school to our knowledge now offers. (Sure, we have another purpose. We believe that as people learn what our products can do, the more these products will be used in future commercial applications. If today we give you the kind of information that will help you do a better job, it seems reasonable to assume you may give us an order someday.)

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our programs to your needs.

As an enrollee in the Magnetics Technology Center you will receive without obligation a continuing flow of printed material. You may have received some of this in previous years, but the bulk will be new material developed especially for our Center. Among the items:

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- Photo-chemically machined parts
- Reducing magnetic circuit size and response time
- Ferrites in transformer design
- Proper selection of cores for saturating transformers

2) Magnetics Technology Center Data Bank Files for designers of chokes, coils, inductors, filters, magnetic amplifiers, converter-inverter transformers and electronic transformers

3) Magnetics Technology Center news, at regular intervals, on advances in magnetic materials, applications, etc.

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### How do we qualify to institute this Center?

- We developed the 550 Mu Flake Core, an industry first, that allows miniaturization without excessive circuit losses
- We tightened up industry inductance tolerances for powder cores. Twelve years ago the accepted tolerance was as high as  $\pm 22\%$ . We went to  $\pm 8\%$  and others followed
- We established ourselves as the only approved source of bobbin cores for the Apollo program
- We patented a one-piece powder core die to increase production and help make a more uniform product
- We developed linear inductance-temperature characteristics in powder cores
- We stabilized miniature cores for inductance changes with temperature
- We developed a guaranteed voltage breakdown finish for tape and bobbin cores, eliminating the need for taping
- We developed our own powder metallurgy techniques and producing facilities to gain stricter control of magnetic core properties
- We tightened limits or standards on tape wound cores and set limits on other cores where no industrial standards were in place

To enroll, clip this and mail today.

**MAGNETICS, Magnetics Technology Center, Dept. ED-106, Box 391, Butler, Pennsylvania 16001**

Please enroll me in the Magnetics Technology Center and forward all curriculum materials, free of charge, to:

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Field of Interest and/or Product Now Working On \_\_\_\_\_

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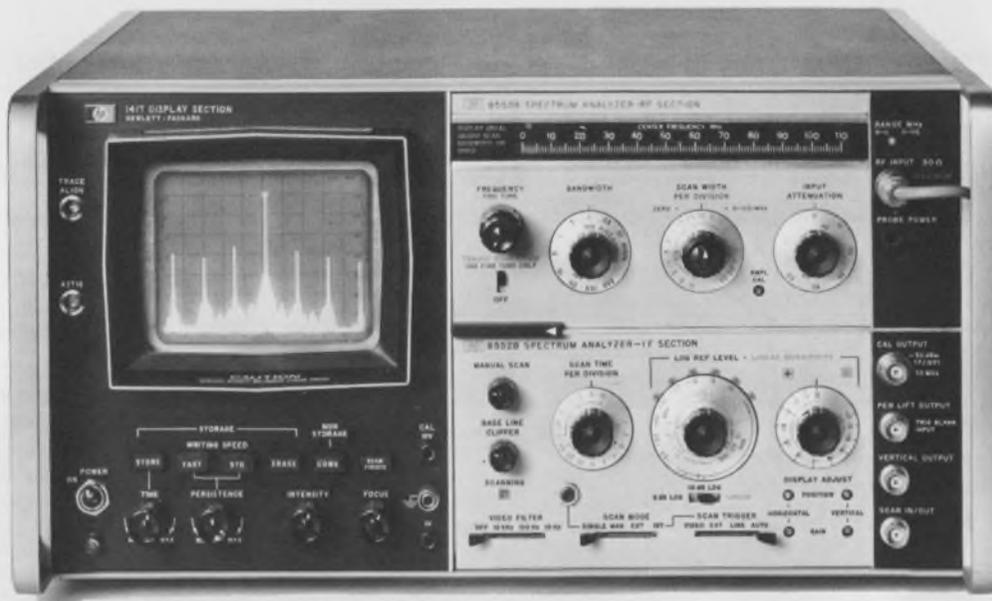
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Your associates may wish to enroll also. Have them furnish the above information on their company letterhead and send it to us. We need this data to assist us in selecting your curriculum.



A DIVISION OF SPANG INDUSTRIES INC.

INFORMATION RETRIEVAL NUMBER 6



## How do you improve the world's best spectrum analyzer?



## Add counter accuracy and a tracking signal source.

Combine HP's new 8443A Tracking Generator/Counter with the HP 110 MHz Spectrum Analyzer and you can make the most precise, complete frequency-domain measurements ever. The 8443A produces a visible marker that you can place anywhere on the spectrum analyzer display and immediately get 10 Hz resolution digital measurement of that point. The 8443A is more, too: a precision signal source that will make swept measurements over a 120 dB range and still produce the marker to determine any specific frequency with counter accuracy.

The 8553B/8552B Analyzer itself covers 1 kHz to 110 MHz with scans as wide as 100 MHz and as narrow as 200 Hz. It provides absolute amplitude calibration, better than -130 dBm sensitivity, over 70 dB dynamic range, 10 Hz resolution, plus exceptional stability (<1Hz FM) and flatness. The 8443A capitalizes on all the qualities of the analyzer to function both as an accurate frequency counter and as a precision source for complete swept frequency measurements.

With the system you can make much more precise design and production

line measurements of filters, mixers, modulators, oscillators, amplifiers and RF systems. For example, you can now:

- measure to 10 Hz the frequency of nanovolt signals in the presence of much larger ones. Use the tunable marker to find the signal and measure its frequency on the 8443A counter readout. You can easily identify IM distortion products, hum sidebands, spurious signals, and the like, because the 8443A is a frequency-selective counter with the analyzer's incredible sensitivity.
- completely characterize devices such as narrowband, high Q devices with simple, quick measurements. Use the tracking generator to sweep the spectrum and measure the frequency of any point on the response curve to 10 Hz. You can precisely measure passband flatness and shape factor on filters as narrow as 20 Hz, and make swept-reflection or return loss measurements. In other words, the tracking generator combines with the analyzer to provide a complete swept test system.

- test and align RF communications systems with unprecedented ease, thoroughness and precision. The high resolution and stability of the analyzer lets you see each and every signal, and the 8443A measures their frequency to 10 Hz. The system is also a natural for surveillance applications since you can scan broad and narrow ranges, resolve all signals of interest and count their frequency.

Call us for a demonstration. The system is easy to set up and you'll find it simple to use as an oscilloscope. If you've already got an HP 110 MHz spectrum analyzer, you can add the tracking generator/counter for \$3500. The high-resolution 8553B/8552B with variable persistence display costs \$6750. Ask your HP field engineer for details. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

04015

**HEWLETT *hp* PACKARD**  
SIGNAL ANALYZERS

INFORMATION RETRIEVAL NUMBER 7

## Our new compact oiltight pushbuttons give you up to six functions in a 1 $\frac{7}{16}$ " square.

Size is the only thing that's small about our new compact pushbuttons. They handle full-size jobs.

We've gone square to give them style, and full 600-volt quality and flexibility.

And we've gone small to give you six operating and indicating functions in a 1 $\frac{7}{16}$ " square.

You save space, and money.

You also get unlimited flexibility with stacking contact blocks.

And a choice of pushbuttons and indicating lights that doesn't quit—with a virtually unlimited range of sizes, forms and colors of buttons and lenses.

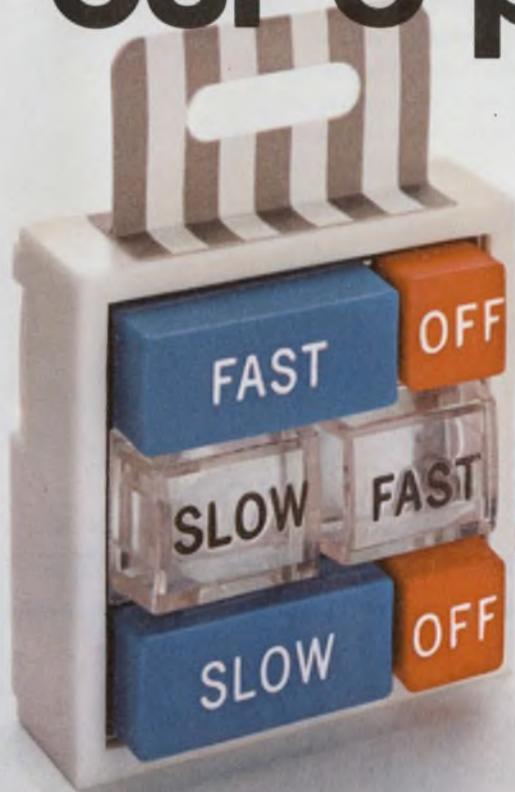
With all you're getting, you still get the same oiltight performance you're used to with full-size Cutler-Hammer oiltight pushbuttons.

Ask your Cutler-Hammer Distributor or Sales Engineer to show you our six packs. Remember, the best things come in small packages.



New Cutler-Hammer compact pushbuttons put a world of control into a 1 $\frac{7}{16}$ " square, and mount in industry-standard 1 $\frac{3}{16}$ " round holes.

# Try our 6 pack.



See your Cutler-Hammer Distributor—  
the man who has everything



**CUTLER-HAMMER**

POWER DISTRIBUTION & CONTROL DIVISION, Milwaukee, Wis. 53201

INFORMATION RETRIEVAL NUMBER 8



# Designer's Calendar

DECEMBER 1970

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

For further information on meetings, use Information Retrieval Card.

Dec. 2-3

Conference on Display Devices (New York City). Sponsor: IEEE. Sam Stone, General Tel. & Elec., 208-20 Willets Pt. Blvd, Bayside, N.Y. 11360.

CIRCLE NO. 401

Dec. 2-4

International Wire and Cable Symposium (Atlantic City, N.J.) Sponsor: USAEC. Jack Spergel, U. S. Army Electronics Command Attn: AMSEL-KL-EE, Fort Monmouth, N.J. 07703.

CIRCLE NO. 402

Dec. 2-4

Vehicular Technology Conference (Washington, D.C.) Sponsor: IEEE. P. M. Kelly, Kelly Scientific Corp., 3900 Wisconsin Ave. N. W., Washington, D.C. 20016.

CIRCLE NO. 403

Dec. 6-9

National Electronics Conference (Chicago, Ill.) Sponsor: IEEE, et al. National Electronics Conference, Oak Brook Exec. Plaza #2, 1121 W. 22 St., Oak Brook, Ill. 60521.

CIRCLE NO. 404

Dec. 14-16

International Symposium on Circuit Theory (Atlanta, Ga.) Sponsor: IEEE. Ivan Frisch, Network Analysis Corp., Beechwood, Old Tappan Rd., Glen Cove, N. Y. 11542.

CIRCLE NO. 405

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119 MODELS  
VOLTAGE OUTPUT TO 48 VDC  
CURRENT OUTPUT TO 2 AMPS.

The Mini/Mate series provides a new level of performance, quality, and reliability, previously unattainable, plus they are a pin for pin replacement for other manufacturers supplies. The new series is particularly appropriate for use in modern designs which make use of linear and digital integrated circuits, operational amplifiers, decimal displays and other related semi-conductor circuitry.

All Mini/Mates may be printed circuit board or chassis mounted. The output of all Mini/Mates may be trimmed to precisely adjust the DC voltage to your circuit needs.

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**PERFORMANCE . SELECTION . PRICE . DELIVERY**

119 MODELS WITH OUTPUT VOLTAGES FROM 3.6 TO 48 VDC & CURRENT TO 2 AMPS.

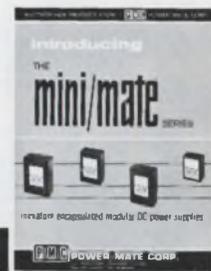
\* \* FIVE YEAR WARRANTY \* \*

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INFORMATION RETRIEVAL NUMBER 10

# Great Milestones in Packaging

43RD IN A "PEOPLE PACKAGING"  
SERIES DRYLY APPROVED BY  
JONATHAN MANUFACTURING COMPANY



Long, long ago, in the early awakenings amongst the Isles, a happy accident happened.

A grape, then a series of grapes were squashed in such a peculiar way that, fermentation being what it is, someone sensed

putting the results in a container would prove of high interest. Thus does history begin.

Bacchus, who established the first really popular excursion trips with his Dionysian Tours to Egypt, India, etc., forthwith then set another record as the world's original wine bottler.

His own person found this endlessly pleasurable and grew to accommodate more of the same. In fact, the Bacchus chassis soon became unstable, unable, even fixed. Or, if you like, utterly stoned, thus making necessary an evolutionary step in package movement so admirably exemplified today by products made for modern markets by the well known firm of Jonathan.

One of the results of Jonathan's great humanitarian interests is movement by the

Jonathan Type 110 Ultra Thin Steel Series Precision Full Ball-bearing Slide. In fact, they decided that the bulky balking that was Bacchus' bag is still a problem for electronic chassis slides. Modern packaging concepts demand high capacity, compact design and ruggedness. And solutions for quick disconnect and tilt problems still must be solved. The people at Jonathan have the perfect solution—the Type 110.



The Type 110 is a full ball-bearing steel slide with a heavy duty pivoting mechanism that will easily handle any rated load requirement. It is readily available and inexpensive.

Jonathan's Type 110 is so improved that its smooth action would make the Saturnalia Santa smile with delight.

Others, too, such as Raytheon, who utilize this versatile slide in its 706 Computer, (see photo) an expandable, low-cost processor with large computer capability and compatibility. This newest addition to the Raytheon computer family uses a packaging concept designed for reliability and maintenance ease. Sm-o-o-o-th Jonathan Slides help make it possible. What's your requirement? Detail us your needs, today!



Have a  
happy  
chassis!



**JONATHAN MANUFACTURING COMPANY**  
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INFORMATION RETRIEVAL NUMBER 11

INFORMATION RETRIEVAL NUMBER 12 ►

Next time you spec a solenoid, odds are 61,034 to 1 that Guardian can provide the one that will do the job. Because we've got that many standards . . . solenoids in every imaginable shape and size to meet virtually any electro-mechanical requirement. AC or DC. Hefty 50 pound pull or a fraction of an ounce. Intermittent or continuous duty. Pull

or push. Laminated, C-frame, box-frame or tubular. In 25 basic designs and 61 thousand variations. Not enough? Then we'll custom engineer a solenoid to fit your specialized application. (And you didn't know there was a Guardian Angel watching over engineers!) **NEW 44-PAGE GUARDIAN SOLENOID CATALOG** is yours for the asking. Write for Bulletin G-3.

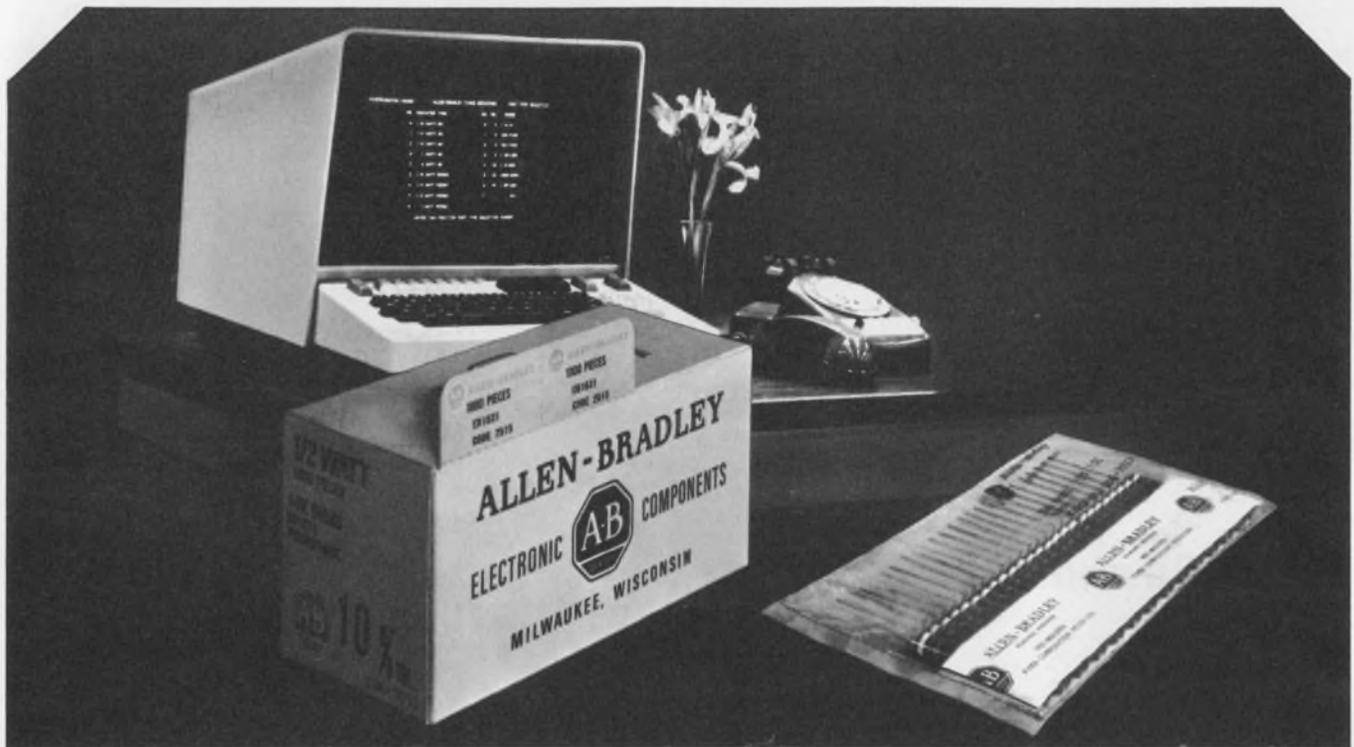


**GUARDIAN® ELECTRIC**

**MANUFACTURING COMPANY**  
1550 West Carroll Avenue, Chicago, Illinois 60607

***Your Guardian Angel stacks the odds in your favor  
(61,034 to 1)***





## Better packaging; one more reason our distributors are faster on delivery.

Your business is too important for procurement delays. That's why we asked your local Allen-Bradley distributor what would help him serve you better. The result; better fixed resistor packaging. Color coded boxes to eliminate errors. Bold identification of all the vital statistics. New clarity that will help your receiving and stockroom people, too.

Inside the carton there are more improvements. Each strip of 25 or 50 resistors is sealed in plastic. Leads are protected, resistors can't fall out. Yet the perforated end zips in a hurry. And every plastic wrapper is clearly marked with wattage, resistance, tolerance, military and commercial part numbers.

Better packaging and IRIS (Instant Response Information System); key elements in our distributors' better service program. It's a whole new dimension in electronics distribution.

**San Francisco**  
Elmar Electronics, Inc.  
(415) 961-3611

**Los Angeles**  
Kierulff Electronics, Inc.  
(213) 685-5511

**San Diego**  
Kierulff Electronics  
(714) 278-2112

**Phoenix**  
Kierulff Electronics Corp.  
(602) 273-7331

**Denver**  
Hyer/Cramer, Inc.  
(303) 758-2100

**Seattle**  
Kierulff Electronics  
(206) 763-1550

**Chicago**  
Newark Electronics Corp.  
(312) 638-4411

**Detroit**  
Newark-Detroit Electronics, Inc.  
(313) 548-0250

**Boston**  
Cramer Electronics, Inc.  
(617) 969-7700

**New York**  
Schweber Electronics  
(516) 334-7474

**Cleveland**  
Schweber Electronics Corp.  
(216) 464-2970

**Philadelphia**  
Almo Electronics Corp.  
(215) 676-6000

**Baltimore**  
Cramer/Baltimore  
(301) 354-0100

**Washington, D.C.**  
Cramer/Washington  
(301) 424-2700

### ...and in Canada:

**Montreal**  
Cesco Electronics Ltd.  
(514) 735-5511

**Ottawa**  
Cesco Electronics Ltd.  
(613) 729-5118

**Quebec**  
Cesco Electronics Ltd.  
(418) 524-4641

**Toronto**  
Cesco Electronics Ltd.  
(416) 638-5250

NEW DIMENSION ELECTRONICS

# ALLEN-BRADLEY

Milwaukee, Wisconsin 53204

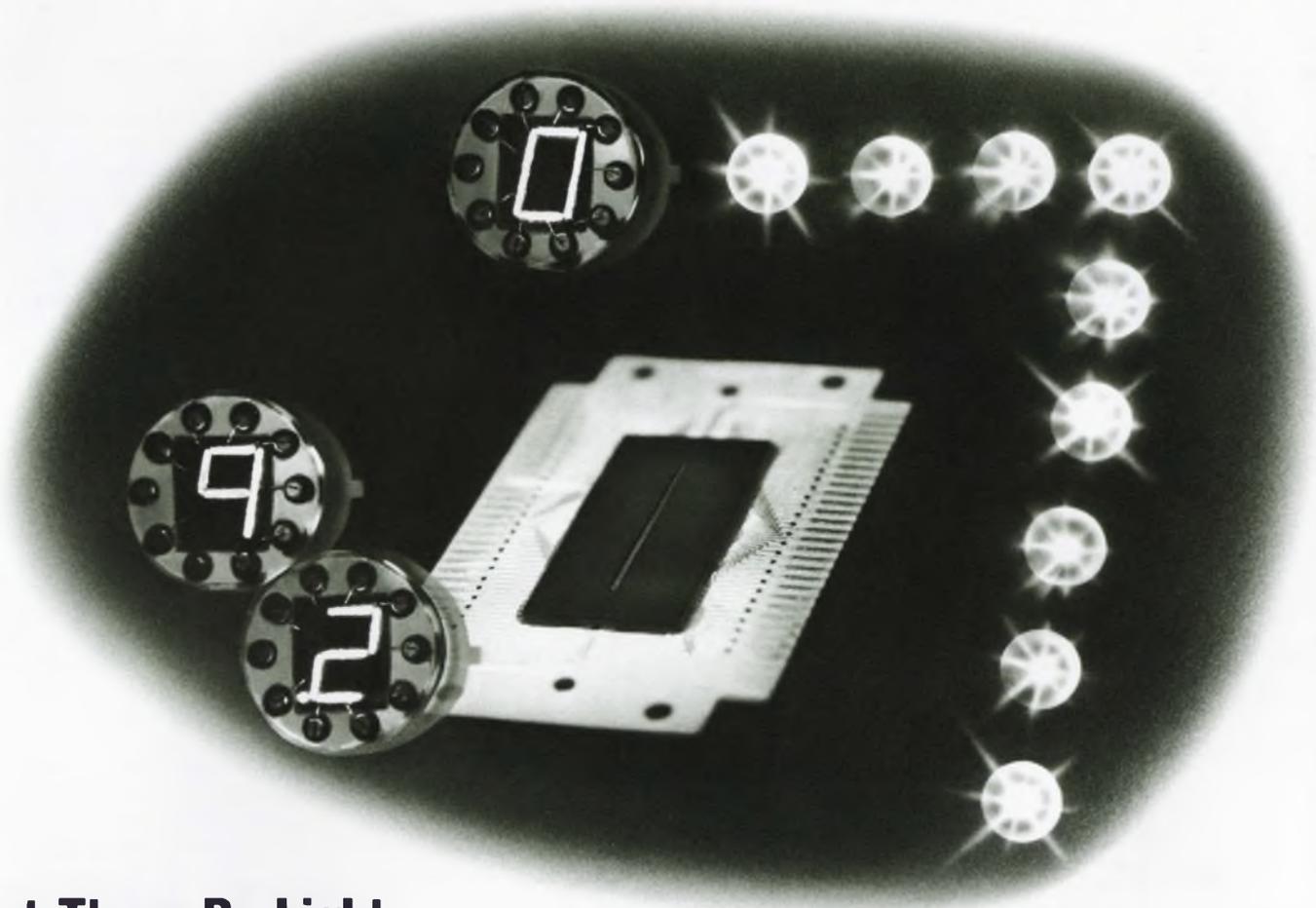


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EC70-17

# SEMICONDUCTOR NEWSBRIEFS

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



## Let There Be Light

Optoelectronics — sparkling new star for the 70's at Motorola where 5 new red and IR light-emitting diodes, 13 new photodetectors and 2 new photodiode and transistor arrays have just debuted.

In new visible red LED's, price and brightness play equal roles. The MLED-50, cased in the economical, subminiature, plastic Micro-T package, features 750 fL-@-20 mA brightness and costs only \$1.50, 100-up. For equally compact designs, the MLED610 in the hermetic "pill-package" offers reliability and 1100 fL brightness @ 50 mA for only \$2.60. And for perfect spectral matching with silicon, Motorola infra-red emitters in

plastic Mini-T, "pill" or TO-18 package combine versatility with power outputs from 150  $\mu$ W to 650  $\mu$ W and 100-up prices low as \$1.50.

In detectors, a great performer is the MRD3050 series — fast, rugged TO-18 packaged devices with a wide range of sensitivities that offer ultra-economical, 100-up prices low as 80¢! In addition, 5 new Darlington amplifiers in Unibloc plastic packages furnish ultra-high  $h_{FE}$  of 5,000, sensitivity from 1 to 4 mA/mW/cm<sup>2</sup> and 100-up costs down to 40¢. The new units bring Motorola's photo diode, photo transistor and PIN detector-

unit-total to 24.

Challenges in character recognition can now be met with the industry's first standard, 39-element, monolithic photo diode array in ceramic flat-pack and a super-sensitive, 5-mil-spaced, 39-element photo-transistor array. The MRD6039D and MRD6039T are ideal for OCR, star tracker and mark sensor applications or any design requiring high-resolution radiation sensitivity.

A special, basic design guide containing all opto device specifications, applications and characteristics is available now.

*For details, circle 101*



## Beam Lead Intros Boost TTL Systems Reliability

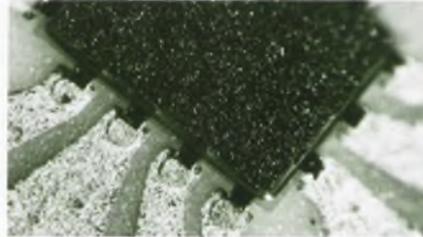


Beam lead TTL! Motorola, longtime supplier of proven high reliability Safeguard beam lead devices, now offers seven MTTL series 5400 functions built with beam lead technology. The initial introductions provide a basic family of standard logic — and more devices will be announced shortly.

The TTL Beam Lead ICs provide the user with specifications similar to their 5400 series counterparts. They differ in that beam lead interconnect metal is gold rather than aluminum. And the aluminum bonding pads formerly required for flying wire leads are replaced with strips of gold 6 mils long, 3 mils wide and 0.5 mils thick that cantilever over the chip edge for connection purposes. Silicon nitride passivation renders the chip impervious to impurities and contaminating ions.

Use of beam lead devices eliminates both die and wire bonding. The result is simple, faster, and more reliable bonds.

Beam lead ICs are especially well suited for use in hybrid systems because the higher bond reliability minimizes the replacement of costly hybrid circuits. In hybrid circuit use, the nitride passivation of the ICs eliminates the need for hermetic packaging and reduces costly yield loss. And beam lead chips make higher density hybrid techniques possible.



Motorola Beam Lead ICs — the ultimate in bond reliability for TTL systems.

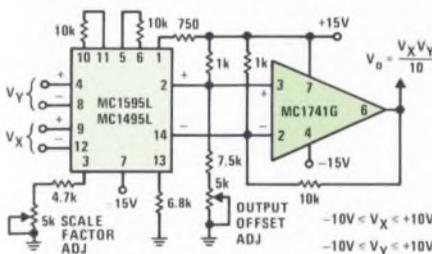
The newly available devices are produced in chip form (MCBC5400 series) or in flat packages (MCB5400F series). Check the table and contact your local Motorola distributor for evaluation units.

DEVICE TYPE (Chips)	DEVICE TYPE (Flat Packs)	DESCRIPTION	100-UP PRICES (Chips)	100-UP PRICES (Flat Packs)
MCBC5400	MCB5400F	Quad 2 Input NAND Gate	\$3.65	\$6.20
MCBC5440	MCB5440F	Dual 4 Input NAND Buffer	4.15	6.80
MCBC5453	MCB5453F	Expander 4 Wide 2 Input AND/OR/INVERT Gate	3.65	6.20
MCBC5454	MCB5454F	2 Wide 2 Input AND/OR/INVERT Gate	3.65	6.20
MCBC5460	MCB5460F	Dual 4 Input Expander for AND/OR/INVERT Gate	2.70	5.05
MCBC5472	MCB5472F	J-K Flip Flop	5.10	7.90

For details, circle 102

## MC1595 Multiplier Level Shift Circuit Uses MC1741 Op Amp — Cuts Component Count

In your MC1595 four-quadrant multiplier applications where level shifting is required, a simple, new circuit



all resistor tolerances are  $\pm 5\%$

can greatly reduce external components, increase accuracy, and simplify adjustment. The circuit takes advantage of the high common-mode range of the

For details, circle 103

MC1741 (or MC1556) op amp. As shown, you save seven resistors and one capacitor over the multiplier data sheet version.

In this circuit, by operating the multiplier at 2 mA with 10k resistors, linearity is 0.5% (typ) for the X input and 1.0% (typ) for the Y input.

As illustrated, both inputs to the MC1741 op amp are at 11.5 V, one-half volt below the 12 V minimum and 1.5 V below the 13 V typical input common-mode range. The MC1741 acts as a differential current to single ended voltage converter with  $V_{OUT}$  referenced to ground. Note also that you can accommodate  $\pm 10$  V inputs using conventional  $\pm 15$  V symmetrical supplies.

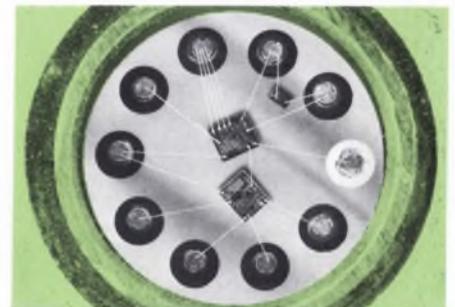
## Op Amp And Power Booster Circuits Joined In MCH2870 Hybrid Power Op Amp IC

The end is at hand for many of the problems and much of the cost in op amp circuits for driving low impedance loads. Motorola has combined the MC1741 op amp and MC1538 power booster circuits in one hybrid Power Op Amp, the MCH2870. And you get the function in the nine-pin case 614 formerly required for the power booster, alone.

Now the MCH2870 offers the merged benefits of the op amp and booster in both full and limited temperature range versions, with each priced below the equivalent in separate ICs. In 100-999 quantities, the MCH2870MR ( $-55$  to  $+125^\circ\text{C}$ ) is \$16.00; the MCH2870CR ( $0$  to  $+75^\circ\text{C}$ ) \$8.50. Further savings are realized through reduced external interconnection and board space requirements, and through halved handling.

The output current of the MCH2870 can be limited to any value from 100 mA (typ) to a full 300 mA (typ) with the simple addition of two external resistors. Or, the MCH2870's internal limiting can be utilized to provide a typical 100 mA (pins 2 & 4 open) or 200 mA (pins 2 & 4 shorted). Open loop  $Z_{OUT}$  is a low 10 ohms (typ) and  $A_{VOL}$  is a high 200,000 (typ, MCH2870MR). The MCH2870 is internally compensated and offers offset voltage null.

The MCH2870 was designed for driving low impedance/high current loads and is ideal for line driver and servo-synchro amplifier applications. Nine representative applications are described on the data sheet including inverting ampli-



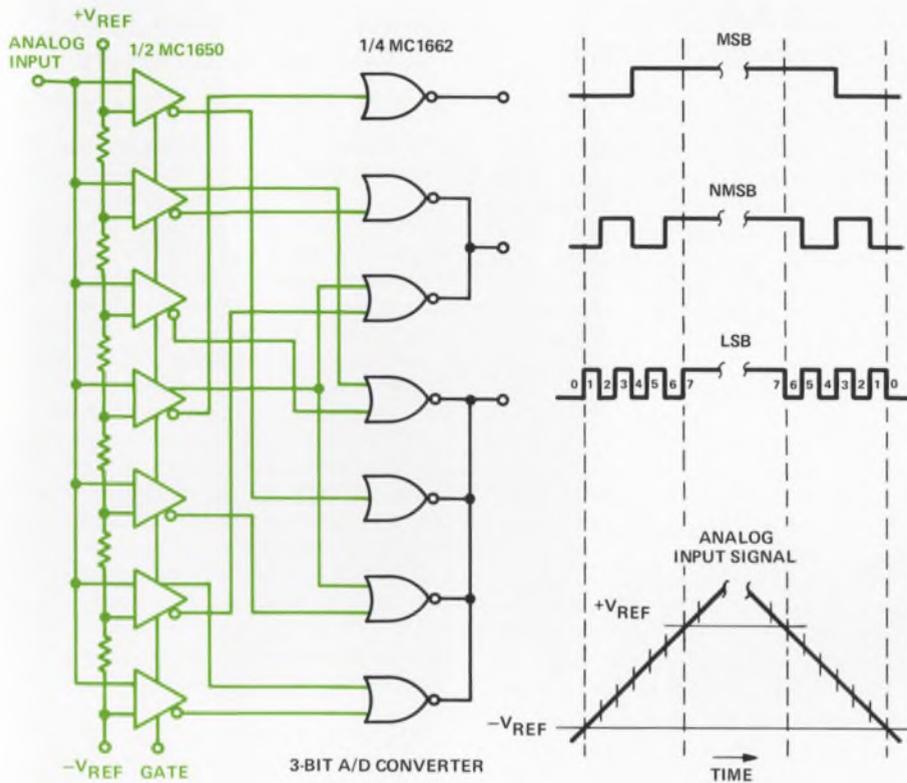
The MCH2870 Power Op Amp combines three chips in a single nine-pin case.

fier, unity gain voltage follower, programmable voltage source, and power splitter circuits.

Your Motorola distributor will meet requests for product from stock.

For details, circle 104





## MECL III Devices Convert And Move Data—Faster

Would you believe an A/D conversion time of 3.5 ns *and* a line receiver with a typical delay of 1.0 ns? MECL III now offers two new devices, the MC1650 A/D comparator and the MC1692 quad line receiver — opening up new concepts of high-speed data handling.

When its control gate is in the logic “1” state, the MC1650 compares an analog signal to a reference voltage. If the analog level is greater than the reference, the output of the comparator is a logic “1.” If the analog signal is less than the reference voltage, the compar-

*For details, circle 105*

## More MC9300/8300 MSI Eases DTL/TTL Design—Reduces Can-Count

DTL/TTL designers! Five additional MC9300/8300 functions offer you an easier building block approach to design. Direct replacements (electrically and functionally) for older 9300/8300 types, the versatile DTL/TTL compatible functions will reduce can-count and board space in your system.

For instance, the MC8308 dual 4-bit latch can replace eight flip-flops or two 4-bit latches. Each half of the device contains four latches with common enable (E0 and E1) and common master reset (MR).

Then the MC9310/8310 presettable decade counter and the MC9316/8316 presettable 4-bit binary counter accomplish counting functions that would require four J K master-slave flip-flops

plus additional gating. Both devices have parallel inputs for presetting data and parallel outputs for full counting flexibility.

These counters are typically used for multistage counting and high-speed programmable division.

The MC8311 one-of-sixteen decoder converts four BCD inputs to select 1-of-16 outputs. Two enable inputs provide increased logic capability. The MC8311 function plays an integral part in memory selection control, demultiplexing and data routing.

For an economical high-speed serial storage building block, there's the MC-9328/8328 dual 8-bit shift register with separate clocks and a common master reset. Each 8-bit register is provided with

tor output voltage goes to a logic “0.”

Operating at a typical delay of 3.5 ns, the MC1650 accepts analog signals with slew rates up to 340 v/μs. Used in an A/D converter, the MC1650 is capable of providing digital information at rates up to 200 megabits per second, at the least significant bit (LSB). And, for sample and hold applications, when the control gate is taken to a logic “0” level, all bits of digital information remain in their present state, regardless of a change at the analog input. For maximum design flexibility, the MC1650 incorporates two comparators in one package — both with complementary outputs.

The MC1692 Quad Line Receiver is used to terminate long lines over which high-speed information is transferred. Typical applications might be a cable between a computer installations central processor and a peripheral device or between a measurement terminal and the control center of an instrumentation or navigation system. Comprised of four differential amplifiers with emitter follower output transistors, the MC1692 is especially well suited to accept complementary signals from twisted pair transmission lines and provide high external noise immunity.

Evaluation quantities of these devices are available now in your choice of the ceramic “stud” flat-pack (suffix S) or the 16-lead ceramic dual in-line package (L). 100-up prices are: MC1650L/\$21.95; MC1650S/\$27.20; MC1692L/\$9.25; MC1692S/\$11.00. Introduce your system to new high-speed dimensions in data handling.

a 2-input multiplexer circuit and complementary serial outputs. If desired, the two registers can be clocked together with a common line.

Your Motorola distributor has these DTL/TTL “compatibles” waiting for your evaluation. Give your system the advantages of building block design.

0 to +75°C	100-Up Price	-55 to 125°C	100-Up Price
MC8308P	\$ 7.50	MC9310L	\$18.55
MC8310P	9.40	MC9316L	18.55
MC8311P	7.30	MC9328L	19.00
MC8316P	9.40	L = Dual in-line ceramic P = Dual in-line plastic	
MC8328P	7.40		
MC8310L	11.70		
MC8316L	11.70		
MC8328L	11.90		

*For details, circle 106*



## New MMT Micropower Series Advances High Frequency/Low Power State-Of-The-Art

Attention designers!! Have you been having nightmares because your miniature, high frequency amplifier design



Miniaturization of portable electronics is made easier by the MMT806 Micropower series of amplifiers and switches.

requires transistors capable of over 100 gain at microamperes collector current. Is your dream of a miniature counter for a portable instrument "impossible"

For details, circle 107

because it requires a transistor capable of over 1 GHz operation?

Wake Up!! Heed this Motorola reveille! Here are two complementary pairs of switching and amplifier transistors — the MMT806 Micropower series — that provide the previously unobtainable combination of low input/output capacitance and high-frequency operation at ultra low power levels that is ideal for portable communications gear, medical electronics and remote control monitoring systems. In their rugged, Micro-T plastic package, the MMT806 (NPN), MMT808 (PNP) switches and MMT807 (NPN), MMT809 (PNP) amplifiers make the miniaturization of your design a waking reality.

Check the Micropower spec highlights then take advantage of the low introductory 100-up prices of \$13.00 for the MMT806/807 and \$15.00 for the MMT808/809. There's plenty of warehouse stock to breadboard that dream design.

## Twenty Versions of 2N3055 Fill 5-25 Amp Industrial Gap!

Next time you need the dependable "old standby," 2N3055 NPN power transistor in a new circuit design — but at a current rating different from the 3055's, 15 amps — don't panic!

BECAUSE . . . There are twenty, new, 2N3055-type devices that do just that — give 2N3055 performance at 5, 7, 10, 15 and 25 amperes of continuous current. And, they're complementary! Offering you the exact current-gain you want, the new 2N5867-86 family handles up to 200 W of power. No need now for expensive 2N3055 "specials."

Their complementary symmetry means simplified, audio-servo amplifiers less output transformers and installation

costs. In dc-coupled pulse generators, they give positive and negative outputs when used as PNP/NPN pairs.

These 60-80 volt units specify gain at 3 points within each individual current category, and provide a complete gain range of 20-100 at 6 A.  $V_{SAT}$  characteristics are given at two points also, providing a full picture of operation making the choice of the right "2N3055" for your design even easier.

Design the 2N5867-86 transistors into relay and solenoid drivers, inverters, converters and audio/servo amplifiers — get all the 2N3055 silicon power you need, for the price you want to pay!

Type		I <sub>c</sub> (Cont) A	P <sub>D</sub> W	h <sub>FE</sub> @ I <sub>c</sub> (min/range)	V <sub>CE(sat)</sub> @ I <sub>c</sub> V	Rise & Fall Time μs	PRICE, 100-UP	
PNP	NPN						PNP	NPN
2N5867 2N5868	2N5869 2N5870	3	87½	35 @ 0.3A 20-100 @ 1.5A 5 @ 3A	1 @ 2A 2 @ 3A	1.0 @ I <sub>c</sub> (max) 2	\$1.35	\$1.25
2N5871 2N5872	2N5873 2N5874	5	100	35 @ 0.5A 20-100 @ 2.5A 5 @ 5A	1 @ 4A 2 @ 5A		1.60 1.95	1.40 1.75
2N5875 2N5876	2N5877 2N5878	8	150	35 @ 1A 20-100 @ 4A 5 @ 8A	1 @ 5A 3 @ 8A		2.45 2.85	1.70 2.00
2N5879 2N5880	2N5881 2N5882	12	160	35 @ 2A 20-100 @ 6A 5 @ 12A	1 @ 7A 4 @ 12A		3.70 4.20	2.70 3.00
2N5883 2N5884	2N5885 2N5886	20	200	35 @ 3A 20-100 @ 10A 5 @ 20A	1 @ 15A 4 @ 20A		4.10 4.50	3.75 4.25

For details, circle 108

## Six-Amp Axial-Lead Silicon Rectifier Series Offers "Twice The Amps Per Dollar"

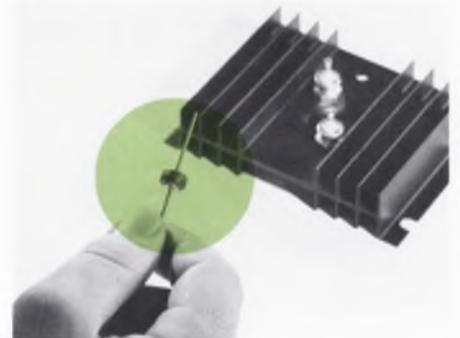
If you're getting hot from looking for dollar rectifier savings and finding pennies . . . cool it! Let the industry's first 6-amp axial-lead rectifiers save *real money* in your design by providing both "twice the amps per dollar" and significant mounting and assembly savings.

Compared to stud rectifiers of similar current rating, the silicon MR751 series devices install quicker, easier and take less space. And, their new, button-shape, voidless plastic case provides insulation against accidental shorting or grounding.

But the *big* savings is in the initial cost . . . less than half that of the typical stud-packaged 6-amp counterpart.

The MR751 series rectifiers come in four working peak reverse voltage ratings up to 600 volts. Each features a 600-ampere inrush current surge capacity for increased capacitive-loaded design latitude.

And if you *really* want to cool it — with a proper heat sink and mounting —



The new 6 A MR751 series of silicon "button" rectifiers reduces heat-sink costs.

this little "button" will handle up to 26 amperes. These and other outstanding characteristics — like complete surge current specs, forward voltage drop of 0.9V (max), reverse current at rated dc voltage of 0.25 mA (max) — make the MR751 series rectifiers a real cool buy.

Buttonhole your nearest Motorola rep and ask for evaluation samples — today!

Use the bingo number and get a free 200V MR752 plus a data sheet.

VOLTAGE RATING	100-Up PRICES	
	Typical 6-A Stud ASP	MR751 Series Device
V <sub>r</sub> 100V	\$0.90	\$0.45 MR751
V <sub>r</sub> 200V	1.25	0.49 MR752
V <sub>r</sub> 400V	2.00	0.62 MR754
V <sub>r</sub> 600V	3.75	0.90 MR756

For details, circle 109



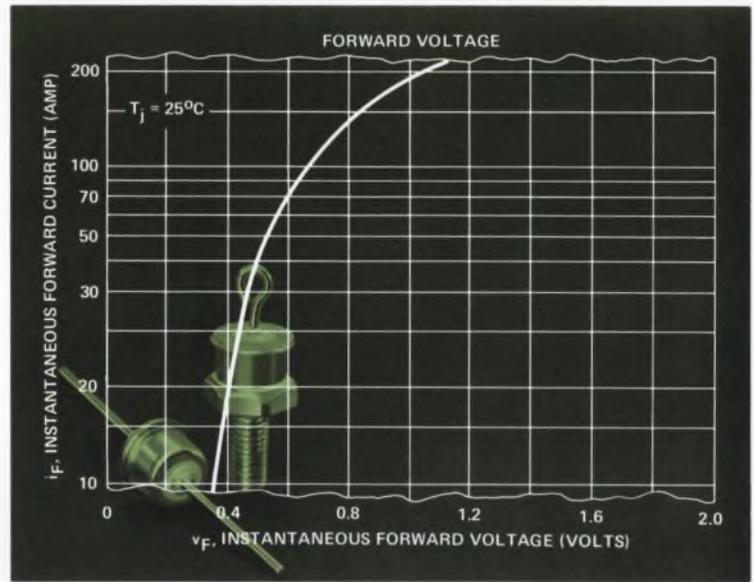
# Hot Carrier Rectifier Trio Halves Power Loss

With hot carrier diodes, the word is rectification efficiency. At Motorola, the story is *three* hot carrier rectifiers—MBD-5500A, the 50 amp, 20 volt industry first, and now the 5 amp, 20 volt MBD5300 and the 25 amp, 20 volt MBD5400.

Like the MBD5500A, the new rectifiers employ the Schottky barrier principle in a large area, metal-to-silicon power diode. The state-of-the-art geometries feature epitaxial construction, oxide passivation and metal overlay contacts. The result is a forward voltage drop less than half that of conventional silicon rectifiers, low stored charge from majority carrier operation, and high surge current capacity. These three features translate into major benefits:

- The extremely low  $V_F$  over the entire forward current range means 50% less power loss than conventional alloy or diffused devices, a real breakthrough for low voltage power supplies and other applications where power loss hurts.
- Majority carrier operation results in virtually no stored charge (even at very high frequencies) plus extremely fast forward and reverse recovery times. Rectification efficiency is flat to beyond 50 kHz and rectification continues into

Even at 20 amperes the forward voltage of the MBD5400 is less than 0.4 V, a real benefit for low voltage power supplies.



the megahertz range making the rectifiers ideal for high frequency use, where low stored charge is required or where reduced commutation transients are desired.

- High surge current capacity allows extra design latitude in capacitive loaded circuits as well as providing extra protection.

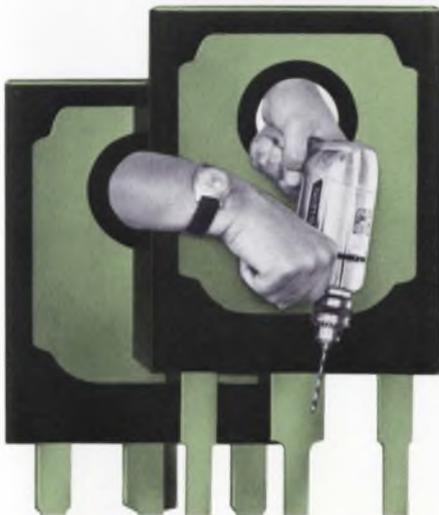
The MBD5400 is encased in the standard DO-4 stud package, the MBD-5300 in an axial-lead hermetic metal Motorola 60 case. 100-up prices are MBD5400 — \$6.00, MBD5300 — \$3.60, the non pareil MBD5500A — \$8.50. Production quantities of both devices are in the warehouse now, ready to rectify — efficiently.

For details, circle 110

## Plastic Trigger/Triac Pairs Lower Control Cost

Now, a plastic thyristor/trigger power control pair that will match your design needs for cost and performance!

The new **MAC10/11 Series Triacs**



Put "muscle" into your power control circuits with Motorola's Thermopad cased Triac/Trigger Pairs.

control full-wave power to 500 V and are the answer for 10 A current handling in light dimmers, motor controls, home appliances, anywhere a balance between price and performance is desired.

These Thermopad-packaged devices offer symmetrical gating and holding (1st and 3rd quadrants have the same limits), low "on" voltage and 50 mA gate trigger (quadrants I & III) and holding currents.

Their hand-in-glove partner in phase-control, the MBS4991-92 bilateral switch, provides 0.2% / °C temperature coefficient and uniform conduction characteristics in both directions.

Cost for the new "dynamic duo"? Just \$1.15, 100-up!

And when half-wave SCR control is your need, reach for the **MCR106/**

**MUS4987 SCR/Trigger** combination that has an ultra-economical, 100-up price as low as 92¢!

MCR106's are Thermopad-cased, compatible with existing sockets, capable of 110°C junction temperature and available in quantity from stock. They're favored in consumer-industrial heat, light and motor control where cost is important.

Their confederate in control — the MUS4987 unilateral switch — offers uniform characteristics and an excellent, 0.02% / °C temperature coefficient for stable performance.

Motorola plastic Triacs and SCR's now provide hermetically-sealed junctions for uncontaminated, reliable operation. Pair up with them today!

New Thyristor Series	$I_F$ A	Blocking Voltage Range V	Thyristor/Trigger Pair Price (Lowest 100-up)	"On" Voltage V (max)	Typical Switch Voltage V	New Trigger Series
MCR106-1 thru -4 Plastic SCR's	4	30-200	\$ .92	1.5	8	MUS4987,88 Unilateral Switch
MAC10/11 Plastic Triacs	10	25-500	\$1.15	1.7	8	MBS4991,92 Bilateral Switch

For details, circle 111



# NEW PRODUCT BRIEFS

## MODULATOR-DEMODULATOR GETS NEW PACKAGE

— *And A Limited Temperature-Range Running Mate*

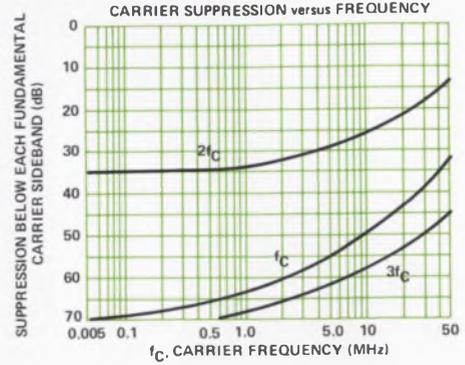
Now you can get Motorola's versatile, low cost MC1596 monolithic balanced modulator-demodulator, and the new limited temperature range MC1496, in "easy insert" ceramic dual in-line "L" packages.

Balanced inputs and outputs, high common-mode rejection of 85 dB (typ), adjustable gain and signal handling, and carrier suppression of 65 dB (typ) @ 0.5 MHz are just a few of the factors which make the circuit popular.

Remember, these devices are used wherever the output voltage is a product of signal and carrier in communications applications such as suppressed carrier and amplitude modulation, synchronous AM-FM and phase or single sideband detection, and frequency doubling or mixing. They've also been found excellent as choppers, as comparators for phase locked loop receivers, and as components in phase correcting and phase encoding circuitry.

The MC1596L is a low \$4.80 (100-up) and the MC1496L is only \$2.25. Units are available from all Motorola distributors.

For details, circle 112



## RADIATION-HARDENED AMPLIFIER/HIGH-SPEED SWITCH

— *Provides Balanced Resistance To All Forms of Radiation*

Semiconductor devices are generally the most radiation-vulnerable element of an electronic package. Recently, designers have been able to obtain special, radiation resistant devices for "hardening" systems that must operate in nuclear reactor or Van Allen Belt types of environments. Most of these, however, are resistant to only a part of the different kinds of damaging radiation.

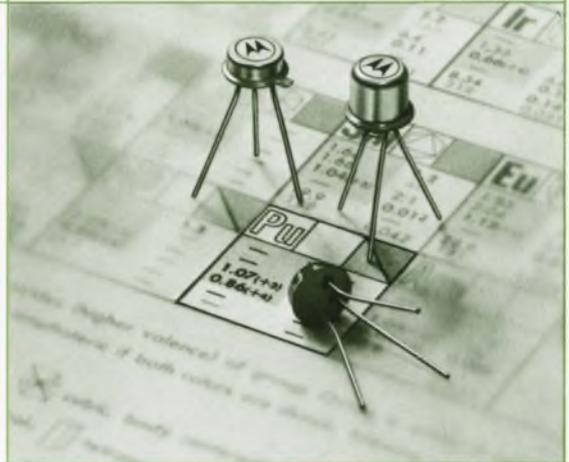
Now, from Motorola, you can get two new, off-the-shelf, PNP silicon transistors that are specially designed to cope with the entire spectrum of harmful radiation, and, provide this performance:

- The 2N5763 general purpose amplifier features a dc current gain specified from 1.0 to 500 mA and high collector to emitter breakdown voltage of  $BV_{CEO} = 60$  Vdc and  $BV_{CER} = 65$  Vdc.

- The 2N5332 high-speed switch displays typical switching times of  $t_{on} = 9$  ns and  $t_{off} = 40$  ns.

500-up prices: In the TO-18 package, the 2N5763 is \$10.80; in the TO-46 package, the 2N5332 is \$8.45.

For details, circle 113

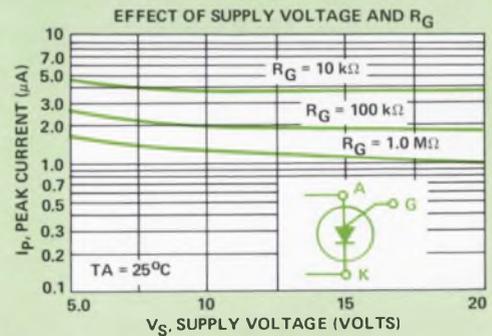


## METAL PROGRAMMABLE UNIJUNCTION

— *Puts Hermetic, High-Reliability Into Pulsing, Timing and Sensing*

Now you can program specs of unijunction transistors that come in a rugged, reliable package. In their hermetic, metal TO-18's, the MPU231-33 PUTs offer an operating temperature range of  $-55^\circ$  to  $125^\circ\text{C}$  . . . ideal for demanding industrial and military pulse sensing, timing, thyristor-triggering and relaxation oscillator applications. "Big brother" to the lower-cost, plastic MPU131-33 PUTs, the hermetic series has identical specs including low, 1.5 V on-state voltage, 5 nA maximum leakage current, 16 V typical peak output voltage and, of course, the option of programming  $R_{BH}$ , etc.  $I_V$  and  $I_P$  simply by varying the two external resistor values. The MPU233 is especially suited to long-interval timers with its 150 nA  $I_V$ . 100-up price range is \$.90 to \$1.85.

