# Electronics

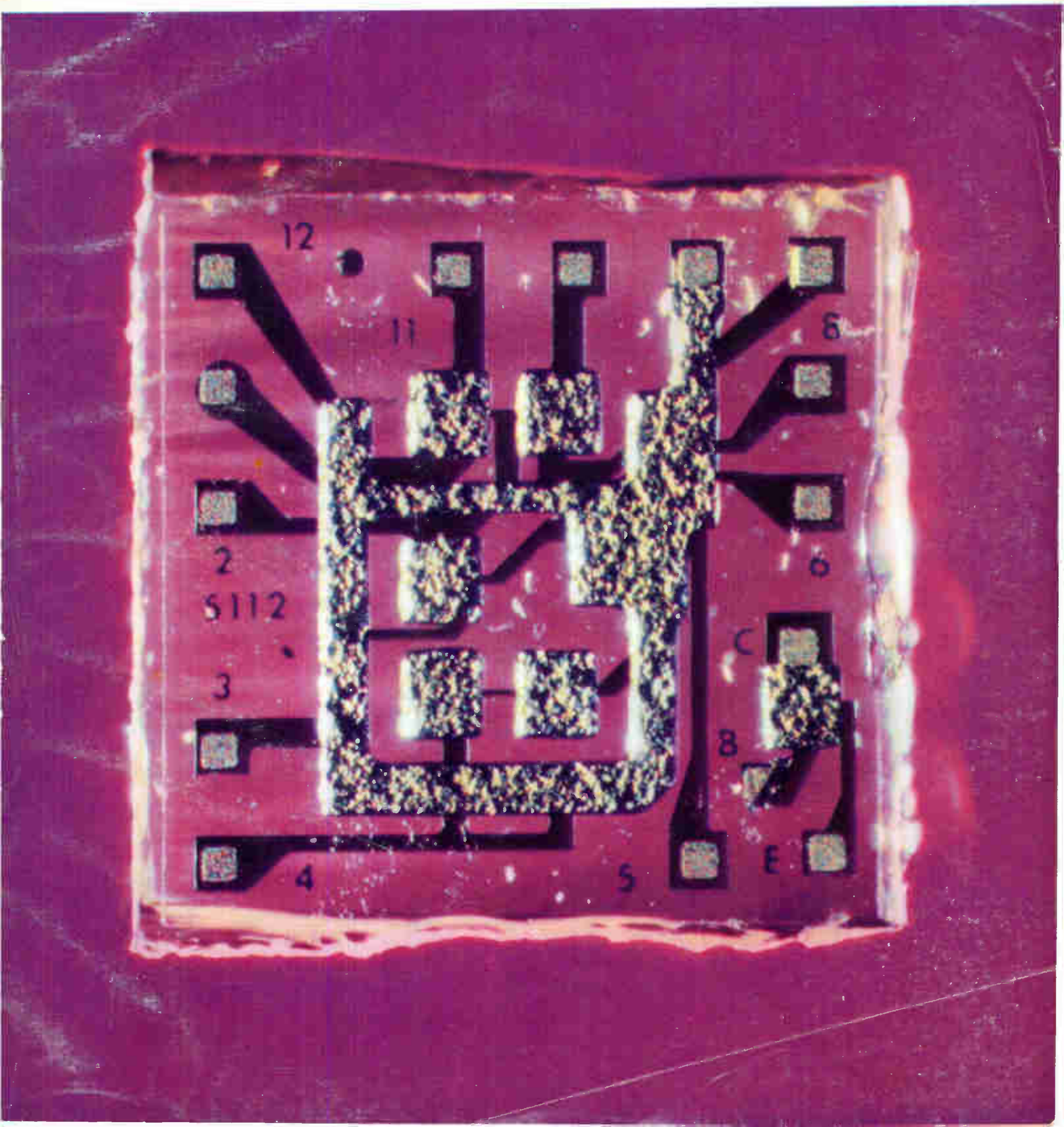
Detecting signals digitally: page 82

Integrated techniques for microwave: page 112

Computers that fit on space projects: page 127

March 20, 1967
$1.00
A McGraw-Hill Publication

Below: Glass isolates integrated circuits, page 91



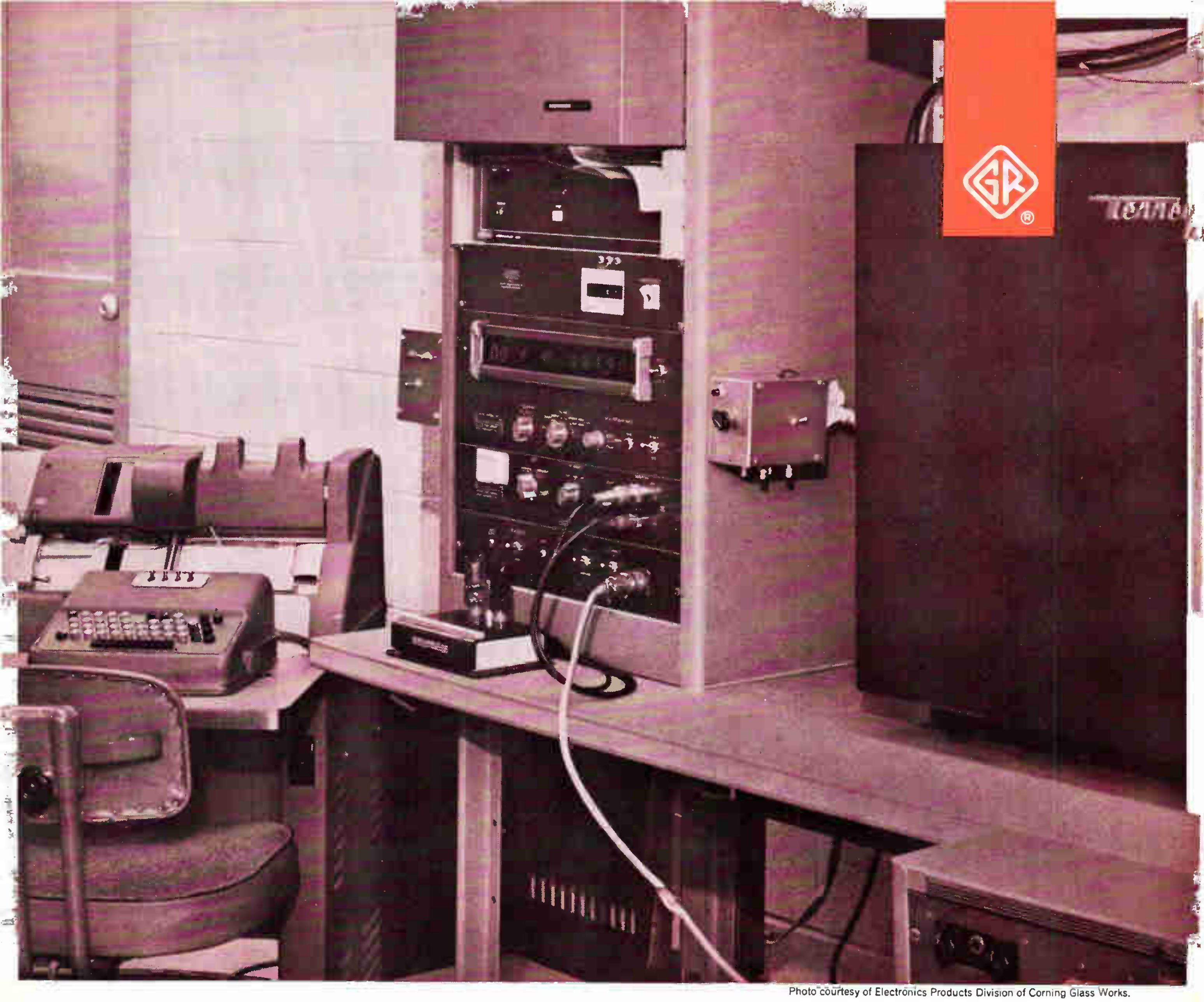
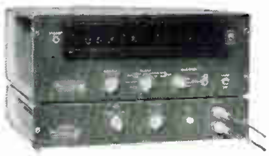


Photo courtesy of Electronics Products Division of Corning Glass Works.

# Customer Report:

## 1680-A Eliminates Human Error



Type 1680-A Automatic Capacitance Bridge Assembly, $4975 in U.S.A.

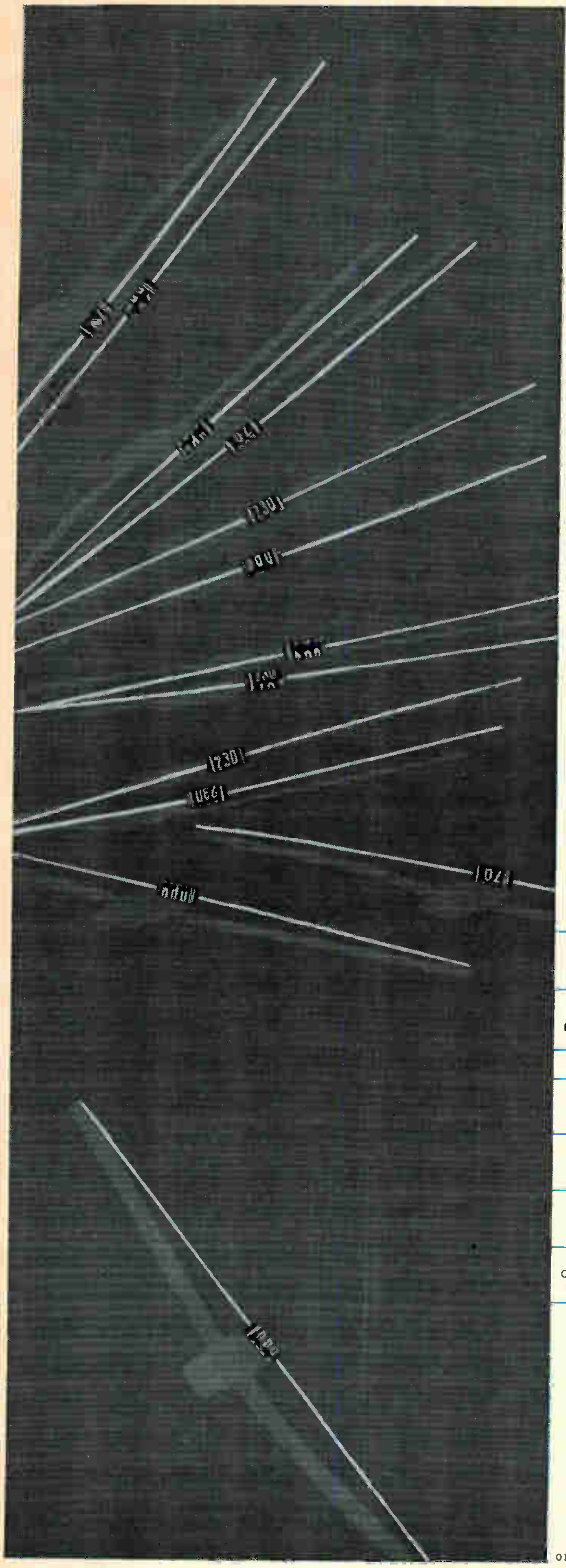
Corning Glass Works' Electronics Products Division uses a GR automatic capacitance-measuring and recording system in its Quality Control Laboratory to log data of capacitors under test in an environmental chamber. The brains of the system is a GR 1680-A Automatic Capacitance Bridge Assembly, which is used with an automatic component indexer and an IBM 526 Card Punch. Each capacitor is placed across the bridge's input terminals by the indexer; almost instantly the measured values are automatically punched on an IBM card. Human error is thus eliminated, and data acquisition is made rapidly, accurately, efficiently, and in a form suitable for computer processing.

The 1680-A automatically selects C and D (or G) ranges, balances, and displays measurements in digital form, showing decimal point and units of measurement. Measurement takes only 0.5 second at 1 kHz under worst conditions. Basic accuracy is 0.1% of reading for C and G, 1% of reading $\pm 0.001$ for D. Measurement range is 0.01 pF to 1000 $\mu$F.

For complete information, write General Radio Company, 22 Baker Avenue, W. Concord, Massachusetts 01781; telephone: (617) 369-4400; TWX: 710 347-1051.

**GENERAL RADIO**

Circle 900 on reader service card



# OPTIMUM IN ULTRA-FAST SWITCHING...

Low leakage, high conductance

Majority carrier conduction

High pulse power

Low forward voltage

## ...from HPA

Specify and get Hot Carrier Diodes from HPA —the 2300 Series. Low noise, wide dynamic range, extremely fast turn on, turn off times. Hermetically sealed in a miniature glass package, temperature range —60° C to +125° C. Meets MIL-S-19500C specification. Ideally suited for mixer, detector, limiter and sampling applications requiring the ultimate in a high-speed component.

Check the table below, then call your local Hewlett-Packard field engineer or write direct for complete data, including application information, HP Associates, 620 Page Mill Road, Palo Alto, California 94304.

### Specifications

| Device | Forward Voltage @ | Forward Current | Forward Voltage @ | Forward Current | Breakdown Voltage | Leakage Current | Capacitance | Effective Minority Carrier Lifetime* |
|---|---|---|---|---|---|---|---|---|
| | $V_{F1}$ | $I_{F1}$ | $V_{F2}$ | $I_{F2}$ | $V_{BR}$ | $I_R$ | $C_0$ | $\tau$ |
| 2301 min. max. | 1.0 V | 50 mA | 0.4 V | 1.0 mA | 30 V | 300 nA | 1.0 pF | 100 ps |
| 2302 min. max. | 1.0 V | 35 mA | 0.4 V | 1.0 mA | 30 V | 300 nA | 1.0 pF | 100 ps |
| 2303 min. max. | 1.0 V | 35 mA | 0.4 V | 1.0 mA | 20 V | 500 nA | 1.2 pF | 100 ps |
| Test Conditions | — | — | — | — | $I_R=10\mu A$ | $V_R$ = 15 V | $V_R$=0 V f=1.0 MHz | — |

01703

HEWLETT PACKARD

HP ASSOCIATES

# Look at signal generator stability 50 KHz-455 MHz, any frequency in the range.

## Now make it 250 times more stable.

Using the HP 8708A Synchronizer with the improved 606B and 608F Signal Generators gives you a frequency stability of 2 x 10’ per ten minutes over the universally important range of 50 KHz to 455 MHz. This is a 250 times improvement over previous signal generator performance. And that's at any frequency you choose, not just at discrete points.

The equipment is easy to use because lock is automatically re-established after changing frequencies. The stabilized rf signal has high spectral purity. In addition you can frequency and phase modulate with excellent linearity.

The improved 606B and 608F are MOPA-type signal generators that can be synchronized with the 8708A while retaining their own full performance flexibility. This means you can amplitude or pulse modulate the instruments and utilize the full output level range while stabilized. The generators provide constant output level with frequency change and low modulation distortion (<3% at 70% AM).

PRICE: *8708A Synchronizer, $1800*
*606B Signal Generator (50 KHz-65 MHz), $1550*
*608F Signal Generator (10 MHz-455 MHz), $1600*

For full information, including Application Note 71—"Advances in RF Measurement, Using Modern Signal Generators"—call your local HP field engineer or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

04701

Circle 2 on reader service card

# Electronics

March 20, 1967
Volume 40, Number 6

## News Features

### Probing the News



### Electronics Review



### Electronics Abroad



### Departments



Title R registered U.S. Patent Office; © copyright 1967 by McGraw-Hill, Inc. All rights reserved, including the right to reproduce the contents of this publication, in whole or in part.

## Technical Articles

### I. Design



### II. Application

# Electronics

**Editor-in-Chief: Lewis H. Young**

**Associate managing editors**
**Design:** Samuel Weber
**Application:** George Sideris
**News:** Robert Henkel
**Copy:** Sally Powell

**Senior editor**
**Special projects:** Donald Christiansen

**Senior associate editors**
John F. Mason, Joseph Mittleman, Stephen E. Scrupski

**Department editors**
**Advanced technology:** Stephen E. Scrupski
**Avionics:** W.J. Evanzia
**Communications:** Leonard Weller
**Computers:** Wallace B. Riley
**Design theory:** Joseph Mittleman
**Industrial electronics:** Alfred Rosenblatt
**Instrumentation:** Carl Moskowitz
**Military electronics:** John Mason
**New products:** William P. O'Brien
**Staff writers:** Paul Dickson, Jan Rahm

**Section editors**
**Electronics abroad:** Arthur Erikson
**Electronics review:** Stanley Zarowin
**Probing the news:** Eric Aiken

**Regional bureaus**

**Domestic**
**Boston:** Thomas Maguire, manager; Robin Carlson
**Los Angeles:** Lawrence Curran, manager; June Ranill
**San Francisco:** Walter Barney, manager; Mary Jo Jadin
**Washington:** William D. Hickman, Patricia C. Hoehling, correspondents

**Foreign**
**Bonn:** John Gosch
**London:** Michael Payne
**Tokyo:** Charles Cohen

**Copy editors**
Albert Tannenbaum, James Chang, Frederick Corey

**Graphic design**
**Art director:** Saul Sussman
**Assistant art directors:** Ann Mella, Valerie Betz
**Production editor:** Arthur C. Miller

**Editorial secretaries:** Marlene Angrist, Claire Benell, Lynn Emery, Lorraine Fabry, Kay Fontana, Patricia Gardner, Lorraine Longo

**McGraw-Hill News Service**
**Director:** John Wilhelm; **Atlanta:** Fran Ridgway; **Chicago:** James Rubenstein;
**Cleveland:** Arthur Zimmerman; **Dallas:** Marvin Reid;
**Detroit:** N. Hunter; **Houston:** Robert E. Lee; **Los Angeles:** Michael Murphy, Gerald Parkinson
**Pittsburgh:** Louis Gomolak
**San Francisco:** Margaret Drossel
**Seattle:** Ray Bloomberg; **Washington:** Arthur L. Moore, Charles Gardner, Herbert W. Cheshire, Seth Payne, Warren Burkett

**McGraw-Hill World News Service**
**Bonn:** John Johnsrud; **London:** John Shinn;
**Mexico City:** Bruce Cross; **Milan:** Ronald Taggiasco;
**Moscow:** Howard Rausch; **Paris:** Peter Kilborn;
**Rio de Janeiro:** Wes Perry; **Tokyo:** Marvin Petal

**Reprints:** Susan Nugent

**Publisher: Gordon Jones**

**Electronics: March 20, 1967, Vol. 40, No. 6**

Published every other Monday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1958.

Printed at 99 North Broadway, Albany, N.Y. 12207; second class postage paid at Albany, N.Y.

Executive, editorial, circulation and advertising addresses: McGraw-Hill Building, 330 W. 42nd Street, New York, N.Y. 10036. Telephone (212) 971-3333. Teletype TWX N.Y. 212-640-4646. Cable address: MCGRAWHILL N.Y.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription prices: United States and possessions and Canada, $8.00 one year, $12.00 two years, $16.00 three years; all other countries, $25.00 one year. Single copies: United States and possessions and Canada, $1.00; all other countries, $1.75.

Officers of McGraw-Hill Publications: Joseph H. Allen, President; Bayard E. Sawyer, Executive Vice President; Vice Presidents: J. Elton Tuohig, Operations; John R. Callaham, Editorial; Donald C. McGraw, Jr., Marketing; John M. Holden, Marketing Services; Huber M. Gemmill, Circulation; Angelo R. Venezian, Production; Robert M. Wilhelmy, Controller.

Officers of the Corporation: Donald C. McGraw, Chairman of the Board; Shelton Fisher, President; L. Keith Goodrich, Hugh J. Kelly and Robert E. Slaughter, Executive Vice Presidents; John J. Cooke, Vice President and Secretary; John L. McGraw, Treasurer.



Title ® registered in U.S. Patent Office; © Copyright 1967 by McGraw-Hill, Inc. All rights reserved. The contents of this publication may not be reproduced either in whole or in part without the consent of copyright owner.



**Subscribers: The publisher, upon written request to our New York office from any subscriber, agrees to refund that part of the subscription price applying to copies not yet mailed. Please send change of address notices or complaints to Fulfillment Manager; subscription orders to Circulation Manager, Electronics at address below. Change of address notices should provide old as well as new address, including postal zip code number. If possible, attach address label from recent issue. Allow one month for change to become effective.**

**Postmaster: Please send form 3579 to Fulfillment Manager, Electronics, P.O. Box 430, Hightstown, New Jersey** 08520


## Readers Comment

### Antenna test

To the Editor:

In the "Washington Newsletter" [Feb. 6, p. 48], it is erroneously stated that an antenna provided by Dorne and Margolin "proved erratic in December tests with the ATS-1" communications satellite.

Personnel of the Federal Aviation Agency who conducted the tests have reported that the antenna operation was completely satisfactory and have authorized us to quote them to this effect. Analysis of data recorded during the initial tests and on flights made in the succeeding several days shows that signal levels at the FAA's airborne receiver were fully up to expectations.

There were some periods of poor communication during the test program. None of these were caused by the antenna. The major cause was interference from, at that time, unidentified ground stations operating at both the satellite and aircraft receive frequencies.

I would also like to note that United Airlines is currently performing ground tests with our antenna at their San Francisco facility. Results have been very good and United will have the antenna installed on a DC-8 for flight tests within the next few weeks. Pan American World Airways has also run successful ground tests with our antenna at Miami.

Joseph Margolin
Vice president
Dorne and Margolin, Inc.
Bohemia, N.Y.

▪ FAA officials hedge by saying "It is a matter of when and how you read the data points."

### Drawing the line

To the Editor:

"Credibility gap" [Mar. 6, p. 23] is a nice way to say someone is playing loose with the truth.

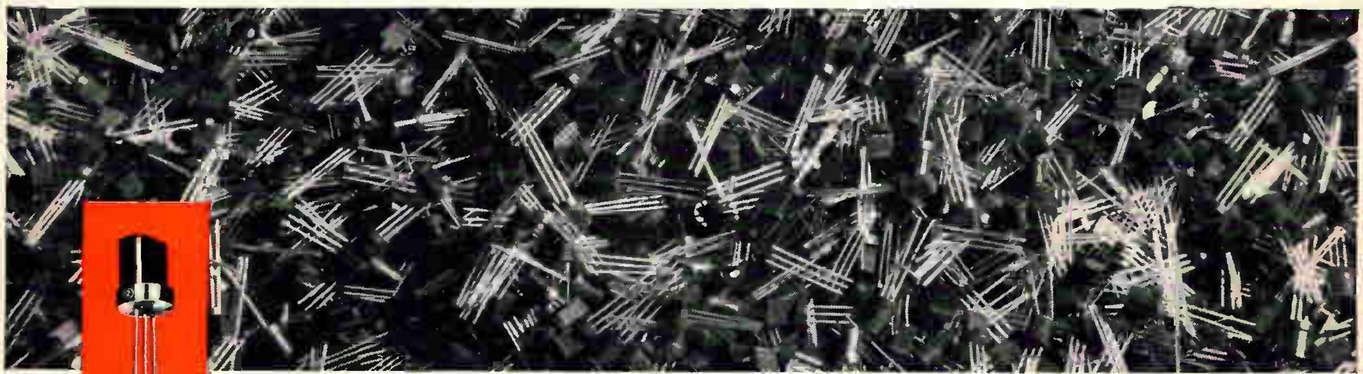
I could fill your magazine with stories of double crosses, age discriminations, misuse, abuse, humiliation, and waste of engineers that come into my office looking for jobs.

I hired a 43-year old man whose

**Now from Sprague!**

# ECONOLINE* SILICON PLANAR PLASTIC TRANSISTORS

## can save you 30 to 40% over metal-encased types



## 56 POPULAR N-P-N TYPES IN VOLUME PRODUCTION FOR OFF-THE-SHELF DELIVERY

- Small-signal amplifiers
- Medium-speed switches
- Large-signal amplifiers
- High-frequency amplifiers
- Oscillators
- High-voltage indicator drivers

*trademark

Sprague Econoline transistors. Quality planar devices in plastic packages. You save the cost of metal cans. And with dual source back-up, too. For further information and prices call your local Sprague office today.


**For comprehensive specifications write for catalog CN200A to:**

**Technical Literature Service**
**Sprague Electric Company**
**35 Marshall Street**
**North Adams, Mass. 01247**

SPRAGUE COMPONENTS

TRANSISTORS
INTEGRATED CIRCUITS
THIN-FILM MICROCIRCUITS
CAPACITORS
RESISTORS
PULSE TRANSFORMERS
INTERFERENCE FILTERS
PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS
CERAMIC-BASE PRINTED NETWORKS
PACKAGED COMPONENT ASSEMBLIES
BOBBIN and TAPE WOUND MAGNETIC CORES
SILICON RECTIFIER GATE CONTROLS
FUNCTIONAL DIGITAL CIRCUITS

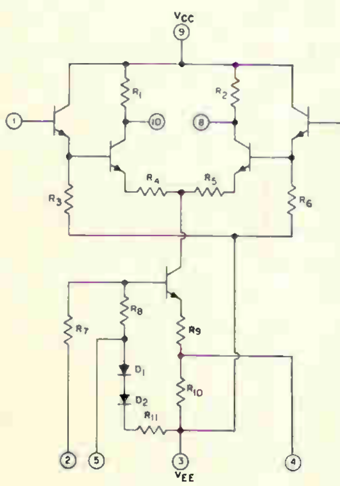
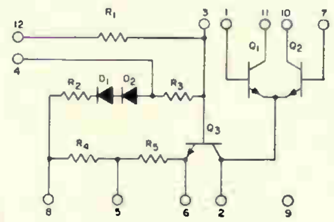
SPRAGUE®
THE MARK OF RELIABILITY

'Sprague' and '②' are registered trademarks of the Sprague Electric Co.

4SS-7104

RCA integrated circuits

# From RCA Versatility plus Economy...

| FROM DC | TO RF |
|---|---|
|  |  |





## CA3000

- 37 dB Voltage gain (typ)
- 98 dB Common-mode rejection ratio (typ)
- 90 dB AGC range (typ)
- Push-pull input and output
- Temperature range stable operation from −55° to +125°C
- 10-lead TO-5 package

## CA3005

- 0-100 MHz operation
- 20 dB (typ) Cascode power gain @ 100 MHz
- 16 dB (typ) Differential power gain at 100 MHz
- 101 dB (typ) Common-mode rejection ratio @ 1 KHz
- −60 dB (min) AGC Range @ 1.75 MHz
- 12-lead TO-5 package

## ECONOMY $2.95 (1,000+)

### VERSATILITY

Schmitt Trigger
RC-coupled Feedback Ampl
Mixer
Comparator
Modulator
Xtal Osc
Sense Amplifier

## AVAILABILITY

FROM STOCK

## ECONOMY $1.75 (1,000+)

### VERSATILITY

| | |
|---|---|
| Wideband Ampl | Mixer |
| Narrowband Ampl | Limiter |
| AGC | Modulator |
| Detector | Cascode Ampl |
| RF Ampl | *and* |
| IF Ampl | Uncommitted collectors |
| Video Ampl | for broad |
| | design flexibility |

## AVAILABILITY

FROM STOCK

Ask your RCA Representative about CA3000 and CA3005. Or check your RCA Distributor for his price and delivery schedules. For technical literature, write RCA Commercial Engineering, Section ICN3-3 RCA Electronic Components and Devices, Harrison, N.J. 07029.

SEE YOUR RCA DISTRIBUTOR FOR HIS PRICE AND DELIVERY

RCA ELECTRONIC COMPONENTS AND DEVICES

RCA The Most Trusted Name in Electronics creativity is amazing and whose competence is respected by everyone in the company. But he went four months unemployed because he's over 40, has white hair, and looks his age. I got him for $3,000 less than his previous salary and he was delighted. This in a time of so-called shortage.

Thank God the working engineers are no longer being fooled: Maybe if engineers stop putting up with the nonsense and the credibility gap and start drawing a line, this situation will change.

Young engineers have left recently for promises that were out of this world and then were looking for jobs within three to six months. Some even come back with their tails between their legs. Not that we're so great, but the other guys were not telling the truth.

There are only two bright spots: the magazines are speaking up and the engineers are changing.

Name withheld

### Delayed mail

To the Editor:

I have just received my copy of the Dec. 12 issue of Electronics containing my contribution to the Designer's casebook: "Bipolar pulse generator tests fast flip-flops" [p. 109].

Unfortunately, the article as it appears contains some small errors that should be noted.

1) The last sentence of the second paragraph should read: "When $L_1$ is increased, the frequency goes down." (Not up!)

2) As the pulses at terminals 2 and 3 are both positive-going (from 0 to +1.8 v) and are only shifted in time to form set-reset signals, the title should read "double pulse generator . . ." (not bipolar).

Therefore the last sentence in the next-to-last paragraph should read: "A positive set pulse can be taken from terminal 2, and a positive reset pulse can be taken from terminal 3."

Also the second sentence of the text accompanying the diagram should read: "Positive going set and reset pulses with the magnitude of 1.8 volts. . . ."

Otakar A. Horna

Prague
Czechoslovakia

▪ Slow mail service from Czechoslovakia delayed the arrival of author Horna's corrections.

### Credit is due

To the Editor:

In an article on the history of various IC logic families [March 6, p. 149] Electronics gives credit to the originators in all cases but one. That one is current mode logic. Since Electronics is evidently not aware of it. I can tell you that Motorola was the first to introduce CML IC's under the tradename of MECL about five years ago. We also have patents on those devices . . .

Allen Snyder
Advertising manager
Motorola Semiconductor
Products Inc.
Phoenix, Ariz.

▪ Although Electronics was aware that Motorola had indeed developed current mode logic first, it inadvertently did not credit Motorola with this discovery in the discussion of current mode logic in the article.

**SUBSCRIPTION SERVICE**

Please include an Electronics Magazine address label to insure prompt service whenever you write us about your subscription.

Mail to: Fulfillment Manager
Electronics
P.O. Box 430
Hightstown, N.J. 08520

To subscribe mail this form with your payment and check ☐ new subscription ☐ renew my present subscription

Subscription rates: in the U.S.: 1 year $8; two years, $12; three years, $16. Subscription rates for foreign countries available on request

**CHANGE OF ADDRESS**

ATTACH LABEL HERE

If you are moving, please let us know five weeks before changing your address. Place magazine address label here, print your new address below.

name

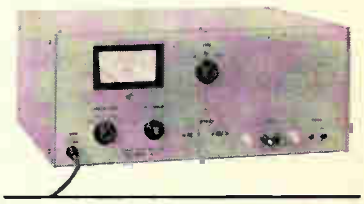
address

city state zip code

# What is this?

This display is the output of a typical regulated power supply when pulse loaded with the new PM Test Set. This waveform gives you a precise measurement of transient response and DC output impedance... plus a direct indication of proper regulation and loop stability.

# What is this?



The new Pacific Measurements Model 1003 Power Supply Test Set that contains an electronic load capable of pulse loading a power supply up to 20A and 70V. The PM 1003 operates in both the pulse and DC mode. Regulated load current is continuously adjustable and is monitored by a front panel meter. A guarded input differential amplifier allows measurement of microvolt ripple with an ordinary oscilloscope.

If you make, use, or sell regulated power supplies, you need this new PM Test Set.

**Let us prove it — write or call**

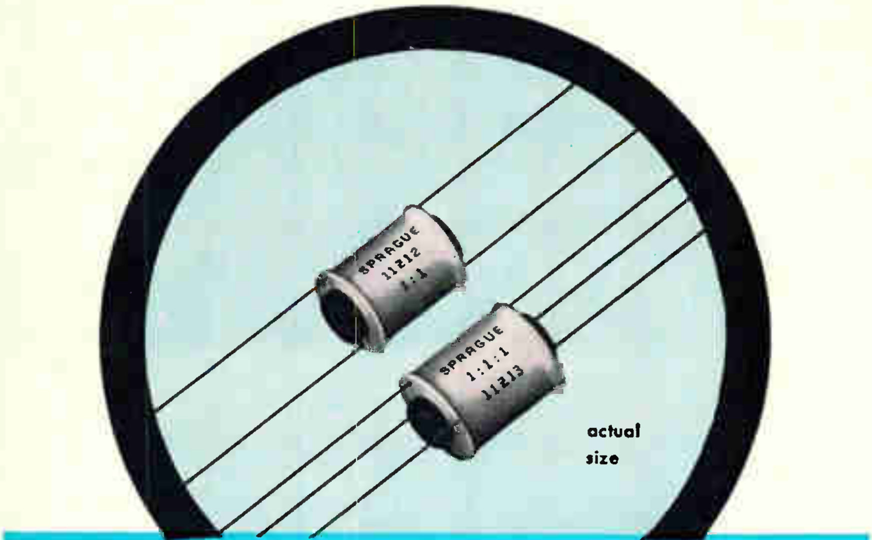
PM **PACIFIC MEASUREMENTS INCORPORATED**

940 INDUSTRIAL AVENUE,
PALO ALTO, CALIFORNIA
(415) 328-0300

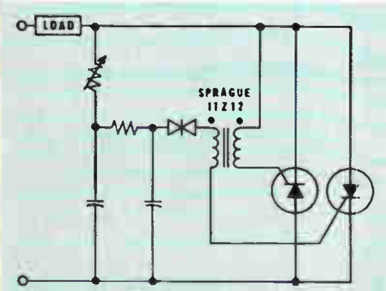


Circle 7 on reader service card

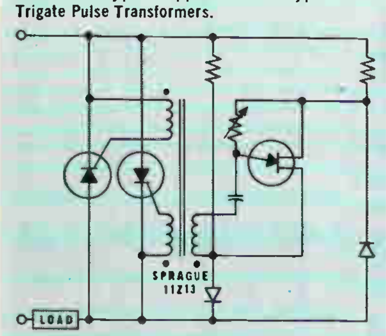
# New from Sprague!




## TRIGATE* PULSE TRANSFORMERS...
## the industry's lowest-cost SCR triggers!




This breakdown-diode/transformer triggering circuit is a typical application for Type 11Z12 Trigate Pulse Transformers.




This unijunction-transistor/transformer triggering circuit is a typical application for Type 11Z13 Trigate Pulse Transformers.

### Dependable enough for industrial equipment, yet priced for high-volume commercial applications

Here's good news for designers of appliances; lighting controls; air-conditioning and heating controls; industrial controls. You can actually cut costs while upgrading your present method of SCR triggering!

Type 11Z Trigate* Pulse Transformers offer these unique features:

1. Balanced pulse characteristics and energy transfer from primary to secondary and tertiary windings.
2. Minimum saturation effect to allow operation where increased pulse widths are required.
3. Fast pulse rise time and increased current capability to prevent SCR *di/dt* failure.
4. Increased energy transfer efficiency.

Temperature operating range, −10 C to +105 C. 2- and 3-winding designs for half- and full-wave applications. Turns ratios, 1:1, 1:1:1, 2:1, 2:1:1, 5:1. Available for use with line voltages up to 240 VAC or 550 VAC.

*For complete information, write for Engineering Bulletin 40,003A to the Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247*

*trademark

SPRAGUE COMPONENTS

PULSE TRANSFORMERS
CAPACITORS
TRANSISTORS
RESISTORS
THIN-FILM MICROCIRCUITS
INTEGRATED CIRCUITS

INTERFERENCE FILTERS
PACKAGED COMPONENT ASSEMBLIES
FUNCTIONAL DIGITAL CIRCUITS
MAGNETIC COMPONENTS
CERAMIC-BASE PRINTED NETWORKS
PULSE-FORMING NETWORKS

4SSQ-6102R2

SPRAGUE®
THE MARK OF RELIABILITY

'Sprague' and '②' are registered trademarks of the Sprague Electric Co.


## People

Lanky, cigar-smoking **Charles E. Sporck** apparently feels that he startled the industry sufficiently for the time being by giving up his position as general manager of the Fairchild Camera & Instrument Corp.'s Semiconductor division to become president of the National Semiconductor Corp.—taking with him four key Fairchild employees [Electronics, March 6, p. 45]. Now, with things somewhat calmer, National—with Sporck at the helm—will take its time exploiting the new talent in the house.

C. E. Sporck

There are barely 20,000 square feet of manufacturing space at the Santa Clara, Calif., plant that is now National's headquarters. The company had been headquartered in Danbury, Conn.

"Our intent is to make full use of the facilities we have here before we think about expansion," the 39-year-old Sporck said; "and at present we have more furnaces than we can use." He indicated that the West Coast plant would not be operating at capacity before the end of this year.

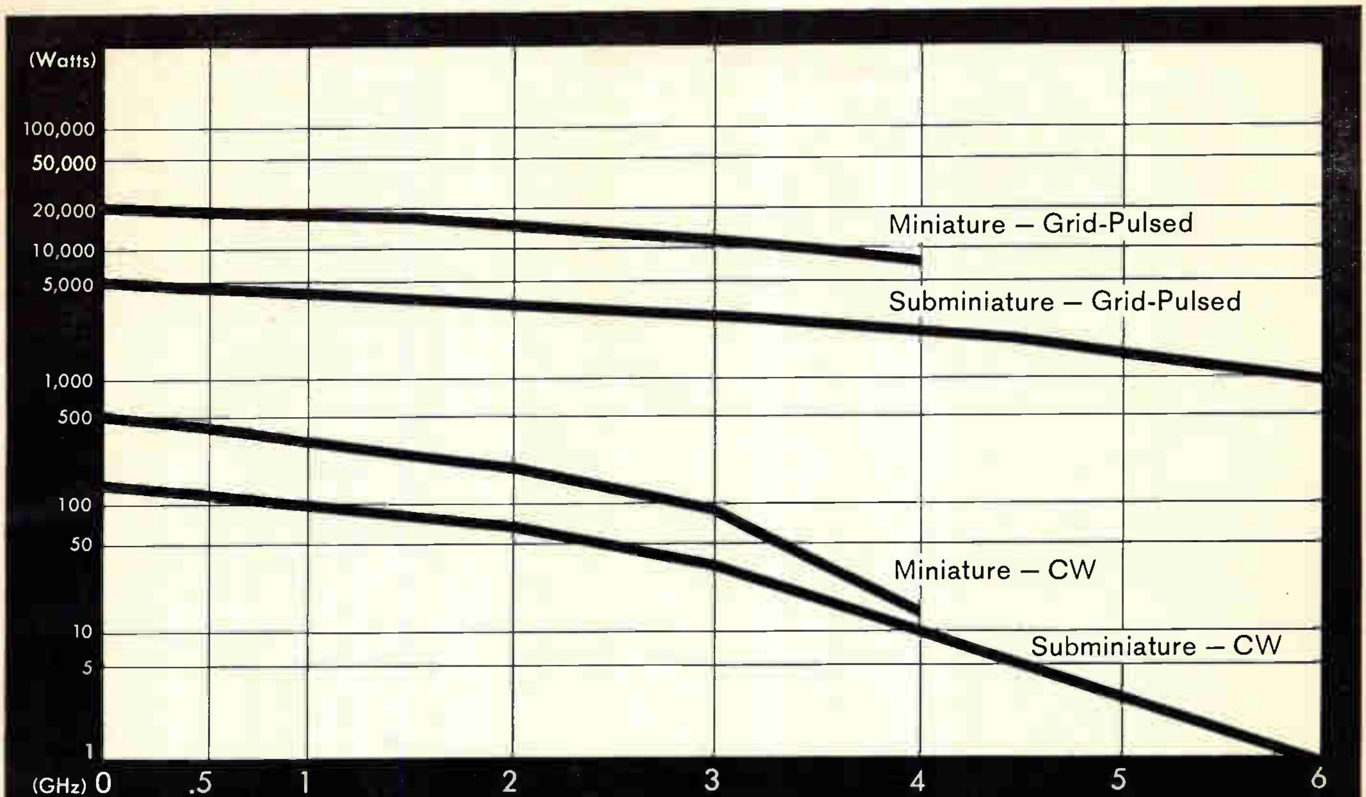
"Obviously, our objective is to concentrate on hybrid and monolithic integrated circuits," he continued. "We are laying out long-range plans as to the specific products we will make, a process that should be completed in a month or so. Then we will have to arrange finances. We will develop our own product lines; any Fairchild circuits we make will be secondary efforts."

**Westward ho!** All monolithic development work will be concentrated at Santa Clara, Sporck said. To take full advantage of this work, National wanted to keep its marketing activities directly coupled to it, and therefore moved top management west from the Connecticut operation.

The change from Fairchild, whose huge plant is only a few miles away in Mountain View, Calif., will be a big one. Sporck

MACHLETT

# Check these Machlett planar triode advantages for microwave applications.




**Power vs. frequency...some typical curves for grid-pulsed or CW operation**

### Electrical Advantages

Superior frequency stability

Negligible phasing problems

Comparable or superior efficiency

Low plate voltage

Low noise

Faster warm-up

### Mechanical Advantages

Small size

Very low weight

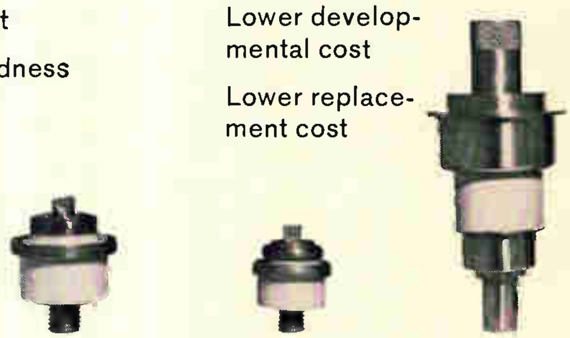
Greater ruggedness

### Cost Advantages

Lower initial cost

Lower developmental cost

Lower replacement cost



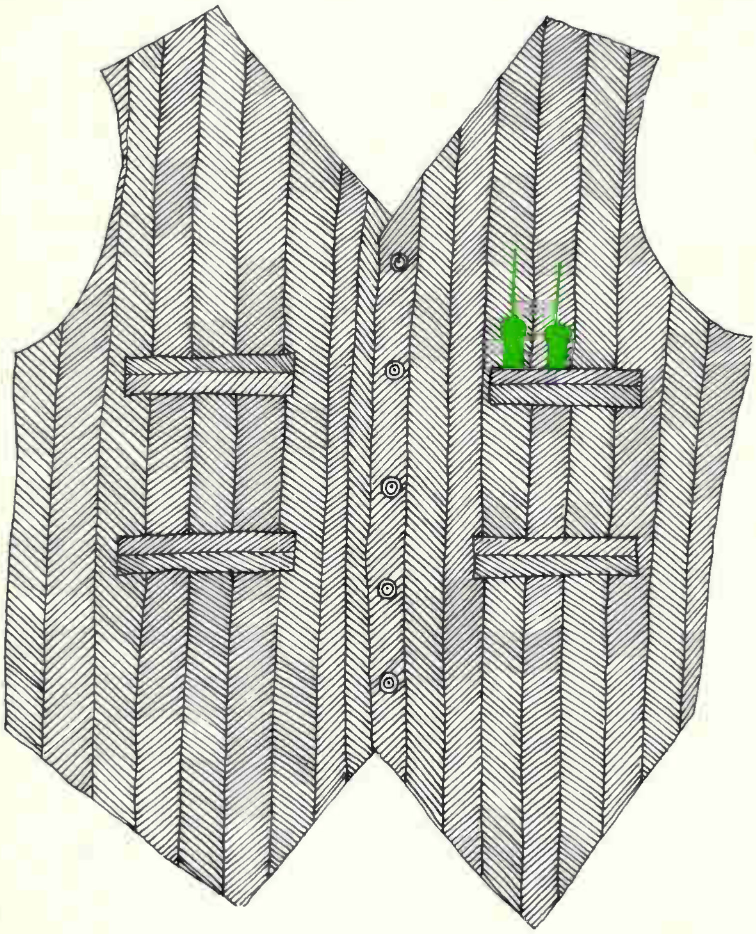
Write us now for application information on Machlett planar triodes: subminiature, miniature and standard. The Machlett Labs.,Inc., 1063 Hope St., Stamford, Conn. 06907

*The Machlett Laboratories, Inc.,welcomes resumes from engineers and scientists.*

RAYTHEON

THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY



**After millions of Mallory MOL's, here's where we keep our rejects.**

Of the many millions of Mallory MOL metal oxide film resistors we've made in the past three years, not enough have come back to fill your vest pocket. The reason? Highly automated production with automatic quality control tests on *every* resistor.

MOLs have high stability. Resistance change on 10,000 hour load-life test is less than 5%.

Delivery is prompt. And the price is right.

No wonder most leading TV manufacturers use MOL resistors. Get the details. Write or call Mallory Controls Company.

MALLORY

MALLORY CONTROLS COMPANY
a division of P. R. MALLORY & CO. INC.
Box 327, Frankfort, Indiana 46041

## People

was at Fairchild for seven years.

"There's always a challenge in making a small company a success," he says. "Fairchild became the most successful and profitable company in the business. I think they're on top now, and there's no chance that they will not continue to be on top. But the challenge present there in the early days became less and less evident as the company became larger and larger."

Added to the lure of the challenge was, reportedly, a large stock profit for Sporck. If National is relatively quiet now, it promises action for the future.

---

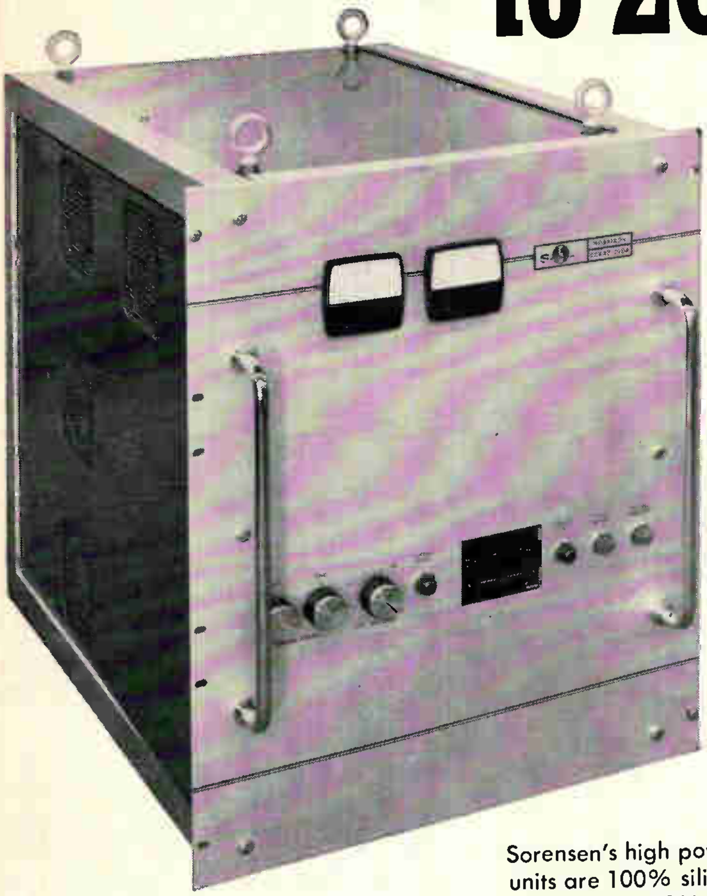
Located a few miles north of Santa Clara on the Bayshore Freeway, Fairchild presents an unruffled front to the world. Sitting in Sporck's old office is 41-year-old **Thomas H. Bay,** who was plucked from his job as manager of the corporation's Instrumentation division to take over as general manager of Fairchild Semiconductor. He is no stranger to the Mountain View operation; only 16 months ago he was its marketing director, having come to the Semiconductor division soon after its founding in 1957.

T.H. Bay

Bay thinks his brief tenure at the Instrumentation division was the perfect training for his present job. "I'm not fundamentally an operations man," he says. "I guess you'd say that primarily I'm a peddler since I've been in marketing almost all my career. But the Instrumentation division was small enough so that you could keep an eye on everything."

"My first order of business," Bay says, "is to plug the holes" left by the departure of Sporck, integrated circuit manager Pierre Lamond, IC manufacturing manager Roger Smallen, IC marketing manager Floyd Kvamme, and international operations director Fred Bialek.

# DCR Wide Range Power Supply to 20,000 W "Stock Delivery"



Sorensen's high powered DCR's are now available. These compact units are 100% silicon, with temperature capability to 71°C and are rated to 79% efficiency. Regulation, line and load combined to ±.075%. They are particularly well suited for such applications as: Multiple testing and aging of automotive accessories • In medical research • Aging and life testing SCR's, diodes and high power transistors • Capacitor forming • In test equipment for simulating shipboard power • Substituting of motor generators • As magnetic field power supplies for atomic research • For linear accelerator focus coils • As electric oven power supplies for mass spectrum analysis (Units are remotely programmable by voltage and resistance).

| MODEL | RANGES | PRICE |
|---|---|---|
| DCR 20-125A | 0-20V, 0-125A | $1,180 |
| DCR 20-250A | 0-20V, 0-250A | $1,550 |
| DCR 40-125A | 0-40V, 0-125A | $1,390 |
| DCR 40-250A | 0-40V, 0-250A | $2,100 |
| DCR 40-500A | 0-40V, 0-500A | $3,050 |

For DCR details, or for data on other standard/custom power supplies, AC line regulators, frequency changers, or for our free catalog #662A, call your local Sorensen rep, or write:

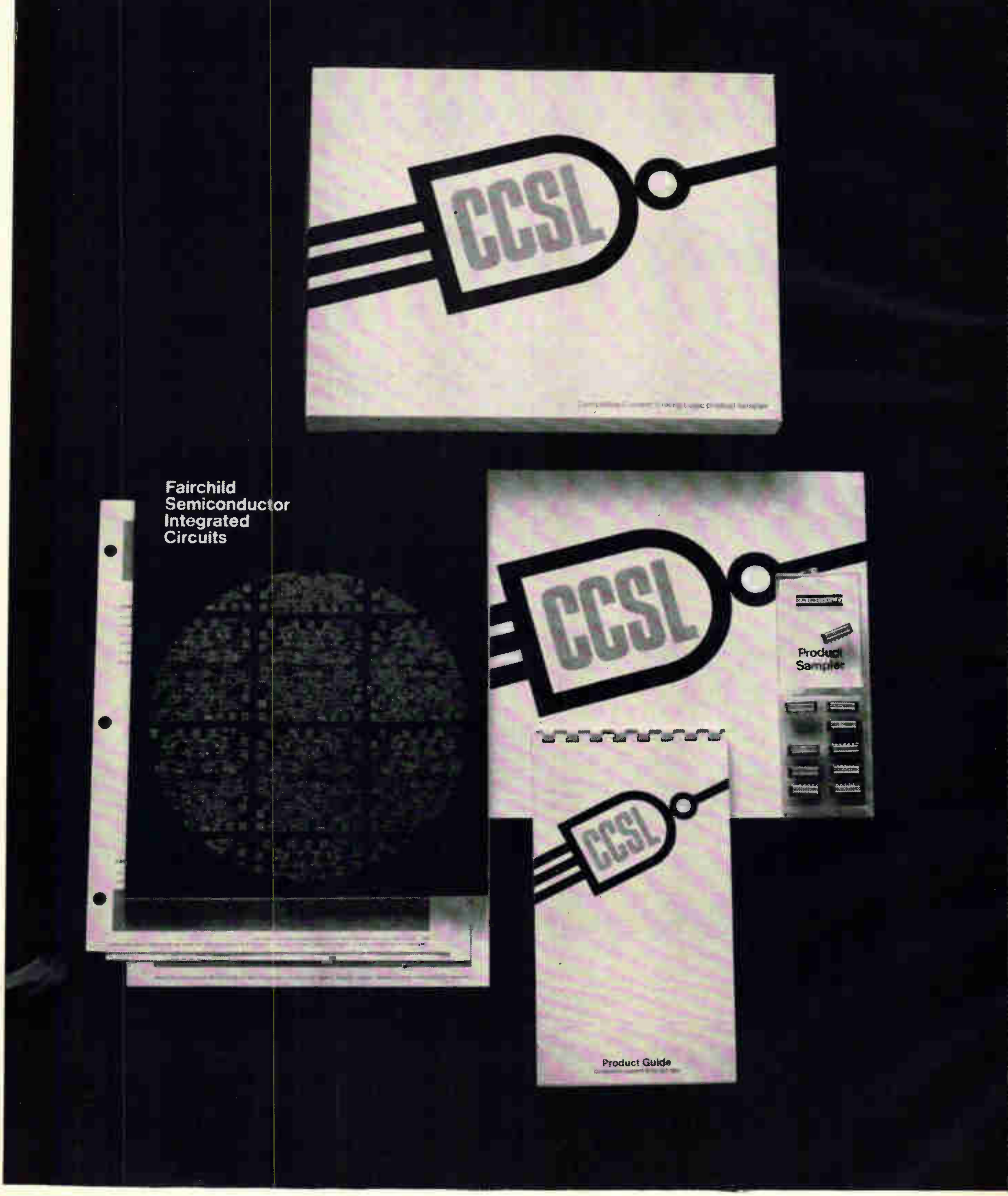
RAYTHEON Raytheon Company, Sorensen Operation, Richards Ave.,/Norwalk, Conn. 06856. Tel: 203-838-6571.

See us at IEEE (New York) Booths 2C06-08.



Circle 11 on reader service card

# CCSL is waiting for you.



We have prepared a special product sampler to help you discover the advantages of designing with Fairchild's Compatible Current Sinking Logic. You can get it for less than you'd normally pay for the samples alone.

Integrated circuits are conventionally classified by family, and within each family by function. This method of classification restricts you to a single family within a system. Now Fairchild allows you to cross family boundaries and to design by function, selecting circuits from compatible logic families. This permits you to choose the best circuit for each function, and to optimize the system as a whole.

What is compatible logic? Fairchild classifies all digital integrated circuits into compatible logic groups: current sinking logic, current sourcing logic, and current mode logic. A current sinking logic gate (for example, a DTL gate) draws current into its output ("sinks" current) when in the low state, and draws virtually no current when in the high state. A current sourcing gate (for example, an RTL gate) drives current out of its output in the high state and, except for minor leakage, drives no current in the low state. Current mode logic can draw or drive current.

Compatible current sinking logic: There are three families within the Fairchild current sinking group: TTμL (Transistor-Transistor Micrologic®), DTμL (Diode-Transistor Micrologic) and LPDTμL (Low-Power Diode-Transistor Micrologic) integrated circuits. By crossing family boundaries within the compatible logic group, you can optimize your system design. Here's how:

How compatible logic helps you: TTμL is the fastest of the three families and also the one that dissipates the most power. LPDTμL dissipates the least power, but is slower than the others. DTμL is right in between, both in speed and in power dissipation. There are clearly some functions in your system that require all the speed you can get. There are other functions where the speed of TTμL, for example, is wasted, because it is waiting for slower system elements. So you can use a slower logic family and optimize your power dissipation without sacrificing overall system speed. When you design with Fairchild's current sinking logic group, you are assured that all the families within the group are fully compatible.

What we mean by compatibility: All three families use NAND logic, and all basic NAND logic functions are available in any of the three forms. All three families use a single 5V power supply, and all three are guaranteed to perform compatibly when the specified fan-out and fan-in rules for interconnecting between logic forms are observed. Pin configurations for the same functions are the same, and all three families come in the same two package configurations (maximum-density ¼"x¼" Flatpak, and easy-to-handle Dual in-line). Finally, all three families are manufactured using the same technology, so that within the same working environment they will maintain a uniform stability over a period of time.

Get our product sampler: We want you to get acquainted with Fairchild's compatible current sinking logic group at first hand, so we have prepared a special product sampler you can get. The sampler contains a 90-page book describing Fairchild integrated circuits; a guide to current sinking logic; data sheets on individual products and families; and actual product samples (see listing). Our complete product sampler sells for $51.00, which is the over-100 price of the samples alone. But quantities are limited, so act now.

How to get it: Simply return the attached coupon. Or call. For data-pack only, use reader service card No. 484.

Fairchild Product Samples:

| | | | | |
|---|---|---|---|---|
| 4 ea. | 9000 | J-K flip-flop | 1-99 price | $ 5.10 ea. |
| 2 ea. | 9002 | Quad 2-input gate | 1-99 price | $ 3.65 ea. |
| 2 ea. | 9946 | Quad 2-input gate | 1-99 price | $ 3.65 ea. |
| 2 ea. | 9046 | Quad 2-input gate | 1-99 price | $20.00 ea. |

These products are in the industrial temperature range.

# What are you waiting for?

**Compatible Logic Can Optimize Your System. Send For Proof.**

Please send me the Compatible Current Sinking Logic Product Sampler.

Name__________

Title__________

Company__________

Address__________

City__________

State__________ Zip__________

☐ Check enclosed ☐ Bill me

☐ Bill my company. P.O. No.__________

☐ Check here for data-pack only.

FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR/A Division of Fairchild Camera and Instrument Corporation ■ 313 Fairchild Drive, Mountain View, California (415) 962-5011 ■ TWX: 910-379-6435

# there's a better way to do it!

## JERROLD SS-300 Sweep System

Jerrold has come up with a **new idea** – a solid-state sweep frequency **system** that does it all – in one compact unit. The extraordinary SS-300 incorporates a sweep generator (500 kHz to 300 MHz), plus a variable frequency **marker generator** and a **detector** system.

**Features include:**

- Remote Programming
- Start-Stop Frequency Tuning
- Exceptional Sweep Frequency Linearity
- Automatic Leveling Without Frequency Shift.

There's a brochure detailing every exciting feature . . . and we'll be happy to send it to you on request.

JERROLD MEASUREMENT AND TEST INSTRUMENTATION

JERROLD ELECTRONICS CORPORATION
*Government and Industrial Division*
Philadelphia, Pa. 19105

**there's a better way to do it!**
Jerrold TECH/NOTE No. 5001 details "a better way to do it" than the static point-to-point technique of determining AM rejection of limiter design. Request your copy.


## Meetings

**Symposium on Modern Optics,** Polytechnic Institute of Brooklyn; Waldorf-Astoria Hotel, New York, **March 22-24.**

**Lectures on Glass in Electronics,** New York State Science of Technology Foundation; Polytechnic Institute, Troy, New York, **March 28-29.**

**Photovoltaic Specialists Conference,** IEEE; Sheraton Cape Colony Inn, Cocoa Beach, Fla., **March 28-30.**

**Advancing Technology & Purchasing Management Workshop,** Institute of Science & Technology; University of Michigan, Ann Arbor, Mich., **March 29-30.**

**Structures, Structural Dynamics & Materials Meetings,** American Institute of Aeronautics and Astronautics; Palm Springs, Calif., **March 29-31.**

**Symposium on Microwave Power,** International Microwave Power Institute; Stanford University, Stanford, Calif., **March 29-31.**

**Conference on the Transport Properties of Semiconductors,** Solid State Physics Committee of Institute of Physics; Canterbury, Kent, England, **March 30-31.**

**Rubber & Plastics Industries Technical Conference,** IEEE; Sheraton-Mayflower Hotel, Akron, Ohio, **April 3-4.**

**Business Aircraft Conference and Engineering Display,** Society of Automotive Engineers; Broadview Hotel, Wichita, Kan., **April 5-7.**

**Intermag Conference,** Magnetics Group of the IEEE; Shoreham Hotel, Washington, April 5-7.

**Symposium on the Ocean from Space,** American Society for Oceanography; Rice Hotel, Texas, **April 5-7.**

**American Nuclear Society Meeting on Fast Reactors,** American Nuclear Society; San Francisco Hilton, San Francisco, **April 10-12.**

**International Electronic Components** Show, FNIE; Porte de Versailles, Paris, **April 5-10.**

**Technical Meeting and Equipment Exposition,** Institute of Environmental Sciences; Washington, **April 10-12.**

**International Conference on Electronics and Space,** Electronic Industries Association of France; Paris, **April 10-15.**

**Electronics Conference,** IEEE; Cleveland, **April 11-13.**

**International Conference on Medical and Biological Engineering,** International Federation for Medical and Biological Engineers; Stockholm, Sweden, Aug. 14-19.

**International Measurement, Testing, Control and Automation Exhibition and Congress,** Mesucora; Paris, **April 14-21.**

**Technical Conference of the Society of Motion Picture and Television Engineers,** Society of Motion Picture & Television Engineers, New York Hilton Hotel, New York, **April 16-21.**

**Meeting of the Anti-Missile Research Advisory Council,** Advanced Research Projects Agency; Institute for Defense Analyses, Arlington, Va., **April 17-19.**

**Region III Meeting,** IEEE, Heidelberg Hotel, Jackson, Miss., **April 17-19.**

**Thermophysics Specialist Conference,** American Institute of Aeronautics and Astronautics, New Orleans, **April 17-19.**

**Physics Exhibition,** Institute of Physics; Alexandria Palace, London, **April 17-20.**

**American Society for Testing and Materials National Technical Meeting on Applications-Related Phenomena in Titanium Alloys,** American Society for Testing and Materials; International Hotel, Los Angeles, **April 18-19, 1967.**

**Spring Joint Computer Conference,** IEEE; Atlantic City, N.J., **April 18-20.***

## Call for papers

**Symposium on Switching and Automata Theory,** IEEE; Austin, Texas, Oct. 18-20. **May 1** is deadline for submission of abstracts to Raymond Miller, IBM Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, N.Y. 10598.

* Meeting preview on page 16

This is the solid state 0.003% voltage calibrator with variable current limiting and overvoltage trip. ☐ Line and load regulation, 0.0005% of setting. ☐ Panel meter monitors either output voltage or current. ☐ No cooling fan is needed, so you can forget about damage from dirt and dust. ☐ All circuits are shielded and guarded. ☐ Resolution is 0.1 ppm. ☐ Only 7 inches high. ☐ Weighs 40 lbs. ☐ Price is $2295. ☐ For more information on the Fluke 332A Voltage Calibrator, call your full service Fluke sales engineer (listed in EEM) or write directly to the factory.


# In a crowd or all alone, the Fluke 332A DC Voltage Calibrator stands out. There isn't another calibrator on the market at any price that offers all the advanced technical and user features. By any measure, it's the leader!

FLUKE

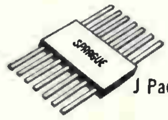
Fluke • Box 7428, Seattle, Washington 98133 • Phone: (206) 776-1171 • TWX: (910) 449-2850
In Europe, address Fluke International Corporation, Sophialaan 2, The Hague, The Netherlands

See us at the IEEE, Booths 2C02, 2C04.

Circle 15 on reader service card

You Can Get All These Microcircuits from Sprague Electric

*SERIES SE100, NE100, US700 DTL LOGIC (Signetics CS700)



J Package

Eighteen functions in two operating temperature ranges: —55 C to +125 C and 0 C to +70 C. Circuits include NAND/NOR gates, clock and line drivers, gate expanders, RST and JK binary elements, one-shot multivibrator.

Circle 494 on readers service card

*SERIES SU300, LU300 UTILOGIC*

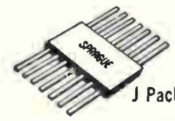
K Package

For use in commercial, industrial, ground support applications. Available in two operating temperature ranges, —20 C to +85 C, and +10 C to +55 C. Propagation delay of 15 to 40 nanoseconds.

*Trademark of Signetics Corp.

Circle 495 on readers service card

*SERIES SE400, NE400 LOW POWER LOGIC



J Package

Operating temperature ranges: —55 C to +125 C, and 0 C to +70 C. For use in Aerospace and other applications where low power drain is required. Optimized speed, noise margin.

Circle 496 on readers service card

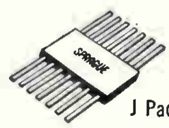
*SERIES SE500 LINEAR AMPLIFIERS

K Package

Operating temperature range: —55 C to +125 C. Two linear circuits available in 10-lead low silhouette TO-5 case. SE501K is a video amplifer, SE505K is a general purpose differential amplifier.

Circle 497 on readers service card

*SERIES SE800, NE800 TTL LOGIC



J Package

Designed for high-speed avionics systems. Eight high level circuits including four NAND Gates, Power Gate, Exclusive-OR Gate Input Expander, J-K Flip-Flop.

Circle 498 on readers service card

DIGITAL-TO-ANALOG CONVERSION CIRCUITS

| | 4-BIT SERIES | 5-BIT SERIES |
|---|---|---|
| Ladder Network | UT-1000 | UT-1001 |
| Ladder Switch | UD-4001 | UD-4036 |
| Buffer Amplifier | UD-4024 | UD-4037 |

Circle 499 on readers service card

*Series SE100, NE100, CS700, SU300, LU300, SE400, NE400, SE500, SE800, NE800 are all available from Sprague Electric under technology interchange with Signetics Corp.

For data on the microcircuits in which you are interested, write Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Massachusetts 01247

455-7100

SPRAGUE®

THE MARK OF RELIABILITY

'Sprague' and '②' are registered trademarks of the Sprague Electric Co.

## Meeting preview

### Question of privacy

The Spring Joint Computer Conference, to be held in Atlantic City, N.J., April 18-20, will concentrate on the growing problem of privacy and secrecy in time-shared and multiprogramed computers.

The privacy-secrecy problems will be discussed both in the keynote address and in a technical session. Keynote speaker is Rep. Cornelius E. Gallagher (R., N.J.) chairman of a House special subcommittee on the invasion of privacy. Gallagher, concerned about the possible impact of a national data center on the constitutional rights of individuals, will describe legislation that he believes is necessary to insure privacy in the use of all time-shared and multiprogramed computers, not just those in a national data center. Such legislation, says Gallagher, might even make violation of privacy with computers a Federal crime. He believes technical innovations to guarantee computer privacy are possible.

**Computer snooper.** At the technical session, Willis H. Ware of the Rand Corp. and Bernard Peters of the National Security Agency will discuss computer problems associated with privacy and secrecy. The session will also deal with accidental destruction and disclosure, deliberate snooping, and specific approaches to safeguard a memory system.

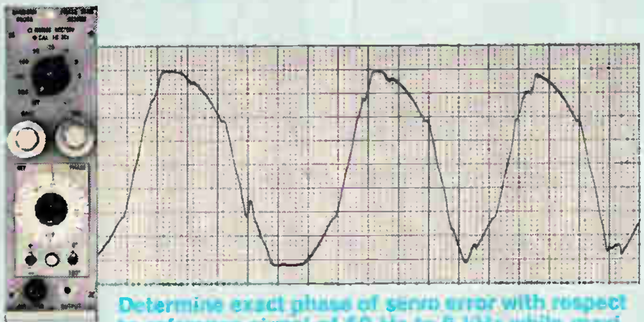
In several technical areas where the issues are controversial or the direction of computer development is uncertain, the conference directors have established panel discussions. These topics include dynamic allocation of computer resources, analog-hybrid techniques, and combined logic and memory functions.

Other sessions include one on various approaches to the design of very large computing systems, one on computer-assisted instruction, and one on computers for industrial process analysis and control.

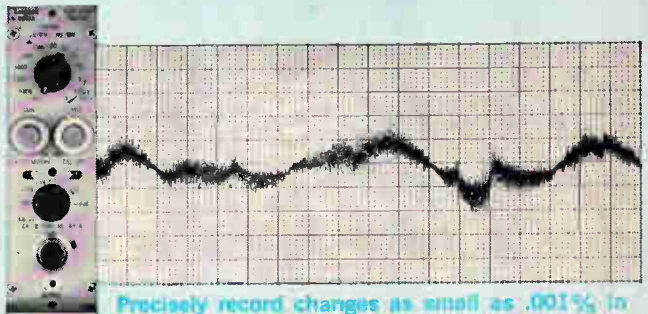
The conference is sponsored by the American Federation of Information Processing Societies.

# Bring on your complex, small, noisy, difficult signals.

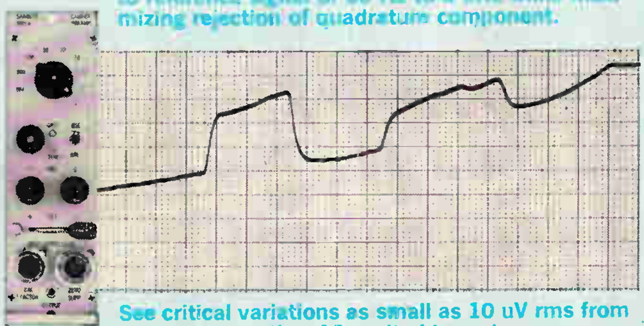
## We'll give you traces that show them for what they really are.



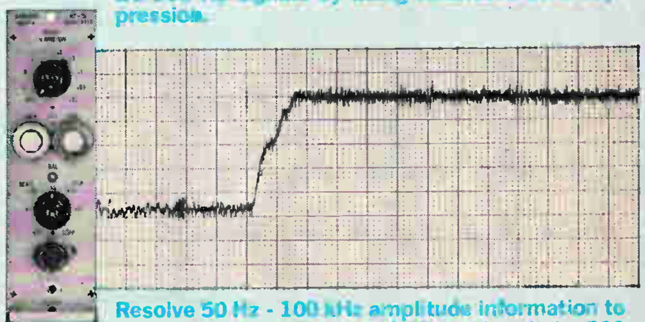
Determine exact phase of servo error with respect to reference signal of 60 Hz to 5 kHz while maximizing rejection of quadrature component.



Precisely record changes as small as .001% in DC-100 Hz signals by using calibrated zero suppression.



See critical variations as small as 10 uV rms from strain gages, other AC-excited transducers.



Resolve 50 Hz - 100 kHz amplitude information to 0.02% of full scale signals from 1 volt to 500 volts.

When you need the greatest possible degree of signal-conditioning precision and operational control, Sanborn 7700 Series oscillographs with solid-state "8800" plug-ins will give you chart recordings of *maximum resolution and intelligibility.*

Seven highly versatile signal conditioners offer unique performance capabilities: three DC types with a 1 uV - 250 V dynamic range, floating differential input and calibrated zero suppression . . . an AC-DC Converter with calibrated zero suppression and scale expansion permitting resolution better than 0.1%, 10 ms response and isolated, 1 meg. input . . . a phase-sensitive demodulator with calibrated reference phase shift, 90° calibrated dial with four quadrant selections, and a frequency range of 60 Hz to 5 kHz . . . a carrier preamp with 2400 Hz internal transducer excitation supply, calibrated zero suppression, cal. factor control and conversion gain of 10,000 . . . and a general-purpose DC preamp particularly useful for 100 mm wide chart recording.

Use any of these "8800" plug-ins in the 7700 thermal writing oscillograph matched to your packaging and channel requirements — 4-, 6- and 8-channel 7704A, 7706A and 7708A console types . . . 2-channel 7702A system in rack-mount or mobile cart versions . . . single-channel 7701A wide chart (100 mm) portable system. Every one of these thermal writers will give you permanent, rectangular-coordinate recordings whose resolution and accuracy make all your measurements more useful.

For a new brochure describing the advantages and wide choice of Sanborn thermal writing oscillographs, write Hewlett-Packard Company, Sanborn Division, 175 Wyman Street, Waltham, Mass. 02154.

**Be sure to visit us at IEEE, Aisle 2F.**

HEWLETT PACKARD hp SANBORN DIVISION

Circle 17 on reader service card


# RCA...where the

From RCA "overlay"...
the industry's best performing plastic RF-power transistor—15 watts min. at 400 MHz

Now . . . get in on the action with the rf-power advantages of RCA "overlay" in plastic!!

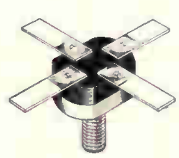
RCA's new 2N5017 stud-mounted plastic transistor provides 15 watts at 400 MHz . . . 22 watts typ. at 225 MHz . . . operates from 28-v supply! And this circuit capability is delivered in a unique package that sets new standards for performance, ruggedness, and versatility at VHF and UHF frequencies.

Performance—the industry's lowest emitter and base inductances (0.1 nH and 0.2 nH respectively) result in optimum gain and power capability right up to 700 MHz . . . efficient for broadband and narrowband transmitters.

Ruggedness—unexcelled mechanical strength with short "anchor" pins eliminating problems due to lead breakage or vibration.

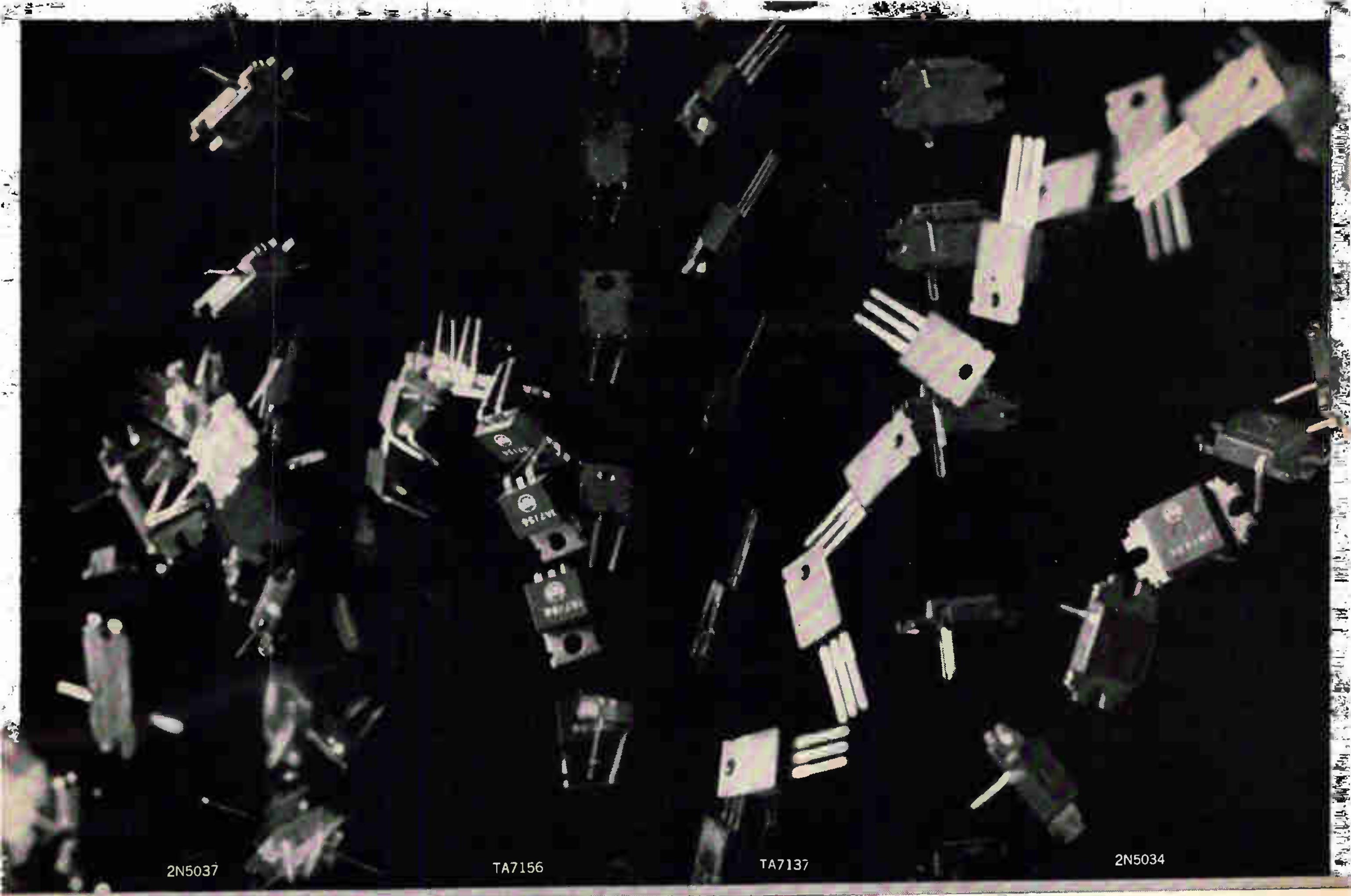
Versatility—"terminal block" structure permits choice of stripline, printed circuit (both flush and bottom-mounted), or lumped circuit mounting.

Call your RCA representative today for more information on the 2N5017 for military, microwave, and industrial communications usage. If your applications still call for hermetically sealed packages, ask him about the RCA 2N5016—it offers similar electrical performance but in the popular TO-60 case. For technical data, write RCA Commercial Engineering, Section IJ3-3A, Harrison, N. J. 07029.



Strip-line leads can be easily soldered to terminal block with pins providing additional mechanical strength.

See A Man of Action About RCA Plastic Transistors at IEEE, Booths 3C-01—3C-10




# action is plastic

From RCA
Hometaxial-Base...
the industry's most powerful plastic power transistors—dissipation up to 83 watts

Tomorrow's action needs are here today... as RCA, leader in silicon power, now introduces its famous Hometaxial-Base technology in plastic!

Eight transistors in all, RCA's new power program is the first to combine the low cost of plastic with brute power-handling ability—83 watts or 36 watts—each is an industry-high for plastic! And this power comes in your choice of package... a straight-lead design for PC-board mounting or a bent-lead design compatible with standard TO-3 or TO-66 mounting techniques.

| TYPE | PACKAGE | $V_{CER}$ (sus) | $I_C$ | $h_{FE}$ | $\theta_{JC}$ | $P_T$ @ 25°C |
|---|---|---|---|---|---|---|
| 2N5036<br>2N5037 | TO-3 equivalent<br>P.C. type | 60 V @ $R_{BE}$ = 100 ohms | 8A | 20-70 @ 3A | 1.5 °C/W | 83 W |
| 2N5034<br>2N5035 | TO-3 equivalent<br>P.C. type | 45 V @ $R_{BE}$ = 100 ohms | 6A | 20-70 @ 2.5A | 1.5 °C/W | 83 W |
| TA7155<br>TA2911 | TO-66 equivalent<br>P.C. type | 60 V @ $R_{BE}$ = 100 ohms | 4A | 25-100 @ 0.5A | 3.5 °C/W | 36 W |
| TA7156<br>TA7137 | TO-66 equivalent<br>P.C. type | 50 V @ $R_{BE}$ = −500 ohms | 4A | 20-120 @ 0.1A | 3.5 °C/W | 36 W |

Performance is tops—RCA mounts the silicon chip directly onto a solid copper base for better current handling, thermal resistance, and dissipation capabilities. You get unsurpassed freedom from second breakdown... the inherent advantage of RCA Hometaxial-Base technology.

Put the cost and performance benefits of RCA plastic transistors in your circuits... they'll do the big job for audio amplifiers and a broad range of industrial applications. Call your RCA representative for more information or write Commercial Engineering, Section IJ3-3B, Harrison, N. J. 07029.

Also available through your RCA distributor.

RCA Electronic Components and Devices

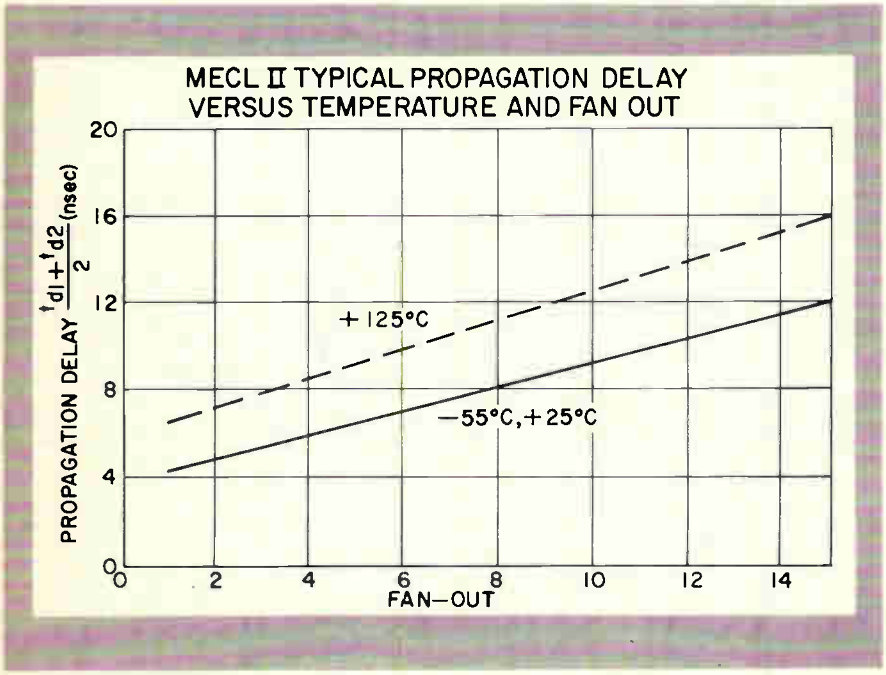
**The Most Trusted Name in Electronics**

Circle 19 on reader service card

(Advertisement)

# Why aren't all advanced computers designed with current-mode logic?

## Here are some interesting insights into the merits of CML in logic designs




Fast speed even under heavy fan-out conditions typifies Motorola's MECL II type current-mode logic integrated circuits.

### Speed

Current-mode logic is practically and theoretically the fastest form of logic. That's because it isn't subject to transistor "storage time" which is a major speed limiting factor in every other form of logic. While we don't imply that either saturated or current-mode logic has yet reached its maximum theoretical limit, the fact is that present current-mode J-K flip-flops operate at a *minimum* toggle frequency of 70 MHz (Motorola MECL II* type MC1013), while the fastest saturated logic flip-flops have a *typical* frequency of 50 MHz. And, while saturated-logic speeds are nearing the limits of their speed capability, current-mode logic speeds still have a long way to go.

### Noise Immunity

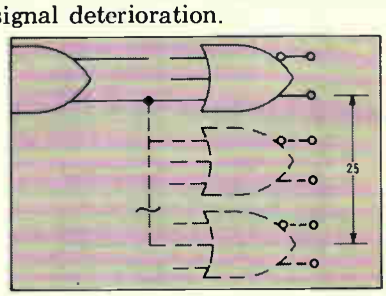
Inherently, current-mode logic is immune to state-changing transients that are integral to all forms of saturated logic. That's because current drain in CML remains constant even during the switching interval whereas with saturated logic any slight difference in transistor characteristics (and there's always a slight difference in transistor characteristics) causes current and voltage spikes whenever a transistor is driven from cutoff to saturation or vice versa. Propagating down a line, these transients produce cross-talk and other forms of noise that can result in spurious or false triggering of succeeding stages. Consequently, the logic levels of saturated logic cicuits must be considerably higher than those of CML for the same noise immunity. Since circuit speed is a function of logic levels, this requirement further increases the practical speed differential between CML and SL.

### Complementary Outputs

Because CML normally is designed with a differential input stage (consisting of a pair of transistors, one of which is turned off while the other is turned on), this logic form inherently provides a function and its complement without the need for a separate inverter. In many CML integrated circuits, these complementary signals are available at separate output terminals to simplify system design, reduce can-count and equipment cost.

### High Fan-Out, Fan-In

The normal CML gate is followed by a pair of emitter-follower stages (one for each of the complementary outputs) which are used as level translators to make the output voltage levels of a circuit compatible with input voltage level requirements of an identical circuit. These emitter followers, however, provide a very real additional functional benefit. Because of their very-low-output impedance, they can drive a relatively large number of succeeding stages without serious speed degradation. This high fan-out and fan-in capability is further enhanced by the high-input impedance of CML gates. A high-frequency fan-out of 15 is normally used, but even a fan-out of 25 at lower frequencies can be tolerated without excessive signal deterioration.




The capability of MECL II current-mode logic to fan-out up to 25 makes it superior in this category to all other available integrated circuit digital systems.

# SO, why aren't all advanced computers being designed with current-mode logic?

One reason might be that CML circuits, *in the past,* have been available with only a relatively simple logic function per package. As a result, it has been impossible to implement complex systems, in some instances, with "low can counts."

*But take another look now. With the introduction of Motorola's MECL II line, utilizing 14-pin flat ceramic and plastic packages, circuit complexity has been increased to include full adders as well as a variety of other multifunction units.*

A second reason might be that current-mode circuits in the past have operated at speeds that are approachable with a form of saturated logic so that high-speed requirements have been served by two IC lines.

*With the MECL II line, current-mode logic has significantly surpassed the high-speed capability of any saturated logic form. Flip-flop clock rates are two to three times those of the fastest saturated logic lines, and gate propagation delays, typically on the order of 5 ns, are well ahead of all other logic forms. And with a third line of current-mode logic (MECL III*) presently in the prototype evaluation stage (speeds in the one nanosecond range and fully optimized to drive 50 ohm transmission lines), it is clearly predictable that, for high-speed computers, current-mode logic is the only logic form capable of meeting the needs of the most advanced systems.*

A third reason might be the misconception held over from the discrete circuit design era that current-mode is a relatively expensive form of logic, due to the abundant use of transistors in place of diodes and resistors.

*Unquestionably, this has been true for circuits designed with discrete components—but it isn't with integrated circuits where transistors are no more expensive and are as easy to make as any other component. Motorola's pioneering efforts with current-mode integrated circuits have raised manufacturing yield to a level where these devices are price competitive (per function) with most other logic forms. And, though it is still possible to buy some logic circuits at a lower average per-package cost, it is quite likely that the systems oriented approach MECL* design (complementary outputs, etc.) can reduce total system cost.*

## MECL ≫ MECL II ≫ MECL III

Due to family-to-family compatibility between all MECL logic series, the designer can use highest speed forms where critical speed requirements exist, while using other types throughout balance of the system.

## And did you know

That Motorola's MECL lines are completely compatible? That is — MECL, MECL II, and the imminent MECL III lines have identical logic levels and power-supply requirements so that they can be judiciously mixed for optimized system needs. With this logic form, it is possible to customize each computer subsystem so that the total system will achieve the best possible speed-power product and the lowest cost.

## Therefore —

Do we recommend MECL for all possible computer designs? Definitely not! There may always be special requirements where other logic forms may provide advantages in the form of system cost or simplicity, or where special performance requirements will stipulate another type of circuit. That's why we manufacture and supply virtually every other logic form in use today ($T^2L$, DTL, RTL, VTL, HTL (High threshold), etc. We do maintain, however, that MECL should be carefully evaluated for every application, and we predict that current-mode logic will become the predominant logic form in the years ahead.

(As a matter of fact, you might be surprised to learn the large number of advanced computer systems being designed today using MECL).

For a package of selected Application Notes describing the MECL line in use, write for Application Note Group #1. Send your request to Dept. TIC, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

*Trademark of Motorola Inc.



Circle 21 on reader service card


# A post-graduate course in money-making

Some people think of Digital Equipment as a manufacturer of digital computers and modules for the university and scientific community exclusively. They're wrong.

Since the PDP-8/S was introduced in August of 1966, more than 300 such machines have been sold to be part of other people's money-making devices — blood analyzers, X-ray diffractometers, spectrum analyzers, batch controllers for cookie baking. One pipeline manufacturer ordered 25 PDP-8/S computers just to log data. (PDP-8/S is the world's first under-$10,000 computer.)

For bigger, faster problems, the bigger, faster PDP-8 has been incorporated into money-making automatic transistor check out equipment, petroleum controllers, thickness testers for rolled steel. (PDP-8 costs $18,000.) PDP-9 is bigger yet.

And modules. We sell more digital logic circuit modules to manufacturers who resell them as part of their instruments and systems than to all our university customers combined.

So we're very big in the universities. True.

But if you make instruments or systems (and particularly if you sell these instruments to the scientific disciplines) maybe you should discover us. Before we get too well known.

digital
COMPUTERS · MODULES

DIGITAL EQUIPMENT CORPORATION, Maynard, Massachusetts 01754. Telephone: (617) 897-8821 • Cambridge, Mass. • New Haven • Washington, D.C. • Parsippany, N.J. • Rochester, N.Y. • Philadelphia • Huntsville • Pittsburgh • Chicago • Denver • Ann Arbor • Houston • Los Angeles • Palo Alto • Seattle • Carleton Place and Toronto, Ont. • Reading, England • Paris, France • Munich and Cologne, Germany • Sydney and West Perth, Australia • Modules distributed also through Allied Radio

## Editorial

# Engineers abroad flee . . .

**Electronics companies** in the U.S. are intensifying their recruiting of engineers abroad, the story on page 171 reports. The word will raise blood pressures in many European capitals where government and industry leaders are already concerned about the "brain drain," the exodus of professional men—particularly good engineers—to the U.S. Any increase in this emigration is going to trigger a demand for some kind of action to stem the outflow.

In Washington, a Congressional committee is already mulling legislation that would keep emigrating engineers out of the U.S., a sop to angry foreign governments. But laws barring immigration—or emigration—of engineers aren't the answer to this problem.

Superficially, the great magnet is the higher salaries paid by American companies. However, closer examination shows the lure of the U.S. for most foreign engineers to be the opportunity to work in new technology or to employ technical talents fully.

Offered equal professional opportunities at home, most engineers would stay put. Family ties, nationalistic feelings, language familiarity, and intimacy with local customs would more than offset offers of higher salaries. But throughout most of Europe, engineers are not getting a chance to use their technical talents to the fullest. These men may be aware of new technical developments, but their managements are unwilling to let them apply them.

An official of a U.S. manufacturer of sophisticated, high-performance field effect transistors tells of the success and failure of a technical seminar program he conducted in Europe last year. "Engineers came to the meetings in droves —910 to the session in London alone—but we can't attribute $50 worth of business to the whole tour because European management won't let those engineers use these advanced devices."

The answer to keeping engineers at home lies in a change in local management attitude rather than in legislation.

# . . . to put ideas to work

**One reason** foreign countries are so concerned about the exodus of engineers is that many experts evaluate the ability of a company to survive in today's technically oriented economy by the number of engineers working for it and the amount of money it spends on research and development. That's because so many people, including engineers and scientists, confuse invention with innovation. Invention is the conceiving of an idea. Innovation brings a useful product based on the idea to market.

Business is built on innovation, not invention. and development and technically oriented firms. novative process* by a blue-ribbon panel of technically minded executives exploded a lot of the myths that have built up around research and development and technically oriented firms.

For example, the study found that research and advanced development expenses amount to only 5% to 10% of the total cost of innovations. The big investment goes into readying the idea for manufacture and starting up marketing.

The panel also noted that 90% of the R&D in the U.S. is performed by 300 large companies, but that these companies contribute a far smaller percentage of the good new ideas and products. An explanation was volunteered by one member of the panel, Peter G. Peterson, president of Bell & Howell: "Large companies always have an analytical process to screen new ideas, but the process crushes them instead."

The investigators concluded that too many management men aren't innovation-minded and don't understand how a technical idea is translated into a successful product.

In a minor but interesting digression, panel members, examining how new companies get started and why, found that universities and banks play leading roles. In Boston, Palo Alto, Washington, and Pittsburgh, for example, financial institutions are eager to help technical enterprises get started. But in some other cities, notably Philadelphia, Chicago, Atlanta and Kansas City, the money men are reluctant to back newcomers in technical fields. In a study of some small new companies in the Boston area, the probers found that a university in the area had played a role in the founding of every company.

In their report, the panel members urge legislation to ease the tax load on concerns and the antitrust restrictions on innovation. But their most important contribution is to put the innovation process in proper perspective.

For the first time, a group of businessmen have clearly stated and shown that research and development isn't the only factor in a company's technical progress. The mistaken belief that it is is a continuing source of bankruptcies in the U.S. and Europe.

* Technological Innovation: Its Environment and Management, January 1967, U.S. Government Printing Office, Washington, D.C.: price $1.25

# 9 good reasons why Philco Epoxy Transistors (PET) are your best buy.

1. PET TO-18 is rated from 360 to 675 mW at 25°C (chip dependent).

2. PET TO-5 is rated from 550 mW to 1.2 W at 25°C (chip dependent).

3. PET packages have reliability factors equal to or exceeding that of *metal* cans.

4. PET's are immediately available in large volume production quantities.

5. PET's have a special deep-well interlock construction that insures hermeticity and reliability.

6. PET packages are permanently and legibly marked—lettered black on white.

7. PET's are packaged in our low-cost Taiwan production facility—to keep *your* cost low.

8. PET amplifiers operate on currents ranging from 10 $\mu$A to 1 A; PET switches to speeds 8 ns turn on and 11 ns turn off.

9. PET's cover frequencies from 40 MHz to 1400 MHz.

Call or write: **Philco-Ford Corporation Microelectronics Division Sales Offices:** 2920 San Ysidro Way, Santa Clara, California (408-245-2966) / 999 North Sepulveda, El Segundo, California (213-772-6226) / Northwest Industrial Park, Second Avenue, Burlington, Mass. (617-272-1600) / Benson Manor, Suite 114B, Washington Lane, Jenkintown, Pa. (215-885-0430) / 1215 Drew St., Clearwater, Florida (813-446-0124) / 815 Connecticut Avenue, N.W., Washington, D.C. (202-298-7810) / Suite 208, 700-108th St., N.E., Bellevue, Washington (206-454-5061) / New York, N.Y. (212-244-1373).

PHILCO Ford

PHILCO-FORD CORPORATION
Microelectronics Division
Santa Clara, California • 95051

See us at the IEEE Show, Booth 3A36—3A39

# Electronics Newsletter

March 20, 1967

**End of the road for IBM series 90**

No new orders will be accepted by the IBM Corp. for its 360 model 90 series computers. The company insists, however, that all current orders for the giant system—largest offered by the firm—will be filled. It's estimated that about one to two dozen 90 series computers have been sold. According to reports, IBM—on at least three other occasions—was on the verge of withdrawing the computer and only pressure from top management kept it from being dropped. First deliveries of the 90 series, originally scheduled for early this year, reportedly have been put off until summer, at the earliest.

**RCA scores first with cool memory**

For years, companies have been chasing the elusive cryoelectric memory that promised batch fabrication and very high bit capacity in a small space. **Researchers at RCA Laboratories have now scored a breakthrough.** Although the company won't discuss details, it has been learned that an operating cryoelectric memory system has been developed around a new memory cell and memory organization. The system that demonstrated feasibility of the new approach reportedly is a 14,000-bit unit with a cycle time in the microsecond range. It is said to lend itself to expansion to much higher bit capacities.

**Signetics collects data to back claim of IC reliability**

A sure way to start an argument recently has been to bring up the subject of the reliability of plastic-packaged integrated circuits. Makers—notably Motorola Inc., Texas Instruments Incorporated, and the Signetics Corp. —have insisted that their products can meet military specifications [Electronics, Sept. 5, 1966, p. 38]. Now, **Signetics, a division of the Corning Glass Works, reportedly has accumulated extensive data on its 14-lead dual in-line plastic package to back up its reliability claims.**

The big question posed by users has been whether plastic IC's can meet hermeticity and temperature specs; since there's no void inside a plastic package it's impossible to test for hermeticity. But Signetics has deliberately fabricated IC's with cavities in the plastic and reportedly has found that the lead-to-plastic interface is indeed hermetically sealed. **The company is also said to have found that its plastic package can meet military requirements for temperature cycling from —55° C to 125° C.**

**Volume output of E-Cell starts after long delay**

**It's taken nearly three years, but the Bissett-Berman Corp.'s E-Cell—a liquid electrolytic cell that can generate time delays, integrate pulses, and store signals—has moved into volume production.** The Santa Monica, Calif., company reportedly is tooled up to turn out 150,000 of the cells a month, and the military is said to be buying large quantities as replacements for electromechanical timers in fuses. The very-low-current devices can drive solid state circuits directly.

The major barrier to volume output was the problem of packaging to meet military specifications. **With a silver can replacing its original glass package, the E-Cell now conforms to requirements for ordnance and air-drop applications.** The cell, ¾ inch long and ⅜ inch in diameter, has discharge currents ranging from 3.5 milliamps to 1 microamp. Accuracies are held within 5% over charging ranges up to 1,500 microamp-hours.

A two-terminal unit is priced at $4 in large quantities; a three-terminal cell for start-and-stop timing is roughly twice as much.

**Air Force eyes time-sharing for top secrets**

A computer system for which the Air Force will soon request proposals will be one of the first to process classified information on a time-shared basis. The computer complex, to replace a second-generation multipurpose system in the Pentagon, will present a number of difficult technical problems. Because it will handle several levels of classified data, the system probably will have to be divided in some way by security levels, functions, or other criteria. Precautions will have to be taken to prevent unauthorized persons from using the system [Electronics, Feb. 6, p. 36]. The separation requirement also creates the problem of how to set up a data base for common access. The present system is made up of several IBM 7094 and 1401 machines, each capable of being used for any purpose within the system.

**Varian unveils new X-ray tube**

An X-ray image intensifier tube that eliminates one of the stages in conventional devices is being introduced at the IEEE convention by Varian Associates. The intensifier and two other devices also being introduced at the show are the first products to come out of the company's new Light Sensing and Emitting division. According to Varian's Wilfrid F. Niklas, the new tube converts X rays directly into electrons that are accelerated against a phosphor plate to provide the amplification. Conventional tubes convert the X rays into light, then send the light through an intensification system. The new tube provides enough amplification for motion pictures or for closed-circuit television. The division's other products are a wafer-sized image intensifier for electronic cameras and an image intensifier inverter for low light-level tv systems.

**2 ways to watch the cars go by**

The probable winners of contracts to develop automatic license-plate scanning equipment for New York State will be the Itek Corp. and the Bendix Research Laboratories division of the Bendix Corp. Negotiations are still in progress and the awards will be announced in early April. Because the pattern recognition schemes proposed by each of the companies are significantly different, New York is willing to finance two separate efforts.

**Millimeter-wave stationkeeping runs into trouble**

The future of a millimeter-wave stationkeeping project for a "follow-the-leader" flight formation system is in doubt. The system developed by TRG Inc. reportedly has been turned down by the Army Electronics Command because it couldn't meet the specified stationkeeping requirements. The Army was considering TRG's system, along with others, for future helicopter transport use but an informed source says that the Army may now decide to drop the plan to use millimeter waves.

**Bell fails to ring at ESS offices**

Electronic switching system installations have slid a year or more behind schedule at Bell Telephone Co. offices. At least four New England ESS's have been delayed by unexpected software problems. Until the programing difficulties are solved no more installers will be trained; this may push installation dates even further back.