For details, circle 114



## NEW TTL QUAD LATCHES

— *Fill Need For Temporary Data Storage In High Speed Systems*

Two new TTL latches have joined Motorola's growing latch line. The 4-bit devices — MC4035/4335 and MC4037/4337 — are ready to act as temporary stores in the transfer of binary information between processing units and input/output units in your high speed system.

The MC4035/4335 consists of four latch circuits with open collector outputs, a common strobe input, and an output enable. The open collector feature is useful for bussing or wire ORing outputs together and the output enable facilitates gating information out of the latches according to a predetermined timing scheme. The MC4037/4337 features an active pullup network for driving highly capacitive loads.

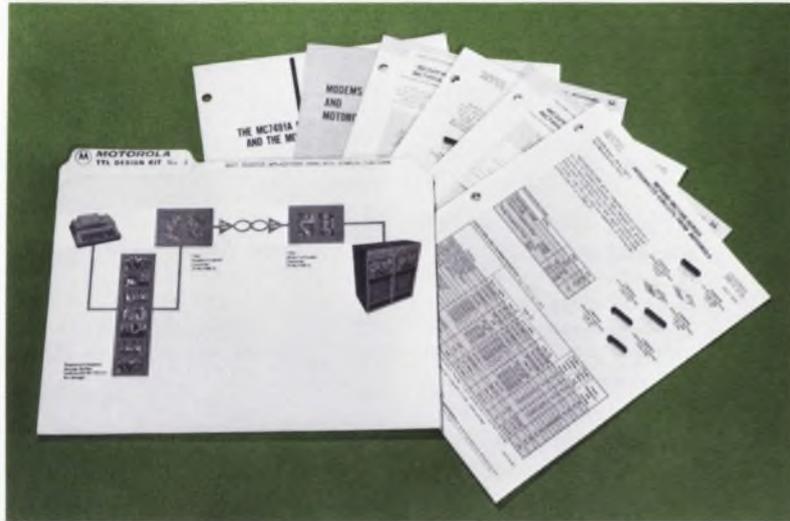
Both latches are supplied in plastic and ceramic dual in-line, and ceramic flat packages. 100-up prices are — MC4035P or MC4037P: \$3.50, MC4035L or MC4037L: \$4.40, MC4035F or MC4037F: \$4.40, MC4335L,F or MC4337L,F: \$8.80.

For details, circle 115

Device Number	Package	Strobe Inputs	Q and $\bar{Q}$ Outputs	Open Collector	Typ Power Dissipation	Typ Prop Delay	Output Enable
MC4035	14 Pin	1	no	yes	140 mw	25 ns	yes
MC4037	14 Pin	1	no	no	150 mw	25 ns	no
MC7475	16 Pin	2	yes	no	160 mw	30 ns	no
MC7477	14 Pin	2	no	no	160 mw	30 ns	no

Note: all latches are available in full and limited temperature range.





## Shift Register Applications Detailed In New TTL Systems Design Kit

Designers concerned with data transmission will find prime use for Motorola's new TTL Design Kit #2. The file provides typical shift register applications evolving around the MC5491A/7491A 8-bit shift register, with emphasis placed on the data transmission

capabilities of the devices. Included in the kit are data sheets, an application note, and comprehensive listings of 54/74 circuits and complete functions. A "special offer" sheet enables designers to obtain additional data on MODEM ICs.

*To obtain your copy, circle 116*

## Laser Beam Zener Chip Scribing Increases Yield, Reliability

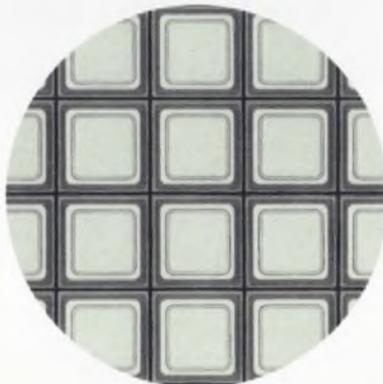
Motorola's zener chips are the first in the industry to be scribed by the revolutionary, new laser beam method. Under development for 18 months, the state-of-the-art technique is producing cleaner, smoother, and straighter chip edges than can conventional means.

By removing the uneven stresses inflicted on a wafer by the former "scratch" method, cracks that can extend into the active junction area have been virtually eliminated, resulting in an improvement in long-term reliability.

The exclusive use of the laser scribing of zener chips at Motorola has increased yield in this operation to a startling 99% — and at a rate four times faster than with previous methods. The increased yields will result in quicker response to customer volume requirements.

In the laser-scribe process, the use of a very short laser pulse dura-

tion (500 ns) and the slow thermal conductance (time constants of  $\mu\text{s}$  are typical) in semiconductor ma-



A repetitively Q-switched, continuous wave, neodymium-doped YAG laser is used to scribe the zener products at Motorola. Depth of penetration into the semiconductor material is 1 mil.

materials confine the heat generated in the kerf (scribed area) to a region approximately 2 mils wide.

*For details, circle 117*



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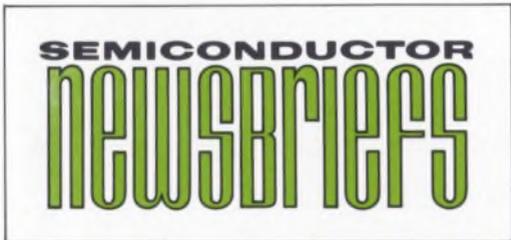
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## NEW LITERATURE BRIEFS

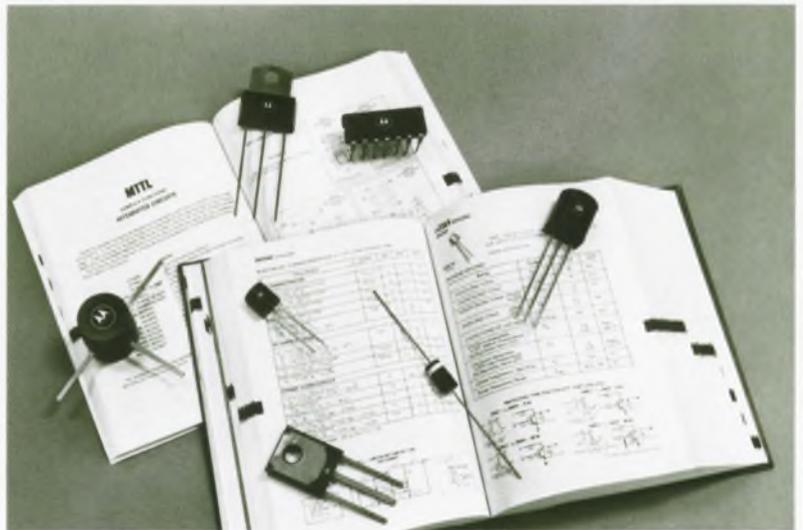
### Master Guide / Price List Now Updated Quarterly

In 137 efficient pages, the latest revision of the Master Selection Guide And Price List brings together all the selector guides and price lists for every product line offered by Motorola. The Oct., Nov., and Dec. prices for more than 14,000 semiconductors are listed along with selector guides for 17 product families.

To make it easy for you to keep tabs, a quick reference section lists new additions and the devices affected by this guide. Pricing and ordering policies for all products are included.



For details, circle 118



### Fifth "Industry Bible" Edition Published And Second IC Data Book Supplement Ready

No working library will be complete without Motorola's just published, fifth edition of the Semiconductor Data Book. This version is the largest ever — 2560 pages — and provides three indexes for sure entry to the device you want.

The indexes also serve as a 208 page listing of the key parameters of all semiconductors registered by the EIA plus Motorola non-registered devices. The book proper includes 2150 pages of complete specifications for all 1N, 2N, 3N and Motorola discrete semiconductors and features a new micro-circuit components section.

Single copies of the book are

\$5.95 and an updating service is available for \$2.00 entitling you to a minimum of two supplements.

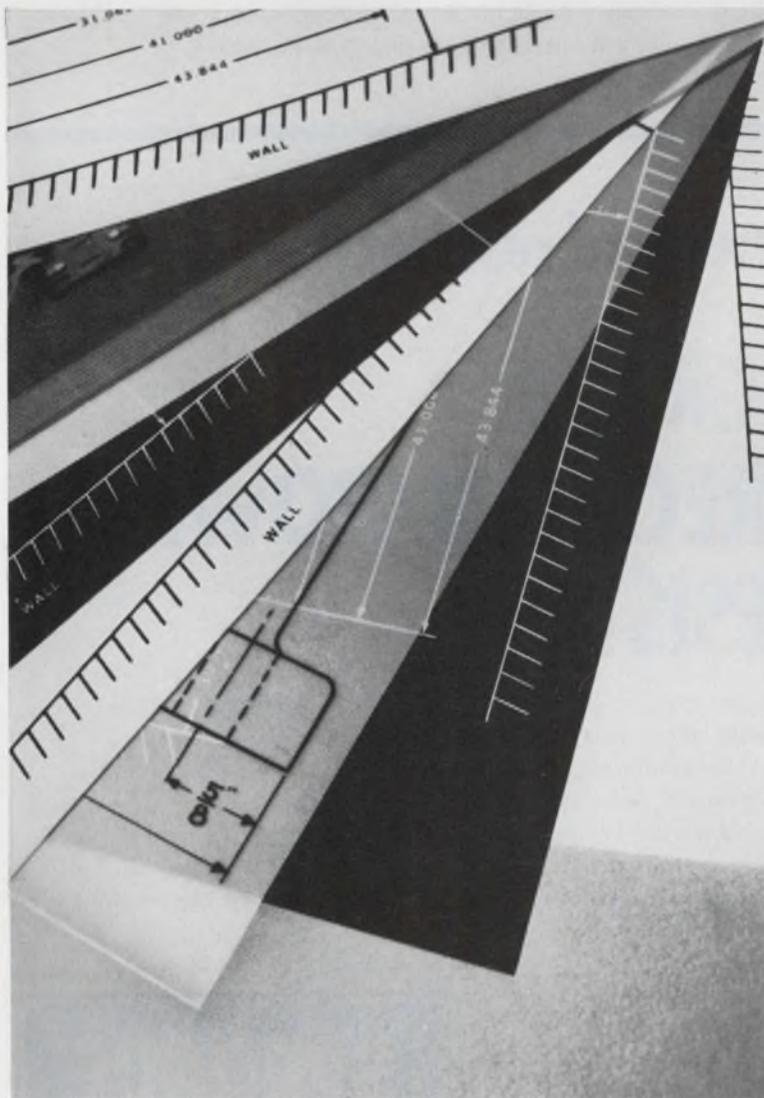
The 336 page Supplement 2 to the Microelectronics Data Book provides complete specifications for 68 new devices. The app note abstract section now includes abstracts for all current Motorola application notes. Sections devoted to the new additions to each digital logic family also provide logic diagrams and truth tables for *all* functions in that family.

To order either the fifth edition or the supplement, use the handy coupon on the left.

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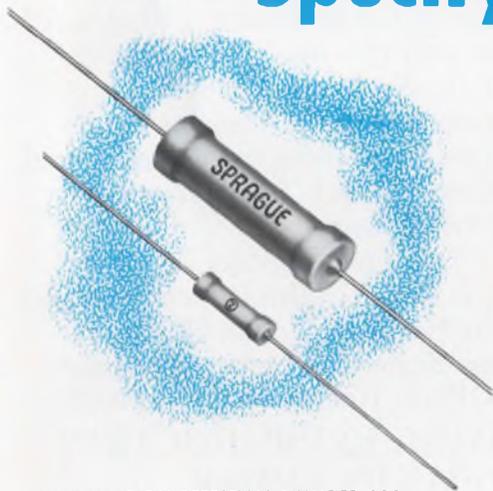
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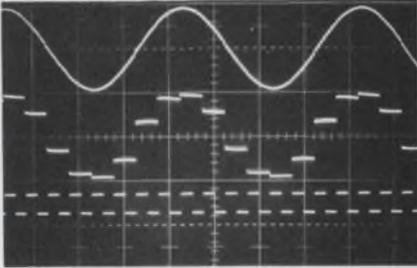


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THE ISSUE

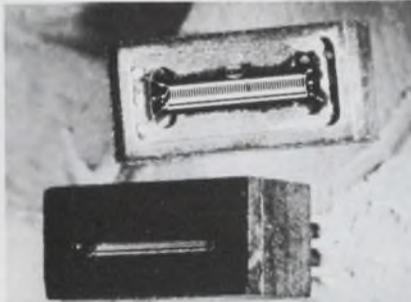


Suppose you require low-frequency, high-Q bandpass filters. If you use conventional filter synthesis you may get physically impractical designs. But there is an alternative—commutating filters.

Although it is an attractive alternative, it was not feasible for most applications before solid-state switching became available to replace mechanical commutators. Now you can make use of the many advantages of commutating filters, including:

- Wide frequency range.
- Good temperature stability.
- Small size and weight.

**Page 76**



By integrating on the same silicon chip a linear 48-element photodiode array with 5-mil centers, a shift register and multiplex switches, the new FPA-600 monolithic photodiode array has made possible low-noise and high-resolution video in optical character recognition and facsimile scanning.

This single-chip construction technique has reduced the number of external leads, which are independent of the number of sensors, to only six.

The technique has eliminated the problem of capacitive imbalances between sensor arrays and generators due to large bundles of wire interconnecting them, which caused switching noise to appear in the output video information.

**Page 101**



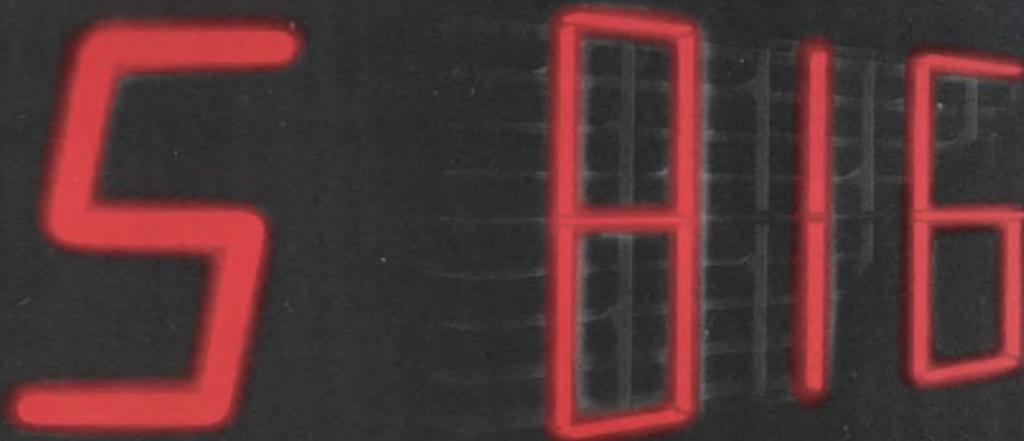
The next big consumer electronics product on the market—with sales of \$1-billion projected by 1980—will be the home TV recording systems.

The pity is, according to Quantum Science Corp., a market and product planning concern with offices in New York City and Palo Alto, Calif., that a standardization battle is bound to ensue. Already six basic designs are emerging, it reports, with at least a dozen variations.

**Page 32**



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# INTRODUCING PANAPLEX™ NUMERIC DISPLAY

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power required is less than for any competitive readout panel and the display has superior brightness characteristics. What's more, reliability of PANAPLEX numeric panel display is comparable to that of Burroughs' NIXIE® tubes.

For additional information write: The Burroughs Corporation, Electronic Components Division, P. O. Box 1226, Plainfield, New Jersey 07061.



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**Burroughs** 

## U.S.—Soviet space docking? Communications needed

WASHINGTON, D. C.—What electronics would be needed to enable U. S. and Soviet spacecraft to rescue one another in space?

Earlier this month the Russians agreed to discuss such cooperation in a committee of the International Academy of Astronauts. The discussion to be held in Moscow, October 26-27, will be aimed at allowing the spacecraft of the two nations to dock with one another.

Sam Fordyce, NASA's principal engineer for communications on the Space Station Task Force, outlined the communications problems this way in an interview with *ELECTRONIC DESIGN*:

"The only rigid requirement is voice communications. For space-to-space, spacecraft-to-astronauts outside the craft, and from the lunar module to men on the moon, we use vhf transceivers [259.7 MHz and 296.8 MHz] with a simple AM modulation, operating with a 28-V power supply.

"The Soviets use a lower vhf frequency for space-to-space and probably different voltage. We might supply them with transceivers like ours. They'd have to put in their own antennas.

"Rendezvous could be achieved in two ways: by direction to both craft from NASA's 14 ground stations, telling them how to maneuver until they were close enough to detect each other with flashing lights, or they could guide themselves to rendezvous by radars on each spacecraft.

"The ground-based radars are powerful enough to skin-track—receive good echoes without the use of craft-borne transponders. But the ground stations would have to communicate with the Russian craft. We use S-band for ground-spacecraft communications and the Russians use high frequency [20 MHz]," Fordyce said.

"They chose high frequency because their flight altitudes have often been low, ruling out line-of-sight transmission. Hf signals get over the horizon by bouncing off the ionosphere.

"Now, we plan higher flights, above the ionosphere making hf impractical. The transmission would have to go through the ionosphere, losing power by attenuation, and bounce off the earth and back to the ionosphere.

"If the spacecraft want to rendezvous on their own, they could use their own radar, but we'd need compatible transponders. Skin-tracking without transponders requires too much power for spacecraft," said the NASA engineer.

### Satellite arrays could supply billions of watts

A series of synchronous satellites, each with an array of solar cells five miles square, was proposed by Dr. Peter E. Glaser, at the fifth annual symposium for the International Microwave Power Institute, held this month in Scheveningen, the Netherlands. The system would collect energy from the sun and send it to earth via microwave beams carrying power on the order of  $10^7$  kW.

Then receiving arrays of similar size would rectify the power beams on the earth. Glaser, head of the engineering sciences section of Arthur D. Little, Inc., Cambridge, Mass., said it is probably essential that we build such a system within the next two or three decades. Otherwise, he said, we'll pollute ourselves out of existence in our effort to meet ever-increasing demands for power.

Glaser's views were backed by microwave power experts who presented papers at the symposium.

The satellite system is preferable to a system of terrestrial solar cell arrays, because the earth-bound system would be subject to a loss of input energy every night and during periods of heavy rain or cloud cover.

The only other approach mentioned by Glaser for supplying the world's power needs without excessive pollution is nuclear fusion. But he said that fusion is still a problem.

"I do not want to minimize the engineering problems involved in the satellite project," Glaser said in an interview with *ELECTRONIC DESIGN*, "but I believe that if our governments decided today to institute a crash program to construct such a system it could be built within 10 years."

### Tariff Item 807 appears likely to remain intact

While the White House has taken no official action yet on the U. S. Tariff Commission report on Item 807, the odds are that it will be retained largely as is.

Item 807 is the Tariff Code provision that allows duty-free import of all components made in the U. S. and assembled into products abroad (see "Item 807: A Boon or Bust for Electronics?", *ED* 9, April 26, 1970, pp. 24-26). Organized labor opposes 807 as a threat to jobs in this country, but industry groups favor it, on the whole, as necessary to compete with foreign manufacturers. Last year President Nixon asked the Tariff Commission to investigate the merits of the arguments.

In its report to the President last month, the commission pointed out that while 121,000 workers were employed overseas in the assembly of U. S. goods, few of those jobs would be returned to the U.S. They would "likely be more than offset by the loss of workers now producing components for export and those who further process the imported products," the commission held.

The commission also refuted the idea that overseas assembly of products was hurting the U. S. balance of trade. In fact, it said, repeal of Item 807 would result in a deterioration of \$150-million to

\$200-million in the U. S. foreign trade position.

White House action on the commission report is not deemed likely until after the Nov. 3 elections.

## TV tube stops action and stores it in tube

A new type of silicon-vidicon television tube can capture and store a still picture from a moving scene and hold it as long as a month before playback. Or the tube can provide stop-action as fast as 200 frames a minute.

Developed by RCA, the picture is electronically stored within the tube itself, in contrast with other systems that use film or video tape.

Principal applications, according to Dr. William M. Webster, staff vice president, RCA Laboratories, Princeton, N. J., will be in closed-circuit TV for data processing, education, defense, aerospace and surveillance.

For surveillance, the tube can store a picture of an intruder for later identification. With conventional TV systems, the intruder often moves in and out of the camera field too quickly to be able to identify him or to take a good picture.

The key to the storage technique is a silicon dioxide insulating layer having 600,000 holes that coincide with a like number of photosensitive diodes on the vidicon target surface. This dioxide layer isolates the individual diodes, making it possible to build up and hold a charge on each diode.

## Central processor made on single MOS chip

A general-purpose central processing unit on a single MOS chip is scheduled for delivery by Intel Corp., Mountain View, Calif. in January, 1971, to its first customer for the device—Computer Terminal Corp., San Antonio, Texas. The processor will be used for its Data

Point 2200 "smart terminal".

The chip can execute 30 different instructions, such as "add with carry," "compare," "execute if condition true," and "jump to a new instruction if condition false", with each operation taking 6 to 10  $\mu$ s.

It contains eight 8-bit data registers and an 8-bit parallel binary arithmetic unit, as well as a 14-bit program counter and seven 14-bit words used to store program subroutine addresses.

Intel expects to stock distributors' shelves with this chip during the first quarter of 1971.

## 'Fastest minicomputer' heads for market

Semiconductor random-access memories (RAMs) continue their push into the computer mainframe with the announcement by Data General Corp. of "the fastest minicomputer available."

Called the Supernova SC, the 16-bit computer will have a cycle time of 300 ns and is aimed at applications requiring very high speeds. The 4096-word by 16-bit memory consists of sixty-four 1024-bit MOS memory chips manufactured by Intel Corp., Mountain View, Calif.

The Supernova SC is one of the new minicomputers announced by Data General for delivery next year. All three are compatible with one another as well as with the company's other models, the Nova and Supernova.

## Burroughs computer an 'electronic grid'

The largest and most powerful member of Burrough's new data-processor family, announced earlier this month, the B7700 series, incorporates a central-exchange type of architecture.

This "grid" arrangement is said to permit independent communication between up to eight memory subsystems and a combination of eight 16-MHz central processors or 32-channel, 8-million byte-per-second input output processors. Multiple read-write-compute operations occur simultaneously. The central processor speed, with IC memory, is 62.5 ns. The disk file memory

system can store up to 112 billion bytes, according to Burroughs.

Deliveries of the B7700 are to begin in early 1972.

## Intermediate-speed printer fills gap

A new line printer, designed to fill the current void between low-speed typewriters and expensive high-speed line printers, has been developed by Centronics Data Computer Corp., of Hudson, N. H.

The new unit prints at 165 characters per second, or 60 to 150 lines per minute on standard computer-output paper. The print head, a linear array of seven wires that impact five times per character, is hefty enough to make up to four carbon copies.

## Low-cost landing system offered to small airports

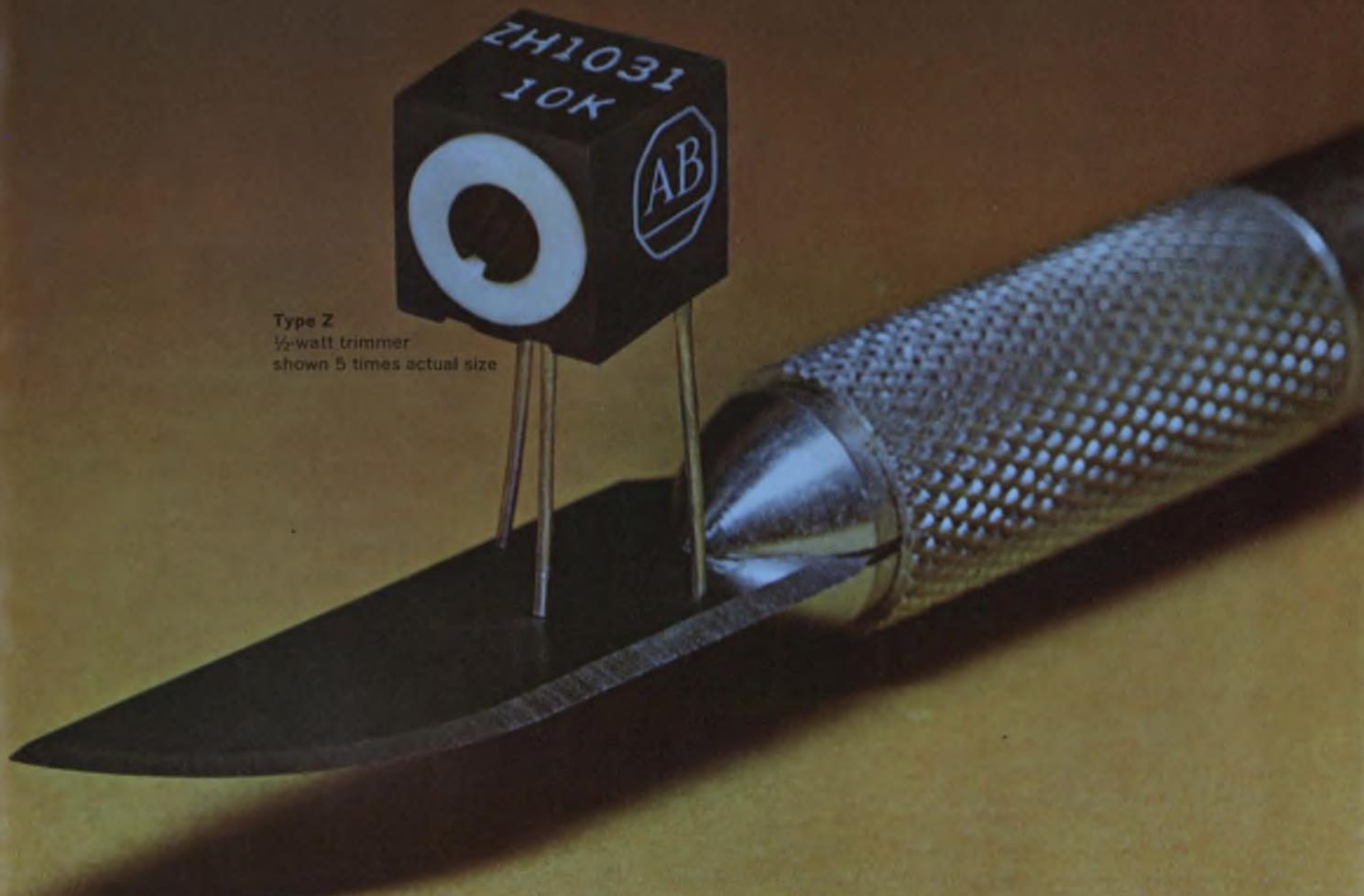
The very-low cost, all weather, electronic aircraft landing aid called Vorloc II has been accepted by the Federal Aviation Administration for use at airports. Selling for \$24,000, installed, the system puts instrument landings in a price range that small airports can afford.

Developed by Cubic Corp., San Diego, the system requires aircraft to have a localizer receiver and display—the same kind every plane capable of instrument landings has already. Anton B. Witzel, technical director of the project for Cubic, describes the operation this way:

"Vorloc II transmits on the ILS (instrument landing system) channels between 108 and 112 MHz. It uses phase comparison to generate 90-Hz and 150-Hz modulating tones. A combination of phase-modulated and amplitude-modulated carriers are transmitted from a two-element antenna 14 feet above the ground. The amplitude and phase-modulating components vary with the azimuth position of the receiving aircraft, to produce signals whose amplitude modulation components vary with azimuth.

The 90-Hz signal predominates when the aircraft is on the left of the proper course, and the 150-Hz signal predominates when the aircraft is on the right." ■■

# Allen-Bradley cuts space requirements with new sealed type Z cermet trimmers



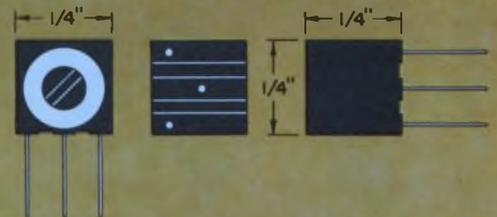
Type Z  
½-watt trimmer  
shown 5 times actual size

this latest addition to the Allen-Bradley line of cermet trimmers...the type Z...affords high performance in an especially compact package

The cermet material — an exclusive formulation developed by Allen-Bradley — provides superior load life, operating life, and electrical performance. For example, the full load operation (½ watt) for 1000 hours at 70°C produces less than 3% total resistance change. And the temperature coefficient is less than  $\pm 250$  PPM/°C for all resistance values and throughout the complete temperature range ( $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ).

The Type Z is ruggedly constructed to withstand shock and vibration. The unique rotor design ensures smooth adjustment and complete stability under severe environments. The leads are permanently anchored and bonded. The connection exceeds the lead strength — opens cannot occur. Leads are weldable.

The enclosure is *SEALED*. It is both dust-tight as well as watertight and can be potted. Mounting pads prevent moisture migration and also post-solder washout. You can get immediate delivery at factory prices from your authorized A-B industrial electronics distributor. Or write: Marketing Dept., Electronics Div., Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, N. J., U. S. A. 07003. In Canada: Allen-Bradley Canada Limited.



#### SPECIFICATIONS SUMMARY

- Adjustment:** Horizontal or vertical.
- Temperature Range:**  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .
- Resistances:** 50 ohms through 1 megohm.  
Lower resistances available.
- Tolerances:**  $\pm 20\%$  standard,  $\pm 10\%$  available.
- Resolution:** Essentially infinite.
- Rotational Life:** Less than 2% total resistance change after 200 cycles.
- Rotation:**  $300^{\circ}$  single turn.
- End Resistance:** Less than 3 ohms.



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# Cassette TV players face 'war' on 5 fronts

**Lack of standardization appears destined to spur fierce competition for sales and buyer confusion**

**John N. Kessler**  
News Editor

Remember these standardization battles: 33-rpm vs 45-rpm records . . . reel-to-reel vs cartridge audio tapes?

Will the cassette video player segment of the electronics industry, now emerging, be caught up in a similar struggle?

As matters stand now, it's almost inevitable that it will be, says Quantum Science Corp., a market and product planning concern with offices in New York City and Palo Alto, Calif. Five basic home video player designs are emerging, it reports, with at least a dozen variations of these five designs.

And the pity is, Quantum Science says, that TV players are destined to be the next big consumer electronics product on the market, with sales (both hardware and software) of \$1-billion projected by 1980.

In the U. S. it looks like a dog-eat-dog situation with no standardization in sight. An EIA spokesman points out that video cassette players are just coming on the

market, and "we have to see which product is viable—then the EIA will move in and set voluntary standards at the earliest possible point."

Samuel W. Gelfman, vice president for programming and production at Avco Cartridge Television, Inc., New York City, typifies the marketing attitudes of manufacturers: "We think we've got the best system. Let the best man win."

Already Motorola is producing the CBS-developed EVR system, but sales have been limited so far largely to educational and industrial users. Avco has announced that its Cartrivision cassette video tape system will go on sale to home consumers next April. Sony Corp. of America, New York City, will probably be out next, and its system will be compatible with helically scanned magnetic videotape recorders in Europe.

Last month Sony and Philips—along with other European and Japanese companies "agreed on the Philips helical-scan system as the basis for complete interchangeability

of cassette videotape recorders in Europe," according to a Philips spokesman.

Will the lack of standardization in the U. S. result in consumer resistance? Here's how Richard C. Hilton, senior scientist at Quantum Science in Palo Alto, sees the American market after study of the field:

"The companies are overly optimistic in their grand and glorious predictions of the new market in the next year or two. But by the end of this decade, it will be a strong and significant market, in view of the equipment and the software that goes with it. There is such a profusion of different types of playback and recording equipment that the consumer is likely to be confused by the whole thing. And he may hold off buying until he is assured that the system he buys is one he can get software for. There are at least a dozen incompatible systems."

The five basic contenders are:

- Helical magnetic tape. A system similar to voice tape recorders, it uses two or three rotating heads that move across the tape at an angle. (Avco, Ampex, others)

- EVR (electronic video recording. Essentially it's a movie film. It uses a fine-grained film in which the black-and-white images can be seen by close inspection; the color part is coded. (CBS-Motorola)

- SelectaVision. Also for playback only, it uses a laser beam to illuminate holographic images on Mylar tape. The information is embossed on the tape by thermo-mechanical means, in which a nickel master containing the holographic information is used to press out tapes the way records are made. (RCA)

- Super 8 movies. Adapted for viewing on home television sets via a videoplayer. (Kodak, others)

- Longitudinal magnetic tape. It uses a single fixed head. Since the tape speed must be 120 to 160 inches per second, this places stringent requirements on the tape transport mechanism and reels. (Arvin) ■■



**Home videotapes** in color and with sound are offered by Avco's Cartrivision system, due to reach market next year.

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**Signetics** 

## Diode laser array offers 30-to-40-W power

**RCA infrared source, developed for military, has possibilities for police and firefighting applications**

**Jim McDermott**  
East Coast Editor

Sight through fog, smoke and camouflage, or beyond blinding lights, may be at hand for the police, firefighters and civilian intrusion-detection systems through adaptation of a military development unwrapped by RCA at the recent Electro-Optical Systems Design Conference in New York.

The development? A 3.5-inch, high-power, invisible laser source, comprised of about 1000 gallium-arsenide (GaAs) diode lasers. The source gives a cone of coherent infrared (IR) radiation, with an exceptionally high injection-laser output of 30 to 40 W average, or 1.5 to 2 kW peak at 2% duty cycle, with a 4 A input. The new device

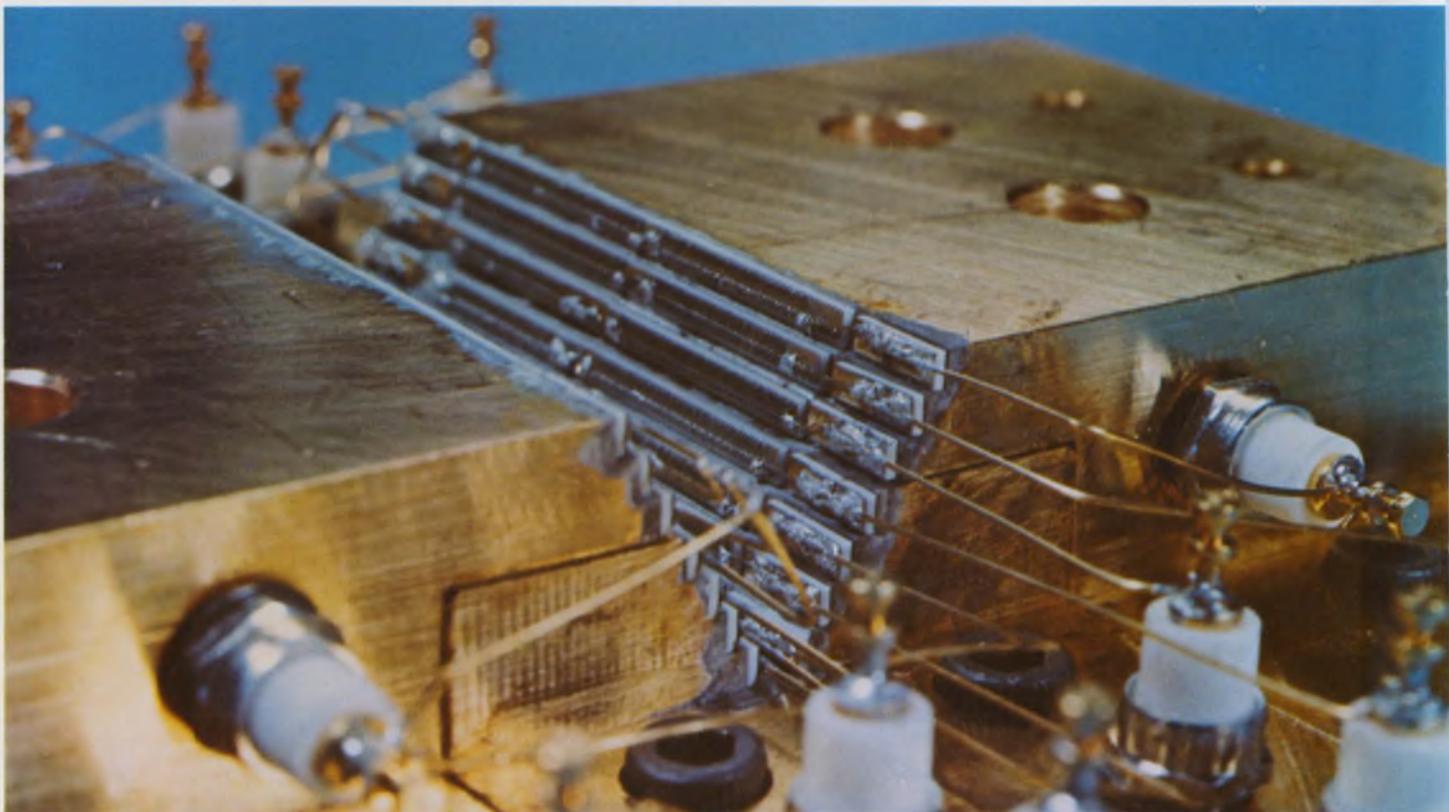
operates in the invisible IR region at 8850 Å and at a cryogenic temperature of 77° K. Reliability of better than 1000 hours has been demonstrated, RCA says.

The array was developed by the RCA Solid State Div., Somerville, N.J., for the Army Electronics Command in Philadelphia and the Army Night Vision Laboratories at Fort Belvoir, Va. The powerful IR source in military viewing systems uses pulsed-IR illumination in conjunction with synchronized image-intensifier viewers. These systems minimize back-scattering and other forms of optical interference by gating the image-intensifier tube ON for selected periods, during which the IR pulses, reflected from an obscure

target, impinge on the image-intensifier input screen.

The RCA laser array, according to Richard Glicksman, manager of semiconductor optoelectronics products engineering, provides a smaller system with greater optical efficiency than the older Xenon flashlamp sources. The array has a relatively small, 140-V dc power supply gated with 2- $\mu$ s pulses at 10 kHz. By contrast, the Xenon tube system requires a multi-kilovolt triggered power supply and is limited to a much lower pulse rate.

The high IR output of the new laser arrays is due, in part, to the high packing density of the diodes (see construction in photo). The radiation pattern is rectangular in form, with about a 2:1 ratio for the sides. Because of the discrete lobe of radiation from each subarray, an optical beam-smooth-



Detailed view of RCA's new 30-W, 1000-diode, gallium arsenide laser array. Emitters are 6-mils across and mounted on 10-mil centers for each of the 14 strings of

75 diodes. The arrays are operated by pulsing in the forward bias direction. The diodes in each string are wired in series, thus reducing required current drive.

ing element plus a lens, is needed to obtain a uniform, projected beam. With an optical system providing a square  $5^\circ \times 5^\circ$  beam, the IR illumination at 1000 yards is about 50-feet square.

Laser peak efficiency of better than 20% is achieved because of two factors: use of a "close-confinement" junction formation process plus a reflective end-coating process—two significant developments, Glicksman reports.

The close-confinement process, introduced by both RCA and Bell Telephone Laboratories, produces an optical waveguide effect in the emitting layer of the GaAs diode that sharply reduces internal losses, by preventing radiation leakage into the highly absorbing region adjoining the lasing region. In addition electrons are confined only to that portion of the material where the IR is emitted, and consequently the optical gain for a given current density is increased.

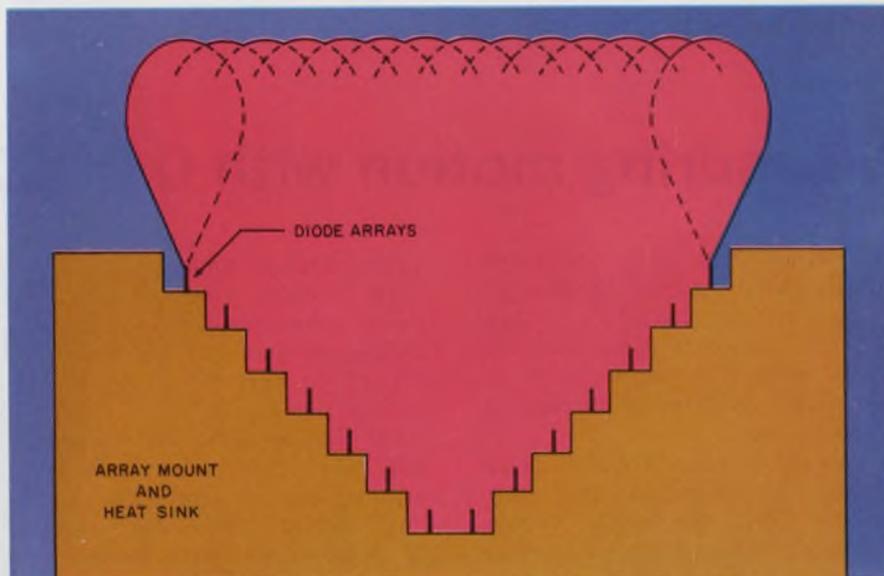
The special reflective coating on the back end of the laser chip is an RCA development, Glickman says. The coating reflects what would be wasted radiation out the back end of the laser diode; instead of exiting, the radiation rebounds and adds to the light emerging from the front end. At  $77^\circ \text{ K}$ , the useful power output is doubled. At room temperature ( $300^\circ \text{ K}$ ), the reflected power gain is about 40%.

### GaAs laser diodes combined

The 30-W injection laser array that has been constructed (see photo) is comprised of 28 individual strips of laser diodes. Two strips are mounted end-to-end to make 14 single strings, or sub-arrays of about 75 diodes each—a total of approximately 1000 diodes.

Each individual strip is made from a single 3-mil-thick wafer that is cleaved into a long sliver some 12 mils wide. This sliver is bonded to a supporting surface and is then notched, to give about 75 identical laser emitters per strip.

The emitters are 6 mils across and are mounted along the strip on 10-mil centers. Although each string of lasers emits its own beam, the total effective emitting area is  $2.7 \text{ cm}^2$ . The combined beam has a fan-out of greater than

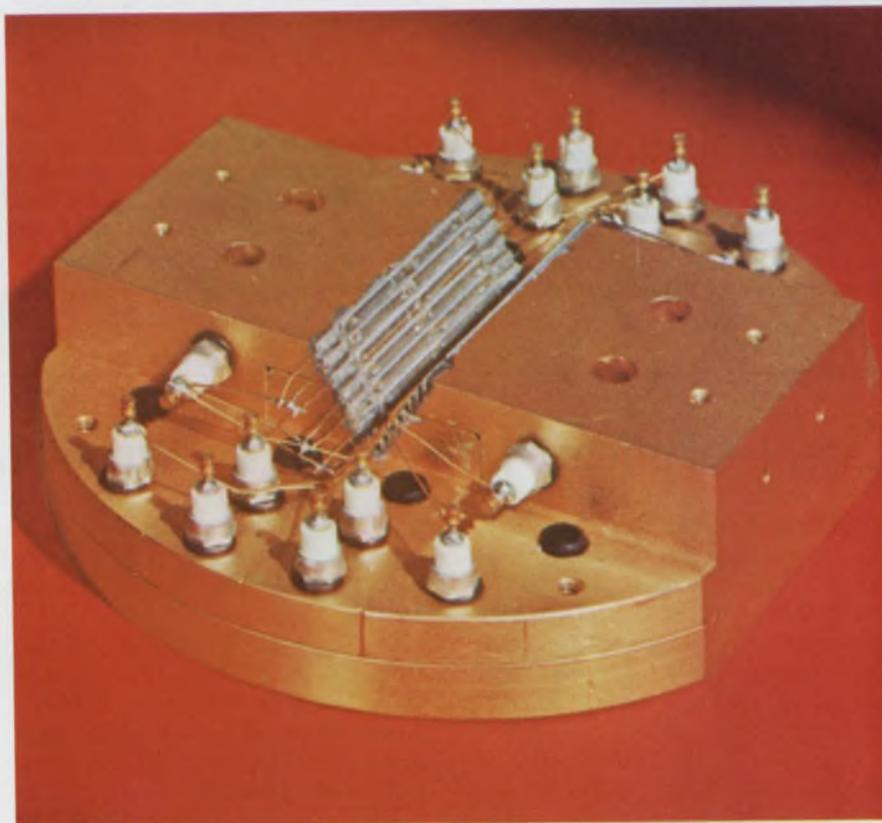


The radiation pattern of RCA's 1000 laser-diode array exits at right angles to the array base. The total output is the summation of the radiation from 14 strings of diodes. Optics smooth beam irregularities.

$45^\circ$ , but 90% of the power is radiated in a beam half-angle of  $22^\circ$ .

Advanced work is being done by RCA, Glicksman told *ELECTRONIC DESIGN*, on stacking two laser diodes one on the other, for each strip. The effect, Glicksman says,

will be to double the light output. And the better packing factor will give the same brightness in about half the space, thus simplifying the optics. Glicksman predicts this new stacked array will be available in the next year. ■■

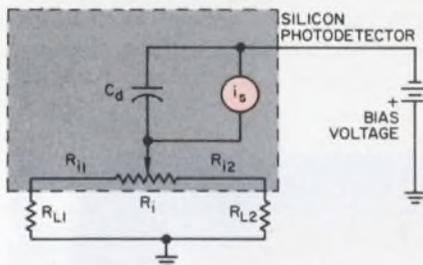


The 30-W, IR laser array is designed to interface with a flat,  $77^\circ \text{ K}$  surface. Invisible IR radiation, at  $8850 \text{ \AA}$ , is emitted from each diode string along each strip. Reliability of better than 1000 hours is reported by RCA.

## Measuring motion with 0.0001-inch accuracy

With a low-cost laser and a new silicon photodetector, it's possible to measure the change in position of a moving object more than 100 yards away. The resolution is reported better than 0.0001 inch in an x-y plane.

The silicon photodetector, manufactured by United Detector Technology Corp. of Santa Monica, Calif., is mounted on the moving object. A low-cost laser, such as a HeNe in the visible red, is mounted in a fixed position and focused on the center of the photodetector. As the object moves, the position of the spot on the 0.75-by-0.75 inch active area of the photodetector moves. The position of the spot on the active cell is determined by a



Position-sensitive photodetection can be accomplished through the use of this equivalent circuit. The motion of a moving spot of light on the surface of the photodetector corresponds to movement of center contact  $R_i$ .

nulling bridge technique.

Phil Davis, vice president of United Detector Technology, described the single-axis operation of the cell to *ELECTRONIC DESIGN* as follows:

"If we consider the measurement of position in just the x-axis, we can use an equivalent circuit (see figure). Since the detector is really a two-axis device, the second axis is merely the same equivalent circuit in the orthogonal direction.

"The input light spot generates a constant current,  $i_s$ . This current is generated at a particular point on the junction surface, which corresponds to a pickoff point on the internal resistance film,  $R_i$ .  $C_d$  is the junction capacitance. As the light spot moves around the surface, the pickoff point in the equivalent circuit moves across the resistive track. The current,  $i_s$ , is split into two legs  $R_{L1}$  and  $R_{L2}$ .

"The amount of current flowing in each leg depends on the resistance values  $R_{i1} + R_{L1}$  and  $R_{i2} + R_{L2}$ . If  $R_{i1} > R_{L1}$  and  $R_{i2} > R_{L2}$ , the current flowing in each leg depends entirely upon  $R_{i1}$  and  $R_{i2}$ , and these resistance values are linearly proportional to the light-spot position. By observing the voltage difference across  $R_{L1}$  and

$R_{L2}$ , the position of the light spot can be determined."

Signals from the position-sensing photodetector are then fed into a differential amplifier. The output is used to drive a nullmeter. The deflection of the nullmeter in the positive or negative direction corresponds to the deflection of the spot from the center of the detector. With an external nulling control, the nullmeter can be centered for a light spot that is anywhere on the active area of the cell, thus eliminating the need for exact alignment of the laser with the center of the cell.

Typical light impinging on the detector would be on the order of 1 mW. However, it is possible to handle larger amounts of power by adjusting the bias current.

Davis notes that the cell can be used for automatic positioning by merely taking the output of the differential amplifiers and using them to drive the light source to a desired position through a servo system.

Other applications that Davis cites include monitoring for machine-tool flatness, skew and levelness, measuring vibration amplitude and frequency in two simultaneous axes, and auto-collimating a laser. ■■

## Laser heat offers a faster way to make photomasks

An experimental laser technique that harnesses the device's heat rather than its light permits the simultaneous production of positive and negative photomasks for integrated circuits—a process that ordinarily requires several image-reversing steps.

Described at the fall meeting of the Electrochemical Society by Dr. Wayne Moreau, an engineer at the IBM Components, Div., East Fishkill, N. Y., the method uses a power pulse of laser thermal energy, last-

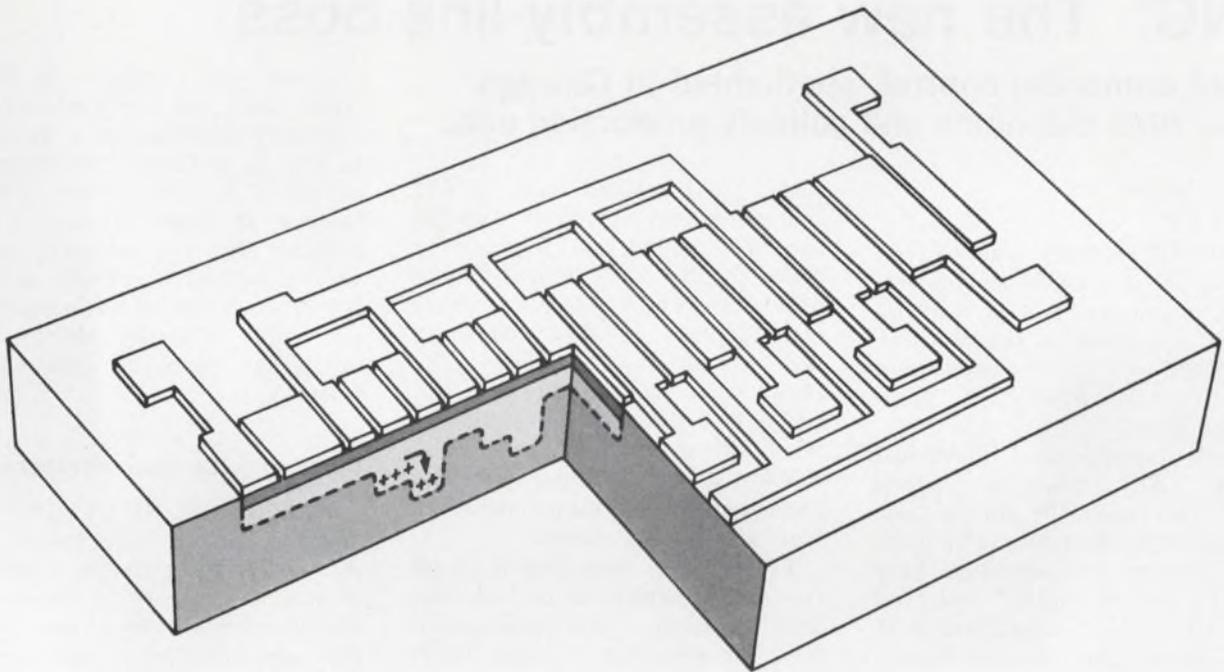
ing a few billionths of a second, to evaporate a metal image from one glass surface and deposit it on another.

A glass plate, coated on one side with 1000 Å of chromium, is sandwiched in a vacuum frame between a master mask and a clear glass plate, Dr. Moreau told the meeting in Atlantic City, N. J.

This sandwich is then aligned at right angles to the optical path of a ruby laser, which emits a 1-to-3-joule pulse lasting 15 ns. As the

beam passes through the clear portions of the mask and strikes the chromium layer, it causes a portion of the metal to pass into the gaseous state. But the gas instantly condenses against the surface of the adjoining glass plate, thus depositing a thin, opaque metal film that has the form of an IC pattern.

The original metal-coated glass plate has now become a positive photomask, and the second glass plate is the negative photomask, each with the original pattern. ■■



**Functional device without junctions**

A junctionless semiconductor device that performs complete circuit functions has been invented by Bell Labs scientists Willard Boyle and George Smith. It may replace complex integrated circuits for information storage and other processing.

The new device consists of a layer of semiconductor (silicon) covered by a layer of insulation (silicon dioxide), with a row of closely spaced metal plates on top of the insulation. It operates much like an array of capacitors passing a stored charge—representing a binary information bit—from one capacitor to the next.

If all plates are held at a small negative voltage, the charge (holes) will remain stationary . . . stored in so-called "potential wells" below

the plates. If, now, a stronger negative pulse is applied to a plate adjacent to one under which charge is stored, the charge will "spill over" into the deeper potential well thus produced (figure). So, charges can be shifted, plate by plate, along the surface of the semiconductor.

One use is as a shift register. Holes may be created at one end, moved along the semiconductor surface, and detected (read out) at the other end. Charge can be detected through the capacitance change it causes when present under a plate. The basic shift register may be used as part of a recirculating memory or as a delay line.

The new device can also convert images to electrical signals. By projection through a narrow slit, one horizontal strip of the image is

focused on the semiconductor. Beneath each plate, this produces charge proportional to brightness. The shifted-out charge stream is an analog of that strip. Successive strips compose a complete image.

The first device was made of silicon. But since junctions are not needed, devices can be made from many semiconductors.

The device is so new that we haven't explored all possible applications. But its simplicity promises high reliability. And the comparatively few steps required to make it will keep costs low. We expect it to have considerable impact on telephony and on other high-volume information systems.