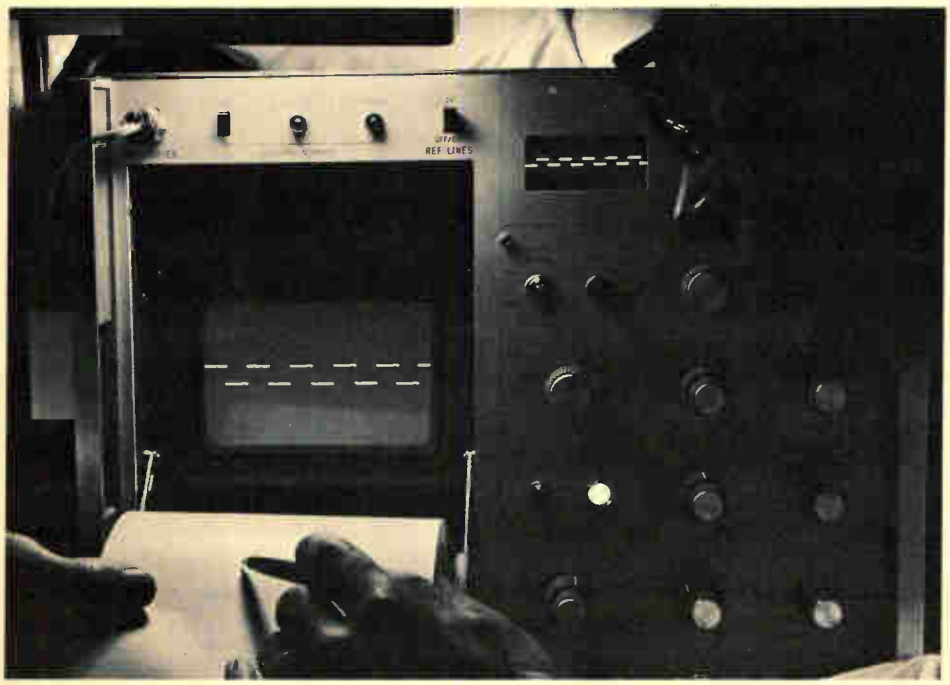
*Component and Circuit Design*

# IDEAS

from SYLVANIA Electronic Components Group

CRTs

## How fiber-optic CRTs allow direct recording of 1 MHz signals



Honeywell's new Model 1806 CRT Visicorder

*How do you combine the direct-write features of oscillographs with the high-frequency measuring capabilities of modern oscilloscopes? Simple, if you use the electron beam of a specially designed Sylvania fiber-optic CRT to provide immediately available direct printout recordings of high frequency analog data and video signals.*

A special Sylvania fiber-optic CRT has helped engineers at Honeywell's Test Instruments Division to produce an instrument with recording speeds nearly 100 times greater than previously available oscillographs. Honeywell's Model 1806 Visicorder is a single-channel, 4-axis unit which employs the electron beam of the fiber-optic CRT to record continuous transient data directly on standard oscillographic paper.

The new instrument can record responses of from dc to 1 MHz on either the vertical or horizontal axis, or simultaneously on both, and has continuous or intermittent chart drive modes. In addition, video pictures can be recorded as a continuous series of individual 3 by 4 inch frames on the direct-record paper at the rate of 30 pictures per second.

The essential component in Model 1806 is the specially-designed Sylvania fiber-optic CRT. This new tube (SC-4082E) has an improved electron gun for initial fine spot resolution. Spots produced by the new gun have a diameter of 4-7 mils compared to 15-30 mils for typical laboratory scopes.

More than 35 million fibers, each 10 to 15 microns in diameter, insures that the initial small spot size is retained as it is conducted to the face of the CRT for recording. Here, signals are recorded by passing ultraviolet-sensitive paper over the ½-inch thick faceplate of the tube. Low-level ultraviolet light develops the paper as it comes out of the instrument to give a permanent record within seconds.

The SC-4082E, with its 3″x5″ face, has the largest fiber-optic faceplate commercially available today. It uses a P16 phosphor and has electrostatic focus and deflection. Helical-resistor post-deflection acceleration is employed to get high writing rate, high deflection sensitivity, and freedom from pattern distortion.

In addition to the fiber-optic recording tube, the new oscillograph

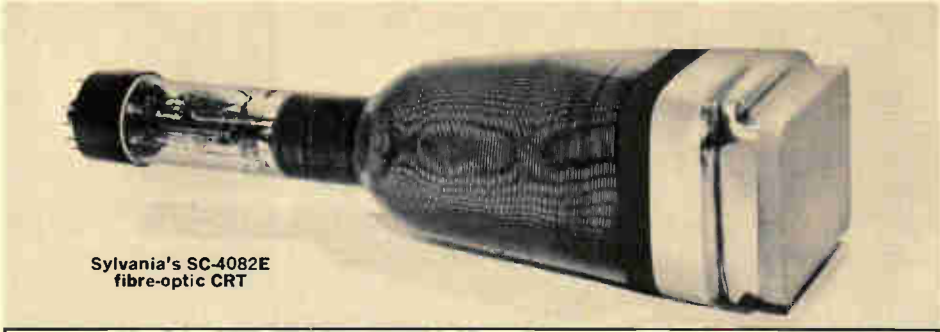
*(continued)*

## This issue in capsule

uses a conventional CRT, the Sylvania 3ASP1, to monitor the signal being recorded.

Sylvania has designed many other types of high resolution cathode ray tubes with fiber-optic faceplates as well as full faceplate arrays. Fiber size ranges from 4 microns up to 75 microns, depending on the specific tube and application. Basic characteristics on a few of these types are listed in the table.

CIRCLE NUMBER 300



Sylvania's SC-4082E fibre-optic CRT

**BASIC CHARACTERISTICS OF TYPICAL FIBER OPTIC CRTS**

| Tube Type | Fiber Strip Size | Focus | Screen Size |
|---|---|---|---|
| SC-3304 | 2¾" x ¼" | magnetic | 3" x 1½" |
| SC-3507 | 8 11/16" x ½" | magnetic | 10" x 3½" |
| SC-3800 | 8 11/16" x ½" | electrostatic | 10" x 3½" |
| SC-3850 | 4½" x ½" | magnetic | 5" dia. |
| SC-3876 | 8 11/16" x ½" | magnetic | 10" x 3½" |

INTEGRATED CIRCUITS

# How to step servo motors with SUHL/TTL ICs

*Until recently, discrete components were used exclusively to control the stepping of servo motors. Now, the same function can be done easily with Sylvania's versatile SUHL units. The only ICs you'll need are OR gates, AND gates, and J-K flip-flops. With SUHL, this can be done with as few as five packages.*

Sylvania ICs can perform all the logic, counting, and decoding necessary to control the stepping of servo motors. The specific circuit described here can handle shift pulses of up to 28 volts while delivering 10 mA to the driver transistor of each of four motor windings.

Key elements in the control (see figure) are these Sylvania SUHL types: SF-60 J-K flip-flop, SG-90 exclusive OR, and SG-280 dual AND gate or the SG-140 quad 2-input NAND/NOR gate. Whether you use the SG-280 or SG-140 series, the counting and decoding require only five IC packages.

In the circuit, pulling the direct set input to ground will set the Q outputs of both flip-flops to a "1." This corresponds to the unbarred letters A and B, and places both inputs to the #1 decoder gate high. Since the gate performs the AND function, the output will go high, turning on its transistor and activating the #1 winding. Now, should a shift right pulse be generated, the #2 winding will be activated. However, if instead a shift left occurs, the #4 winding is activated. Sequence for shift right pulses is: 1, 2, 3, 4, 1... For shift left it is: 1, 4, 3, 2, 1...

The 28 V shift pulses are dropped to approximately 3.5 V with the 7:1 ratio resistor network shown. When the pulse edges exceed a 1.0 μsec/volt slope it may be necessary to sharpen them with an SG-83 pulse shaping AND gate placed after the voltage divider.

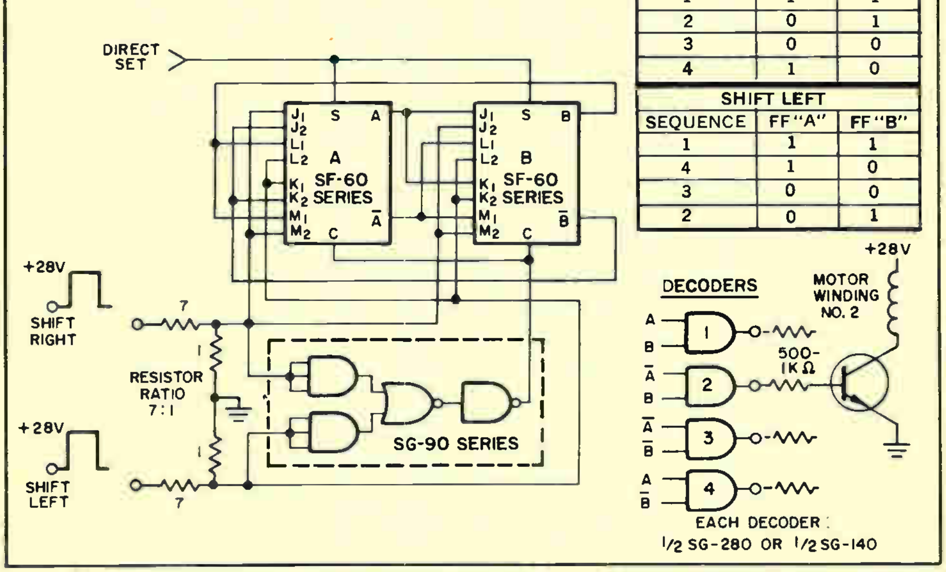
The +28 V dc supply is cut to 4.5 to 6.0 V to provide dc for the ICs. This is done with a series dropping resistor. However, if the motor causes voltage spikes of considerable amplitude, a zener diode can be used for regulation.

The decoder gates perform the AND function. This can be accomplished with two SG-280 devices. Each SG-280 is a dual AND gate in a single package. However, two NAND gates in series will accomplish the same thing. By using the SG-140 quad two-input NAND gate, the function is provided with the same number of packages.

The transistor at the decoder gate output handles the motor's high voltage and coil current requirements. Value of the 500 to 1K resistor shown in the base will depend on the beta characteristics of the transistor. A 500-ohm resistor will supply a base drive of from 4 to 5 mA and 1K from 2 to 2.5 mA. If the resistor is dropped below 500 ohms for more current, SUHL II device SG-220 or SG-280 is recommended. Either can supply 10 mA or better with a 250-ohm resistor.

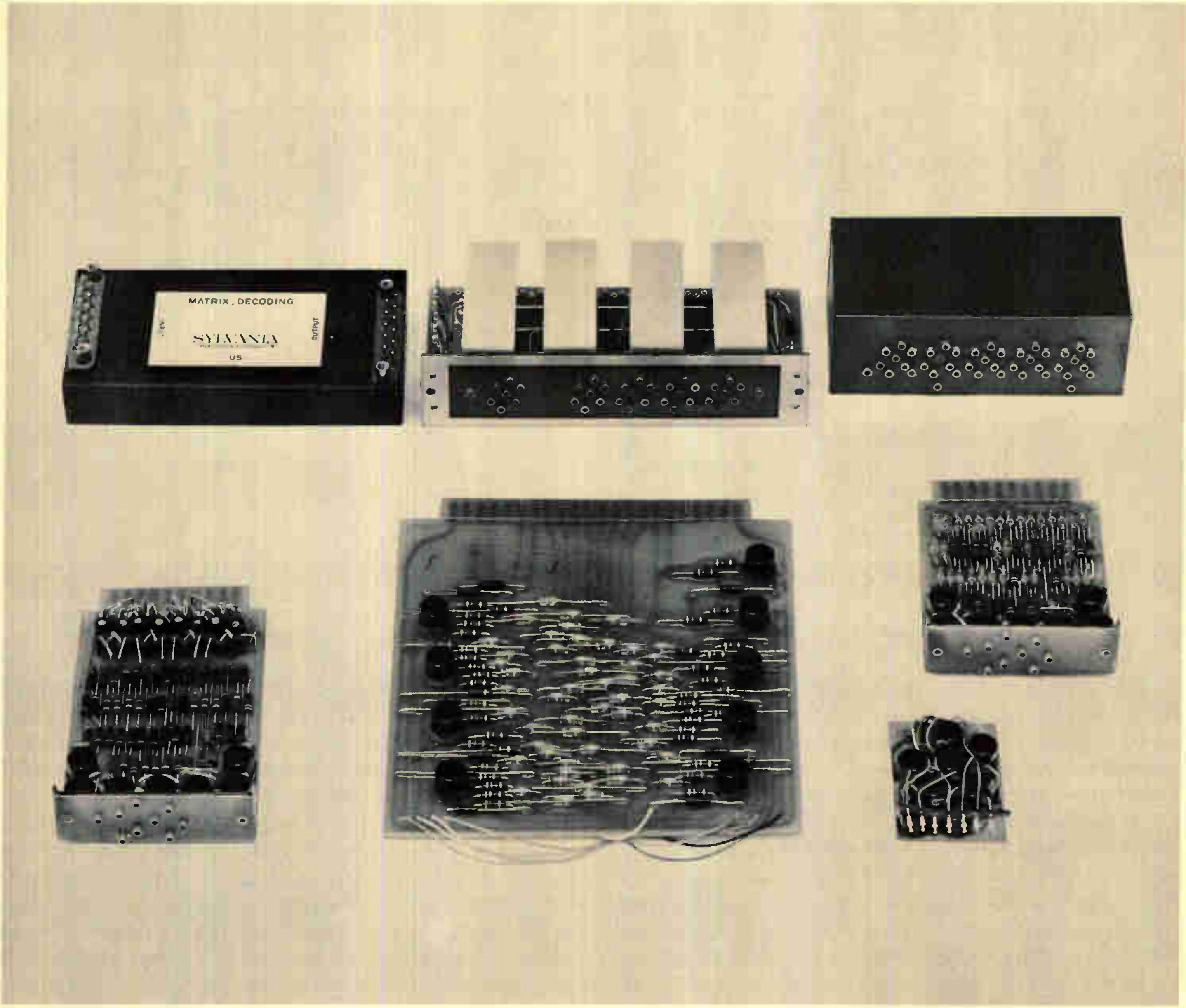
CIRCLE NUMBER 301

Ring Counter for Stepper Motor Control




| SHIFT RIGHT | | |
|---|---|---|
| SEQUENCE | FF "A" | FF "B" |
| 1 | 1 | 1 |
| 2 | 0 | 1 |
| 3 | 0 | 0 |
| 4 | 1 | 0 |

| SHIFT LEFT | | |
|---|---|---|
| SEQUENCE | FF "A" | FF "B" |
| 1 | 1 | 1 |
| 4 | 1 | 0 |
| 3 | 0 | 0 |
| 2 | 0 | 1 |




# Translators/Drivers, like EL panels, can be customed to specific needs

*It naturally figures that, whatever the electroluminescent display application, Sylvania engineering would provide the best interface between computers (or counter outputs) and EL panels. After all, experience gained as a prime producer as well as user of EL readouts gives us the custom-engineering capability which we apply over a wide application spectrum.*

The right translator or driver, singly or in combination, should be applied to your application—be it a relatively simple readout system for a non-critical environment or an advanced system for an aerospace application which may incorporate Sylvania's new all-glass EL panel designs.

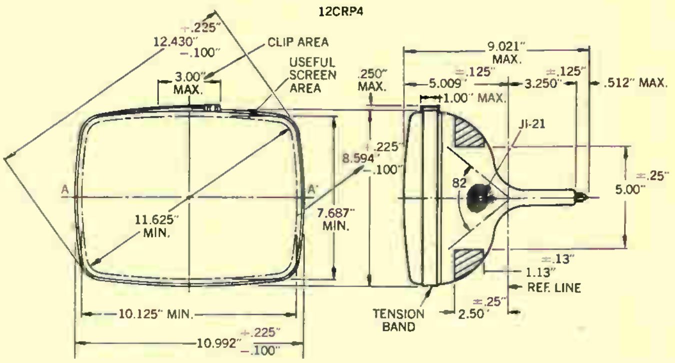
In all applications, translators and drivers combine to perform the double function of input translation and EL panel segment switching. They feature compact design, low-power requirements, fast switching, low-level logic input, long life, modular design and solid state reliability. In addition, they can be supplied with or without a memory capability.

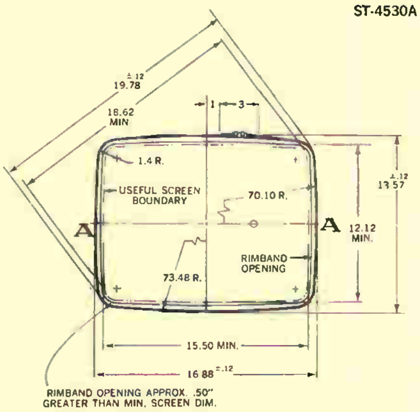
Typically, in these Sylvania units, binary input codes are translated to numeric readout by diode logic circuits and El readout panel power is switched by SCRs.

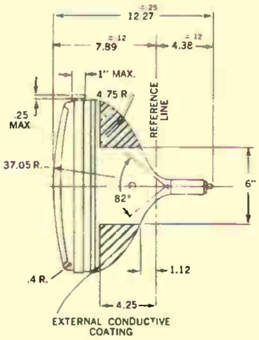
Translator power requirements are a low 6 to 12 volts at a few milliamperes. Readout driver power depends on the size and type of the EL readout used. Units can have either positive or negative logic inputs of as low as 6 volts at 2 ma per data bit and pulse widths of 1 $\mu$sec.

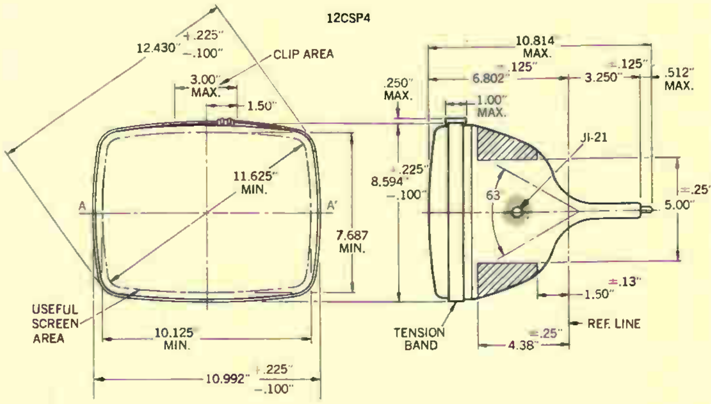
Sylvania has already developed units which encompass the needs of a wide variety of EL readouts requirements. We'll undertake custom designs which implement your special codes and fit your mechanical configurations. Sylvania design engineers use a computer program to determine the best translator circuitry for these customed devices.

# Broad monochrome tube line for 1967 TV set designs




*Already one of the most complete in the industry, Sylvania's monochrome picture tube line is still growing. Availability of production quantities of the new 20″ tube, developed late last year, means designers are now choosing from even more tube sizes to find the specific picture tube to fulfill 1967 requirements.*

Whatever the TV picture tube size needed today, chances are there's a Sylvania monochrome picture tube that size, today. That's because Sylvania produces a broad line of picture tubes that includes eleven standard sizes covering up to 26 inches. Tubes like the new 20″ ST-4530A for building 19″ sets to the new FTC labeling requirements. Or two recently announced 12-inch picture tubes to keep pace with the call for smaller, more portable TV sets.

The new 20″ has a useful screen dimension of 18.625″. This 114° dark bulb device gives 184 square inches of viewing area, yet has an overall length of only 12.27″.

The 12CRP4 and 12CSP4 are 12″ units of small-neck size, making them ideal for smaller portable set requirements. Overall lengths of these tubes are a short 9.021″ (12CRP4) and 10.814″ (12CSP4).

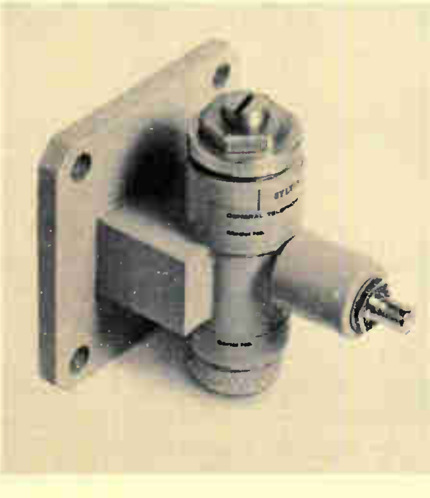
The 12CRP4 employs 110° magnetic deflection, the 12CSP4, 90° deflection. Both have aluminized screen with a useful area of 7.687″ x 10.125″ to give a minimum useful diagonal of 11.625″.

Other sizes in the Sylvania line are also tailored to meet the specific need for present set production. All include the latest advancements in tube design, material and production techniques made available by Sylvania's continuing tube technology development program.

CIRCLE NUMBER 303

MICROWAVE COMPONENTS

# Now an X-Band avalanche diode oscillator for parametric amplifier pumping



*Use of parametric amplifiers in military systems has been limited because of the need for a pump source with a frequency much higher than the signal frequency. Traditionally klystrons provided this pump frequency. However, they require very large and expensive power supplies which usually weigh more than the rest of the solid state circuitry. More recently, varactor multiplier sources have been used, but this usually involves many semiconductors as well as complicated circuitry. Now a simple single device from Sylvania which converts dc to rf directly at frequencies in X-band can be used to pump parametric amplifiers.*

Sylvania's new SYA-3200 avalanche diode oscillator simplifies construction of parametric amplifiers by producing a minimum of 10 mW at any frequency in X-band (8.2 to 12.4 GHz). Requiring only a single dc power supply, the SYA-3200 is much more efficient and much lighter than any other solid state or tube pump currently in use.

This new source is mechanically tunable by means of a single screw adjustment over a range of at least 200 MHz and has a temperature coefficient of frequency typically of 200 KHz/°C. This is comparable to that of the existing klystrons which it replaces.

Parametric amplifiers pumped by the SYA-3200 avalanche diode oscillator have exhibited performance which is indistinguishable from that obtained using conventional klystrons. A parametric amplifier operating in L-band was pumped at 11 GHz by a SYA-3200. Result: a noise figure of 1.8 db, exactly what was obtained using a klystron. Saving in power supply, size, and weight reduced the overall weight and size of the amplifier by 50 percent. Gain, bandwidth, and stability were unchanged from the performance obtained from a klystron.

In addition to use as pumps, these oscillators function successfully as local oscillators in heterodyne receivers and as beacon transponder sources. Of course, these represent only the first uses of this new device. We'll work with you in applying the full capabilities of an avalanche oscillator to your application.

The SYA-3200 is currently available in developmental quantities. Continued development over the next several months is expected to lead to improved devices with higher output power, electronic tuning, and additional frequency band coverage.

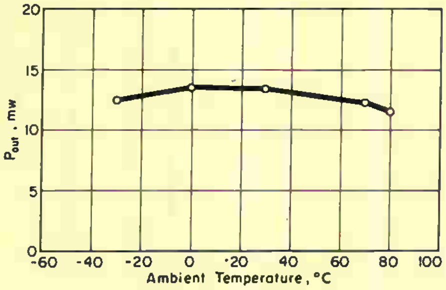
**CIRCLE NUMBER 304**

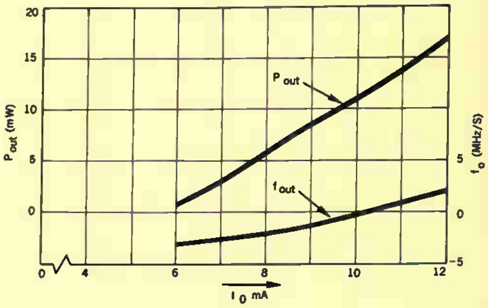
**ELECTRICAL CHARACTERISTICS OF SYA-3200**

| | |
|---|---|
| Frequency | 8.2-12.4 GHz* |
| Mechanical tunability | ±100 MHz |
| Power output into matched load | 10 mW min. |
| Efficiency | 1-2% typical |
| Power variation over tuning range | 1 db max. |
| Operating temperature range | —30 to +71°C |
| Temperature coefficient of frequency | —200 KHz/°C typical |
| DC bias voltage | —50 to —90 volts** |
| DC operating current | —10 to —25 ma** |

*To be specified within this range.

**Required operating voltage and current will be specified with each unit. Constant current supply should be used.




MARKETING SERVICES MANAGER'S CORNER

# "Trade shows are a waste of time"

"...and a waste of money too." How often have you heard this? You may have said it yourself. For a great many people it's true, shows are wasted efforts.

After all, too many exhibits are little more than 3-dimensional catalogs. Nothing's exciting in seeing cold lifeless products tacked to a back wall. We at Sylvania shudder to think of the dull repetition (and, possibly, repulsion) of 100 receiving tubes in a row.

And what if you just happen to see one product that interests you? Ask a reasonable question at the booth about it, and you usually find that the expert on the subject is out to lunch. (Would you believe this at 9:30 AM?)

But exhibitors are only partners in the crime of trade shows. Attendees share a large portion of the blame. Engineers are in New York during the IEEE show often for three or four days. But during that time they're seen in the Coliseum for as much as four hours! Ask them if they saw the show. Why, certainly they did! To have seen every exhibit in that period of time, they would have had to be Olympic track stars if only to go through all of the aisles.

After our sprinter does complete his exhaustive survey, general comments run from "same old stuff" to "nothing really new." Anything less than the discovery of a new energy source seems to be a disappointment. Well, we could go on and on, but essentially our point of view is that, like most things, trade shows are valueless *unless* all exhibitors and attendees work at it.

Sylvania has made some innovations in presentation techniques—live presentations, information booth and telephone hot line. We hold no licenses on these methods and wish (in fact, strongly urge) other exhibitors would liven up their booths in a similar manner.

A better show benefits everyone. In fifteen minutes at the Sylvania booths, 3G01-3G12, we feel an engineer can be initially exposed to the full scope of Sylvania's manufacturing and engineering efforts. Included, of course, are new product developments, particularly those that are pertinent to today's designs and requirements. A few more minutes and we'll give detailed information on specific product types from our microfilm data file right at the booth.

Visitors also have the option of talking directly to our plant and engineering locations anywhere in the country. Further, they can request that specific information be sent to them at the completion of the show on any product which we manufacture. It isn't necessary to ask ten people in order to receive this information. Our purpose at a trade show is not to take orders there on the floor, but rather to disseminate the maximum amount of information on our overall company capabilities.

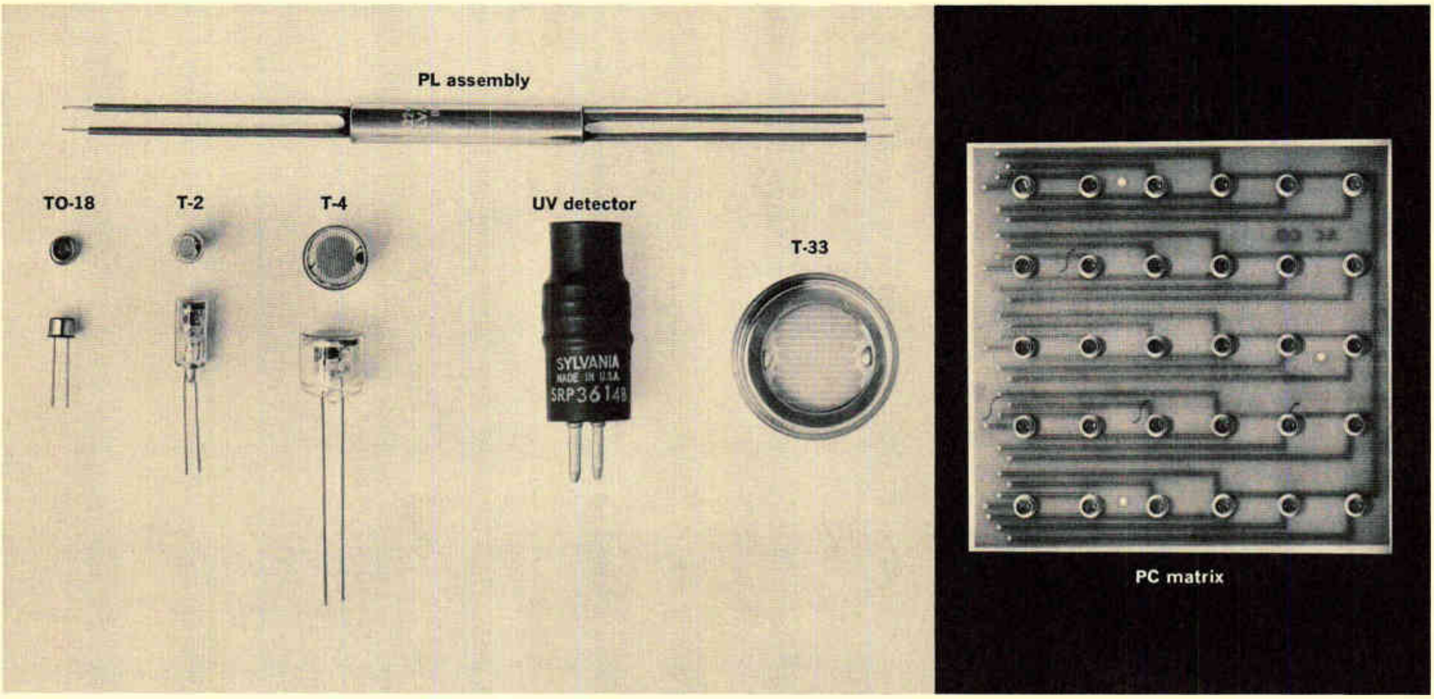
We want people to know more of what Sylvania can do today and in the years to come.

For your company, trade shows can be a waste of time, but there is also the opportunity to learn a great deal at a relatively small cost. We sincerely hope you share our thoughts for maximizing the time and money devoted to the trade show concept. Sylvania wants to make good use of the time you give us.

Bill Dixon

W. R. DIXON

NOTE: Interest in this column, in IDEAS last year at IEEE Show time, was unusually high. We thought it deserving of a rerun. Mr. Dixon, Merchandising Manager a year ago, is now Marketing Services Manager of Sylvania's Electronic Components Group.




# Newest additions to an extensive PC line: TO-18 50-milliwatt cells

*How do you evaluate the completeness of a photoconductor line? By the range of power ratings? Sylvania has 50 mW and 500 mW units. By physical size? We now have photoconductors in TO-18 packages, in addition to the glass encapsulated T-2s and T-4s; also, the T-33 which is used for our street lighting cells. Specialty PC lines? Sylvania offers custom designed photoconductive matrices as well as both standard and customized photoconductor-lamp (PL) assemblies, and also ultraviolet types. Now with the introduction of the new TO-18 units, the line becomes even more functional. And more and more Sylvania becomes the logical source for all photoconductive devices.*

The TO-18s, latest additions to Sylvania's already varied line of photoconductors, are miniature, end-view packaged, cadmium sulfide cells. Because they are hermetically sealed, the new PCs are not affected by moisture. For the circuit designer, this means stable electrical characteristics and long term reliability.

The light and dark resistance characteristics of the new TO-18 units are similar to Sylvania's T-2 line. Power dissipation rating is 50 mW compared with 75 mW for the T-2 line.

Sylvania's T-2 cells are also miniature photoconductors. With these rugged ¼-inch diameter units, the designer can select devices which have light resistance values in the range of 2000 to 128,000 ohms. Resistance change ratio of the T-2 PCs is better than 100.

The T-4 line consists of ruggedized photoconductors which can withstand 300-g impact shocks and 2.5-g vibrations for extended periods. These ½-inch diameter, end-view cells have high sensitivity and are rated at 400 volts. Light resistance values range from 750 ohms to 16 K ohms. Ratio of dark/light resistance is 100 to 1.

Sylvania's outdoor lighting control cell Type 7163 has a demand rating of 750 mW and a continuous rating of 500 mW. This cell easily operates relays directly in outdoor lighting control circuits. Orientated to north sky illumination, it detects the blue end of the spectrum. A response time faster than is found in the standard T-2 and T-4 photoconductor lines makes the 7163 one of the fastest cadmium sulfide cells and, therefore, a versatile vehicle for more industrial applications.

Because of its small size, the new TO-18 photocell is also an ideal choice for use in PC arrays. Any number of photoconductors can be imbedded in a printed circuit board, depending on the area available. Various pattern configurations and element sizes are possible to meet the demands of dissipation, resistance, and space requirements.

With Sylvania's PC type SRP-3614A, detection and measurement of ultraviolet radiation is simplified. Requiring only comparatively simple low voltage circuitry, a power handling capability of 300 mW enables this device to translate UV to signal levels which can operate a sensitive relay directly. This UV detector is supplied in a T-4 envelope.

In another specialty series, photoconductors and lamps are combined in light-proof housings to perform a wide variety of electronic functions. PL assemblies offer an economical and efficient approach to generating special musical effects. Other circuit applications of PL assemblies include: on-off switching, sequential switching, logic function, gain controls, linear amplification, delays, oscillators, filters, and regulators. These assemblies, like the other units in Sylvania's broad photoconductive devices line, are available in customed versions with a wide range of characteristics.

CIRCLE NUMBER 305

# SUHL circuits can simplify noise and power problems in systems design

*Sylvania's high-level TTL circuits are especially adaptable to systems applications. The inherent characteristics of SUHL units—high speed, low propagation delay time, high noise margin, low power, high fan-out and logic swing, high capacitance drive—can all be advantageously applied to systems design. SUHL is constantly solving designers problems where speed, low power and noise protection are considerations. Some of these aspects of SUHL are discussed below in a section excerpted from a forthcoming Sylvania brochure, "Optimum Design of Integrated Circuit Output Networks."*

In the design of high speed digital integrated circuits, special consideration must be given to circuit output networks.

In nearly all system wiring methods, circuit output loads include capacitance due to the driver loads and associated interconnection wires. This is particularly true in multilayer boards where the capacitance can reach 6 pf per inch. Driving such capacitance at high speeds requires low impedances, with a resulting requirement for additional power dissipation.

Output networks with loadings approaching voltage sources in both the "1" and "0" state are desirable to reduce noise pickup and simplify loading rules.

With most saturated logic, output stage delay in going from the "0" or saturated state to the "1" or OFF state is primarily a function of the storage time of the output transistor. This storage time impairs circuit speed at room temperature and becomes progressively worse as the temperature increases. With proper design of the output portion of integrated circuits, transistor storage time variations can be reduced.

When the principles are examined, the desirability of this output network in a general-use high-speed monolithic circuit will be evident. By judicious use of transistor geometries as well as consideration of the associated life times and the stray capacitance of other components, effective networks such as those illustrated in Figure 1 can be designed.

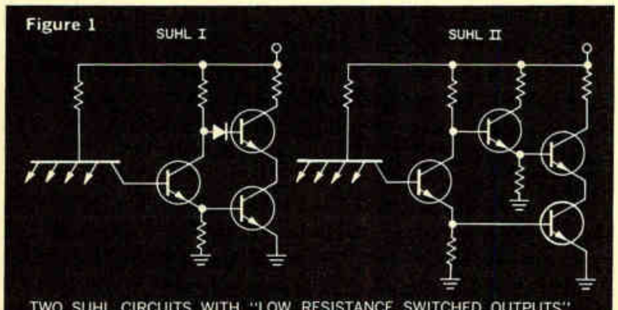
By using an output circuit shown in Figure 1, the pull-up network effectively removes the charge stored in the output transistor and virtually eliminates storage time as a factor in output characteristics. The result is a circuit having a propagation delay time which is constant over the full temperature range of —55 to +125°C. This is particularly evident when compared to high resistor pull-up networks.

The output networks shown in Figure 1 are coupled to a high speed TTL front end. To demonstrate the stability of this type circuit, typical propagation delays versus temperature, fan-out, and capacitance loading are shown in Figure 2.

In the circuit diagrams shown in Figure 1, both the "0" and the "1" output levels are obtained through low impedances. Aside from the drive capabilities, this also provides a stiff source which in turn provides a damping element for reflected signals and for noise pickup in a high speed system.

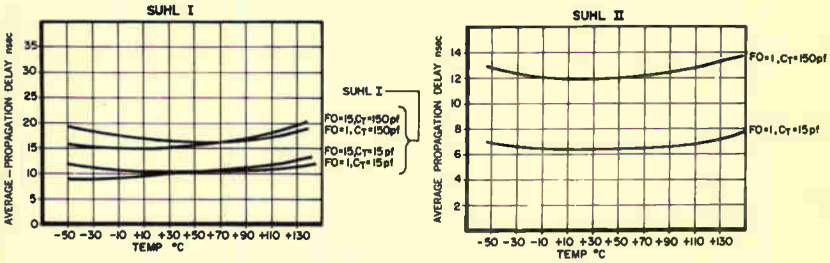
CIRCLE NUMBER 306

Figure 1




TWO SUHL CIRCUITS WITH "LOW RESISTANCE SWITCHED OUTPUTS"

Figure 2




SEE OUR SPECIFICATIONS IN VSMF MICROFILM CATALOG FILE

Use Sylvania's "Hot Line" inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information almost by return mail.

FIRST CLASS
Permit No. 2833
Buffalo, N.Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY

SYLVANIA ELECTRONIC COMPONENTS GROUP

Sylvania Electric Products Inc.
1100 Main Street
Buffalo, New York 14209

Dept. B33

# Low-leakage types included in Sylvania's silicon alloy junction DF-7 series

*Sylvania's DF-7 series of high conductance silicon alloy junction diodes can solve a wide variety of your circuit design problems. In such applications as magnetic amplifiers, modulators, demodulators and power supplies these general purpose diodes combine excellent electrical characteristics, device uniformity and closely controlled manufacturing methods to give reliable operation.*

Device uniformity comes from Sylvania's alloy batch processing techniques with their emphasis on precise control of materials and manufacturing procedure. The user gets uniformity from unit to unit as well as a product less prone to failure. Electrical characteristics of these diodes include high conductance, excellent stability and extremely low leakage. Stringent quality control procedures assure conformance to specification and reliability in operation.

With the DF-7 line, you're not limited to selecting from a narrow range of types. The line includes two general purpose JEDEC groupings (1N456A through 1N464A, and 1N-482A/B through 1N488A/B), a series of low leakage devices (D6623 through D6625), a stabistor (the 1N816) and several voltage variable capacitors (1N3182).

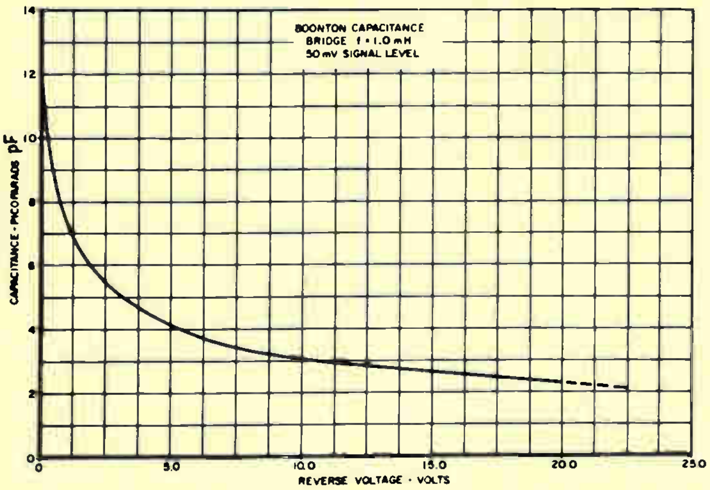
All units have a power rating of 250 mW, and a junction temperature range of −65° C to +175° C. Typical specifications show minimum forward currents of 100 ma at 1V, breakdown voltages of from 30 to 420 volts, and maximum reverse leakage currents of 2 to 50 nanoamps.

The large junction capacitance of these alloy junction diodes means they are less sensitive than epitaxial types to stray triggering pulse in many circuits. This makes these Sylvania DF-7 units ideal for slow speed industrial control circuits where the circuit may be exposed to ac switching transients.

The capacitance characteristic of these alloy units also makes them excellent voltage variable capacitors. Typical capacitance change over a voltage change of 10 volts is on the order of 4 to 1.

All diodes in the line are available in Sylvania's improved DO-7 package with assured hermeticity.

TYPICAL CAPACITANCE VS VOLTAGE DF-7




CIRCLE NUMBER 307

This information in Sylvania Ideas is furnished without assuming any obligations.

SYLVANIA

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS GT&E

NEW CAPABILITIES IN: ELECTRONIC TUBES • SEMICONDUCTORS • MICROWAVE DEVICES • SPECIAL COMPONENTS • DISPLAY DEVICES

NAME ____________

TITLE ____________

COMPANY ____________

ADDRESS ____________

CITY ____________ STATE ____________

Circle Numbers Corresponding to Product Item

300 301 302 303 304
305 306 307

☐ Please have a Sales Engineer call

HOT LINE INQUIRY SERVICE

Need information in a hurry? Clip the card and mail it. Be sure to fill in all information requested. We'll rush you full particulars on any item indicated.

You can also get information using the publication's card elsewhere in this issue. Use of the card shown here will simplify handling and save time.

# Tantalum A Go-Go

**KEMET C-Series Solid Tantalum Capacitors.** For the swinging new mood in consumer electronics.

You don't have to be rich to buy these low-leak tantalums. We've priced them in line with standard electrolytics. Yet they'll give you tantalum performance in transistor auto radios, portable phonographs, tape recorders—the mass-produced products that keep today's consumers turned on.

We make the KEMET C-Series in 0.1 to 220 microfarads, 6 to 50 vdc, for environments from −55° to +85°C. Catalog items are available for immediate or lightning-fast delivery, in any quantity from thousands to millions.

Shouldn't you go tantalum for today's go-go products?

For details, call our representative, or mail the coupon.

Clip, fill in name and title, attach to letterhead.

Union Carbide Corporation
Components Department
Dept. E-33
P. O. Box 5928
Greenville, S. C.

UNION CARBIDE
ELECTRONICS

Please send details on "C" Series
KEMET Solid Tantalum Capacitors

Name____________________

Title____________________

KEMET is a registered trade mark of Union Carbide Corporation.

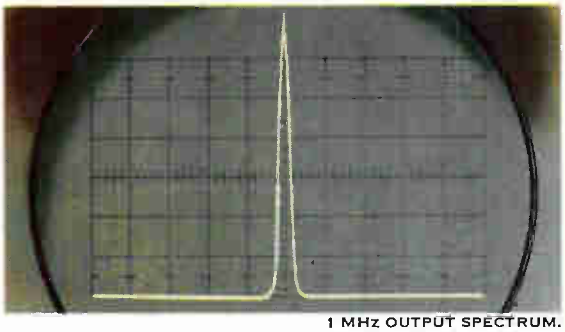
**REGIONAL SALES OFFICES. New England:** T. J. Roper, 300 First Ave., Needham Heights, Mass. Phone: 617-444-5400. **Mid-Atlantic:** R. H. Robecki, 1341 Hamburg Turnpike, Wayne, New Jersey 07472. Phone: 201-696-2710. **Mid-West and South:** K. S. Collart, P. O. Box 6087, Cleveland, Ohio 44101. Phone: 216-221-0600. C. F. Fields, 2 Talcott Road, Park Ridge, Ill. 60068. Phone: 312-825-8189. **West Coast:** D. Purcell, 701 East Whittier Boulevard, Whittier, California 90605. Phone: 213-698-8077. C. E. Volpe, 2680 Bay Shore Frontage Road, Mountain View, California 94041. Phone: 415-969-9390. **For Overseas Inquiries contact:** J. G. Egan, 1341 Hamburg Turnpike, Wayne, New Jersey 07472. Phone: 201-696-2710.

Circle 35 on reader service card

# Now there's a "4th generation"

# of signal instrumentation

**This new Monsanto™ Model 3100A Digital Frequency Synthesizer has a computer-optimized design that creates new standards of stability, purity, precision and value for general purpose signal generators.**



1 MHz OUTPUT SPECTRUM.

Gather 'round and look it over. From its clean, functional, prize-winning* cabinet to its all-solid-state, I/C circuitry, this unique design is all new . . . the first of our "fourth generation" instruments.

The 3100A outperforms all other synthesizers. Select or program any frequency from 0.01 to 1.3 MHz (in 130 million steps). You've never had it so pure—from any signal source. Harmonics are down at least 50 db, and spurious components are down at least 80 db! Stability? 1 part in $10^9$/day, by an oven stabilized crystal oscillator.

The output is DC coupled with a ± 2 v offset bias control at a constant 50 ohms, through an accurate 90 db stepping attenuator. There is a flexible dual-frequency internal sweep and external AM, too. For maximum computer-system compatibility, the programming time is less than 20 microseconds. This versatile instrument has more of what you need in a signal source.

Here is the clincher. At $3950, the Monsanto 3100A sells well below old-styled frequency synthesizers. (USA price f.o.b. New Jersey) Write or phone us for the full story. Monsanto Electronics Technical Center, 620 Passaic Avenue, West Caldwell, N.J. 07006 (201) 228-3800.

*First Prize, Enclosures, NEP/CON '67 West.

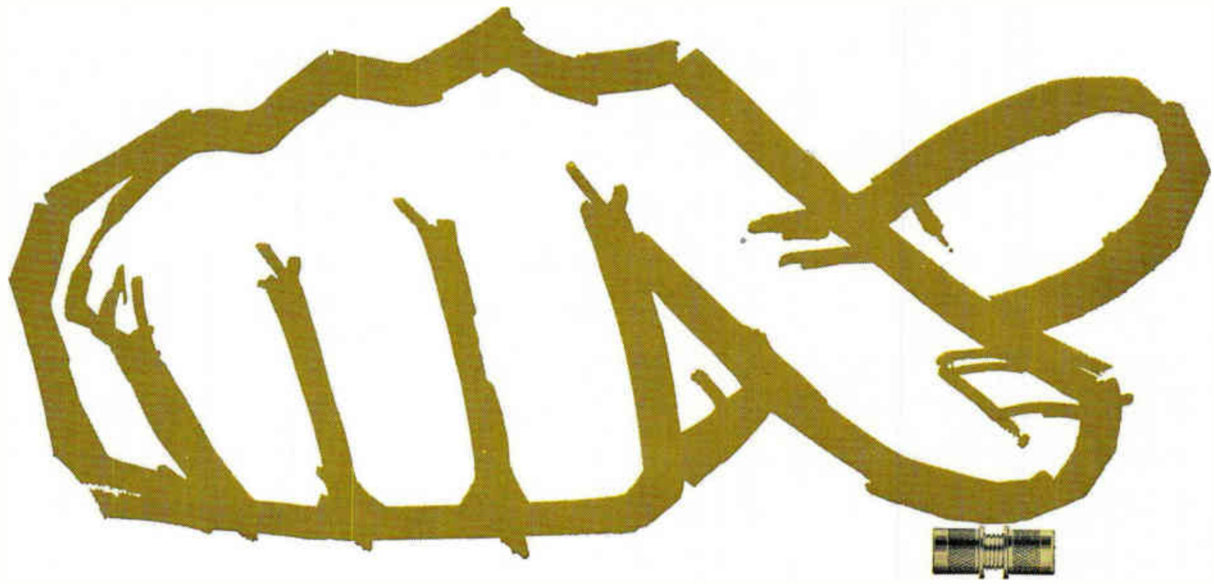
Monsanto®

ELECTRONIC

INSTRUMENTS

Circle 37 on reader service card

# PUT YOUR FINGER ON REAL MINIATURIZATION



It's one thing to build small connectors. It's something else again to make them tiny *and reliable.* Like BRM, designed and developed by BENDIX/DAGE. BRM is one-fourth the size and weight of standard BNC and TNC, yet is loaded with quality features such as hermetic sealing, captive contacts, gold-over-silver plating . . . and low, *low* VSWR. That's *real* miniaturization. BENDIX/DAGE engineering contributes to the state of the art by helping *you* move forward to greater capabilities in *your* field.

Write for BRM/BRMM brochure and Engineering Qualification Test Reports. If you have a special problem, call. Call today!

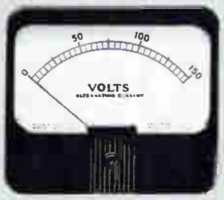
Bendix

**DAGE ELECTRIC COMPANY**

a subsidiary of the Bendix Corporation

Hurricane Road • Franklin, Ind. • Phone 317/736-6136

FIRST WITH IDEAS • FIRST WITH QUALITY • FIRST WITH SERVICE

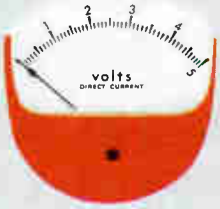



Time's up:

Honeywell now has a taut-band meter that actually goes for even less than a pivot-and-jewel meter. (About 10% less, on the average.)

What kind of a taut-band meter could we possibly sell at those prices?

An ingeniously simple one.




We designed every single unnecessary part right out of it. (Fewer parts: fewer things to go wrong.)


And we make this meter by machine. (This not only gives us a very good cost advantage. It also gives you a more reliable meter.)