From the Research and Development Unit of the Bell System:



**Bell Labs**

# DNC: The new assembly-line boss

Direct numerical control, spotlighted at Chicago show, runs machines and collects production data

John F. Mason  
News Editor

CHICAGO—Direct numerical control (DNC)—machines controlled by computers—was by far the biggest attraction at the Machine Tool Show here and its companion exhibition, the Production Engineering Show.

Unlike tape-operated numerical control (NC) machines, which broke down repeatedly during their show debut in 1960, the 70 or more DNC systems demonstrated here "worked like a charm," observed W. J. Frank, a systems planner at the General Electric Co.'s Manufacturing Automation Systems Operation in Charlottesville, Va. "I think everyone was surprised at how little down time there was with all the DNC systems on exhibit. And this is a rough environment. It's hot, dusty and, in spite of the size of these buildings, cramped for space."

The space consisted of approximately 18 acres. But the machines were big and there were a lot on display. The Machine Tool Show, which ended Oct. 2 in Chicago's International Amphitheater, exhib-

ited 1000 machines built by 170 companies and valued at \$40-million. The Production Engineering Show in the Navy Pier Building demonstrated 12,000 products manufactured by 372 companies and valued at \$20-million. The shows were sponsored by the National Tool Builders Association of Washington, D. C.

Visiting the exhibits were an estimated 80,000 machine-tool users from all over the world.

The common denominator of all the direct numerical control systems on display was automation, with the computer portions ranging from a small minicomputer to a large general-purpose machine. What the systems automated, however, varied.

Besides operating machine tools directly from a computer core memory, the systems controlled the movement and storage of materials, supervised production and fed back management information to the computer.

"The big advance in the whole DNC concept," said E. J. Loeffler, technical director of the National Machine Tool Builders Association,

"is that the computer is finally right down on the factory floor operating machine tools. It's built to live in a factory environment, not off in an air-conditioned room. Instead of tapes, it uses a core memory that can be easily reprogrammed. And it operates a number of machines at the same time, all doing different things, and capable of changing jobs at any time."

## Cores and ICs spur advances

R. T. Blakely, GE's project manager in Charlottesville, noted: "One reason DNC is possible is because of advances in core memories. The manufacturing costs of core memories have been cut in half, making the minicomputer economical. They are three times faster than they were, thus enabling them to do more work. And the minicomputer's architecture has been changed.

"In the past," Blakely said, "to reach the memory, the instructions and the memory data had to go through the central processor. Now, with the memory bus, the memory is directly accessible by peripheral devices. The memory is shared by the input-output devices and the central processor."

Blakely also pointed out that the evolution from transistors to ICs and to LSIs had made a cheaper, more reliable product.

This increased computer capability, Loeffler added, has enabled the machine tool's controller to be a simpler, smaller machine. "The computer does arithmetic computations that used to be done in the machine controller, and it tells the controller what to do," he said. The controller is the last link before the machine itself.

"The larger memory also permits a machine-tool operator or foreman to talk back to the computer," Loeffler continued. "A qualified operator can modify a program, or he can ask the computer to solve a problem. For example, he may tell the computer



Adaptive control was the featured capability of several direct numerical control systems at the Machine Tool Show, including this system by Bendix.

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## NEWS

(DNC, *continued*)

that a hole should be in a different place or that the size is wrong. The computer then takes over and changes its instructions to the controller."

The trend, Loeffler pointed out, is to give simpler information to a computer and let it do the calculations and the work. "In this way, less qualified people can work with the computer," he noted.

Manufacturers cautioned, however, that the software costs for such a brainy system might be higher than keeping a programmer on the payroll.

A big advantage of DNC, Loeffler said, is its factory feedback capability. "At the same time a computer is controlling 10 or 15 machines, it is collecting production data from these machines. Is the machine overloaded? Is the cutting edge getting dull? Should a part be replaced? How long is the production of each item taking? What is the inventory at this moment of finished products, of raw material?"

### Variety of systems debut

Typical of the systems on exhibition was the new CommanDir, Run by a GE-PAC 30 processor and a GE-PAC 4020 data processor, it operated 10 machines. The system, which is capable of handling up to 30 machines, was built by GE's Manufacturing Automation Systems Operation in Charlottesville.

Another system, the Omnicontrol DNC, operated six machines at the show, though with a full hierarchy of equipment, it reportedly can handle 256. It was built by Sunstrand Corp.'s Machine Tool Div. at Belvidere, Ill., and it uses an IBM 360-30 or Digital Equipment Corp. PDP-11.

Cincinnati Milacron's DNC, also shown, is built to operate with a variety of computers, "starting small and growing in logical, economical steps," according to a company spokesman. In one configuration, the system will control 64 machines or process stations.

Kearney & Trecker's System Gemini used a Hewlett-Packard 2114B minicomputer as a satellite to run up to eight machines. It can also operate several minicomputers

via an IBM 1800.

Westinghouse Electric's new DNC system, unveiled at the show, was controlling a 3-axis Burgmaster drill via a Westinghouse P-2000 computer. In a plant the company is building, the DNC system will control up to 35 machines.

Westinghouse also showed a unit that operates a machine without a feedback capability. Others of this type were displayed by Bendix Corp., Ann Arbor, Mich.; Digital Equipment Corp., Maynard, Mass.; the Xenox Corp., Waltham, Mass., and Allen Bradley, Cleveland.

A production monitoring system that automatically sends performance data on 200 or more machines to a central memory and printout display was offered by A. B. Dick, Chicago.

A people-oriented production monitoring system that provides data on departments, personnel and factory positions, was shown by the Singer Friden Div., San Leandro, Calif. The factory system is similar to the company's point-of-sale system being built for retail stores (see "Magic Wand Terminal to Speed Store Sales, ED 21, Oct. 11, 1970, p. 46).

One of the most important efforts to improve DNC systems right now is adaptive control. Only

### DNC vs NC

What is the difference between direct numerical control (DNC) and numerical control (NC) in systems to operate machines?

NC is a one-way street. Paper-taped instructions are prepared on an off-line computer system and put into a machine controller, which operates the machine.

DNC sends instructions to the machine controller directly, without tape, and then permits information from the machine controller or the machine to flow back to the computer.

When an NC unit needs reprogramming, the tape has to be taken back physically to the off-line computer and reprocessed. With DNC, reprogramming can be requested by the machine-tool operator on the floor by direct link to the computer. This saves time and money and provides a control not possible with NC.

4 or 5% of the 70 DNC machines demonstrated at the show offered any adaptive control, and most of these were lathes.

"The computer is ideal for providing adaptive control," Loeffler said: "It can sense that a cutting tool is worn and is not cutting the designated amount. It can compute the error and move the cutting tool over accordingly."

The Dynapath System 4, built by Bendix Corp.'s Industrial Control Div. in Detroit, demonstrated its adaptive control capability with a Jones and Lamson Combi 312 lathe. Instead of programming feed rate, the maximum tool force was programmed and the lathe was equipped with a sensor. When the force sensor detected too much force, the computer adjusted the lathe.

When the part processor had difficulty in determining the desired feed rates because the workpiece was unpredictably hard or the cut was deeper than usual, the system would not allow the cutting to proceed fast enough to damage the cutting tool.

GE displayed an adaptive control device that sensed the power being used by the machine tool spindle and automatically adjusted the feed rate.

Cincinnati Milacron showed a unit that controlled feed rate as a function of tool deflection.

### Software problems remain

When will automatic factories become commonplace in the U. S.?

"We could have an automatic factory tomorrow if we wanted to pay the price," said GE's Frank. "Technically there is no reason it can't be built. Economically, however, it is cheaper to leave people in certain places to perform decision-making functions than trying to build such a capability into the system. Software can be far more expensive than a technician."

But the exhibition was a big help in demonstrating the potential of direct numerical control.

"Conditions are right for DNC," said GE's Frank. "Money is scarce, overhead and taxes are high, and competition is keen. DNC answers these complaints by cutting personnel and speeding up production." He added: "This show has put DNC on its feet and running." ■■

# Technology Abroad

A simple method of recording holograms of objects subject to intentional or unintentional movement has been discovered at the Brown Boveri Research Center in Baden, Switzerland. When a small mirror that reflects the reference beam is attached to the object, the phase angle needed for production of a hologram remains constant, despite any motion. The new method overcomes a principal difficulty in recording holograms—namely, that the apparatus must remain stationary to within a fraction of the laser's wavelength during the exposure, which may last from seconds to minutes. Any movement of the object ordinarily changes the phase angle between the two beams and results in a photographic blur. In the Brown Boveri method, holography is possible without special antivibration tables for the optical setup. A practical application of the new method is the measurement of relative motion in mechanical systems.

A thermometer that determines the temperature of conducting bodies by measuring their electrical noise has been developed in the Soviet Union. The new instrument, designed by Leningrad engineers, uses a phenomenon predicted by Albert Einstein at the beginning of the century. He pointed out that it was possible to determine the temperature of a conductor by measuring the thermal electrical noise produced by movement of ions and electrons in the conductor. The Russian thermometer can measure electrical noise as low as one-billionth of a volt. The operating range is 1-100° K.

A third 97-foot-diameter antenna for the satellite earth station at Goonhilly Downs, Cornwall, England, is expected to be in service by 1972. The antenna, to be built by Marconi for the British Post Office, is designed to work with Intelsat IV satellites that are to have four times the capacity of the

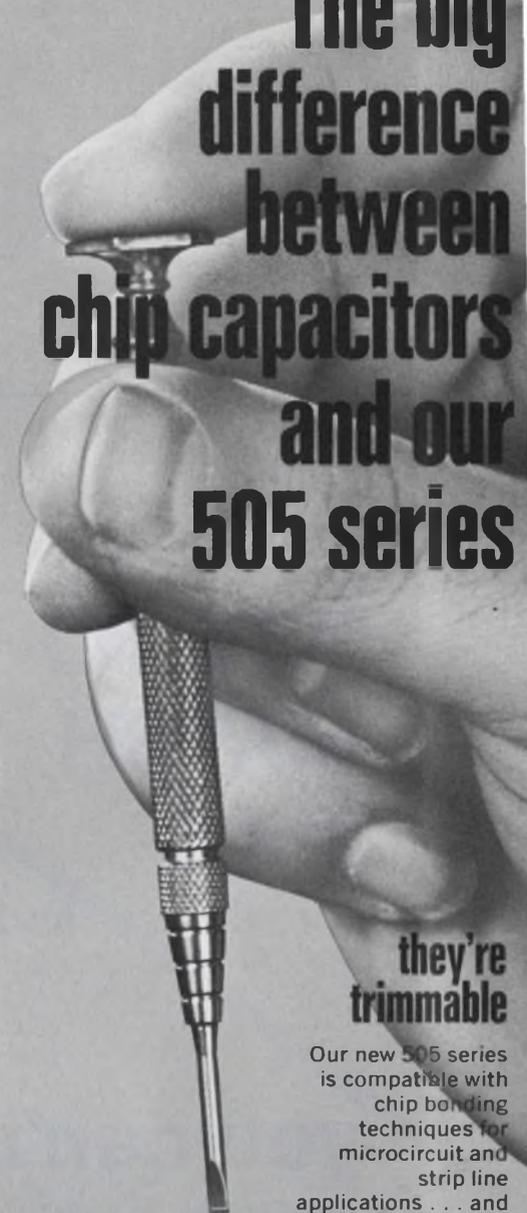
present Intelsat III system. The first Intelsat IV satellite, scheduled for launching into a synchronous orbit over the Atlantic next year, will be able to carry up to 5000 two-way telephone calls. Even without Intelsat IV, a third antenna would have been needed at Goonhilly to provide for current growth in traffic across the Atlantic. The demand for telephone, telegraph, computer data transmission and other facilities is expanding rapidly enough to exhaust the capacity of both Atlantic Intelsat III satellites by the time the new antenna is ready.

The best features of British and West German numerical machine-control computer programs have been assembled in one program by the British National Engineering Laboratory and German Tool Institute of the Technical University at Aachen. Known as 2c,L-EXAPT 1, the program can produce tapes for numerically controlled milling and drilling machines. Components that require both contour milling and hole-making operations can be machined with a single setup on a machining center.

Electronically controlled navigational buoys as possible replacements for lightships of the United Kingdom lighthouse authority are being investigated by the British government. The buoy prototype, manufactured by Hawker Siddeley Dynamics Ltd., weighs 84 tons, is 40 feet in diameter, and has lights and horns for warning. It will be moored off the channel coast later this year. On-board systems—powered by three 5-kW diesel generating sets—are to be shore-monitored every half hour by a telemetering link.

The shore-based control station can perform 40 separate systems checking operations and regulate 22 different buoy operations. Data transmission from buoy to shore is handled by means of a uhf-frequency shift keying system and colinear antennas. On-shore receiver and transmitter antennas are each 12-element Yagis. Redundant systems are included throughout the buoy.

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# Washington Report

DON BYRNE, WASHINGTON BUREAU

## Election stymies controversial legislation

The specter of Election Day hangs heavy over Congress, and it appears almost certain that proposed funding for the supersonic transport and the committee action on the controversial foreign trade bill will not be considered until after Nov. 3.

The \$294-million authorization for the SST has been stalled in the Senate for months, with neither side sure of enough votes to pass or defeat the measure. Senate sources say the plan of action for the SST is to put off the vote until after the election and then add "sweeteners" to draw liberal votes. The sweeteners are expected to come in the form of amendments that would prevent flights over populated areas and otherwise curb environmental pollution by the new aircraft.

Meanwhile the Senate Republican leader, Hugh Scott (R-Pa.), says he will support a measure to bring the foreign trade bill to the floor of the Senate as an amendment to some other measure, thus by-passing committee hearings. As it now stands, the bill limits imports of shoes and textiles but leaves the door open for limitation of imports in virtually any other industry.

Scott told the Senate recently: "I believe we ought to go further, to include other industries that have been hurt by imports . . . Why then should we exclude electronic products [from import taxes]?"

## Bill would force defense plants to convert

Sen. George S. McGovern (D-S. Dak.), a leading Congressional dove, has introduced legislation to force defense and space contractors to plan post-war conversion to civilian production. McGovern's bill would require 12.5% of a defense contractor's profits from defense and space work to be set aside as a conversion reserve, held by a National Economic Conversion Commission. The funds would be used to finance contractor conversion plans and to pay benefits to employees who might face unemployment during the conversion period. Once switched over to civilian work, the contractor could petition for any funds of his remaining in trust, and they would be returned with interest, tax-free. Failure to convert could mean that all the contractor's money would be used up in unemployment benefits.

## Ex-Bell official wins rapid Senate approval

In what might have been record time the Senate rapidly approved George F. Mansur Jr., former Bell Laboratories official, as deputy director of the Office of Telecommunications Policy. Spectators were still filing into the Senate Commerce Communications Subcommittee hearing room when the session adjourned. Chairman John O. Pastore, (D-R. I.) and Sen. Howard H. Baker Jr. (R-Tenn.), the only two members present, had no questions for Mansur. The gavel rang down after the nominee put a page-and-a-half statement into the record. The full committee promptly

approved him, and two days later his nomination was approved by the full Senate.

Mansur is joining a federal office that Commerce Secretary Maurice Stans plans to reorganize. Under the new setup, the Office of Telecommunications will undertake technical and economic studies for the newly created, independent Office of Telecommunications Policy. The Institute of Telecommunications Sciences, formerly housed in the Weather Bureau, will move and be under the jurisdiction of the reorganized Commerce Dept. office.

## FAA backs hybrid satellite system

The Federal Aviation Administration has altered its stand on the type of satellite communications system it favors for aeronautical use. Administrator John H. Shaffer now says the agency favors a hybrid system using both vhf and uhf for ocean communications. The FAA and NASA had previously been leaning toward uhf, which is favored by most European airlines but not the U. S. carriers. Taking note of the European position, Shaffer says his agency will temporarily abandon plans for a satellite over the North Atlantic and switch to the North Pacific, "where the FAA has the primary responsibility for air traffic control." Shaffer says he believes a first-generation satellite, providing vhf for early operational use and uhf for experimentation, can be made available by 1973. Plans to use the satellite for surveillance, opposed by the airlines as too soon and too costly, are being soft-pedaled by FAA. The subject will be considered Jan. 11 to 22 in Montreal at an International Civil Aviation Organization air navigation subcommittee meeting.

**Capital Capsules:** NASA plans to switch to the metric system in reporting data in most of its technical publications and reports. The space agency has been cooperating since 1968 with a Commerce Dept. study on the advantages and impact of a switch to the metric system. The idea was first proposed to Congress in 1790 by Thomas Jefferson. . . . A 6.4-million request for data-processing equipment by the Defense Communications Agency has been killed by the House Appropriations Committee because of system design difficulties. The committee said it would await the results of a study now under way by the General Accounting Office on the agency's proposed world military command and control system. The final costs could run as high as \$1-billion. . . . The House has approved \$3.1-billion over the next five years to help cities build and improve mass transit systems. Senate passage is expected. The bill allows for multi-year planning and funding, thus almost completely bypassing the uncertainty of Congressional appropriation procedures. . . . Hughes Aircraft has won a \$82-million contract for the multimode radar for the McDonnell Douglas F-15 in competition against Westinghouse. The two companies will compete again for the radar contract for the Airborne Warning and Control System (Awacs).

# A NEW SPECTRUM ANALYZER SYSTEM

The New Tektronix 1401/323 Spectrum Analyzer System is for people who like to travel light.



The 3½ x 8½ x 13-inch 1401 Spectrum Analyzer Module weighs only eight pounds including an internal rechargeable battery pack.

Add a 323 Sony/Tektronix Oscilloscope for a display indicator: Total weight of both? Less than fifteen pounds!



For fifteen pounds, here's some of what you have: A portable, 1-to-500 MHz analyzer with 60-dB dynamic range and up to 500-MHz frequency span—plus a complete DC-to-4 MHz, 10 mV/div, DC powered (AC, too) oscilloscope.

AND FOR PRESENT SCOPE OWNERS: The 1401 Spectrum Analyzer Module is compatible with any oscilloscope with full-screen deflection of 5-volts horizontal (adjustable ±10%) and 1.2-volts vertical.

**WEIGHS ONLY 15 LBS.**



When you make local service calls or field trips, climb towers, are in and out of airplanes and ships, and use spectrum analyzers and oscilloscopes, take along the New 1401 and the 323. With this pair of light-weight performers you'll travel easier and solve more field problems with much less effort.



For additional information contact your local Tektronix Field Engineer or see the 1970 Tektronix catalog supplement.

1401/323P7 Spectrum Analyzer System ..... \$2860  
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# BULOVA Crystal Oscillators with high stability over extended temperature ranges

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## TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR

Frequency Stability:

$\pm 5 \text{pp} 10^7$  over temperature range of  $-55^\circ\text{C}$  to  $+85^\circ\text{C}$ .

Employs a computer-selected and optimized compensation network designed to maintain frequency stability over wide temperature ranges without the need for an oven ( $\pm 0.5 \text{PPM}$  from  $-55^\circ\text{C}$  to  $+85^\circ\text{C}$ ). Operating over a frequency range of 3MHz to 5MHz, it consumes only 50MW and is just four-cubic-inches. Aging rate is  $1.0 \text{pp} 10^8$  per week.



PCOXO-101

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Frequency Stability:

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If you have a crystal oscillator problem that needs solving, call (212) 335-6000, see EEM section 2300, or write —



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## Inside a giant industrial show

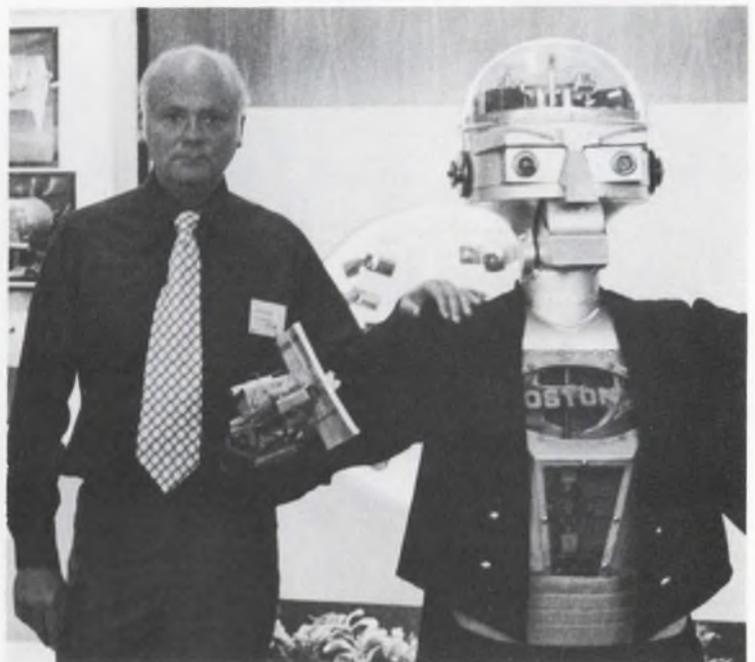
"Big, hot, noisy"—these are the words that News Editor John F. Mason used to describe the recent Machine Tool Show and its companion exhibition, the Production Engineering Show, both held in Chicago.

Imagine 18 acres of exhibition space crammed with working industrial machinery—some of it two stories high—and you will understand the "big." As for the heat, the thermometer registered  $92^\circ$ . And as for "noisy," Mason lost his voice trying to get the story that begins on p. 38.

The main attraction of the show was electronics—in particular direct numerical control (DNC)—computer-operated machines that drove lathes, cutting machines and other tools. But scene stealers were the industrial robots that worked day and night in a comically monotonous manner. Industrial robots make no attempt to look like men—they leave that to North American Rockwell's veteran show stopper, a robot that for some 30 years has been a professional hand-shaker.

Industrial robots can learn to do a repetitive task like stacking parts. Many of them bustle about, transferring parts from one machine to another. They can also do tasks that human beings can't do at all—like picking up pieces of hot steel from the furnaces and dumping them into water to cool off.

Automation was the theme of the show—and automation in many forms is what 80,000 viewers got. Mason stayed a week to get technical details on the exciting developments in industrial electronics.



News Editor John F. Mason stops at the Production Engineering Show in Chicago to visit with North American Rockwell's robot.



## Look at Acopian's new mini-module dc power supplies

Look at their size. Single output models (there are duals, too) are as small as 2.32" x 1.82" x 1.00". And they can all be soldered directly into printed circuit boards.

Look at their performance. Load and line regulation is 0.02 to 0.1% depending on the model selected. Ripple is only 0.5 mv RMS. And Acopian's long experience in power supply technology assures high reliability.

Look at the choice of outputs. There are 58 different single output modules ranging from 1 to 28 volts, 40 ma to 500 ma. Duals are available in 406 different combinations

of voltages. And these are true dual power supplies, with like or different outputs in each section that are electrically independent of each other. Perfect for powering operational amplifiers. Or for unbalanced loads.

Acopian mini-module power supplies		
	Singles	Duals
Output Voltages (vdc):	1 to 28	1 to 28
Output Currents (ma):	40 to 500	40 to 250
Line and Load Regulation:	0.02 to 0.1% depending on model	
Ripple:	0.5 mv RMS	
Ambient Temperature (without derating)	0 to 55°C	
Polarity:	outputs floating and isolated	

Look at their price. Single output models start at \$39, duals at \$58.

For a look at all the facts, write or call Acopian Corp., Easton, Pa. 18042. And just like Acopian's other 82,000 power supplies, every mini-module is shipped with a tag that looks like this . . .



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**★ NOTICE ★**

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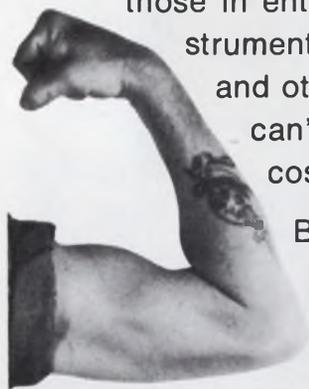
# \$OLID TANTALUM\$

## Who says you can't afford them?

All solid tantalums are not created equal...

It's true. There *are* critical circuits in life-saving medical devices and in outer space guidance systems that demand the kind of solid tantalum capacitors that are expensive.

However, maybe you work with circuits that do not require space system reliability, like those in entertainment systems, instruments, computers, avionics, and other industrial uses, and can't afford capacitors that cost a lot of money.



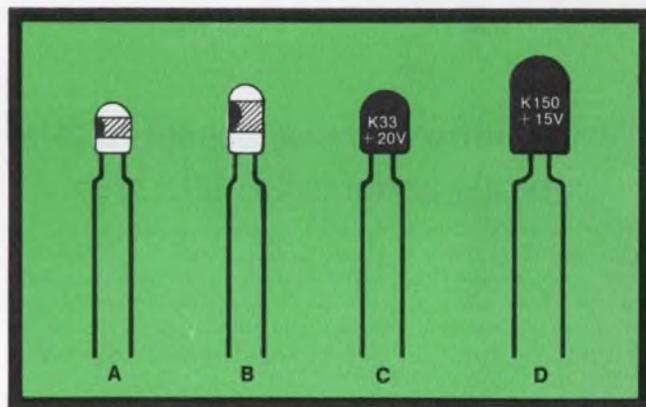
But, you still need capacitors with muscle. You don't want to give up everything for price.

For instance, you want dependable shelf and operational life without rejects—without trouble—just good dependable capacitors at a low, low price . . . and with good delivery time. (For example, all CV ratings from stock or up to four (4) weeks maximum.)

**KEMET® E Series Dipped Solid Tantalums are the answer.** 4 Case Sizes—plug in radial leads on either .125" or .250" centers—0.1 to 330uf, up to 50 volts. -55°C—85°C tempera-

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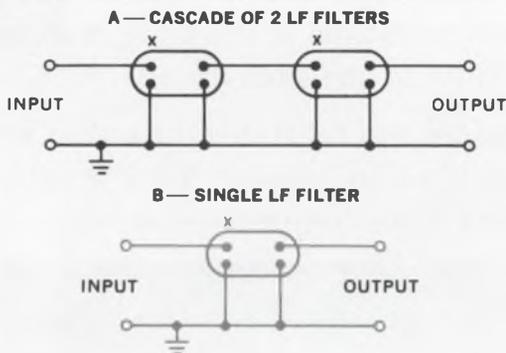
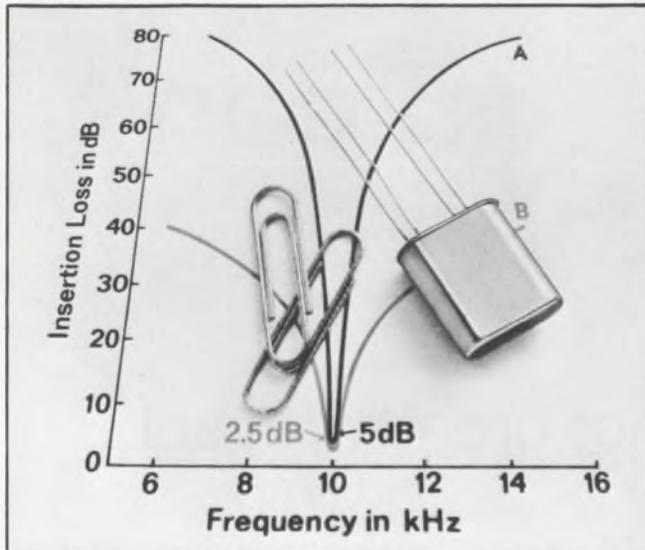
formation and free samples, or write **Union Carbide Corporation, Components Department, P.O. Box 5928, Greenville, S.C. 29606. Tel. (803) 963-7421.**



THE DISCOVERY COMPANY

INFORMATION RETRIEVAL NUMBER 25

# Breakthrough in low frequency filtering!



## New Vernitron ceramic bandpass filter puts big performance into 1/4 oz.

Vernitron low frequency (LF) ceramic filters—from 9 to 50 kHz—are about one-tenth the size and weight of comparable conventional types—have narrower bandwidths, lower insertion loss and greater stability. This means you can pack more channels into a given portion of the spectrum with less sacrifice in volume and weight. They're fixed tuned, so you have no installation adjustments, simpler assembly and inspections.

Typical characteristics: 1% min. 3 dB pass bandwidth, 20 dB/3 dB bandwidth ratio not exceeding 13, and passband insertion loss less than 5 dB. Stopband attenuation exceeds 30 dB from dc to above 100 kHz. For even better selectivity they can easily be cascaded without worrying about matching or big insertion losses.

All this performance comes in a miniature HC-6/U can that weights just 1/4 ounce (it's shown here actual size). They're hermetically sealed, immune to environments . . . there's no need for magnetic shielding. And LF filters are independent of the power source, so there's no current drain.

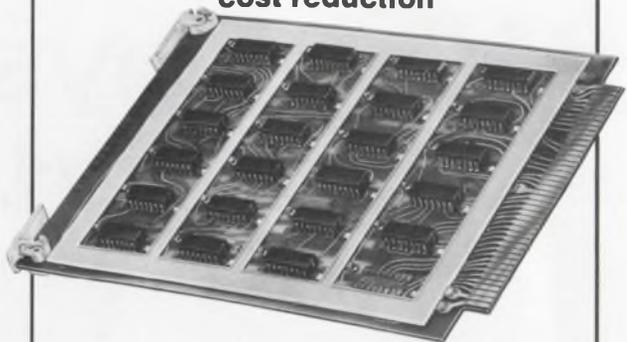
New Vernitron LF filters are ideal for low frequency communications receivers, control circuits, selective calling systems, underwater sound systems and military/navigation systems. Write today for full specs and technical data. Vernitron Piezoelectric Division, 232 Forbes Road, Bedford, Ohio 44146, U.S.A. Or: Vernitron Limited, Southampton, England.

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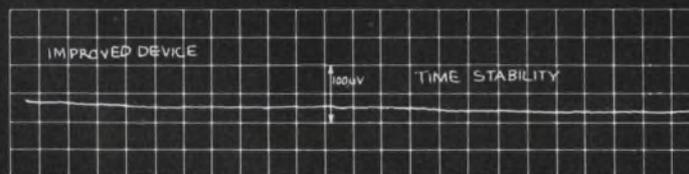
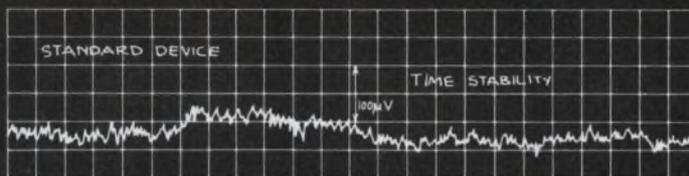
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# Centralab Introduces THE PACERS

*the most stable temperature-compensated reference diodes offered—voltage stability within 10 ppm/1000 hrs.*

1N821  
thru  
1N829A  
1N935  
thru  
1N939B  
1N941  
thru  
1N945B  
1N1735  
thru  
1N1742A  
1N3154  
thru  
1N3157A  
1N4565  
thru  
1N4569A  
1N4570  
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1N4574A  
1N4575  
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1N4579A  
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1N4765  
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1N4769A  
1N4770  
thru  
1N4774A  
1N4775  
thru  
1N4779A  
1N4780  
thru  
1N4784A  
1N430, A  
1N1530, A

- In our new **Pacers** near-perfect combination of planar reverse biased chip and proprietary-process forward-biased chips assures time stability of reference voltage previously available only at extreme price premium.
- Average long-term stability of reference voltage: 10 parts per million per thousand hours. Customer tests demonstrate exceptional short-term stability, minimal "warm-up" time (see actual plot of these voltage/time tests shown below).
- Our **Pacers** exhibit lower noise than products previously available — both low frequency and broad band.
- And the **Pacers** exhibit significantly lower dynamic impedance.



JAN devices available.  
All JEDEC numbers competitively priced and ready for delivery.

**CHALLENGE US! PLEASE REQUEST COPIES OF OUR FACTORY TEST DATA AND SAMPLES TO EVALUATE FOR YOURSELF ON YOUR COMPANY'S LETTERHEAD.**

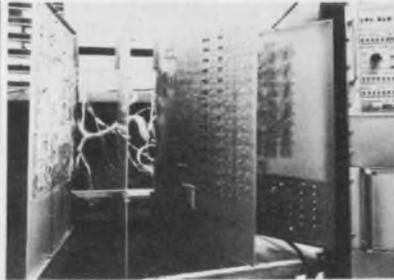
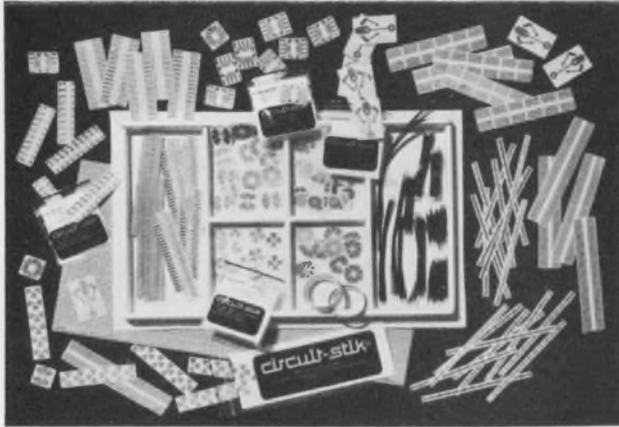
*NEXT MONTH: Hi-Rel Rectifiers*



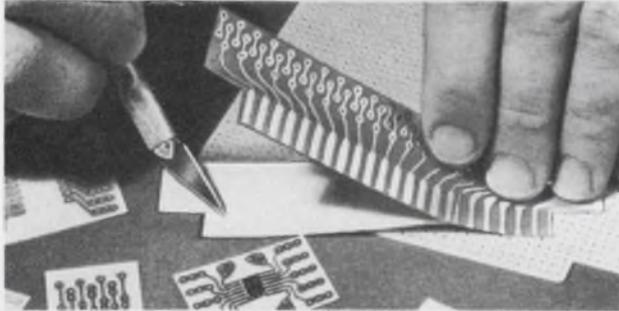
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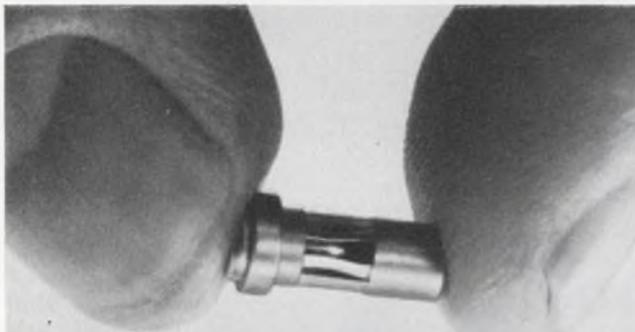
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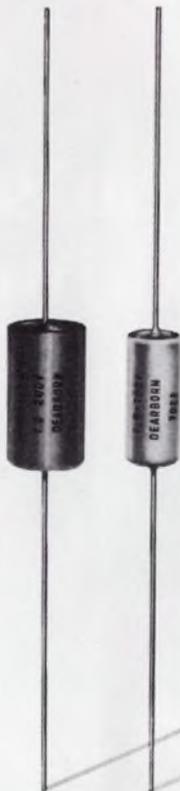
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INFORMATION RETRIEVAL NUMBER 73

ELECTRONIC DESIGN 22, October 25, 1970

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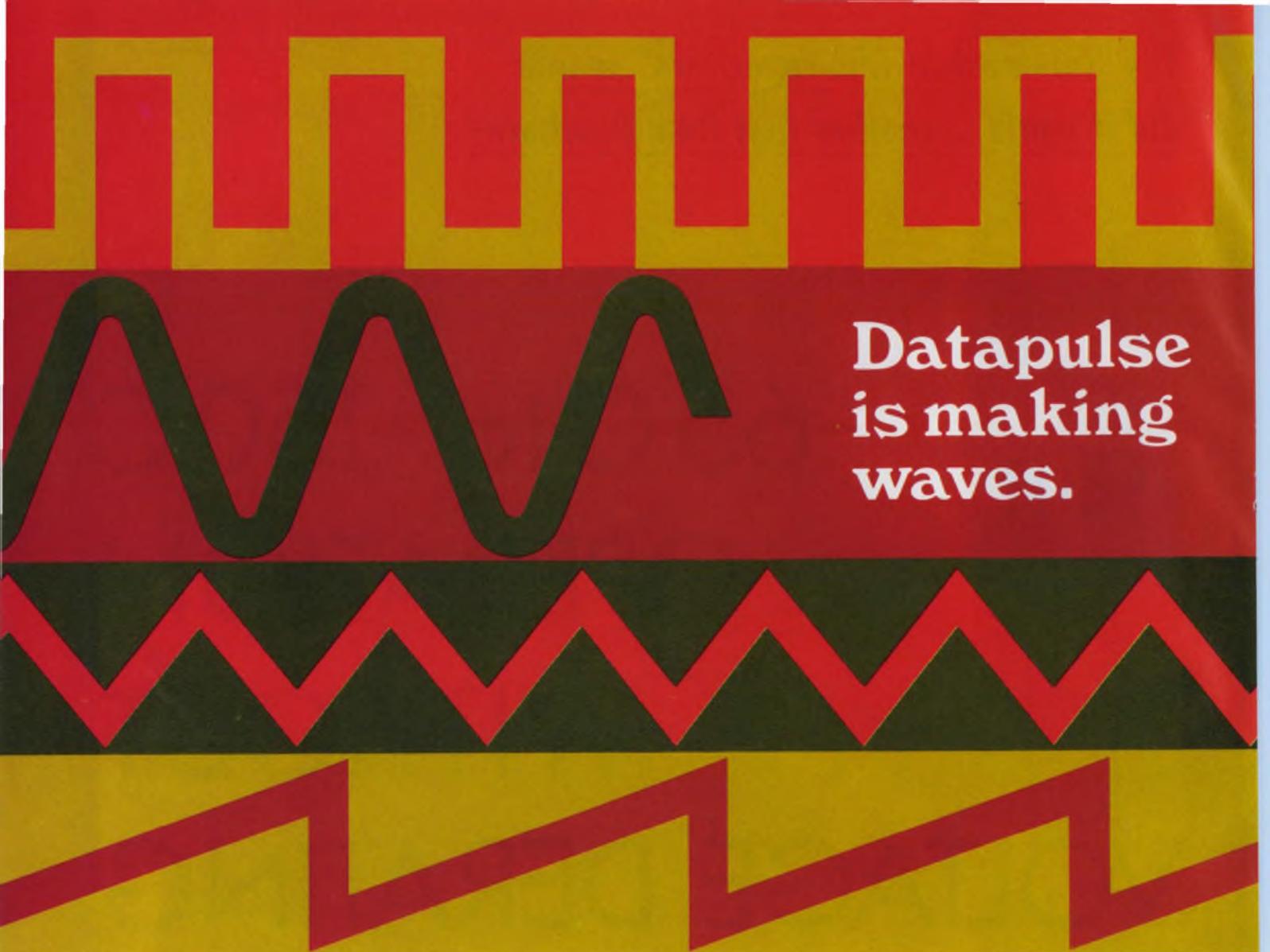
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## Datapulse is making waves.

Big or little, one channel or two, FM or AM, square, triangular, sine or swept, the new family of Datapulse function generators makes better waves. What's more, we've put a couple of new ideas to work in the design so that you get more    for your \$\$\$.

The little beauty on top, the Datapulse Model 401, sells for only \$395 and gives you a dial accuracy of one percent (that's about twice as good as the competition). Frequency is 0.02 Hz to 2 MHz, and sine distortion is only 0.25 percent in the audio range.

Square-wave rise time is a

fast 40 nanoseconds. To handle low levels, we give you 80 db dynamic amplitude range.

You can field calibrate the 401 with a screwdriver, and we give you a calibrated 1V p-p square wave out for scope work. A switchable 40 db attenuator and your choice of 50 or 600 ohms output impedance further simplifies your life. You get 1000:1 voltage control, too.

The other unit, the one with all the buttons, bells and whistles, is the elegant and sophisticated Model 410. It takes up where the 401 leaves off.

Frequency is 0.0002 Hz to 2 MHz. Dial accuracy is 1%. Uniquely among function generators, the 410 allows you to both AM and FM outputs for an extra dimension in wave generation. A built-in triggerable sweep generator gives complete flexibility using either or both of the independently controllable 40V p-p output channels to generate sine, square, triangle, sawtooth, and swept waves. Price is a modest \$995.

To arrange a demonstration or obtain more data, contact your local S-D man. Or address Datapulse Division, Systron-Donner Corporation, 10150 W. Jefferson Blvd., Culver City, California 90230. Phone (213) 836-6100.



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## EDITORIAL



## Whatever happened to our space program?

The U. S. space program appears to be falling victim to the federal emphasis on social needs—so rapidly, in fact, that Neal Armstrong's and Buzz Aldrin's historic landing on the moon seems like something from the distant past, instead of an event that took place just 15 months ago.

The decline in the space effort is apparent from some of the major statistics involved. For example, employment in the space industry has dropped by more than 75,000 over the past five years. In this same time, annual space outlays have dropped from a high of almost \$6-billion to \$3.3-billion, and further cuts are anticipated.

In the 15 months since Apollo 11 landed on the moon, employment at Cape Kennedy has fallen by 11,000. This is so sharp a cut that the region has been declared a depressed area by the U. S. Department of Commerce and therefore entitled to federal aid.

Statistics, however, tell only part of the story—the most obvious part. Less apparent is the effect the cuts will have on our future space capability. The largest and most sophisticated design team the world has ever known is being pared—and rightfully so—in line with our new national priorities. But with the American penchant for overreacting, will the paring be too severe? And will the effectiveness of those who remain in the program be diminished by low morale? In essence, will the space program be so emasculated that meaningful follow-on to the accomplishments of the 1960s is impossible?

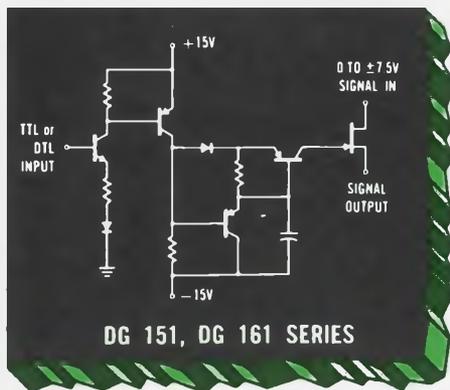
We hope not, particularly in view of the many billions spent on it so far.

FRANK EGAN

## Don't miss the next issue

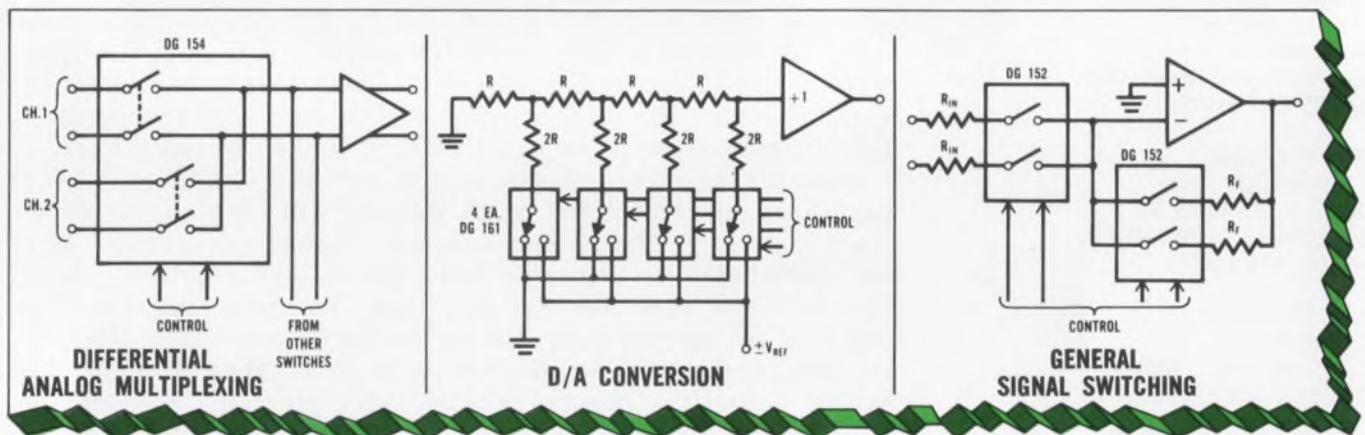
If you miss the Nov. 8 issue you may not receive another for a while. The reason—annual requalification. This year all ELECTRONIC DESIGN subscribers are being simultaneously asked to requalify for their free subscriptions.

Qualification cards and instructions will be contained in the next (Nov. 8) issue.



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# Cut production costs with this technique

for ordering and bunching capacitors. Faster assembly and lowered inventories provide the savings.

In the large-scale production of such circuits as high-quality filters and oscillators, the need often arises for considerable numbers of capacitors of various values, adjusted to very close tolerances. For economy, the required values should be synthesized by bunching, in parallel, a number of cheap, wide-tolerance, standard-value capacitors.

Existing methods for bunching capacitors and stocking them suffer from one or both of two major drawbacks:

- They result in excessive inventories of dormant stock.

- They require an extensive number of cut-and-try measurements to achieve the desired result. The cut-and-try approach is not only time-consuming and expensive, it may also result in large bunches of capacitors, which can add physical packaging problems to the production engineer's woes.

## Improved approach uses charts

The new method of ordering and bunching guarantees that each bunch will contain, at most, two capacitors and that only one measurement will have to be made in the assembly process. No measuring or sorting at all have to be done when a shipment of capacitors is received. The assembly is further simplified by the use of charts that eliminate tedious calculations.

To see how the method works, let's suppose that we need a capacitor of value  $C$  accurate to  $\pm x\%$ , and we want to make it out of cheaper capacitors of tolerance  $\pm a\%$  where  $a > x$ . Our capacitor bunch will have two capacitors—a main capacitor and a trimmer.

The first step is to select the main capacitor, whose value is  $C_M$ , out of our selection of standard values.  $C_M$  is chosen so that

$$C_M(1 + 0.01a) \leq C(1 + 0.01x). \quad (1)$$

The actual value of  $C_M$  will, of course, vary between  $C_M(1 - 0.01a)$  and  $C_M(1 + 0.01a)$ .

Depending upon the actual value of the main capacitor, a suitable trimmer will have to be added to bring the total value within the desired range. To make sure that one of our trimmers will be sufficient to bring the main capacitor within the desired tolerance, we must have a number of standard trimmers,  $C_{T_1}$  through  $C_{T_n}$ , on hand. Their values are given by:

$$C_{T_1} \leq C[(1 + 0.01x)/(1 + 0.01a)] - C_M \quad (2a)$$

$$C_{T_2} \leq C_{T_1} [(1 - 0.01a)/(1 + 0.01a)] + [0.02Cx/(1 + 0.01a)], \quad (2b)$$

$$C_{T_3} \leq C_{T_2} [(1 - 0.01a)/(1 + 0.01a)] + [0.02Cx/(1 + 0.01a)], \quad (2c)$$

and so on. The trimmer of highest value is

$$C_{T_n} \geq C[(1 - 0.01x)/(1 - 0.01a)] - C_M. \quad (2d)$$

In each of the preceding cases, the actual value of the trimmer is the closest standard value that satisfies the inequality. In the design example that follows, a  $\pm 0.5\%$  capacitance will be synthesized out of two  $\pm 2.5\%$  capacitors.

The 2.5% figure is a good practical number because polystyrene capacitors with that tolerance can be easily mass-produced. The standard values are listed in the table. Note that only 238 different sizes are needed to cover the complete range from 2 pF to 0.1 $\mu$ F.

## How to use the charts

Two charts are included with this article; similar charts can be prepared for capacitors of any other tolerances. Chart No. 1 is used to

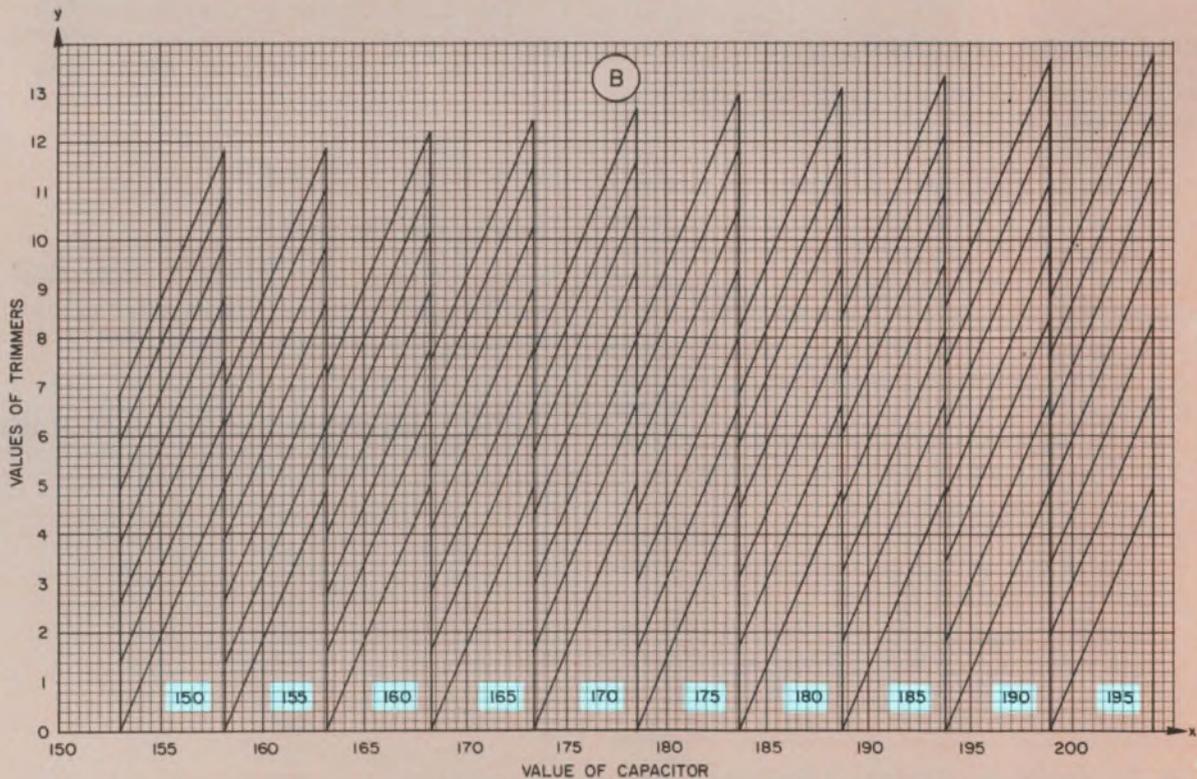
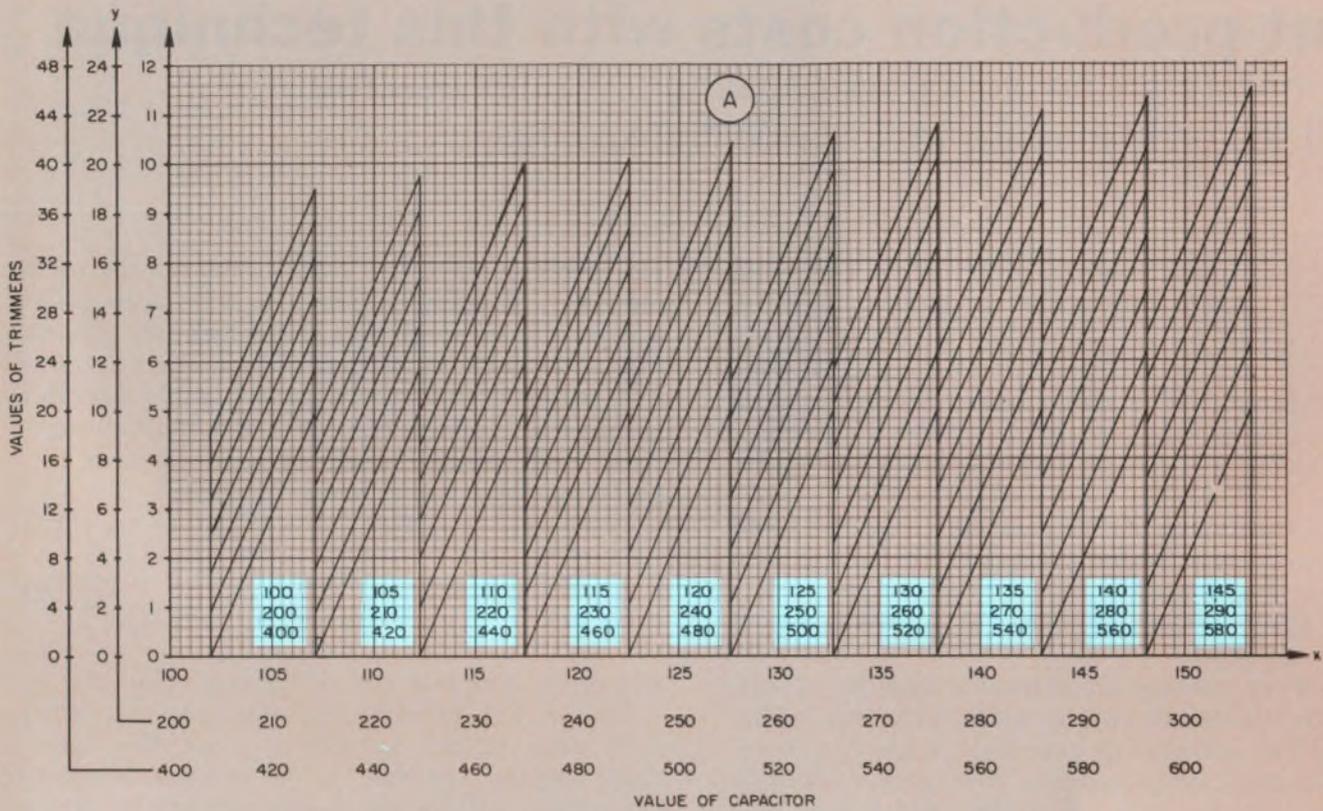
**Table. Standard 2.5% capacitors**

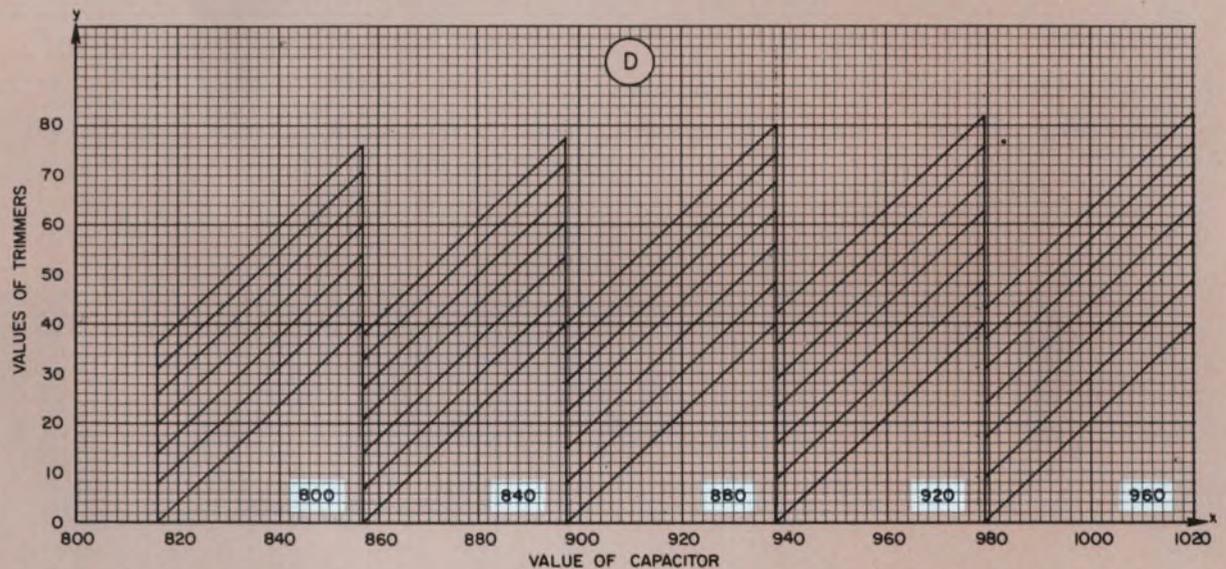
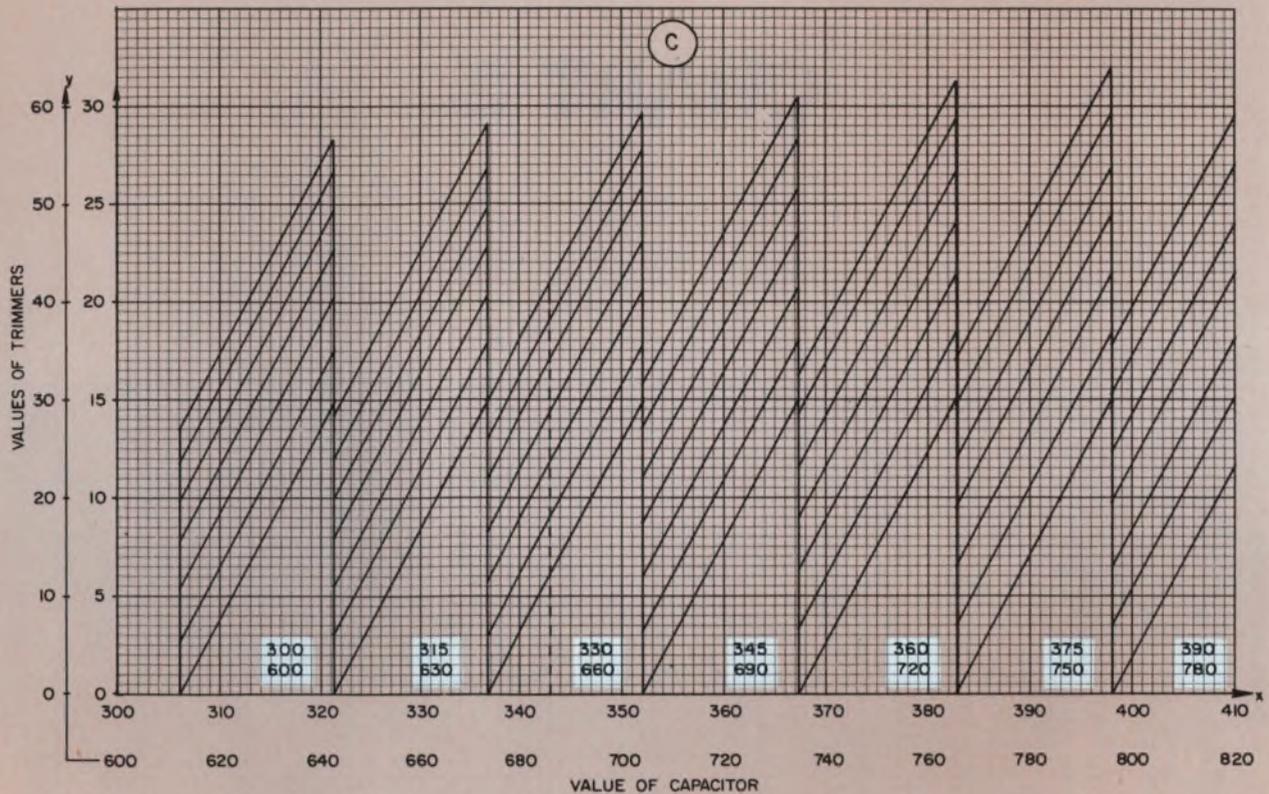
All values are in picofarads.				
2	to	39	in steps of	1
40	"	58	"	2
60	"	78	"	3
80	"	96	"	4
100n	"	195n	"	5n
200n	"	290n	"	10n
300n	"	390n	"	15n
400n	"	580n	"	20n
600n	"	780n	"	30n
800n	"	960n	"	40n

$n = 1, 10, 100, 1000, \text{etc.}$

Miss M. C. Ramamani, Research Department, Indian Telephone Industries Ltd., Dooravani Nagar, Bangalore-16, India.

# CHART 1





make 0.5% capacitors out of 2.5% units. Chart No. 2 is used to get 1.0% tolerances out of the same 2.5% capacitors.

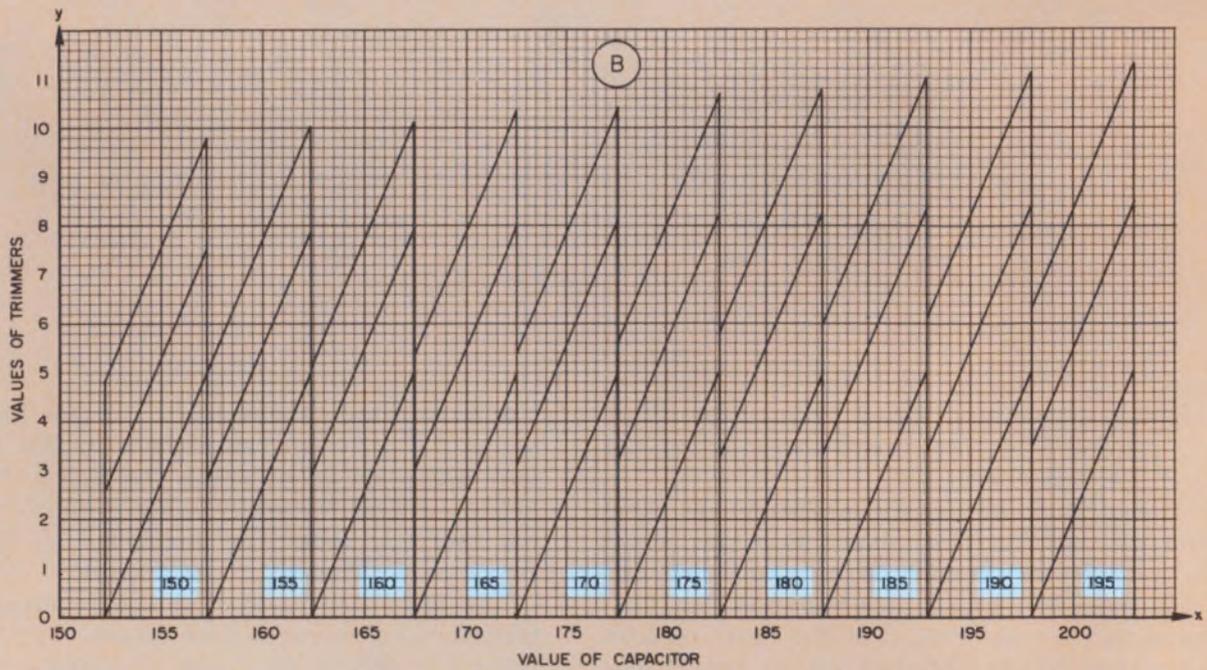
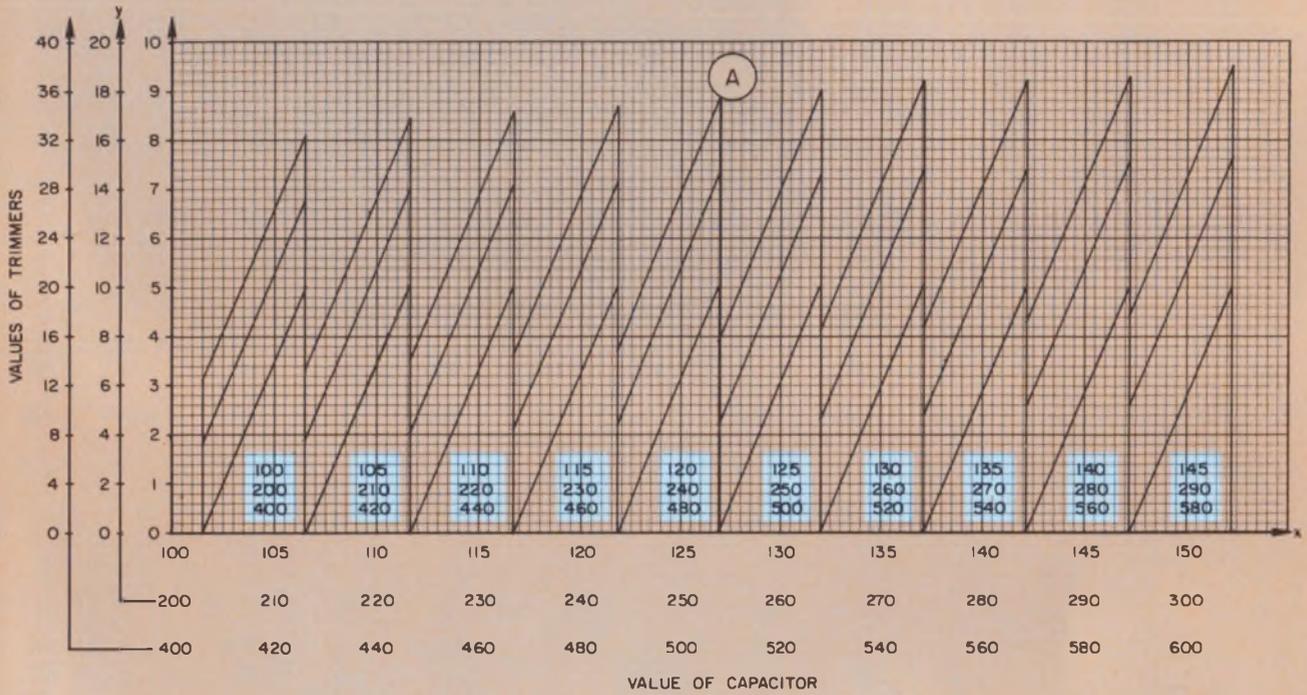
Let's say we want to make a capacitor of value 68,600 pF  $\pm 0.5\%$ . This means that the actual value must lie between 68,257 pF and 68,943 pF. We use chart No. 1 since it pertains to 0.5% tolerances, and we use Part C of the chart because it covers the 600 to 820-pF range of capacitance (and decimal multiples thereof).

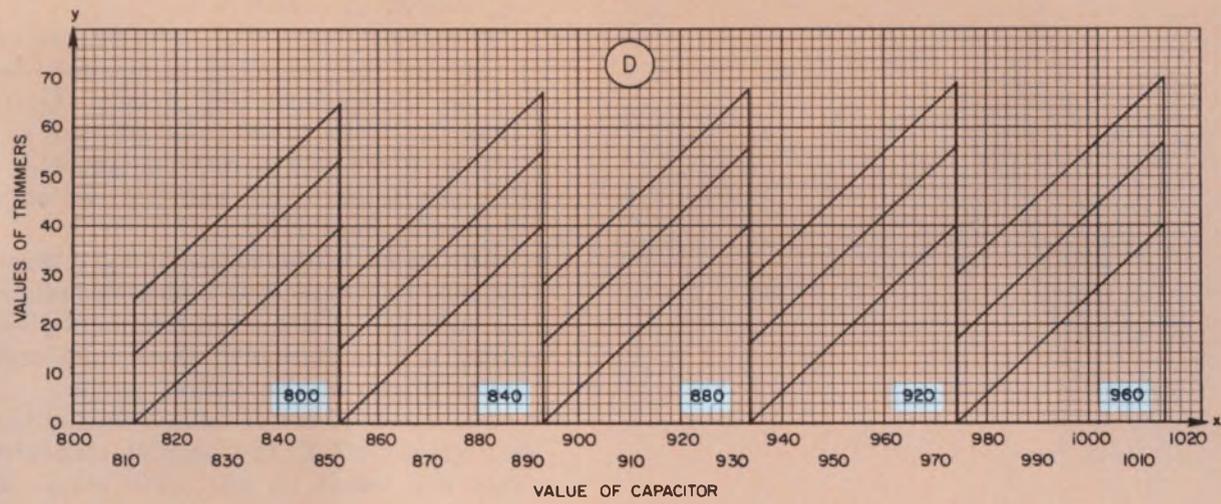
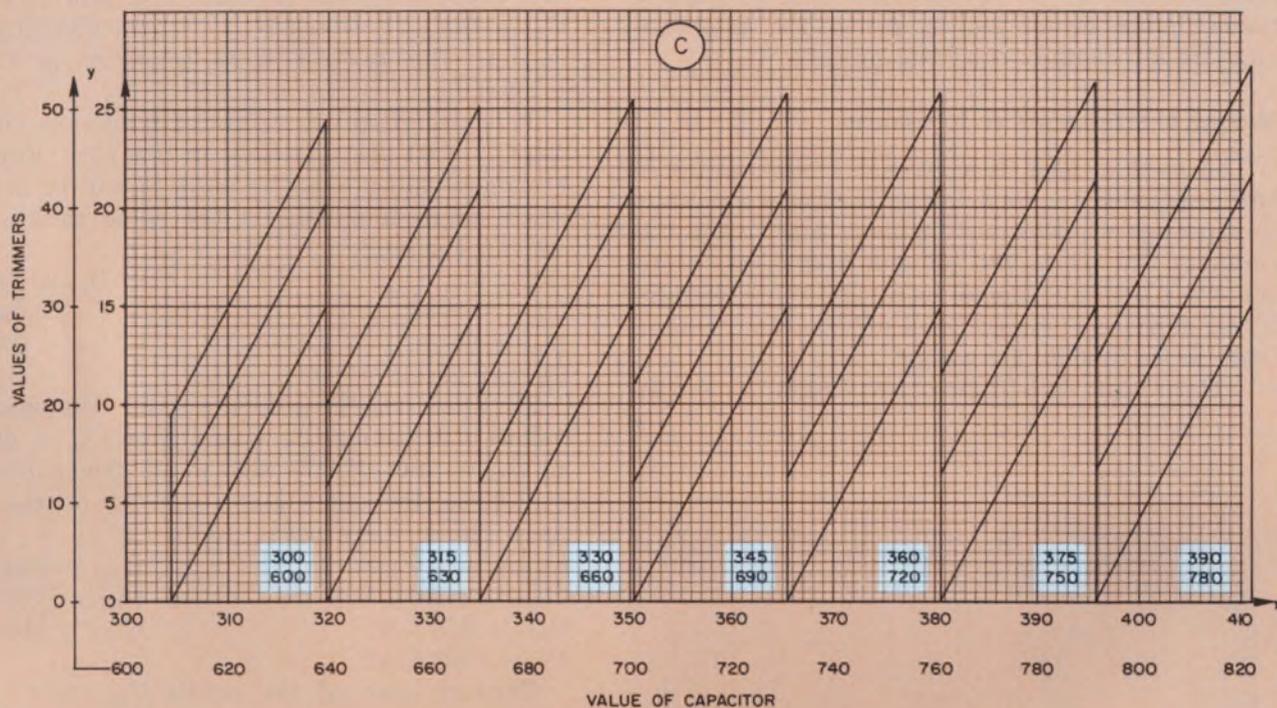
On the chart we look for the segment of the

x-axis in which the value  $x = 686$  lines. The value of  $C_M$  for all values of  $x$  in this segment is given in the block above the x-axis. For  $x = 686$ ,  $C_M = 660$ . Naturally, when decimal multiples are used,  $C_M$  should be multiplied by the same factor as  $C$ . Thus  $C_M = 66,000$  pF.

The next step is to find the required set of trimmers. A vertical line drawn through the point  $x = 686$  on the x-axis will intersect the set of parallel lines. The y-coordinates of the points of intersection are the values of the required

# CHART 2





trimmers. These values will probably not be standard values; therefore, the nearest standard values should be chosen.

In the present example, the y-coordinates are: 12.7, 18.3, 23.9, 29.0, 34.3, 38.8 and 42.0. The nearest standard values, multiplied by the appropriate power of ten, are: 1250, 1850, 2400, 2900, 3450, 3900 and 4200 pF.

At this point, the sole measurement demanded by this fabrication procedure is made. This measurement is made on the main capacitor, and,

based on it, the appropriate trimmer is chosen.

In the example, if the measured value of  $C_M$  turns out to be 64,450 pF, then the 4200-pF trimmer should be used. The final value of  $C$  will then be 68,650 pF. Since the trimmer has a tolerance of 2.5% (105 pF), the final value of  $C$  will actually lie between 68,545 and 68,755 pF—well within the desired range.

Note that a tremendous advantage of this system is that no money need be wasted purchasing odd-ball values of useless stock. Only one value

of a main capacitor and seven values of trimmers need be ordered to produce the desired capacitance. From Chart No. 2, for a 1% tolerance only three trimmers need be ordered.

### Making charts for other tolerances

The method used to construct these graphs is best explained by considering a typical example. Suppose we want to make a chart that covers the range of 600 pF to 780 pF and that allows us to achieve 0.5% tolerances using 2.5% capacitors. If we rewrite Formula 1 as an equation, rather than as an inequality, we get

$$C = C_M(1 + 0.01a)/(1 + 0.01x) \quad (3)$$

or  $C = C_M(1.025)/(1.005)$ . Substituting this last expression into Eqs. 2a, b, c and d, we get  $C_{T1} = 0$ ,  $C_{T2} \leq 0.00995C_M$ ,  $C_{T3} \leq 0.01942C_M$ , and so on. The highest-value trimmer is  $C_{Tn} \geq 0.04082C_M$ .

It is clear that six values of trimmers (including  $C_{T1} = 0$ ) are sufficient in this case. But since standard values must be used, it will be safer to select seven trimmers in the same range. Thus we can choose

$$\begin{aligned} C_{T1} &= 0 & C_{T5} &= 0.033C_M \\ C_{T2} &= 0.009C_M & C_{T6} &= 0.039C_M \\ C_{T3} &= 0.018C_M & C_{T7} &= 0.045C_M \\ C_{T4} &= 0.026C_M & & \end{aligned}$$

To draw the graph, we mark the standard values of  $C_M$  along the x-axis from  $C_{M1} = 600$  pF to  $C_{M7} = 780$  pF. We also mark the points  $C_{M1A} = 1.02C_{M1}$  through  $C_{M7A} = 1.02C_{M7}$  on the same axis. These values are:

$$\begin{aligned} C_{M1A} &= 612.0 \text{ pF} & C_{M5A} &= 734.4 \text{ pF} \\ C_{M2A} &= 642.6 \text{ pF} & C_{M6A} &= 765.0 \text{ pF} \\ C_{M3A} &= 673.2 \text{ pF} & C_{M7A} &= 795.6 \text{ pF} \\ C_{M4A} &= 703.8 \text{ pF} & & \end{aligned}$$

Through each of the points  $C_{M1A}$  to  $C_{M7A}$  we next draw a vertical line. On the line through  $C_{M1A}$  the following points are plotted.

$$\begin{aligned} C_{T1} &= 0 \text{ pF} & C_{T5} &= 0.033C_{M1} = 19.8 \\ C_{T2} &= 0.009C_{M1} = 5.4 & C_{T6} &= 0.039C_{M1} = 23.4 \\ C_{T3} &= 0.018C_{M1} = 10.8 & C_{T7} &= 0.045C_{M1} = 27.0 \\ C_{T4} &= 0.026C_{M1} = 15.6 & & \end{aligned}$$

Then, since  $C_{M2} - C_{M1} = 30$  pF, we add 30 pF to each of the preceding values and mark them off on the vertical line drawn through  $C_{M2A}$ . Thus,  $C_{T1}' = C_{T1} + 30 = 30$  pF, and so on.

Now, if we join points  $C_{T1}$  and  $C_{T1}'$ ,  $C_{T2}$  and  $C_{T2}'$ , and so on to  $C_{T7}$  and  $C_{T7}'$ , we obtain a set of parallel lines (Fig. 1).

Any value in the range of  $C_{M1A}$  through  $C_{M2A}$  can now be obtained by bunching main capacitor  $C_{M1}$  with one of the seven trimmers given by the points of intersection of these lines and the ordinate drawn at the desired value.

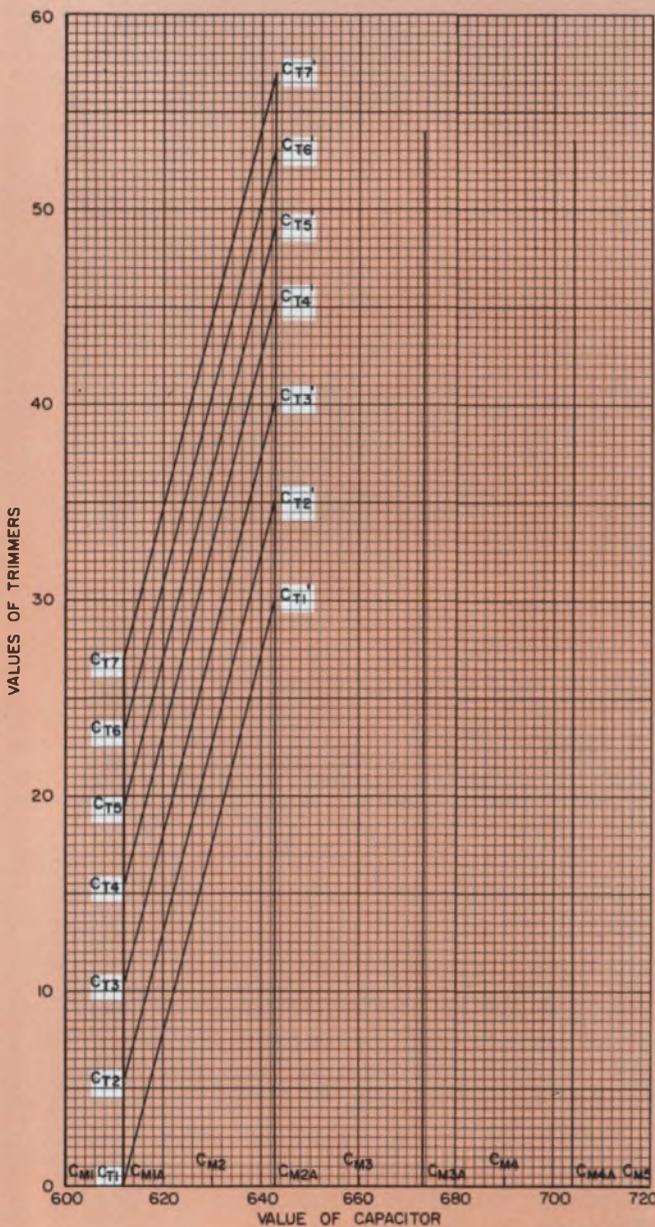
The values of the trimmers thus obtained may be rounded off to the nearest standard values. This will result in negligible error, since the values of trimmers have been selected to be sufficiently close to each other.

Parallel lines can also be drawn between the ordinates at  $C_{M2A}$  and  $C_{M3A}$  by marking the following points on the vertical line drawn through point  $C_{M2A}$ :

$$\begin{aligned} C_{T1} &= 0.000 & C_{T5} &= 0.033C_{M2} \\ C_{T2} &= 0.009C_{M2} & C_{T6} &= 0.039C_{M2} \\ C_{T3} &= 0.018C_{M2} & C_{T7} &= 0.045C_{M2} \\ C_{T4} &= 0.026C_{M2} & & \end{aligned}$$

and similar points on the line through  $C_{M3A}$ .

Then, any capacitor in the range of  $C_{M2A}$  through  $C_{M3A}$  can be obtained with main capacitor  $C_{M2}$  and one of the seven trimmers whose values are obtained as explained above. ■



1. The slanted lines are all parallel since the primed quantities all differ from their unprimed counterparts by the same amount—the difference between  $C_M$  values.



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INFORMATION RETRIEVAL NUMBER 32

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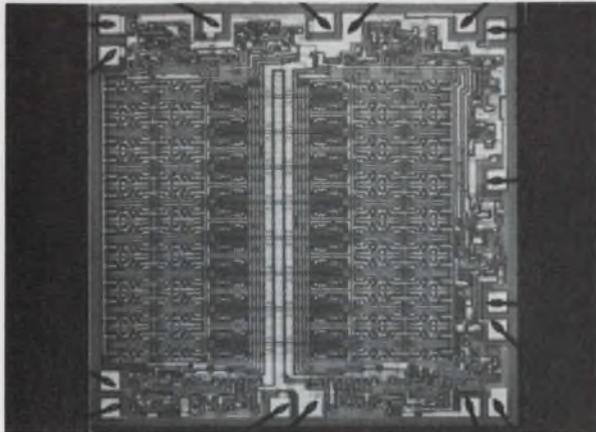


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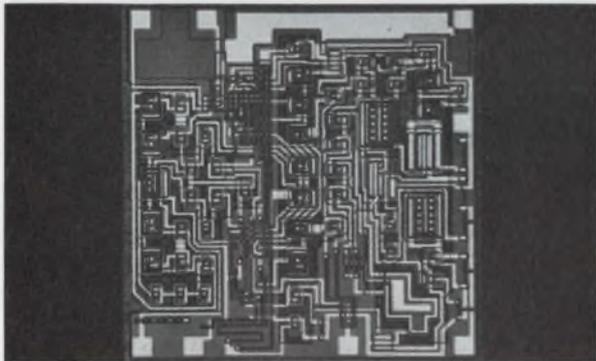


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INFORMATION RETRIEVAL NUMBER 33

# Versatile table simplifies convolution.

It allows you to look up this operation on two exponential functions as easily as a logarithm.

Convolution is one of the most powerful mathematical operations in linear circuit analysis. It can be derived from the superposition integral that relates total system output to superposed outputs resulting from infinitesimal inputs. It is also related to correlation functions.

However, the application of convolution is sometimes made difficult by its mathematical

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complexities. The table shown here eliminates these difficulties by giving the results of the convolution of several pairs of exponential functions.

The following examples demonstrate the use of the table.

1. Given:

$u(t)$  = unit step input function

$h(t) = e^{-kt} u(t)$

= filter impulse response function

Find:

$y(t)$  = step response filter

NO.	$f_1(t)$	$f_2(t)$	$f_3(t) = f_1(t) * f_2(t)$
1	$e^{-at}u(t)$	$e^{-bt}u(t)$	$t e^{-at} u(t)$ <span style="float:right"><math>a = b</math></span>
			$\frac{1}{b-a} [e^{-at} - e^{-bt}] u(t)$ <span style="float:right"><math>a \neq b</math></span>
2	$e^{at}u(-t)$	$e^{bt}u(-t)$	$(-t) e^{at} u(-t)$ <span style="float:right"><math>a = b</math></span>
			$\frac{1}{b-a} [e^{at} - e^{bt}] u(-t)$ <span style="float:right"><math>a \neq b</math></span>
3	$e^{-at}u(t)$	$e^{bt}u(-t)$	$\frac{1}{2a} e^{-a t }$ <span style="float:right"><math>a = b \neq 0</math></span>
			$\frac{1}{a+b} [e^{-at} u(t) + e^{bt} u(-t)]$ <span style="float:right"><math>a \neq b</math></span>
4	$e^{-at}u(t)$	$e^{-b t }$	$te^{-at}u(t) + \frac{1}{2a} e^{-a t }$ <span style="float:right"><math>a = b \neq 0</math></span>
			$\frac{1}{a-b} [e^{-bt} - \frac{2b}{a+b} e^{-at}] u(t) + \frac{1}{a+b} e^{bt} u(-t)$ <span style="float:right"><math>a \neq b</math></span>
5	$e^{at}u(-t)$	$e^{-b t }$	$(-t) e^{at} u(-t) + \frac{1}{2a} e^{-a t }$ <span style="float:right"><math>a = b \neq 0</math></span>
			$\frac{1}{a+b} e^{-bt}u(t) + \frac{1}{a-b} [e^{bt} - \frac{2b}{a+b} e^{at}] u(-t)$ <span style="float:right"><math>a \neq b</math></span>
6	$e^{-a t }$	$e^{-b t }$	$[\frac{1}{a} +  t ] e^{-a t }$ <span style="float:right"><math>a = b \neq 0</math></span>
			$\frac{2}{b^2 - a^2} [b e^{-a t } - a e^{-b t }]$ <span style="float:right"><math>a \neq b</math></span>

Solution:

$$y(t) = h(t) * u(t)$$

From line No. 1 in the table, let  $a = 0$ ,  $b = k$ , to obtain:

$$y(t) = \frac{1}{k} (1 - e^{-kt}) u(t)$$

2. Given:

$$R_{xx}(\tau) = \text{input covariance function of } x(t) \\ = A e^{-k_1 |\tau|}$$

$$h(t) = \text{filter impulse response function} \\ = e^{-k_2 t} u(t)$$

Find:

$$R_{yy}(\tau) = \text{output covariance function}$$

Solution:

$$R_{yy}(\tau) = h(\tau) * h(-\tau) * R_{xx}(\tau)$$

From line No. 3 in the table, let  $a = b = k_2$  to obtain

$$h(\tau) * h(-\tau) = \frac{1}{2k_2} e^{-k_2 |\tau|}$$

$$\text{Thus, } R_{yy}(\tau) = \frac{A}{2k_2} e^{-k_2 |\tau|} * e^{-k_1 |\tau|}$$

From line No. 6 in the table, let  $a = k_1$ ,  $b = k_2$  to obtain

$$R_{yy}(\tau) =$$

$$\frac{A}{2k_2} \left[ \frac{2}{k_2^2 - k_1^2} \right] [k_2 e^{-k_2 |\tau|} - k_1 e^{-k_1 |\tau|}]$$

for  $k_1 \neq k_2$ . ■■

### Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. To what other basic mathematical concepts is convolution related?

2. What are the difficulties in using convolution?

3. How does the table make convolution more useful?

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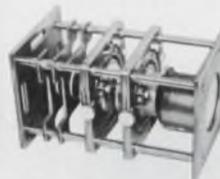
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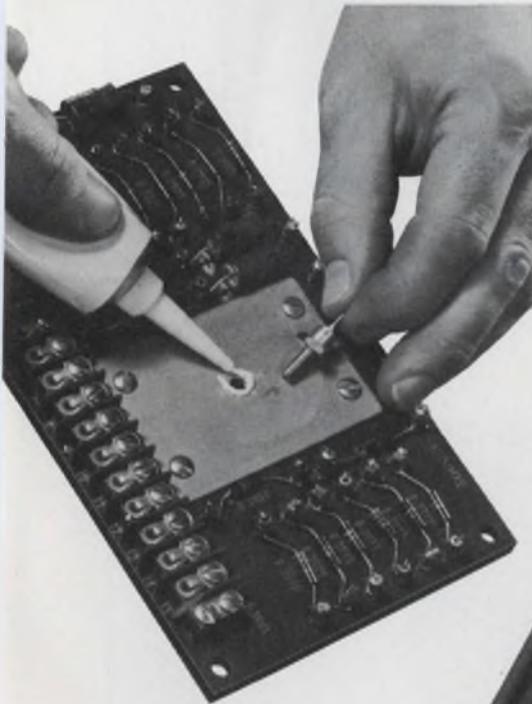
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# Reduce motor/tachometer coupling

and improve servo-system performance. It's essential to the design of stable, compact control systems.

Servo motors and tachometers when combined in a single package must use available space efficiently while satisfying rigorous dynamic response and stability requirements. Such compact motor/tachometer assemblies have found applications in data-communications systems, film transports, motion simulators (rate tables) and antenna drives.

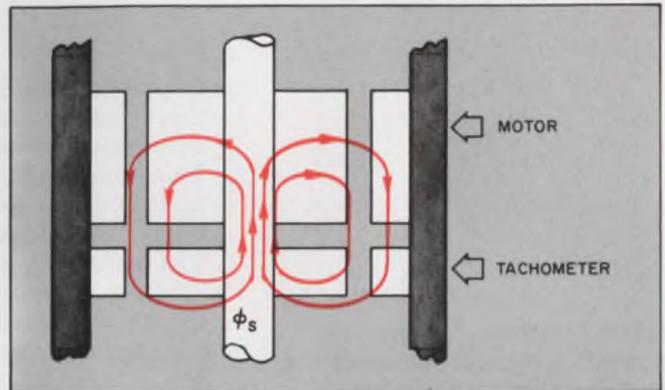
While small physical size brings about some desirable features, such as greater servo bandwidth due to improved mechanical resonance in torsion, close motor/tachometer proximity accentuates unwanted electromagnetic coupling. Without proper design, this coupling can override any mechanical advantages and the compact servo package will prove inferior to control systems with a separate motor and tachometer.

Although many shielding schemes are available to reduce mutual inductance, sound engineering design requires optimum motor/tachometer magnetic-circuit construction. Derivation of the motor/tachometer transfer function provides the necessary insight and background.

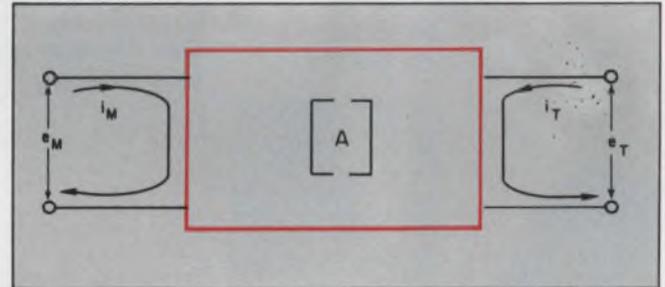
## Black box serves as circuit model

Electromagnetic coupling is caused by a stray magnetic flux linkage,  $\Phi_s$ , between the motor and tachometer armatures (Fig. 1). The cross-magnetizing field generated by the motor and tachometer armature currents should ideally be confined to the individual units. When motor and tachometer are mounted close together, some small portion of this flux becomes common to both armatures. The resulting electromagnetic coupling can be described by a mutual inductance,  $M$ , and the motor/tachometer combination can be represented by the four-terminal network of Fig. 2.

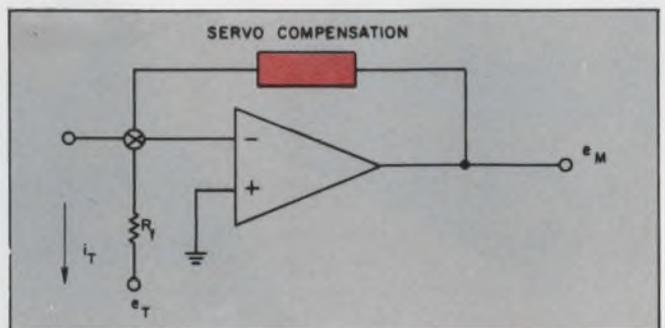
In practical applications the servo is operated by applying the tachometer signal through a four-terminal network into the summing junction of an amplifier. For the purposes of this analysis, it is assumed that the four-terminal network is reduced to the single resistor  $R_t$  (Fig. 3).



1. Here's where the problem starts. Stray magnetic flux,  $\phi_s$ , couples the motor and tachometer armatures, allowing interaction between the adjacent windings.



2. A four-port "black box" representing the motor/tachometer provides an ideal circuit model. [A] is the transformation matrix, which relates motor and tachometer electrical parameters.



3. A resistor simplifies the analysis. Here it's assumed that  $R_t$  can replace the four-port motor/tachometer network of Fig. 2.

Stanley Ronchinsky, Vice President Engineering, Torque Systems, Inc., Waltham, Mass.

Motor voltage  $e_M$  and tachometer voltage  $e_T$  are related to motor current  $i_M$  and tachometer current  $i_T$  by a transformation matrix so that

$$\begin{bmatrix} e_M \\ e_T \end{bmatrix} = \begin{bmatrix} A \end{bmatrix} \begin{bmatrix} i_M \\ i_T \end{bmatrix} \quad (1)$$

where

$$\begin{bmatrix} A \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}.$$

Since the summing junction of the amplifier (Fig. 3) acts as a current sink, the tachometer current and voltage are related by

$$e_T = - (R_f) (i_T). \quad (2)$$

Equation 1 then becomes

$$\begin{bmatrix} e_M \\ 0 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} + R_f \end{bmatrix} \begin{bmatrix} i_M \\ i_T \end{bmatrix}, \quad (3)$$

which yields the tachometer current

$$i_T = e_M \left[ \frac{a_{21}}{a_{11}(R_f + a_{22})} \right] \left[ \frac{1}{1 + \frac{a_{21}}{a_{11}(R_f + a_{22})} (-a_{12})} \right]. \quad (4)$$

This equation is represented as a block diagram in Fig. 4.

The coefficients of matrix [A] are now determined from basic electrical equations and the equation of motion. It is assumed that friction is negligible compared to the total inertia J (includes motor, tachometer and load inertia) expressed in foot-pound-seconds<sup>2</sup>.

Then

$$e_M - K_B \frac{d\theta}{dt} = R_M i_M + L_M \frac{di_M}{dt} + M \frac{di_T}{dt}, \quad (5)$$

$$e_T - K_V \frac{d\theta}{dt} = R_T i_T + L_T \frac{di_T}{dt} + M \frac{di_M}{dt}, \quad (6)$$

$$J \frac{d^2\theta}{dt^2} = K_T i_M. \quad (7)$$

Taking the Laplace transformation of Equations 5, 6, and 7 and rearranging the terms gives

$$e_M = \left( \frac{K_B K_T}{sJ} + R_M + sL_M \right) i_M + Ms i_T$$

and

$$e_T = \left( \frac{K_V K_T}{sJ} + Ms \right) i_M + (R_T + sL_T) i_T.$$

Comparison with Eq. 1 yields the coefficients of matrix [A]:

$$a_{11} = \frac{K_B K_T}{sJ} + R_M + sL_M; \quad (8)$$

$$a_{22} = R_T + sL_T; \quad (9)$$

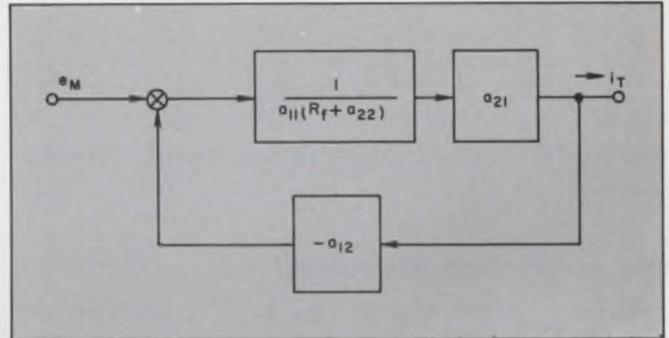
$$a_{12} = Ms; \quad (10)$$

and

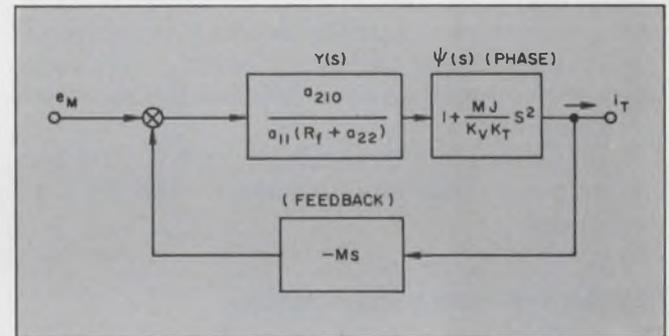
$$a_{21} = \frac{K_V K_T}{sJ} + Ms. \quad (11)$$

For convenience the coefficient  $a_{21}$  can be rewritten as

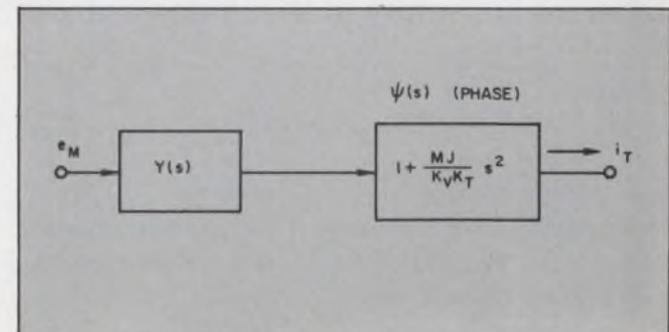
$$a_{21} = a_{210} \left( 1 + \frac{MJ}{K_V K_T} s^2 \right), \quad (12)$$



4. The tachometer current formula derived in Eq. 4 is illustrated as a block diagram. Coefficient  $-a_{12}$  represents coupling feedback while  $a_{21}$  accounts for coupling phase shift.



5. Matrix [A] coefficients derived from electrical and mechanical equations are substituted into Eq. 4.  $-Ms$  is the coupling feedback,  $\Psi(s)$  is the coupling phase shift and  $Y(s)$  is the transfer function with zero coupling.



6. The motor/tachometer is stable when the choice of feedback resistor makes  $-Ms$  negligible. Phase shift due to the mutual coupling can now be examined.

where by definition  $a_{210} = K_v K_T / sJ$  is the coefficient  $a_{21}$  at zero coupling ( $M = 0$ ).

The transfer function of a motor/tachometer with mutual coupling is represented by Fig. 5. At zero coupling the transfer function reduces to

$$Y(s) = \frac{i_T}{e_M} = \frac{a_{210}}{a_{11}(R_f + a_{22})}$$

and after substitution from Equations 8, 9, 11, and 12

$$Y(s) = \left[ \frac{K_v s}{R_f + R_T + sL_T} \right] \left[ \frac{1}{sK_B \left( 1 + \frac{R_M J}{K_B K_T} s + \frac{L_M J}{K_B K_T} s^2 \right)} \right], \quad (13)$$

which is the standard tachometer/motor transfer function.

### What is the effect of coupling?

Mutual inductance  $M$  can have a positive or negative sign, depending on the physical construction of the motor/tachometer package. With  $M$  positive, the quadratic term in the transfer function denotes minimum phase. When  $M$  is negative, the quadratic term becomes a nonminimum phase function.

The effect of the mutual coupling on the motor/tachometer transfer function is twofold:

- It introduces a feedback element,  $-Ms$ , into the transfer function, thus creating the potential for instability.

- It introduces a quadratic term  $\Psi(s)$  (either minimum or nonminimum phase) into the forward loop.

### Negative real roots assure stability

The effect of feedback element  $-Ms$  can be made negligible by appropriate selection of feedback resistor  $R_f$ . To assure stability, the roots of the characteristic function of the matrix in Eq. 3

must have negative real parts. This means that  $f(s) = [a_{11}(a_{22} + R_f) - a_{12}a_{21}]$  is a Hurwitz polynomial.

After substitution,

$$f(s) = s^3 b_3 + s^2 b_2 + s b_1 + b_0 \quad (14)$$

where

$$b_3 = J(L_M L_T - M^2),$$

$$b_2 = J[L_M(R_f + R_T) + L_T R_M],$$

$$b_1 = K_B K_T L_T + R_M J(R_T + R_f) - K_v K_T M$$

and

$$b_0 = K_B K_T (R_T + R_f).$$

According to mutual coupling theory,

$$M^2 < L_M L_T,$$

and therefore  $b_3$  is always greater than zero.

Since the coefficient  $b_2$  is also always greater than zero, the condition sufficient and necessary for the polynomial,  $f(s)$ , to have roots with negative real parts is that

$$\begin{vmatrix} b_2 & b_0 \\ b_3 & b_1 \end{vmatrix} > 0$$

must be positive. This procedure leads to a definition of motor/tachometer stability:

*Under the condition of mutual coupling the motor/tachometer will be inherently stable if the mutual inductance  $M$  satisfies the inequality*

$$M^2 K_B K_T (R_f + R_T) - M K_v K_T [L_M (R_f + R_T) + R_M L_T] + R_M L_T^2 K_B K_T + R_M J (R_T + R_f) [L_M (R_f + R_T) + R_M L_T] > 0. \quad (15)$$

This complex criterion can be reduced by neglecting the term containing  $M^2$ . A simplified expression for stability is therefore obtained:

$$M < \frac{R_M J}{K_v K_T} (R_T + R_f) + \frac{K_B R_M L_T^2}{K_T [L_M (R_f + R_T) + R_M L_T]}. \quad (16)$$

The stability can always be assured by making the feedback resistor,  $R_f$ , large enough so that Eq. 15 or 16 is satisfied.

Note that motor/tachometer instability can exist only with minimum-phase coupling. For nonminimum-phase coupling, the mutual induct-

## Here's a summary of the important parameters

Sym- bol	Parameter	Unit	Sym- bol	Parameter	Unit
$e_M$	Motor Voltage	volts	$K_v$	Tachometer Velocity Constant	volts/radians/second
$i_M$	Motor Current	amperes	$R_T$	Tachometer Resistance	ohms
$K_T$	Motor Torque Constant	foot pounds/ampere	$L_T$	Tachometer Inductance	henrys
$K_B$	Motor Velocity Constant	volts/radians/second	$M$	Mutual Inductance	henrys
$R_M$	Motor Resistance	ohms	$\theta$	Displacement Angle	radians
$L_M$	Motor Inductance	henrys	$t$	Time	seconds
$e_T$	Tachometer Voltage	volts	$s$	Laplace operator	radians/second
$i_T$	Tachometer Current	amperes			

ance  $M$  is negative and the function  $f(s)$  is always a Hurwitz polynomial.

### Don't neglect phase effects

Assuming that the motor/tachometer package is inherently stable and that the feedback element,  $-Ms$ , can be neglected, the transfer function is reduced to the block diagram of Fig. 6. The mutual coupling,  $M$ , effects the transfer function by introducing quadratic term  $\Psi(s)$  into the servo loop. Again, this mutual coupling may be positive or negative.

When  $M$  is positive, the polynomial  $\Psi(s)$  is a minimum phase function with zeros on the  $s$ -plane's imaginary axis. The zeros occur at a frequency

$$\omega_z = \pm [(K_v K_T) / (MJ)]^{1/2}.$$

At  $\omega_z$ , servo gain is reduced to zero, and phase is shifted to lead by  $180^\circ$  (Fig. 7).

The quadratic function  $\Psi(s)$  has a zero damping coefficient as a result of the assumption that disregards friction torques. When friction exists in the system the function  $\Psi(s)$  will have a finite damping factor, and the phase will change gradually.

The effect of  $\Psi(s)$  on servo performance depends mostly on the location of the zeros with respect to the servo cross-frequency. If the zero location is at or near crossover, the effect is bandwidth reduction and increased servo damping. This case is exemplified on a frequency response plot (Fig. 7).

Zero location below the servo crossover is highly undesirable because servo gain reduction around  $\omega_z$  severely limits the system dynamic response (particularly with regard to torque-disturbance rejection). Secondly, the 40-dB-per-decade servo gain rise above  $\omega_z$  complicates the problems associated with the servo rolloff characteristics.

When zero is located above the crossover, the mutual coupling does not create any serious problems in the servo design. The 40-dB-per-decade gain rise must be taken care of by a suitable rolloff, but this task is not difficult.

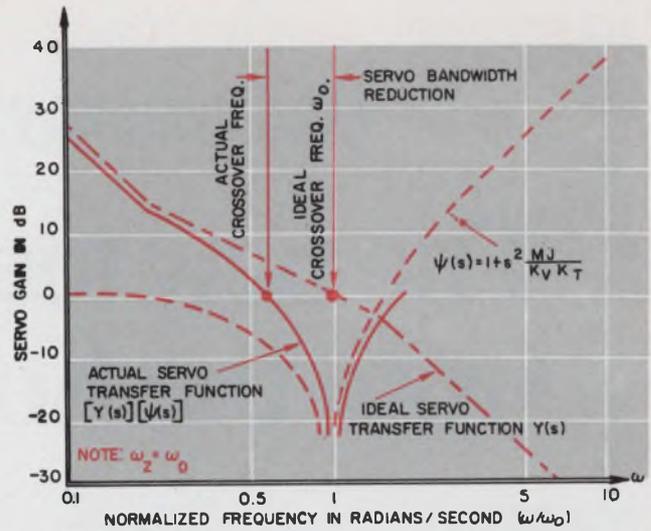
When  $M$  is negative, the polynomial  $\Psi(s)$  becomes a nonminimum phase function. The zeros are located on the  $s$ -plane's real axis at

$$\sigma = \pm [(K_v K_T) / (MJ)]^{1/2}.$$

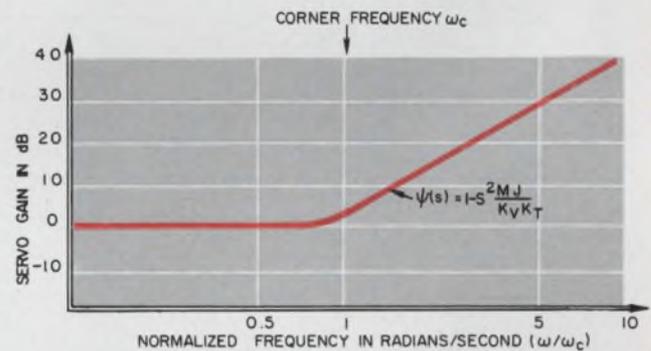
The function of  $\Psi(s)$  now exhibits zero phase shift everywhere, and its frequency response is such that 0-dB gain is followed by a 40-dB-per-decade rise (Fig. 8) at corner frequency  $\omega_c$  where

$$\omega_c = [(K_v K_T) / (MJ)]^{1/2}$$

This function has serious impact on servo design. If  $\omega_c$  falls anywhere near the crossover, servo stabilization by ordinary means (such as minimum-phase active or passive networks) is



7. Positive mutual inductance means that  $\Psi(s)$  is a minimum phase function. In a real system, friction provides a finite damping factor and phase shift is gradual.



8. Negative mutual inductance allows  $\Psi(s)$  to be a nonminimum phase function.  $\Psi(s)$  exhibits universal zero phase shift and a 40-dB/decade gain increase beyond corner frequency  $\omega_c$ .

impossible. From a practical standpoint,  $\omega_c$  should be at least 10 times the desired servo bandwidth.

### A quick check on coupling

A useful formula for specifying the maximum mutual inductance follows directly from the previous analysis. To avoid difficulty in applying the motor/tachometer package to servo design, the mutual inductance,  $M$ , should satisfy the relationship.

$$M < (K_T K_v) / [(\xi B)^2 J],$$

where

- $B$  = Desired System Bandwidth (radians)
- $\xi$  = (10 nonminimum phase coupling)
- $\xi$  = 2 (minimum phase coupling) ■■

### Reference

1. Stewart, J. L., *Circuit Theory and Design*, J. Wiley & Sons, New York, N.Y., 1956, pp. 65, 77, 88, 129.

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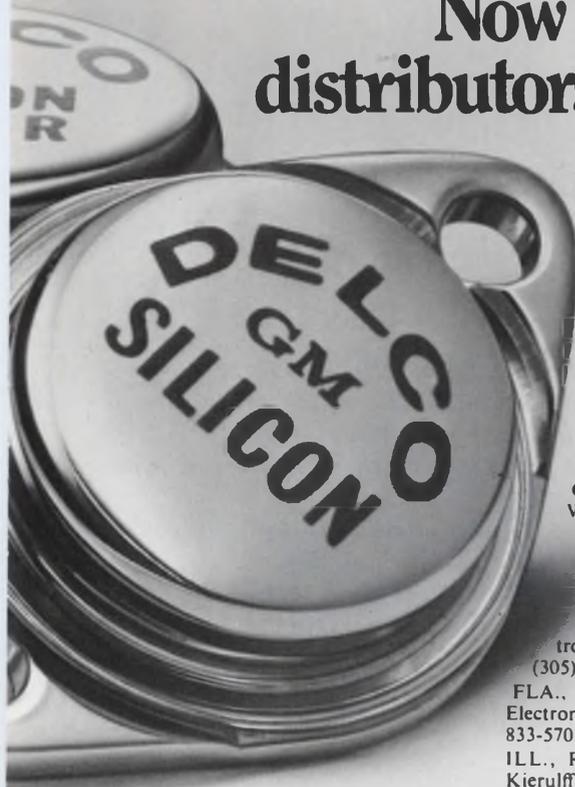
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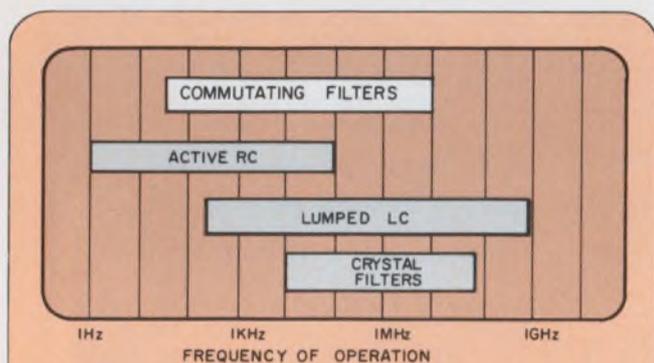
Suppose you require low-frequency, high-Q bandpass filters. If you use conventional filter synthesis you may get physically impractical designs. But there is an alternative—commutating filters.