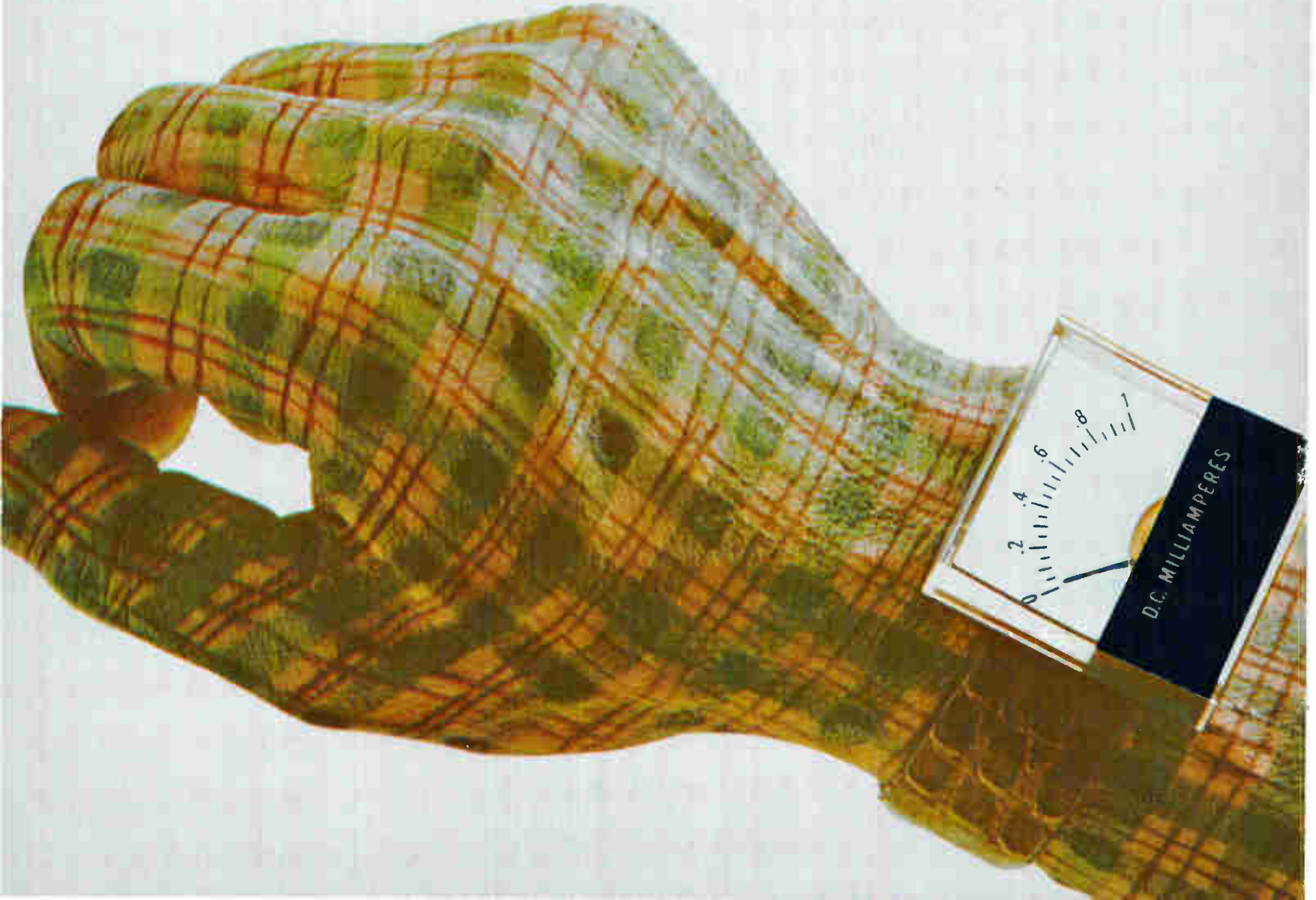
It'll last practically forever because there's no friction in the moving parts. It'll mount anywhere without special calibrating because it's self-shielded.

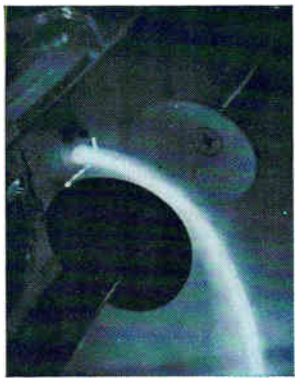
And you can get one of these low-cost taut-band meters in just about any style you like.

But don't make up your mind yet. Take a look at our catalog first. Write Honeywell Precision Meter Division in Manchester, N.H. 03105.

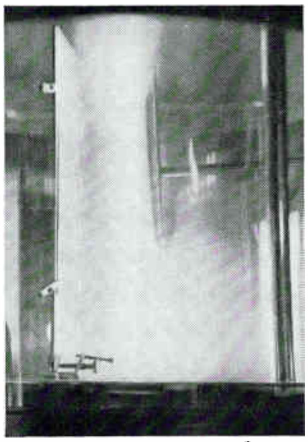
**Honeywell**

# How long have you waited for a low-cost taut-band meter?





Electron Beam Gun.



Plasma-Vac® low-energy sputtering with RF capability.

CV-type coaters.


# Thin film and CVC

Here's all the equipment you need to put thin-film techniques to work on a research or production basis . . .

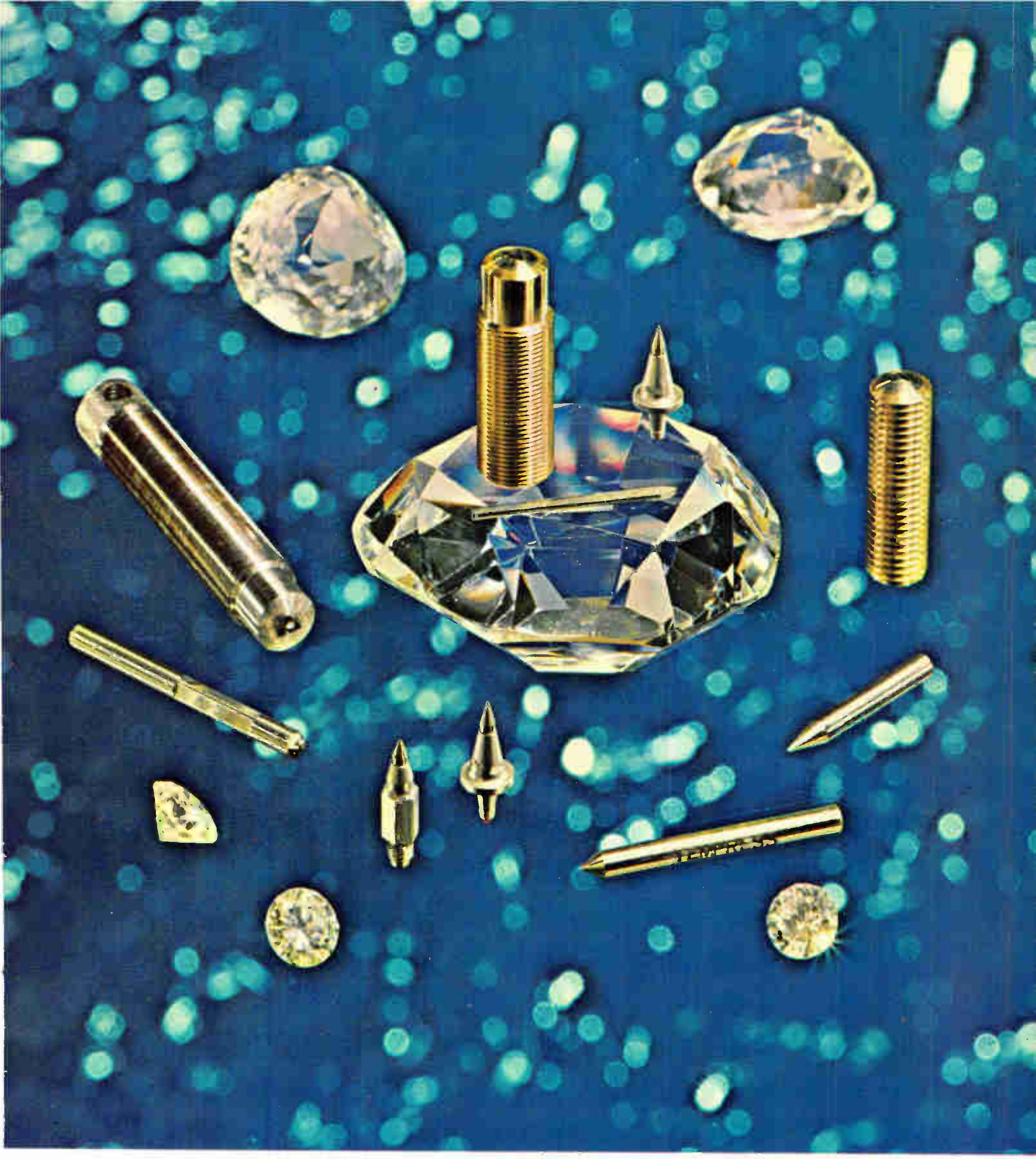
CVC's PlasmaVac® low-energy sputtering system gives you controlled deposition of metals, alloys, semi-conductors and insulators. Quality and yields are of a degree that make production-line operations a commercial reality.

Or, if your research or production application calls for resistance heating or electron beam gun evaporation, CVC has the equipment you need.

More important to you, we have the technological background and the applications laboratory to analyze your requirements and help you decide which thin-film deposition method will best handle your application.

Let us know how you would like to use thin-film deposition. We'll be glad to make recommendations. Consolidated Vacuum Corporation, 1775 Mt. Read Blvd., Rochester, N.Y. 14603. A subsidiary of Bell & Howell.

CVC



# Micro-machined from Jewel-hard Materials

SEMICONDUCTOR PRODUCTION TOOLS ARE THE EXCLUSIVE PRODUCTS OF TEMPRESS RESEARCH COMPANY, based on unique processes developed by Tempress engineers for micro-machining diamonds and jewel-hard materials, such as titanium and tungsten-carbide. The company has become the principal source for the nation's leading semiconductor manufacturers because of the extreme durability and precision of these tools, immediate delivery from stock, and constant, personalized service at a high technical level. Among the Tempress products displayed on this page are: hydrogen flame-off torches, tungsten carbide lead bonding wedges, tungsten carbide lead bonding capillary tubes, diamond scribing tools, tungsten carbide probe contact needles, and diamond lapping points. If you have a requirement for any of these devices, let us place a highly detailed booklet in your hands, listing specifications, prices, and ordering information. Please write to us, noting the name of your company, address, and your specific applications.

DIAMONDS COURTESY OF MICHAEL WERDIGER, INC.

**TEMPRESS**

Tempress Research Co., 566 San Xavier Ave., Sunnyvale, Calif.

Circle 41 on reader service card


# *Sure, DVM's have to be fixed*

Cimron just makes it easy! We all know digital voltmeters are influenced by environment and the work demanded of them—and they do have to be calibrated at times. So Cimron makes it easy by etching this procedure on the guard shield. Lift 4 screws and you can do it in 15 minutes. That's Cimron's customer concern in action, a philosophy you'll see at work in everything from the way the instruments operate to after-sales interest. Premium Line P9000B Series Instruments offer a 3-year warranty; 5 digits, automatic, programmable or manual ranging; 1 year stability of 0.001% F.S.+0.01% of reading; ratio, AC, low-level DC, resistance, true RMS available as options. Price: the P9200B DVM, $3190. Write Cimron, Dept. A-101, 1152 Morena, San Diego, California 92110.

CIMRON
*A Division of*
*Lear Siegler, Inc.*


IEEE BOOTH: 4J31-33


# 500 to 1,000 V.

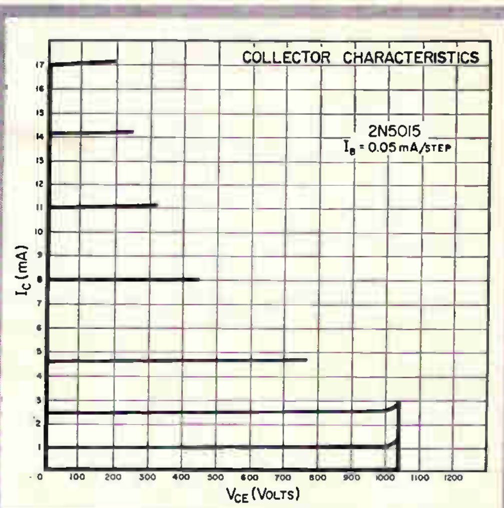
# VOLTAGE

## NPN SILICON TRANSISTORS

| DESIGN LIMITS | | | | | |
|---|---|---|---|---|---|
| Type | $BV_{CBO}$ Volts | | $BV_{CER}$ Volts | $BV_{EBO}$ Volts | PT Watts |
| | $I_C = 0.1$ MA | $I_C = 0.2$ MA | $I_C = 0.2$ MA $R = 1K\Omega$ | $I_E = 50$ $\mu A$ | @100°C Case |
| | Min. | | Min. | Min. | Max. |
| 2N5010 | 500 | | 500 | 5 | 2 |
| 2N5011 | 600 | | 600 | 5 | 2 |
| 2N5012 | 700 | | 700 | 5 | 2 |
| 2N5013 | | 800 | 800 | 5 | 2 |
| 2N5014 | | 900 | 900 | 5 | 2 |
| 2N5015 | | 1000 | 1000 | 5 | 2 |

| PERFORMANCE DATA | | | | | | |
|---|---|---|---|---|---|---|
| Type | $h_{FE}$ | | $V_{BE}$ Sat. Volts | | $V_{CE}$ Sat. Volts | |
| | $V_{CE} = 10v$ | | $I_B = 5$ MA | | $I_B = 5$ MA | |
| | $I_C = 25$ MA | $I_C = 20$ MA | $I_C = 25$ MA | $I_C = 20$ MA | $I_C = 25$ MA | $I_C = 20$ MA |
| | Min. | | Max. | | Max. | |
| 2N5010 | 30 | | 1.0 | | 1.4 | |
| 2N5011 | 30 | | 1.0 | | 1.5 | |
| 2N5012 | 30 | | 1.0 | | 1.6 | |
| 2N5013 | | 30 | | 1.0 | | 1.6 |
| 2N5014 | | 30 | | 1.0 | | 1.6 |
| 2N5015 | | 30 | | 1.0 | | 1.8 |

Now in stock! A complete line of high voltage diffused npn silicon transistors. The 2N5010–2N5015 series has a voltage range of 500 to 1,000 volts. They are available in either a TO-5 or flanged package. These high voltage silicon transistors can extend many standard applications as well as open the door to new design capabilities (i.e., replacing vacuum tubes for driving CRTs). For complete information on these and our full range of intermediate and lower voltages, call or write today.




# M. S. TRANSISTOR CORPORATION

SUBSIDIARY OF SILICON TRANSISTOR CORPORATION

Executive offices and main plant: EAST GATE BLVD., GARDEN CITY, N. Y. 11530 (516) Pioneer 2-4100, TWX 510-222-8258

# Bendix Pancake connectors can cut weight 60%, length 50%.

# Call them JT for short.

That's their name: Bendix® JT Pancake™ connector. And you might say they're just short of phenomenal. They're the smallest, lightest miniature cylindricals available. They're versatile, too. You can choose from crimp, solder, hermetic, potted, or grommetted versions. You can select from eight shell styles including wall mount, box mount, jam nut, straight or 90° plug. You can choose from nine different shell sizes. From 40 different insert patterns, with 16-, 20-, 22- or 22M-contact sizes, that will accept a wire range of 16 through 28 gage.

Bendix JT Pancake connectors make short work of other problem areas, too. With provisions for up to 128 contact pins in our Double-Density models, increased resistance to pin bending, greater contact retention, temperature capabilities up to 392°F and improved electrical characteristics through rigid, glass-filled epoxy inserts. For a short description of the Bendix JT connector best suited to your application, write Electrical Components Division in Sidney, New York 13838.

**Bendix Electronics**

Circle 44 on reader service card

# Electronics Review

Volume 40
Number 6

## Avionics

### Aiming for AAFSS

Honeywell Inc. has developed a system that literally requires that a pilot use his head to control a helicopter's navigational computer, armaments or reconnaissance cameras.

The aiming system, developed as an in-house project by the System's and Research Division in Minneapolis, is being proposed for use on the newly developed AAFSS (advanced aerial fire support system). The first production models of this helicopter are expected to fly shortly, and the Army plans to test the Honeywell aiming system some time in June.

Completely controlled by head movements, the system reportedly reacts fast enough to track a target while the craft is flying as fast as 660 knots or at altitudes as low as 150 feet.

**Light link.** The basic idea for such a hands-off control is hardly new, but earlier designs lacked the required accuracy and maneuverability. Further, older units had a mechanical link between the pilot and the steering mechanism which limited the pilot's movements. The Honeywell system's link is a beam of light.

The system consists of a target sight attached to a plastic band which fits over the pilot's helmet, four photodetectors (two on each side of the helmet), two low-intensity light sources (one on either side of the cabin) that produce rotating beams, a small special-purpose computer, and an on-off switch for the system.

To aim the system, the pilot merely sights the target through his eyepiece and flips the switch. This action aligns the navigational system, the armaments, or the cameras onto the target. Naturally, though, he must not view the target out of the corner of his eye—he must sight it head-on.

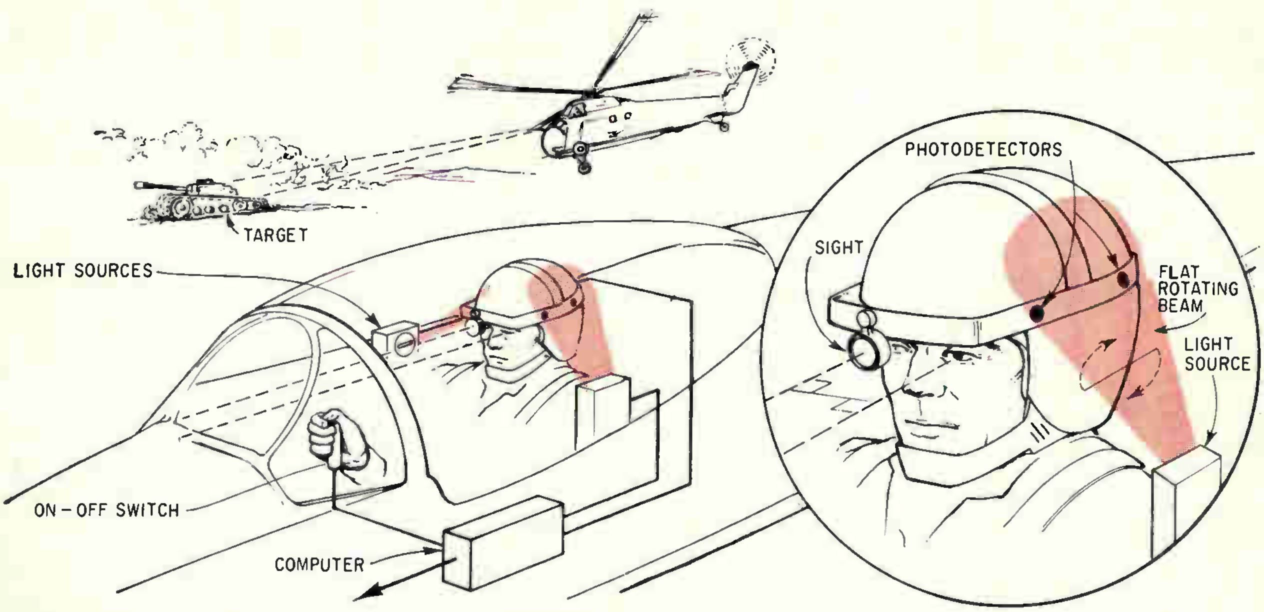
The spatial relationship between the four sensors and the two light sources provides all the information necessary to calculate the position of the pilot's head and to establish the line of sight to the target.

Since the lights are clamped to the sides of the cabin, only the sensors move—in tandem with the pilot's head motion.

The sight is mounted on the headband so that its projection axis is parallel to the axes of each pair of photodetectors. Thus, the pilot can adjust the sight in any axis without affecting the alignment of the system.

**Angle solution.** As the two lights spin around, their thin beams hit each detector in sequence; the time interval between the triggering of each sensor is a measure of the angle between each light source and each pair of sensors. Hence the position of the pilot's head relative to the light sources is calculated by simple trigonometry.

The angle-resolving computer is designed with digital integrated circuits; it translates the time intervals into angles and subsequently into azimuth and elevation signals for the aiming mechanisms




**Using his head.** When helicopter pilot has target lined up in sight, he flips on-off switch and then computer system aims weapons or reconnaissance cameras automatically.

of the weapons or cameras.

A headband unit weighs 13 ounces, while the total system, with sufficient hardware for two headbands (one for the pilot and one for the copilot) weighs 35 pounds.

Honeywell concedes that its system is more expensive than all the previously tested designs, but it won't say how much the Army paid for the nine prototypes it recently delivered.

## Integrated circuits

### Mask program

One of the most tedious, error-prone steps in integrated circuit manufacture is making the set of diffusion and metalization masks. Cutting the master by hand often results in errors that show up only after the complete circuit has been built, when much time, effort, and money has already been invested in the diffusion masks. With a new computer program developed at International Business Machines Corp., however, it can all be done automatically.

Working from instructions based on a simple hand sketch of the chip layout, the computer generates a tape to drive a light table. The light table traces out each of the complex circuit diffusion masks on a photographic plate 10 or 20 times larger than the eventual circuit on the wafer. The masks then are inserted in a step-and-repeat camera and each image on the wafer is exposed in sequence.

**Chip built.** IBM engineer Dale L. Critchlow of the Yorktown Heights, N.Y., research center will describe the process later this week in a paper at the IEEE convention. He reports that a 55-circuit metal oxide semiconductor chip has been built and the art work for a 100-circuit MOS chip has been produced. Art work for a 50-circuit bipolar chip also has been produced.

The key to the development is the new computer program. The designer, working from his planned layout of the chip, can instruct the computer to generate commands to the light table at several levels of complexity. Once he has described a transistor geometry to the computer, he can give it a code name and, if it is used again, he need only refer to it by its code and the computer will reproduce the previous set of instructions. He may also work at the logic circuit level; after describing a NOR gate, for example, he need only refer to it by code name to have the computer reproduce the whole circuit in subsequent locations.

**Checking syntax.** Once the program is entered in the computer, the machine examines it for consistency of syntax and then separates the diffusion and the metalization instructions. It then generates tape for each of the masks. The light table can produce the oversized masks in a relatively short time: 1 hour for a MOS chip with 100 logic circuits and about one-half hour for the 50-circuit bipolar chip.

In conventional techniques, the mask must be cut out manually, line by line—a chore that sometimes takes days.

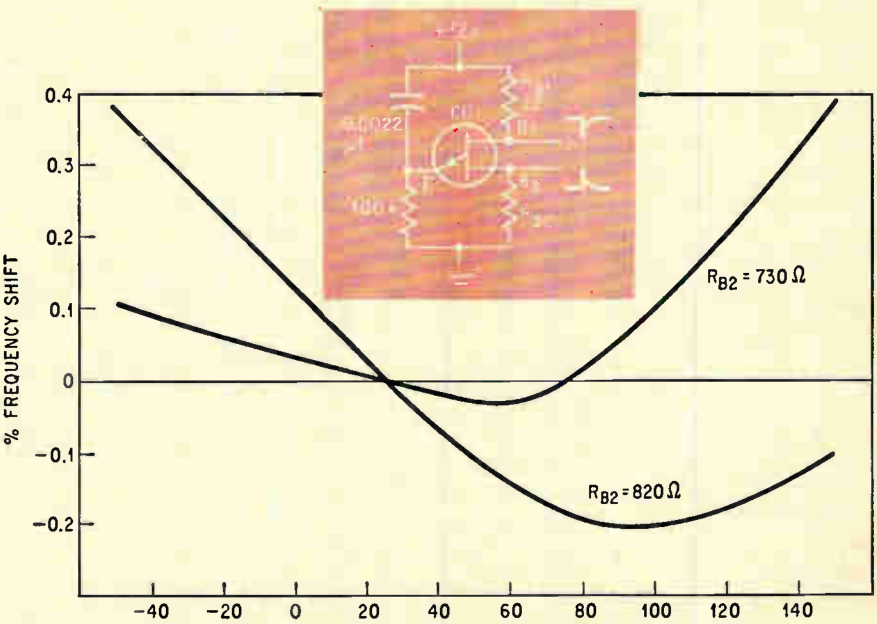
The designer still must do the basic layout of the chip. The computer does not make decisions on optimum use of chip areas, for example. However, IBM has previously reported success with computer-generated art work for metalization patterns whose routing is under control of the computer. The two programs have not yet been combined, but that is the next logical step, IBM says.

## Solid state

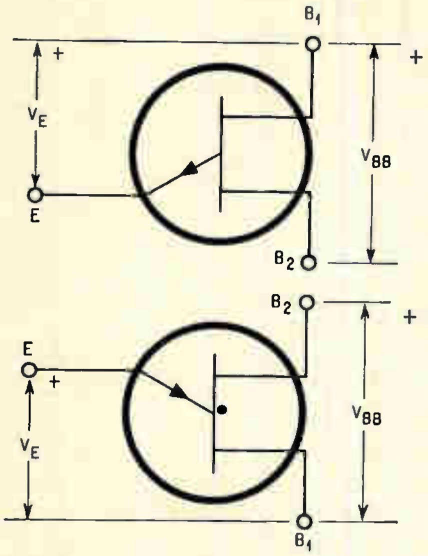
### Unijunction rivals crystal

Until now the unijunction transistor has failed to crack applications such as television sweep circuits chiefly because of its poor stability at higher frequencies. But the General Electric Co.'s semiconductor department has developed an integrated circuit that performs like a unijunction. The device, GE says solves the stability problem and may open up new markets when its price is reduced.

Oscillators built with the new device will be demonstrated at the IEEE convention this week. They exhibit accuracies as good as 0.5% over the —55°C to 150°C range at frequencies up to 50 khz, rivaling crystals for accuracy. Previous unijunction oscillators were hard pressed to meet an accuracy of




**Despite wide change in value of base-2 bias resistor the frequency shifts less than 0.5% in a 5-khz relaxation oscillator built using GE's new unijunction transistor. Bias resistor is selected to get curve closest to zero frequency shift line.**




Complementary unijunction, top, has all currents and voltages reversed from standard unijunction. The complementary unit is made in IC form.

±5% over the same temperature range and useful oscillators above 50 khz were virtually out of the question.

**Basic steps.** Key to the IC unijunction's stability is the excellent temperature tracking and accurate ratios of the interbase resistors. They are fabricated as p-type diffused resistors directly in the monolithic silicon chip. The chip is about 25 mils square. The temperature coefficient of the interbase resistors is 0.25% per °C, compared with about 0.8% per °C for conventional unijunctions. The temperature coefficient is also more linear. Thus, GE engineers note, oscillators and timers for the first time can be precisely temperature compensated and calibrated in just one step at room temperature.

Because of the way it is fabricated, the new device turns out to be the complement of existing types. That is, it operates as a p-type unijunction device; all polarities are reversed from those of the usual n-type unijunction. Although the polarity inversion was not part of the original design goal, GE engineers think that new circuits will be generated that use both n- and p-type unijunctions in complementary fashion, much as npn and pnp transistors are now used.

The magnitudes of the IC unijunction characteristics are comparable to those of the standard devices except for emitter reverse-breakdown voltage, which is only about 9.5 volts. Intrinsic standoff ratio, for example, is about 0.6. Since intrinsic standoff ratio is a function of the ratios of interbase resistances, however, it is accurate to within ±1%.

Because of the complementary function, GE will call the device a complementary unijunction, designating it CU. The first device in the line is the CU-5K1; it is priced at $4.64 each in lots of more than 100.

## Germanium's hot

Most germanium transistors are rated at a maximum temperature of about 85°C, compared with 200°C for silicon. Texas Instruments Incorporated has refined a technique which will permit germanium devices to operate satisfactorily at a free air temperature of 125°C and possibly even 150°C.

The method, originally developed to take advantage of germanium's inherent speed, is a planar technique in which a silicon dioxide layer is deposited atop the germanium starting wafer [Electronics, April 6, 1964, p. 62]. The fine geometries and tight tolerances needed for high-frequency operation are made possible by the silicon oxide. With it, photolithographic processes like those used in making high-frequency silicon devices can be carried out. Without it, geometries are gross and frequencies limited. For example, emitter and base stripes of conventional germanium devices run about a mil in width, since 0.5 mil wires must be bonded to them. Stripes for the new planar germanium devices can be made an order of magnitude smaller because the wires are bonded to expanded contact areas that are easy to make by the planar method.

The silicon oxide layer is deposited to a thickness of about 2,000 angstroms by a pyrolytic decomposition technique.

**A myth.** The higher permissible temperatures for the devices have been determined experimentally by Texas Instruments. The old maximum of 85°C, TI engineers reasoned, was partially a myth. It had been perpetuated from the days of antimony-doped devices. With them, low temperatures could cause impurity migrations and failure at the wafer's surface. Several of today's improved alloy germanium devices are already rated at 100°C and others can probably operate at that temperature, TI notes, even though specification sheets continue to list the 85°C maximum.

The silicon-oxide coated germanium offers even greater protection against surface instabilities under high temperatures, and results in the permissible rating of 125°C. All planar type germanium devices ought to be able to pass the full military specifications for temperature, TI thinks, and already has some devices under test at 150°C.

**Low noise.** Another feature of the planar germanium transistor is low noise. At frequencies above 200 Mhz, noise figures of the new devices are typically 2.0 decibels better than those of low-noise silicon transistors.

A planar germanium transistor to be announced by TI this week will be rated at 125°C free air temperature, have a noise figure of 2.5 db at 400 Mhz, and a minimum $f_T$ of 1,500 Mhz. It has a permissible 15 mw dissipation that can be doubled if the temperature is reduced to 100°C.

Because of its high-frequency capabilities, the new transistor, type 2N5043, will be characterized by scattering parameters [Electronics, Sept. 5, 1966, p. 78]. It's the first transistor to be so characterized, according to TI.

## Advanced technology

## Forget it

After four years of effort the Itek Corp. seems ready to give up on its plans for a marketable photo-optical memory.

Indications are the project will remain a laboratory development.

Says Itek president Franklin A. Lindsay: "It [the prototype] was brought to the stage which clearly demonstrated the technical feasibility of using optical techniques for storage and retrieval of digital information. But it has also become evident that the equipment we have actually built was not sufficiently reliable for continuous operation, because of defects in some of the electronic circuitry and in some of the electromechanical components in this particular equipment."

**Laser woes.** Modulation of the laser beam is believed to be one of the problem areas, but the company declines to elaborate.

In 1964, Itek disclosed plans for an information processing service center in New York City to be built around a memory-centered processor using the laser memory. The center was to keep look-up files for insurance companies, government agencies, and others needing massive record-keeping.

At the time, Itek had brought in, as a vice president, Gilbert W. King, formerly a researcher at the International Business Machines Corp., to head its then newly formed Digital Data Systems division. King left the company in June 1965, about the same time Itek dropped its plans for the New York center and decided to install the equipment in its Lexington plant.

The memory-centered processor, called Photostore, was conceived as a peripheral system that would tie in with conventional computers. "We are not going into the general computer business," Lindsay had said often. Photography-based technology, rather than a magnetic storage medium, was to be used in data processing. The reasons given were that photographic materials inherently offer higher storage capacity, and writing and reading by a light beam is simpler than moving a magnetic head.

The long-range goal was to use a new photo-sensitive material being developed by Itek, but the prototype memory used a conventionally sensitized disk. These disks could be stacked to produce a mass memory device that far exceeded anything available in magnetic storage, Itek claimed.

The prototype stores 15 million bits of information that can be searched at a rate of 4 million bits per second. The laser, a helium-neon design that operates at 25 milliwatts, continuous power, writes at the rate of 100,000 bits per second and reads at a rate of 4 million bits per second in serial operation.

**Remember.** According to Lindsay, experience indicates that in a second-generation photo-optic memory device, density could be increased from 5 million to 20 million bits per square inch and the laser writing rate could be stepped up to a million bits. Units containing many disks, says Lindsay, could provide storage for a trillion bits in 2 cubic feet, with a random access time of no more than 3 seconds. "And we should be able to read and transfer information to a computer at the rate of 25 million bits a second," he told a group of New York security analysts less than five months ago.

Itek in recent years also has been exploring the possibility of using the high-capacity memory for automatic transcription of stenotype notes on a service basis. A day's proceedings in a courtroom, or at an administrative hearing, could be transcribed and printed out shortly after adjournment if the stenotypist's notes were continually being fed to a computer system with a high-capacity look-up memory.

The stenotype project is continuing at Itek, but the work reportedly will be done using a commercially available computer.

## Computers

### Strong attraction

Despite the onrush of new electrical and electro-optical techniques for logic and memory functions in data processing, magnetic techniques remain attractive. In fact, the all-magnetic computer is a continuing goal among some research groups. In addition to advantages in power consumption, reliability, radiation resistance, and size, a magnetic device is nonvolatile. If power fails, the information is not lost; the device will remain in its magnetic state, essentially forever.

This is the major feature of a new thin-film shift register developed by the Laboratory for Electronics Inc. of Boston. It's the first commercial product to emerge from a four-year research program on domain-tip propagation logic [Electronics, May 2, 1966, p. 25]. The device provides synchronous or asynchronous operation at a speed of 350 kilohertz. Storage capacity is 2,048 bits.

**Compete with cores.** The memory element, including electronics, weighs 1 pound and measures 4 by 7 by ⅞ inches. According to Robert A. Barbary, product manager, it will compete with delay lines, core- and metal-oxide-semiconductor arrays for initial applications in data recorders, communications buffers, airborne flight recorders, desk-top displays tied to time-shared computer systems, and in machine-tool control directors.

Domain-tip propagation logic uses magnetic domains that are confined to a pattern of narrow zig-zag channels photoetched in a film element. Information is stored in the form of reversed magnetization, the opposite polarity from the surrounding film. The information is propagated through the channels by an applied field that expands the domains at their tips, which are spikes of magnetic force. The direction of domain-tip propagation is controlled and domain tips within adjacent channels interact to build logic and memory networks.

To obtain a high coercive force outside the propagation channels, and thus provide magnetic stability, a thin film of aluminum is evaporated onto the glass substrate prior to deposition of the nickel-iron-cobalt film. This underlayer increases the coercive force of the overlying magnetic film. By photoetching, the aluminum film is removed in the regions which are to become the low-force channels under the influence of applied magnetic fields. The evaporated magnetic film will be of high coercive force except where the aluminum


*To be shown at the 1967 International Exhibition of Electronic Components, Paris, France — April 5-10 and the Hanover Fair, Hanover, Germany, April 28 - May 7.*

# Adlake Presents The Series 15000 Form D Sensitive Relays

Complementing our extensive line of mercury wetted contact relays, the Series 15000 Form D Relays are available in several packages: plug-in styles (standard, miniature and sub-miniature), wax filled and epoxy molded for printed circuit boards, in addition—the newest concept in relay packaging—Adlake Type AW.

Typical of Adlake's proven-in-industry neutral Form D and sensitive Form C Mercury Wetted Contact Relays, Series 15000 Form D relays are manufactured under strict supervision and quality control conditions.

To learn more about this quality product, its advantages and details of the entire line address your inquiry on company letterhead to Dept. RLL and ask for Bulletin 15000.

**THE ADAMS & WESTLAKE COMPANY**
Elkhart, Indiana U.S.A. 46514 • Phone (A.C. 219) 264-1141

Adlake SINCE 1857

**TRANSPORTATION EQUIPMENT • ARCHITECTURAL PRODUCTS • MERCURY RELAYS • DOORS AND ENTRANCES • CONTRACT MANUFACTURING**

has been removed.

Connection with the electronics is made through inductive coupling with coils etched in copper and bonded next to the film surface. Since both coils and the film element can be batch fabricated, basic manufacturing costs are low, according to the officials of the Boston company.

The electronics consists of logic, a timing circuit, four current drivers, and a sense amplifier. Logic and timing are provided by standard diode-transistor-logic integrated circuits. The magnetic field sequence required to produce the shifting of information through the zig-zag path is furnished by three bipolar current drivers, pulsed through the etched copper conductors. Writing is accomplished by a pulse applied by the write driver through a conductor. Another conductor is connected to the sense amplifier for reading.

## Writing style

Man - machine interaction boils down to two problems: how does the computer user enter information into the machine and how does he get it out inexpensively. Sylvania Electric Products Inc. is about to introduce a graphic input tablet that will cost less than $6,000. Currently available hardware, such as the Rand tablet, costs about $10,000.

Developed at Sylvania's Applied Research Laboratory in Waltham, Mass., the data tablet, with an electronic ballpoint pen, is being demonstrated for the first time at the annual IEEE convention in New York this week.

Like other data tablets, it permits the user to communicate with a computer through symbols and diagrams. But unlike most of its predecessors, the Sylvania tablet is transparent. It can be placed over the face of a cathode-ray tube to change data already in the computer. With most other graphic input devices—including the Rand tablet—the operator has to look up and down, at the display and then at the drawing surface. Also, conventional tablets transmit digital signals only; the Sylvania tablet can also send analog signals over low-bandwidth wires (such as telephone lines) to remote locations.

The Sylvania device employs a new phase-detection technique, which does not depend on contact between the pen and the conductive surface. Hence paper or film can be placed over the tablet to produce a permanent copy of the graphics.

**Light tracker.** The new device measures pen movements as small as 0.003 of an inch. It has a higher speed than a stubby light pen, which has to capture and then track a point of light on the crt surface, detecting the displacement of the spot. This process also takes up extra computer power.

According to Roy P. Sallen, head of the engineering department at the Sylvania laboratory, the earliest applications will probably be in computer-drive displays for the military and for research projects. The equipment will also be marketed for computer-aided design applications in the automobile and other industries.

In military tactical situations, data on friendly and hostile positions can be changed on the display as new intelligence is received; these changes are fed to a computer to calculate speed and direction of enemy movements, and simultaneously transmitted to field commanders for television display.

In addition to horizontal and vertical coordinates, the pen senses its distance from the conductive surface, and four separate positions in this Z axis can be used to convey further information. These levels can be programed to produce broken lines, dots and dashes, thin lines, or other variations.

"We have no intention of trying to solve the whole computer graphics problem," says Sallen. "We've concentrated on a convenient kind of entry device."

The idea for the tablet goes back more than a decade to work on radar pickoff techniques. Then, as now, most of the problems with such techniques came from the necessary physical contact between a pen and a conductive surface. "We resurrected the search for a device which does not depend on such contact," says Sallen.

In the Sylvania tablet, the conductive film is imbedded in the tablet, sandwiched between two layers of glass. The stylus—which uses an ordinary ballpoint pen filler for the metallic tip—is coupled capacitively to an electric field created along the metal-oxide film, which is the heart of the sandwich.

**Phase detector.** "Since the pen detects phase, not amplitude," Sallen points out, "it is less sensitive to stray signals." Amplitude detection is used only to give the system a crude idea of where the pen is on the tablet. The phase variations are then detected at a rate of 200 points per second as the pen moves in horizontal and vertical directions.

Sallen reports that limitations of the present device arise principally from the conductive film, which is coated onto a substrate by glass manufacturers. It is not a precision process at the present time. "The methods we use to excite the surface help performance by counteracting some of the nonuniformities in the film," says Sallen. But in 99% of the applications, he claims, the linearity, or positional accuracy, is more than adequate. The linearity is specified as 1 part in 100, or 1% of full scale in each coordinate.

Sallen would like to explore market possibilities for a less accurate tablet. "For some areas—like architectural engineering and kinds of computer-aided design—you could loosen up on resolution and accuracy and come up with a less expensive but very useful design aid," he claims.

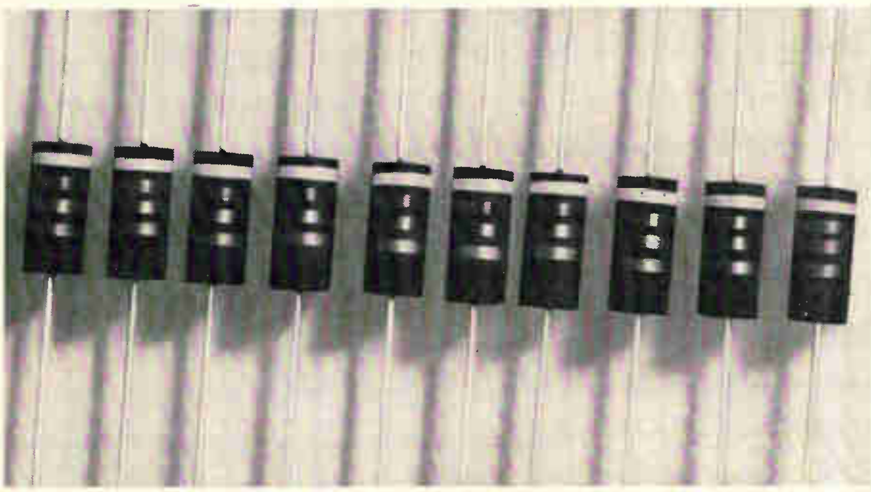
## Industrial electronics

## Great expectations

Full-scale deployment of the worldwide Omega system will open up a new market for very-low-frequency navigation equipment that could easily exceed $1 billion over the next five or so years. The giant plum is being eyed eagerly by at least five producers of vlf receivers

# SPEER COMPONENT COMMENTS

## 9 out of 10 of our SC commercial resistors will deliver military quality. We're just not sure which 9



Nevertheless, you'll have to admit that those are pretty good odds.

The secret of our superior commercial carbon composition resistors is that they aren't, strictly speaking, "commercial" resistors at all.

They're made from the same materials—on the same equipment—and with the same in-process quality controls—as our MIL-R-11 and MIL-R-39008 "military" resistors. In fact, the only thing that sets our SCs apart (aside from having to meet merely commercial AQLs) is that they don't undergo the costly testing required for military documentation.

But if they did, there'd be a better than 90% chance that they'd meet even the stringent MIL-R-39008 specifications!

Are you paying for more commercial reliability than you actually need? Why not get more reliability than you actually pay for? Come to Speer—where the odds are definitely in your favor.

For complete information about our generous SC commercial resistors, mail the coupon.

## Here's a capacitor that can give your assembly line a run for its money

High-speed production assembly operations happen to be rather rough on some kinds of capacitors. If you've been stymied by this particular problem, it's time we put in a good word for the Type JM fixed composition capacitors made by our Jeffers Electronics Division.

With their dimensional uniformity, rugged construction, small size and axial lead wires, these inexpensive general-purpose units can survive even the speediest assembly operation. They're unusually well-suited for special applications, too.

At the moment, JMs are being used most widely in TV sets, FM car radios and other commercial products. However, they also possess the degree of reliability required for military applications.

So get a real run for your money, with these extra-durable capacitors. Available capacitances range from 0.1 to 10.0 ps. To learn more, just send us the coupon.

## Oops! Watch out for Typical Error #7 in inductor testing

As we indicated in an earlier issue, there are eight errors that are easy to make when you're using the test procedures for measuring inductance and Q (see MIL-C-15305).

Error #7? Specifying a non-standard test frequency.

Where this is unavoidable, inductance values between 0.10 and 10 Microhenries can be determined by using the following formula:

$$L = \frac{25{,}330}{F^2C}$$

with L in $\mu$h, F in Mc/s and C in pf.

For values above 10 Microhenries, use a 260 Q meter. And we recommend that you stay below 1/10th of the Self Resonant Frequency of the inductor at all times.

For additional errors — and their remedies — stay tuned to this frequency.

SPEER® Speer Carbon Co.

St. Marys, Pennsylvania 15857

Speer Carbon Co. is a Division of Air Reduction Company, Inc.

Rush complete information on ☐ SC resistors and ☐ JM capacitors.

Name________

Title________

Company________

Street________

City_____ State_____ Zip_____



Circle 51 on reader service card

who expect nearly all of the money to go for the receivers needed by ships and aircraft to navigate with the system.

The Navy, which currently is conducting tests with a partial four-station Omega network after a long period of research and development, is counting on approval from the Pentagon [Electronics, March 6, p. 68] to construct four new transmitters and upgrade the four stations now on the air. Defense Department sanction—delayed for more than six months apparently because of rising expenditures for Vietnam—will give the Navy $50 million for the transmitter network and another $60 million over the next four years to buy Omega receivers for its ships, attack submarines, and subsonic aircraft. Also buying receivers will be the Army, the Air Force, and the Coast Guard.

Meanwhile, the Navy is going ahead with the purchase of receivers using money previously appropriated for Omega development. By April it will ask for proposals from manufacturers on what is described as the largest purchase of Omega receivers made to date. The Navy is expected to specify a very high-mean-time-between-failures for the solid state receivers, which will be for both aircraft and shipboard use. The Navy won't say what the rate will be, but it is expected that receiver producers will be forced to conduct burn-in tests on all components before installation into the sets in order to meet the Navy reliability requirement.

**Interest abroad.** The biggest portion of Omega business will not come from the U.S. government, however, but from commercial and overseas customers, including foreign military demands. About 75% of the total Omega sales will come from these customers, marketing officials of the equipment producers predict.

Some of the receiver manufacturers plan to sell units costing less than $2,500. Officials of the Federal Maritime Commission believe the price is low enough so that fishing-boat owners will buy Omega receivers to replace their loran-A equipment. Omega will provide fixes accurate to within one mile every 10 seconds, while the shorter range 2-megahertz loran-A cannot provide any better than four or five mile accuracies.

By adding a number of extras to the basic Omega receiver the cost can go as high as $50,000. A computer can be linked to convert Omega coordinates to latitude and longitude, and amplitude measurements can be added to the phase-measuring capability. Receivers can also be expanded from a single 10.2-kilohertz frequency to the full Omega range of 10.2 to 13.6 khz.

Companies now developing and building Omega receivers include the Ryan Aeronautical Co., Tracor Inc., the Nortronics division of the Northrop Corp., the International Telephone & Telegraph Corp., and Lear Siegler Inc.

**More improvements.** The Navy expects to make additional improvements in the system, although it says it has cleaned up many of the early problems. The Naval Research Laboratory recently solved one of the knottier ones—static in Omega airborne antennas caused by precipitation—by replacing the short stub or wire antennas with crossed-loop antennas and enclosing them in a radome.

Ionospheric disturbances (caused by solar storms) which disrupt the vlf signal will not seriously hamper Omega operations, the Navy insists, because the storms last for only three to five minutes and can be predicted.

## Fingerprints in 3-D

The Federal Bureau of Investigation may soon be adding another dimension to the job of recording and grouping fingerprints, and scanning its fingerprint files—a third dimension provided by holography.

The General Electric Co. and the Bendix Corp. are trying to sell the FBI on the idea of substituting holographic techniques for the age-old ink-stamp process. They note that the whorls, loops and arches of a subject's prints would stand out more distinctively in 3-D than in 2-D pictures. Furthermore, holography lends itself to automatic scanning techniques to ferret out a set of prints from the many millions on file.

**Time lag.** The FBI currently stores some 177 million sets of prints and employs 2,300 people to handle these files. It often takes the FBI staff more than 48 hours to track down a set of prints. To the police departments around the country this time lag is a constant source of frustration because many states don't permit a suspect to be held more than 48 hours.

When the FBI last month requested bids on an automatic system for recording and processing prints, fully 30 electronics companies responded. The industry's interest goes beyond simply the hope of a large Federal contract. The companies are aware of many applications in the offing for such equipment. Fingerprints may someday replace signatures on credit cards, and proposals have been heard for a nationwide fingerprint identification system.

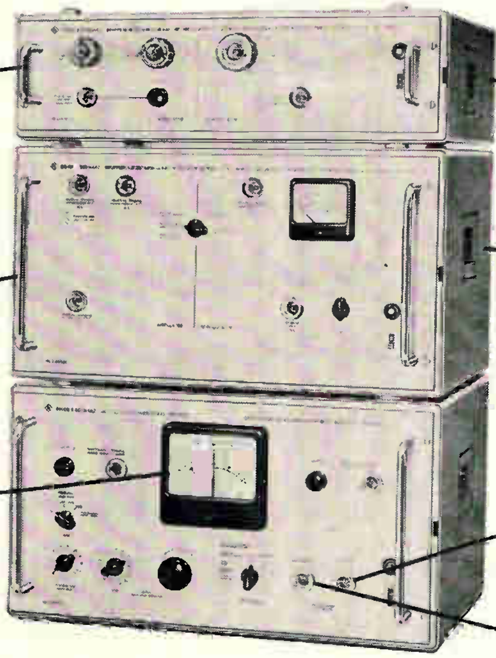
**Competing plans.** At the First National Symposium on Law Enforcement Science and Technology in Chicago this month, some of the competing companies outlined their technical plans:

- GE said it was working on spatial filtering to compare racks of prints. The technique, still in the early stages of development, offers the advantage of an "optical computer" approach to fingerprint hunting. Also, GE says its system could identify a print even if part of it was missing or smudged.
- Bendix is also investigating spatial filtering, but for a method in which the photo of a print is rotated to produce a pattern of easily differentiated concentric circles representing its idiosyncracies. The firm is also considering a technique to extract from a complex print a simple pattern of dots that represents only ridge endings and where two lines converge.
- The Advanced Data Systems division of Litton Industries Inc. has been working for three years on a systems approach called Fact, for fingerprint automation classification technique. The project's manager, Bernard Van Emden, says

See us at NAB—Booth 239 West Exhibit Hall

NEW!