Although it is an attractive alternative, it was not feasible for most applications before solid-

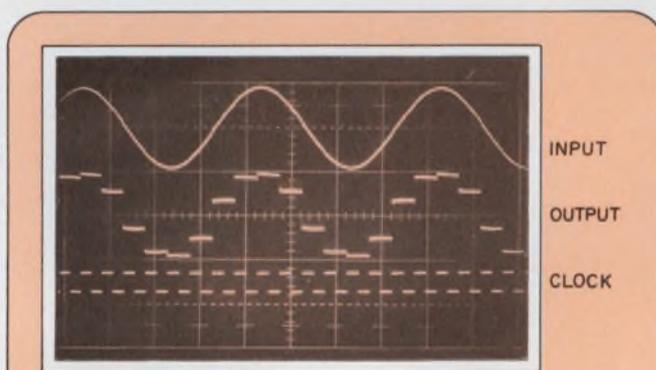
**Bud Broeker**, Applications Engineer, Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, Ariz. 85008.

state switching became available to replace mechanical commutators. Now you can make use of the many advantages of commutating filters:

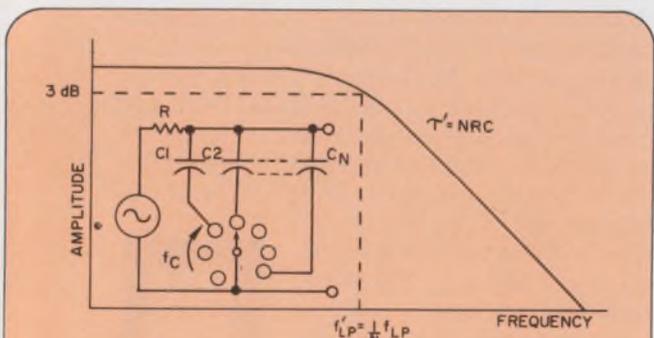
- They can be made to operate over a wide frequency range.
- They have excellent temperature stability.
- They are small in size and weight.
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- Bandwidth is easily adjusted by changing the number of sections commutated, since band-



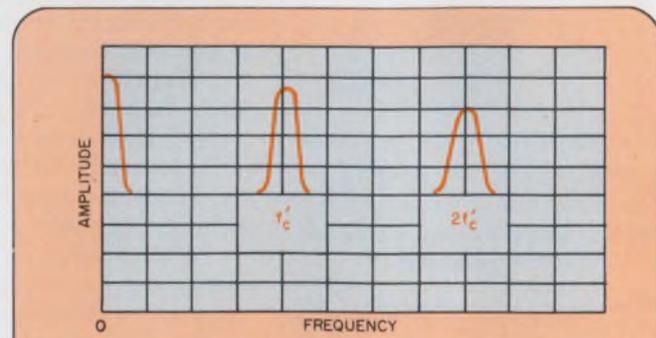
1. Commutating filters operate over a wider frequency range than do most standard forms of bandpass filters. High-speed IC switches make this technique feasible for many applications.



3. The stepped output matches the input signal when the filter is switched at a rate equal to the frequency of the input signal. The filter acts as a bandpass filter around this frequency.



2. Commutating  $N$  simple RC low-pass filter sections results in a bandpass filter with a resonant frequency equal to the commutating frequency. Commutation is produced by solid-state switches.



4. The comb-filter response characteristic is typical of commutating filters. A low-Q bandpass filter after the commutating filter will reject the harmonic response and eliminate the step format.

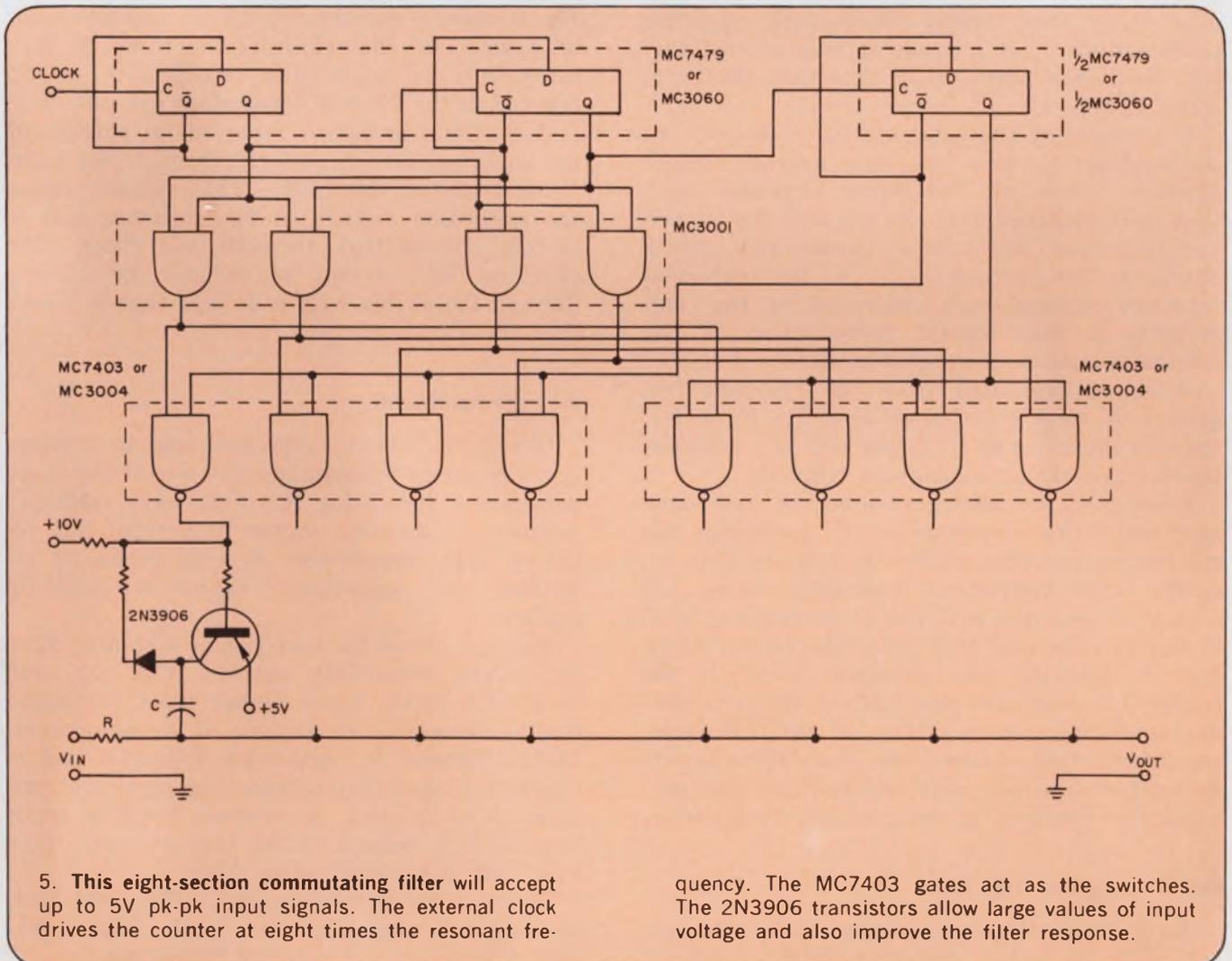
width is inversely proportional to the number of sections being switched.

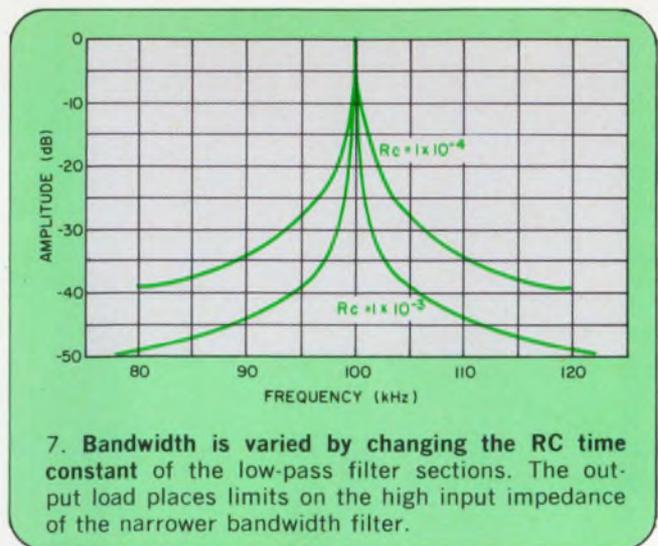
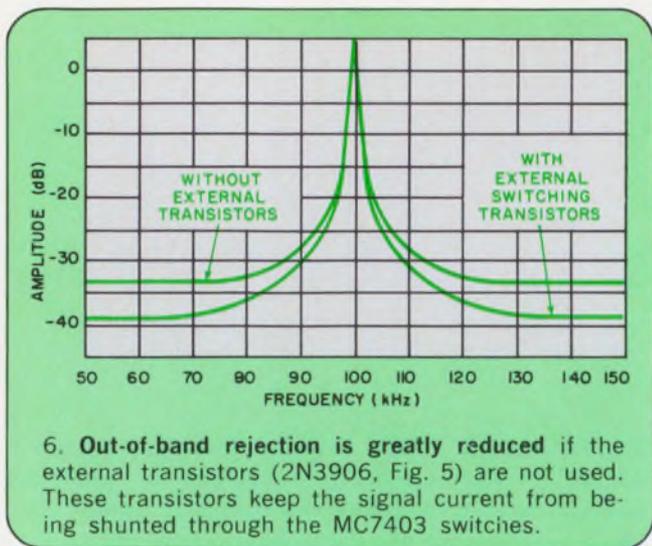
### How commutating filters work

The operation of commutating filters is based on switching between  $N$  identical low-pass filter sections at a clock rate  $N$  times the desired center frequency. This switching has the effect of reflecting the low-pass response about the commutating frequency, thereby generating a bandpass response. The bandwidth is  $2/N$  times

the bandwidth of the original low-pass sections, which is equivalent to reflecting a low-pass section with  $1/N$  times the original bandwidth. The commutating filter also has passbands centered at 0 Hz and at harmonics of the commutating frequency, but these responses are generally of minor interest for most applications.

The operation is most easily understood by considering a simple low-pass filter section as an integrator with time constant  $\tau = RC$ . If we cascade  $N$  of these sections with a commutating switch, we have a commutating filter (Fig. 2).





The commutating switch rotates at  $f_c$  rotations per second. Since each capacitor is connected to the input only  $1/N$ th of the time, its time constant is increased by  $N$  to  $\tau' = NRC$ . The time constant of the cascaded group is also  $\tau' = NRC$ , yielding a 3-dB low-pass response of  $f'_{lp} = \frac{1}{2\pi NRC}$ . The output of this commutated low-pass filter is in step format where each capacitor charges toward the average voltage applied during the  $1/N$ th segment of time that the input signal is applied.

If a signal at the commutating frequency,  $f_c$ , is applied to the filter, the same average voltage appears across an individual capacitor each time it is switched into the circuit. The capacitors thus "see" a stationary signal and quickly charge to the average value. As the individual capacitor segments are sequenced by the commutator, a step format reproduction of the original signal is derived (Fig. 3).

A signal separated from the resonant frequency by some value, such as  $f_s$  Hz ( $f_c \pm f_s$ ), appears the same as  $f_s$  to the low-pass sections, thereby generating a bandpass response.

Responses are also generated, by the same mechanism, at harmonics of  $f_c$ , producing the comb-filter response shown in Fig. 4. This response is not desired for most applications, and so a filter designed with more conventional techniques is generally used after the commutating filter to eliminate the unwanted "teeth" in the comb. This same bandpass filter or low-pass filter eliminates the step waveform of the commutating filter output. A low-Q bandpass filter is sufficient for these purposes and is easily and economically constructed, even at low frequencies.

### Build an eight-section filter

An eight-section commutating filter that operates with up to 5-V peak-to-peak input signals

is shown in Fig. 5. The counter, operating at a clock frequency of  $8f_c$ , drives the switches. The MC7403 open-collector gates decode the counter output and also could provide the switches.

The 2N3906 transistors serve the dual purpose of allowing large values of input voltage and improving filter response. This is seen by comparing the filter response. Curves shown in Fig. 6, using a capacitor of  $0.1 \mu\text{F}$  and a resistor of  $1 \text{ k}\Omega$ . The bandwidth is the same in both cases, but the out-of-band rejection is greatly reduced in the 2N3906 transistors are not used.

With the transistors removed, a portion of the signal current is shunted through the transistor switches (MC7403). This current varies the saturation voltage of the switches and is thereby transmitted through the filter. The effect of the current is reduced by biasing through the switch with a dc bias that is larger than the signal current.

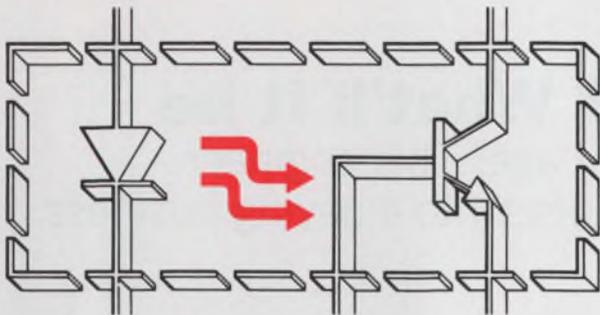
### Vary the bandwidth

Bandwidth, which is proportional to  $1/NRC$ , is easily varied by changing any one of the three parameters. Increasing  $N$  (using more sections) produces a smoother output waveform but requires more components. A wide choice of resistance and capacitance values is normally available.

Figure 7 shows the response of a similar filter for several bandwidth options. The narrower bandwidth option has a higher input resistance that decreases the magnitude of signal current. The difference in stop-band rejection shows clearly the advantage of reducing signal current as much as possible. A practical limit on input impedance is defined by the type of wave filter that loads the commutating filter.

The high switching speeds of TTL and ECL are required when operating at the higher frequency limits of commutating filters. ■■

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#### Characteristics:

Max. emitter forward voltage 1.5 V @  $I_F = 100$  mA  
Detector  $H_{FE}$  typ. 150 @  $V_{EE} = 5$  V,  $I_c = 100$   $\mu$ A  
Bandwidth 300 kHz @  $I_c = 2$  mA  
Price: 1,000 quantities, \$3.55. (All prices quoted are suggested resale price.)



#### MCD 2:

**if you need a really fast GaAsLITE opto isolator, this is it.**

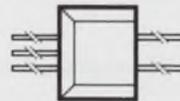
In the MCD series, we've coupled a GaAsLITE to a diffused planar Si PIN photodiode. The new MCD 2 gives you a turn-on time of 5 nanoseconds, yet offers the high voltage (1500 V) and resistance ( $10^{11}$  ohms) isolation you need for amplifiers, isolation transformers, pulse transformers, relays, feedback circuits or logic switches. Its coupling capacitance is very low, too; 1.3 pF. It will perform beautifully in linear or digital circuits. And the ISO-DIP packaging makes pc board stuffing a snap.

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Max.  $V_F$  1.5 @  $I_F = 100$  mA  
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$V_{AX} \geq 200$  @  $R_{GK} = 27K$   
 $V_{AK} = .9$  V (typ.) @  $I_A = 200$  mA  
 $I_F = 4$  mA } @  $V_{EE} = 50$  V,  $R_{GK} = 27K$   
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# Pasture or production? What'll it be

for you after 60, 50, or even 40 years of age? This engineer parlayed ambition, ability and a few ideas into a paying business.

By **Richard L. Turmail**, Management Editor

"NASA Layoffs Hit von Braun Team," read a headline in the New York Times for Sept. 3, 1970.

If it can happen to them, it can happen to you. And, if you're an engineer who doesn't want to be put out to pasture, why not prepare now for your future?

Take the example of Californian H. B. McLaughlin, an older engineer, who had been on someone else's payroll for 35 years. In 1964, the company merged, and he was laid off. When no one would hire him, he decided to go into business for himself.

Today, McLaughlin is president of LASTEC (Laser Technology, Inc.), North Hollywood, Calif. His company, a producer of standard and custom-designed laboratory and production equipment, did \$140,000 in sales last year. Quite an accomplishment for an engineer who is 69 years old.

## Personal promotion campaign is launched

According to McLaughlin, many engineers approaching the age of 45 or 50 find it increasingly difficult to keep their jobs, and even more difficult to replace those jobs if they're laid off. He adds, "In California, Thomas Alva Edison couldn't get a job today if he applied at the age of 50 or older."

While the severance of older engineers is accelerated by company mergers, company policy plays a leading role in keeping them unemployed. Many companies, for example, have no intention of hiring older engineers. They'd rather invest in a recent college graduate who has boned up on the latest technology, and who can be hired at a lower salary than his older counterpart.

"If your health is good, and you're ambitious," McLaughlin says, "being laid off is a terrible blow to your sense of usefulness."

To keep from getting stale, McLaughlin made plans to start a company. The first step of the plan was to get on someone's payroll, so he would have personal operating expenses to work on the second step of his plan—starting a company. With the help of his wife, he launched a personal

promotional campaign to find a job. And he added a twist to the usual job-hunting method that may be helpful to engineers who are looking for work.

Although he followed the usual method of answering the ads that covered his experience, he found a way to simplify the procedure. He made up 75 standard paragraphs: some were openers, some were for the main body of his reply, and some were closers. When he answered an ad that required the experience he'd had as a production manager, for example, he'd send paragraphs 2, 7, 9, 17, 41, and 72. When the paragraphs were in sequence, they made a logical letter that applied to the ad he was answering.

"Because of my varied experience," McLaughlin says, "I answered every ad from president to technician. During the eight months I was out of work, I was offered 14 jobs. But as soon as the prospective employers found out how old I was—I had carefully left my age out of my replies—they wouldn't hire me."

Finally, McLaughlin accepted a job as technician in the solid-state laboratory of a university. Step one in McLaughlin's plan to start a company was phased out. The bigger challenge was still ahead.

## Something on which to build a business

Starting one's own business is not a sinecure for the unemployed engineer. He must have an idea or a product—something that will induce people to invest. The "something" that McLaughlin had was a line of equipment he had been developing off and on since 1948. In that year a new gemstone made of titanium dioxide, which had a refractive index exceeding that of a diamond, came on the market.

"I enrolled at the time in a course on gem cutting," McLaughlin said, "because I was then marketing gems as jewelry. The process was interesting but too slow, so I automated the faceting and crowned the gemstone with sapphire to improve its resistance to scratching."

One piece of equipment led to another. The crown required a joint between the two surfaces which were optically flat in order to prevent the formation of light interference fringes, so Mc-

Laughlin developed a machine with diamond wheels that could lap and polish materials to the proper flatness. He also built a Verneuil furnace that could produce gemstones and oxides. And he developed a double-disk diamond wheel grinder to grind both sides of the sapphire crowns, simultaneously.

McLaughlin now had a double-disk diamond wheel grinder, a six-wheel polishing machine, a Verneuil furnace to make the gemstones and an automatic faceting machine.

"All of this took a total of 26,000 hours to develop," McLaughlin says, "but it gave me the basis for a business."

During the 14 years it had taken McLaughlin to develop his equipment, he had talked with many of his friends about organizing a manufacturing company. Now he set a date for a backer's meeting at which he would present his case for starting a company. As the date of the meeting neared, McLaughlin tried out his pitch on fellow members of the Toastmasters Club, an international organization designed to help its members improve on their public presentations.

"I took notes while they took my speech apart," he says. "After four trials, they okayed it."

"If you want to sell an idea," McLaughlin says, "never discuss what you're going to do—discuss what you've done, and the audience will project the facts into what can be done."

He told his audience that the laser industry is predicted to grow at a rate greater than the semiconductor industry, that he had a furnace that has grown, among other gemstones, rubies that are used in solid state lasers, and another machine that polishes the ends of the rubies, doubling their value. He also told them he would put

these machines into the company for stock.

McLaughlin raised \$20,200 at the meeting—cash so meager that his friends said he couldn't last six months. But he had decided to start the company on whatever he could raise. The company was incorporated, officers were elected, 2500 feet of space was leased, and a milling machine was purchased. Anyone with talent, regardless of age, was offered an opportunity to work and acquire equity in the company. Most of the employees' wages were allowed to accumulate, and permission was granted by the California Securities Commission to pay them in stock at year's end.

"We had to retain enough money to pay them in cash," McLaughlin says, "in the event that state permission was denied."

A few of the employees, who wanted out at the end of the first year, were paid in cash. But the majority of the original investors, mostly engineers and scientists, who were voted a pay rate of \$2 per hour, continued to work at the company part-time. According to McLaughlin, some of them were making top salaries at regular jobs.

"And that was a good thing," McLaughlin says, "because our first year's sales amounted to a little over \$3,000." Since then, company sales have, reportedly, doubled each year.

#### Company product used on 'moon rocks'

Before LASTEC reached an annual sales figure of \$140,000, it had traveled through rough financial waters. On two occasions the company's capital had fallen below \$1500.

"But we never allowed the company to go into debt," McLaughlin says. "We have a hard, fast rule: Don't buy unless you can pay. That policy has carried up through some trying times."

The company's success has been particularly pleasing to McLaughlin because he says that the skeptics told him he couldn't sell a thousand-dollar product by direct mail.

"My wife," he says, "sold \$100,000 worth of equipment last year through national advertising and direct mail solicitation."

The prime reason for the company's sales success has probably been its capability. One of the firm's products was selected by Industrial Research as one of the 100 most significant new technical products developed during 1967.

"The award was given," McLaughlin says, "for the development of our diamond-impregnated wire, which is used to slice crystals and semiconductor material. In fact, NASA found our wire the only thing they could use satisfactorily on the 'moon rocks.'"

McLaughlin says that if you're an engineer and don't want to be put out to pasture before you're ready, now is the time to start developing your abilities and ideas for your future. ■■



H. B. McLaughlin points out that "if an engineer doesn't have ambition, ability and ideas, he'd better settle for his Social Security, because he has no business starting a business in the electronics industry."

# Ideas For Design

## Telemeter sensor outputs with simple FM transmitter

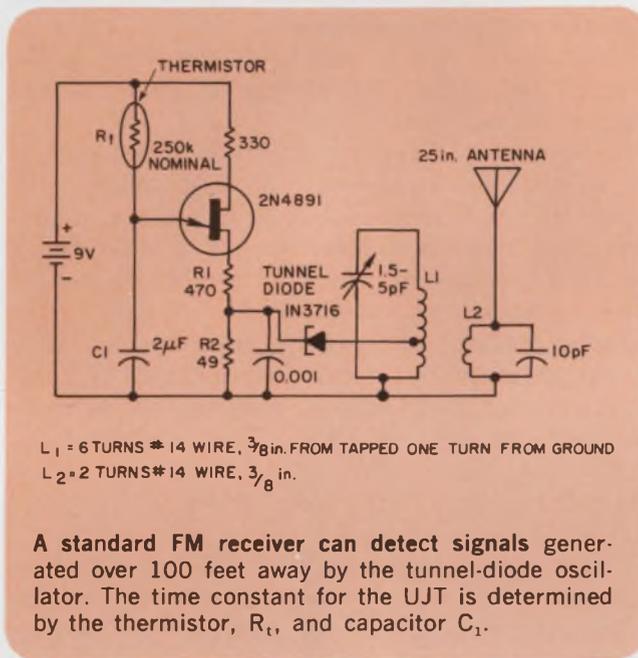
Unijunction transistors are good for temperature-stable pulse sources and tunnel diodes for simple vhf oscillators. Combined, they can be used to construct a low-cost, low-drain telemetry transmitter for slowly varying signals.

Thermistor  $R_1$  (see diagram), which in our application is loosely implanted in a patient's ear to measure body temperature, and capacitor  $C_1$  determine the frequency of the UJT oscillator. Each pulse discharged through the UJT base activates the tunnel-diode oscillator and generates a burst of rf that can be detected more than 100 feet away by a standard FM receiver. There is just enough FM in the signal to make tuning non-critical.

Temperature can be gauged, after calibration, by counting pulses with a stop watch or timer.

*John D. Griffith, M.D., Dept. of Psychiatry, School of Medicine, Vanderbilt University, Nashville, Tenn. 37203.*

VOTE FOR 326

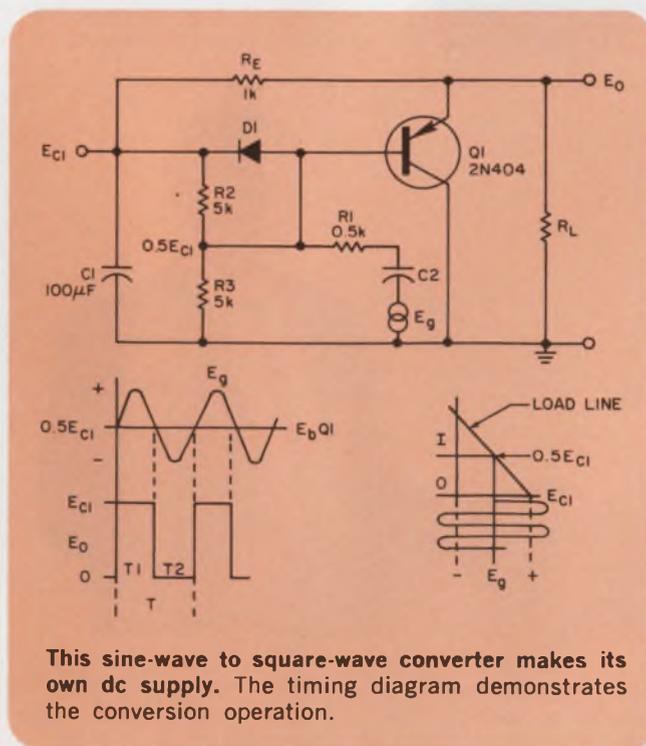


## Convert sine to square waves with no external dc source

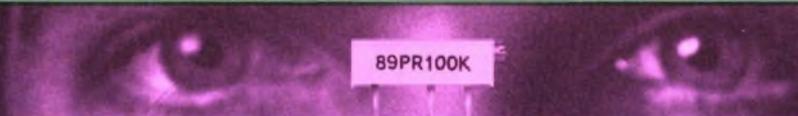
A sine-wave generator, a half-wave rectifier circuit, and a transistor amplifier combine to yield symmetrical square waves. The circuit requires no external dc source, dissipates power only when the input is present and has symmetrical output regardless of the amplitude of the input voltage. It has wide bandwidth (Hz to MHz), requires few parts and is inexpensive and simple to design.

When the input voltage swings positive,  $Q_1$  (see drawing) is driven off while  $D_1$  is driven on, and  $C_1$  charges through  $R_1$ ,  $C_2$  and  $D_1$ . When the input voltage swings negative,  $D_1$  is driven off while  $Q_1$  is driven on. After several cycles,  $C_1$  charges to an average dc voltage, which is determined by  $R_1$ ,  $R_E$  and  $R_L$ .

Thus,  $D_1$  and  $C_1$  function as a half-wave dc power source;  $R_1$  prevents the overloading of the generator; and  $C_2$  is used to ac-couple the input voltage to the circuit.



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When the input voltage swings negative ( $-E_v$ ), the emitter follows the base, which goes below the zero voltage level;  $Q_1$  saturates and the emitter and the output voltage are clamped near ground (0.2 V). While  $Q_1$  is in saturation, part of the energy stored in  $C_1$  is discharged through two parallel series resistance paths:  $R_2 + R_3$  and  $R_E + R_{sat}$  of  $Q_1$ . Since  $R_2 + R_3 \gg R_E$  and  $R_E \gg R_{sat}$ , the discharge path is mainly through  $R_E$  and  $Q_1$ . Therefore, to ensure that  $Q_1$  remains saturated during the time  $E_v$  is negative, the discharge time constant  $R_E C_1$  must be greater than  $T/2$ .

Connected across  $C_1$  is a voltage divider network consisting of two equal resistors,  $R_2$  and  $R_3$ , the junction of which is connected to the base of  $Q_1$ . Since  $R_2 = R_3$ , the voltage at the junction of

$R_2$  and  $R_3$  will automatically adjust itself to equal one-half of the dc voltage across the capacitor, regardless of the amplitude of the input voltage. This voltage establishes an operating point for  $Q_1$  at the center of the load line. The input sine wave and the output square wave must now swing above and below this dc bias voltage. Therefore, the input and output waveforms are symmetrical and in phase: when the input voltage swings positive, the output voltage is equal to the dc voltage across  $C_1$ ; and when the input voltage swings negative, the output voltage is clamped at ground. Thus, the circuit converts sine waves to square waves.

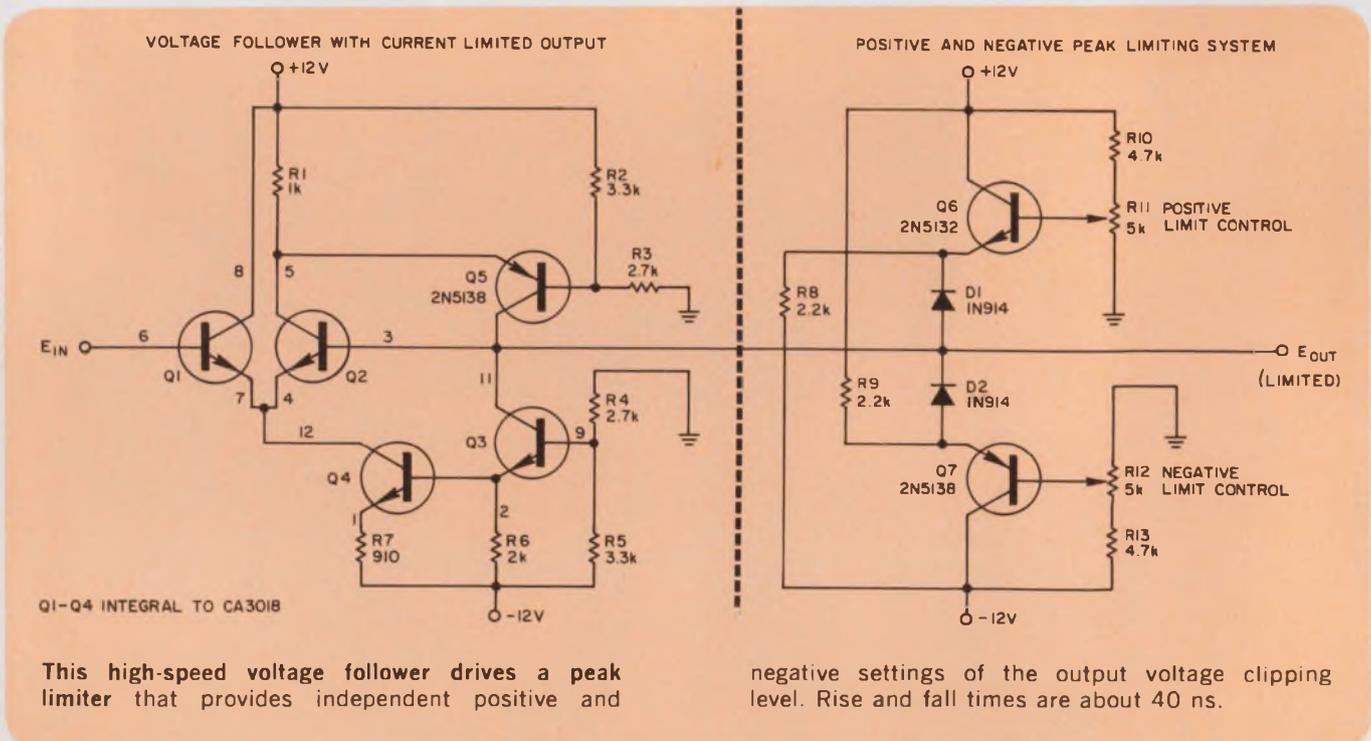
*Raymond Marcoux, Sylvania Electric Products Inc., Dept. 675-2, 189 B St., Needham Heights, Mass. 02194.*  
**VOTE FOR 327**

## Voltage follower has separate limiting for each polarity

A high-speed voltage follower with a zero offset input-output voltage can be constructed by using the naturally balanced properties of a monolithic transistor differential pair.<sup>1</sup> By adding current-biased elements in a closed-loop follower configuration, the output voltage swing becomes bidirectional with a predetermined current limit in both directions of signal swing

(current sourcing and current sinking).

Referring to the voltage follower circuit in the diagram,  $Q_1$  and  $Q_2$  are the matched differential pair with current-source biasing provided by  $Q_4$ . To visualize circuit operation, assume an input dc referenced to ground at the base of  $Q_1$ .  $Q_1$  operates as a common-collector amplifier, driving  $Q_2$  common base.  $Q_2$  and  $Q_3$  form a folded cascode



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tions, the higher power levels utilize high speed switching techniques to implement the pulse width modulation operation. They provide the electromechanical designer with functional building blocks for system design, and offer significant cost improvements. All four units are available off-the-shelf. For further information and appli-

cations assistance, contact TRW Semiconductor Division, 14520 Aviation Blvd., Lawndale, Calif. 90260. Phone (213) 679-4560. TWX 910-325-6206.



amplifier with all of  $Q_2$ 's dynamic collector current being transferred to  $Q_3$ 's collector circuit by way of the latter's common-base connection. The collector load for  $Q_3$  is another source,  $Q_4$ .

The high incremental impedance afforded by  $Q_3$ 's low collector conductance allows a high open loop voltage gain to be realized by the composite amplifier. And since the loop is closed by the 100% voltage feedback to  $Q_2$ 's base, this results in tight closed-loop control as the output is being directly compared to the input by the  $Q_1$ - $Q_2$  combination.

The circuit features wide bandwidth because of the common/collector-collector/base drive of the  $Q_1$ - $Q_2$  combination and the absence of Miller effect. Other desirable characteristics include high common-mode range and current-limited output caused by  $Q_3$  and  $Q_4$  current source biasing. Rise and fall times are on the order of 40

ns and the output voltage swing can be clipped at any desired level.

By introducing biased diodes  $D_1$  and  $D_2$ , which will absorb the output current above or below a preset voltage level, the circuit develops high output impedance while depleting  $Q_3$ 's or  $Q_4$ 's current output. Thus,  $E_{out}$  becomes peak-limited. Because of the bidirectional nature of the circuit, the clipping is easily applied to both negative and positive peaks. The clipping potentials can be made variable, and a complete video limiting system is obtained with independent adjustment of positive and negative clipping levels.

**Reference**

1. Jung, Watler G. "TV Applications of IC Differential Amplifiers," *Broadcast Engineering Part I*, September, 1969.

Walter G. Jung, Senior Engineer, Control Concepts Corporation, Rockville, Md.

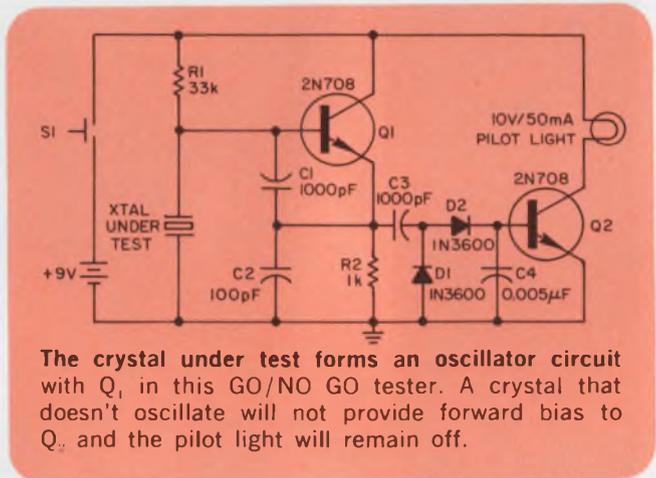
VOTE FOR 328

## Check crystals easily with this GO/NO GO tester

Go/No Go testing of crystals can be easily accomplished by means of the simple unit shown. This tester has been used with crystals ranging from 3.5 MHz to 90 MHz.

The crystal to be tested is inserted into a test socket, and  $S_1$  is closed. If the crystal is good the pilot light will glow. If the crystal is bad the pilot light will remain off. What could be simpler? The unit can be battery-operated and can be constructed in a package that measures 2 by 4 by 1-1/2 inches.

Transistor  $Q_1$  forms an untuned Colpitts oscillator with the crystal under test. With a good crystal in the circuit and  $S_1$  closed, several volts pk-pk will appear across  $R_2$ . This arc is then level-shifted and peak-detected by the action of  $C_3$ - $D_1$  and  $C_4$ - $D_2$ . The resulting dc voltage provides forward bias to  $Q_2$  and turns on the pilot light, signifying a good crystal. A crystal that



The crystal under test forms an oscillator circuit with  $Q_1$  in this GO/NO GO tester. A crystal that doesn't oscillate will not provide forward bias to  $Q_2$  and the pilot light will remain off.

fails to oscillate produces no bias for  $Q_2$ , and the pilot light remains off.

Mike Kaufman, Member of Technical Staff, Hughes Aircraft Co., 3733 Meadville Dr., Sherman Oaks, Calif. 91403.

VOTE FOR 329

## SCR and programmable UJT make adjustable timer

This versatile timing device has continuously adjustable turn-on delay that is developed from the  $R_1$ ,  $C_1$  time constant and is controlled by  $R_2$ , which sets the threshold level of  $Q_1$ . If the +24-V supply voltage is applied (see figure), the voltage

across  $C_1$  increases. When the threshold level is reached,  $Q_1$  fires, triggering  $Q_2$ . Thus the supply voltage is applied to the load. With  $Q_2$  on, the timing circuit is deactivated until the supply voltage is removed.

# Our 1¼ oz. alarm will blast you with 80db of the most irritating noise in the world.

Nothing can drown out or cover up the persuasively piercing sound of the Mallory Sonalert® electronic audible signal. It's made to be heard.

The light, compact Sonalert is of solid state design for maximum efficiency and reliability and requires as little as 3 milliamps current. No arcing. No mechanical wear.

You can use Sonalert in hundreds of places—autos, trucks, boats, planes, laboratory, home and industry—anywhere a warning signal is required. Its penetrating audible signal scares burglars, warns of dangerous conditions and is an adjunct to many types of visual signals. It produces no RF noise, making it ideal for low-volt-



age circuits in computers, medical electronics, instrumentation and communications equipment.

Sound intensity range is 68db @ 6VDC to 80db @ 28VDC. Sound frequency levels are  $2900 \pm 500$  Hz and  $4500 \pm 500$  Hz, depending on model. Warbling, pulsing and AC models also are available. You can get Sonalert from your local Mallory distributor.

For a free 48-page idea booklet of applications, #9-406 "How to Use Sonalert," write to Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

Sonalert® — Registered trademark, P. R. Mallory & Co. Inc.

**MALLORY**

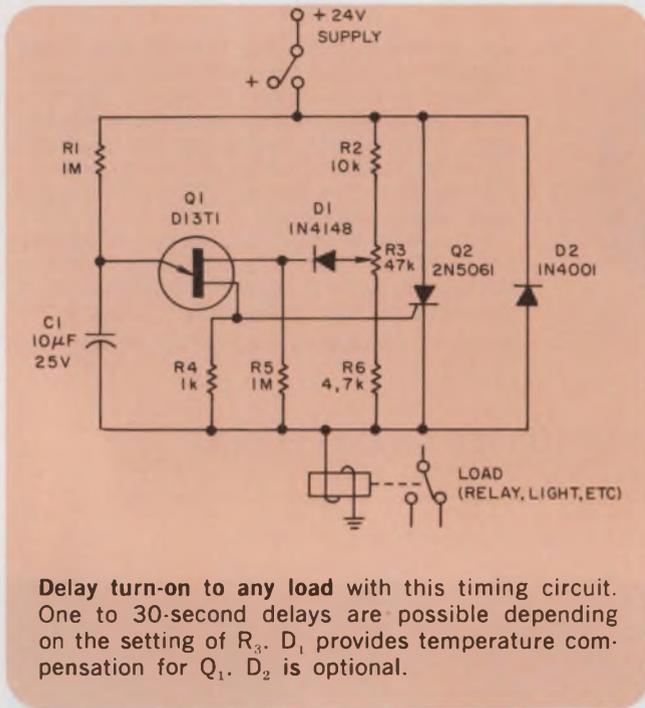
## MALLORY CAPACITOR COMPANY

a division of P. R. MALLORY & CO. INC.

3029 E. Washington St., Indianapolis, Indiana 46206; Telephone: 317-636-5353

Electrical and Electronic Components • Sequence Timers • Metallurgical Products • Batteries





Delay turn-on to any load with this timing circuit. One to 30-second delays are possible depending on the setting of  $R_3$ .  $D_1$  provides temperature compensation for  $Q_1$ .  $D_2$  is optional.

$D_1$  provides temperature compensation for  $Q_1$  (see D13T1 application note).  $D_2$  is optional and protects the circuit against reversed supply voltages.

Time delays between one second and 30 seconds are obtained depending on the setting of  $R_3$ . Longer delay (up to one hour) may be obtained by using a low-leakage D13T2 UJT for  $Q_1$  and larger values for  $R_1$  and  $C_1$ .

In a typical design with 1/4-W resistors, a tantalum capacitor and miniature trimpot, the complete device measures only half a cubic inch.

*Robert L. Billon, Consultant Engineer, 20 Ave. de Plaine Fleurie 38, Meylan, France.*

VOTE FOR 330

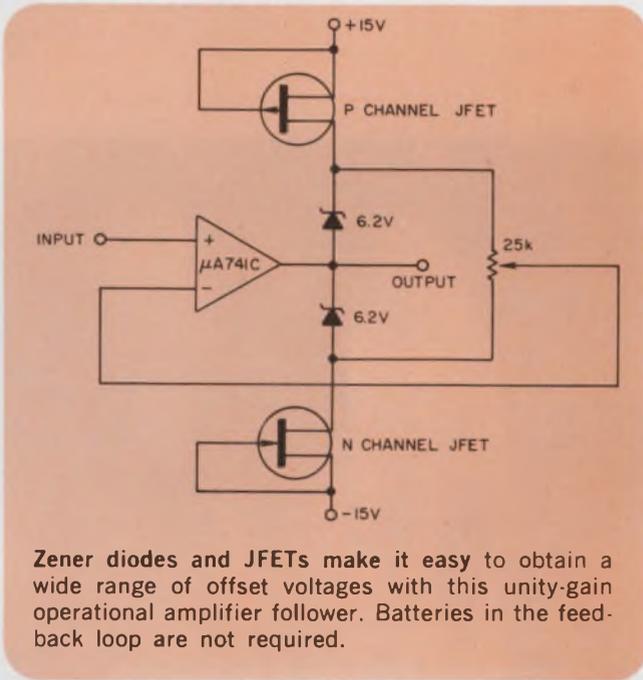
## Op-amp follower has wide adjustable offset voltage

An adjustable offset voltage with a unity-gain op-amp follower is usually difficult to obtain because many circuits require a battery in the feedback loop. However, it can easily be obtained with two zener diodes, an N-channel and P-channel JFET as constant current sources, and a pot.

The op amp drives the junction of the zener

**VOTE!** Go through all Idea-for-Design entries, select the best, and circle the appropriate number on the Reader-Service-Card.

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



Zener diodes and JFETs make it easy to obtain a wide range of offset voltages with this unity-gain operational amplifier follower. Batteries in the feedback loop are not required.

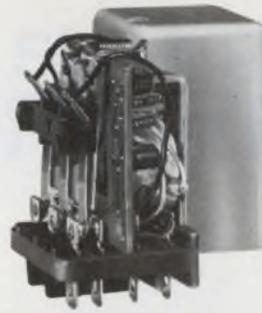
diodes, and the wiper arm of the 25-k $\Omega$  adjustment potentiometer selects the offset voltage to be fed into the inverting terminal of the op amp. The op-amp output is the negative of the voltage at the wiper arm.

Gain error is less than 0.2% at 1 kHz. The output is adjustable to match the zener voltages. The FETs must have sufficient  $I_{DSS}$  to bias the zener diodes into conduction. The op amp used must have the differential and common-mode input voltage ratings in excess of the input and output offset signal.

*Burton J. Schultz, Electrical Engineer in Bio-engineering, University of Missouri, Missouri Regional Medical Program, 406 Turner, Columbia, Mo. 65201.*

VOTE FOR 331

# New Potter and Brumfield magnetic latching/solid state IMPULSE RELAY has permanent memory



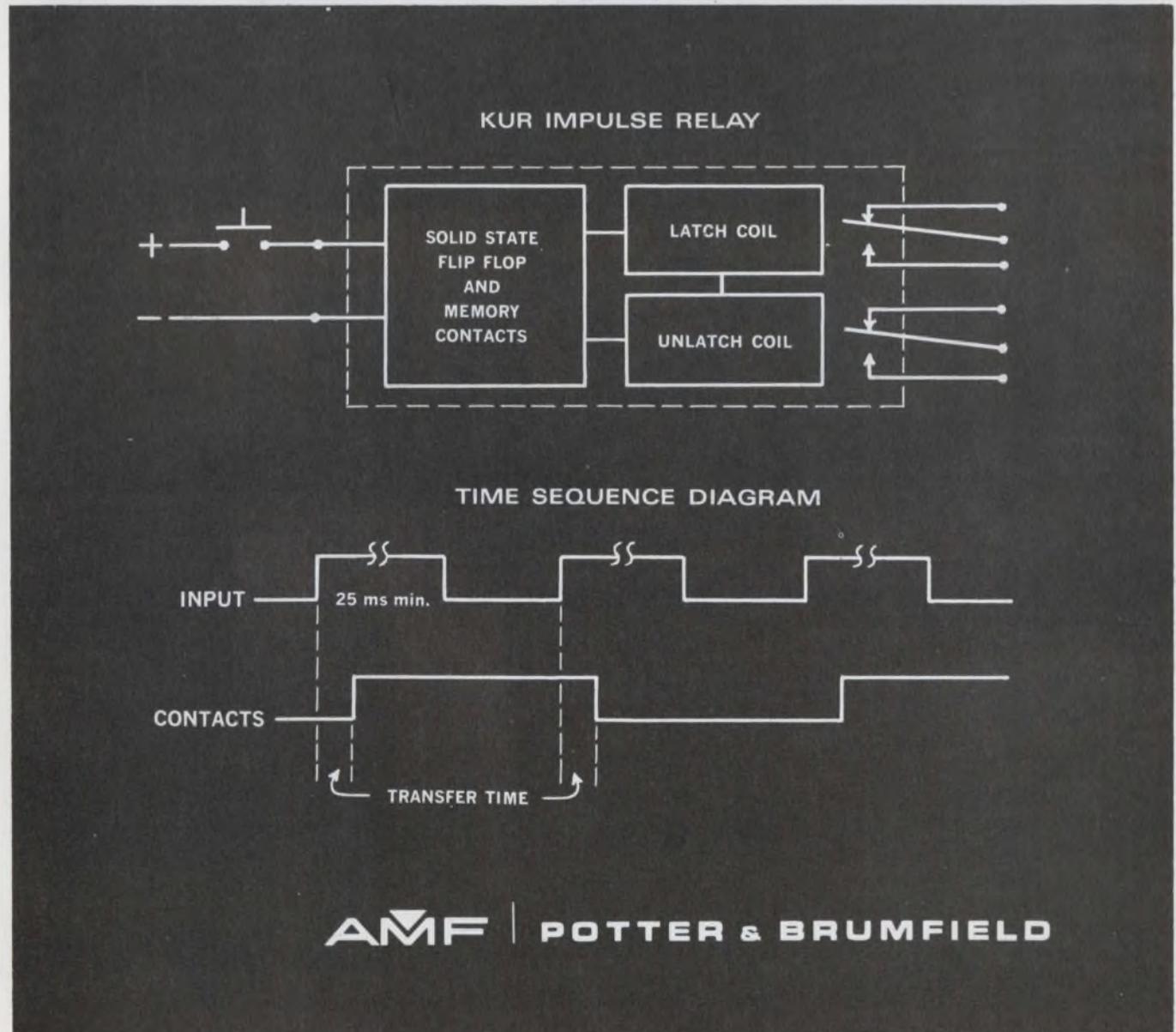
This hybrid impulse relay is unique. Its basic structure is our KUL, a single coil latching relay employing a shunting-type magnetic circuit. To that we have added a solid state flip-flop circuit to obtain a truly modern, alternate-action, impulse relay.

Consider the many features of this extraordinary device:

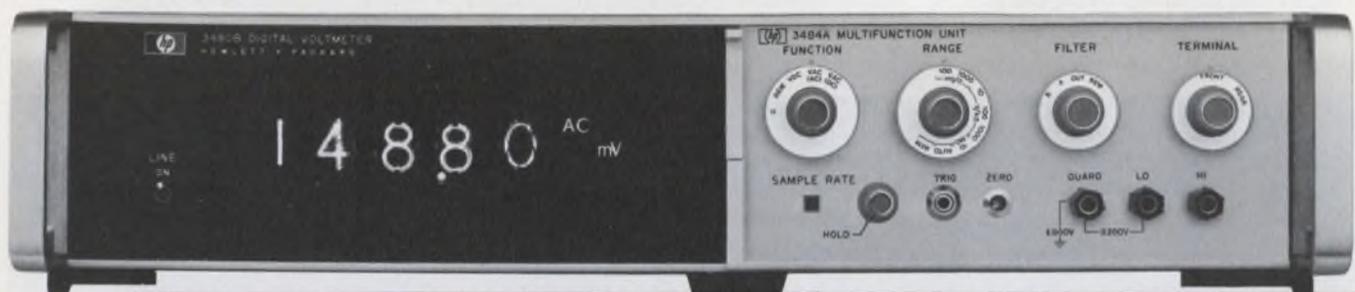
- A pulse width of 25 milliseconds (min.) effects transfer of the DPDT contacts to switch 5 or 10 ampere loads.
- Contacts will hold in their last position without power. This memory is obtained through the magnetic latching ability of the relay.
- There are no mechanical linkages as found in ordinary impulse relays, to wear out or malfunction.
- The assembly is neatly packaged in a popular-size case which provides a wide choice of mountings, terminations and readily available sockets. Mounted height is only 2.126".
- An ordinary SPST switch will operate the KUR impulse relay. As coils are rated for continuous duty, there is no limit (except minimum) to the pulse length.

The price? A modest \$15.00 in single lots. Quantity discounts apply. Today, call your local P&B sales representative for complete information.

Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana 47570. (812) 385-5251.



# When is True RMS Really True RMS?



$$\sqrt{(DC)^2 + (AC_{rms})^2}$$

**TRUE RMS** =  $\sqrt{(dc)^2 + (ac_{rms})^2}$  — and HP's new 3480 DVM is the only four-digit multi-function meter that can give you this true RMS value — ac, dc, or **ac plus dc**. And, the 3480 eliminates the errors caused by odd harmonic distortion added by average responding converters. With the 3480 you get measurements within 0.1%, not just to within 1%! (A 1% third harmonic distortion =  $\pm 0.33\%$  error or  $\pm 33$  counts of error in a four-digit average responding DVM.)

Whatever type of signal you're measuring — from the purest sine wave to the most irregular pulse train — the HP 3480 DVM gives you the results you need in one second. And, when you're working with an ac-plus-

dc signal, you don't have to make two separate readings and then calculate the combined RMS value. It's all there, in one set of figures.

**THE SECRET: A PAIR OF MATCHED THERMOPILES.** At the heart of the 3480, there is a tiny chip, less than  $\frac{1}{4}$ " square, which contains matched sets of thermopiles. One measures the heat produced by the signal you're testing; the other does the same for a reference voltage.

The full scale ranges of the HP 3480 DVM are from 100 mV to 1000 Vac and the frequency range is from 1 Hz to 1 MHz. And with the correct plug-in, the 3480 can give you up to 1,000 **straight-dc** or **ohms** readings per second — with 5 dc ranges and 6

ohms ranges.

Prices range from \$1150 for one range of dc to \$3375 for multi-function ac, dc and ohms capabilities with isolated BCD and isolated remote control.

Find out how the HP 3480 DVM can help solve *your* measurement problems. Contact your local HP field engineer, or write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

090/12

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DIGITAL VOLTMETERS

INFORMATION RETRIEVAL NUMBER 41

# Product Source Directory

## IC and Semiconductor Testers

The data included in this Product Source Directory is divided into two sections—on discrete component and integrated circuit testers—and then arranged in order of ascending basic price. Listed are testers of electrical parameters only. Handling and environmental test equipment is not included.

Note that some testers can be used to test both ICs and discrettes; these are included in the IC tester section. Note also that many of the more

expensive IC testers and test systems can be used to check memory modules, digital logic boards or systems and discrete devices when they are equipped with handling and other options. Please check with the manufacturers.

Tester manufacturers are identified by the abbreviations shown in the Master Cross Index. The following abbreviations are used in the tables:

ina—information not available

n/a—not applicable

Abbrev.	Discrete	Integrated	Company	Information Retrieval No.
AAI		•	AAI Corp. P.O. Box 6767 Baltimore, Md. 21204 (301) 666-1400	450
ADAR		•	ADAR Associates, Inc. 73 Union Sq. Somerville, Mass. 02143 (617) 623-3131	451
AEL	•		AEL Inc. P.O. Box 552 Lansdale, Pa. 19446 (215) 822-2929	452
Affil Manuf		•	Affiliated Manufacturers Inc. P.O. Box 248 Whitehouse, N.J. 08888 (201) 538-8500	453
Aritech		•	Aritech Corp. 130 Lincoln St. Brighton, Mass. 02135 (617) 254-2990	454
Auto Meas		•	Automated Measurements Corp. Div. of E-H Research Labs, Inc. P.O. Box 1289 Oakland, Calif. 94604 (415) 834-3030	455
B&K		•	B&K Div. Dynascan Corp. 1801 W. Belle Plaine Ave. Chicago, Ill. 60613 (312) 327-7270	456
Baird		•	Baird-Atomic, Inc. 125 Middlesex Turnpike Bedford, Mass. 01730 (617) 276-6016	457

Abbrev.	Discrete	Integrated	Company	Information Retrieval No.
Beckman		•	Beckman Instrs., Inc. Electronic Instruments Div. 2200 Wright Ave. Richmond, Calif. 94804 (415) 526-7730	458
CGS Units		•	CGS Units, Inc. 73 Saginaw Dr. Rochester, N.Y. 14623 (716) 244-2080	459
Caltron		•	Caltron Industries 2015 2nd St. Berkeley, Calif. 94710 (415) 548-1966	460
Dantronics		•	Dantronics Inc. 3175 Hafner Ct. Saint Paul, Minn. 55112 (612) 484-2108	461
Datatron		•	Datatron Inc. 1562 Reynolds St. Santa Ana, Calif. 92705 (714) 540-9330	462
E-H		•	E-H Research Labs, Inc. P.O. Box 1289 Oakland, Calif. 94604 (415) 834-3030	463
EICO		•	EICO Electronic Instr. Co., Inc. 283 Malta St. Brooklyn, N.Y. 11207 (212) 949-1100	464
Fairchild Inst		•	Fairchild Instrumentation 974 E. Arques Ave. Sunnyvale, Calif. 94086 (408) 735-5011	465
Heath		•	Heath Co. Dept. 180 Benton Harbor, Mich. 49022 (616) 983-3961	466

Index continued on page 94

# Learn to evaluate IC tester performance

Besides looking at price tags, shopping for an IC tester involves knowing the sort of checks you want to run, where your tester will be used and what trade-offs you can make on specifications.

A digital integrated circuit can be checked for logical operation or function, which is described by its truth table. Testing is accomplished by applying various combinations of ONEs and ZEROs to the inputs of the IC while checking that the output is in the proper state. The input pattern is generally changed at 50 to 100 kHz, a low rate in comparison to the device's maximum operating frequency.

The test pattern can also be varied at a rate fast enough to provide an operational check of the high-frequency performance of the device. This clock-rate testing or high-frequency functional testing is becoming popular for MOS ICs since they are often operated near their maximum usable frequencies (generally a few megahertz).

Dc parameters, such as output voltage, input leakage and fan-out, are tested by forcing a specified current and measuring a voltage, or vice versa, while applying the given  $V_{CC}$  and other conditions. Ac (dynamic) parameters, like propagation delay and rise time, can also be checked, but only at much greater expense. Because of this, users rarely test ac parameters 100% unless the parameters are critical. It is usually better to depend on sample testing and assume that manufacturers rate their circuits conservatively.

In practice, no single type of test—functional, dc parametric or ac parametric—is usually adequate. If only the dc parameters are tested, an incorrect or missing internal connection may not be caught. If only logic tests are performed, insufficient fan-in or fan-out may not be detected.

Consequently, different types of tests are generally performed on the same device; they may even be run simultaneously. The combination of parametric and functional tests is called analogical (analog/logic) testing. In this type of

testing, precisely programmed input drive conditions and output detectors are used instead of simple ZERO and ONE drivers and sensors. Analogical testing is frequently used in automatic inspection instruments and provides an excellent screen that will catch most device faults.

Linear tests, which are performed only on linear integrated circuits, include dc and ac parametric tests. But these are quite different from digital tests and cannot generally be performed with the same instruments.

## Match the tester to your need

Most digital IC test equipment falls into three general classes: manually programmed testers, automatic test instruments, and computer-operated test systems.

**Manually programmed testers** are the least expensive IC test instruments, most of them being priced from \$500 to \$2500. They perform dc parametric tests, which are usually set up individually with various panel controls. This permits great versatility.

Data for programming must usually be obtained from IC data sheets and is a job for a relatively skilled technician. The programming process can be very tedious and slow, since as many as 20 separate tests are required for a simple IC. Errors are also likely to occur because manual programming requires meticulous care.

Test results are usually displayed on an analog or digital meter. The digital display is easier to read but is more expensive. Frequently it is not really necessary since high accuracy and resolution are not generally required in semiconductor testing.

These simple manually programmed testers are useful in evaluating sample ICs and in analyzing IC failures. They are also excellent for training technical personnel. However, they are not practical for the high-volume testing encountered in incoming inspections.

**Automatic test instruments** are usually of interest to most users. They are intended for incoming inspection but can also be used for evaluating ICs. They cost from \$2500 to \$12,000.

With this type of equipment, the IC is simply inserted in the test socket and the instrument

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Paul Franson, Engineer, Teradyne, Inc., 183 Essex Street, Boston, Massachusetts 02111

automatically performs a rapid series of analogical tests that determine whether the IC is good or bad. Automatic testers can check devices from simple gates to complex MSI arrays such as memories.

For incoming-inspection tests, GO/NO-GO results are needed. Sometimes it is also useful to know the nature of the failure. In both cases, these results are most conveniently and simply indicated by lamps. Meters and digital readouts frequently lead to misinterpretation and confusion.

Because automatic test instruments are used in incoming inspection by unskilled personnel, simple operation is vital. The most critical setup function is programming. Hard-wired plug-in programming is ideal since it eliminates the possibility of incorrect switch and dial settings. Program cards can either be prepared by the user or bought preprogrammed from the instrument manufacturer.

When ICs are evaluated with an automatic instrument, actual device parameters must often be measured. A digital readout is most convenient, and this can be provided by either an internal or external digital voltmeter. Analog meters, which are less expensive, can also be used, as well as the nulling method of adjusting switches or potentiometers to control biases or measurement references while watching the failure lamp.

Some instruments use a combination of program-card and switch-or-knob programming. This type of equipment is a little more convenient for evaluation than a manually programmed instrument or one programmed only by program cards. The combination instrument is, however, less satisfactory for incoming inspection.

**Computer-operated test systems** offer the ultimate in test versatility and power. These systems not only make GO/NO-GO decisions, but they also classify ICs into categories and provide distribution analyses and summaries for production control. They check dc parameters, logic operation, and in some cases, ac parameters.

Capability, however, is related to cost. An exceptionally versatile system that can perform all these tests may cost several hundred thousand dollars. Therefore, few IC users have computer-operated systems unless they handle very large volumes of devices or have special requirements for quality control, extensive life, and environmental or burn-in testing.

### Compare equipment capability and cost

The first questions that usually occur to the prospective buyer of an IC test instrument concern its specifications. What voltages and currents will it supply? How accurate is it? How many device pins will it accept? But these tradi-

tionally vital items may be less important in many applications than cost and throughput rate.

Integral voltage and current sources, for example, should be adequate to handle most of the devices to be tested. External supplies, however, often provide a better solution to the special requirements of particular circuits like display-tube drivers and emitter-coupled-logic ICs.

Accuracy is not the overriding consideration normally required for laboratory instruments. Semiconductor manufacturers try to set generous—or realistic—specifications. Therefore, devices are usually not marginal; they are good or bad. Since many semiconductor parameters are very dependent on temperature, a large number of high-precision measurements are pointless.

Although the number of device pins an IC test instrument will accept seems fixed, clever programming and simple adapters can increase this capability. For example, Teradyne's model JI33C appears to be limited to 16-pin devices, but it can test many 24 and 32-pin ICs.

In many applications, test instruments are chosen to meet technical requirements without much regard for the cost of using the equipment after purchase. But this attitude is not possible in volume-production and incoming-inspection applications where testing costs are critical.

Throughput considerations, for example, immediately eliminate any slow instrument such as a manual tester. Even for a fast automatic instrument, a maximum practical test rate is about 600 devices per hour if the ICs are being inserted manually into a single socket. With an automatic handler, rates of 7000 per hour are possible.

Programming costs are often hard to determine. The simplest testers require considerable skilled time, which can be very expensive. Computer-operated systems can be inexpensive and fast to program since, after the initial preparation of a test program, a relatively unskilled operator can load the equipment and be ready to test in seconds. For minimum programming time and low costs, the card-programmed automatic tester is attractive.

Another factor to be considered is obsolescence. If an instrument has a very short life—either because it wears out or is not usable with new devices—the cost per test rises greatly. Rental of instruments may reduce this drawback at slightly higher expense.

Most of the general considerations mentioned apply to test equipment for linear integrated circuits. Relatively few instruments are available for linear ICs, and these generally require more extensive programming. A special feature of computer-operated linear test systems is their ability to test these ICs, a must for certain stereo and chroma demodulators, multiplexers and FM detectors. ■■

Abbrev.	Discrete	Integrated	Company	Information Retrieval No.
Hickok	•		Hickok Electrical Instr. Co. 10514 DuPont Ave. Cleveland, Ohio 44108 (216) 541-8060	<b>467</b>
Hy-Cal	•		Hy-Cal Engineering 12105 Los Nietos Rd. Santa Fe Springs, Calif. 90670 (213) 698-7785	<b>468</b>
IPT	•	•	IPT Corp. 185 Evelyn Ave. Mt. View, Calif. 94040 (415) 961-9521	<b>469</b>
Julie		•	Julie Research Labs, Inc. 211 W. 61st St. New York, N.Y. 10023 (212) 245-2727	<b>470</b>
Leader Inst	•		Leader Instrument Corp. 37-27 27th St. Long Island City, N.Y. 11101 (212) 729-7410	<b>471</b>
Lear		•	Lear Siegler, Inc. 3171 S. Bundy Dr. Santa Monica, Calif. 90406 (213) 391-7211	<b>472</b>
Lorlin	•		Lorlin Industries Inc. Precision Rd. Danbury, Conn. 06810 (203) 744-0096	<b>473</b>
Macrodata		•	Macrodata Test Systems Div. 20440 Corisco St. Chatsworth, Calif. 91311 (213) 882-8880	<b>474</b>
Mastech	•		Mastech Inc. Box 178 E. Molloy Rd. Syracuse, N.Y. 13211 (315) 455-6662	<b>425</b>
Meas/Data		•	Measurement/Data Div. Signetics Corp. 341 Moffett Blvd. Mt. View, Calif. 94949 (415) 961-9399	<b>426</b>
Microdyne		•	Microdyne Instruments, Inc. 203 Middlesex Turnpike Burlington, Mass. 01803 (617) 272-5691	<b>427</b>
Optimized	•	•	Optimized Devices, Inc. 220 Marble Ave. Pleasantville, N.Y. 10570 (914) 769-6100	<b>428</b>
Philbrick		•	Philbrick/Nexus Research A Teledyne Co. 70 Allied Dr. Dedham, Mass. 02021 (617) 329-1600	<b>429</b>
Pulse		•	Pulse Monitors Inc. 351 New Albany Rd. Moorestown, N.J. 08057 (609) 234-0556	<b>430</b>

Abbrev.	Discrete	Integrated	Company	Information Retrieval No.
Quan-Tech	•	•	Quan-Tech Labs, Inc. 43 S. Jefferson Rd. Whippany, N.J. 07981 (201) 887-5508	<b>431</b>
RCA	•		RCA Electronic Components 415 S. 5th St. Harrison, N.J. 07029 (201) 485-3900	<b>432</b>
Redcor		•	Redcor Corp. 7800 Deering Ave. Canoga Park, Calif. 91304 (213) 348-5892	<b>433</b>
Rohde	•	•	Rohde & Schwarz Sales Co. (U.S.A. Inc.) 111 Lexington Ave. Passaic, N.J. 07055 (201) 773-8010	<b>434</b>
Spec Dynamics		•	Spectrum Dynamics P.O. Box 23699 Fort Lauderdale, Fla. 33307 (305) 566-4467	<b>435</b>
Tektronix	•	•	Tektronix Inc. Oregon Corp. Box 500 Beaverton, Ore. 97005 (503) 644-0161	<b>436</b>
Teledyne Semi	•	•	Teledyne Semiconductor Continental Devices Div. 12515 Chadron Ave. Hawthorne, Calif. 90250 (213) 772-4551	<b>437</b>
Teradyne	•	•	Teradyne, Inc. 183 Essex St. Boston, Mass. 02111 (617) 426-6560	<b>438</b>
Test Equip	•	•	Test Equipment Corp. Box 20215 Dallas, Texas 75220 (214) 357-6271	<b>439</b>
TI		•	Texas Instruments Inc. Industrial Products Div. Box 66027 Houston, Texas 77006 (713) 526-1411	<b>440</b>
U-Tech	•	•	U-Tech Div. Industrial Physics & Electronics 4190 S. State St. Salt Lake City, Utah 84107 (801) 262-2663	<b>441</b>
Varadyne	•	•	Varadyne Instrumentation Inc. Div. of Varadyne, Inc. 10060 Bubb Rd. Cupertino, Calif. 95014 (408) 255-3440	<b>442</b>
Wakefield	•		Wakefield Engineering, Inc. Electronic Div. Teal & Audubon Rds. Wakefield, Mass. 01880 (617) 245-5900	<b>443</b>
Wiltron	•		Wiltron Co. 930 E. Meadow Dr. Palo Alto, Calif. 94303 (415) 321-7428	<b>444</b>

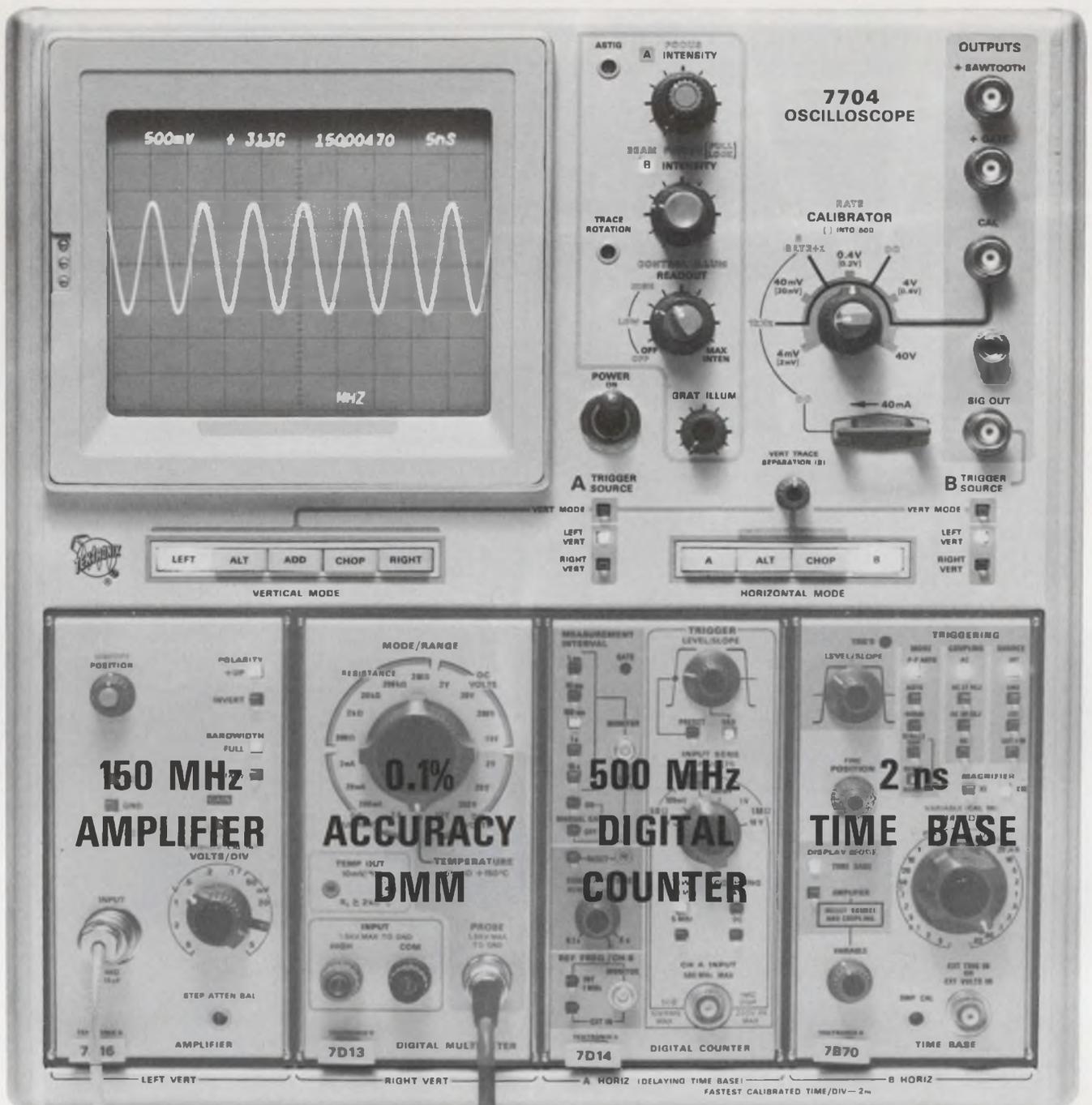
Manufacturer	Model	Types of Devices Tested	Types of Digital Logic Tested	Type of Programming	Maximum Number of Device Leads	Type of Readout	Basic Price	Parameters Tested	Notes
Pulse Pulse Caltron Lear Spec Dynamics	1280C 1210 100 3101 101	digital digital digital digital digital	TTL, DTL, RTL, other RTL, TTL, DTL, other TTL RTL, DTL, TTL RTL, DTL, TTL, ECL, CTL, MECH-DIP	n/a n/a mylar overlay manual manual	ina any 16 n/a 16	visual visual GO/NO-GO scope GO/NO-GO, analog display, A, B, C & D logic outputs	69 89 229 295 295	dc  dc, functional dynamic	optional model 102 accepts DIP, TO-5 and flat pack carrier.
Aritech	ict-516	digital	TTL, DTL, RTL, ECL, CSL	prewired program plugs, manual patch cards	16	GO/NO-GO	350		functional only.
Rohde	15P	digital	TTL, DTL, RTL, ECL, DTL, MOS	manual	16	meter	360		
Varadyne	1100	digital	TTL, DTL, RTL, CTL, ECL	manual	16	GO/NO-GO voltage	415		portable, no program card, verifies truth table, toggles flip flaps. built-in toggle rate testing, source and sink currents to 100MA, variable Vih and Vil to 10V.
Beckman	999	digital	TTL, DTL, RTL, ECL, MECH	switch matrix	16	self-contained meter, external scope, DVM	595	dc	
U-Tech	782	linear	ina	plug-in test socket	14	user-furnished scope	695		plug-in for Tektronix 530, 540, 550 and 580 series scope. up to 4096 tests.
Varadyne	1460	digital	TTL, DTL, RTL, ECL, CSL, CTL	pc card	20	GO/NO-GO	750	functional	
Beckman	998	linear	n/a	switch matrix	16	self-contained meter, external scope, DVM	945	dc	separate input and output metering circuits for simultaneous "quick look" analysis. Source and sink currents to 100 MA.
Microdyne Test Equip Microdyne	824 82 711	digital digital digital, linear	TTL, DTL, RTL TTL, DTL, RTL DTL, TTL, RTL, COS-MOS, HNIL	pc board program board patch, hard wired, matrix	24 16 16	GO/NO-GO GO/NO-GO GO/NO-GO	1200 1200 1500	functional only functional	
Philbrick	5102	linear (op amps)	n/a	manual	ina	analog meter	1650	dynamic	manual
CGS Units Optimized	250 OPT-101A	digital linear (op amps)	RTL, DTL, TTL n/a	pc card dials, switches	16	GO/NO-GO meter, external DVM output	1950 2000		
Varadyne	1600	linear	n/a	manual	16	GO/NO-GO, analog meters	2295	dc, dynamic	
IPT	201	digital, linear	HTL, TTL, DTL, RTL, ECL n/a	manual	24	analog	2480		
Varadyne	2000	linear digital, linear	all n/a	handler	16	none	2495		
CGS Units	12-D	linear	RTL, DTL, TTL	pc board	16	nixie	2500		
CGS Units	12-DE	digital	ECL, RTL, DTL, TTL	pc card	16	nixie	2800		
Pulse	2080	digital	TTL, DTL, RTL	manual	16		2590		
IPT	103	digital	TTL, DTL, RTL, ECL, CSL, HTL	manual	16	digital, GO/NO-GO GO/NO-GO	2750		
Microdyne	716A	digital, linear	TTL, DTL, RTL, ECL, HNIL, COS-MOS, CTL	patch, hard wired, matrix	36	GO/NO-GO GO/NO-GO	2990	dc	
Beckman	997	digital	TTL, DTL, RTL, ECL, MECL	plastic cards, manual switch matrix	16	GO/NO-GO	2995	dc, functional	complete 512 step truth table analysis and voltage comparison. Low cost programming. dynamic spot noise tests.
Quan-tech Test Equip	2283/2181 80	linear digital, linear	n/a TTL, DTL, RTL, MSI	pc card slide switch matrix	40	meter DVM, GO/NO-GO, peak reading voltmeter	4100 4200		
Rohde	1CM	digital, linear	all n/a	pc card	16	analog	4310	dc, dynamic	
Varadyne	1740C	digital	CTL, HNIL, TTL, DTL, RTL, ECL, ESL	pc card, manual	16	GO/NO-GO, DVM	4495	dc, functional	
Microdyne	721A	digital	TTL, DTL, RTL, ECL, CTL, COS-MOS, HNIL	pc card	16	GO/NO-GO	4850	dc, functional	
Teradyne	J133C	digital	TTL, DTL, RTL, ECL, other	pc card	32	GO/NO-GO	4850	dc, functional	automatic, adapters available for IC evaluation.
Meas/Data	1110	digital	TTL, DTL, RTL, ECL, CSL	single hard wired program board	16	indicating lights	4950	dc, functional	available with engineering evaluation option for additional \$450.
Pulse Philbrick	2090 5104	digital linear (op amps)	TTL, DTL, RTL, other n/a	manual manual	56 ina	GO/NO-GO, analog meter	5000 5500	dynamic	automatic
IPT	101	digital	TTL, DTL, RTL, ECL, CSL, HTL	pc program unit	16	GO/NO-GO	5500		
Redcar	990	digital	TTL, DTL	hard wired manual	16	nixie tube	5500	dc, functional, dynamic	
Meas/Data	2405C	linear	n/a	hard wired program board	ina	indicating lights	5700		
Meas/Data	1410	linear, (op amps)	n/a	single hard wired program board	16	DPM as percent of programmed limit	5950	dynamic	operates as access to series 1400 linear testers, available with BCD output. Total test time 2 seconds.

Manufacturer	Model	Types of Devices Tested	Types of Digital Logic Tested	Type of Programming	Maximum Number of Device Leads	Type of Readout	Basic Price	Parameters Tested	Notes
Philbrick	5107	linear	n/a	manual	ina	GO/NO-GO, analog meter	6000	dynamic	tests slew rate, automatic. full computer data-logging & classification available. available with BCD output. Total test time 2 seconds.
Microdyne	735	linear (op amps)	n/a	pc card, computer	16	digital, GO/NO-GO	7850	dynamic	
Meas/Data	1420	linear (op amps)	n/a	single hard wired program board	16	DPM as percent of programmed limit	7950	dynamic	
Microdyne	724	digital	TTL, DTL, RTL, MECL, CTL, COS-MOS, HNIL	pc board	24	digital, GO/NO-GO	8850	dc, functional	
Test Equip	79	linear	n/a	special program board	16	DVM, GO/NO-GO	9750	dynamic	auto or manual test sequencing.
Adar	SRT2000	digital (shift registers)	MOS	manual	12	GO/NO-GO	10,000	functional, dynamic	
Teradyne	S257	digital	all	computer	ina	GO/NO-GO, printer, magnetic tape	12,000 plus J259 or J283	dc, functional, dynamic	
Tektronix	S3110	digital, linear	RTL, DTL, ECL, CSL, MOS, TTL	15 diode cards	16 (active input/output)	digital, GO/NO-GO, printer	13,150	dc, functional, dynamic	this is a control and logging interface. Serial ASCII I/O on user's side, 10-wire BCD on equipment side.
Julie	ATS-106/20	resistance networks, voltage and current sources	ina	any serial or parallel ASCII source	per customer specifications	serial or parallel ASCII	14,000	dc	
Tektronix	S3111	digital, linear	RTL, DTL, ECL, CSL, MOS, TTL	15 diode cards	16 (active input/output)	digital, GO/NO-GO, printer	15,150	dc, functional, dynamic	
Tektronix	S3121	digital, linear	RTL, DTL, ECL, CSL, MOS, TTL	paper tape, optional disc, optional computer	16	digital, GO/NO-GO, printer, magnetic tape, computer option, teletype	25,100	dc, functional, dynamic	
Macrodata	MD-APT	digital		computer	64	teletype, digital, printer	29,800	dc	
Optimized	5000E	digital	DTL, TTL, RTL, ECL, CSL	magnetic disk	48	digital, data logging, GO/NO-GO	30,000	dc, functional	
Tektronix	S3122	digital, linear	RTL, DTL, ECL, CSL, MOS, TTL	random access disc, paren 1600 test, optional paper tape, optional computer	16	digital, GO/NO-GO, printer, magnetic tape, computer option, teletype	30,900		
Tektronix	S3120	digital, linear	RTL, DTL, ECL, CSL, MOS, TTL	paper tape, random access disc, paren 1600, computer option	16	digital, GO/NO-GO, printer, magnetic tape, computer option, teletype	32,350	dc, functional, dynamic	
Optimized	5200	linear	n/a	magnetic disk	20	digital, data logging, GO/NO-GO	34,000	dc, dynamic	
Tektronix	S3131	digital, linear	TTL, DTL, RTL, ECL	paper tape, optional disc	64	GO/NO-GO, printer, magnetic tape	39,400	dc, functional, dynamic	
Auto/Meas	9001	linear, digital	TTL, DTL, RTL, ECL, CSL	punched paper tape	40	digital, GO/NO-GO	40,000		
E-H	4003	digital	RTL, DTL, TTL, ECL	punched card	14	GO/NO-GO	40,000		
Tektronix	S3132	digital, linear	TTL, DTL, RTL, ECL	random access disc, optional paper tape	64	GO/NO-GO, printer, magnetic tape	45,300		
Teledyne Semi	FAT-28	digital, linear	DTL, TTL, RTL, DT $\mu$ L, ECL, linears	perforated paper tape, digi-switch computer	multiples of 20 up to 120	nixie display, computer storage, magnetic tape, teletype	46,000	dc, functional, dynamic	
Tektronix	S3130	digital, linear	TTL, DTL, RTL, ECL	RAM disc, paper tape	64	GO/NO-GO, printer, magnetic tape	46,700	dc, functional	
Teradyne	J261	linear	n/a	computer		GO/NO-GO, printer, magnetic tape	49,000 in addition to J259	dc, functional, dynamic	linear adapter for J259 digital test system.

Manufacturer	Model	Types of Devices Tested	Types of Digital Logic Tested	Type of Programming	Maximum Number of Device Leads	Type of Readout	Basic Price	Parameters Tested	Notes
Datatron	4400	digital	TTL, DTL, RTL, ECL, MOS	computer	256	GO/NO-GO, teletype	52,000	dc, functional	
Teradyne	J259	digital	all	computer	48	GO/NO-GO, printer, magnetic tape	52,000	dc, functional	multiplex up to seven test stations.
AAI	Series 1000	digital, linear	TTL, DTL, RTL, ECL	paper tape input, drum storage, computer optional	90	decimal, GO/NO-GO, annunciator, teletype	62,000	dc, functional, dynamic	abbreviated English programming language, dual-limit digital comparisons, hi-speed A/D converter, single-socket dc & dynamic testing.
AAI	1000	digital, linear	TTL, DTL, RTL, ECL, CSL	computer	99	digital, GO/NO-GO	62,000		
Adar	Doctor 32	digital	all	computer	32	teletype	62,000	functional, dynamic	
Fairchild Inst	500-C	linear (memories)	all	manual, magnetic tape, paper tape	72	digital, GO/NO-GO	65,000	dc, functional, dynamic	
TI	580	digital	TTL, DTL, CTL, ECL	computer	224	visual readout, GO/NO-GO, printer, tape	67,000	dc, functional	
E-H	4004	digital	RTL, DTL, TTL, ECL	punched card	14	digital, stop on error	70,000		
TI	553	digital, linear	TTL, DTL, CTL, ECL	tape, computer	128	visual readout, GO/NO-GO, teletype, tape	75,000	dc, functional, dynamic	
Teradyne	J263	linear	n/a	computer	n/a	GO/NO-GO, printer, magnetic tape	86,000	ina	
Macrodata	MD-210	digital	ROM, RAM, shift registers, random logic	computer	64	teletype, digital, GO/NO-GO, printer	89,500	dc, functional	
Teradyne	J283	digital	all	computer	60	GO/NO-GO, printer, magnetic tape	94,800	dc, functional	up to 8 multiplex test stations, dynamic test capability available. computer control option.
E-H	4305	digital	all	paper tape	80	digital	99,000		
Macrodata	MD-220	digital	RAM, ROM, shift registers, random logic	computer	64	digital, teletype, GO/NO-GO, printer	99,600	dc, functional	
Macrodata	MD-230	digital	ROM, RAM, shift registers, random logic	computer	64	teletype, GO/NO-GO, printer	109,600	dc, functional	
Adar	Doctor 64	digital	all	computer	64	teletype	120,000	dc, functional, dynamic	
Auto/Meas	9003	digital, linear	TTL, DTL, RTL, ECL, CSL	computer	40	digital, printout, GO/NO-GO	120,000		
E-H	4500	digital	TTL, DTL, RTL, ECL, CSL	computer	40	digital, printout	120,000		
Tektronix	S3150	digital, linear	MOS, TTL, RTL, DTL, PCLII, CSL	computer, random access disc	48	GO/NO-GO, printer, magnetic tape	120,000	dc, functional	
Macrodata	MD-240	digital	ROM, RAM, shift registers, random logic	computer	64	teletype, digital, GO/NO-GO, printer	133,100	dc, functional	
Macrodata	MD-260	digital	ROM, RAM, shift registers, random logic	computer	64	teletype, digital, GO/NO-GO, printer	158,500	dc, functional	
Fairchild Inst	Sentry-400	digital	all	magnetic tape, paper tape	240	digital, GO/NO-GO	160,000	dc, functional	
Redcar	PAFT-II	digital	MOS	computer stored	64	printer, GO/NO-GO	160,000	dc, functional	

Manufacturer	Model	Types of Devices Tested	Type of Programming	Maximum Number of Device Leads	Type of Readout	Basic Price	Notes
Heath RCA Heath	IT-27 WC-506A IT-18	transistors transistors, diodes transistors	manual manual manual	3 3 3	meter meter meter	6.95 18 24.95	out-of-circuit testing - battery operated; in-circuit or out-of-circuit testing - transistor and circuit tester, battery operated.
EICO	680	transistors, diodes	manual	3	meter	34.95 kit 49.95 wired	
Heath	IM-36	transistors, diodes	manual			61.95 kit 92.50 wired	
RCA Leader Inst Rohde EICO	WT-501A LTC-901 TSP 685	transistors, diodes transistors, diodes transistors, diodes transistors, FETs, diodes, SCRs, triacs	manual manual manual manual	3 8 4 4	meter meter meter meter	66.75 69 70 89.95 kit 139.95 wired	
Baird Leader Inst	KT-1 LTC-902	transistors transistors, diodes	manual manual	4 8	meter meter	95 99.50	signal injector; signal tracer.
B & K	162	transistors, FETs, diodes, SCRs, triacs, unijunctions	manual	4	meter	99.95	transistors and FETs can be tested in- or out-of-circuit.
Rohde Hickok AEL	TDP 990A 245M	transistors, diodes transistors, diodes transistors, diodes, rectifiers	manual manual manual	4 3 3	meter meter meter	120 235 250	checks static and dynamic functions - in-circuit testing - in-circuit and out-of-circuit testing.
AEL	259C	transistors, diodes, rectifiers, FETs	manual	3	meter	360	in-circuit and out-of-circuit testing.
Hickok	870	transistors, diodes	manual	3	analog meter	425	will check transistors rated up to 5 A.
AEL	245MA	transistors, diodes, rectifiers	manual		meter	440	in-circuit and out-of-circuit testing.
Hy-Cal	SA104-5CCH-50	transistors, diodes, ICs	manual	2	GO/NO-GO	445	single input system.
AEL Hy-Cal	240A SAX104-5CCH-52	transistors transistors, diodes, ICs	manual manual	2	GO/NO-GO GO/NO-GO	450 495	dual input system.
Varadyne	800	transistors	manual	3	GO/NO-GO. Lead orientation. NPN/PNP. SI/GE	595	automatic ranging.
U-Tech U-Tech	681 682	transistors, diodes transistors, diodes	manual manual	3 3	user-furnished scope user-furnished scope	655 675	plug-in for Tektronix 560 scope - plug-in for Tektronix 530, 540, 550 and 580 series scope. uses any X-Y scope.
U-Tech Dantronics	683 Dantec 100	transistors, diodes transistors, diodes	manual manual pushbutton	3 3	user-furnished scope GO/NO-GO; printer, etc. optional	685 695	
Test Equip Baird	1-01R NC-1	zener diodes medium and high power transistors	front panel controls manual	2 4	meter	970 985	
Test Equip	1	transistors, diodes	front panel controls (auto sequencing from one test to next)	3	meter or optional GO/NO-GO	1000	
Tektronix Quan-Tech	575 512	transistors, diodes transistors	manual manual	3 3	CRT meter	1300 1375	dynamic test; noise figure bandwidth 10 Hz-10kHz.
IPT Wakefield	204 LV101	matched pair FETs power semis. 1 watt & up	manual	4 optional	digital or analog none	1540 1735	
IPT IPT	2018 202	FETs bipolar, MOSFETs, JFETs, dual-FETs	manual manual	4 4	digital or analog digital or analog	1770 1795	
IPT	203	JFETs, MOSFETs, single or dual FETs	manual	4	digital or analog	1950	
Baird	PB-1	transistors, diodes, SCRs	pc card	4	GO/NO-GO	1985	
Tektronix	576	transistors, diodes, FETs	manual	6	analog	2250	
Quan-Tech	340-1340	transistors	manual		meter	2500 (16-1800 for plug-in heads)	dynamic test; rf noise figure 1MHz to 60 MHz.
Quan-Tech	310	transistors	manual		meter	2725	dynamic test; spot noise 100Hz, 1kHz, 10kHz.
Quan-Tech	311	transistors	manual		meter	2725	dynamic test; spot noise 100Hz, 1kHz, 10kHz.
Rohde	TYM	transistors, diodes, FETs	manual	4	meter	2770	rf measurement of dynamic parameters.

Manufacturer	Model	Types of Devices Tested	Type of Programming	Maximum Number of Device Leads	Type of Readout	Basic Price	Notes
Teradyne Quan-Tech Test Equip	D157 327 1-21	diodes zener diodes transistors, diodes, SCRs	manual manual manual	2 3	GO/NO-GO meter GO/NO-GO	2950 3250 4300	automatic; dc parameters . dynamic test; spot noise 10Hz, 1kHz . 100 A pulsed tester .
Quan-Tech Teradyne Teradyne Rohde	2173C/2181 D158 Z180 TLM	transistors diodes zener diodes transistors, diodes, rectifiers, thyris- tars, zener diodes	manual manual manual manual	2 2 2 4	meter GO/NO-GO GO/NO-GO meter	4995 5180 5400 5695	dynamic test; spot noise 10Hz to 100kHz . automatic; dc parameters . automatic; voltage and impedance . static parameters of power devices .
Affil Manuf  Wiltron  Teradyne Teledyne Semi	DH-F-VIL  310/311  D141 SCAT-32	diodes, unilayer capacitors high frequency transistors diodes transistors, diodes	cam and switch  manual  manual digi-switch, computer	  4  2 6	depends on interface  Smith chart and polar oscilloscope GO/NO-GO teletypewriter, and nixie display	5750  6445  6480 7000	automatic probing and sorting system for interfacing with test set . network analyzer; tests S-parameters .  automatic; dc parameters .
Teradyne Test Equip Quan-Tech	D210 33 2307/2310	diodes power transistors transistors	manual manual manual	2 3	GO/NO-GO GO/NO-GO lights meter and GO/NO-GO	7800 8000 8000	dc parameters . automatic transistor noise analyzer .
Lorlin Affil Manuf  Teradyne Lorlin Mastech Lorlin Wakefield	DA TTT  T135 TA 2711 DB F1014	diodes, rectifiers T-pack transistors  transistors transistors zener diodes diodes, rectifiers rectifiers, zener diodes	digit switch cam and switch  manual digit switch digit switch digit switch	2 3  3 3 2 2 500	GO/NO-GO depends on interface  GO/NO-GO GO/NO-GO digital GO/NO-GO GO/NO-GO	8600 8650  8750 8800 9000 9600 9950	4 to 24 tests; 10 A, 2000 V . automatic probing and sorting system for interfacing with test set . automatic, dc parameters, ac gain . 4 to 24 tests; 1 A, 200 V . 300 V, 10 A operating range . 4 to 24 tests; 25 A, 2000 V . life test system; modified to custom needs .
Teradyne Teradyne Mastech  Lorlin Teradyne Teradyne IPT	D223 T179 2610  TB D189 Z137 Monitor II	diodes transistors, diodes transistors, diodes  transistors rectifiers, diodes zener diodes FETs	manual manual digit switch, card reader, core memory digit switch manual manual manual	2 3 3  3 2 2 4 plus duals	GO/NO-GO GO/NO-GO digital GO/NO-GO  GO/NO-GO GO/NO-GO GO/NO-GO digital, GO/NO-GO, analog printer, punched card or tape	10,900 11,500 12,500  12,900 13,500 13,500 14,000	dc parameters . automatic; dc parameters, ac gain . 300 V, 600 V, 1 A or 1000 V at 10 A models available; data logging option .  4 to 24 tests; 10 A, 600 V . dc parameters automatic
Lorlin Teradyne Mastech Teradyne Teradyne  Teradyne Fairchild Inst IPT	DC D233 203 T217 Z218  Z128 PATT ZIP	diodes, rectifiers diodes SCRs transistors, diodes zener diodes, diodes zener diodes transistors FETs	digit switch manual digit switch manual manual  manual cassette or manual pinboard	2 2 3 3 2  2 3 4	GO/NO-GO GO/NO-GO digital GO/NO-GO GO/NO-GO GO/NO-GO  GO/NO-GO GO/NO-GO GO/NO-GO with classification	14,400 14,500 15,000 16,500 16,800  16,800 18,000 19,988	4 to 24 tests; 100 A, 500 V . dc parameters . 1000 V, 10 A operating range . automatic; dc parameters, ac gain . automatic  automatic dc parameters
Lorlin Teradyne Lorlin Optimized  Teradyne Teradyne  Fairchild Inst	TC T311 VVC-24 3500  T243 D251  600-C	transistors FETs varactor diodes transistors, diodes, SCRs transistors, diodes diodes discrete devices	digit switch manual digit switch digital thumbwheel  computer computer  manual and cassette	3 3 2 3  3 2  3	GO/NO-GO GO/NO-GO GO/NO-GO digital and data log- ging and GO/NO-GO GO/NO-GO GO/NO-GO, printer, magnetic tape, paper tape digital and GO/NO- GO	22,900 23,500 24,000 24,000  39,000 42,100  43,000	4 to 24 tests; 100 A, 600 V . automatic; dc parameters, transconductance. 24 tests dc pulse and small-signal parameters .  automatic; dc parameters, ac gain . automatic  dc and dynamic .
Teradyne Fairchild Inst  Teradyne Teradyne	T241 700-T  T331 Z220	transistors, diodes discrete devices  FETs zener diodes, diodes	computer manual and cassette  computer computer	3 3  3 2	GO/NO-GO digital and GO/NO- GO GO/NO-GO, printer, magnetic tape GO/NO-GO, printer, magnetic tape, paper tape	46,000 49,900  56,100 56,300	automatic; dc parameters, ac gain . dc parameters  automatic automatic



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Perhaps you suspected the new TEKTRONIX 7000 SERIES was intended to be more than just another oscilloscope . . . you were right! Here's why:

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Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

Prices of instruments shown: 7704 150-MHz Oscilloscope \$2500, 7A16 Amplifier \$600, 7D13 Digital Multimeter \$560, 7D14 Digital Counter \$1400, 7B70 Time Base \$600.

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# New Products

## Photodiode array of 48 sensors includes scan generator on chip

*Fairchild Microwave and Optoelectronics, 2513 Charleston Rd., Mountain View, Calif. Phone: (415) 961-9573. P&A: \$600; stock.*

By integrating on the same silicon chip a linear 48-element photodiode array with 5-mil centers, a shift register and multiplex switches, the new FPA-600 monolithic photodiode array has made possible low-noise high-resolution video in optical character recognition and facsimile scanning applications.

This single-chip construction technique has reduced the number of external leads, which are independent of the number of sensors, to only six.

The technique has eliminated the problem of capacitive imbalances between sensor arrays and generators due to large bundles of wire interconnecting them, which caused switching noise to appear in the output video information.

Interfacing a suitable scanning generator to the photodiode array is no longer a problem either, since the FPA600 contains both the array and the scan generator on the same chip.

The new array, which is pack-

aged in a 0.202 by 0.212 by 0.46-in. case, is made by using the silicon-gate process. Its six external leads are: two for clock drives, one for a start pulse, one for an end-of-scan output, a video output lead and a common lead.

Scanning is initiated by applying a start pulse to the shift register's first stage. The pulse is then clocked through the shift register to sequentially interrogate each photodiode in the array. The output then appears as a video string on a video terminal.

A variety of clock waveforms will operate the scanning generator. Complementary sine-wave signals and complementary square-wave clocks can be used. In addition rectangular non-overlapping pulses can also be used. Scanning can be done at a frequency range well below 10 kHz to above 10 MHz. (Some units have operated as low as 20 Hz and as high as 5 MHz with some image lagging).

Typical specifications of the FPA600 array include a photo-sensitive area for each diode of 22 mil<sup>2</sup>, a 1:1 aspect ratio, power dissipation of less than 200 mW

and a photodiode sensitivity of 900 pA/foot-candle.

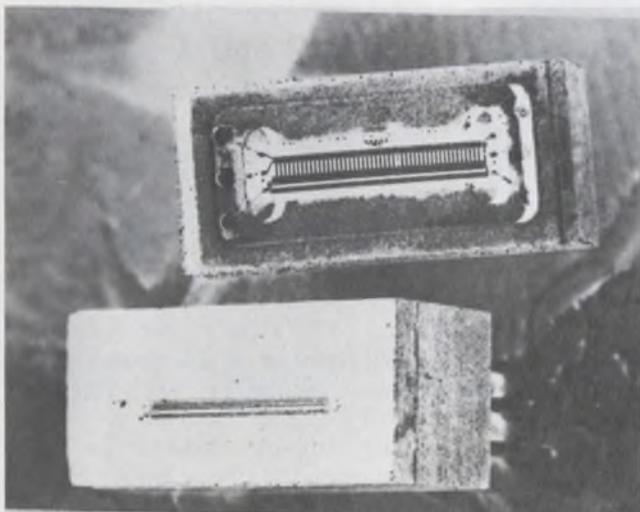
Other specifications include a photo-sensitivity uniformity of less than  $\pm 10\%$ , typical photodiode dark leakage current of 0.1 pA and output capacitance at the video terminal of only 13 pF.

The output impedance of the last or 48th stage of the scanning generator ranges from 30 to 50 k $\Omega$ . Each photodiode has a capacitance of 1.6 pF and requires a bias voltage of  $-8$  to  $-15$  V.

Arrays with 64 elements on 5-mil centers and 128 elements on 2.5-mil centers have been produced and will be available by January, 1971. These should provide optimum resolution for video-scanning applications in optical character recognition and facsimile fields. In addition, other possible fields of application in imaging are CCTV, process control and inspection.

Presently, Fairchild is in the process of constructing a TV camera using self-scanning photodiode arrays to demonstrate photodiode-array feasibility in CCTV applications.

CIRCLE NO. 250

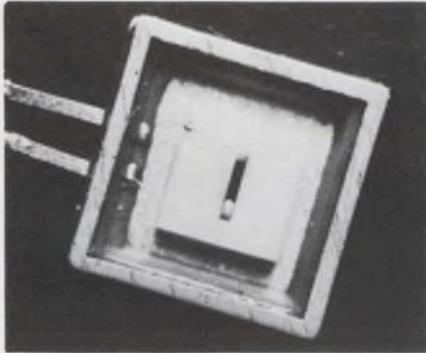


Monolithic 48-element photodiode array (left) with a scan generator on the same chip, was used in scanning a negative photograph which was wrapped around a rotat-



ing drum. Serial video was applied to the input of an oscilloscope. The resulting photograph (right) was taken by a Polaroid camera off the oscilloscope's screen.

### Infra-red detector operates at 293° K



Mullard, Inc., 1100 Finn Court, Farmingdale, N. Y. Phone: (516) 694-8989.

A new cadmium-mercury-telluride flatpack IR detector with a spectral response range of 4 to 6 microns operates at room temperature (293°K). It features a time constant of 1.5  $\mu$ s, detectivity of  $1.5 \times 10^8$  and responsivity of 40 V/W. Sensitive area is 230 square microns and noise equivalent resistance is 1 k $\Omega$ .

CIRCLE NO. 251

### 18-GHz step attenuators shrink down in size



Weinschel Engineering, Gaithersburg, Md. Phone: (305) 948-3434.

Model 9000 Mini Step dc to 18-GHz subminiature step attenuators have overall dimensions of only 1.62-in. in diameter and 1.13 to 3.3 in. in length. These 50- $\Omega$  attenuators are available in five basic models with attenuation ranges of 0 to 9 dB, 0 to 69 dB and 0 to 99 dB in 1-dB steps, plus 0 to 60 dB and 0 to 90 dB in 10-dB steps. All are average-power rated at 2 W at 25°C and peak-power rated at 200 W.

CIRCLE NO. 252

### Solid-state displays come in DIPs and TO-5s



Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: \$14.80, \$8.30; stock.

Two new solid-state numeric displays are the TIXL302 in a 14-pin DIP and the TIXL301 in a TO-5 case. These planar GaAsP types emit visible red light and use 7 segments. Both are partially alphabetical producing the letters A, C, E, F, H, J, L, P and U, as well as digits from 0 to 9.

CIRCLE NO. 253

### Tiny thin-film preamps cover 2 to 4 GHz



Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170.

AMT-4000 series thin-film miniature microwave preamplifiers provide flat gain response over the 2 to 4-GHz frequency range. Seven models ranging in gain from 10 to 40 dB comprise the series. Excellent impedance matching is provided with a low input and output VSWR of 1.2:1 for high-gain applications. Bandpass flatness is  $\pm 1$  dB and noise figure is 10 dB.

CIRCLE NO. 254

### Fast phototransistor has 1.5 $\mu$ s rise time

Sensor Technology, Inc., 7118 Gerald Ave., Van Nuys, Calif. Phone: (213) 781-2154. Availability: stock.

A new oxide-passivated silicon phototransistor features fast switching times with a 1.5- $\mu$ s rise time and a 5- $\mu$ s fall time. Called the STPT40, the new phototransistor responds to modulation well above the audio spectrum and has low-leakage characteristics. Collector-emitter breakdown voltage is 50 V minimum. Packaging is in a glass hermetically sealed case which has a dome-shaped lens on it.

CIRCLE NO. 255

### Light-activated switch varies switching levels

Integrated Photomatrix Ltd., The Grove Trading Estate, Dorchester, Dorset, England.

The IPL15 is a light-activated switch providing controllable and variable switching for a 5000:1 range of illumination. When normally incident light brighter than a predetermined threshold level falls on the device, an internal trigger causes a transition from logic states 0 to 1. The opposite transition occurs when light intensity falls below the threshold level.

CIRCLE NO. 256

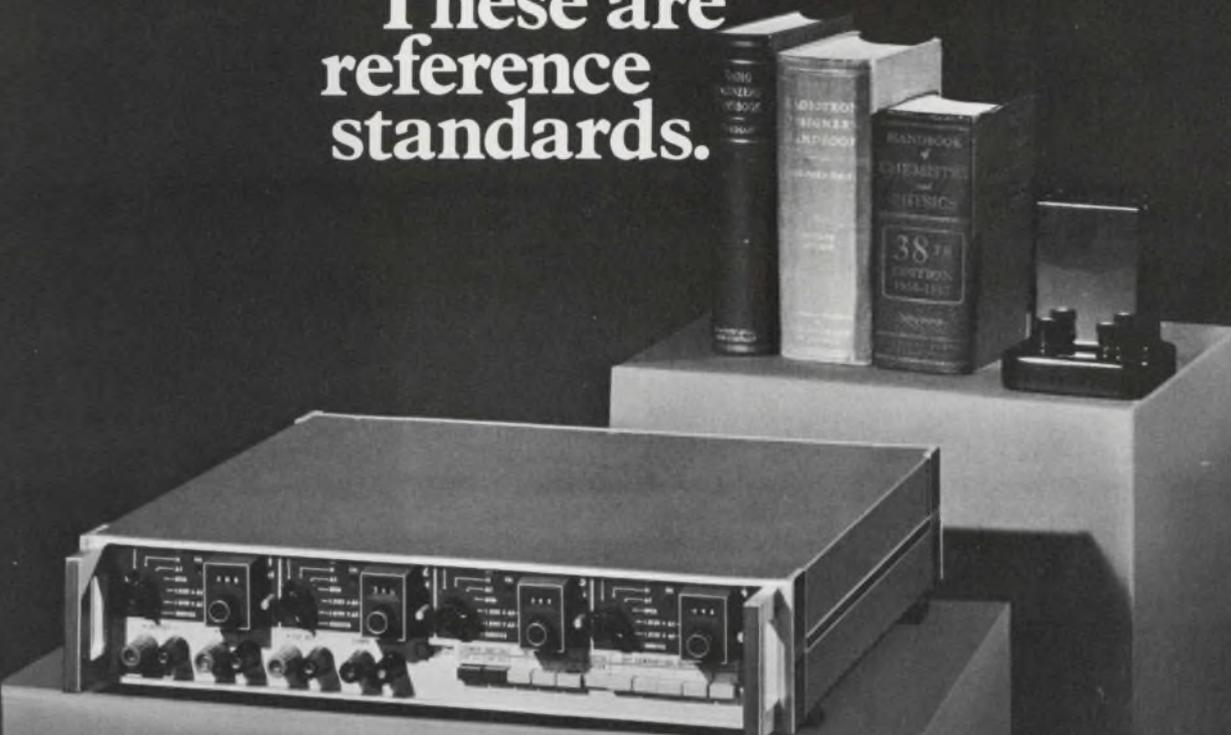
### Microwave oscillators power C and X bands

RCA Electronic Components, 415 S. 5th St., Harrison, N. J. Phone: (201) 486-3900. Price: \$75 to \$350.

A new line of microwave solid-state power sources known as transferred-electron oscillators (TEOs) consists of four microwave-device families covering C-band (4 to 8 GHz) and X-band (8 to 12 GHz) in cw and pulsed modes. These oscillators are fixed-frequency devices. Equivalent mechanically tunable models are also available. Cw units span the output-power range of 10 to 120 mW. Pulsed versions are available with outputs of 1, 5 and 10 W.

CIRCLE NO. 257

These are  
reference  
standards.



This is  
the new Fluke  
working standard.

The new Fluke 730A DC Transfer Standard, a rugged 20 pound, battery powered instrument, takes the fuss out of calibration.

Of course you'll continue to use your standard cell bank as a basic reference. But you'll be time and money ahead if you use the Fluke 730A as your "working standard" and avoid standard cell problems such as temperature sensitivity, length of settling time, and overload. The truly portable Fluke 730A features low temperature coefficient, full accuracy in minutes, overload protection, and quick and easy calibration to your reference standard.

The Fluke 730A consists of four identical independent reference supplies. Output terminals provide individual outputs, the mean output of up to four references and the series output of up to four references. Specific reference voltage outputs available are 1.000, (1.018 +  $\Delta V$ ), (1.019 +  $\Delta V$ ), 10.000 and  $\Delta V$  Volts. The Model 730A may be used as a 1 volt or 10 volt standard, or as an "electronic standard cell."

Transfer accuracy is 2 ppm. Stability is 10 ppm/month for individual references. Only 3½" high, the 730A can be used on the bench or in a rack. Guarded outputs give you freedom from noise in high accuracy floating measurements.

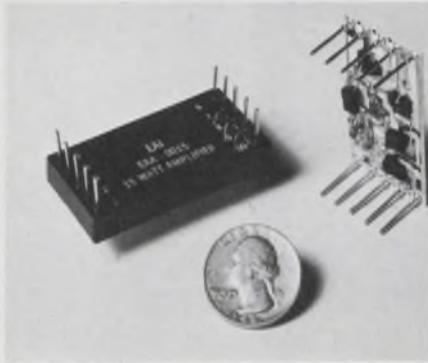
Price is \$1995.