IMMEDIATE DELIVERY
FROM STOCK
$7,010




# GROUP (ENVELOPE) DELAY TEST ASSEMBLY

TYPE LFM

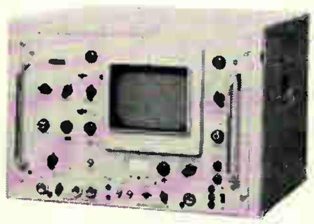
## FEATURES:

- Measures Group Delay Of:
  - Video Systems, 0.1 - 10 MHz
  - VHF Systems, 25 - 250 MHz
  - UHF Systems, 250 - 1000 MHz (extended with Type MAD Modulator)
- Measurement Range: ±10 to ±1000 nsec, f.s.d. with a resolution of 0.25 nsec.
- Accuracy (Group Delay): ±2% f.s.d.
- 20 kHz probing frequency generated by internal Xtal reference
- Measures Group Delay in Presence of Sync. and Blanking Pulses

## APPLICATIONS

Measure Group Delay Of:

- Active and Passive Devices
- TV Transmitters
- Video Tape Systems, Amplifiers, etc.
- Data Transmission Systems



SWOF VIDEOSKOP provides dynamic plotting of envelope delay when used with Type LFM.

Group (Envelope) Delay measurement is of primary importance for the reduction of phase distortion of high quality TV and data transmission systems. Type LFM Group Delay Test Set has been designed particularly for measurements on TV-systems and networks. Measurements are made in the base-band, at VHF and UHF, and on modulated VHF carriers. Measure point-by-point or dynamically by means of Type SWOF Videoskop which plots these data automatically. Use of a low pass (30 Hz) filter in the phase bridge makes plotting of the envelope delay curve possible in the presence of sync and blanking pulses.

Get The Extra Capability, Greater Reliability, and Longer Useful Life Of . . .

**ROHDE & SCHWARZ**

111 LEXINGTON AVENUE, PASSAIC, N. J. 07055 • (201) 773-8010

Inquiries outside the U.S.A. should be directed to Rohde & Schwarz, Muehldorfstrasse 15, Munchen 8, West Germany the method involves the use of three flying spot scanners to identify prints.

**Print what?** Fact has its limitations. For instance, Van Emden was forced to turn down a plan proposed by a group from the National Institutes of Health interested in tracking animal migration. The group wanted to know if the rump prints of baboons could be taken and processed with the Fact system.

## Companies

### Motorola rollback

A soft market for germanium devices and rectifiers is reportedly behind the layoffs that have cut the production force at the Semiconductor Products division of Motorola Inc. by more than 25% since last October. Over-all, the parent company had record sales and earnings last year, but the semiconductor operation in Phoenix, Ariz. was reportedly hit hard by the lessened demand for its products.

One clear indication of the belt-tightening was Motorola's announcement early this month that it wouldn't exhibit at the IEEE or Wescon shows this year. A manifestation less evident to the outside world, because Motorola refuses to discuss it, is the work-force cut.

It's evident in Phoenix, however. After 18 months of steady hiring, Motorola's three Phoenix operations (including the Military Electronics division) reached an employment high of 15,350 last October. The need for workers was so great during those 18 months that Motorola even set up booths in shopping centers and mounted a direct mail campaign. From October through January, though, the company dropped 2,700 workers, mostly personnel on hourly wages; total employment at the end of January was 1,300 under the year-earlier level.

The biggest cutback has been made at the semiconductor plant, where employment has reportedly dropped from about 12,000 last October to under 9,000 now. And, the layoffs have begun to hit engineers.

**Neat trick.** Last month, in the midst of its layoffs, Motorola boldly announced that it had moved up to second place in the industry in the number of integrated circuits shipped in the final quarter of 1966. "It won't last," says one competitor. "They shipped everything but the kitchen sink in December to set that mark." But Stephen L. Levy, Motorola's assistant general manager for IC's, asserts that the division will ship even more IC's in this year's first quarter.

Profits, of course, are another matter. One industry source puts Motorola Semiconductor's 1966 operating loss at $5 million. "There has been a slump in orders in the past six months," the source says. "Tantalum capacitors, for instance, which were on 20- to 40-week delivery last July, are now down to three to six weeks." Another Motorola-watcher says the company was hit hard by production cutbacks in the automobile industry, to which it sells rectifiers.

The indications are that Motorola overexpanded last year to meet a boom that never materialized. Last fall, with much hoopla, it dedicated a 300,000-square-foot IC plant in nearby Mesa, Ariz.; at present, only pilot production is going on there. Levy says it will be July before the shift of IC production to Mesa begins, and the end of the year before the transfer is complete. At present, the division simply isn't that pressed for space. Even though IC production has expanded, the layoffs, on the other hand, have reached the ranks of IC workers.

Since it's Motorola's corporate policy not to discuss layoffs, the company would give no official word on when they will end. The best information in Phoenix is that April 1 will be the turnaround point. The long retrenchment may be just about complete.

The story at Texas Instruments Incorporated, in some respects, is the same. Curtailed operations have resulted in shorter work weeks, and rumor has it that the Dallas company will soon start to reduce its work staff.

## Instrumentation

### Single-handed writing

The same beam of light that an oscillograph uses to trace waveforms on photo-sensitive paper can be used to write alphanumeric figures. But the oscillograph has a limited number of galvanometers to deflect the light beams, and it takes two to generate a figure—one for each side of the conventional seven-bar alphanumeric. The Denver division of Honeywell Inc.'s industrial products group, however, plans to introduce an instrument that splits the beam of light from a single galvanometer and wiggles the double beam fast enough to produce a character single-handed.

The prototype of the Honeywell instrument can write 2,000 lines of 52 digits each per second. Honeywell feels that the unit's chief use will be in recording binery-coded decimal data down the side of an oscillogram so that, for example, a particular waveform characteristic can be precisely placed in time.

**Twin beams.** The reflected beams from a mirror on the galvanometer —points of light about 5 to 10 millimeters in diameter—are about an eighth of an inch apart when they hit a mask in front of photosensitive paper. Between them is a hole about 80 mils square. By judicious deflection of the galvanometer at a rate of 5 kilohertz, the twin beams of light can be made to peel around first one edge of the square and then the other. The movement of the paper itself provides the vertical dimension for the character.

To generate a number 6, for instance, which in Honeywell's seven-bar format has a bar across the top, the instrument first produces a voltage spike to drive one beam of light clear across the square hole, making an 80-mil horizontal line. For the top half of the bar down the left-hand side, the galvanometer is given a small deflection to the right, and none at all past the "neutral" position to the left. Another spike produces

# RESOLVER/SYNCHRO DIGITAL CONVERSION

*A very short course for engineers who are concerned with converting resolver or synchro data to digits and vice versa.*

**Engineers working in digital computer input/output interface systems for tactical airborne equipment, aircraft and space vehicle simulation, antenna positioning or programming, and similar systems are increasingly involved in solving the digital/analog interface problem for resolver and synchro data. Accomplishing this task becomes quite simple by taking advantage of North Atlantic's family of high accuracy resolver/synchro converters. Through the use of solid-state switching and precision transformer techniques, these converters provide single-speed accuracy and resolution from 10 to 17 bits, along with solid-state reliability and calibration-free operation.**

## Resolver/Synchro-To-Digital Conversion

One typical North Atlantic resolver/synchro interface is the Automatic Angle Position Indicator (Figure 1), which converts angular data from both 400Hz resolvers and synchros to digits.

Figure 1. Model 5450 Automatic Angle Position Indicator converts resolver and synchro angles to digital form.

This device uses all solid-state plug-in cards and trigonometric transformer elements (no motors, gears or relays), and operates at all line-to-line voltages from 9 to 115 volts. It can be supplied in a wide range of configurations for specific system requirements, for example, signal frequencies 60Hz to 10KHz, binary or BCD outputs, .001° resolution with 10 arc second accuracy, and multi-speed and/or multiplexed inputs. Its five-digit Nixie readout can be integral or remote.

The unit illustrated has an accuracy of .01°, and two basic modes of operation. They are read-on command (rapid acquisition) and tracking (least significant bit update). Prices start at $5900.

## Digital-To-Resolver/Synchro Conversion

North Atlantic's all solid-state digital-to-resolver/synchro converters (Figure 2) accept digital input data at computer speeds in either binary angle or binary sine/cosine form and convert to either resolver or synchro data. Their high accuracy and resolution (up to 17 bits) and freedom from switching transients meets an important requirement in space-mission simulation and antenna positioning systems for smooth servo performance at low rates of data change. All models are usually supplied with input storage registers.

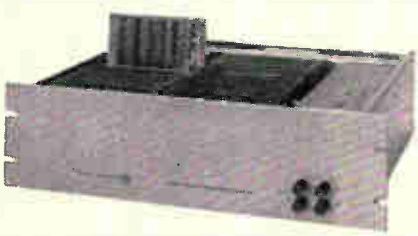


Figure 2. Series 536 Digital-To-Resolver Converters translate binary digital angle to four-wire resolver data.

Depending on the combination of features specified, prices are in the $4500. to $6000. range.

## Modular D-R/S Converters For High-Density Systems

The plug-in converters pictured in Figure 3 were developed by North Atlantic specifically for airborne systems and for aircraft simulation systems requiring high-density multi-channel operation. The modules illustrated provide 11-bit digital-to-synchro conversion and are capable of driving up to four torque receivers. As with other North Atlantic resolver/synchro interfaces, conversion is achieved through solid-state switching and trigonometric transformers, so there are none of the stability or calibration problems associated with conventional resistor-chain/amplifier type converters. Prices, in production quantities, run about $1100. per set. In prototype quantities about $1500. a set.

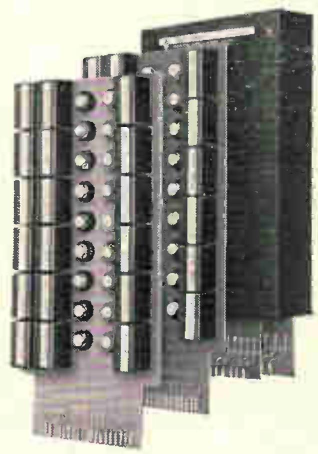


Figure 3. Series 537 D/S Converter Modules can drive multiple torque receivers from 11-bit digital data.

If you would like to take advantage of North Atlantic's state-of-art experience in resolver/synchro computer interface, we would be pleased to show you how these converters can meet your particular requirements. Or if you prefer, we will arrange a comprehensive technical seminar for your project group, without cost, in your own plant. Simply write: North Atlantic Industries, Inc., 200 Terminal Drive, Plainview, N.Y. 11803. TWX 510-221-1879. / Phone 516-681-8600.

*PRECISION AC INSTRUMENTATION FOR TEST, MEASUREMENT AND DATA CONVERSION*

NORTH ATLANTIC *industries, inc.*

the line across the middle. For the two vertical lines in the bottom half of the number the galvanometer is deflected so that each beam barely reaches the edge of the square. A final spike deflects the mirror to produce the bottom line.

The instrument uses off-the-shelf integrated circuits, mostly flip-flops, for memory storage. A second instrument modifies the first to permit a single galvanometer to generate digital data serially. In effect, it delays information so that multicharacter numbers are fed to the galvanometer one character at a time and printed vertically down the oscillograph paper.

## For the record

**Second chance.** Minuteman I's, now on the Air Force's retirement list, may get a new lease on life. Five-month contracts have been awarded the Boeing Co. and TRW Inc. to study the possibility of new uses for the missile, including applications as a space booster. During the next few years, about 800 Minuteman II's will be deployed to replace Minuteman I as the nation's primary strategic deterrent force.

**Over the shoulder.** Motorists of the future may have a television screen, periscope system, or contact analog display in place of rear-view mirrors. Scientists at Tufts University in Medford, Mass. will be studying these types of devices after completing work on convex rear-view mirrors. The three-year project is part of the Injury Control Program funded by the Department of Health, Education and Welfare.

**Clearer image.** Giannini Controls Corp. will change its name to the Conrac Corp. next month to free itself of the limiting identification of "controls" and eliminate confusion with other electronics firms whose name includes Giannini.

**Car cards.** Engineers at the Emerson Electric Co. have developed a system that uses a scrambling and decoding technique to make a car's ignition secure from "jumping" by a thief. The system centers on an electronic "key" that sounds an alarm when an absent-minded owner invites theft by leaving it in his car.

The key, which looks like a plastic credit card, has a unique infrared pattern which is difficult to counterfeit. Sensors in the dashboard ignition slot read the infrared pattern and the cylinders fire when the impulses from the correct card are matched in a logic module with signals from the electronic distributor. A 16-wire cable connects the ignition with the distributor. The odds on a thief's cutting the cable and finding the right combination of wires to jump are set at about 65,000 to 1.

If a motorist pulls his card out far enough to stop the engine, without withdrawing it completely, a mechanical switch with a delay circuit is actuated; and after a moment, a loud alarm goes off. Insertion of the wrong card will also trip the alarm.

The system has a number of ancillary advantages: it will eliminate both distributor points and the addition of a variable delay module to the logic module's output will permit screwdriver adjustment of the spark timing to such variables as temperature, altitude, and fuel.

**Inside job.** The Raytheon Co. has devised an electronic weld-testing technique that may determine quality without resorting to destructive methods. Raytheon drills holes lengthwise through the welding electrodes and inserts infrared-transmitting fiber optics. These "light pipes" transmit the temperature of the metals to a detector the instant they are fused. The output of the detector is fed to a control system that adjusts both welding current and time to get the best results. Output is also displayed on an oscilloscope so it can be photographed for a permanent record of the weld's quality.

**Police reserve.** Policemen, cruising in squad cars, may be using teleprinters to communicate with headquarters. The scheme, which requires FCC approval, was proposed by representatives of the General Electric Co. at a recent symposium on law enforcement in Chicago. Tests have shown that teleprinters permit faster and more efficient communications for such routine matters as license plate checks. The units would operate over standard police radio voice channels, using coded tone signals that could be sent at the time as normal voice transmissions.

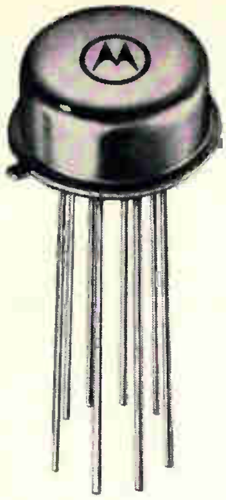
**Getting together.** The Hewlett-Packard Co. has consolidated its tape recorder operations into a new division at its Palo Alto, Calif. plant. Analog recorder manufacturing, now done by the company's microwave unit in Palo Alto, will be moved to nearby Mountain View under the aegis of the Datamec division which was acquired last year.

**Suspended sentence.** Because its Santa Clara, Calif., operation had been suspended as a qualified source of resistor-transistor logic circuits for the National Security Agency's R-13 program [Electronics, March 6, p. 26], the Philco-Ford Corp.'s Microelectronics division has decided to shift all bipolar integrated circuit work from Santa Clara to its facilities in Lansdale, Pa. The move will result in the layoff of at least 350 engineers and production workers. Santa Clara will now concentrate on metal-oxide-semiconductor devices.

J.P. Ferguson, the division's general manager, insists that the problems with the R-13 circuits had been overcome at Santa Clara. But, he says, with 75% of bipolar work being done in Lansdale, the consolidation would eliminate costly duplication.

The shift has given Philco-Ford a chance to redefine management responsibilities. John C. Keyes, formerly in charge of systems activities at Santa Clara, will head Western operations while Charles B. Tague takes charge of bipolar and hybrid IC's, microwave components, and infrared devices in the East.

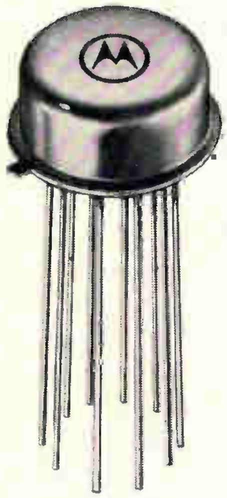
**Flight recorder.** The FAA may require flight recorders measuring up to 25 parameters for large aircraft, instead of the five measured by recorders now mandatory for planes operating above 25,000 feet. Airlines may seek even more flexible devices.



# THIS IS THE MC1709 (Some Call It The $\mu$A 709)

## INTEGRATED CIRCUIT OP AMP

- It has gain of 25,000 (min)
- It has a drift-rate, with temperature, of 6 $\mu$V/°C (typ)
- It has input offset voltage of 5 mV (max)



# THIS IS THE MC1533

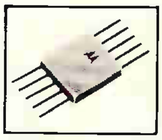
## INTEGRATED CIRCUIT OP AMP

- It has gain of 40,000 (min)
- It has a drift-rate, with temperature, of 5 $\mu$V/°C (typ)
- It has input offset voltage of 5 mV (max) (Adjustable to 0)

## They're Both Available from Motorola . . . Right Now!

Now, Motorola lets you choose either of these two state-of-the-art integrated circuit operational amplifiers. Either one will provide top performance in a wide range of applications such as summing amplifiers, source-followers, twin tee filters and oscillators, for military or industrial equipments. Choose the one that best fits your particular application requirements.

Both the MC1709 ($\mu$A709) and the MC1533 are available in the 10-pin ceramic flat pack. In addition, they are also available in the 8-pin TO-5 and the 10-pin TO-5, respectively. Complete data on both circuits is yours for the asking — including three new application



notes on op amp uses. We'll also send you a data sheet on our MC1433 Op Amp (economy counterpart of the MC1533 — priced at just $15.00 in 100 quantities).

Then, when you're ready for evaluation quantities, call your nearby Motorola franchised semiconductor distributor. Ask for either the MC1709 or MC1533. He has both types available for immediate delivery. To order flat pack, designate suffix "F"; for TO-5, use suffix "G."

*where the priceless ingredient is care!*

**MOTOROLA Semiconductors**

MOTOROLA SEMICONDUCTOR PRODUCTS INC. / P.O. BOX 955 / PHOENIX, ARIZONA 85001 / (602) 273-6900 / TWX 910-951-1334

# 4 to 6 weeks on 50,000 pieces...

(1/10 through 1/2 watt, 1% tolerance)


that's

# better metal film delivery

from DALE®

Four to six weeks on 50,000 pieces–1/10 through 1/2 watt, 1% tolerance! That's better delivery on metal film resistors–much better. No use camouflaging the fact that you swamped us with an unprecedented demand for our Metal Film line. To meet this demand we have increased our capacity more than 60%–and we're geared to go even further when you say so. Need better film delivery? Call Dale today 402-564-3131.

**DALE ELECTRONICS, INC.**
1300 28th Ave., Columbus, Nebraska 68601
In Canada: Dale Electronics Canada, Ltd.

# Washington Newsletter

**March 20, 1967**

**Transatlantic computer hookup via Early Bird**

An experimental computer-to-computer hookup via Early Bird satellite was called "highly satisfactory" by the Communications Satellite Corp. The week-long demonstration, completed Feb. 22, was conducted by Comsat and the IBM Corp. to determine the effect of interference and delay on transmitting computer data by satellite. IBM linked a half-dozen computers in the U.S.—one as far west as San Jose, Calif.—to a computer in Paris. The space portion of the linkup used the Early Bird satellite between Comsat's Andover, Maine, station and French and German ground terminals. Twelve channels or a 48-kilohertz bandwidth were used to transmit data at the rate of 5,100 characters per second.

IBM officials flatly deny it, but sources at Comsat say the big computer firm is considering tying together its 36 domestic computer locations to some of its 17 overseas centers.

**Post Office slates meeting with firms on systems use**

The Post Office Department wants to hear more from industry on how best to apply a systems approach to automating mail delivery. The department will hold a symposium late this spring—the date hasn't been set—to discuss postal automation with companies and get their ideas on necessary hardware.

The man behind this meeting is Assistant Postmaster-General Leo S. Packer, who came to the department last September to head its new bureau of research and engineering [Electronics, Oct. 17, 1966, p. 8]. Established to find ways to automate postal service, the bureau has a $16.5 million budget in the current year and is seeking $23.1 million for fiscal 1968.

**NASA aides hint at plan to recover time lost on Apollo**

Some NASA officials are saying privately that most of the time being lost in investigating the Jan. 27 Apollo spacecraft fire and in modifying the command module could be made up this year under a tight new schedule. They believe the three unmanned flights scheduled this year can also be used partly to qualify and man-rate the reengineered Apollo spacecraft. The launches involve two Saturn 5 boosters and one Saturn 1B carrying a lunar module. The first manned launching of Apollo using a Saturn 1B booster would be in the fall, under the revised schedule. If all goes well the program would just about be on target by December for a manned moon landing before 1970.

**Industry seeks voice in filling technology gap**

The U.S. defense industry wants a voice in the making of policies aimed at helping Europe plug its technological gap. Among other things, companies fear that Washington may direct them to furnish technological know-how without consulting them in advance. Government-negotiated prices have been a bugaboo ever since the Defense Department assumed bargaining responsibility for overseas deliveries of weapons. A plea for representation has been submitted to Defense Secretary McNamara through the National Security Industrial Association, whose 400 members include many electronics firms. The association says it doesn't object to an international technological aid program; it simply wants such matters as sales and licensing agreements to be worked out through industry channels. McNamara hasn't yet responded to their request.

# Washington Newsletter

**Network linking Saigon to Bangkok cable set for June**

A network of five microwave relay stations to link the Saigon area with the Air Force's 439L submarine cable from Bangkok will be completed in June. The over-all system will provide an alternate to the tropospheric scatter system now operating between the cities as a part of the Army's Integrated Wideband Communications System. Reportedly, work on the Air Force's 60-channel cable is being rushed because the tropo path hasn't proved too reliable [Electronics, Nov. 14, 1966, p. 73]. The microwave stations are being built by Page Communications Engineers, a Northrop Corp. subsidiary.

**Up, up and aweigh: plan ship-to-shore vhf test via space**

Industry proposals for an experiment to determine the feasibility of using satellites to relay ship-to-shore very-high-frequency communications are now being opened. The Maritime Administration will work with NASA, using the space agency's Applications Technology Satellite (ATS-1) now in stationary orbit over the Pacific. The vhf communications equipment will be placed aboard a cargo ship.

**Air Force asks cheap and simple avionics for AX**

The Air Force's proposed new attack aircraft—now designated AX, for attack experimental—will carry the cheapest and simplest avionics available. There are indications that some elements of the Air Force's Mark 2 system and the Navy's integrated light attack avionics system (Ilaas) may be incorporated, but the use of these sophisticated integrated subsystems will be minimal because of their high cost.

In asking aircraft manufacturers for proposals to develop and build the AX, the Air Force said it wants an inexpensive long-range plane that can be rushed into production. Proposals are due April 3.

**Draft changes blowing down industry's neck**

The electronics industry will face a tighter market for engineers if Congress okays proposed changes in the Selective Service system. The provisions would reverse the current induction order—calling up the 19-year-olds first—and would end deferments for graduate study, including engineering courses.

After getting a bachelor's degree, students—including badly needed electronics specialists—would be put into the draft pool and face almost immediate callup. Engineers seeking postgraduate degrees would have to wait until after they completed their military service before returning to school, and they probably wouldn't be able to join the industry's ranks until they were in their late 20's.

**Viet spending bill gives EA-6A lift**

More money than originally anticipated may be spent for avionics equipment on Grumman Aircraft Engineering Corp.'s EA-6A aircraft. The Navy has asked $54 million in fiscal 1968 for the electronics-laden craft, but there was no allocation in fiscal 1967. Congress now has overruled Defense Secretary Robert S. McNamara by authorizing another $81 million for the electronics countermeasures aircraft for the Marine Corps in fiscal 1967. The money, which McNamara didn't request, is part of the $4.5 billion supplemental appropriation for Vietnam. The bill—providing $3.7 billion for procurement, mostly for aircraft, and $135 million for research and development—is expected to pass in Congress without much difficulty. McNamara would still have to okay the EA-6A spending, but chances are good that he will.

# FET CHOPPERS ARE THE ONLY ANSWER

Part ELEVEN of a Series On The State of The Chopper Art.

## MODEL 8000

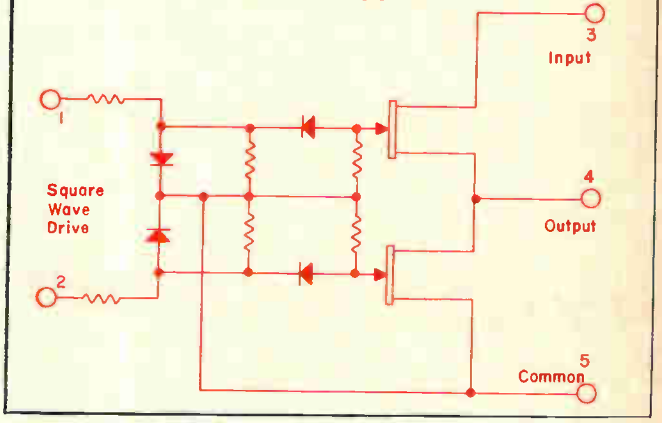

Booze is the only answer at my house, but they frown down at the office when I suggest there is more than one way to solve problems. They should have my mother-in-law — they'd stick to booze, not electronics.

It turns out that an FET chopper is a distinct improvement over photo-choppers, what with 6 volts being enough drive instead of a couple hundred. Now the photo-chopper was better than the transistor choppers, because it looked like a resistor instead of a diode. So there ain't any voltage drops that have to cancel out. Mostly they don't. (Cancel, that is.)

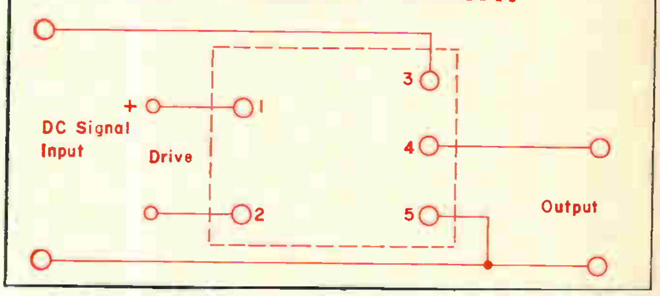
As matters stand on noise and offset — and we sell choppers for only one purpose, which is to allow D.C. amplifiers with very little offset — the best of FET choppers are only two to three orders of magnitude worse than the best of mechanical choppers. Which is real progress. Last week it was three to four orders — before we invented this model 8000 FET chopper. The offset available is below 10 microvolts at 10,000 ohms, and would be lower if there weren't such wierd alloys inside the FET that have to come out eventually to copper.

So today's best mechanical choppers reach down below some 50 nanovolts, the FET chopper gets to about 5 microvolts. That's two orders of magnitude and crowding. Good thing we make solid-state choppers too.

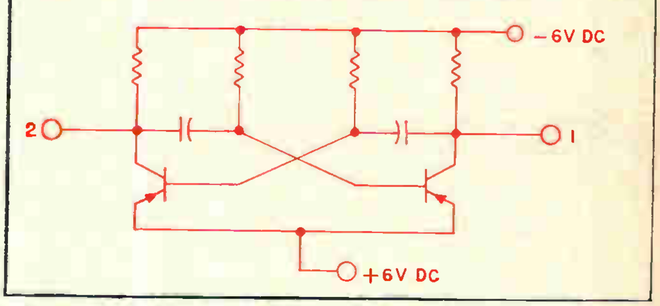
Speaking only of offset, and anyway, what else is speakable about a chopper? I suppose you could say Mechanical Choppers << FET Choppers < Photo Choppers < Transistor Choppers.



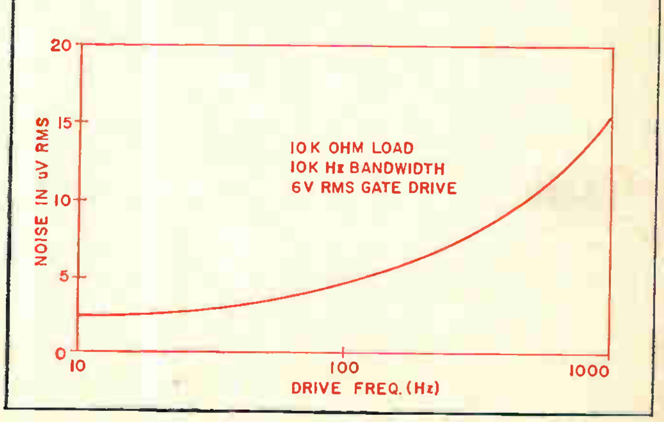

A FET Chopper . . .




in a modulator circuit . . .




with an inverter to drive it . . .




is pretty low noise.

**AIRPAX ELECTRONICS**
**Cambridge, Maryland 21613**

# *Growth of good basic design makes hp oscillators*

# *YOUR BEST CHOICE FOR A WIDE VARIETY*

Hewlett-Packard Oscillators are the progressive growth of the first successful Wien-bridge oscillator design introduced to the measurement industry by Hewlett-Packard in 1939. Now you can select from a variety of fifteen hp instruments using improved components and the well-known Hewlett-Packard RC oscillator design to give you the best price-to-performance ratio on the market! Choose from frequency ranges of 1 Hz to 10 MHz.

**General Purpose Oscillators.**—The *hp Model 200CD* is a direct descendant of the first Wien-bridge design. With its low price, high power, balanced output and low distortion, the 200CD is an ideal instrument for school, communications and military use.

You get a fully-transistorized and battery-powered signal source with easily-portable *hp Model 204B.* Amplitude and frequency control circuits give excellent stability over a range of 5 Hz to 560 kHz. You also get a completely floating output, isolated from chassis and ground. The 204B is ideal for field use.

**Test Oscillators.**—The *hp Model 651B* Test Oscillator is an advanced design, wide-band, solid state test oscillator! This line-operated instrument gives you a wide frequency range of 10 Hz to 10 MHz with highly stable amplitude and frequency. There are separate 50Ω and 600Ω calibrated outputs. A 75Ω output is optional.

Battery-powered *hp Model 208A* Test Oscillator is a compact, lightweight, easily-carried laboratory or field source of 5 Hz to 560 kHz signals.

**Pushbutton Digital Oscillator.**—For your production line or wherever you have repetitive testing, the hp Model 241A Oscillator gives positive pushbutton frequency selection from 10 Hz to 1 MHz. You get repeatable test sigals with three-digit frequency resolution. Set 4500 discrete frequencies!

## A *Pick hp Model 200CD Oscillator For A Low-Cost, General Purpose Instrument*

— When you need a low distortion signal independent of load—you'll get excellent results with hp Model 200CD Oscillator! Use it for generating subsonic to radio frequencies; testing servo and vibration systems; supplying medical and geophysical equipment; for checking audio circuits and systems.

The output of the 200CD is 600Ω balanced, with a balanced accuracy of 0.1 to 1%, depending on frequency. Accurate frequency settings over a range of 5 Hz to 600 kHz are possible with the 85 dial divisions, effective scale length of 78 inches, and a vernier drive for precise adjustment. Frequency response is ±1 dB over the entire range.

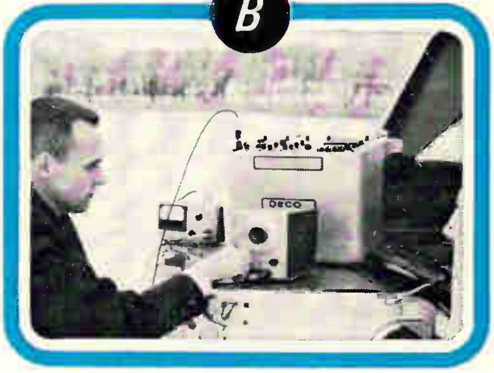
Distortion rating of sinewave output is less than 0.2% below 200 kHz. The modified hp Model H20-200CD provides a low distortion of 0.06% in the 60 Hz to 50 kHz range.

For excellence in design in a general purpose oscillator, pick hp Model 200CD. Price is only $195.00.

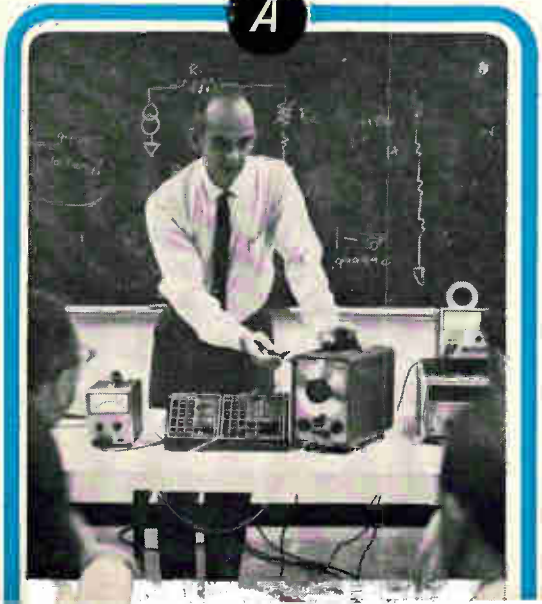
## B *Pick hp Model 204B Oscillator for Portable, Highly-Stable Signal Source*

Solid-state, battery-powered hp Model 204B Oscillator is an excellent choice for a source of stable, accurate signals in the field. You have an unusually low

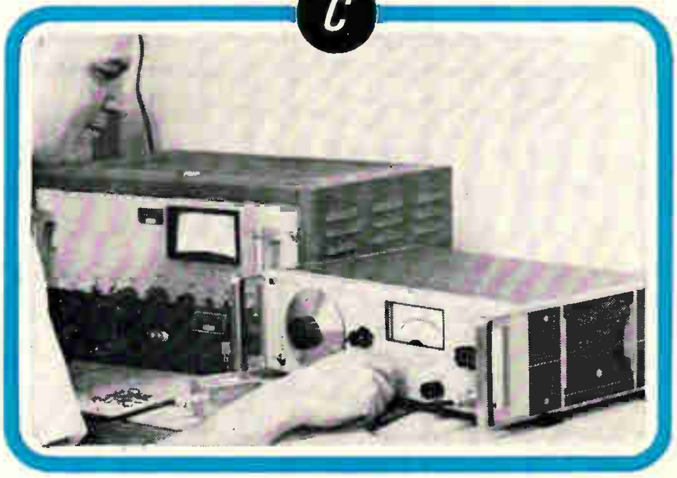
B



A



C



# OF LOW COST, SUPERIOR SIGNAL SOURCES

drift on warm-up; instantly available signals over a frequency range of 5 Hz to 560 kHz!

Stability is typically better than 5 parts in $10^4$—even at 560 kHz! Rapidly changing loads do not affect stability. Output is fully floating, flat within ±3% at all settings of the dial and range switch.

Price of the hp Model 204B: Equipped with mercury batteries, $315.00; with ac power supply in place of batteries (Option: 01), $350.00; with rechargeable batteries and recharging circuit self-contained for ac or dc operation (Option: 02), $390.00.

## C Pick hp Model 651B Test Oscillator for Accurate 10 MHz Frequency Range

— Outstanding flatness, stability and accuracy from 10 Hz to 10 MHz are yours with the hp Model 651B Test Oscillator. You get a typical ±0.1% amplitude stability and ±0.02% frequency stability, and a 1% accurate 90 dB output attenuator.

The 651B has two outputs: 200 mW into 50Ω, and 16 mW into 600Ω. Output attenuator has a 90 dB range in 10 dB steps, with a 20 dB coarse and fine amplitude controls for increased resolution in setting output voltage. Attenuator accuracy is ±0.1 dB from −60 dBm to +20 dBm, ±0.2 dB on −70 dBm range. Output monitor is calibrated to read volts or dBm into a matched load. Price: hp Model 651B, $590.00.

*652A:* The hp Model 652A is identical to 651A, with the additional ability to monitor output amplitudes within 0.25% over the entire frequency range of the instrument using the X20 expanded scale. Uppermost scale of the 652A reads in percent for quick reading of frequency response measurements. Price: hp Model 652A, $725.00.

D

**652A Expanded Scale Monitor**

*208A:* Add a meter for accurate setting of output voltage and an attenuator to the 204B, and you have the hp Model 208A Test Oscillator. Model 208A is calibrated in volts, covering 0.01 mV to 1 V full scale with a 2.5 multiplier to extend range to 2.5 V. Model 208A (Option: 01) is calibrated in dBm for 0 to 110 dB in 1-dB steps. Output is constant within ±3% at all attenuator settings over 5 Hz to 560 kHz range. Price: hp Model 208A, $525.00; hp Model 208A (Option: 01), $535.00.

## D Pick hp Model 241A Oscillator for Pushbutton Repeatability

— Repeatability possible with the hp Model 241A digital oscillator makes it ideal for production line use—or in the laboratory where repetitive testing is a requirement. Set any frequency between 10 Hz and 999 kHz to three significant figures—simply by pushing buttons! This solid state instrument is designed with special hp precision resistors to provide typical frequency repeatability of 0.01%. Frequency accuracy is within ±1% selected value on any range.

Infinite frequency resolution is provided by a vernier control, which also extends the upper frequency to 1 MHz. Output is flat within ±2% over the entire range at any attenuator setting.

Use the 241A as a digital frequency source for filters and frequency sensitive circuits. Response test at audio and communication frequencies, or use it as a repeatable source in production testing. Price: hp Model 241A, $490.00.

For full details on the wide variety of hp oscillators shown here and in our catalog, call your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

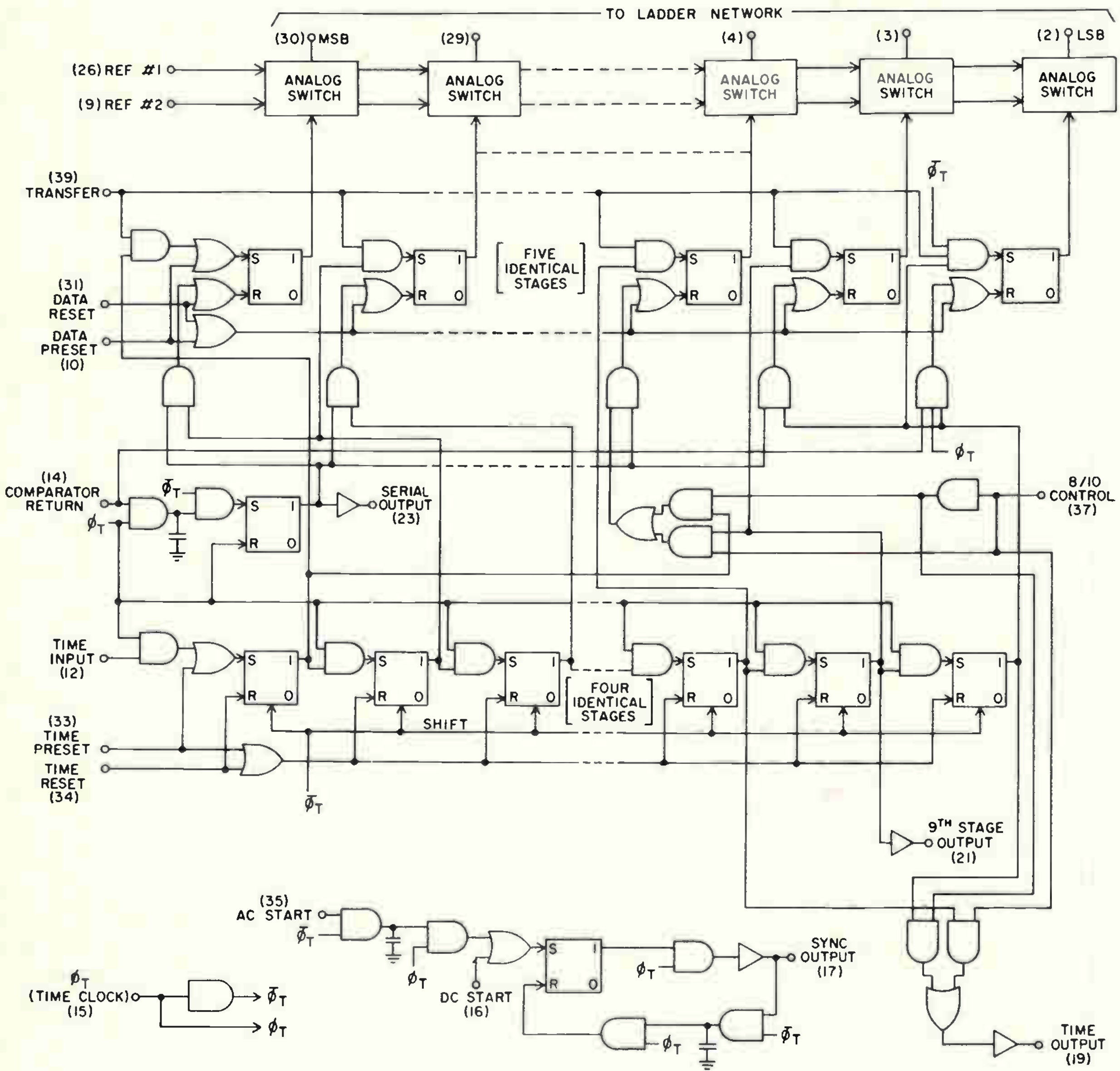
| | 200CD | 204B | 208A | 651B | 241A |
|---|---|---|---|---|---|
| Frequency | 5 Hz to 600 kHz | 5 Hz to 560 kHz | 5 Hz to 560 kHz | 10 Hz to 10 MHz | 10 Hz to 1 MHz |
| Frequency Response (Rated load) | ±1 dB | ±3% | ±3% | ±2% to ±4% | ±2% |
| Accuracy | ±2% | ±3% | ±3% | ±2%, ±3% | ±1% |
| Output | 10 V, 160 mW/600Ω, balanced | 2.5 V, 10 mW/600Ω, floating | 10 mW, nominal 2.5 Vrms (+10 dBm/600Ω), floating | 3.16 V, 200 mW into 50Ω 16 mW into 600Ω, floating | 2.5 V, +10 to −30 dBm/600Ω floating |
| Distortion | 0.2% to 0.5% (200CD) 0.06% to 0.5% (H20-200CD) | <1% | <1% | <1% to 2% | <1% |
| Price | 200CD, $195.00 H20-200CD, $250.00 | 204B, $315.00 | 208A, $525.00 | 651B, $590.00 652A, $725.00 | 241A, $490.00 |

097/10

HEWLETT hp PACKARD
*An extra measure of quality*

Circle 63 on reader service card

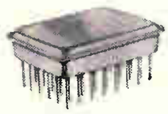
# this is LSI...




**Another MTOS First...** This Monolithic A/D-D/A Converter incorporates General Instrument's **exclusive** MTOS (Metal-Thick-Oxide-Silicon) process which provides Large Scale Integration without the need for high-cost discretionary wiring.

# the first available monolithic analog-to-digital digital-to-analog converter

## And only General Instrument makes and delivers these advanced LSI devices...today!



Actual Size

## MEM 5014 A/D-D/A Converter........... $268.00 each*

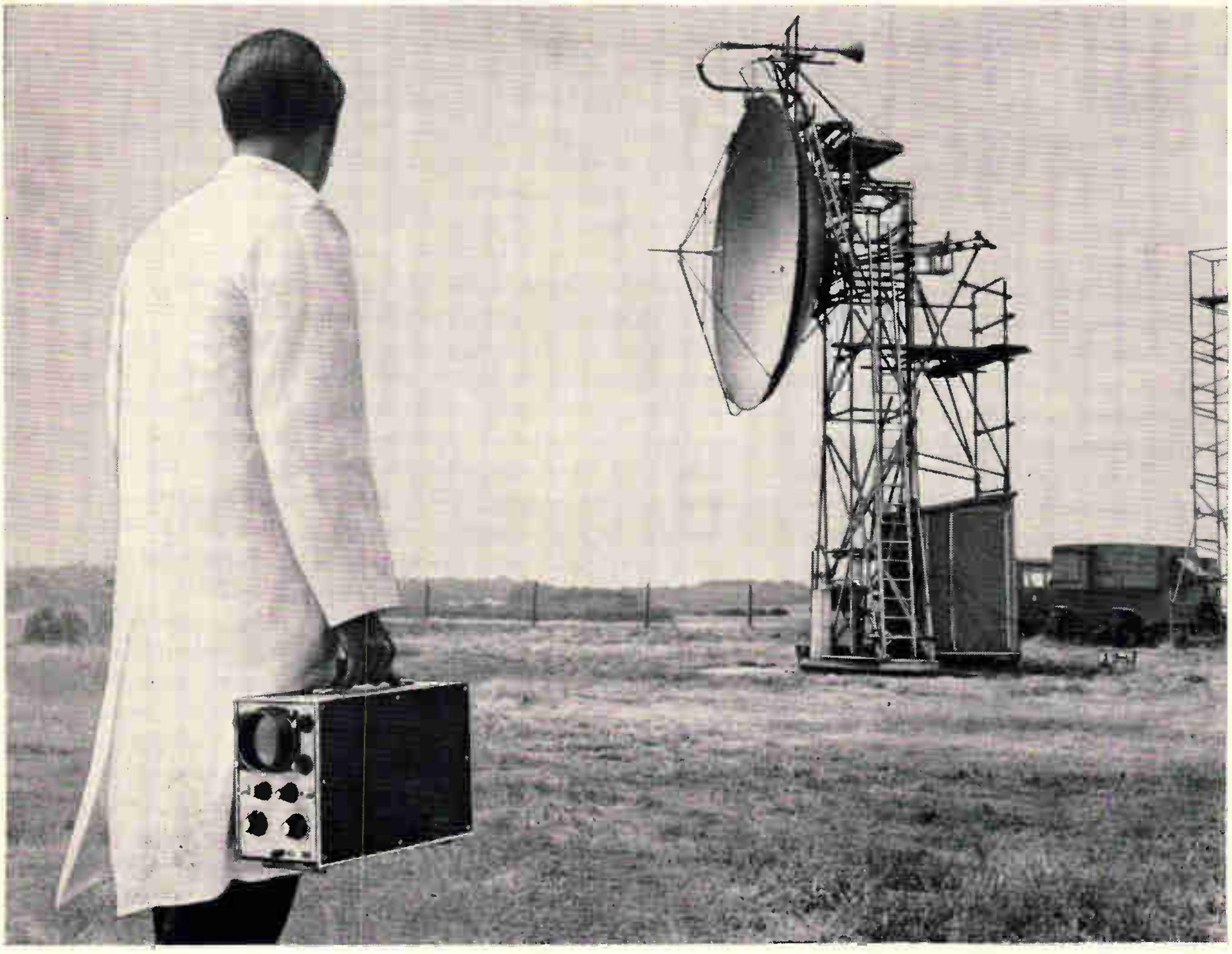
General Instrument's MEM 5014 is a Monolithic MTOS Integrated Circuit containing 350 active components on a chip 62x104 mils. It performs all the logic and analog switching functions for 10-bit successive approximation analog-to-digital conversion. In addition, it operates in two other major modes—as a 10-bit digital-to-analog converter or a 10-channel analog multiplexer.

As an analog-to-digital converter, the MEM 5014 is used in conjunction with an external precision ladder network and voltage comparator. This mode provides both serial and parallel binary outputs. The MEM 5014 is packaged in a 40 lead hermetically sealed in-line package which can be soldered to a printed circuit board or used with a 40 pin socket. Write for complete data and application notes.

**in quantities of 100*

GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION • 600 WEST JOHN STREET, HICKSVILLE, L. I., NEW YORK



*by courtesy of H.M. Postmaster General*

# 20 MHz AND NO MAINS LEAD

A portable fully solid state oscilloscope having a D.C. to 20 MHz bandwidth, which can be operated from its own internal batteries or from any A.C. supply from 110-250 volts, 50-400 Hz.
Its batteries give 4 hours operation per charge, and it has its own integral charging unit. Yet it weighs only 22 lbs. complete.
Y sensitivity is 5 mV per division and the sweep ranges cover 40 nanoseconds to 0.5 second per division. Other features are a 3" high intensity P.D.A. tube and an internal square wave calibrator.
This high performance general purpose oscilloscope is the Bradley Type 150.

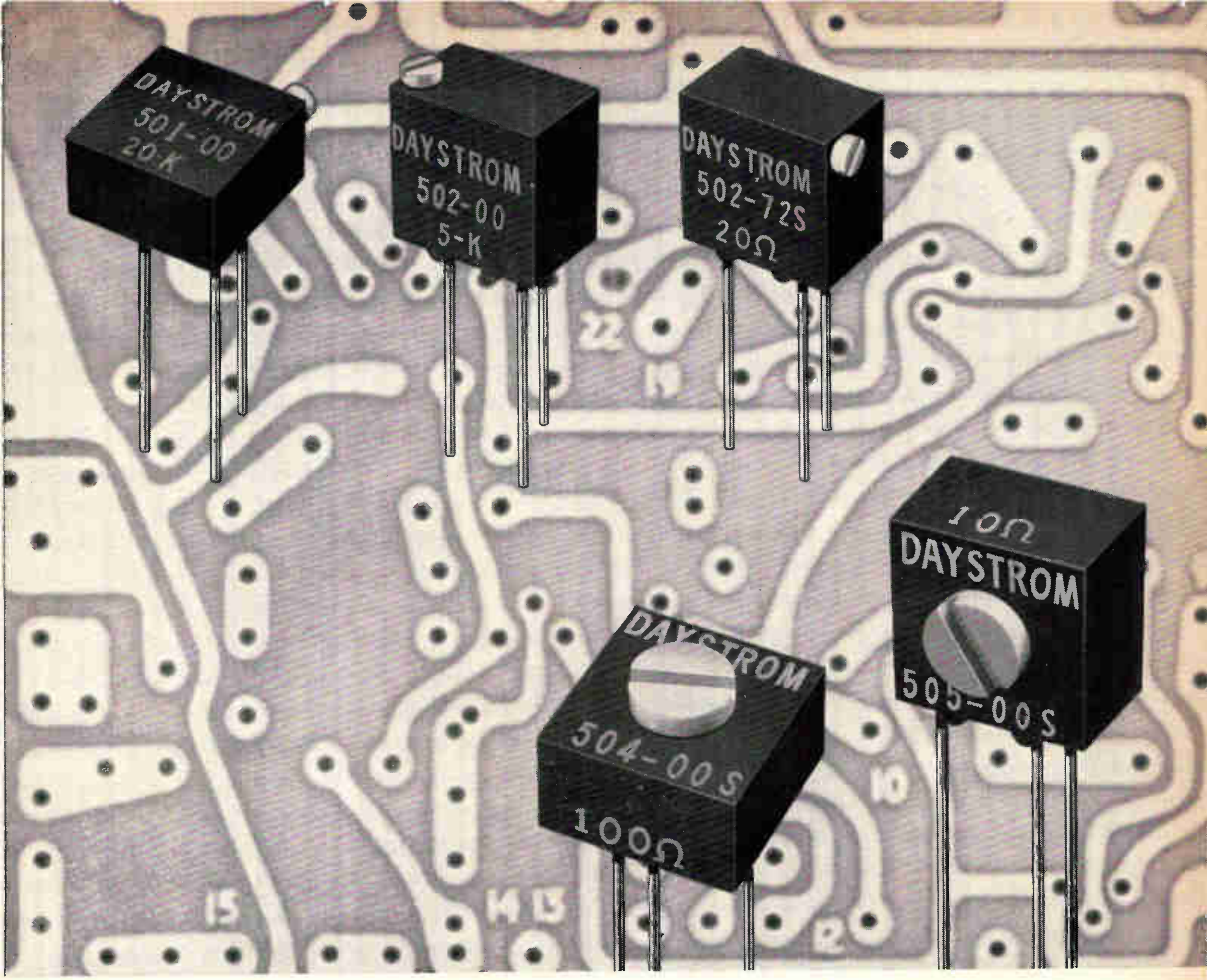
*We shall be pleased to send you full details on request. See your Electronic Engineering Index Library for full technical data.*

GEB

G. & E. BRADLEY LIMITED

Electral House, Neasden Lane, London, N.W.10

Telephone: Dollis Hill 7811  Telegrams: Bradelec London N.W.10  Telex: 25583




# Savings across the board just took a new turn

DAYSTROM Commercial Squaretrim® potentiometers now include single-turn types. *New models 504 and 505 are fully adjustable with just one turn. Models 501 and 502 are 15-turn types. They all clear up to 80% more PC board space—at no extra cost. But the trim .02 cubic inch size is only one reason why these commercial 500 Series pots are proving so popular. They also feature Weston's exclusive wire-in-the-groove design, and all these performance extras:*

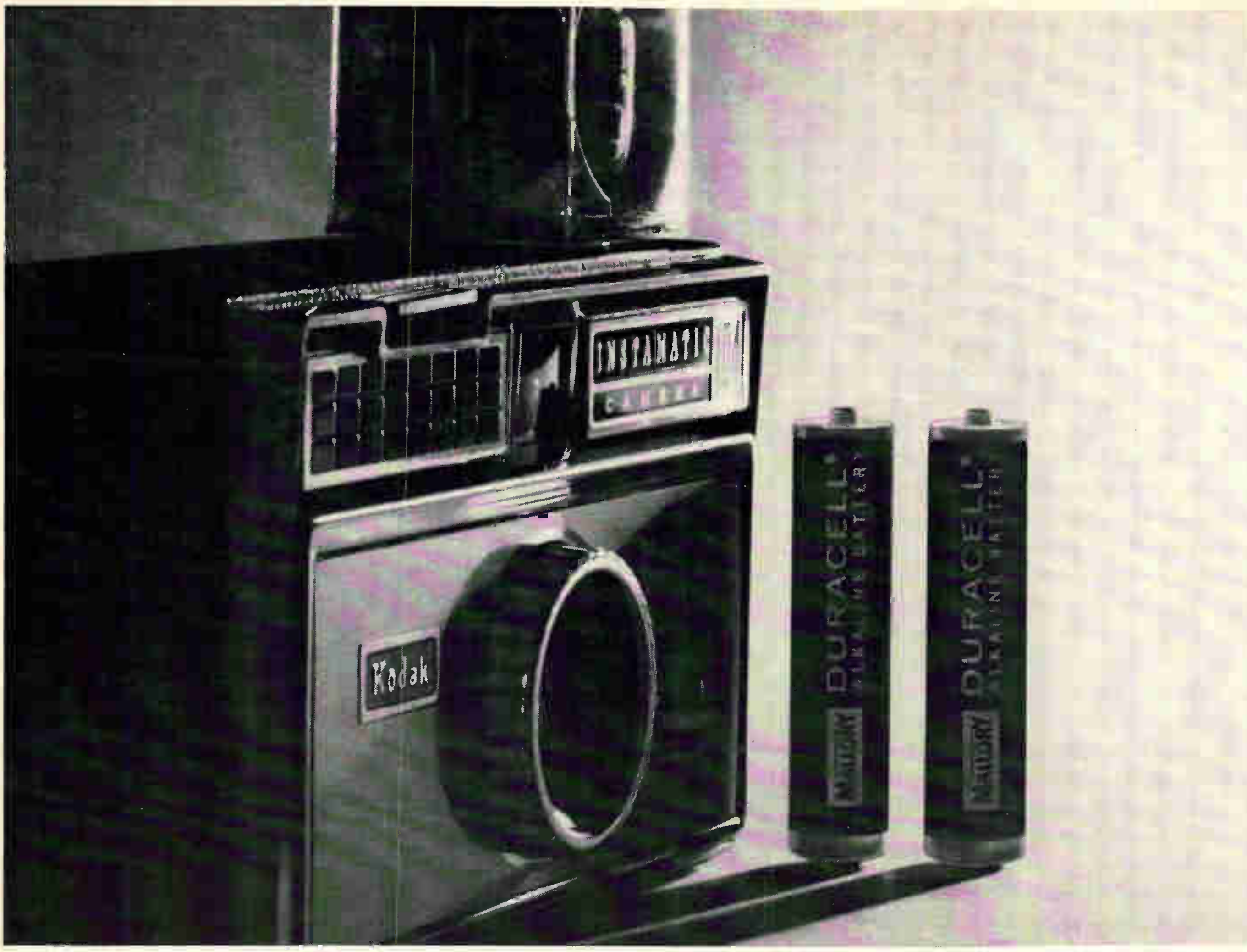
Convenience *5 different configurations with adjusting screw on top, side or end* • Tolerance *±5%* • Adjustability *15 turns or single turn* • Slip Clutch *eliminates wiper damage, cuts production delays* • Suregard™ Terminations *for better protection against vibration, shock and humidity—no pressure taps* • Superior Resolution *0.125% or less* • Wide Range *10Ω to 20K (higher values on request)* • High Power *0.6 watt in still air at 70°C* • Wide Temperature Range *−55°C to 150°C* • Low Temperature Coefficient *70 ppm max.* • Low Noise *100Ω max. ENR* • Small Size *5/16" x 5/16" x 3/16"* • Low Cost *$2.10 each for 501/502 in 500 lot quantity, $1.95 each for 504/505 in 500 lot quantity.*

Daystrom *potentiometers are another product of:*

***Weston Instruments, Inc. • Weston-Archbald Division • Archbald, Pa. 18403***

**WESTON®** *prime source for precision . . . since 1888*

Circle 67 on reader service card




# Kodak needed a battery that could keep Instamatic® camera dealers clicking with their customers for years.

## Mallory made it.

## What can we do for you?

Kodak needed a battery. A battery with the power to fire the flashcubes on Instamatic cameras one right after the other. A battery to keep that power fresh even if shipments were delayed on their way to a dealer. A battery that could provide Instamatic camera users with months, even years of perfect flash pictures. Yet a battery that would be readily available when a replacement was finally needed.

Mallory made it. The battery—a Duracell® alkaline battery. Only 0.4″ in diameter, the "AAA" size battery (Mallory designation—MN-2400) has a volume of .16 cu. in. with a rated capacity of 750 MAH. And it retains 85% of that capacity after 2 years storage.

Duracell® is a registered trademark of P. R. Mallory & Co. Inc.
Instamatic® is a registered trademark of Eastman Kodak Company.

**HIGH-POWERED BATTERIES BESIDE THE CASH REGISTER**

"Where does the customer get a replacement?" It's an important consideration in the design of any battery-operated device. But no longer does it mean that a designer has to settle for low-powered zinc-carbon batteries just because they're available. Today Duracell alkaline batteries are retailed everywhere for heavy current drain uses. Duracell mercury batteries—with their steady flat voltage—are sold all over the world for transistor radio use. Both last so much longer than zinc-carbon types, in use or on the shelf, that the problem of replacement sometimes ceases to exist.

**OVER 1000 DIFFERENT TYPES**

Mallory currently makes over 1000 batteries of all sizes and capacities. If we're not actually producing the battery you need, we'll be happy to work with you in designing a new one. For more information, please write the Technical Sales Department, Mallory Battery Company, a division of P. R. Mallory & Co. Inc., South Broadway, Tarrytown, New York 10591. Or telephone us at 914-591-7000. (In Canada: Mallory Battery Company of Canada Limited, Sheridan Park, Ontario.)

**It's good business to do business with Mallory** MALLORY

# Six New Amelco Hi-Voltage FETs for Solid-State Conversion of Vacuum Tube Circuits

Now you can eliminate extensive redesigning of vacuum tube circuits with these six hi-voltage FETs from Amelco — each a new 'tube analog.' They're ideal for solid-state conversion of CRT deflection circuits, high-level multiplexing and large signal transfer circuits. Consider their improved flexibility: 300-volt operation, low 2 na leakage current, and gains as high as 1500 μmhos. Have an application or two in mind? Send for a data sheet or two! We'll also enclose a copy of our definitive Tech Bulletin No. 7, "Theory and Applications of Field Effect Transistors,"— 24 pages of user-oriented FET facts. You'll find out more from Amelco, world's largest producer of n-channel FETs.

| CHARACTERISTIC | 2N4881 | 2N4882 | 2N4883 | 2N4884 | 2N4885 | 2N4886 |
|---|---|---|---|---|---|---|
| $BV_{DGO}$ (V, min) | 300 | 300 | 200 | 200 | 125 | 125 |
| $BV_{SGO}$ (V, min) | 100 | 100 | 100 | 100 | 75 | 75 |
| $g_m$ ($\mu$mhos, min/max) | 350/1000 | 600/1500 | 350/1000 | 600/1500 | 350/1500 | 600/1500 |
| $I_{GSS}$ (na, max) | 2 | 2 | 1 | 1 | 1 | 1 |
| $C_{rss}$ (pf, max) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| PRICE (100-999) | $8.65 | $9.50 | $6.55 | $7.25 | $5.85 | $6.65 |

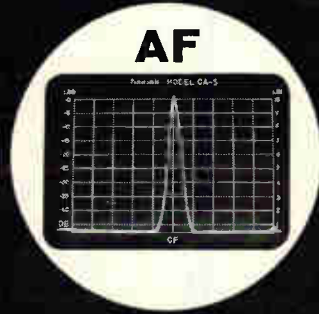
## AMELCO SEMICONDUCTOR

DIVISION OF TELEDYNE, INC. • 1300 TERRA BELLA AVENUE • MOUNTAIN VIEW, CALIFORNIA • Mail Address: P.O. Box 1030, Mountain View, California • Phone: (415) 968-9241 / TWX: (415) 969-9112 / Telex: 34-8416 • REGIONAL OFFICES: Southwest—Suite 213, 8621 Bellanca Ave., Los Angeles, California 90045, (213) 678-3146 • Northwest—1300 Terra Bella Ave., Mountain View, California, (415) 968-9241 East—27 Traphagen Road, Wayne, New Jersey, (201) 696-4747 • Southeast—711 Magnolia Avenue, Orlando, Florida 32803, (305) 423-5833 • Northeast—805 High Street, Westwood, Massachusetts 02090, (617) 326-6600 • Midwest—650 West Algonquin Road, Des Plaines, Illinois, (312) 439-3250 Canada—Deskin Sales, Montreal, Quebec, (514) 384-1420.

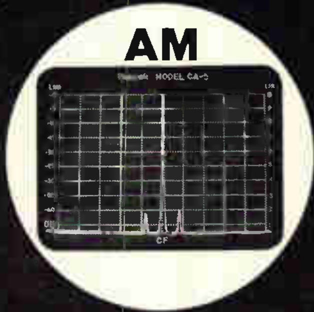
# ASSURE PEAK PERFORMANCE

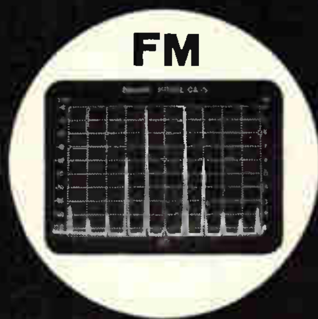
## with Panoramic*

## SPECTRUM ANALYZER

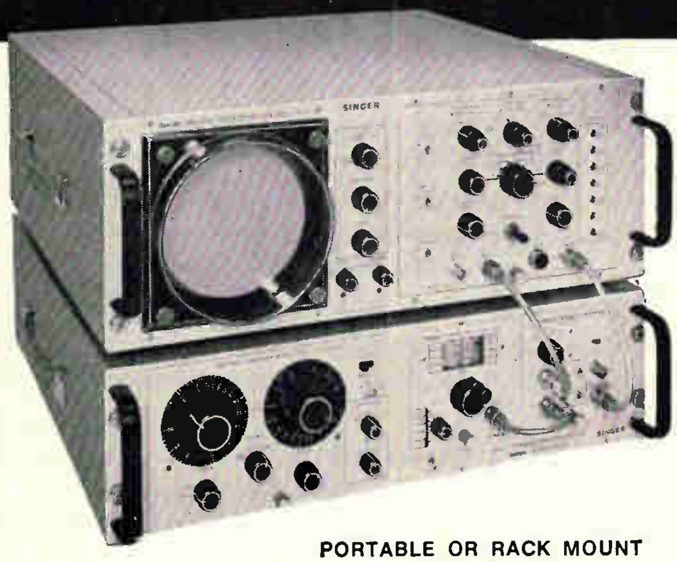




**MODEL SSB-50 • 10 Hz to 40 MHz†**




**DYNAMIC RANGE 60 db • 10 Hz RESOLUTION • 20 $\mu$v SENSITIVITY**




**PORTABLE OR RACK MOUNT**
**MODEL SSB-50**

**The NEW Solid State PANORAMIC Spectrum Analyzer System,** Model SSB-50, is the quick, convenient and accurate means of signal analysis for set-up, operation, and maintenance of SSB, AM, FM, and multiplexed communication equipment. A graphic display identifies and measures the level and frequency of desired and spurious frequencies, facilitating dynamic testing and equipment optimization for airborne, mobile, shipborne, or stationary applications.

### SPECIFICATION HIGHLIGHTS

**Frequency Range:** 10 Hz to 40 MHz (useable to 200 MHz)
**Sweep Width:** Five preset scans plus continuously adjustable 0-100 kHz scan
**Sensitivity:** 20 $\mu$v for full scale linear
**Dynamic Range:** Odd-order IM 60 db down
**Resolution (IF bandwidth):** Adjustable 10 Hz to 3 kHz
**Weight:** Indicator Section 40 lbs., Accessory Section 30 lbs.

† full sensitivity — useable to 200 MHz

*Write or call for complete technical data*

Panoramic*

*A Trademark of THE SINGER COMPANY

EMC • GERTSCH • PANORAMIC • SENSITIVE RESEARCH

**SINGER**
**INSTRUMENTATION**

THE SINGER COMPANY, METRICS DIVISION • 915 Pembroke St., Bridgeport, Conn. 06608, U. S. A. • PHONE (203) 366-3201

P67-2


# Don't be manipulated on SCR's—trust IR.

**IR's Application Fact Book lets you select only specs that count.**

SCR specifications take on a refreshing air of common sense when you read the new IR Application Fact Book. When do premium parameters really affect circuit performance? What do you give up to get a given parameter? What *combinations* of premium parameters are needed *and possible*...and at what price? You get the answers straight from IR, and you make your selection from quality SCR's rated from 4.7 amps to 550 amps RMS—25 to 1300 volts.

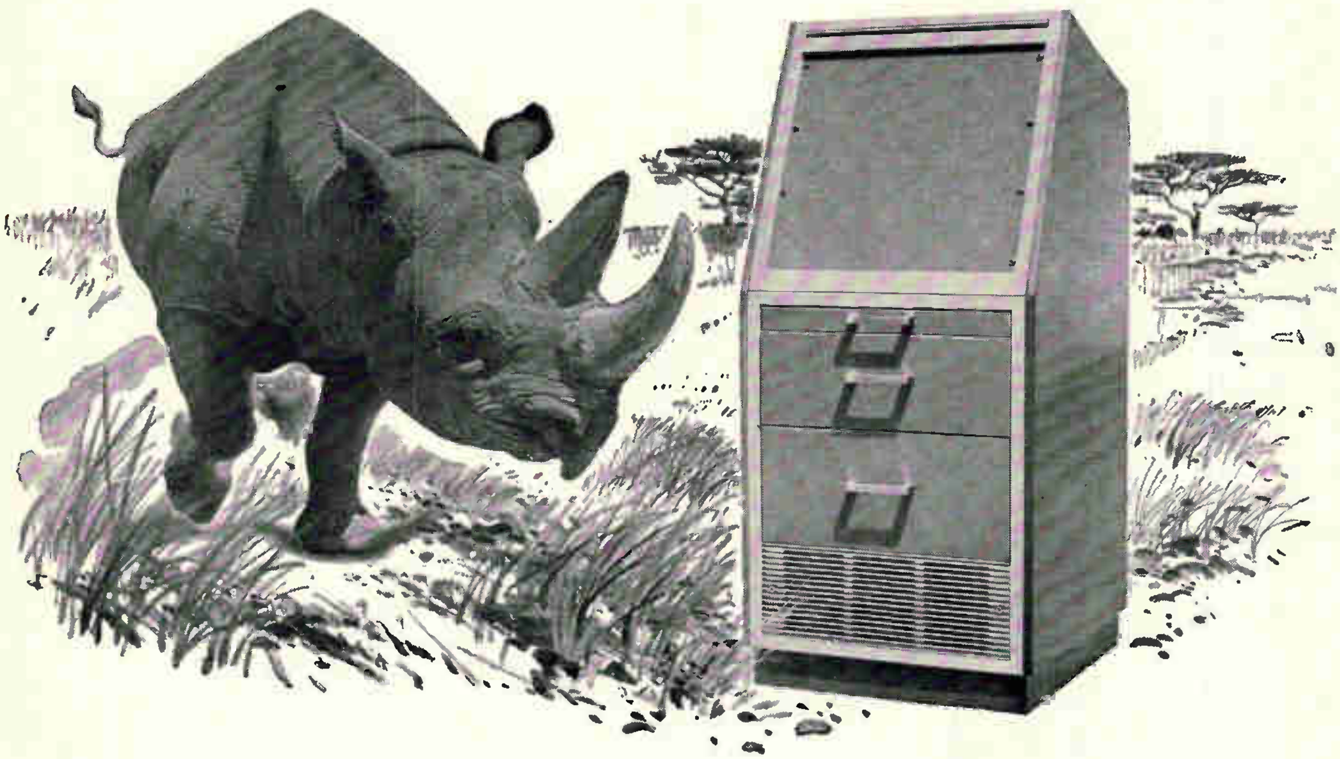
Specifying engineers are in the pivotal position today to smooth out production problems, to end delivery dilemmas, and protect performance. How? By writing specs around the parameters actually needed and actually available...off-the-shelf, overnight. Most of the information needed to write such common sense specs can be found right in the book. If your application is farther out, call an IR sales engineer. We are pioneers, too, and know how to help you innovators.

APPLY YOURSELF TO THE FACTS OF SCR DESIGN. Write for IR's Application Fact Book. It's free, and it's packed with data to help you sidestep problems from design to delivery of: regulated power supplies, frequency converters, DC motor drives...*you name it!*

**INTERNATIONAL RECTIFIER**
(213) OR 8-6281 · TELEX 6-74666 · EL SEGUNDO, CALIF.

ZENER AND REFERENCE ZENER DIODES ☐ SILICON CONTROLLED RECTIFIERS ☐ SELENIUM RECTIFIERS ☐ SILICON ASSEMBLIES

Circle 71 on reader service card



# EMCOR®II—tough, too—but more beautiful

You'll probably never have to pit your EMCOR II cabinet against a rhinoceros, but if you do, you'll find it's pretty tough, too.

EMCOR II cabinets are ruggedly made of steel, carefully welded and bolted for maximum strength and stability. They can bear heavy loads and take plenty of punishment . . . and look beautiful all the while.

Unique, too, in that you can customize EMCOR II to suit your particular preferences . . . with personalized nameplates and designs of your own making. EMCOR II gives you the "custom look."

When you're ready for strong, beautiful protection for your instrumentation, call your local EMCOR Sales and Service Engineer. Or write for our new EMCOR II catalog.

*EMCOR/distinguished cabinetry*

Albany: 436-9649; Albuquerque: 265-7766; Alexandria: 836-1800; Atlanta: 939-1674; Baltimore: 727-1999; Binghamton: 723-9661; Bridgeport: 368-4582; Buffalo: 632-2727; Chicago: 676-1100; Cleveland: 442-8080; Dallas: 631-7450; Dayton: 298-7573; Del Mar: 454-2191; Denver: 934-5505; Detroit: 357-3700; Fort Lauderdale: 564-8000; Ft. Lee (No. N.J.): 944-1600; Ft. Walton Beach: 243-6424; Houston: 526-2959; Huntsville: 539-6884; Indianapolis: 356-4249; Kansas City: 444-9494; Los Angeles: 938-2073; Minneapolis: 545-4481; Newport News: 245-8272; N.Y.C. area: 695-0082; Orlando: 425-5505; Palo Alto: 968-8304; Philadelphia: 242-0150; Pittsburgh: 884-5515; Phoenix; 273-1673; St. Louis: 647-4350; Seattle: 722-7800; Syracuse: 471-7274; Tulsa: 742-4657; Utica: 732-3775; Valley Forge (So. N. J.): 265-5800; Wilmington, Mass.: 944-3930; Winston-Salem: 725-5384. *EMCOR Reg. U.S. Pat. Off.*

**Ingersoll Products** 1002 West 120th St., Chicago, Illinois 60643 DIVISION OF BORG-WARNER CORPORATION

**electronic equipment** **BORG WARNER**®



# PG-16.

**1 Hz to 100 MHz**
**E-Mode: ±20 V at 100 MHz**
**I-Mode: ±400 mA at 100 MHz**
**Tr: less than 2.5 ns to 1 sec.**
**Tf: less than 3 ns to 1 sec.**
**Width: 5 ns to 0.5 sec.**
**Delay: 10 ns to 0.5 sec.**
**Variable PRF, Amplitude, Tr, Tf, Width, Delay**

Single or double pulses with separately variable width and delay for each pulse. Sync pulse. Duty cycle to 100%. DC-offset in either direction. Can be externally triggered or gated. One-shot via front panel pushbutton. All (silicon) solid-state. Rack height 3½".

Write or 'phone for technical data and/or a demonstration. The new generation pulse generators will be at Booth 2B48, IEEE, March 20-23.

Intercontinental Instruments, Inc. . . . an affiliate of Chronetics.

CHRONETICS

U.S.A.: 500 Nuber Avenue, Mt. Vernon, New York (914) 699-4400 TWX 710 560 0014
Europe: 39 Rue Rothschild, Geneva, Switzerland (022) 31 81 80 TELEX 22266


 Circle 73 on reader service card 

Pulse switch assures split-second pulse regardless of operating speed

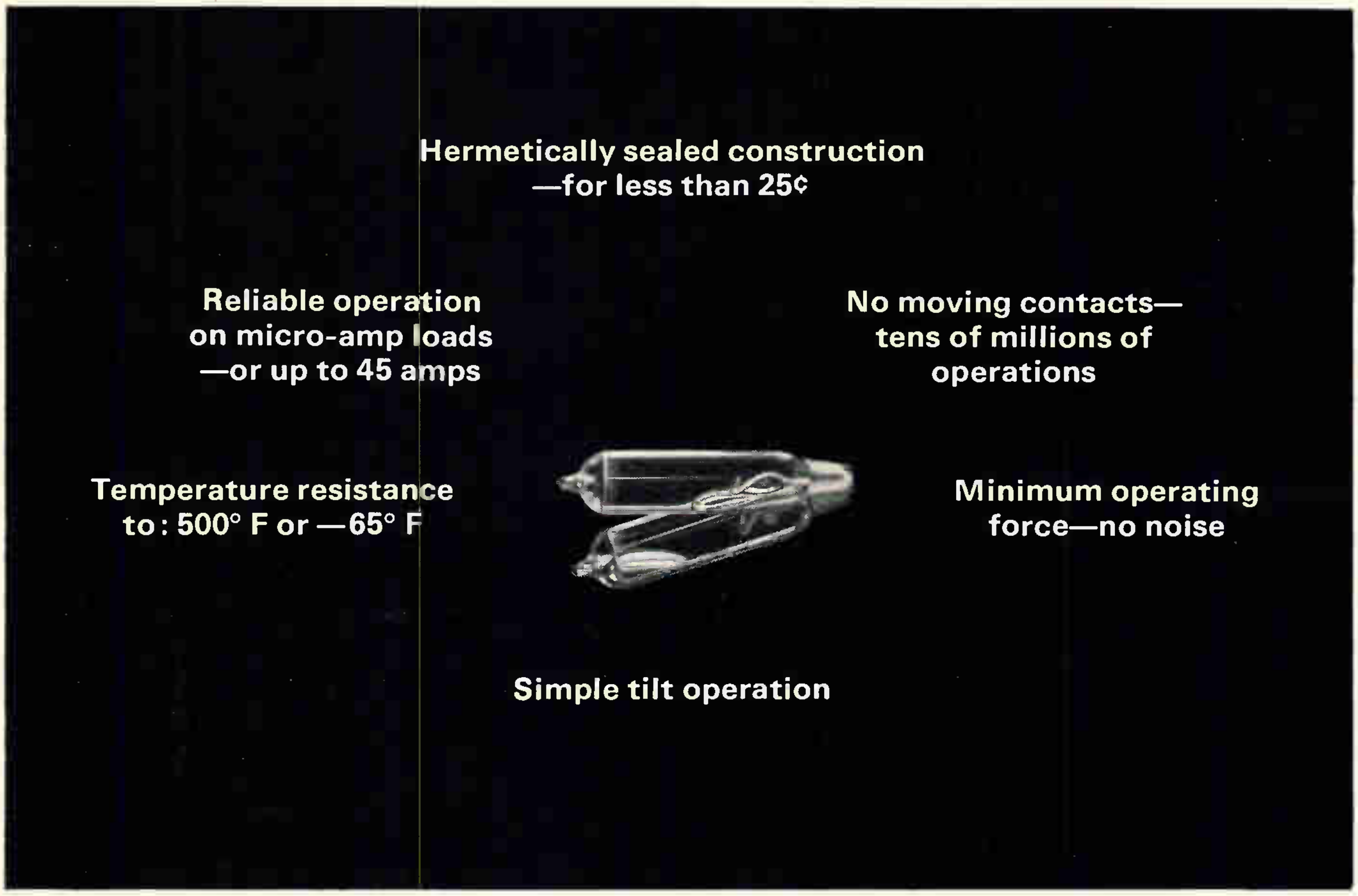
Metal or plastic enclosures protect against damage

Subminiature switch less than one inch long

Heavy duty—mercury to mercury contact

2 isolated circuits in a single switch

Ultra-sensitive switch makes or breaks on a 9 minute tilt angle




# Switching problems? Consider the advantages of mercury switches

Mercury switches are now being used in a wider variety of projects—from gyroscopes to washing machines. The reason: no other switch provides such an unusual combination of advantages.

For example: unequalled reliability—no moving parts and hermetic sealing; a wide variety of contact arrangements and electrical capacities: SPST, SPDT or 2-CKT; up to 45 amps, down to micro-amp; exceptional operating characteristics—operating angles from .15° max. to 20° min., minimum force, no noise.

Call a MICRO SWITCH Branch Office (see Yellow Pages, "Switches, Electric"). Or write for the industry's most complete mercury switch guide, revised Catalog 50.

**MICRO SWITCH**
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

**HONEYWELL INTERNATIONAL** • Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

# This is a naked YAES terminal.

# We've stripped it to show why Burndy YAES Insulug® terminals are unique.

Once the insulation is off, it's easy to see that this terminal is a one-piece unit. That's a Burndy exclusive. Look closely and you'll see that the seam on the terminal body has been brazed. Another unique Burndy feature. And all YAES terminals are *fully* plated. You won't find any exposed copper edges. In fact, there are no unplated edges where the terminal is separated from the carrier. Look inside the terminal body, too. The surface has been serrated to insure intimate contact.

Additionally, each terminal is marked with the range of wire acceptable. As a double check, the tough, nylon insulation is color-coded to indicate wire size.

Installation is quick and easy with either MS 25037 or MR 8-83 ratchet-controlled hand tools.

Automatic installation tools are available, too. Burndy's Bandolug® equipment, the SME and the SME 10, handles wire ranging from 22 to 10. And they handle them quickly, simply and inexpensively. More so than any other tools.

Burndy YAES terminals meet both the Class I and II requirements of MIL-T-7928 when installed with appropriate tools.

There really is more than meets the eye when it comes to Insulug terminals and tools. Write for Bulletin YAES-66 and see for yourself.

**BURNDY**
NORWALK, CONNECTICUT

INTERNATIONAL SALES HEADQUARTERS AND MANUFACTURING FACILITIES:
CANADA: Scarboro, Ontario / ENGLAND: St. Helens, Lancs. / BELGIUM: Mechelen / MEXICO: Naucalpan de Juarez / BRAZIL: Sao Paulo / JAPAN: Tokyo / Sales Offices in Other Major Cities



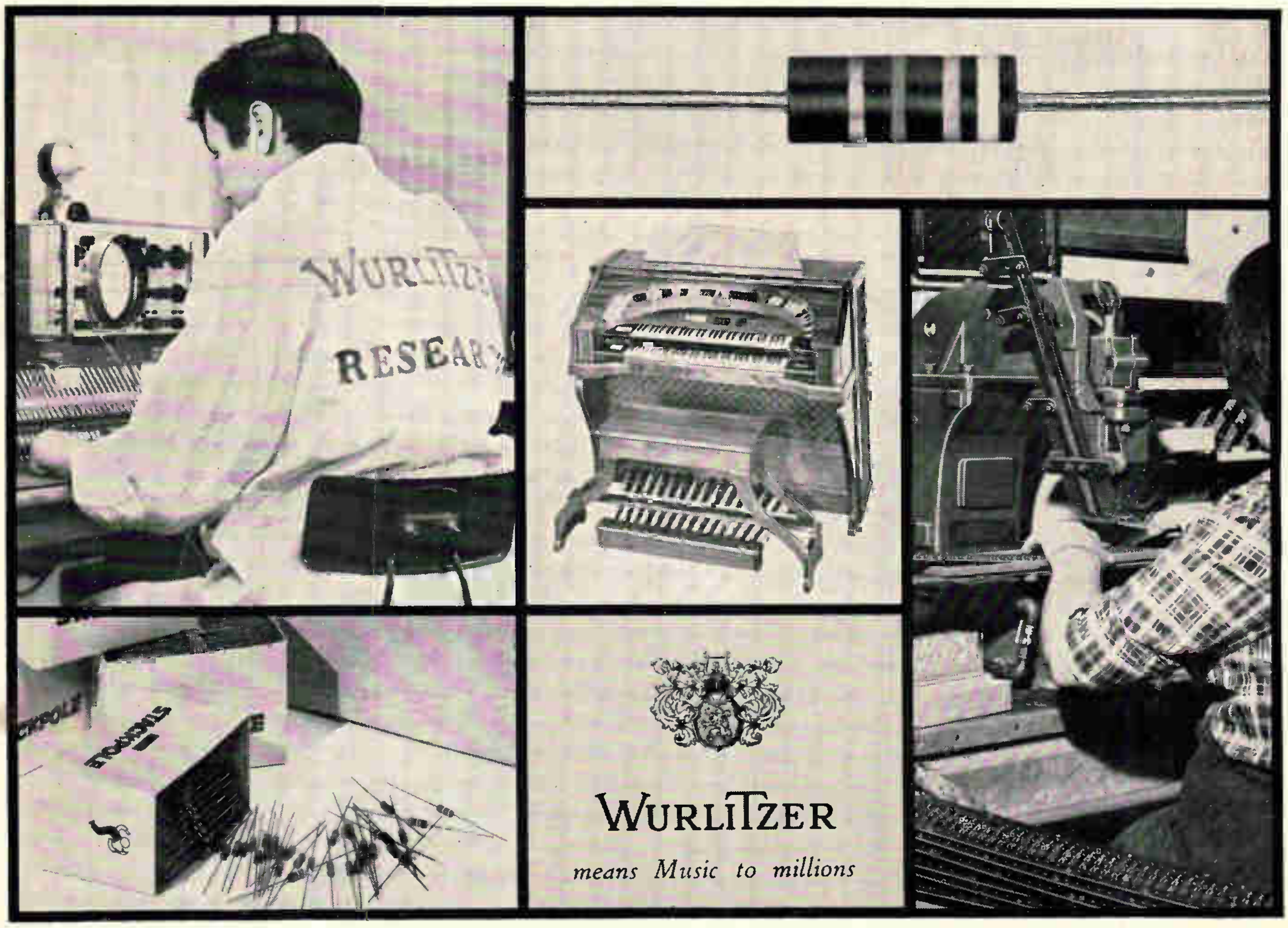
Circle 75 on reader service card

# Stackpole commercial resistors helped Wurlitzer engineers discover a new harmony in four parts....

# quality, price, delivery and service.

**STACKPOLE**
*ELECTRONIC COMPONENTS DIVISION*

Only strict attention to detail produces a fine musical instrument. That's why Wurlitzer engineers so carefully select each component that goes into Wurlitzer Organs. Stackpole commercial resistors help make these magnificent instruments electronic, as well as musical, marvels. Performance in tune with your most demanding needs is the Stackpole guarantee. Write: Stackpole Carbon Company, Electronic Components Division, Kane, Pa. 16735.



# five new linear monolithic IC's

## each with its own claim to fame

**TAA320: The 'BIFET,' world's first bipolar/mosfet IC amplifier. A new, basic, simple building block.**
10,000 megs. input resistance, 40,000 $\mu$mhos Gm. Takes 100 volt transients; will not burn out from static charge. We placed a mosfet and a silicon transistor on a single chip to give you an IC with high input impedance, high forward transadmittance and low noise. 3-lead, TO-18. Under $1.25.

**TAA310: The only IC designed specifically as a record/play-back preamp.**
A single-ended Class A preamplifier with 100 db gain and less than 4 db noise. The ten-pin, TO-5 design allows external frequency compensation, gain control, etc. The TAA310 is an optimally-designed IC preamplifier priced at $1.95 in production quantities.

**TAA293: Features accessibility to internal connections for wide design flexibility.**
Ideal for audio and IF applications, and as an amplifier, oscillator or multivibrator in numerous low-frequency functions. Ten-lead, TO-5 package affords access to every internal component. Put two of them together—and you have an op amp! Priced at $1.60 each in thousand lots.

**TAA263: Low cost, high gain transducer amplifier with a noise figure of only 2.7 db.**
The TAA263 is an economical, low level amplifier, perfect for portable microphones, low-frequency IF's, microminiature receivers; as a preamp for infrared detectors, photocells, strain gauges, accelerometers, etc. In a four-lead, TO-18 envelope. $1.25 in thousand lot quantities.

**TAA103: Smallest integrated circuit amplifier in the business.**
Packaged in a microminiature, plastic flat-pack measuring a scant .002 cubic inches, the TAA103 linear monolithic IC features 75 db gain and is ideally suited for amplifier applications from DC to 600 kHz. Buy as few as a hundred of them for well under $2.00 each.

*These five new linear monolithic IC's from Amperex are products of industry's most advanced technology, most inventive thinking. They are available now at volume-production prices. For data and applications information, write: Amperex Electronic Corp., Semiconductor Division, Dept. 371, Slatersville, R. I. 02876.*

**Amperex®**

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Circle 77 on reader service card

# MEET THE NEW IDEAS IN ELECTRONICS

**You'll see them when you visit the General Electric exhibit at the IEEE Show, Booths 3E01-18 on the third floor of the New York Coliseum, March 20-23. Look into the broadest electronics product market basket available, including these components:**

Compactrons
Klystrons & Magnetrons
Ceramic-Planar Tubes
Ignitrons
Photocells
Reed Switches
Triggered Vacuum Gaps
Film and Paper-oil Capacitors
Tantalum Electrolytic Capacitors
Aluminum Electrolytic Capacitors
A-C - D-C Specialty Capacitors
SCR Commutating Capacitors
Optoelectronics
Rectifier Diodes

Silicon Controlled Rectifiers
Selenium, Copper-oxide Rectifiers
Tunnel Diodes
Signal Diodes
Unijunction Transistors
Economy Transistors
Integrated Circuits
Glow Lamps
Fused Quartz
Electronic Glasses and Lucalox*
Voltage Regulators
Reed Switch Relays
Magnetic Starters
Push-buttons and Indicating Lights
Static Controls

Limiting Switches
Polyphenylene Oxide
Noryl* Thermoplastic Resin
Soldering Irons
Sealed Relays
Panel Meters
Meter Relays
Edgewise Meters
Time Meters
Shunts
Thyrite* Varistors
Alnico & Lodex* Magnets
Thermistors
Molded-case Circuit Breakers
600 to 2500 A CLB*

** Registered Trade-Mark of General Electric Co.*

**See how we've "computerized" our exhibit . . .** via the GE time-sharing computer service. Demonstration programs pick out the products you need and solve your kind of design problems. Just give the computer your specifications . . . in seconds, the computer gives you a report you can take home.

285-28

ELECTRONIC COMPONENTS SALES OPERATION

**GENERAL ELECTRIC**

# Husky team of HF money-stretchers

**G/A multicoupler doubles a single antenna's use; the balun promotes efficiency, flexibility**

Reduce transmission line cost and antenna space up to 50%! A multicoupler lets two independent transmitters broadcast simultaneously over a single HF antenna (2 to 32 MHz). No tuning or adjustment, no interference or interaction. Then, a G/A balun (insertion VSWR below 1.2:1—efficiency above 97%) transfers power to the antenna over economical, open-wire, balanced lines. In modern, high-performance transmission, G/A has the answers *now*. Write for full technical data.

Granger Associates

1601 California Ave., Palo Alto, California 94304 / Russell House, Molesey Rd., Walton-on-Thames, Surrey, England 1-3 Dale St., Brookvale, NSW, Australia

Baluns: 1 Kw average (2 Kw PEP) to 50 Kw average (200 Kw PEP).

Multicouplers: 10 Kw average (20 Kw PEP) to 20 Kw average (40 Kw PEP).



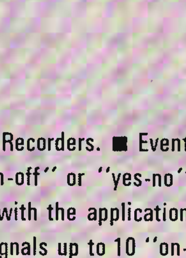

Circle 79 on reader service card


# Want to record the activities of fish?

Not only fish, but snakes, rabbits and humans have had their behavior studied with the help of Esterline Angus Event Recorders. ■ Event Recorders also monitor idle machine time, productivity, life tests, telephone usage and any other operation where "on-off" or "yes-no" records plotted against time are required. ■ A single instrument can monitor up to 20 events. Writing elements deflect with the application or absence of a voltage lasting only 15 milliseconds. These elements will even follow telephone dial pulses and other signals up to 10 "on-off" cycles per second. ■ Our new High Impedance DC Voltage Sensing Event Recorder can be bridged onto low power circuits without upsetting their operation. ■ You can choose the case style (portable, flush, desk top, wall mounted, twin with 40 channels), chart speeds (up to 14 immediately dialable) and writing system (inkless or ink) best suited to your requirements. You also get ten day delivery* and prices as low as $380. ■ More people buy Esterline Angus Event Recorders than buy all other makes combined. Discover the reasons! ■ Write for our informative Event Recorder Catalog or call your Esterline Angus sales engineer. ■ **Quick delivery is possible on certain Event Recorder models which have become so popular we have them in production at all times.*

**You can do it with an Esterline Angus Event Recorder**

ESTERLINE ANGUS INSTRUMENT COMPANY, INC.
BOX 24000 • INDIANAPOLIS, INDIANA 46224

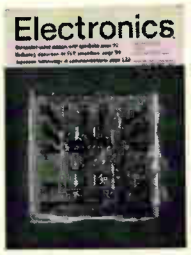



# Technical Articles

**Detecting a signal digitally**
**page 82**

There was a time when almost all receivers had tunable filters, but then superheterodynes came along and replaced nearly all of them. The tunable filter is staging a comeback now because of a new digital synthesis technique. The end result is a more accurate and less expensive tuner.

**Dielectric isolation**
**page 91**




At first glance, how integrated circuits are isolated is of chief concern to the manufacturers of semiconductors. But on closer examination, the engineer who designs higher frequency equipment finds that the application may dictate the kind of isolation technique used. Thus the user has to know as much about dielectric isolation as the manufacturer. On the cover is a Decal circuit isolated by a technique developed by the Radio Corp. of America. The elements of this r-f mixer are diffused and interconnected by thin films, then hermetically sealed to glass. This examination of isolation techniques includes:

1. A challenge: to integrate and isolate, p. 91
2. Getting the most out of circuits with dielectric isolation, p. 97
3. Silicon-on-sapphire transistors point way to microwave IC's, p. 106

**Extending IC technology to microwave equipment**
**page 112**

The next area likely to fall under the onslaught of integrated circuits is the design of microwave equipment. Three approaches are already being used: monolithic, hybrid and dielectric isolation. Designing microwave IC's will be easier than designing integrated microwave systems.

**Small computers for space**
**page 127**

Because of the growing number of experiments called for aboard research satellites, a general-purpose computer is required to replace the special-purpose equipment included in individual experimental packages. But the big obstacle is generating enough power to run such a machine. Here is a proposal for a stored-program computer that uses power stingily, weighs less than most general-purpose computers, and occupies small space.

## Coming April 3

- **Measuring transconductance in field effect transistors**
- **Testing circuits with infrared radiation**
- **Terrain-following radar that doesn't scan continuously**
- **Setting type electronically**
- **The french-fried flatpack, new approach to packaging**

←Circle 80 on reader service card

# Detecting a signal digitally

Synthesis technique automatically searches out frequencies with simpler hardware than conventional tunable filters

By Edmund I. Schwartz, Harold A. Smith, and Robert E. Weiblen
Devenco Inc., New York

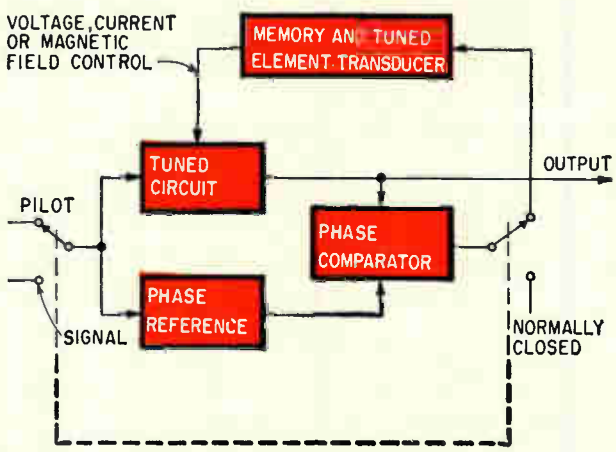
**Tunable radio-frequency** receivers, cast aside for the superheterodyne and almost forgotten, may get a new lease of life thanks to a new digital synthesis technique for detecting and rejecting signals in a band. Signal detection is accomplished with a synthesized tunable filter made with a phase-locked servoloop that positions a tuned circuit to a desired frequency and a digital memory element that stores the frequency's position. The detection is achieved without the tracking errors encountered in mechanically tuned filters. And the hardware required is simpler and less prone to error with changes in environment. If the system requires additional amplification, several units can be cascaded.

Thus, TRF receivers no longer require individual, mechanical tuning arrangements that are expensive, bulky, and affected by environmental conditions. In addition the TRF does not require the nonlinear mixer or local oscillator that go with proper operation of a superheterodyne. Hence, no spurious products are created from strong interference signals and no radiated signals appear on the antenna to reveal the location of the receiver.

### Tuning the filter

To understand the operation of a tunable filter consider the block diagram at the right. All pole determining elements are in phase-locked servoloops and act independently to achieve maximum tuning and tracking accuracy. The poles and zeros, which result from LC or RC circuits, may be controlled by voltage, current, or magnetic field. Tuning is governed by a reference frequency input called a pilot and a single pilot may control many loops. Since the poles need not be tuned precisely to the pilot's frequency (synchronous tuning), stagger-tuned filters may be synthesized. When the switch is placed in the pilot position the servoloop is closed and the tuning-reference frequency (pilot) is applied to both the tuned circuit and the phase-reference circuit. After receiving a phase shift by the phase-reference circuit the pilot is applied to the phase comparator. The output of the tuned circuit becomes the other input to the phase comparator and the output from the phase comparator determines the value of a voltage, current, or magnetic field controlling the center frequency of the tuned circuit. The memory, which is equivalent to a conventional servomechanism, is driven by the output of the phase comparator and changes the control parameter in the tuned circuit. This in turn produces a phase shift in the pilot that reduces the phase-comparator's output to zero. Having completed the phase locking, the comparator is disconnected from the memory. The memory then maintains the control parameter at a fixed value until the system is retuned.

The phase-comparator output is zero when the difference between the tuned-circuit output and the reference channel input is 90°. Thus, if the phase-reference is 90°, the tuned circuit is adjusted to precisely the pilot frequency needed to pass the




A pilot reference signal tunes the servoloop of the digital filter synthesizer. After tuning, the operator opens the loop and the memory elements retain their relative positions.


**An earlier transistorized version of the tunable filter.**

pilot tone without a phase shift (zero degrees). If a phase-reference angle other than 90° is applied, the tuned circuit will be adjusted to complement that angle; the frequency to which the circuit is tuned depends on its Q.

When zero error is present at the phase-comparator output the servo is at null. Then the input is switched from the pilot to the operational (signal) input. Simultaneously, the comparator output is disconnected from the feedback loop. Since the loop is opened after the servo tunes the circuit, the memory must generate a tuning command that does not drift, decay, or otherwise detune the resonant circuit when the pilot is removed.

### Digital element stores count

Open-loop operation is accomplished with a binary counter as the memory element. While tuning, the counter increases its stored value when the polarity of the phase comparator output is postive, and decreases it when the output is negative. The counter stops scaling when the comparator output nulls and the remaining count is held indefinitely; thus the counter acts as a perfect integrator. The value held in the counter register is decoded into an analog command signal and applied to a transducer that produces the proper control parameter for the tuned element.

The operation of the servoloop is similar to that used in automatic tuning of transmitter tank circuits—but with one important difference. In transmitters, the carrier acts as both the processed signal and the pilot; there is no need to open the loop after the circuit has been tuned since pilot and signal are one and the same. But the filter may process other signals that are not necessarily at the resonant frequency of the pole or of sufficient amplitude to effect control even if they were. The digital portion of the filter allows the servoloop to be opened and the distinction made between signal and pilot. Therefore the phase-tuning scheme can be used with any filter.

The switching between pilot and signal inputs can be accomplished electronically to allow rapid tuning. The tuning rate is a function of the counter clock rate and the time constants of the transducer and tuned-circuit.