For the full story, see your Fluke sales engineer or contact us directly.



Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850/  
In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland.  
Phone: (04250) 70130. Telex: 884-50237/ In the U.K., address Fluke International Corp.,  
Garnett Close, Watford, WD2 4TT. Phone: Watford, 27769. Telex: 934583.

### Thick-film amplifier delivers 15-W output

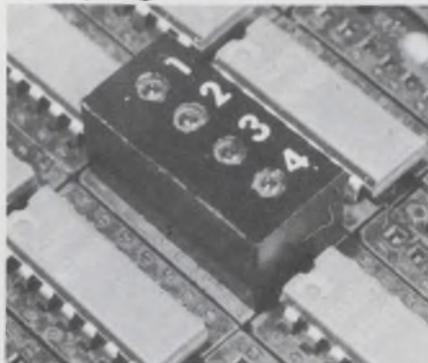


*Electronic Associates, Inc., West Long Branch, N. J. Phone: (201) 229-1100. P&A: \$12; stock.*

A new thick-film hybrid Class-B audio amplifier, the EAA-015, operates continuously at output powers up to 15 W into a conventional speaker load with a 350-mV input signal. Its maximum total harmonic distortion is under 0.5% at 1-kHz full power. Frequency response (measured at -3-dB points) and full power is greater than 20 kHz.

CIRCLE NO. 258

### Four-bit logic readout is a plug-in DIP



*Unique Devices Co., P.O. Box 786, Reseda, Calif. Phone: (213) 881-6634. Price: \$9.*

The LL-4 Logic Lite is a new plug-in readout module with buffered inputs that provides four bits of logic status in a dual in-line package. The LL-4 Logic Lite's inputs are TTL/DTL compatible and represent only one unit load. The new readout module requires only 5 V dc for operation. Various markings are available.

CIRCLE NO. 259

### Op amp with 5 pA bias costs only \$25

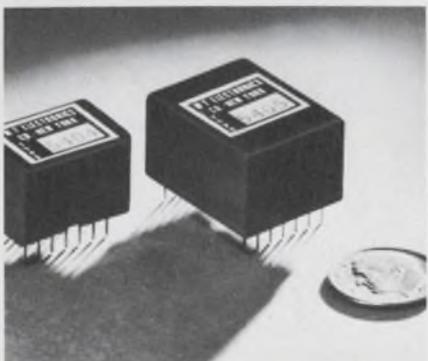


*Bell & Howell Control Products Div., 706 Bostwick Ave., Bridgeport, Conn. Phone: (203) 268-6751. P&A: \$25; stock.*

Featuring only 5 pA of bias current, the C-128 low-cost hybrid operational amplifier retails at only \$25. It is supplied in a hermetically sealed TO-8 package having a diameter of 0.065 in. and a thickness of 0.14 in. The low bias current makes it ideal for sample-and-hold and integrator applications.

CIRCLE NO. 260

### Oscillators to 15 MHz plug in to DIP sockets

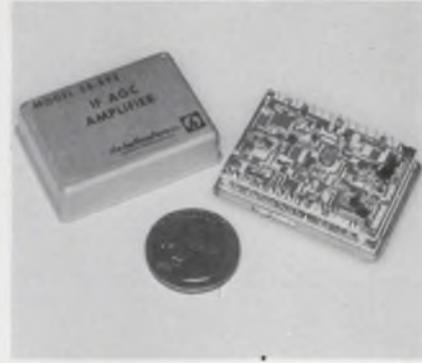


*MF Electronics Corp., 118 E. 25 St., New York, N. Y. Phone: (212) 674-5360. P&A: \$16, \$19; 2 to 3 wks.*

Two new crystal oscillators feature dual-in-line packaging over the frequency range of 80 kHz to 15 MHz. The 5404 ranges over 5 to 15 MHz at  $\pm 0.005\%$  over the temperature range of 0 to 60°C. It takes up socket space of one DIP. The 5405 ranges over 80 kHz to 4.9 MHz at  $\pm 0.02\%$  accuracy. It occupies the space of two DIPs and fits on sockets spaced 0.5-in. apart.

CIRCLE NO. 261

### Thick-film amplifier gains up to 90 dB



*Hallicrafters Co., 600 Hicks Rd., Rolling Meadows, Ill. Phone: (312) 259-9600.*

Operating at 4.5 MHz a new thick-film hybrid i-f agec amplifier has a gain of 90 dB. Model 58-592 has stable gain from -55 to +100°C, is voltage-controlled over several decades of signal level and can be gated OFF with an external voltage. It has two isolated video outputs of 5 V peak each and includes an agec circuit to control a dynamic signal range of 65 dB.

CIRCLE NO. 262

### Thin decoder/drivers have 5/8-in. clearance

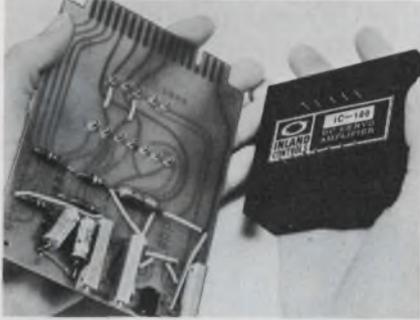


*Luminetics Corp., P.O. Box 1943, Pompano Beach, Fla. Phone: (305) 933-4551.*

A new family of thinline decoder/driver modules in combination with their thinline series 20 DigiCator readouts requires behind-the-panel clearance of only 5/8-in. when used on 1/8-in. panels. Three assemblies are offered. Model 5920-1 is a BCD-to-7-segment device, the model 5925-1 adds on a quad-latch memory and the model 5950 adds on a decade counter.

CIRCLE NO. 263

## Power amplifier module dissipates up to 100 W

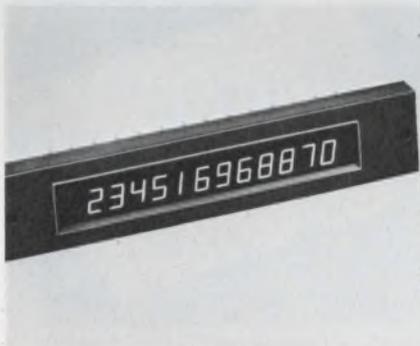


Inland Controls, Inc., 250 Alpha Dr., Pittsburgh, Pa. Phone: (412) 782-3516. P&A: \$180; 2 wks.

The IC-100 modular linear power amplifier features low output impedance of  $0.01 \Omega$  and can dissipate up to 100 W of power (at a case temperature of  $90^\circ\text{C}$ ). It exhibits a high voltage gain of 100,000 V/V minimum and has a frequency response that is flat beyond 20 kHz at a gain factor of 100. Output is single-ended and operating voltage requirements range over  $\pm 15$  to  $\pm 30$  V.

CIRCLE NO. 264

## Numeric panel displays cost only \$1.56/digit

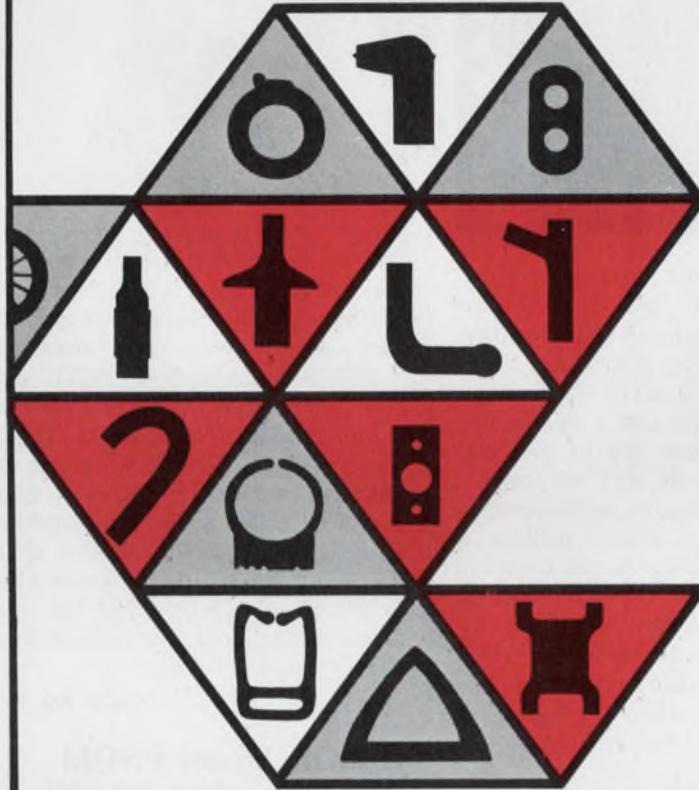


Burroughs Corp., Electronic Components Div., Plainfield, N. J. Phone: (201) 757-5000. P&A: from \$1.56/digit; 8 to 12 wks.

PANAPLEX is a new numeric 8 to 16-digit unitized panel display available for as low as \$1.56 per digit for 16 digit readouts (quantities of 1000). Using a nine-segment character format, and common-cathode construction, PANAPLEX panel displays provide a centered 1, in-plane readout and consistent digit alignment.

CIRCLE NO. 265

## Stalwart Rubber Selector



a guide to evaluating and specifying special rubber compounds for engineered parts

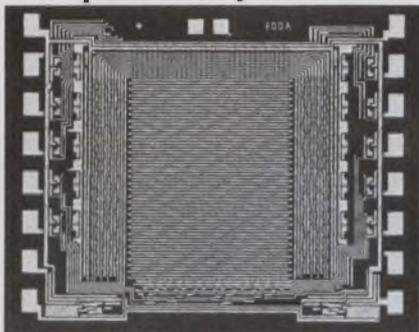
## Expand your knowledge of rubber technology

The new 18-page Stalwart Rubber Selector is an industry-wide guide available to assist engineering and purchasing personnel in evaluating and specifying rubber elastomers. It indicates what elastomer to use, and where to use it. Cost comparisons of 14 different types are contained in the guide. A comprehensive chart rates the elastomers in terms of physical properties and performance. Now, you can determine which rubber elastomers are best suited to your exact requirements. Write today for your personal copy of the new "Stalwart Rubber Selector".

**SR** Stalwart  
Rubber  
Company  
Bedford, Ohio 44146

INFORMATION RETRIEVAL NUMBER 44

### 300-ns-access memory dissipates only 20 mW



*Cartesian, Inc., 10432 N. Tantau, Cupertino, Calif. Phone: (408) 257-0481. P&A: \$24; 5 to 6 wks.*

Containing a basic configuration of 1024 words by 2 bits/word, the V003 high-speed MOS static read-only memory features a fast access time of less than 300 ns and dissipates a mere 20 mW of power.

This low-voltage enhancement-mode p-channel device utilizes a unique dc address decoder and a memory matrix that includes a push-pull transistor arrangement.

Since it is a dc device, no clock signals of any kind are needed. The outputs change when the input address changes, and remain stable indefinitely.

Multiple use of the V003 memory in a wire-OR'd configuration is possible with the use of an output enable control. The outputs are buffered through low-impedance drivers that are TTL/DTL compatible without using external passive components. The input is also DTL/TTL compatible.

Programming the V003 is also possible. This involves the alteration on the gate mask pattern at a nominal tooling charge.

The use of a low-threshold process yields voltages of 1.6 to 2.2 V which allows for direct on-chip decoding and yields a high gain constant.

Decoding circuitry consists of row-select and column-select gates. Row-select gates include push and pull sets. This push-pull decoding arrangement means that the decoding network does not dissipate any dc power.

Output resistance at logic state ZERO is 200  $\Omega$ . At logic state ONE it is 400  $\Omega$ . Address and enable input capacitances are 3 pF.

CIRCLE NO. 266

### 200-V transistors handle 90 amperes

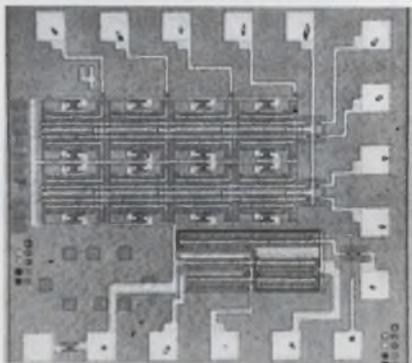


*PowerTech, Inc., 9 Baker Court, Clifton, N. J. Phone: (201) 478-6205. P&A: \$66 to \$84; stock.*

PT-7509 through PT-7511 silicon power transistors feature collector breakdown voltages (open base) of 200 V and dc common-emitter forward current gain specified at 90 A. Collector-emitter saturation voltages are less than 0.6 V at 50 A. Power dissipation is 200 W at 100°C. All of the new power transistors are packaged in TO-63 cases.

CIRCLE NO. 267

### C-MOS 16-bit PROM dissipates but 50 nW

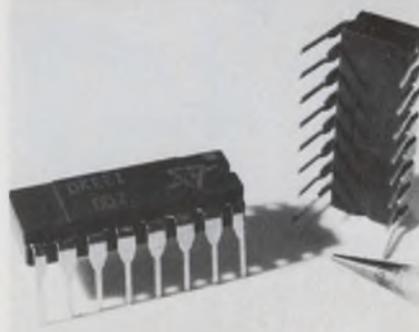


*Solid-State Scientific, Inc., Commerce St., Montgomeryville, Pa. Phone: (215) 855-8400. Price: \$25.*

A new 16-bit C-MOS programmable read-only memory features 400-ns cycle time and static power dissipation of only 50 nW at 10 V. The SCL5510 is organized as 16-words-by-1-bit employing an X-Y select addressing method. It can be made to interface to TTL and DTL and current or voltage-sensing is optionally available. Current-sensing schemes yield cycle times under 100 ns.

CIRCLE NO. 268

### Read/write IC memory has 50-ns access time

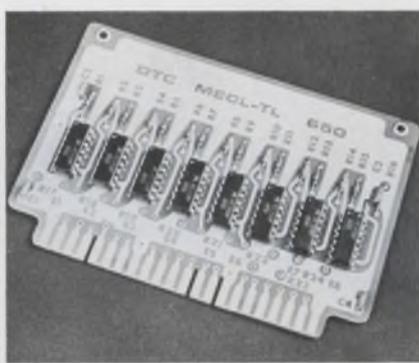


*Sylvania Electric Products, Inc., 730 Third Ave., New York, N. Y. Phone: (212) 551-1000.*

A new monolithic 64-bit read/write memory array features access time of 50 ns. The SMX283 is a non-destructive-readout memory consisting of 64-flip-flop storage elements arranged in a 16-word by four-bit matrix. It includes on-chip address decoding and operates over the temperature range of 0 to +75°C. Write and sense-recovery time is 35 ns. Power dissipation is 36 mW.

CIRCLE NO. 269

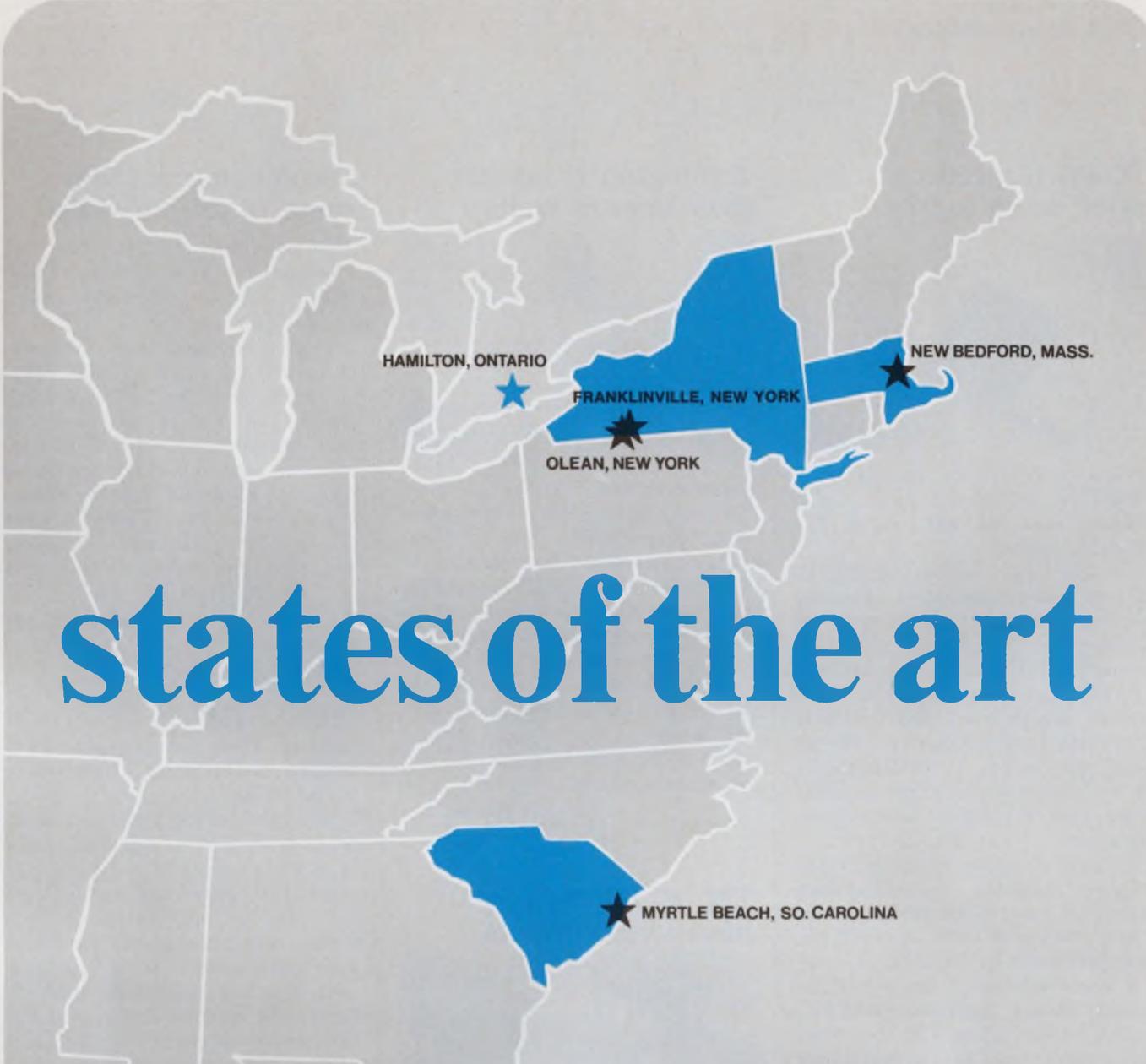
### MECL converter operates to 70 MHz



*Data Technology Corp., 1050 E. Meadow Circle, Palo Alto, Calif. Phone: (415) 321-0551. P&A: \$99; 4 to 6 wks.*

Containing eight 2-input-level conversion circuits and compatible with emitter-coupled logic levels at the input and DTL/TTL-compatible at the output, the model 650 MECL-to-DTL/TTL converter operates up to 70 MHz. Typical rise and fall times are 8 and 19 ns, respectively. The model 650 is contained on a single 3.16 by 4.5-in. PC card.

CIRCLE NO. 270



# states of the art

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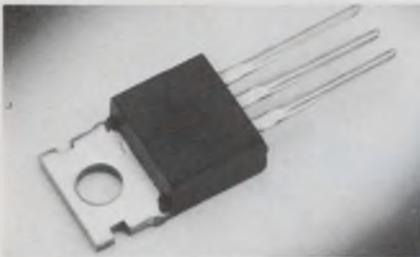
the state-of-the-capacitor art.

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## TO-66 transistors price down to 58¢



Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-5011. P&A: 78¢ to \$1.40; stock.

A new family of low-cost plastic TO-66 power transistors spanning a collector-to-emitter voltage range of 30 to 80 V features unit prices from 58¢ (100 to 999 quantities).

They utilize the Bimesar technology which uses two epitaxial layers to form the active collector and base regions of the transistor. A mesa etch defines the collector-base and a planar emitter-base junction.

The new family of power transistors includes complementary (npn and pnp) chips designated as types 0345 and 0045, respectively, measuring 70 by 90 mils.

Characteristics of the new transistors include excellent linear forward current gain, with less than 50% falloff over the current range of 200 mA to 2 A.

Other characteristics include typical low saturation voltage of less than 0.7 V at a collector current of 2 A and a forward current gain of 10. Typical gain-bandwidth product is 2 MHz.

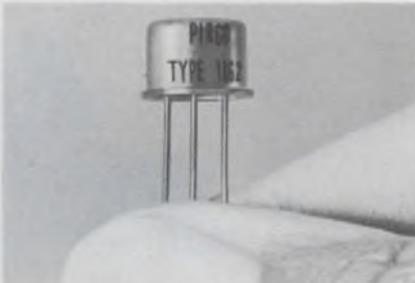
Power rating is 36 W at a temperature of 25°C. The use of high-temperature silicone plastic encapsulants provides an operating temperature range of -65 to +150°C.

Models 2N5293 through 2N5298 (npn) and 2N6021 through 2N6026 (pnp) are non-lead formed versions (ending in an even number) and lead formed versions (ending in an odd number).

Models SDI345 through SDP345 (npn) and SDI445 through SDP445 (pnp) are all non-lead formed devices.

CIRCLE NO. 271

## Darlington transistor dissipates 5 watts

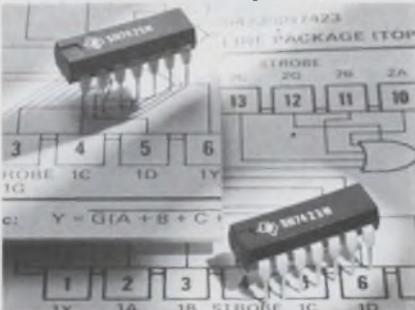


Pirgo Electronics, Inc., affiliate of Sprague Electric Co., 130 Central Ave., Farmingdale, N. Y. Phone: (516) 694-9880. Price: \$22.50.

Type 1162 monolithic Darlington power transistor is a device which will dissipate 5 W of power. Its peak collector current is 10 A and continuous collector current is 7 A. Minimum gain is 2500 and collector-to-base ( $V_{CE0}$ ) and collector-to-emitter ( $V_{CE0}$ ) voltages are 12 and 60 V, respectively.

CIRCLE NO. 272

## TTL IC NOR gates have strobe inputs



Texas Instruments Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: \$1.06 to \$3.60; stock.

Two new TTL ICs, the SN54/7423 and the SN54/7425, are dual 4-input positive NOR gates with separate strobe inputs. The SN54/7423 has the capability of being easily expanded by either paralleling the expander inputs and outputs or by using an expander gate. Each NOR gate can replace four AND gates and one NOR gate while the strobe inputs inhibit the NOR function.

CIRCLE NO. 273

## Second-source MSIs come in 24-pin DIPs

Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, Calif. Phone (408) 732-2400. Price: \$4.85, \$4.95.

Two new second-source MSI 24-pin DIPs are the 9308 dual four-bit latch and the 9311 demultiplexer and 1-of-16 decoder. The 9308 provides active pull-up outputs on each latch for operating speeds to 25 ns. It includes clamping diodes on each input to limit the effect of transient signals. The 9311 can be easily cascaded for multivlevel decoding.

CIRCLE NO. 274

## Monolithic ICs reject noise

Siemens Corp., Components Div., 186 Wood Ave. South, Iselin, N. J. Phone: (201) 494-1000.

The new FZ100 series of monolithic DIP ICs for suppression of high noise have a static margin of 5 and 8 V, depending on the logic state, and a supply voltage of 15 V. Their output resistances are low in both logic states causing noise coupled into the connecting leads to fade away rapidly. Delay, rise and fall times are long enough for a high dynamic noise margin.

CIRCLE NO. 275

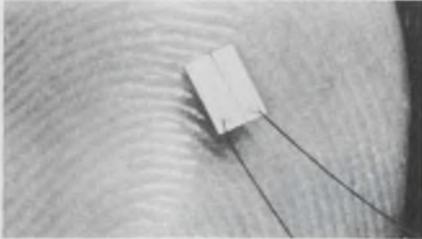
## MOS shift register has dual-32 bits

Varadyne, Inc., Semiconductor Div., 10432 N. Tantau Ave., Cupertino, Calif. Phone: (408) 257-0481. Price: \$4.70.

The V001 is a new low-voltage dual 32-bit MOS p-channel static shift register. It requires only a single-phase TTL-compatible clock and features operation over the frequency range of 0 to 2 MHz. Its operating temperature range is -55 to +125°C. The inputs, clock and power are TTL-compatible without external bias resistors. The outputs can drive two TTL loads directly.

CIRCLE NO. 276

### Thin-film thermistors respond in 20 ms

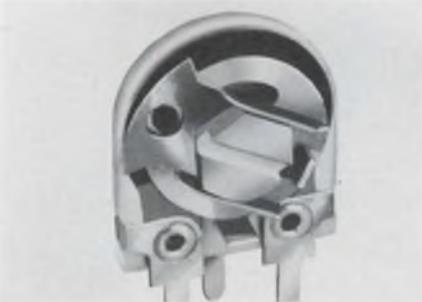


*Ceramic Magnetics, Inc., Micro Mag Div., 87 Fairfield Rd., Fairfield, N. J. Phone: (201) 227-4222.*

A new line of low-cost sealed thin-film thermistors with negative temperature-coefficients of  $3.29/^{\circ}\text{C}$  feature fast response times that range from 20 to 50 ms. The new devices measure only 0.1 by 0.07 in. and have a high surface-area-to-volume ratio. They can be supplied as free-standing units (without substrates) or with substrates of beryllium or aluminum oxide.

CIRCLE NO. 277

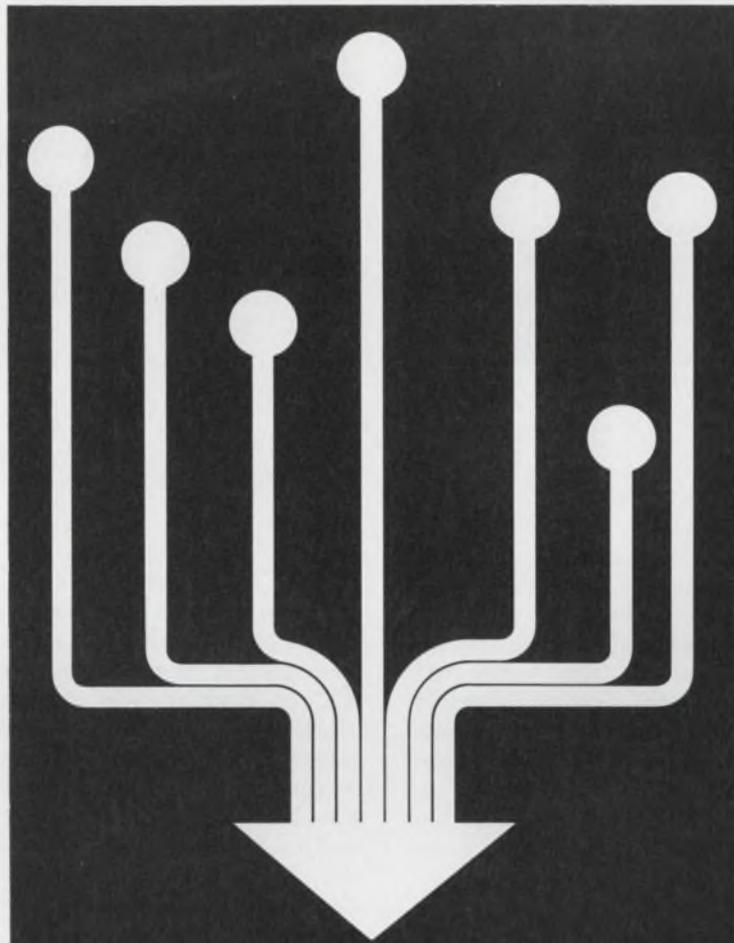
### Cermet PC trimmer costs just 50¢



*Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. Price: 50¢.*

Model 3359 3/8-in.-dia low-cost single-turn cermet potentiometer sells for 50¢ each in 1000-piece quantities. It has a temperature coefficient ranging from 0 to +300 ppm/ $^{\circ}\text{C}$  for resistance values to 1 k $\Omega$ . Temperature coefficient ranges from 0 to +200 ppm/ $^{\circ}\text{C}$  for units with 1 k $\Omega$  to 2 M $\Omega$  values. Operating temperature range is over -65 to +125 $^{\circ}\text{C}$ . Power rating at 70 $^{\circ}\text{C}$  is 1/2 W.

CIRCLE NO. 278



### Buy only what you need for your signal scanning requirements.

You can now select the exact scanning equipment you need—no more, no less. The new Cunningham 2000 Series includes two addressable scanning switch modules—crossbar and reed. Also a universal control module which can be mated with either for a complete scanner (which can also be controlled remotely).

### Buy these units complete, or their switch and control modules separately



**Model 2400 Crossbar Scanner.** Includes:  
 1. Crossbar Module (Model 2100) with capacity from 100 six-wire to 600 single-wire channels. Scans up to 60 channels/sec.  
 2. Control Module (Model 2300) can control more than one Crossbar Module.

### Model 2500 Guarded Reed Scanner.

Includes: 1. Reed Switch Module (Model 2200) with 10 to 100 three-wire channels. Scans up to 250 channels/sec. 2. Control Module (Model 2300) can control up to 10 Reed Switch Modules (1000 channels).



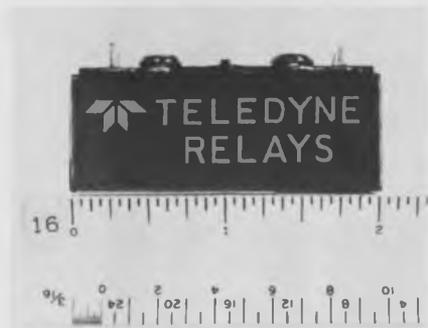
Both scanners and their switches are especially ideal for low-level and low thermal switching, accept BCD address (other optional), and are modular, expandable and 19" rack-mountable. Read the details on Model 2400 (Bulletin 324) and Model 2500 (Bulletin

325). Write Cunningham Corporation, 10 Carriage Street, Honeoye Falls, New York 14472.

## Cunningham Corporation

SUBSIDIARY OF GLEASON WORKS

### Solid-state relays cost a mere \$5.80



Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. Phone: (213) 679-2205. P&A: \$12 to \$13; 2 to 4 wks.

Combining complete four-terminal isolation, the new series 601 solid state relays range in prices from \$12 to \$13 in small quantities, and as low as \$5.80 for production quantities. The series includes 70 types with voltages from 3 to 75 V dc and 9 to 140 V ac. Currents range from 1 to 10 A. No external heat sink is needed on 1-to-7-A units.

CIRCLE NO. 279

### T-1 lamp drawing 23 mA has 0.19 candlepower



Precision Lamp Engineers, Inc., 114 Hamilton Dr., Navato, Calif. Phone: (415) 883-5916.

When operated at a rated voltage of 28 V, a new T-1 1/8-in.-dia incandescent lamp draws only 23 mA of current and produces a brightness level of 0.19 mean-spherical candlepower. This low-current and high-brightness feature is made possible by a new production process which drives down the water content of the lamp's glass envelope to an absolute minimum due to a high vacuum.

CIRCLE NO. 281

### Tiny timing modules span 5 to 10<sup>5</sup> seconds

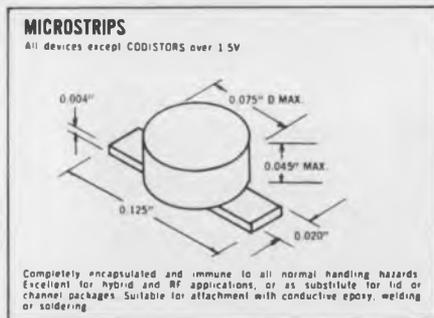


Gould Ionics, Inc., P.O. Box 1377, Canoga Park, Calif. Phone: (213) 341-1040.

Featuring high capacitance density, a new series of solid-state timing modules covers the time range from 5 to 100,000 seconds. ESD Modules provide up to 100,000-second one-shot timing in less than 2.3 in.<sup>3</sup> of volume. Removing an external link provides symmetric repeat cycling up to 50,000 seconds/cycle. Adding external resistors provides a 100:1 range of output cycle time adjustment.

CIRCLE NO. 283

### Ladybug capacitors mount two ways



Codi Semiconductor, Pollitt Dr., Fairlawn, N. J. Phone: (201) 797-3900. Availability: stock.

A line of voltage-variable capacitors in ladybug packages features the choice of conventional mountings or mounting with conductive epoxy pastes. Available types include 1N5139 through 1N5148A for low-leakage and high-Q voltage characteristics. Type 1N4805A through 1N4815A offer high-voltage and low-Q features. Types 1011 through 1019 have high tuning ratios.

CIRCLE NO. 280

### Direct-view storage tube shows 700 foot-lamberts



ITT Electron Tube Div., 320 Park Ave., New York, N. Y. Phone: (212) PL2-6000. Availability: stock.

A new 4-by-5-in. rectangular direct-view storage tube features an equilibrium brightness of 700 foot-lamberts and uniform display with resolution of 75 lines/in. Type F-3046's storage time reaches up to 5 minutes and can be extended to 30 minutes. Optional features include a 1-ms erase characteristic, 1 million in./s writing speed, black face, precollimation and a choice of phosphors.

CIRCLE NO. 282

### Double-throw switch has up to 500 poles

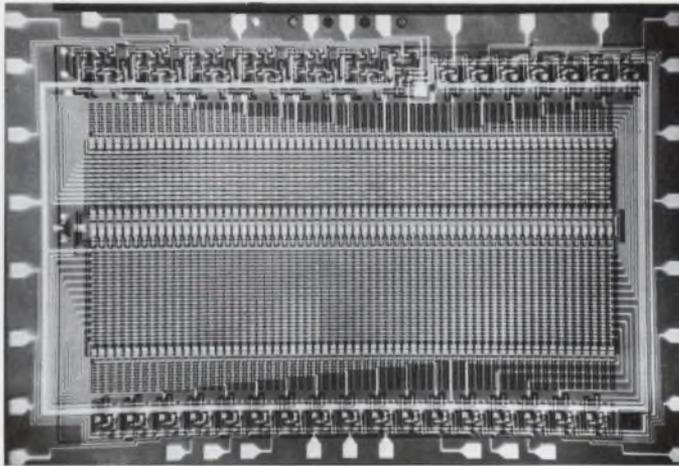


Daven Div. of Thomas A. Edison Industries, Grenier Field, Manchester, N. H. Phone: (603) 669-0940. Availability: 8 to 10 wks.

The new Centipole transfer switch is available in double-throw versions with up to 500 poles. The basic switch module contains 100 poles with double-throw action, five of which can be ganged together to achieve the 500-pole version. Single modules are also available with 50 poles.

CIRCLE NO. 284

# LSI circuits now a commercial reality!



.160"

.250"

bipolar 1536 bit ROM  
64 words  
24 bits per word

at last, production quantities of the industry's largest bipolar and MOS LSI circuits...

**Bipolar 16 segment alpha-numeric decoder/driver**  
**Bipolar and MOS — RAMs and ROMs**  
**A bipolar 16 bit logic family**

HOW DO WE DO IT ?

We achieve high yield by precise workmanship, rigid control of handling, materials purity, designed-in testing, and seven years of solid LSI circuitry experience. LSI monolithic subsystems, by our team, are now in military and deep space environments. Our team will produce the optimum LSI for your product.

APPLY THE BENEFITS of LSI circuit technology: lower overall cost, simpler design, labor savings, and reduced "real estate".

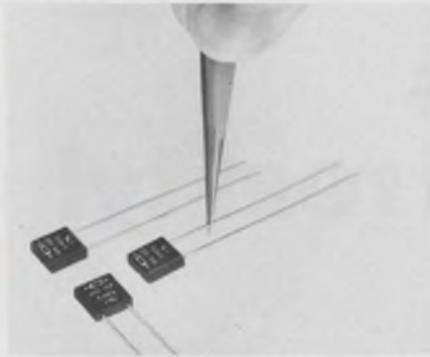
**Call Griffith Jones (617) 868-5100**

**KENICS ELECTRONICS CORPORATION**

Eastern Region Sales Office: 125 Harvard Street, Cambridge, Massachusetts 02139



## Film resistors use epoxy cases

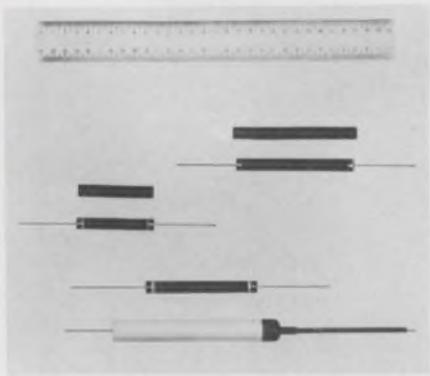


*Caddock Electronics, 3127 Chicago Ave., Riverside, Calif. Phone: (714) 683-5361.*

Model MK132 precision film resistors are encased in rectangular epoxy cases measuring 0.29-in. square by 0.095-in. thick and are supplied with radial leads. They are non-inductive and are rated at 1/2 W at 105°C. Resistances range from 100  $\Omega$  to 5 M $\Omega$ , and operating temperature range is -55 to +150°C. Temperature coefficient is 50 ppm/°C.

CIRCLE NO. 285

## High-voltage elements stabilize 30,000 V



*Matsushita Electric Corp. of America, 200 Park Ave., New York, N. Y. Phone: (212) 973-5700. Availability: stock.*

Hi-ZNR resistors are high-voltage-stabilizing elements that work in the 300 to 30,000-V range. Their voltage-stabilization characteristics are 10 times better than that of silicon-carbide varistors and they absorb 100 times as much surge voltage as zener diodes do. Dissipation power is 0.6 W/cm and temperature coefficient ranges from -0.005%/°C to -0.010%/°C.

CIRCLE NO. 286

## 50-to-400-Hz motor-fan is barely audible



*Globe Div. of TRW Inc., 2275 Stanley Ave., Dayton, Ohio. Phone: (513) 228-3171.*

A new miniature industrial ac motor-fan operates on multiple frequencies ranging from 50 to 400 Hz, with minimum speed changes and with a minimum of noise. This ultra-quiet motor-fan holds its speed within a range of 3000 to 4000 rpm. Operating voltage is 115 V ac. The motor's diameter measures only 1.2 in. and it dissipates only 13 W of power.

CIRCLE NO. 287

## Proximity reed switches cost from \$1.68



*McClintock Matrixes, Inc., Washington Rd., Woodbury, Conn. Phone: (203) 263-4624. Price: \$1.68 to \$4.54.*

New proximity-operated reed switches now cost as low as \$1.68 in large quantities. Models 26-5-4A and 26-5-6A are actuated by any ferrous material and their calibration distance can be specified from 0.075 to 0.15 in. They are stocked in 0.025-in. steps. Normally-closed contacts are rated for 100 V dc at 0.4 A.

CIRCLE NO. 288

## Wide-range heat sensor resolves $\pm 0.1^\circ\text{F}$



*Thermal Systems, Inc., 13920 S. Broadway, Los Angeles, Calif. Phone: (213) 321-4350.*

A new accurate strap-on heat sensor is capable of resistive changes proportional to temperature with a resolution of  $\pm 0.1^\circ\text{F}$  over temperatures from cryogenics to 1200°F. It is adaptable to surfaces 1 to 12 in. in dia. It is also available with a signal conditioner which supplies a linearized 0-to-5-V signal proportional to the temperature range of its platinum transducer.

CIRCLE NO. 289

## Short TV camera tube has a 1-in. diameter

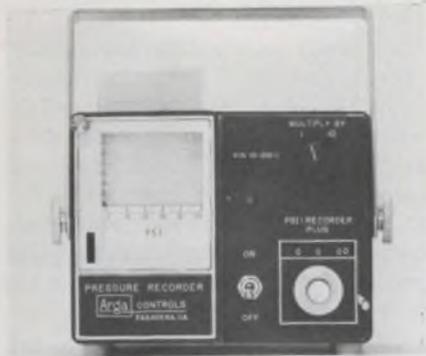


*English Electric Valve Co., Ltd., Chelmsford, Essex, England.*

Type 7262A TV camera tube is a 1-in.-dia vidicon for compact monochrome or color CCTV systems. It is of integral-mesh construction and uses magnetic focus and deflection. With high voltages, center limiting resolution of 850 TV lines can be obtained. Even when operated at low voltages, center resolutions exceed 700 TV lines. Faceplate illumination is 1 foot-candle for average-sensitivity operation.

CIRCLE NO. 290

**Pressure recorder expands chart span**



Arga Controls, 35 E. Glenarm, Pasadena, Calif. Phone: (213) 682-3314. Price: \$250 to \$500.

A new pressure recorder can add to its scale marking of 100 lb/in.<sup>2</sup> any value between 0 to 3000 lb/in.<sup>2</sup> by means of a single control knob. This makes the model 10-015-1 pressure recorder's 4-in. chart equivalent to a chart 10 feet wide. A separate switch changes the chart's span width by a factor of 10. Accuracy of the new recorder is  $\pm 2\%$  of the recording span.

CIRCLE NO. 291

**Handy FM generator simplifies alignment**



Sound Technology, 10601 S. Saratoga-Sunnyvale Rd., Cupertino, Calif. Phone: (408) 257-9171. P&A: \$1250; stock to 60 days.

Containing less than 0.1% of total modulation harmonic distortion at 100% modulation, a new FM generator allows the alignment and measurement of FM receiver distortion directly on an oscilloscope without the use of meters. The model 1000A has adjustable linear sweep width up to 600 kHz and low residual FM of  $-70$  dB when in cw modes.

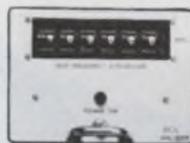
CIRCLE NO. 292

**ACL** ASTRO COMMUNICATION LABORATORY

**Introduces the Most Versatile HF-LF RECEIVER**

**SR-502**

**Now Available**



**SYNTHESIZED HF RECEIVER**

**Rugged Design Easy to Operate**



**SPECTRUM DISPLAY**

**RF TUNER 10-500 KHz SINGLE BAND**



**BATTERY OPERATION**



**FREQUENCY READ OUT**

**RF TUNER 0.5-30MHz SINGLE BAND**

**AM - FM - CW - USB - LSB - SEARCH**

*Versatility in a small package!*

- PORTABILITY—AC DC Battery operation
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*Other plug-in accessories available:*

- SPECTRUM DISPLAY • HF SYNTHESIZER • BATTERY PACK
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500-999	.91
1000-4999	.86
5000 up	.82



## THE HI-RELIABLE!

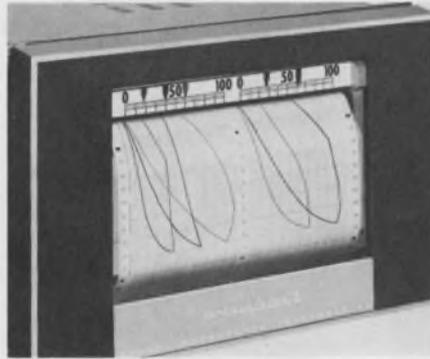
No fragile nail heads.  
Silicon junction aligned between two, parallel, offset tantalum heat sinks . . . great lead tension strength.  
All welded and brazed assembly.  
High pressure molded package.  
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Write or phone for Form 68-4 for complete rating data and other tolerance prices.

Semiconductor Division

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## INSTRUMENTATION

### X-Y recorder shows 6 signals

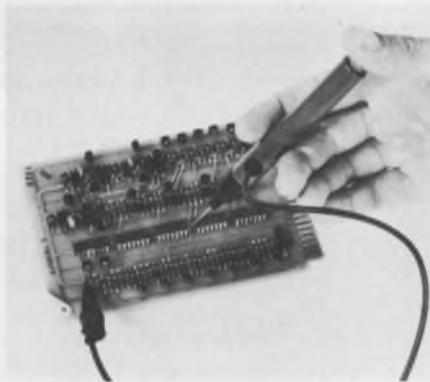


Texas Instruments Inc., Digital Systems Div., Box 66021, Houston, Tex. Phone: (713) 526-1411. P&A: \$2240; 45 days.

As many as six different signals (five X and one Y) may be recorded at the same time on a new X-Y recorder. Housed in a metal case and designed for bench, rack or panel mounting, the Countour/Riter II recorder is available with one, two, three or four overlapping pens, or with dual charts with up to five pens.

CIRCLE NO. 293

### Test probe for ICs delivers 1- $\mu$ s pulses



Concept Electronics, Corp., 8402 Osage Ave., Los Angeles, Calif. Phone: (213) 670-0524. P&A: \$19.50; 1 wk.

Handy Pulse BG-1 is a single-pulse generator capable of delivering a negative-going pulse of a 1- $\mu$ s duration. It requires no external or internal power source. A unique design allows it to be used with a wide range of digital families without fear of damage from accidental probing. It is enclosed in an all-metal case and is suitable for field equipment testing.

CIRCLE NO. 294

### IC tester with cables facilitates checks

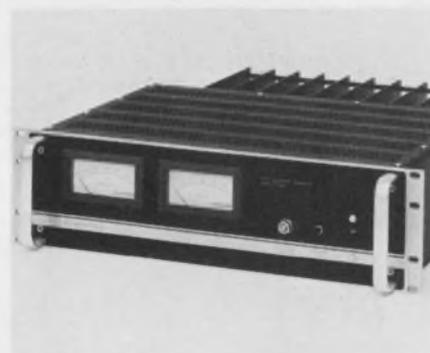


Emcee Electronics, Inc., 177 Old Churchman Rd., New Castle, Del. Phone: (302) 328-1354. P&A: \$120; stock.

A new self-powered IC tester features a clip probe and a flexible cable for in-system resting of both 14 and 16-pin dual-in-line TTL or DTL circuits. Standard cable length is 24 inches. The new tester displays the logic states of all pins simultaneously. The tester's lamps light up for high logic states and turn off for low ones.

CIRCLE NO. 295

### 100-A dc supplies are 60% efficient



Powertec, Div. of Airtronics Inc., 9186 De Soto Ave., Chatsworth, Calif. Phone: (213) 882-0004. P&A: from \$465; stock to 4 wks.

Due to unique filtering and regulation techniques, the RM series of rack-mount power supplies achieves 60% efficiencies with dc outputs of 5 V at 100 A. They require no fans while delivering full loads at a temperature of +55°C. Line and load regulation are  $\pm 0.1\%$  and ripple is 3 mV pk-pk. Output voltages range from 5 to 28 V dc.

CIRCLE NO. 296

### Tiny 40-oz calculator is truly portable



Dictaphone Corp., 120 Old Post Rd., Rye, N. Y. Phone: (914) 967-6211. P&A: \$495; 90 days.

A new portable \$495 calculator with 16-digit capability and an 8-digit readout weighs but 40 oz and measures only 8-1/2 by 5 by 1-3/4 in. It features decimal selection and a constant for successive division and multiplication and can add, subtract, divide and multiply in only milliseconds. It contains a ten-button keyboard and function keys.

CIRCLE NO. 297

### Low-speed data modems transmit at 300 baud



International Communications sub. of Milgo Electronic Corp., 7620 N. W. 36 Ave., Miami, Fla. Phone: (305) 691-1220. Availability: October, 1970.

The new Series 300 data modems designed for low-speed communications can transmit data with speeds as low as 300 baud. Transmission from these new data sets is possible over either dial-up or over private telephone lines. They feature compatibility with most Western Electric data sets which are leased by the Bell System.

CIRCLE NO. 298

### Data logging device handles many sources

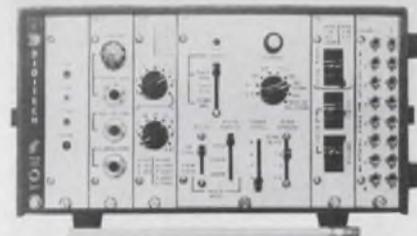


Harshman Associates, Inc., Box 2327, Sanford, Calif. Phone: (415) 961-3304. Price: \$2500.

The Data Logger model 3000 is designed to handle multiple sources of data and is capable of changing codes, editing information and merging data sources. An optional keyboard allows the operator to input letters and numbers directly. It is essentially a means of gathering data from sources, controlling the sources, and sending the data to other sources in an edited form.

CIRCLE NO. 300

### Data/telegraph source supplies many patterns



Digitech Data Industries Inc., 22 Grove St., Ridgefield, Conn. Phone: (203) 438-3731.

The model 2102 is a data/telegraph signal simulator designed for test and alignment of data communications modems, systems, terminals, printers, telegraph equipment, and video displays. It features test messages in various data and telegraph languages such as ASCII, BAUDOT, IBM 1050, plus 8 selectable characters operating in both free run and stepped modes at 16 speeds to 600 baud.

CIRCLE NO. 301

# Now the famous 829 has a "G" for good measure!



Calibrate or Measure with the

## RFL Model 829G

RFL's famous 829, for 15 years the industry calibration standard, now gives way to the new 829G — still the industry calibration standard, but now it's twice as useful. The 829G provides a precision source of AC and DC volts, amps and ohms — plus precision measurements of these parameters from external sources. It offers four-terminal sensing in both source and measurement modes, and high accuracy, resolution and regulation, with 5-digit readout. 5 ranges of AC or DC, 0.1 to 1000V. 6 ranges of current, 100 uA to 10A. 50, 60, 400, 1000 Hz AC plus EXT. And many other features — all for just \$3,350. □ Write for complete data today. RFL Industries, Inc., Instrumentation Div., Boonton, New Jersey 07005. Tel: (201) 334-3100 / TWX: 710-987-8352 / CABLE RADAIRCO, N. J.



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We cross Ref. most MFRS.

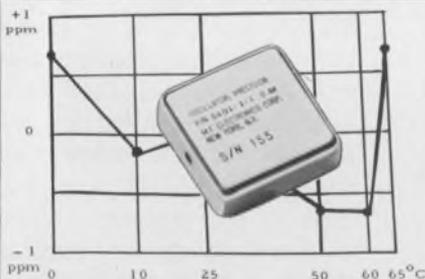
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(212) 777-6571 TWX 710-581-4930

INFORMATION RETRIEVAL NUMBER 51

### TCXO Operates From + 5 Volts



New Series 5400 oscillators are made in flatpack and compact versions and provide choice of stability of 1 to 10 ppm from 0 to 65°C. They deliver TTL outputs at 1 KHz to 10 MHz. Typical specs are:

Input Voltage	5V ±0.5%
Frequency	As specified from 1 KHz to 10 MHz
Screwdriver Adjust	±3 ppm
Temperature Stability	±1 ppm from 0 to 65°C
Output	0 to 4 V, drives 10 TTL loads

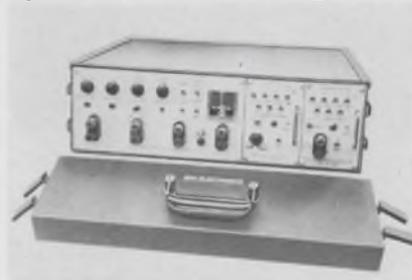
Write or phone for complete catalog  
**M F ELECTRONICS CORP.**

118 East 25th St., New York, N.Y. 10010  
Tel.: 212 674-5360

INFORMATION RETRIEVAL NUMBER 52

## DATA PROCESSING

### Phase-jitter unit spans 0 to 45 degrees



Seg Electronics Corp., 120-30 Jamaica Ave., Richmond Hill, N.Y. Phone: (212) 441-3200. Price: from \$1980.

The model FA1564 phase-jitterer adds adjustable phase jitter from 0 to 45 degrees to a data signal in the telephone voice frequency band from 20 to 360 Hz. Accessory features include adjustable fixed phase shift, phase hits, adjustable harmonic distortion and broadband and impulse noise. Other features include fixed or variable attenuation and delay distortion.

CIRCLE NO. 302

### Data systems test set locates malfunctions

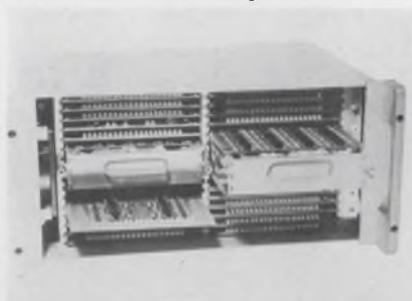


Noller Control Systems, Inc., 150 E. Standard Ave., Richmond, Calif. Phone: (415) 233-8220. Availability: 60 days.

The model DTS 1010 test set is designed to test interface leads between data terminals and data sets as well as test the interface between data sets and transmission links to isolate and identify system malfunction sources. It is fully interactive and provides bridging, and source and load simulation.

CIRCLE NO. 304

### Fast memory system handles 32k-by-36 bits



Information Control Corp., 9610 Bellanca Ave., Los Angeles, Calif. Phone: (213) 641-8250. P&A: less than 4¢/bit; 30 days.

Full cycle time of 900 ns, 350-ns access time and field expandability from 8k-by-36 bits to 32k-by-36 bits are only a few features of the model 1010 random-access core-memory system. The system uses 3D selection and 22-mil cores for high speed and density. All of the system's modules, including the stacks, measure 7 by 9-1/4 in.

CIRCLE NO. 303

### Low-cost calculator retails at \$349

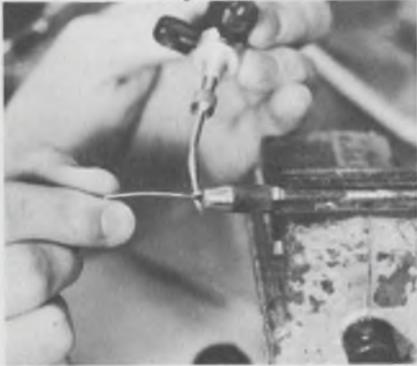


Casio Enterprises, Inc., 46-02 28th St., Long Island City, N.Y. P&A: \$349; stock.