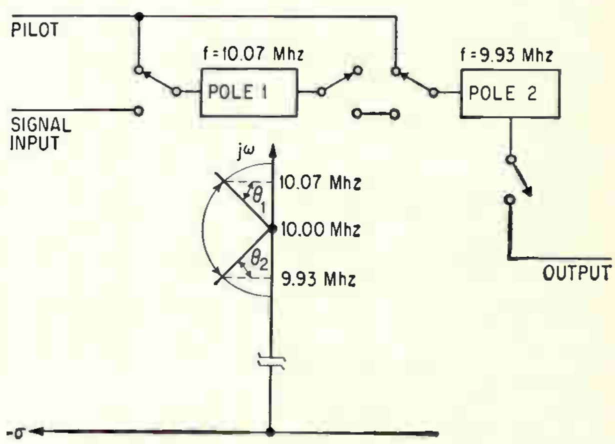
Several tuned circuits may be combined to form a multipole filter, such as a Butterworth, having a flat amplitude response. A cascaded arrangement for a 2-pole Butterworth is shown below. It has a bandwidth of 200 kilohertz and is tunable around 10 megahertz. The design specifications require that the Q at each pole be 70, that they occur with one circuit tuned to 9.93 Mhz, and the other at 10.07 Mhz. Represented in the s-plane, the poles lie on a circle whose center is at $f_0 = 10$ Mhz and intersects the $j\omega$ axis at 9.9 and 10.1 Mhz.

If the pilot is chosen as the center frequency of the filter, nominally 10 Mhz, the pilot will incur phase shifts of approximately +45° through the 9.93-Mhz circuit. The phase shifts are only approximate because of the zeros on the $j\omega$ axis and the conjugate poles in the lower half of the s-plane. For circuits with Q's greater than 10 these poles and zeros cause a phase shift of less than two degrees and can be neglected.

The phase-reference circuit for pole 1 is chosen to impart a −45° phase shift to the pilot tone. When the pilot is shifted +45° by its passage through the tuned circuit, the phase comparator senses a 90° relative phase difference between its inputs and its output d-c level falls to zero. If the center frequency of the pole causes a phase shift of the pilot other than +45°, the comparator develops a nonzero output. This output causes the servoloop to drive the tuned circuit's resonant frequency in a direction to produce the phase shift necessary for a comparator null—in this case, to 10.07 Mhz. For pole 2 the situation is reversed; the phase reference is designed for a +45° shift and the circuit is tuned to 9.93 Mhz to shift the 10-Mhz pilot by −45°.

After the pilot has tuned the two poles, the switches are placed in their lower position and the cascade arrangement acts as a Butterworth maximally flat filter. Note that the tuning of the pole yields a specific resonant frequency.

Placing the switches in their upper positions




**Filter synthesizer controls each pole position in a two-pole Butterworth amplifier.**

and applying another pilot frequency tunes the poles so that they are at 45° angles with respect to the new pilot frequency location on the $j\omega$ axis. If the Q of the tuned circuit remains constant the filter bandwidth varies in direct proportion to the center, or pilot frequency. Thus, at 8 Mhz the filter has a 160-khz bandwidth and at 12 Mhz, a 240-khz bandwidth.

For applications where a constant bandwidth filter is desired, a circuit can be provided that makes the Q of the tuned circuit directly proportional to the frequency.

In the h-f region, voltage-controlled capacitor diodes or current-controlled inductors are used as the tunable elements.

### Obtaining narrow bandwidths

An active circuit can also be attached to an LC circuit to obtain narrower bandwidths than those normally encountered with LC circuits alone (see diagram below). Active filter circuits are not required for the operation of the synthesizer but they are useful in narrow-bandwidth filter designs or in forming constant-bandwidth configurations.

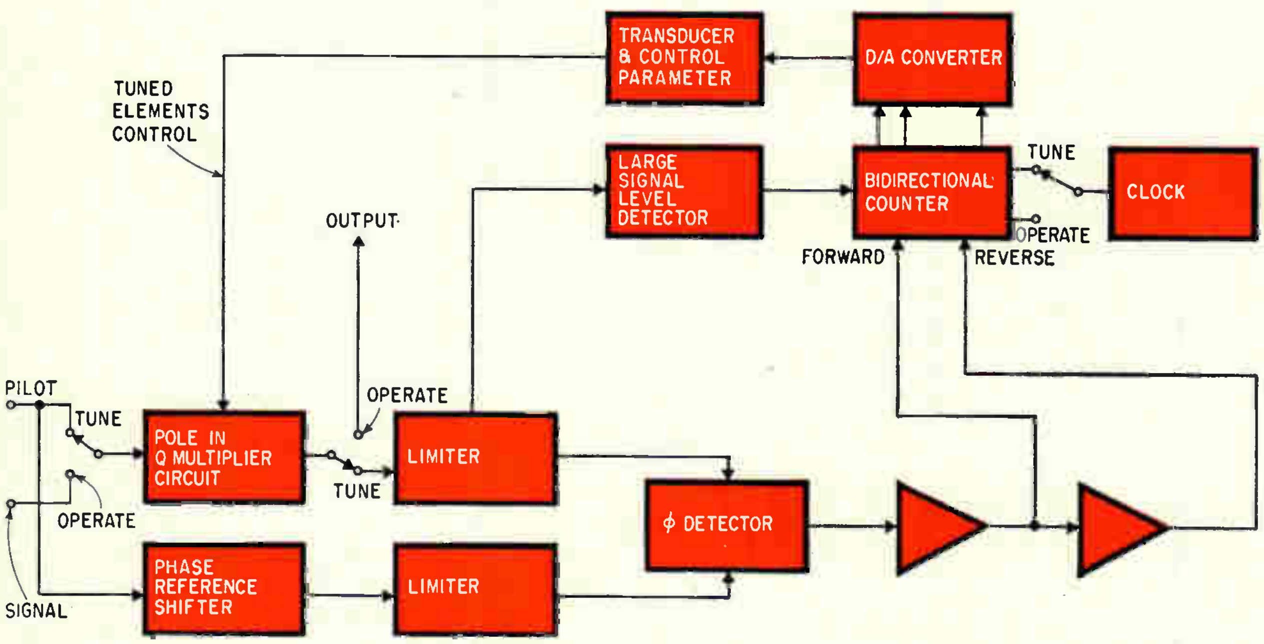
An input (signal or pilot) is applied directly to a tuned resonant circuit that incorporates a Q-multiplier. The multiplier relies on negative feedback to stabilize the positive feedback usually inherent in such circuits. Negative feedback maintains a constant multiplication factor at the desired frequency and decreases circuit sensitivity to minor changes in component characteristics. In the operational mode the signal output is taken directly after the Q-multiplier. This circuit also isolates the resonant elements and allows the designer to tune each pole independently in such amplifiers as a Butterworth or Chebyshev.

The Q-multiplier output is also applied to a limiter, and the pilot, which is not filtered by the Q-multiplier, is applied to an identical limiter after being shifted in phase. The limiters are employed only when the pilot is present.

Both limiters remove the effects of amplitude variations from the pilot signal on the phase detector output. The limiters' outputs are compared in the phase detector. As before, the detector output is zero for inputs with a 90° phase difference. These limiters must be carefully designed so that they do not contribute additional phase shifts.

The phase detector output is positive or negative, depending on the sign that results from the difference between the center frequency of the pole and that of the pilot. After amplification, the phase detector output is applied to two cascade inverter amplifiers. The outputs from the inverters control the direction of count in a conventional bidirectional counter consisting of cascaded flip-flops.

Counter operation occurs in a straight binary mode and counts pulses generated by a clock that is connected to the counter only in the tune mode. Flip-flop outputs from the counter are connected to inputs of a digital-to-analog ladder-network converter. This configuration is the well-known staircase generator for which each step of voltage corresponds to one of the $2^n$ possible counter states, where n is the number of flip-flops in the counter. Thus, the value of the count is continuously converted to an analog representation. An analog form of the count value is applied to a transducer that converts it to the proper form and level for controlling the tuned element over the desired frequency range. If speeding up the tuning process is desirable, a two-speed clock or a continuously-variable frequency clock can be used, in which the clock rate, and thus the speed of correction, is proportional to the difference between the reference and controlled parameter. In most applications in




Narrow bandwidths are achieved by placing active elements in the Q-multiplier circuit.

the h-f region it takes several milliseconds to align the circuits.

After tuning is achieved the servoloop is opened by switching the tuned-circuit input to the signal and the output of the circuit is available for cascading with other tuned circuits. Switching is performed together with the disabling of the clock. The counter register retains the last count value held before the clock was disabled. This count value corresponds to the desired tuning frequency of the circuit. Therefore, decoding this value into the tuning control parameter insures that the tuned circuit remains properly set until changed. The tuned circuit thereby maintains proper alignment when the servoloop is opened.

If temperature induces drifting of the tuned-circuit elements, the digital-to-analog converter, or the flip-flop output levels, the pilot must be reapplied for a short period of time. If signals are filtered that contain information varying at an audio rate, the time taken for retuning can usually be sufficiently short so that the interruption is not heard or noted by the audio circuits. To take advantage of the rapid retuning, electrically-controlled switches perform the double-pole switching.

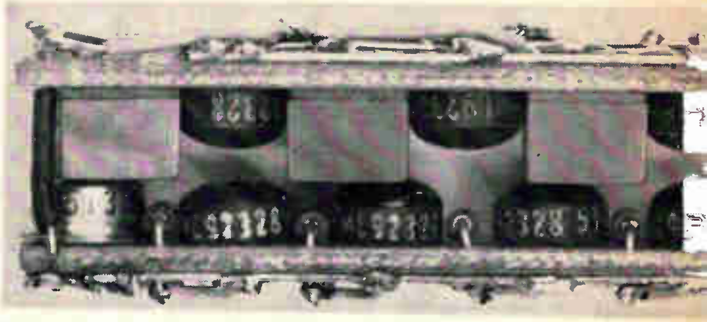
### Speeding up the tuning

Two-speed servocontrol can increase the speed of the tuning process. The output of the limiter following the Q-multiplier is applied to a large-signal-level detector circuit that acts as a coarse error detector. It detects large differences between the Q-multiplier center frequency and the pilot frequency. For such large errors, the detector places the servoloop in a rapid-scanning mode by bypassing flip-flops from the front end of the counter, and thus generates coarse tuning steps. As the desired frequency is approached, the output of the Q-multiplier rises and the output of the level detector becomes large enough to switch additional flip-flops into the counter. The switching rate of the flip-flops is reduced and the finer tuning increments are obtained from the D/A converter.

The resonant frequency of the tuned circuit is not adjustable as a continuous or smooth function. It takes on discrete values as the counter register changes from one count to the next. Inherent error due to this quantization can be as large as ± one-half count. However, when a 10-bit counter is used the one-half count error represents a frequency error of only 0.05%. A 10-bit counter is capable of counting 1,024 pulses. If each of the possible states of this counter is transformed into equally spaced tuning parameters, the worst error that results will be one-half of one counter state, or an error of one part in 2,048—approximately 0.05%. For this example, a 4-Mhz tuning range centered about 10 Mhz results in a maximum tuning error of ±2 khz.

### Pole locations essential

The accuracy of the synthesizer method depends upon the pole locations with respect to the pilot frequency and the $j\omega$ axis. The desired reference



Entire digital element assembly shown with seven IC's can be replaced with two flat packs.

angles are generated by passing the pilot through the phase shift networks. If the resulting reference angles are not stable over the tuning range, or if they are sensitive to component variations the synthesizer merely trades mechanical tracking problems for electrical ones.

A simple but effective method for developing precise and stable phase shifts assures proper pole alignment. The reference is obtained from the pilot source (assumed the zero-degree phase reference) by passing it through an RC circuit. For a series resistor and negligible circuit loading the resultant phase shift is given by

$$\phi = \arctan (RC) \qquad (1)$$

How stable is the generated phase angle? This can be determined by elementary error analysis. Thus, first, consider the phase angle, $\phi$, as a function of three variables; R, C, and the radian frequency, $\omega$. If the phase angle is altered by an amount $d\phi$, then

$$d\phi = \frac{\partial F}{\partial R} dR + \frac{\partial F}{\partial C} dC + \frac{\partial F}{\partial \omega} d\omega \qquad (2)$$

where the last term of equation 2 can be neglected since the pilot frequency is known.

Performing the operation indicated in equation 2 on equation 1 yields an expression for instability of the phase angle caused by R and C.

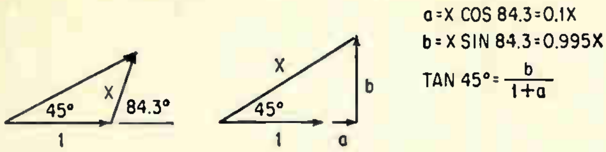
$$d\phi = \frac{R\omega\, dC + C\omega\, dR}{1 + \omega^2 R^2 C^2} \qquad (3)$$

At any given frequency $\omega RC$ can be replaced by a constant, k. Equation 3 is thereby modified to yield

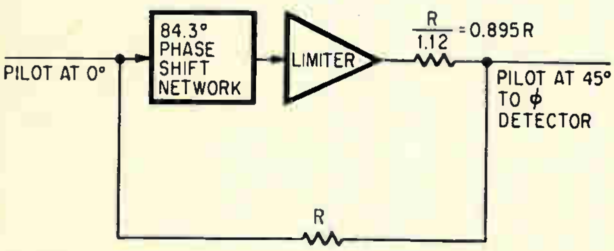
$$d\phi = \frac{k}{1 + k^2} \left[ \frac{dC}{C} + \frac{dR}{R} \right] \qquad (4)$$

Thus, the variation in phase angle (given in radians) is a function of the fractional change in C and R.

It is desirable to make $\phi$ as independent of $\omega$ as possible so that the RC network can be made with fixed-value components. If the $\omega RC$ product is 10 at the lowest frequency of interest $\phi$ will be 84.3°; at one octave higher $\phi$ will be 87.2°—only a 2.9° change. For high values of k the generated phase angle is essentially independent of frequency. Thus, equation 4 can be rewritten so that the phase




**Vector diagram** represents an RC phase-shift network with an RC product of 10. Resultant phase shift is 84.3°.




**By combining** an unshifted pilot with X units of 84.3° pilots a 45° phase shift is obtained.

error is approximately l/k times the fractional change in the components. Making the phase less dependent on frequency also reduces the effect of component instabilities. The variation of signal amplitude with phase shifter frequency is overcome by passing the reference signal through the limiter.

Any desired phase reference angle can be formed by adding a highly shifted (near 90°) pilot from an RC phase-shifting network with an unshifted pilot signal.

If an RC phase-shift network is used with an RC product of 10, the resultant phase-shift is 84.3°. To obtain a 45° phase-shift, one unit of zero (unshifted) pilot must be combined with X units of 84.3° pilot as shown above. The quantity X is 1.12 and the phase reference angle is generated as illustrated. Stability of the resistive summing network is assured since, for resistors with equal temperature coefficients, the ratio (0.895 for the example) of the 0°—and 84.3°—components remain constant as the resistor values change with temperature.

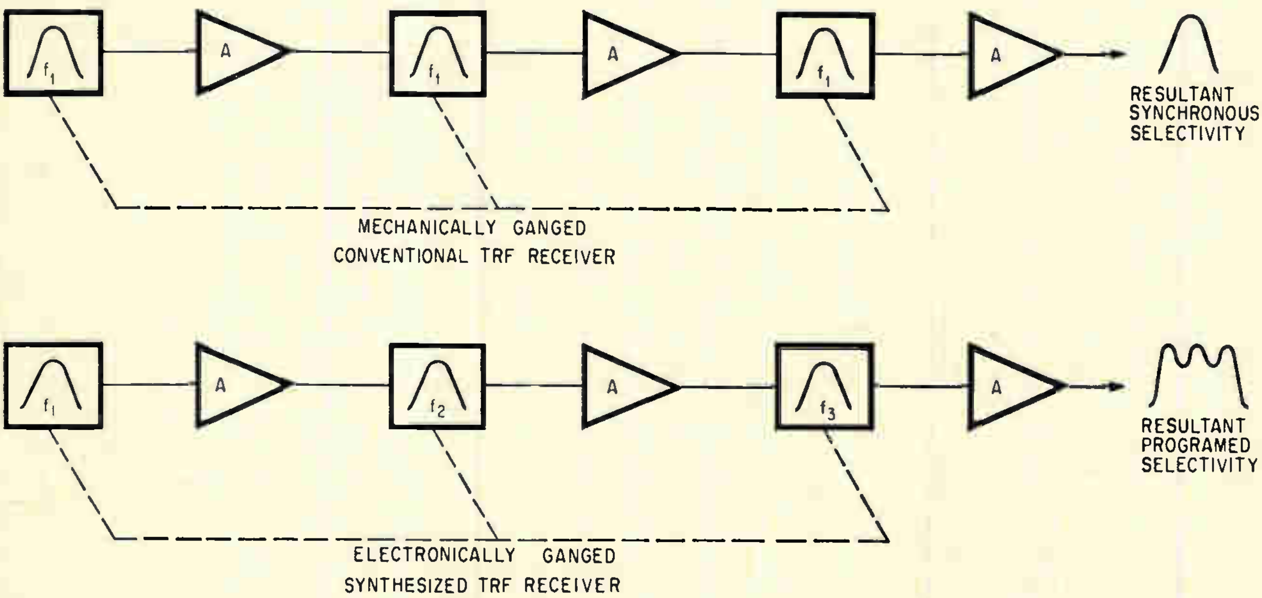
### Synthesizing as a TRF receiver

The principal advantages of a TRF receiver over a superheterodyne is that it doesn't need a mixer or a local oscillator. Also, conversion to an intermediate frequency introduces problems of image frequency reception and oscillator tracking. The solutions to these problems require design compromises. Local oscillators generate relatively large amounts of power near the signal frequency. Leakage of this power through the radio-frequency circuitry and the antenna can cause interference with other receivers operating nearby.

The usual arguments cited against the TRF receiver are that it is difficult to track properly and has poor selectivity. These problems are solved by the synthesizer system since tracking errors are avoided by simultaneously tuning each circuit with a common reference frequency, and since the selectivity can be improved by using many stages with stagger tuning.

The synthesizer may be used as a TRF receiver in which selectivity is achieved in one stage, or distributed among several stages as shown below. A stable, high selective TRF receiver may be obtained by placing an antenna at the synthesizer's input and cascading as many poles as required for the desired in-band characteristics. If sufficient gain is provided, only a simple diode detector is needed at the synthesizer's output. This is followed by an audio amplifier. The receiver is tuned by momentarily inserting a signal at the desired frequency and switching back to the antenna.

Because precise stagger tuning of the filter poles is possible, the synthesized TRF receiver is capable




**When used as a tuned radio-frequency receiver,** the synthesizer can place the selectivity entirely in one stage or distribute it over several stages.

of high selectivity. Filters having steeper skirts and flatter in-band amplitude characteristics can be formed with different phase-reference angles in each synthesizer loop. Greater receiver selectivity can also be achieved and matched filter receivers can be implemented by forming the specified filter shape.

### Eliminating spurious frequencies

The dynamic range of the synthesized filters must be large to avoid replacing the limitation of the superheterodyne's mixer with limitations of the filters' controlled elements. Such limitations occur when controlled elements are used because the signal level can become an appreciable fraction of the controlling parameter level. The signal voltage varies the capacitance of voltage-variable capacitor diodes at the same rate as the signal frequency, and the circuit output contains distortion terms due to the variation of this capacitance at the center frequency of the filter. Modifications to the basic circuit (replacing the tuned element with a large network having the same two-terminal characteristics to distribute the signal energy over several elements) for the controlled pole eliminate the upper limit imposed on the dynamic range. It becomes possible, therefore, to design filters for TRF receiver stages or preselector service in which the dynamic range is limited by the lowest level of signal. This limitation is caused by the low transfer efficiency of tuned circuits and by the noise figures of the active elements in the filter. These limitations always exist in practice and are not inherent in the synthesizer.

### Preselector, another application

The synthesizer may also be used to advantage as a preselector for the superheterodyne receiver. In a conventional superheterodyne receiver the r-f selectivity is obtained with one, two, or, at most, three tuned circuits. However, the circuits must use rather wide bandwidths to reduce the effects of tracking errors. Narrow bandwidth is obtained in an intermediate-frequency amplifier where fixed tuning and lower frequencies produce better selectivity. A major disadvantage of wideband r-f stages is that signal frequencies near those selected are passed on to the mixer. Since the mixer is inherently a nonlinear device, undesirable cross products are generated that may fall in the intermediate-frequency pass band. Unwanted signals also appear at the receiver output and these contribute to the automatic gain control voltage. These effects lower the gain of the receiver. Since the synthesizer can be used as a narrow-band preselector, the problems of mechanical tuning and tracking errors are eliminated. Unwanted signals are blocked from the mixer by inserting selectivity like that of the i-f amplifier in front of the mixer.

As a preselector, the synthesizer is then tuned to a command frequency obtained by sidestepping the local oscillator of the superheterodyne to the desired signal frequency. Since tuning is fast, it is only necessary to connect the synthesizer to the command frequency source for a short time.

Receivers that employ the synthesizer principle have additional capabilities beyond those already mentioned. Combined with a frequency synthesizer, the system forms an accurate signal-seeking or command-tuned receiver. For this the frequency synthesizer must be programed to step its output frequency in small increments, and this output is then applied to the filter as a pilot. When each new frequency appears, the filter is switched from the receiving antenna to the frequency synthesizer for a short period. If the frequency synthesizer is programed to switch a frequency arbitrarily, a random frequency jump receiver (RFJ) is formed. When this receiver is programed in synchronism with an RFJ transmitter the two provide a secure communications system.

The basic synthesizer circuit can, in most applications, be contained on one small printed circuit card especially since all the required digital circuitry is now available in integrated-circuit packages. Any number of these cards can obtain a desired filter characteristic without sacrificing the tuning speed or reducing the tuning accuracy. Tunable elements as diverse as magnetically-controlled yttrium iron garnet devices (YIG), voltage-controlled capacitor diodes, and current-controlled inductors may be used in the digital filter synthesizer to obtain the advantages of the filter in any portion of the frequency spectrum.


**The authors**

Edmund I. Schwartz, director of research and development at Devenco Inc., has devised several active analog filtering techniques. He holds patents for digital matched-filter modems and holographic systems.

Harold A. Smith, assistant director of research and development, holds the patent of the filter synthesizer described in this article. His other patents are for radar, switching circuits and holographic systems.

Robert E. Weiblen, staff member, is presently working with digital signal processing techniques. He has also done work on heat flow in bulk materials.

# Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

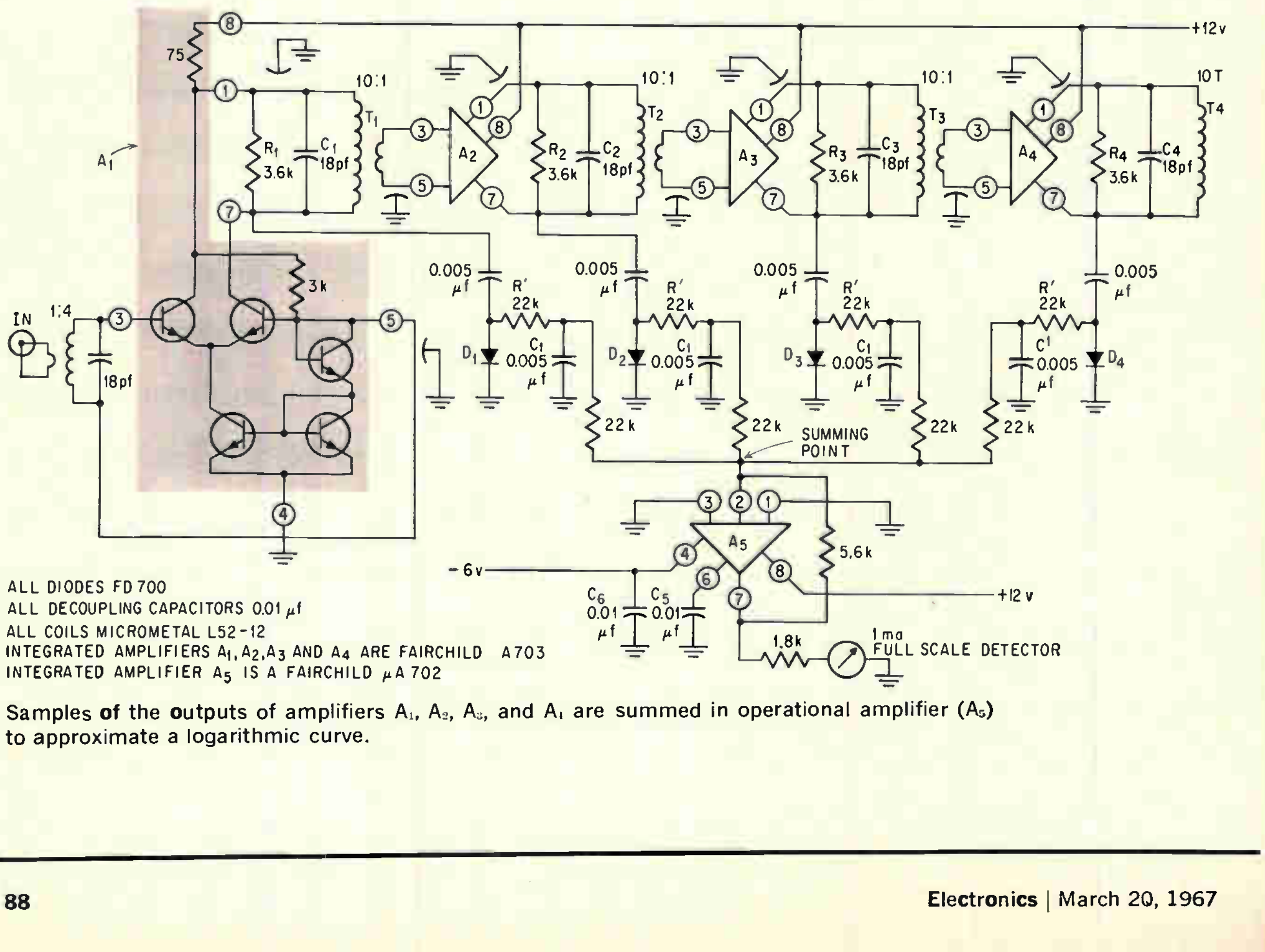
## Low-cost IC's improve 45-Mhz i-f amplifier

By Richard Q. Lane
Fairchild Semiconductor Division, Palo Alto, Calif.

**Integrated circuits** that cost less than $1 each can be used to build one type of intermediate-frequency amplifier and meter driver. This amplifier is advantageous in the detector of a bridge network that operates in the very high and ultrahigh frequency ranges. The circuit was originally designed to operate a 45-megahertz bridge, with 80 decibels of gain. By reducing the capacitors ($C_1$, $C_2$, $C_3$, and $C_4$) and increasing the inductance of the transformer's primary coils ($T_1$, $T_2$, $T_3$, and $T_4$) the designer may extend the bandwidth to 3 Mhz, making it applicable for radar.

The amplifier's logarithmic transfer characteristic is a four-segment piecewise linear approximation. The characteristic is generated by sampling the output of cascaded amplifiers $A_1$, $A_2$, $A_3$, $A_4$ and combining the samples in video summing amplifier $A_5$. These are d-c average values of the a-c output signals at each stage. Diodes $D_1$, $D_2$, $D_3$, and $D_4$ clip the positive half-cycles; the negative half-cycles are filtered by the RC networks and applied to summing resistors $R_1$, $R_2$, $R_3$, and $R_4$.

Each amplifier stage has a 20-db gain and limits at the same output level. A large input signal forces successive stages to limit in sequence, last stage ($A_4$) first. As each stage limits, the slope of the transfer characteristic drops 20 db; this action generates a characteristic of four linked-line segments with successively decreasing slopes. The characteristic approximates a logarithmic plot because the slopes of successive segments decrease geometrically—each having 1/10th the slope of the preceding. With this type of design slow response and bandshape dependence on the input signal are overcome. This is not the case with automatic



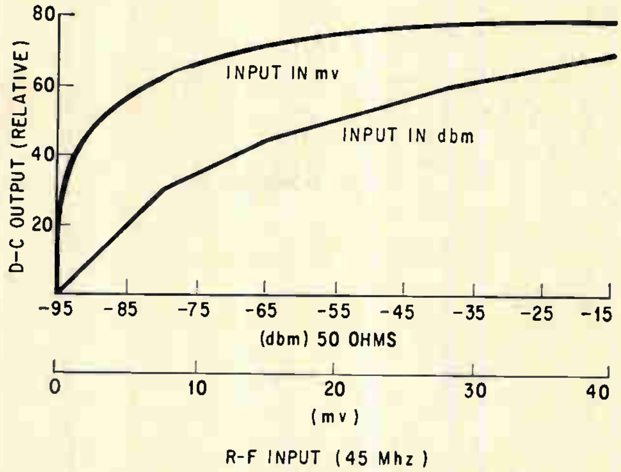

Samples of the outputs of amplifiers $A_1$, $A_2$, $A_3$, and $A_4$ are summed in operational amplifier ($A_5$) to approximate a logarithmic curve.

gain control types of logarithmic amplifier with feedback.

The speed of response in a feedback AGC logarithmic amplifier of sharp selectivity and high forward gain is severely limited because of the accumulated phase shift of the interstages. Placing the dominant pole of the amplifier's AGC loop at the frequency low enough to assure a monotonic step response and freedom from oscillation causes the delay. The slow logging makes the amplifier unsuitable for radar applications. Since the successive detection circuit has no feedback loop, its step response is essentially that of the interstage filters and operational amplifier $A_5$.

Another plus for the successive detection logarithmic amplifier is its stable operating point; this makes the bandshape independent of the input signal level. Feedback-AGC amplifiers, by contrast, have bandshapes which depend on the input and output admittances of the AGC's transistors because the AGC signals continually change the operating point.

The optimum loading resistor $R_L$ and the turns ratio n of the interstage transformers are 3.6 kilohms and 10:1 respectively for the circuit values shown. Typical values of quiescent current $I_{dc}$, forward transfer admittance $y_f$, and input admittance $y_i$ are 2 milliamperes, $-24 + j14$ millimhos, and




Four-segment piecewise linear approximation to logarithmic curve results as large input signals force the amplifier stages to limit in sequence.

$0.76 + j2$ millimhos respectively.

Smaller values of time constant $R'C'C_6$ for the summing filter would be necessary for a 3-Mhz radar application. In fact the RC summing filters would be better replaced by LC combinations. A smaller value for roll-off capacitor $C_5$ would also be necessary, since $C_5$ restricts the frequency response of summing amplifier $A_5$.

## Small lamp bridge regulates line voltage


by Dunford Kelly

Consultant, Los Angeles


**Good line regulation** is possible from a small and inexpensive lamp-bridge circuit that does not generate distortion or large magnetic fields and is insensitive to frequency.

The lamp bridge delivers a 1-volt a-c output that only varies 0.25% from a line voltage change of 105 to 125 volts. Close regulation is maintained by the bridge for line frequencies of 25 to 800 hertz.

The exceptionally close regulation results from the ballast action of the bulbs shown in the schematic when used with a balance voltage source. The lower frequency limit is set by bulb flicker where distortion interferes with the necessary ballast action. The upper frequency limit is determined by stray reactances.

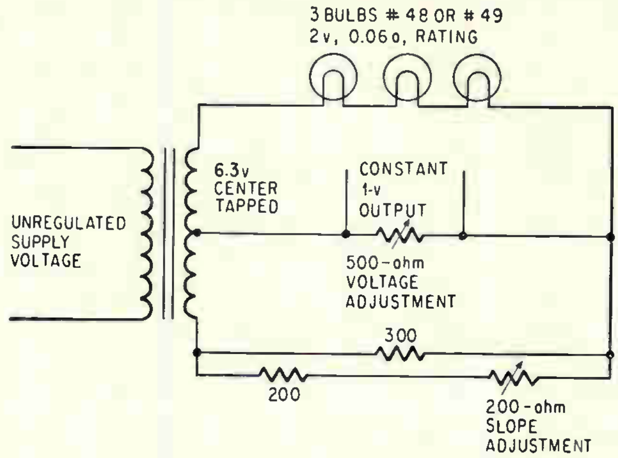
Since a lamp bridge produces a very stable output voltage at any frequency within the range when fed with a balanced source, the bridge makes a convenient laboratory standard for calibrating an oscilloscope at any desired frequency. If a transformer center tap is not available, the balanced source can be provided with a pair of equal resistive bridge arms. When the bridge has four resistive arms, it can be calibrated on d-c and used on a-c as a transfer standard.

At turn-on, the bridge output is about 0.66% high, dropping in about 30 seconds when the filament supports heat up. A constant output voltage is achieved by maintaining a constant current difference between the two sides of the bridge. Since the bridge operates at continual imbalance, a portion of the current flows through output level constant load current for rms supply-voltage involtage is minimized. The bulbs then maintain a constant load current for rms supply voltage increases by providing a compensating resistance increase caused by the increased temperature of the filament.

Correction of voltage variations is slow because of thermal inertia, and a large input variation can require nearly a second for full correction. However, this is not usually a serious handicap. The 2-volt tungsten filament bulbs are operated at about 2/3 volt to obtain the optimum filament temperature for long term stability; the filaments are a bright orange color at this temperature. By reducing the bulb's operating voltage its life is greatly extended since the expected life of a bulb varies inversely with the 13th power of the operating voltage.

Shunt level control $R_2$ maintains an internal impedance of only 60 ohms as seen from the output terminals. Any load over 6,000 ohms causes less than a 1% drop in output voltage. Where maximum output power is needed, the load can replace the 500-ohm rheostat.

For best stability, the fixed resistors should be wirewound or precision film; for adjustments, molded composition potentiometers of the best grade are suitable. The bulbs should be soldered into the circuit.




**Bulb resistance increases** to maintain a constant voltage across the load lamp of a bridge when supply voltage goes up.

# Two-frequency oscillator detects level of liquid


**By J. Kendall Marsh**

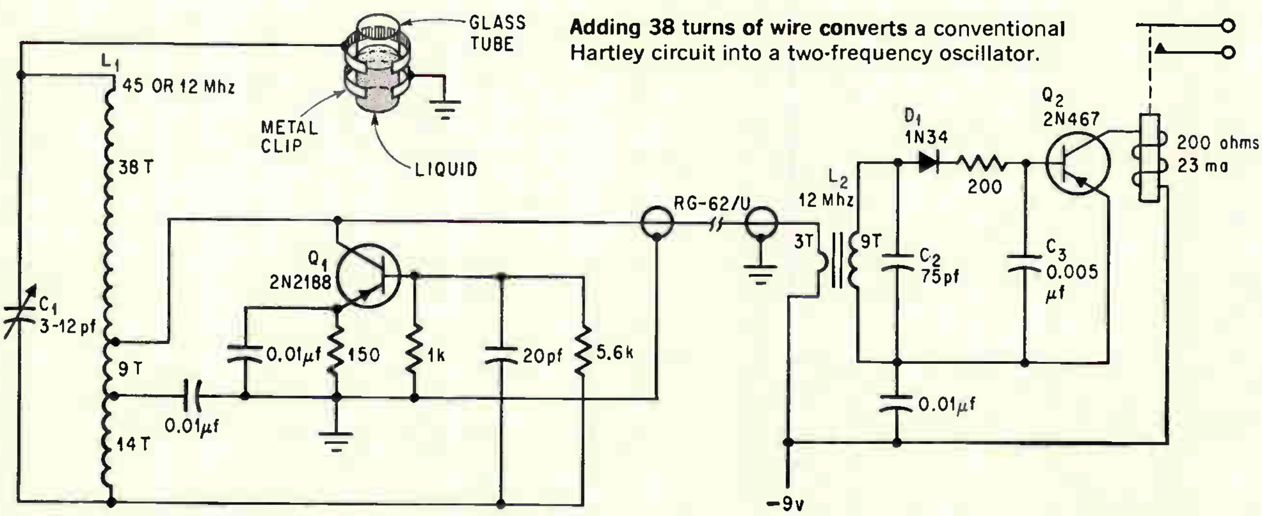
Dow Chemical Co., Midland, Mich.


**One method for sensing** the critical level of a liquid in a glass tube is to vary the dielectric of a sensing capacitor to control the frequency of an oscillator. A suitable sensing capacitor can be formed from a metal fuse clip as one plate, a ground, and a glass tube as a dielectric. When the tube is empty the conventional Hartley oscillator resonates at 45 megahertz. When the liquid reaches a critical level the additional dielectric constant of the liquid column produces a new value of capacitance that abruptly reduces the oscillations to 12 Mhz.

The resonant frequency of the oscillator is determined by coil $L_1$, capacitor $C_1$ and various distributed circuit capacitances. The collector impedance of $Q_1$ is approximately 100 ohms and can feed RG-62/U coaxial cable directly without any matching.

The detector consists of a tuned circuit $L_2$, $C_2$ and a diode with integrating capacitor $C_3$. When the oscillator is operating at 12 Mhz, a signal is developed across $L_2$ and $C_2$ and is rectified by the diode. Transistor $Q_2$ provides the power necessary to activate a rugged relay.

For the values shown, the circuit triggers reliably with a differential capacitance of 0.1 picofarad between the sensing point and ground. This scheme bypasses the problem of small frequency shift usually experienced with conventional oscillator circuitry.




**Adding 38 turns of wire converts** a conventional Hartley circuit into a two-frequency oscillator.

# A challenge: to integrate and isolate

The concept of isolation in integrated circuitry couldn't be simpler; it's the realization that's difficult. A score of manufacturers have taken up the gauntlet

By Donald Christiansen
Senior editor

**Integrated-circuit designers** want to have their cake and eat it, too—achieving the isolated properties of discrete components in a monolithic block.

What is sought is a single-chip IC in which the elements behave as if they were electrically separate. The designer could thus exploit those benefits of discrete-component circuits—chiefly, fewer parasitics and higher-frequency operation—that he enjoyed in the old days.

On the other hand, the advantages of integrated circuits stem largely from the physical proximity of elements in one conglomerate block, a proximity that allows the interconnection of all the devices with thin-film wiring.

A score of schemes have been advanced as solutions to the problem of accommodating the seemingly opposing requirements of integration and isolation. The more practical and promising are detailed in the fold-out chart in this article.

Chief among the benefits of dielectric isolation are higher-frequency operation of linear IC's, higher-speed operation of digital IC's, and high-voltage operation of both. The frequency and speed increases are chiefly due to reductions of the order of 25 to 1 in collector-to-substrate capacitance. The collector-to-substrate breakdown voltage is boosted from less than 100 volts to several hundred volts, and radiation resistance is improved. Some military contractors, in fact, restrict their purchases of IC's to those that are dielectrically isolated.

## Pros and cons

Elements in a monolithic block provide several advantages. Because they are physically close, transmission-line losses and line-matching problems are reduced. Also, batch-fabrication techniques simplify the process of matching the characteristics of two or more devices. Further, the characteristics track well with shifts in temperature since the temperature gradient within the monolithic block is likely to be insignificant.

Weighed against these advantages is the fact that the silicon itself doesn't provide ideal electrical isolation between elements or groups of elements. It has a resistivity in the range of 1 to 100 ohm-cm.

To block leakage between elements in an IC, the p-n junction isolation technique is widely used. The application of this method results in structures with lightly doped isolation substrates containing collector "tubs." The p-n junctions must be kept reverse-biased by, for example, connecting the p-substrate of an IC to the most negative voltage in the circuit.

A number of four-layer parasitic devices are formed by the p-n junction isolation structures, however, and these can wreak havoc even if the reverse junction bias is maintained. Unexpected positive feedback can occur, for instance, or IC's can be burned out by excess currents.

Furthermore, the breakdown voltage is inversely proportional to the doping level of the isolation material, which must be held to a minimum to avoid soaring leakage currents.

Finally, the p-n isolation junction is highly sensitive to radiation.

An obvious answer would be to remove the troublesome silicon from between IC elements and replace it with an insulator having good dielectric and thermal properties. Indeed, an early proposal[1] by workers at Bell Telephone Laboratories was that silicon wafers be diced apart along desired boundaries, then glued back together with insulating germania. The trouble was that the boundaries had to be etched to sufficiently increase the isolation resistance; since etching would destroy any active devices built into the wafer, the approach was abandoned as foolhardy.

Later, the Radio Corp. of America suggested a modification, called mosaic, involving the bonding together of as many as 8,000 silicon chips in a high-grade dielectric matrix of glass and ceramic (see following article).

Other approaches taken have utilized oxides and nitrides, glass, ceramic, and air dielectrics.

### Variations on a theme

Among the basic isolation schemes are:

▪ Polycrystalline. In this technique, the most widely used and perhaps the oldest,[2] a thermal oxide layer envelops islands of single crystal silicon. The support is provided by a polycrystalline substrate deposited over the device islands. Among the early experimenters with this approach were TRW Semiconductors Inc., Motorola Semiconductor Products Inc., Radiation Inc., and the International Business Machines Corp. Variations of this technique include the addition of silicon carbide by experimenters at Westinghouse Electric Corp.'s molecular department,[3] as well as the use of metal layers to surround the device islands or tubs, as proposed by Philco-Ford.[4] Several firms are marketing polycrystalline and oxide isolated devices—notably, Radiation and the Norden division of United Aircraft Corp.

▪ Back fill. After selective etching from the back side of a wafer has provided isolation areas, an insulating material is used to back fill, or embed, the islands. Texas Instruments Incorporated is experimenting with such a technique using a ceramic mix as the back-fill medium.[5] A variation being tried by RCA involves the etching of "mesas" from the face of the wafer.

In either case, a wafer holder or "handle" is needed to keep the devices in registration before the embedment material hardens. If no embedment is used, the holder becomes the permanent substrate, as in a process developed by the Fairchild Semiconductor division of Fairchild Camera & Instrument Corp.[6]

▪ Air isolation. Any technique in which the etched-away silicon isn't replaced can be classified as an air-isolation method. For example, if the back fill is omitted in the mesa method, the devices are air isolated. Bell Labs' beam-lead technique,[7] in which the interconnections are stiffened by electroplating and the wafer is selectively etched, also falls in this category. And the air-oxide technique[8] is similar except that the device island is seated on a polycrystalline, oxide-coated substrate.

A technique that avoids the unwanted silicon in the first place is the silicon-on-sapphire approach [Electronics, May 30, 1966, p. 152A] under study by Autonetics division of North American Aviation, Inc., Hughes Aircraft Co., and RCA.[9]

Despite the benefits promised by dielectric methods, the p-n junction approach isn't dead. It affords a pronounced cost advantage because it requires fewer and simpler processing steps. Typical dielectric isolation procedures take up to 30 steps, driving yields down and costs up. The uniformity of the isolation etch has proved to be the biggest problem for many producers. P-n junction isolation, on the other hand, is well established and generally uses less wafer space than dielectric isolation methods. Some dielectrically isolated IC's are up to 30% larger than their p-n junction counterparts.

While many vendors experimenting with dielectrically isolated digital IC's have realized speed improvements of typically 10%, it remains doubtful whether this gain alone is worth the added cost.

Dielectrically isolated IC's back-filled with ceramic may be difficult to cool in operation because of the high thermal resistivity of ceramic; one solution could be face cooling.

On the other hand, the poor conduction could be an advantage when high-power devices and heat-sensitive devices are to be included in the same substrate. One could play games with the thermal path, making it short but wide, for example. An embedding material that would conduct preferentially—toward the outside of the package, but not laterally—might be ideal. Or the lower-dissipation devices could be centered on the substrate and the high-dissipation elements located on the periphery.

During fabrication of dielectrically isolated IC's, care must be paid to process temperatures. The isolation procedures may be carried out before the active devices are built into the wafer, after they are built into the wafer but before metalization, or after metalization.

If the device is to be heated after metalizing, a temperature of about 575°C can't be exceeded or the aluminum will alloy with the silicon. If heating follows diffusion but precedes metalizing, the device temperature shouldn't exceed 950°C.

Specific techniques to avoid temperature problems in fabrication are described in the article beginning on page 97.

Choice of the dielectric to be used depends on application. Air is a good dielectric, but its breakdown voltage capability is limited. Whether device characteristics will track well with temperature in air-isolated devices is also open to question.

### References

1. D.A. Naymik, "Silicon mosaic for integrated devices," 1964 International Solid State Circuits Conference.
2. D. McWilliams, C. Fa, G. Larchian, and O. Maxwell, "A new dielectric isolation technique for high-quality silicon integrated circuits," Journal Electrochemical Society, Vol. 111, No. 7, p. 153C, 1964.
3. T.V. Sikina, B.D. Joyce, N.P. Formigoni, C.C. Roe, and F. Schliesing, "A novel oxide isolation process," 1965 International Electron Devices Meeting.
4. C.G. Thornton, "The application of new metallurgical technology to integrated circuits," National Electronics Conference, Oct. 1964.
5. T.H. Ramsey and T. Smith, "A process for ceramic dielectric isolation for integrated circuits," International Electron Devices Meeting, Oct. 1966.
6. B.L. Frescura, R. Rusert, and J. Schroeder, "Mesa isolation—an isolation technique for integrated circuits," International Electron Devices Meeting, Oct. 1966.
7. M.P. Lepselter, N.A. Waggener, and R.B. Davis, "Beam-leaded and intraconnected integrated circuits," International Electron Devices Meeting, Oct. 1964.
8. J.A. Cunningham, "Air-oxide isolated integrated circuits," Texas Instruments Incorporated semiconductor research and development laboratory report, 1966.
9. J.F. Allison, J.R. Burns and F.P. Heiman, "Silicon on sapphire complementary MOS memory systems", 1967 International Solid State Circuits Conference

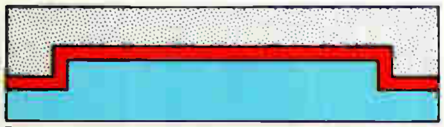
## Polycrystalline silicon and oxide

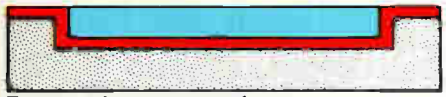

Oxide-protected starting wafer

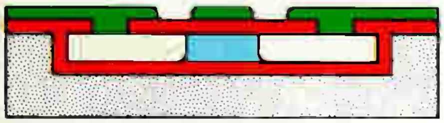

Masking


Etching


Reoxidation


Polycrystalline silicon grown


Excess n-layer removed

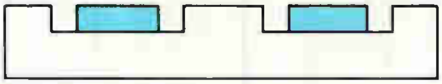

P-regions diffused and electrodes deposited

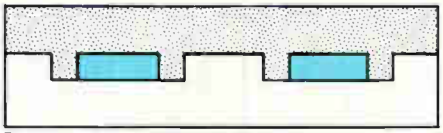
**Oxide is thermally grown** atop a layer of n-type starting silicon and is etched to provide a mask. Preferential etching forms moats in the silicon, which is then oxidized again. A backing layer of polycrystalline silicon is grown above the silicon crystal. The wafer is then inverted and excess n material is removed by etching and lapping, leaving n-type isolated islands. After oxide growth, p-type regions are diffused in the islands and metal electrodes are deposited to produce metal-oxide silicon transistors. Bipolar devices and resistors can also be fabricated in the islands. Variations of this technique are being used to produce commercial devices. Breakdown voltages above 200 volts and capacitances of less than 0.01 pf/sq. mil are possible. However, the process is somewhat complex and wafer planarity is hard to achieve.

## Complementary


P starting material


N-type diffusion


Selective etching

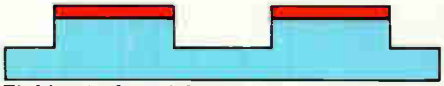

Polycrystalline silicon growth

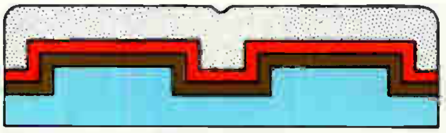

Lapping and etching exposes n and p silicon tubs

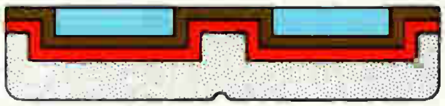
**Complementary npn** and pnp transistors are formed in one chip. N-type diffusion is made into a p starting layer. Moats are then etched and polycrystalline silicon grown. The wafer is inverted and excess p-layer is lapped to provide isolated n and p islands in which complementary npn and pnp transistors can be fabricated. For the latter, standard oxide masked diffusion steps are used and doping is carried out in open-tube diffusion setups using liquid impurity sources. The number of steps required add to the complexity and cost of fabrication.