The model 121-A low-cost electronic desktop calculator with a capacity of 12 digits retails at only \$349. It can perform the four basic mathematical functions of addition, subtraction, multiplication and division. In addition, it can also perform multiplication with a constant and can also forward a grand total. The calculator has a compact design and a wood-grained top panel.

CIRCLE NO. 305

### Tiny 6300°F torch welds many metals

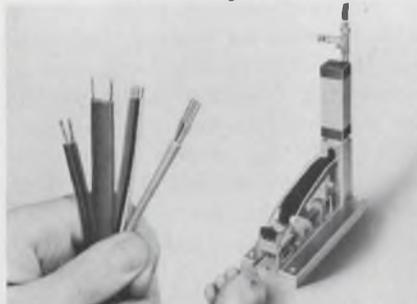


Tescon Corp., Instrument Div., 2633 E. 4th St., Minneapolis, Minn. Phone: (612) 331-1311.

A miniature 1.5-oz torch called the Little Torch can weld metals from 0.002-in. wire up to 16-gauge steel with temperatures up to 6300°F. It uses oxygen and a fuel gas (acetylene, hydrogen, LP or natural gas) to operate at pressures of 1 to 6 psi. Five different tip sizes are available. Each tip swivels 360 degrees to give complete handling ease.

CIRCLE NO. 306

### Bench wire stripper handles many sizes



Thomas & Betts Co., 36 Butler St., Elizabeth, N.J. Phone: (201) 354-4321. Availability: stock.

The ABMK-300 is a new self-adjusting tool that will cleanly strip insulation from single or multiple wires of #22 to #10 AWG aluminum or copper without nicking the conductor. Multiple cutting blades mounted in a wide jaw eliminate critical wire positioning and permit stripping up to six #16 wires at the same time. It is pneumatically operated and is actuated by a foot control.

CIRCLE NO. 307

### Micro-miniature tools interchange easily

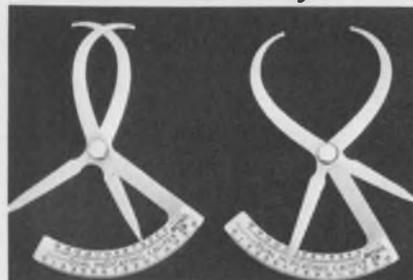


Circon Corp., Santa Barbara Airport, Goleta, Calif. Phone: (805) 967-0404. Availability: stock.

An extensive line of new interchangeable micro-miniature tools designed for use in producing and repairing the smallest electronic and mechanical instruments is now available. Termed MicroTools, the new line consists of 60 screw-based tips which can be used interchangeably on either of two delicately balanced handles. Features include miniature tip sizes, a wide range of tip designs and interchangeable handles. Each tip is mounted on a 0.03-in.-dia corrosion-resistant stainless-steel shaft.

CIRCLE NO. 308

### Dual caliper measures two ways



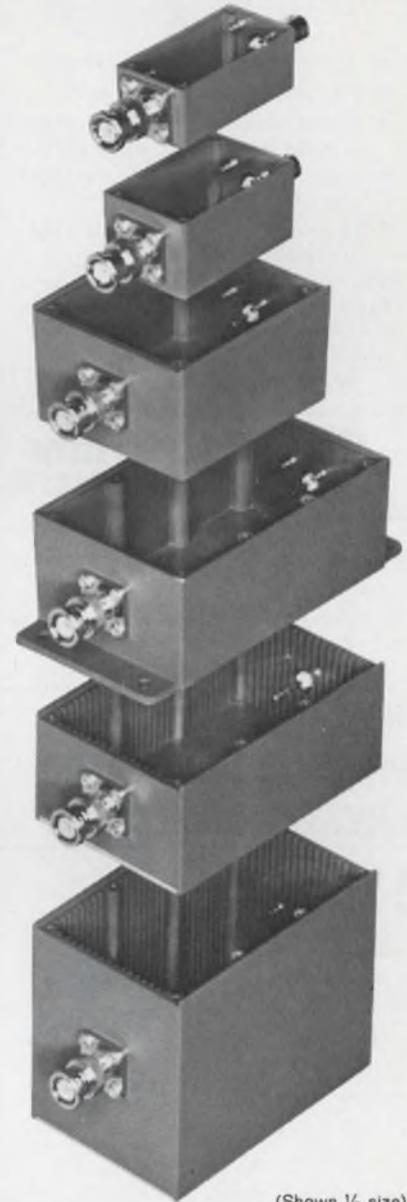
Indicating Caliper Co., Box 51, Oak Park, Ill. P&A: \$22.50; stock.

A new direct-reading dual-indicating caliper can be used for taking measurements on the outside and inside of surfaces. It is available with metric and English scales to measure up to fifteen cm or six inches. The new caliper can be locked in place at any reading and thereby serve as a fixed gauge. Its construction is of heavy-gauge steel stampings and it is chromium-plated for longer life.

CIRCLE NO. 309

## SHIELDED BOXES

# Take your pick.



(Shown 1/3 size)

The newly expanded line of Pomona Shielded "Black Boxes" now comes in six different sizes; in cast or extruded aluminum; some slotted to accept circuit boards; in a broad choice of connector combinations or no connectors. There's bound to be one to meet your requirement. Write for complete information in our General Catalog.

**POMONA ELECTRONICS**

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INFORMATION RETRIEVAL NUMBER 53

## What can you expect from a \$165 pulse generator?



- Accurate integrated circuits?
- Crystal controlled clock?
- Pulse widths from 1 microsecond to 200 milliseconds?
- Pulse rates from 1 to 500,000 per second?
- Rise and fall times less than 100 nanoseconds?

The answer is "YES" to all questions . . . if the pulse generator is a Model 3200 from Houston Magnetics. In stock at just \$165.

Write for more information.



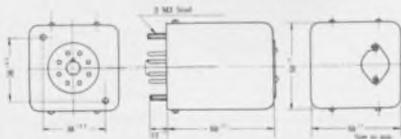
INFORMATION RETRIEVAL NUMBER 54

## 1MHz HIGH PRECISION PACKAGED CRYSTAL OSCILLATOR

- LOW COST
- READY SUPPLY

### TYPE:

TCO-8D  
TCO-9D  
TCO-9E



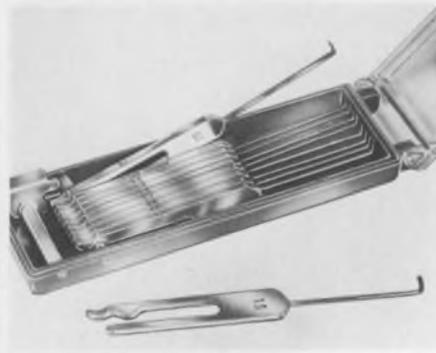
This oscillator features a 4MHz, 3rd overtone cold weld vacuum sealed high stability crystal element having a Q of greater than 1,500,000, 4:1 frequency division by means of IC, continuous control constant temperature oven, new mechanism, and high reliability components. Extremely fine frequency adjustment on the order of  $10^{-6}$  ~  $10^{-9}$  is possible with a single trimmer.



INFORMATION RETRIEVAL NUMBER 55

## TOOLS & ENGINEERING AIDS

### Handy blade set checks wire gauges



Jonard Industries Corp., Precision Tools Div., 3047 Tibbet Ave., Bronx, N. Y. Phone: (212) 549-7600. P&A: \$19.40; stock.

The new T-271 wire gauge set, specially designed for use in restricted places, contains 9 different blades in the most commonly-used sizes to facilitate wire-thickness gauging. Simply press a travel-type blade selector guide and the blades pop up for use. Blades are marked in both metric and English scales.

CIRCLE NO. 310

### Handy tool kit simplifies IC work

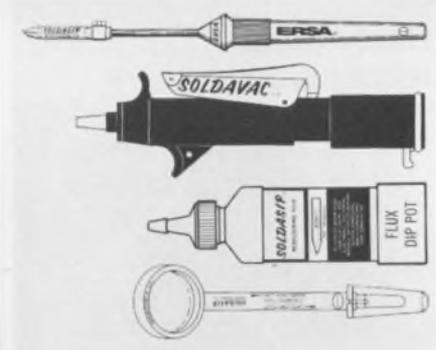


C. H. Mitchell Co., Electronic Tools Div., 18531 Ventura Blvd., Tarzana, Calif. Phone: (213) 454-5190.

A new tool kit contains nineteen tools, each selected particularly for its applicability in servicing transistorized and integrated circuits. Included in the kit are ten screwdrivers, tweezers, nippers, scissors, pliers, a magnifying mirror, a 35-W miniature soldering iron, and a 1 to 80 power microscope. A zippered case is included.

CIRCLE NO. 311

### Soldering station comes in a kit

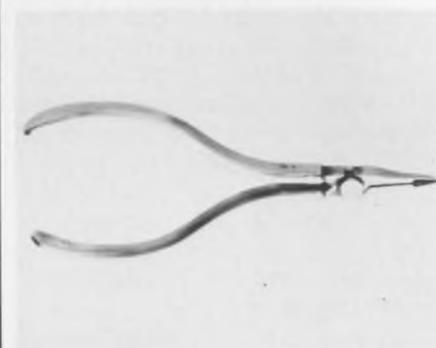


Edsyn Inc., 15954 Arminia St., Van Nuys, Calif. Phone: (213) 989-2324. Price: \$10.95.

The X-34 soldering kit contains all the necessary elements for a modern soldering station. Included is a fast-warmup soldering iron, a desoldering tool, a resoldering tip for use on the iron, 4 oz of flux with a flux dip pot and a burnishing tool. The soldering iron features 60-second warmup and the desoldering tool is self-contained and spring-loaded.

CIRCLE NO. 312

### Cutting pliers speed assembly

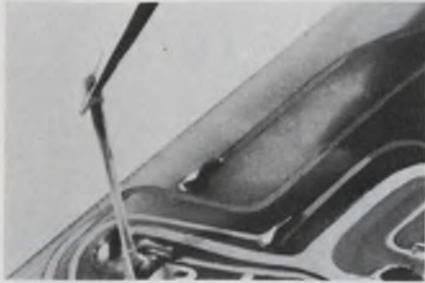


E.T.M. Corp., 144 W. Chestnut Ave. Monrovia, Calif. Phone: (213) 359-8102.

A new line of cutting pliers combines tool-steel heads with lightweight stainless-steel handles to reduce assembly time in the computer and hybrid circuits industries. There are six pliers, which will cut up to 0.025-in. round nickel wire, and two bending pliers in the line. They weigh only 1/2 oz., and can be used over long periods without fatigue.

CIRCLE NO. 313

### Latex covering repels solder

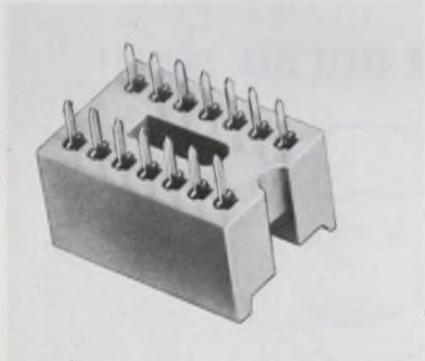


*Techni-Tool, Inc., 1216 Arch St., Philadelphia, Pa. Phone: (215) 568-4457.*

Easily applied with a dispenser, brush or syringe, a new latex-based protective covering keeps holes and areas free of solder during reflow and repair operations. Soder Mask is a specially formulated elastomer that comes as a solvent or water-soluble formulation. It may be removed by peeling or rubbing, and leaves no residue. It can withstand 300°F.

CIRCLE NO. 314

### 14-pin DIP socket fits 0.1-in. centers

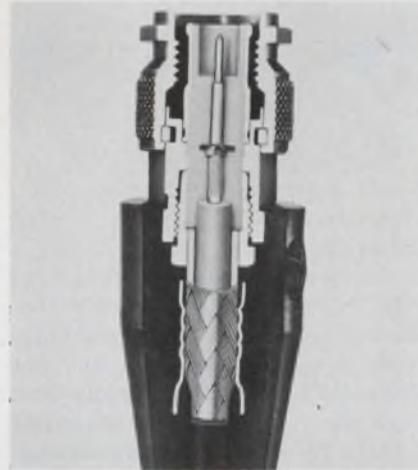


*Connector Corp., 6025 N. Keystone Ave., Chicago, Ill. Phone: (312) 539-3108. P&A: 20¢; 4 to 6 wks.*

The type 561 socket is designed to fit 14-pin dual-in-line ICs on 0.1-in. centers for adjacent terminals. Consistently reliable mating of the IC package is assured by a tapered pin design. Solder tail centers of the socket permit the use of standard board layouts as desired. Contact platings are available as cadmium, silver, gold over silver, or gold over nickel.

CIRCLE NO. 315

### Molded terminations protect cables fully



*Times Wire and Cable Co., div. of Insilco Corp., 358 Hall Ave. Wallingford, Conn. Phone: (203) 269-3381.*

Plastic terminations for cable assemblies, which are said to assure trouble-free protection against stress and environment, are now available. Called Impervemold, these injection-molded terminations completely encapsulate the cable-connector face with a hard strong thermoplastic material. This protects the connectors from even excessive bending and twisting.

CIRCLE NO. 316

### Two-component epoxy bonds hybrid substrates

*Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. Phone: (617) 926-0136. Price: \$15/sample kit.*

Epo-Tek H74 is a thermally-conductive two-component epoxy for bonding substrates in hybrid IC packages. Its thermal conductivity measures 7.6 Btu-in/ft<sup>2</sup>-h-°F and lap shear strength is 3500 psi. This epoxy can be used in the 300-to-400°C range for short periods and has a continuous operating temperature of 250°C maximum. Volume resistivity is 2.5 x 10<sup>15</sup> ohm-cm. Dielectric constant is 5.5 at 1 MHz and dielectric strength is 470 V/mil.

CIRCLE NO. 317

# Discreet Device Test Set with Direct Digital Readout



Model 2610 DCP

assures accurate testing at moderate cost.

The Mastech Model 2610 DCP test set has an operating range of 1000 volts and 10 amperes. This transistor/diode test set features direct readout of any test parameter, data logging outputs and type selection classifier for sorting up to 20 categories.

The set is designed for both user and manufacturer and can be interfaced with mechanical equipment for completely automated systems. The equipment is fully warranted for trouble free operation.

Model 2610 DCP is one of several transistor/diode test sets. Other Mastech models offer 300 volt - 1 ampere, or 600 volt - 10 ampere operating range with 6, 12, 18 or 24 test positions.

Further versatility is provided with slave and master multiplex stations, card reader or core memory programmers and full line of test fixtures. Consult Mastech for your discreet device test equipment requirement.



P.O. Box 178 - Syracuse, N. Y. 13211  
Telephone (315) 455-6662

INFORMATION RETRIEVAL NUMBER 56

**Ballpoint marker makes rugged labels**

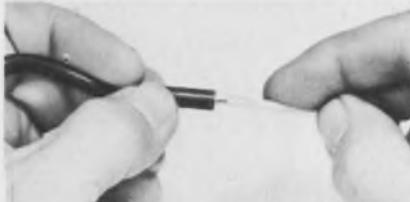


*Tri-Chem, Inc., 345 Cortlandt St., Belleville, N.J. Phone: (201) 759-4900.*

A new multi-colored all-purpose ballpoint marker not only adheres to nearly all materials but also resists alkalis, dyes, most acids, and extended exposure to hostile environments. Tri-Mark is a fast-drying product that marks glass, metal, plastic, porous and non-porous surfaces. The inert formula can be used to cover small breaks in electrical insulation.

CIRCLE NO. 318

**Lossy flexible tubing suppresses rfi/emi**

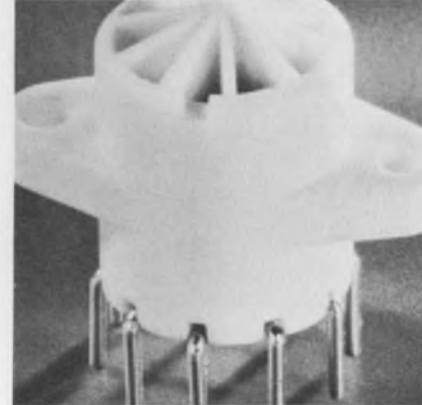


*Lundy Electronics & Systems, Inc., Glen Head, N. Y. Phone: (516) OR6-1440.*

A new flexible lossy tubing provides rfi/emi suppression at microwave frequencies and shielding from low-frequency electric and magnetic fields. It slips easily over any wire and filters unwanted signals by the absorptive-dissipative method. At 1 GHz, conducted attenuation is 20 dB/in. and radiated attenuation is 100 dB/in. At 10 GHz, attenuation exceeds 100 dB/in. Attenuation rises with frequency in a smooth continuous manner without dips or nulls, and is directly proportional to the tubing length.

CIRCLE NO. 319

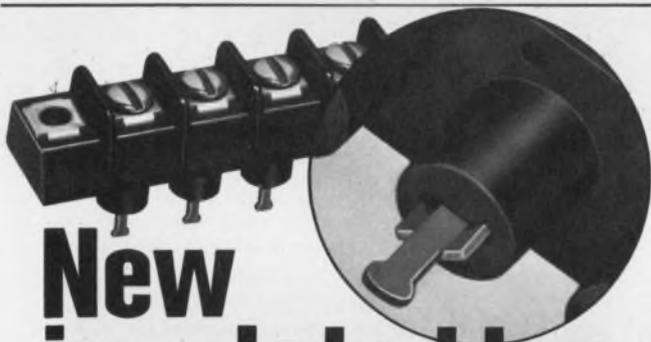
**TO ceramic sockets work up to +300°C**



*Barnes Corp., 24 N. Lansdowne, Lansdowne, Pa. Phone: (215) 622-1525. P&A: 75¢ to \$4; 4 to 6 wks.*

A new series of alumina ceramic burn-in and test sockets for TO devices accept temperatures from -65 to +300°C. They may be subjected to 300°C for continuous operation in excess of 10,000 hours. Electrical contacts are beryllium nickel and can be used in a variety of pin configurations.

CIRCLE NO. 320



**New insulated leg**

An exclusive design improvement for insulated feed-thru terminal blocks. Available in a variety of terminal pin and hardware configurations.

This is one of the many new products Kulka has for engineers who innovate. Kulka keeps up to date with new terminal block concepts, new designs, and new materials to meet every requirement. Send for the latest Kulka catalog. Kulka Electric Corp., 520 So. Fulton Ave., Mount Vernon, N.Y. 10551 or call (914) 664-4024.

*A North American Philips Company*

**Kulka**

INFORMATION RETRIEVAL NUMBER 57

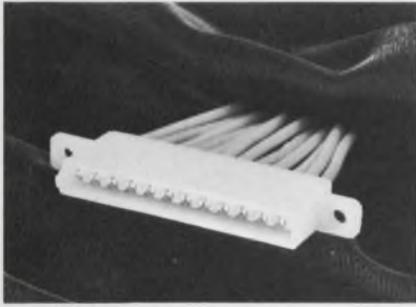
**"IT'S GOOD BUSINESS TO HIRE THE HANDICAPPED."**

**ISN'T THAT A GREAT IDEA, SNOOPY?**



THE PRESIDENT'S COMMITTEE ON EMPLOYMENT OF THE HANDICAPPED, WASHINGTON, D. C.

# Evaluation Samples



## PC 12-pin connector

Free samples of a new printed-circuit 12-pin straight-on connector are available. Like other connectors in its EdgeCon series, this new connector has reliable crimp-type terminals supplied in chain-link form. The terminals snap-lock into nylon housings and can easily be removed with a simple tool. They can also be easily handled with automatic crimping machines. Molex, Inc.

CIRCLE NO. 340

## Patch cords

A new piggy-back series of plug and jack patch-cord combinations feature pin diameters of 0.08 in. Type 445-3391 patch cords allow the convenient patching of circuits and multiple electrical contacts at any point in a circuit. They are available in lengths of 4, 6, 8 and 12 in. and in three colors of black, blue and red. Samples are available. Cambridge Thermionic Corp.

CIRCLE NO. 341

## Ferrite beads

Samples of new low-cost beads designed to solve noise and filtering problems are available. The new beads are easily installed in systems by simply sliding one or more of them over conductor leads. They provide effective rf decoupling, shielding and parasitic suppression without sacrificing low-frequency power or signal level. They can be used either grounded or ungrounded. National Moldite Co., Inc.

CIRCLE NO. 342

# Everything's clearer with the flat one!

Letters! Digjts! Symbols! Equations! All varieties of data are displayed as undistorted images on Zenith Flat-Face Metal CRTs. Ideal for light pen operations, alphanumerics and analog presentations — they're even available with a rear port for optical chart projection. When you need CRTs, face up to the flat one. Write for details.

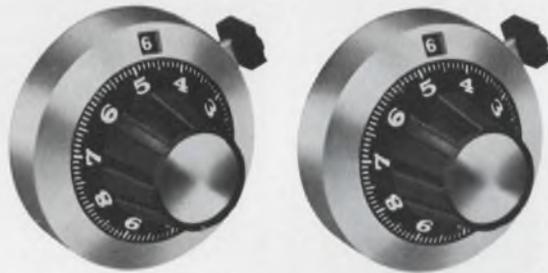


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# SQUINT-PROOF



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*with the readability of 1 13/16" dial in a third less space.*

White set points pop right out at you. No misreading. Ten turns, setable to one part in a thousand. Tough die-cast housing. Only 4 moving parts, including brake and counter assemblies. Zero backlash. **ONLY \$3.99 IN 1,000 LOTS.**

Available through your Bourns distributor.

Call or write your nearest Bourns sales office or representative for more data on the H-510 potentiometer turns-counting dial.



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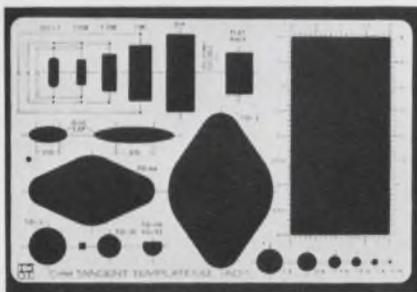
# Design Aids



## Hexadecimal calculator

Containing 50% more indicial marks than an earlier version, this new hexadecimal-decimal slide-rule calculator allows its user to easily perform all routine arithmetic and algebraic calculations in a hexadecimal base. Equivalent operations can be performed in a conventional decimal base with provided scales. Calculation accuracies are said to range from 2 to 3 significant figures and conversion accuracies are to 2 significant figures. The price is \$14.95. Spectrum Sciences, Inc.

CIRCLE NO. 321



## PS assembly template

A new drafting template for printed-circuit assemblies cuts drafting time for drawings and layouts. Assembly drawings are completed with little effort since most commonly used electronic components are represented on the new template. Lead spacings and components are accurately outlined to prevent them overlapping. Scales of 1:1, 2:1 and 4:1 are available. The 1:1 and 2:1 scales are priced at \$3.50. Scales of 4:1 cost \$7.00. Tangent Template Co.

CIRCLE NO. 322

# Get four FREE transistors from your authorized GE semiconductor distributor

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# GENERAL ELECTRIC

221-31

## FREE EPOXY TO-18 TRANSISTORS

Present or mail this coupon to your authorized GE semiconductor distributor for up to four free transistors. Just enter the quantities opposite the type numbers below (maximum of four).

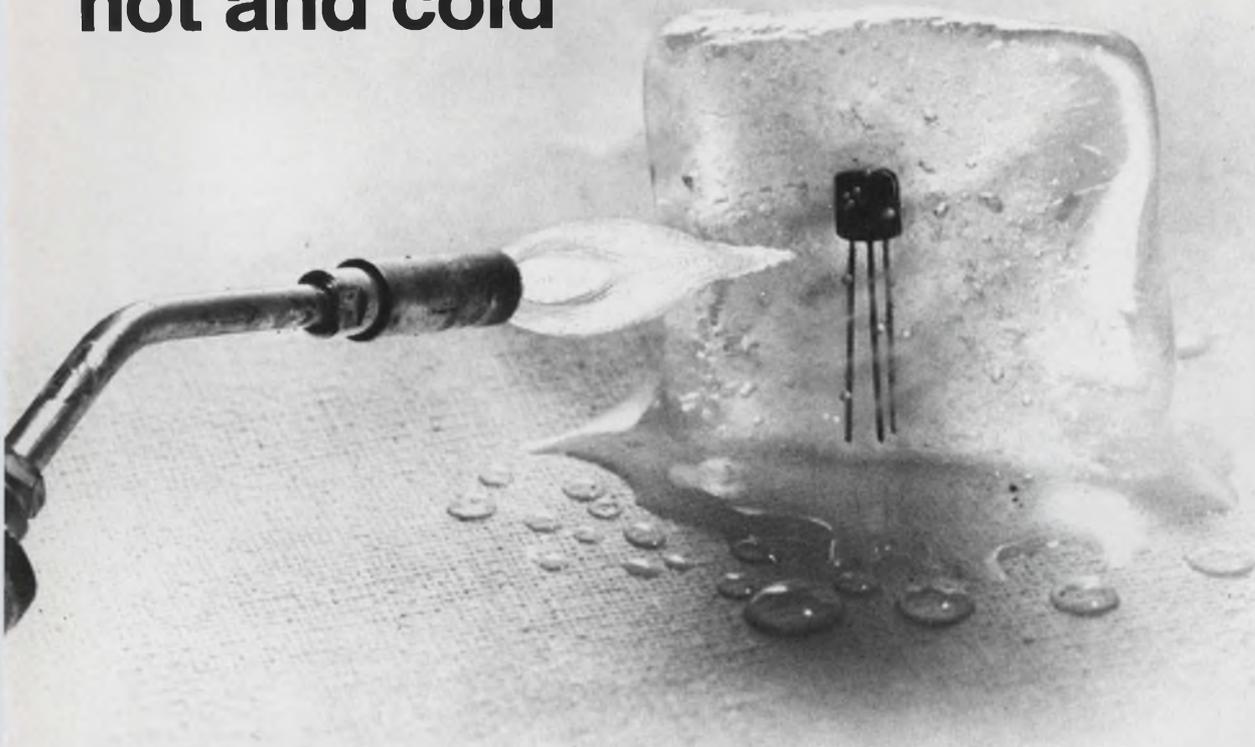
Type No.	Qty.													
2N6000		2N6004		2N6010		2N6014		GET706		GET930		GET2222A		GET3014
2N6001		2N6005		2N6011		2N6015		GET708		GET22221		GET2369		GET3638
2N6002		2N6006		2N6012		2N6016		GET914		GET2221A		GET2484		GET3638A
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B

# General Electric's new epoxy TO-18 transistors run hot and cold

**FREE  
SAMPLES**



✓ **PASSED**  
85C @ 85% R.H.

✓ **PASSED**  
-65 to +150C  
temperature cycling  
MIL TEST

General Electric has just introduced 32 new TO-18 based epoxy transistors. And we know they're good. We've tested them over and over again. Tests like temperature cycling from -65C to +150C. Not just a few times . . . but 300 times. That's 30-times the normal MIL requirement for reliability.

We've subjected these new epoxy transistors to other tests, too, such as 85C at 85% relative humidity for up to 8000 hours just to find out how reliable they really are.

GE's epoxy TO-18 transistors can take the bumps, too. No need to worry about shock or vibration damage. Their solid epoxy encapsulant provides rigid mechanical stability . . . seals trouble out and performance in.

We've got 16 new JEDEC types and many new GET replacement devices that will substitute for common 2N types with no redesign at all. We're adding more new types every month. They're available in NPN's, PNP's, matched pairs and Darlington amps with breakdown ratings up to 60V and dissipation as high as 500 mw.

We've tested these transistors in every way possible. See the results for yourself in our new reliability brochure (Pub. #95.28). We'll send

the brochure along with four free samples for testing in your circuits. Prove to yourself that GE's new epoxy TO-18 transistors meet all your transistor requirements.

To get your four free samples, specification sheets and reliability brochure, fill out the coupon on the opposite page and mail it to your authorized GE Semiconductor distributor shown on the list. We think you'll find that GE's new epoxy TO-18 transistors meet your reliability standards with ease. 221-30

PD mW	Ic mA	NPN				PNP					
		JEDEC Type	h <sub>FE</sub>		Noise (f <sub>g</sub> , dB (max))	JEDEC Type	h <sub>FE</sub>		Noise (f <sub>g</sub> , dB (max))		
			Ic=100 Vce=1V	Ic=300 Vce=2V	Ic=800 Vce=5V		Ic=100 Vce=-1V	Ic=300 Vce=-2V	Ic=800 Vce=-5V		
400†	500	2N6000	50	40		2N6001	90	35		3.0	
400†	500	2N6002	130	80		2N6003	210	50		1.5	
400††	500	2N6004	50	40		2N6005	90	35		3.0	
400††	500	2N6006	130	80		2N6007	210	50		1.5	
500†††	800	2N6010	45	85	45	5.0	2N6011	70	65	45	3.0
500†††	800	2N6012	90	160	50	3.0	2N6013	180	135	70	2.0
500†††	800	2N6014	45	65	15	5.0	2N6015	70	60	35	3.0
500†††	800	2N6016	90	60	15	3.0	2N6017	180	125	55	2.0

† V<sub>CE</sub>=25V; †† V<sub>CE</sub>=40V; ††† V<sub>CE</sub>=60V

GE Type	Replaces	GE Type	Replaces	GE Type	Replaces
GE1706	2N706	GE12221A	2N2221A	GE13013	2N3013
GE1708	2N708	GE12222	2N2222	GE13014	2N3014
GE1914	2N914	GE12222A	2N2222A	GE13638	2N3638
GE1929	2N929	GE12369	2N2369	GE13638A	2N3638A
GE1930	2N930	GE12484	2N2484	GE13646	2N3646
GE12221	2N2221				

# Tempilaq<sup>®</sup> signals rated temperature... in milliseconds!



Now you can simply and reliably monitor temperatures on smooth surfaces such as polished metal, glass or plastics, and in hard-to-reach areas—at the cost of a cent or less per application. More than 100 certified ratings to choose from. Applied by brush or aerosol spray.

Tempilaq<sup>®</sup> dries almost immediately to a dull-opaque coating, which liquefies sharply as soon as its stated rating is reached. On cooling, the melted Tempilaq<sup>®</sup> does not revert to its original appearance, but remains glossy transparent—which makes subsequent interpretation easy. Accuracy of Indication: within 1% of the stated rating of the Tempilaq<sup>®</sup>. Response delay of a thin coating is only a few milliseconds! You'll find it ideal for determining temperatures of polished metal surfaces, electronic tubes, fabrics, rubber, plastics, glass and similar items.

Technical data sheet on request.

#### AVAILABLE IN THE FOLLOWING DEGREES (°F)

100	169	250	331	475	900	1400	1950
103	175	256	338	488	932	1425	2000
106	182	263	344	500	950	1450	2050
109	188	269	350	525	977	1480	2100
113	194	275	363	550	1000	1500	2150
119	200	282	375	575	1022	1550	2200
125	206	288	388	600	1050	1600	2250
131	213	294	400	625	1100	1650	2300
138	219	300	413	650	1150	1700	2350
144	225	306	425	700	1200	1750	2400
150	231	313	438	750	1250	1800	2450
156	238	319	450	800	1300	1850	2500
163	244	325	463	850	1350	1900	

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 INFORMATION RETRIEVAL NUMBER 62

## Application Notes



### Power-supply handbook

Presenting a most thorough treatment of dc power supplies, this new 138-page handbook is a goldmine of information for power-supply users.

It is written in a clear and concise language and is broken up in-

to six main sections: Definitions, Principles of operations, Ac and load connections, Remote programming, Output voltage and current ratings and Performance measurements.

Intended for the user of power supplies rather than the theorist, it discusses both traditional and unusual problems and applications of regulated power supplies.

Examples of questions answered include: "What is meant by auto-tracking?", "How can ground loops in multiple loads be avoided?" and "What is the difference between a constant-voltage/constant-current power supply and a constant-voltage/constant-current limit supply?" Hewlett-Packard

CIRCLE NO. 335

### MOSFET design

A new application note discusses the design of dual-gate MOS field-effect transistors that use a built-in signal-limiting diode structure for an effective short-circuit to static discharge across the gate insulation. Breakdown mechanisms, gate-protection methods, electrical requirements, monolithic MOS devices, current-handling capability, input capacitances and resistances and power gain and noise factor are all illustrated and discussed thoroughly. RCA Solid State Div.

CIRCLE NO. 336

### Microwave measurements

Various techniques for measuring microwave power, diode detectors, thermistors, and thermoelectric devices are discussed and compared in terms of accuracy, dynamic range and stability in a new 12-page application note on microwave measurements. A separate section contains a catalog of microwave instruments such as power meters and monitors, calorimeters and customized power monitoring systems. PRD Electronics, Inc.

CIRCLE NO. 337

### Silicone resins

New developments in silicone resins as molding compounds for semiconductors are discussed in a new technical report entitled "Environmental Protection of Semiconductor Devices." The report is based on a paper presented at the 9th Electrical Insulation Conference by a member of the General Electric Company's Silicone Products Dept. Discussed in the report are the new silicones available and laboratory evaluations of these materials for semiconductor packaging. Suggested methods of encapsulation are also outlined. General Electric Co., Silicone Products Dept.

CIRCLE NO. 338

### VSWR measurements

The simplicity of making broadband VSWR measurement at high accuracies is discussed and illustrated in the first issue of the quarterly "Wiltron Technical Review." It details the use of a resistive bridge that operates from 10 MHz to 4 GHz with the equivalent of less than a 1.02 residual VSWR. Wiltron Co.

CIRCLE NO. 339

# A significant advance in silicon rectifier power handling capacity

3 new series of silicon rectifiers from Tung-Sol permit designers to meet extremely high power requirements.

- Reverse voltage ratings to 5000 Volts
- Average forward current to 500 Amperes
- Surge overload ratings up to 8500 Amperes

Controlled avalanche characteristics provide transient handling capability that results in increased reliability.

All units feature ceramic-to-metal seals, mount in any position and are supplied in either polarity.

## 1511 SERIES

Max. av. forward current at 120° C—420 Amperes

Surge overload rating, 1 cycle—6000 Amperes

Controlled Avalanche Voltage—1250-3500 Volts

## 1621 SERIES

Max. av. forward current at 135° C—500 Amperes

Surge overload rating, 1 cycle—8500 Amperes

Controlled Avalanche Voltage—1100-2300 Volts

## 1611 SERIES

Max. av. forward current at 135° C—470 Amperes

Surge overload rating, 1 cycle—5200 Amperes

Controlled Avalanche Voltage—2600-5000 Volts



Write for technical data bulletins—

Tung-Sol Division, Wagner Electric Corporation  
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## TUNG-SOL High Power Silicon Rectifiers

Trademark TUNG-SOL Reg. U. S. Pat. Off. and Marcas Registradas

INFORMATION RETRIEVAL NUMBER 63

# New Literature

## Displays and lamps

Three catalogs describe lines of neon indicators, incandescent read-out modules and indicating lamps and assemblies. Alco Electronic Products, Inc.

CIRCLE NO. 343

## Photo-electric devices

A range of photo-electric controls, counting equipment, projectors, receivers and relays are described in a 54-page booklet. Applications are also given. Hird-Brown, Ltd.

CIRCLE NO. 344

## Film capacitors

Twenty-eight pages of a new catalog illustrate and describe 23 types of precision film capacitors, which include polystyrene and hermetically sealed mylar and mica types. Arco Electronics.

CIRCLE NO. 345

## Magnetic components

Pulse transformers, delay lines, SCR-trigger transformers and inverter transformers are included in this catalog. Pulse Engineering, Inc.

CIRCLE NO. 346

## Hewlett-Packard Journal

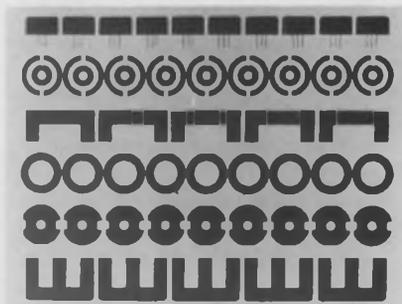
The September 1970 Hewlett-Packard Journal deals with a programmable data coupler, time-shared computers and Q measurements. Hewlett-Packard.

CIRCLE NO. 347

## Fans and blowers

A complete line of stock fans and blowers is described in a new 18-page catalog. Dimensional drawings and performance charts are also included. Howard Industries, Div. of MSL Industries, Inc.

CIRCLE NO. 348



## Ferrite materials

A comprehensive 170-page catalog, divided into eight easily accessible sections, lists toroidal and pot cores for linear and saturating magnetic devices, special-purpose machined ferrites, H cores, ferrite shielding beads and chokes, and E, U and I cores for linear and saturating devices. Ferroxcube Corp.

CIRCLE NO. 349

## Acoustic coupler

A new 4th-generation acoustic coupler is described in a literature package. The coupler is compatible with conversational terminals operating in excess of 450 baud. Omnitec Corp.

CIRCLE NO. 350

## Components

A new general component catalog contains a line of IC accessories, logic cards and thermoelectric devices. Cambridge Thermionic Corp.

CIRCLE NO. 351

## MOSFETs and static

A technical article dealing with the phenomenon of static electricity and its role in damaging sensitive electronic devices such as MOSFETs is available. A method of offsetting static electricity so that problems to sensitive electronic devices are eliminated and is outlined in detail in the article. Custom Materials, Inc.

CIRCLE NO. 352

## Fans and blowers

A quick-reference catalog contains a selection of fans and blowers. Included are propeller, squirrel-cage, axial, high-pressure/vacuum and spiral types. Rotron, Inc.

CIRCLE NO. 353

## Delay lines

Custom-built, standard fixed and variable and laboratory-type delay lines are covered in a 12-page catalog. Also included are custom-built LC filters, Allen Avionics, Inc.

CIRCLE NO. 354

## Rectangular connectors

A line of miniature rectangular and hexagonal plug and socket connectors is in a new catalog. Included are contact sizes ranging from 4 to 40. Continental Connectors Corp.

CIRCLE NO. 355

## Components

A fully indexed 110-page components catalog contains listings of connectors, metal film resistors, terminals, filters, relays, trimmers and lamps. Powell Electronics, Inc.

CIRCLE NO. 356

## Photomultiplier tubes

A new series of photomultiplier tubes and their accessories are detailed in a catalog. Gencom Div. of Varian/EMI.

CIRCLE NO. 357

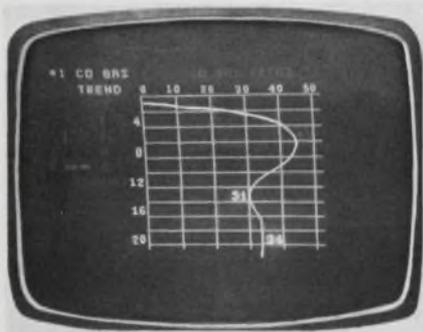
## Ceramic chip capacitors

A bulletin contains complete specifications of type NPO and K 1200 monolithic ceramic chip and feed-through capacitors, and capacitor kits. Monolithic Dielectrics, Inc.

CIRCLE NO. 358

# Bulletin board

of product news  
and developments



Hitachi, Ltd. has improved its previously announced **process monitoring system**, which displayed computer-controlled process data on a color-TV screen in numerals and letters, to now include a trend-graph display. Process information is transformed into a visibly progressive movement on the TV screen giving a trend-graph presentation in several colors.

CIRCLE NO. 359

A 1024-bit MOS read-write random-access memory costing 1¢ per bit (quantities of 15,000 or more) and having full on-chip decoding is now being stocked on distributor shelves according to Intel Corp., Mountain View, Calif. Its speeds are a 300-ns access time and a 600-ns cycle time.

CIRCLE NO. 360

**Type IN4004 silicon rectifier is now available for only 5¢**, when purchased in quantities of 25,000 each or more, according to General Instrument Corp.

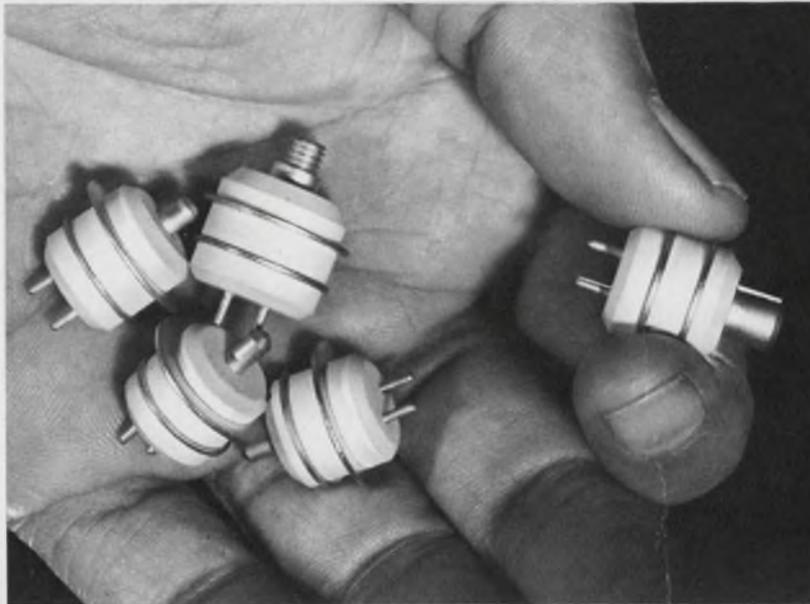
CIRCLE NO. 361

**Price reductions of up to 54%** have been announced by Fairchild Semiconductor on its line of uA700 linear ICs.

CIRCLE NO. 362

In January, 1970, Intersil Memory Corp., Cupertino, Calif., expects to announce a **1024-bit n-channel silicon-gate random-access read/write memory with full on-chip decoding at 1¢/bit** in volume quantities. Speeds are 100-ns access time and 200-ns full cycle time.

CIRCLE NO. 363



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# Design Data from Manufacturers

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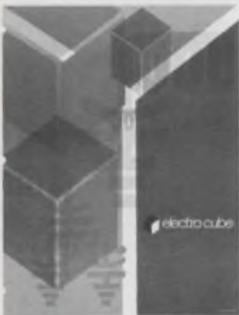
This 8-page catalog provides design data on the complete group of DZUS 1/4-turn self-locking fasteners for standard, high speed and panel applications, as well as universal high strength multiple thread fasteners for high tensile and shear stresses. Dzus stud assemblies, wire forms and receptacles offer an exceptional, wide variety of combinations from stock to fit specific fastening requirements. Diagrams and tables give full details for rapid, unlimited design selection. Condensed or complete Catalog available on request.

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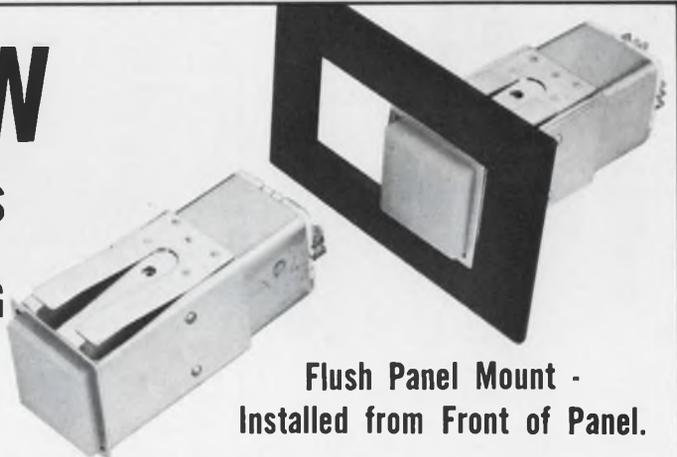


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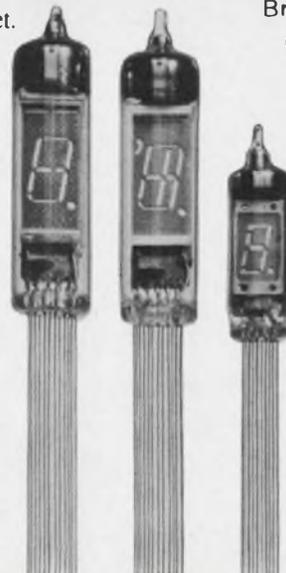
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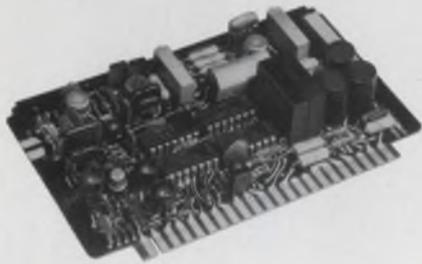


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DG 10A

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# Product Index

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Category	Page	IRN	Category	Page	IRN
<b>Components</b>			<b>Packaging &amp; Materials</b>		
capacitors, variable	110	280	epoxy, two-component	119	317
fan, motor	112	287	marker	120	318
lamp, T-1	110	281	masking, solder	119	314
modules, timing	110	283	socket, 14-pin DIP	119	315
relays, solid-state	110	279	sockets, test	120	320
resistors, high-voltage	112	286	terminations, cable	119	316
resistors, thin-film	112	285	tubing, rfi/emi	120	319
sensor, heat	112	289			
switch, transfer	110	284	<b>Tools &amp; Engineering Aids</b>		
switches, proximity	112	288	caliper, dual	117	309
thermistors, thin-film	109	277	gauge, wire	118	310
trimmer, cermet	109	278	kit, soldering	118	312
tube, CCTV	112	290	pliers, cutting	118	313
tube, storage	110	282	stripper, wire	117	307
			tool kit	118	311
<b>Data Processing</b>			tools, miniature	117	308
calculator, 12-digit	116	305	torch, tiny	117	306
calculator, 16-digit	115	297			
data logger	115	300			
generator, pattern	115	301	<b>New Literature</b>		
memory system, core	116	303	capacitors, chip	126	358
modems, low-speed data	115	298	capacitors, film	126	345
phase jitterer	116	302	components	126	351
test set, data	116	304	components	126	356
			components, magnetic	126	346
<b>ICs and Semiconductors</b>			connectors	126	355
converter, MECL	106	270	coupler, acoustic	126	350
gates, TTL NOR	108	273	delay lines	126	354
ICs, monolithic	108	275	displays and lamps	126	343
memory, programmable	106	268	fans and blowers	126	348
memory, read-only	106	266	fans and blowers	126	353
memory, read/write	106	269	ferrites	126	349
MSIs, dual-in-line	108	274	photo-electric devices	126	344
shift register, MOS	108	276	photomultipliers	126	357
transistor, power	108	272			
transistors, power	106	267			
transistors, power	108	271			
			<b>Application Notes</b>		
<b>Instrumentations</b>			handbook, power-supply	124	335
generator, fm	112	292	microwave measure-		
generator, single-pulse	114	294	ments	124	337
power supplies, 100-A	114	296	MOSFET design	124	336
recorder, pressure	112	291	resins, silicone	124	338
recorder, X-Y	114	293	VSWR measurements	124	339
tester, IC	114	295			
			<b>Design Aids</b>		
<b>Microwaves &amp; Lasers</b>			calculator, decimal	122	321
array, photodiode	101	250	templates, drafting	122	322
attenuators, step	102	252			
detector, IR	102	251	<b>Evaluation Samples</b>		
displays, solid-state	102	253	beads, ferrite	121	342
oscillators, microwave	102	257	connector, 12-pin	121	340
phototransistor	102	255	cords, patch	121	341
preamplifiers, thin-film	102	254			
switch, light-activated	102	256			
<b>Modules &amp; Subassemblies</b>					
amplifier, power	105	264			
amplifier, thick-film	104	258			
amplifier, thick-film	104	262			
decoder/drivers	104	263			
displays, numeric	105	265			
op amp, hybrid	104	260			
oscillators, crystal	104	261			
readout, plug-in	104	259			

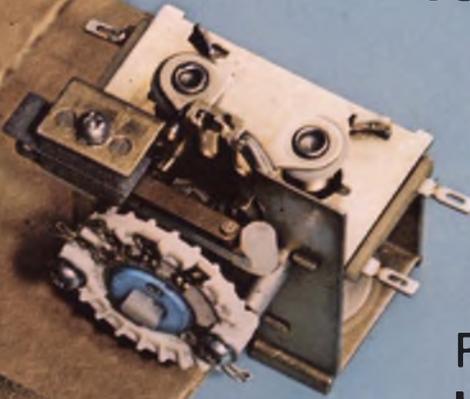
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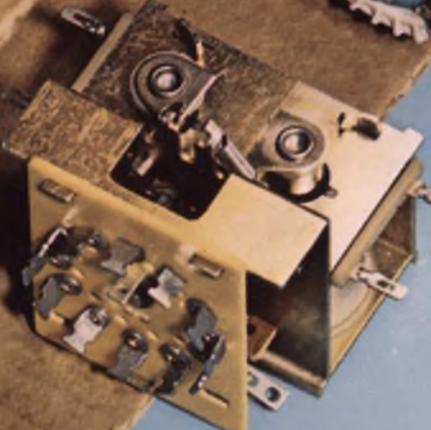
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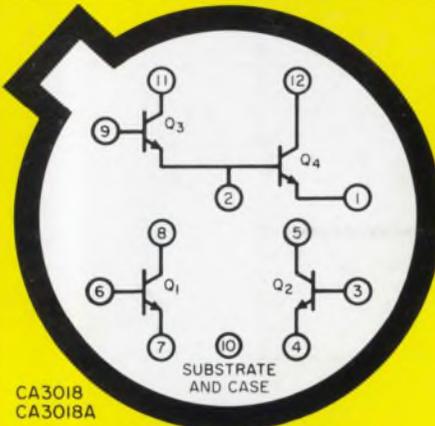
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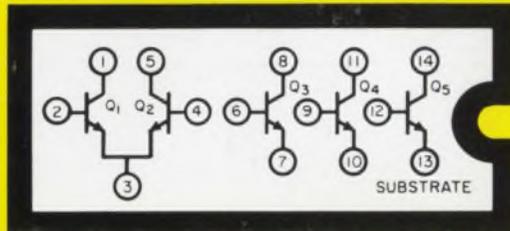
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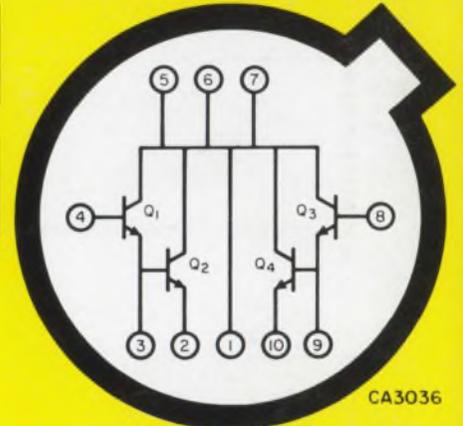


CA3018  
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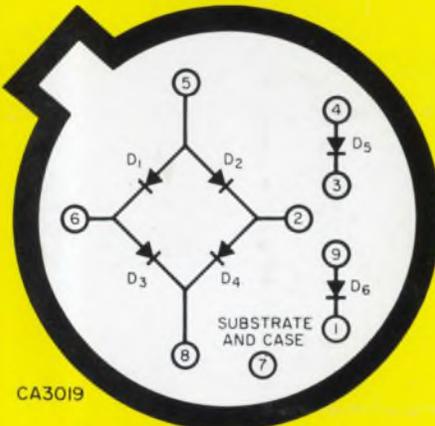


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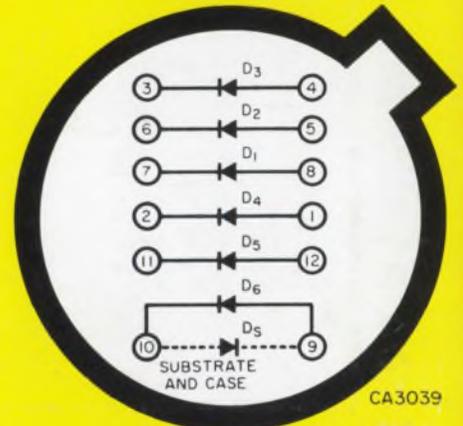


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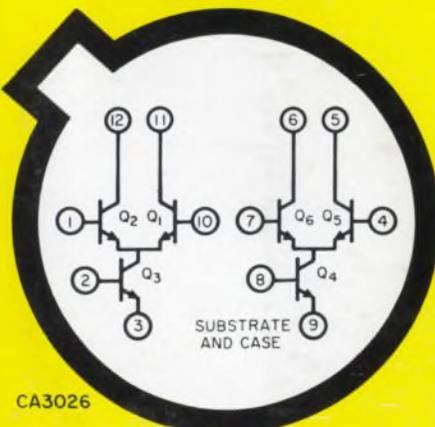


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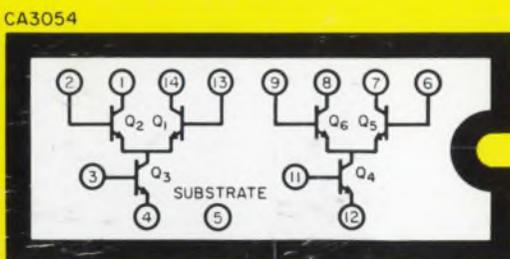
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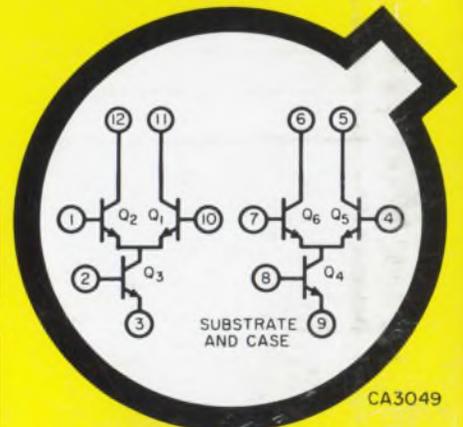
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