## Silicon carbide


Masking


Etching to form islands


Silicon oxide, silicon carbide, and polycrystalline silicon layers formed

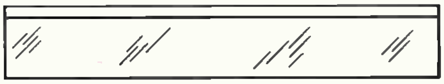

Rough lapping


Fine lapping

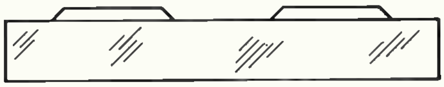
**Silicon oxide** and silicon carbide layers are formed before polycrystalline growth. The silicon carbide facilitates removal of the excess n-type silicon. After rough lapping is stopped by the carbide flange, a short fine lapping step removes this flange. The method shares the disadvantages of the polycrystalline approach, and requires the additional steps of forming and removing the carbide.

polycrystalline silicon
glass
thermally grown oxide
metalization
p-type silicon
n-type silicon

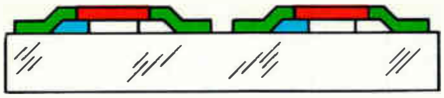
## Silicon on sapphire



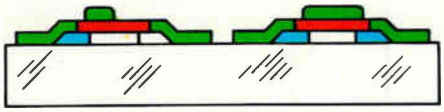
Epitaxial silicon layer formed on sapphire substrate



Selective etching forms silicon islands



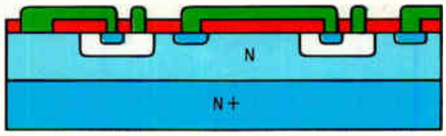
P-n junction diodes are fabricated



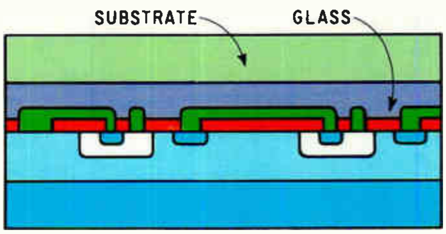
Alternately, MOS triode (left) and pentode (right) are formed.

**Heteroepitaxial silicon** film is grown atop a sapphire wafer and selectively etched to form isolated islands. If the film is p type, p-n diodes are formed by n+ and p+ diffusions, and MOS triodes and pentodes by n+ diffusions. A major advantage may be realized in making microwave IC's, since the sapphire itself can be used as a high-grade dielectric in strip transmission lines between devices. Parasitic capacitances are low — down to as little as 0.05 pf for p-n junction diodes.

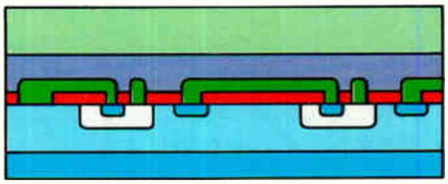
## Mesa



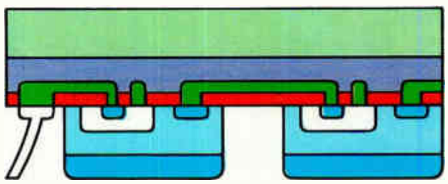

Devices and interconnections formed




Glass layer binds IC wafer to substrate



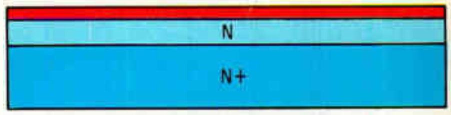
Excess n+ layer removed



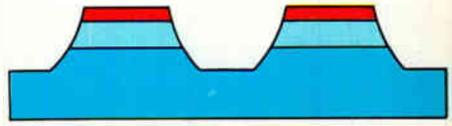
Selective etch isolate device islands

**After transistors** and interconnections are formed in the usual way, a substrate is joined to the wafer surface by a glass layer. Excess n+ layer is removed and a selective etch isolates the devices from one another. All active devices can be produced by conventional methods prior to isolation. The wafer surface isn't made irregular by isolation processing, high-temperature isolation steps are avoided, and additional encapsulation may be unnecessary. The fabrication is complex; lapping as well as etching may be required to remove the unwanted silicon.

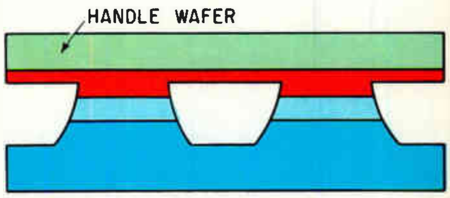
## Handle wafer



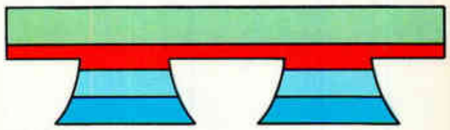

Devices are fabricated and oxide-protected



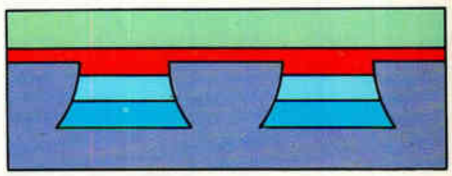
Mesas are etched



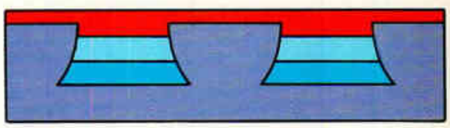

Handle wafer is fused to mesas



Wafer is lapped



Glass is backfilled

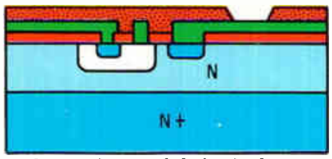


Handle wafer is etched away

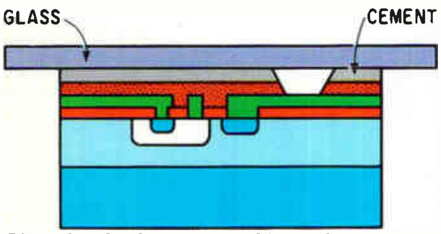
**Active elements** formed in the usual way are protected by thermal oxide layers, and mesas containing the devices are formed by etching. A glass-coated silicon "handle wafer" is fused to the mesas, which are then isolated by the lapping of n+ material. Glass is formed around the exposed mesas and the handle layer is removed by etching. The registration needed for contact and interconnection metalization is retained in this technique. A choice of dielectric fill-in is possible. The method is especially applicable to small arrays of odd-shaped devices.

©Copyright 1967 Electronics® A McGraw-Hill Publication

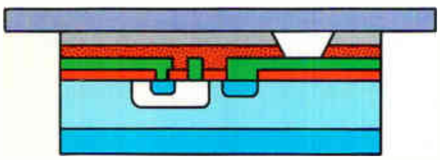
## Ceramic



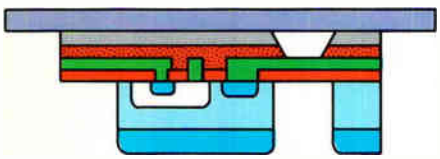

Active elements are fabricated



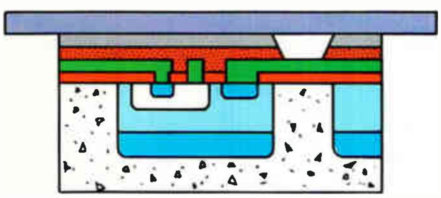

Glass holder is cemented to wafer



N+ layer is etched back



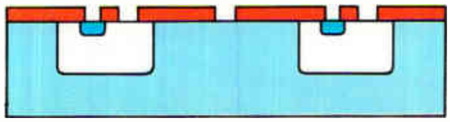
Selective etching isolates islands



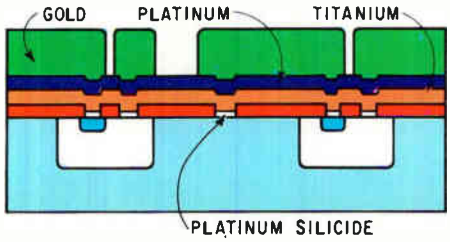
Ceramic cement is backfilled

**A glass carrier** similar to the handle wafer is cemented atop finished devices. The n+ layer is thinned and the device islands are isolated by selective etching. Finally, a ceramic and glass cement is filled in around the voids between islands. The advantages here are similar to those provided by the basic polycrystalline and handle-wafer methods. The glass holder must be removed.

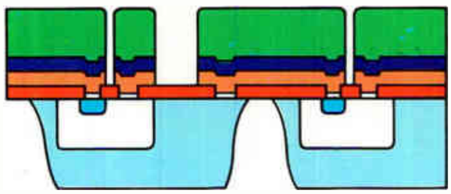
## Beam lead



Transistors are formed, protective oxide-nitride layer added



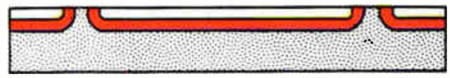

Platinum silicide contacts are formed, titanium and gold layers sputtered, beam leads built up by electroplating



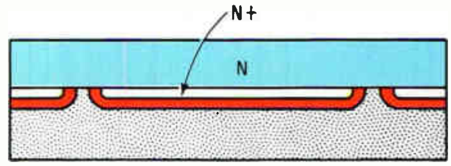
Metallic layers are etched away; silicon is etched, forming islands

**Protective oxide** is added after active elements have been fabricated in the wafer. Platinum silicide contacts are formed, titanium and gold layers are sputtered on, and beam leads are built up by gold electroplating. Finally, metallic layers are etched away to isolate the electrodes, and excess silicon is etched away to isolate the devices. The leads form both electrical and mechanical connections between several discrete circuit elements. Close electrode spacing makes for high-frequency capability. The use of hermetically sealed cans is avoided. The process is complex and the resulting device is tiny and fragile, but it is easily bonded to a carrier or hybrid circuit substrate because of the relatively massive beam leads.

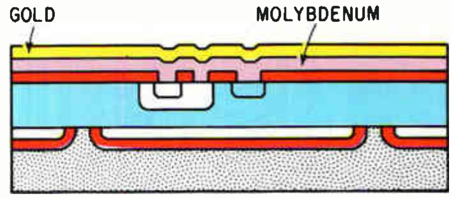
## Air-oxide



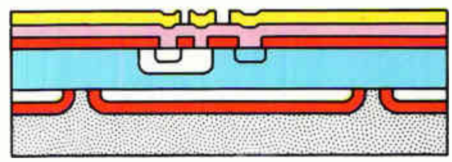
N+ regions formed in isolated structure



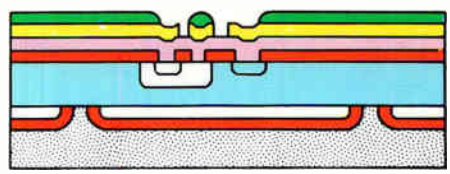

N-type epitaxial film deposited



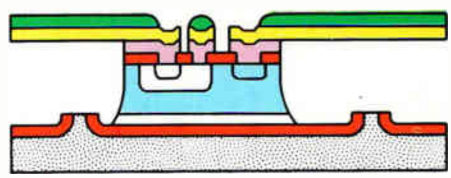

Devices formed, molybdenum and gold layers added



Gold is etched, forming interconnections

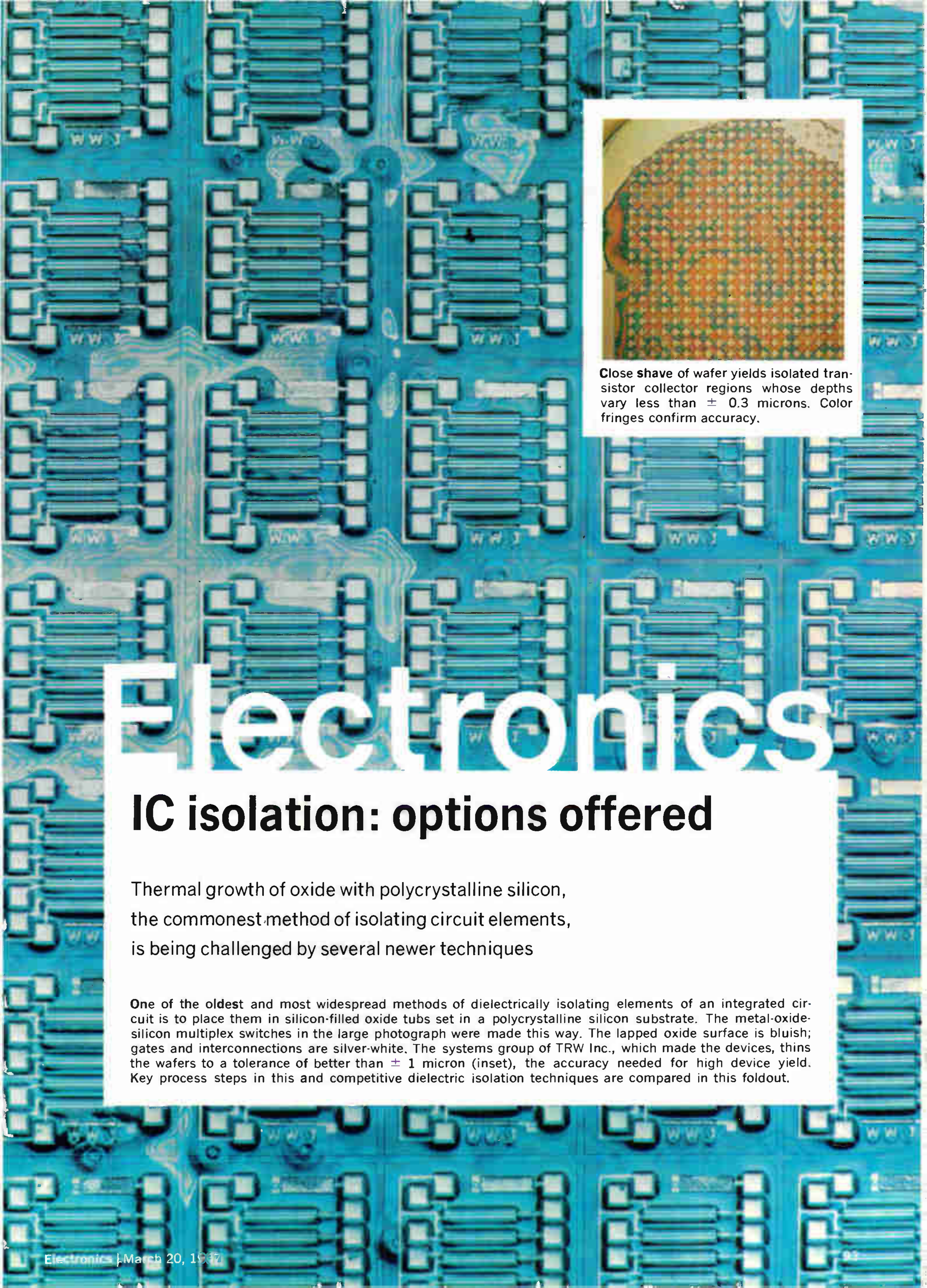


Electroplating gold builds up lead



Moly layer is etched, then silicon

**Regions of n+ material** are formed in a polycrystalline structure, and n-type epitaxial film (not to scale) is deposited. Devices are then fabricated and layers of molybdenum and gold are deposited. The gold layer is etched to form the interconnection pattern and is built up in certain areas by gold electroplating. Finally, the molybdenum layer is etched and the silicon is selectively etched down to the oxide layer to air-isolate the device islands. The substrate provides good heat-dissipation properties, but the metal-deposition and etching steps are complicated.



**Close shave** of wafer yields isolated transistor collector regions whose depths vary less than ± 0.3 microns. Color fringes confirm accuracy.

Electronics

# IC isolation: options offered

Thermal growth of oxide with polycrystalline silicon, the commonest method of isolating circuit elements, is being challenged by several newer techniques

**One of the oldest** and most widespread methods of dielectrically isolating elements of an integrated circuit is to place them in silicon-filled oxide tubs set in a polycrystalline silicon substrate. The metal-oxide-silicon multiplex switches in the large photograph were made this way. The lapped oxide surface is bluish; gates and interconnections are silver-white. The systems group of TRW Inc., which made the devices, thins the wafers to a tolerance of better than ± 1 micron (inset), the accuracy needed for high device yield. Key process steps in this and competitive dielectric isolation techniques are compared in this foldout.

Integrated electronics

# Getting the most out of circuits with dielectric isolation

Isolation is as important to the circuit designer as it is to the manufacturer of integrated circuits. The application in which a circuit is used can dictate the kind of dielectric required—air, glass or ceramic

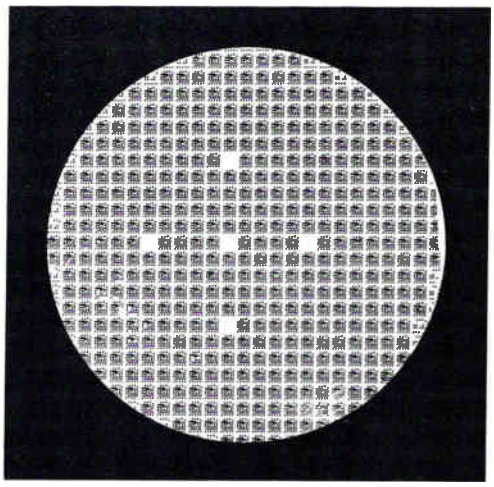
By Arthur I. Stoller, James A. Amick and Nikolaus E. Wolff
RCA Laboratories, David Sarnoff Research Center, Radio Corp. of America, Princeton, N.J.

**True dielectric isolation** of the elements of an integrated circuit can overcome many of the performance limitations inherent in monolithic circuits. When an IC's elements—its components—are isolated by air, glass, or ceramic, the circuit behaves almost like an assembly of discrete components.

Frequency response, in fact, may approach or even better that of a discrete-components circuit[1]; dielectrically isolated circuits can operate at frequencies well into the microwave region, for example, compared with a limit of about 100 megahertz for monolithic IC's. In addition, significant increases in voltage and power levels, radiation resistance, and logic-circuit speed can be achieved with isolation, and circuit designers can look forward to IC's that are easier to design, package, interconnect, and cool.

Process technologists have developed, to the point of demonstrable practicality, a variety of isolation techniques—each with different design advantages. Now it is up to the circuit designers to accept the challenge and find applications that can exploit their unique advantages, such as those discussed in the article on page 112 on microwave integrated circuits.

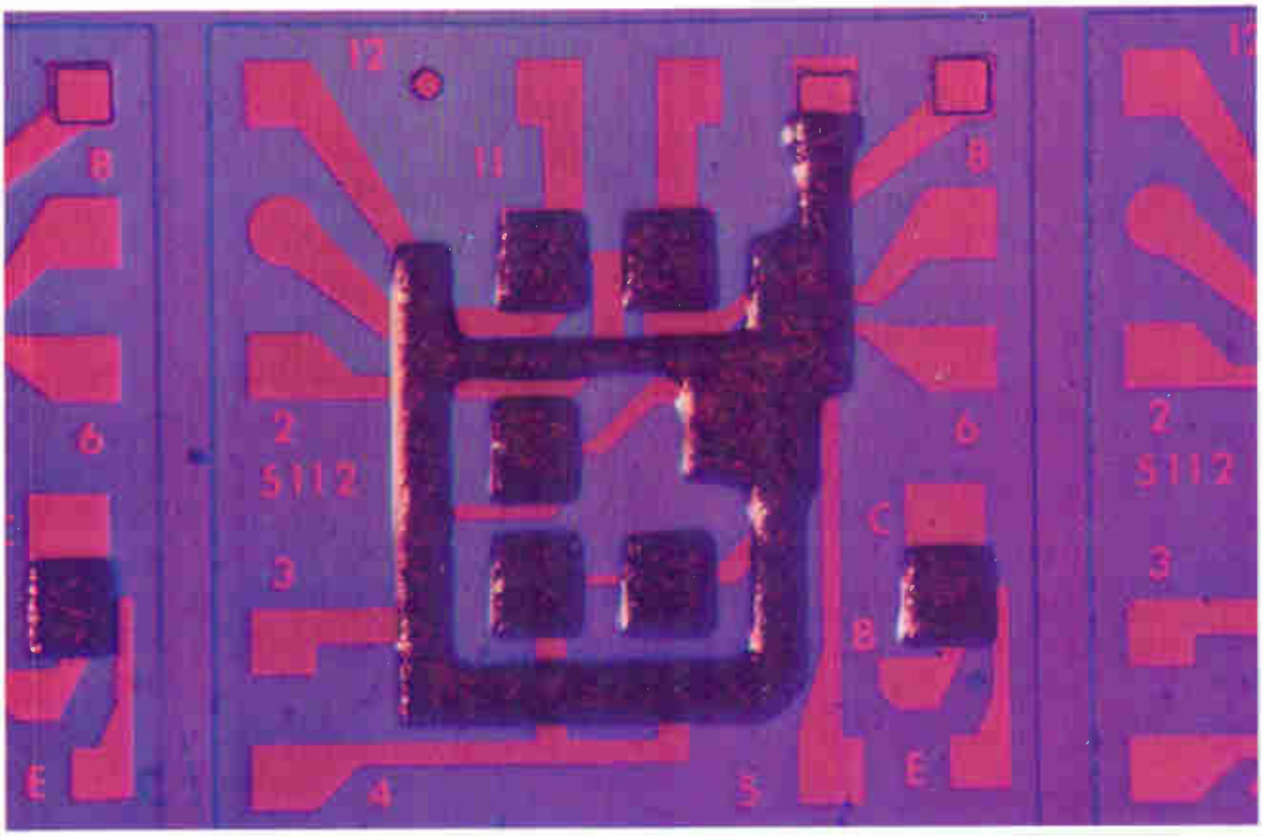
Some of the isolation processes being developed at the Radio Corp. of America provide for the fabrication of arrays of complementary active devices, and some will acommodate thin-film or thick-film passive devices for circuits with nearly ideal electrical characteristics. In such arrays, microstrip-transmission-line techniques can be employed, and many components can be connected in parallel if desired. Paralleling is a technique well-suited to solid-state radar and other systems requiring high-power outputs at high frequencies.


Mosaic wafer allows the diffusion of active devices and their interconnection after isolation processing to make the circuits seen on page 99. Each tiny dot is an island of silicon, surrounded by dielectric.

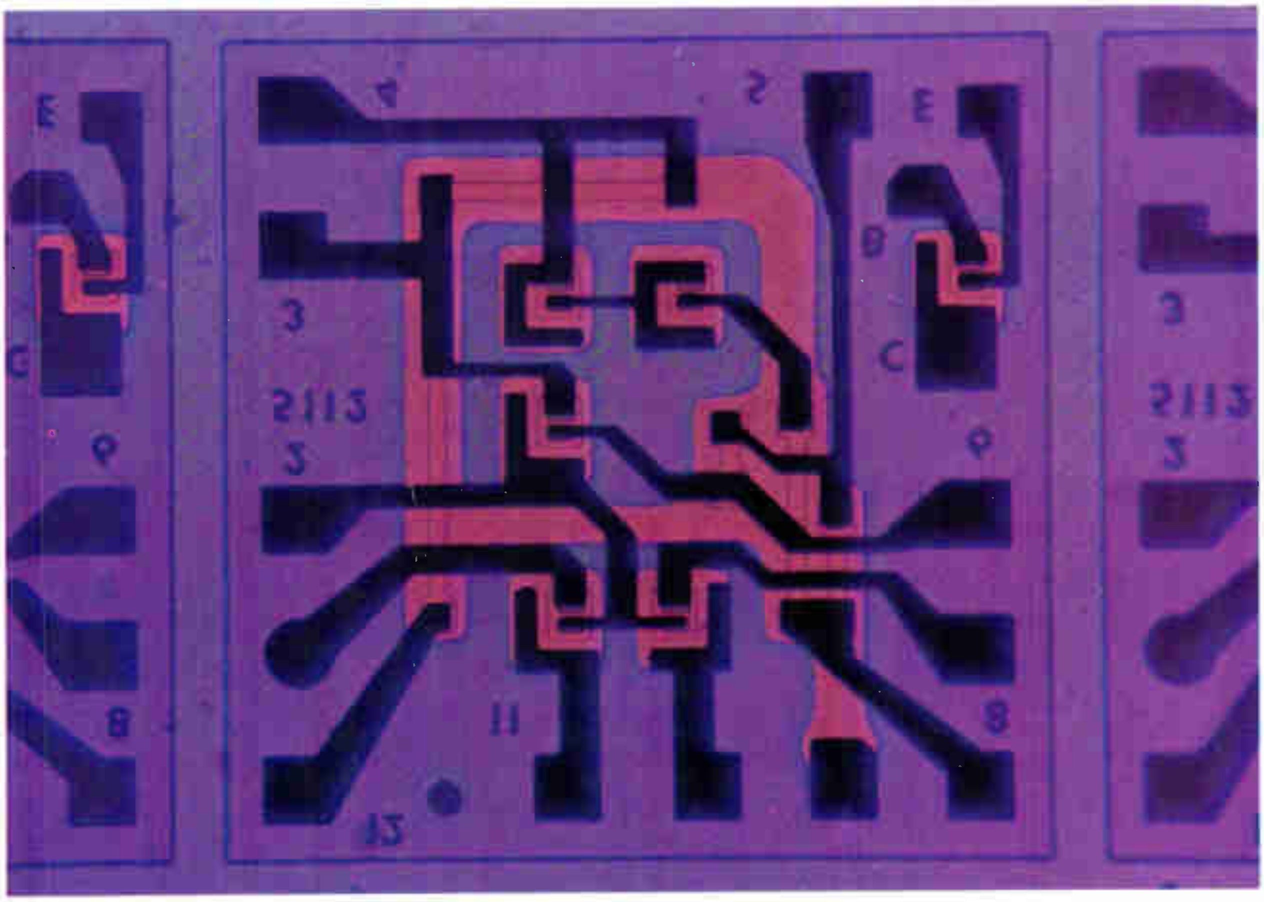
These are the immediate benefits of using a true dielectric instead of p-n junctions, the form of isolation most commonly used in the monolithic IC's available today. Although dielectric isolation requires several additional processing steps, the increased fabrication cost is largely offset by elimination of the lengthy high-temperature diffusion needed to form p-n isolation junctions. Little is gained, however, by simply replacing the isolation junctions in standard IC's with a dielectric. Many clever techniques of designing around monolithic shortcomings have made monolithic IC's economical and highly effective in many applications.

Many silicon transistors and diodes are inherently capable of operating at frequencies above 1 gigahertz. But,

## Air isolates Decal circuits



Chunky portions of Decal circuit are pieces of silicon isolated by etching and held together by a glass substrate.



Devices and metalization are visible in this bottom view of the Decal circuit, seen through the glass substrate.

largely due to parasitic capacitances in the chip, a monolithic IC whose elements are equivalent to such components generally has an upper frequency limit between 50 and 100 Mhz.

Transistors and integrated circuits are made by nearly identical processes. However, each IC element must somehow be electrically isolated from its neighbors in the single crystal chip of silicon. Customarily, a p-n "bathtub" junction is formed around each element; when this junction is reverse-biased, it approximates an insulator. Unfortunately, the "insulator" so formed is an extremely thin depletion layer—so thin that sizable parasitic capacitances arise between neighboring elements and between the elements and the IC's silicon substrate; these capacitances lower maximum operating frequencies and may cause unwanted feedback. The extra p-n junctions also add undesired "transistors" to the circuit.

Besides these disadvantages, the isolation junctions will break down like any diode, and will no longer provide isolation if the potential across them exceeds about 40 to 60 volts. Furthermore, their impedance under reverse bias isn't infinite, so that significant current leakage occurs even at normal voltage levels.

## Dielectric advantages

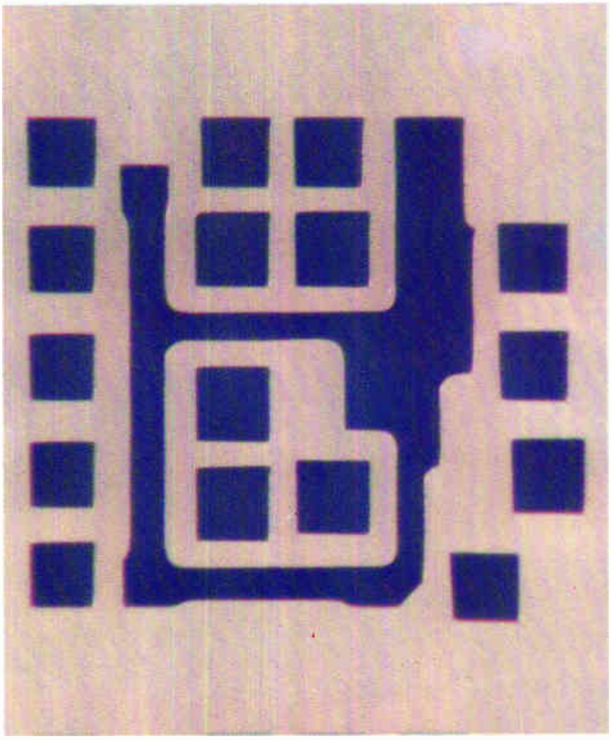
Integrated-circuit breakdown and capacitance problems are alleviated somewhat by refilling openings around the elements with polycrystalline silicon separated from the single crystal regions by a thin silicon dioxide layer.[2,3] However, this silicon refill is lossy at frequencies near or above 250 Mhz and still permits appreciable parasitic capacitances. These can be also eliminated if, instead, the isolation junctions are replaced with a high-quality insulator many times thicker than a junction depletion layer, and if the silicon substrate is almost completely removed.

In the techniques being investigated by RCA, elements become silicon devices in tiny islands separated by air or surrounded by a glass, a ceramic, or a glass-ceramic composition. All the isolation materials have very low losses, even into the gigahertz range. The dielectric can be selected to withstand voltage swings up into the kilovolt range between adjacent devices, eliminating breakdown problems in most applications.

Dielectric isolation imposes little or no sacrifice in IC size and retains the processing advantages of monolithic IC's, especially the interconnection of many components in one operation. Dielectrically isolated IC's should be superior to present hybrid integrated circuits and discrete-component circuits, as well as to monolithic IC's, in numerous applications. For example, the small size of these IC's in comparison to hybrid circuits should enhance efficiency at microwave frequencies because the components are only a few thousandths of an inch across and interconnections can be extremely short.

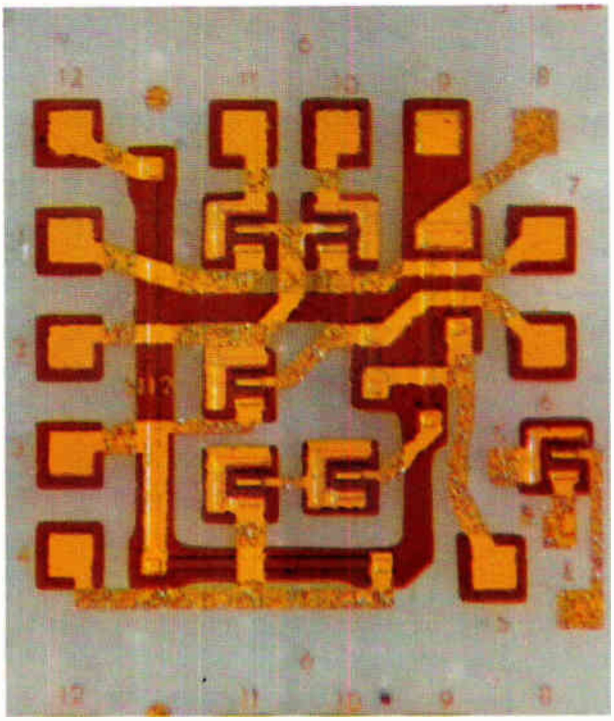
In computers, the use of IC's with dielectrically isolated elements can reduce the power dissipation

**Mosaic after isolation . . .**

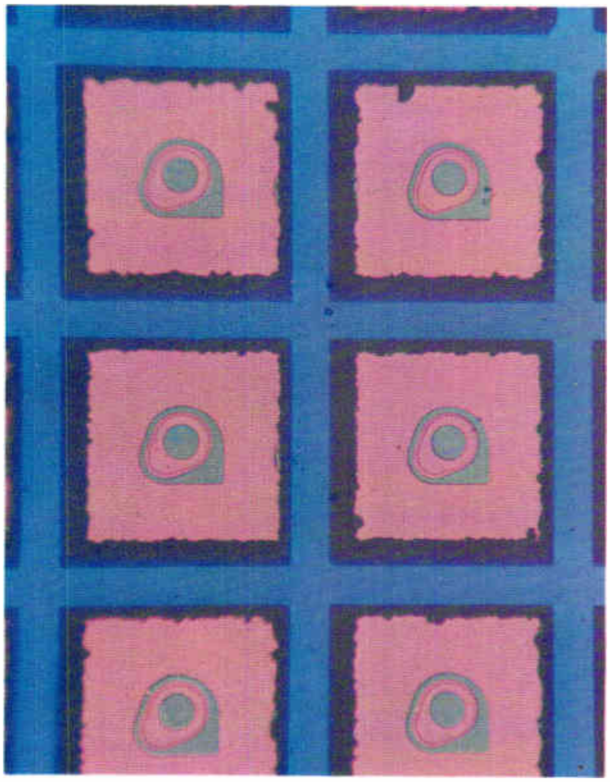


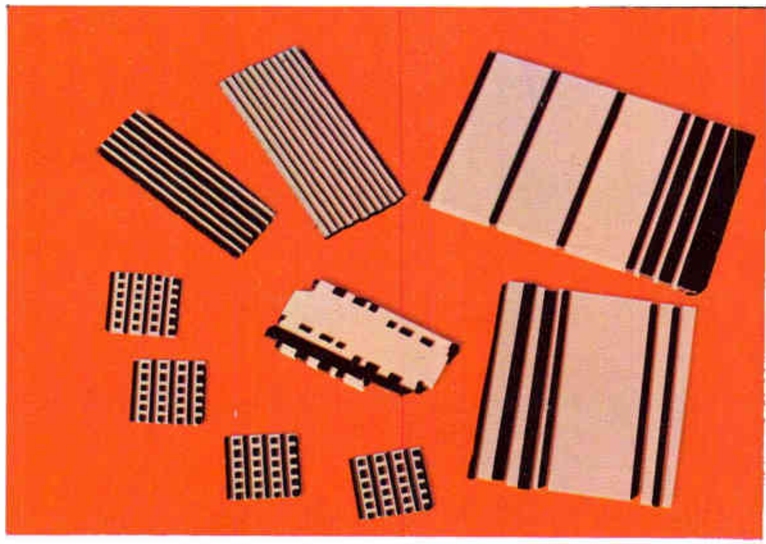
**Glass and ceramic** mixture—the white material—is the matrix that isolates the islands of silicon and keeps them in place during the high-temperature processing needed to fabricate an integrated circuit. Only enough silicon for a circuit remains after isolation etching.

**. . . and after the circuit is made**



**Diffusion and metalization** processes similar to those used to make conventional IC's have converted the mosaic into a radio-frequency mixer circuit. The isolation between devices allows this circuit to operate at higher frequencies than can regular IC's.





High-frequency transistors are diffused into a checkerboard matrix made by cutting a silicon wafer into squares and pressing glass into the saw cuts.

Sandwiches of silicon—the dark material—and ceramic are used for arrays of complementary devices and when large dielectric areas are needed for thin-film parts.

and switching times achieved with monolithic IC's. Radiation resistance of dielectrically isolated circuits should be superior to that of monolithic IC's, since the isolation junction is the monolithic element most sensitive to radiation damage.[4] The thermal problems that arise when a relatively high-power device is included in the monolithic silicon structure can also be significantly reduced.

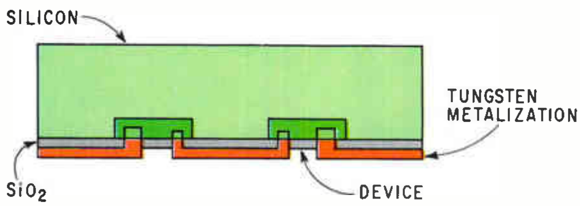
## Choosing a process

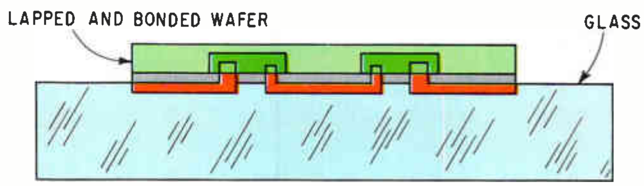
By definition, the IC with isolated elements is an array of single-crystal islands embedded in or attached to an insulating support. Each island must be held in precise registry with the others to retain the advantage of making all the device interconnections simultaneously. Besides not degrading the finished circuit's electrical performance, the isolation process must be compatible with possible fabrication steps required after isolation.

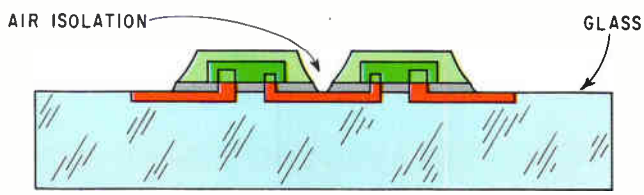
Isolation may be provided

- as a final operation after the devices have been fabricated and interconnected;
- after device fabrication but before interconnection;
- in the substrate wafer, before the devices are made and interconnected.

Although the isolation techniques discussed in this article all involve the use of bulk single-crystal silicon as a starting material, a whole new isolation technology—the use of silicon epitaxially deposited




**Decal circuits** are metalized with tungsten so they won't be destroyed by high-temperature isolation processes. After diffusion and metalization (above), the silicon wafer is bonded to glass (right). Removing the excess silicon around the devices leaves the devices isolated by air.

on a suitable insulator such as sapphire—is currently being developed [see article on page 106].

## The Decal

Perhaps the simplest and most versatile isolation method is the one that produces Decal circuits (named after decalcomania, the transfer of patterns to a surface). These circuits are diffused, interconnected by thin-film metalization, and hermetically sealed to glass before the steps on page 100 isolate the elements with air.[5]

Since the glass is heated and fused to the silicon during processing, ideally it should match silicon's thermal coefficient of expansion. It should also be impervious to moisture and other atmospheric constituents and be free of such impurities as alkali metal ions. Several commercially available glasses meet these requirements, but they soften at about 700 to 800°C. Aluminum—the conventional metalization material for IC's—alloys with silicon at about 575°C, so glassing at 700 to 800°C would destroy the devices. And glasses that can be softened or deposited at 550°C or less don't meet other needs.

Metalization is therefore carried out with a metal that doesn't alloy readily with silicon. Tungsten has proved to be a good choice; it's readily deposited, forms highly conductive layers that adhere well to the silicon's passivation coating of silicon dioxide, and can be etched into wiring patterns. Its thermal expansion closely matches that of silicon and of glasses that will satisfactorily seal to silicon, such as the Corning Glass Works' 7070 glass.

Most important, the silicon-tungsten system's eutectic temperature is near 1,390°C, so glassing temperatures can rise to 800°C without observable degradation of device performance.

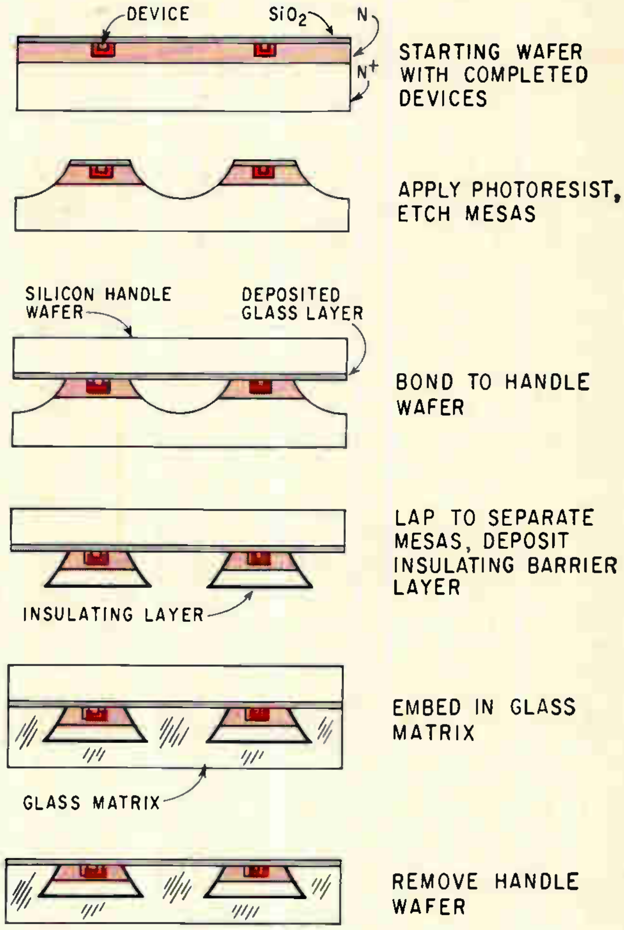
The fabrication of Decal circuits starts with standard processing in a single-crystal silicon wafer, except that the deep diffusion needed for p-n junction isolation is omitted. After tungsten interconnections are formed, a barrier layer such as silicon oxide or silicon nitride can be deposited.

The device side of the silicon wafer is fused to an insulating glass substrate by pressing the two together for a few minutes at a temperature of 700° to 800°C. With the glass as a support, the back of the silicon wafer is then lapped down until the silicon is only 10 to 20 microns thick. The thickness isn't critical, since only electrically inactive silicon—silicon not part of the devices—is removed. The isolation pattern is then etched into the back of the silicon wafer by standard photoresist techniques and a hydrofluoric-nitric acid silicon etchant that doesn't attack silicon dioxide rapidly.

The individual devices of each circuit are now isolated by air from one another, but are still bonded and sealed to the glass wafer that serves as a support [see cover and photographs on page 98]. Other dielectrics can later be filled into the isolation spaces, if desired.

The tungsten interconnection pattern extends beyond the edges of the silicon islands. At this stage, the tungsten is covered by silicon dioxide, which can be etched open to permit contacts to the circuit. Either the ends of the interconnections can be bared or small contact holes can be etched at selected locations. If external leads are to be attached by ultrasonic or thermocompression bonding, aluminum or other ductile metal is first applied to contact areas. If contacts are to be welded or provided via solder balls, an overlay of nickel or other suitable metal is applied to the tungsten.

**Holding the pieces**



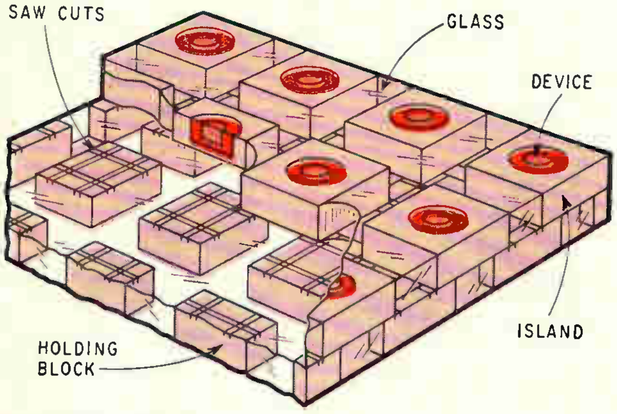

**Handle wafer holds** isolated islands in position cn a silicon wafer until they are embedded in a dielectric matrix.

## Handle-wafer technique

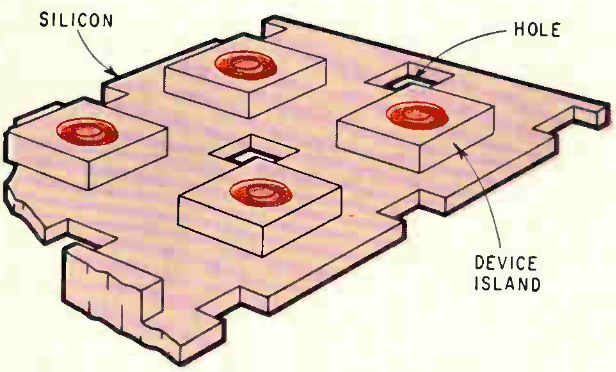
Temperature is again the main concern when isolation is to be provided between device diffusion and metalization. Uncontrolled rediffusion of the dopants in the silicon can occur at about 950°C. Nor should the temperature be raised for more than a few minutes. However, metalization after isolation can be done with aluminum if the final encapsulation temperature doesn't go above about 500°C.

A "handle wafer" is one of the tools developed at RCA Electronic Components and Materials division to produce a matrix of isolated devices without losing the registration neded for interconnection. The handle wafer is prepared by depositing

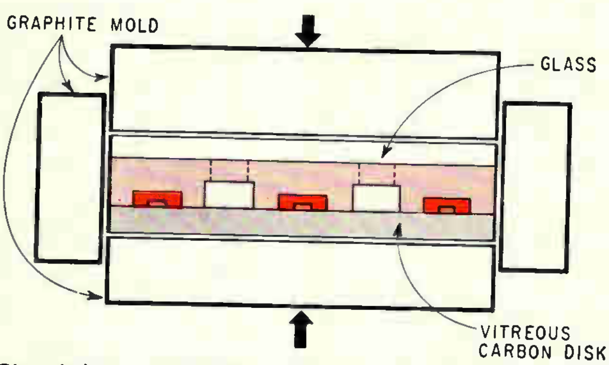
### Checkerboard squares



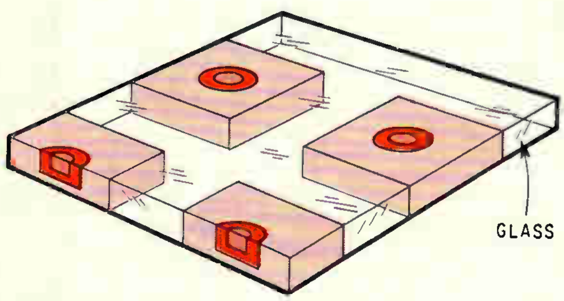

Matrixes can be made by sawing the wafer into squares . . .




. . . or by etching to form mesas before glassing.




Glass is hot pressed around the squares or mesas, and the excess silicon at the back of the wafer is removed.




Devices in the silicon islands are isolated by the glass, on which thin-film wiring and components can be deposited.

1 to 5 microns of glass on a wafer of single-crystal or polycrystalline silicon having plane parallel, optically polished surfaces.

An isolation pattern is etched into the device wafer, leaving each device in a silicon mesa about 25 microns high. The glass on the handle wafer is then fused to the devices by pressing the two wafers together for a few minutes at a temperature of about 800°C.

The back of the device wafer is lapped down until the mesas become isolated islands, attached to the handle wafer. Softened glass is forced into the moats between the islands at a temperature low enough to ensure that the islands won't move about on the handle wafer.[5] Finally, the silicon handle wafer is etched away. The metalization process is conventional.

## Checkerboard squares

Another RCA isolation-before-metalization process produces a matrix of isolated devices with the checkerboard appearance shown at the left.

In one version of this process, isolation channels about 5 mils deep are cut into the front of the wafer; the cuts can be made by a ganged saw of the type used to dice transistor wafers. A second set of cuts, displaced about half a device width from the first, is made in the back of the wafer.

When the combined saw-cut depths add up to more than the wafer thickness, the regions where the cuts on the top surface cross those on the bottom surface become holes. Each device is then supported by the corners of four cubes of electrically inactive silicon. An earlier version has channels and holes etched in the silicon wafer.[5]

The cut or etched wafer is placed face-down on a disk of vitreous carbon, and a disk of glass is placed against the back of the wafer. Heat and pressure soften the glass and force it through the holes to fill the isolation channels. Careful preparation of the carbon disk is required to make sure the glass is coplanar with the devices, dense, free of pinholes, and optically flat.

The excess silicon, which maintained the registration during glassing, is lapped off, leaving the wafer ready for metalization.

## Isolation before diffusion

If isolation leads off the processing cycle, the temperature during this step can rise above 1,200°C since the only danger is melting or damaging the silicon crystal. If the starting wafer has an epitaxial layer, the maximum temperature must be held low enough to prevent substantial diffusion of the dopants present. However, the isolated structure must withstand device processing, which may require heating to 1,200°C for a few hours.

No commercially available dielectrics have been found satisfactory. Some otherwise suitable glasses become too soft, allowing the silicon islands to move about in the dielectric matrix during device diffusion. Diffusion from the glass into the silicon can also cause problems. Crystalline ceramics, too, meet all the requirements but one—they don't deform readily at the allowable isolation processing temperature.

A happy medium has been struck in glass-ceramic compositions prepared as intimate mixtures of finely powdered materials. Initially, the glass in the composition permits the mixture to flow at a reasonable temperature, so the dielectric can be molded around intricate shapes of silicon without leaving voids. As high temperatures continue, however, the composition becomes less fluid and more refractory. Nucleated perhaps by the ceramic particles, the glass partially crystallizes until the mixture is sufficiently rigid to lock the silicon islands in place during device fabrication.

Dielectric compositions have been successfully made with commercially available calcium-aluminosilicate glasses (such as Corning 1715), and such ceramics as mullite ($3Al_2O_3 \cdot 2SiO_2$) and cordierite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$).[5]

### Mosaics and sandwiches

Glass-ceramics and a modified handle-wafer technique can be used to prepare isolated substrates suitable for processing into devices.

After silicon mesas are etched in a single-crystal wafer, an oxide layer, about 1 micron thick, is thermally grown on the handle wafer and the wafers are bonded together, again by hot pressing. After the back of the mesa wafer is lapped off to separate the wafer into islands, a barrier layer of silicon dioxide or silicon nitride is deposited over the exposed side of the mesas. When the devices are processed later, the barrier will minimize diffusion of impurities into the mesas.

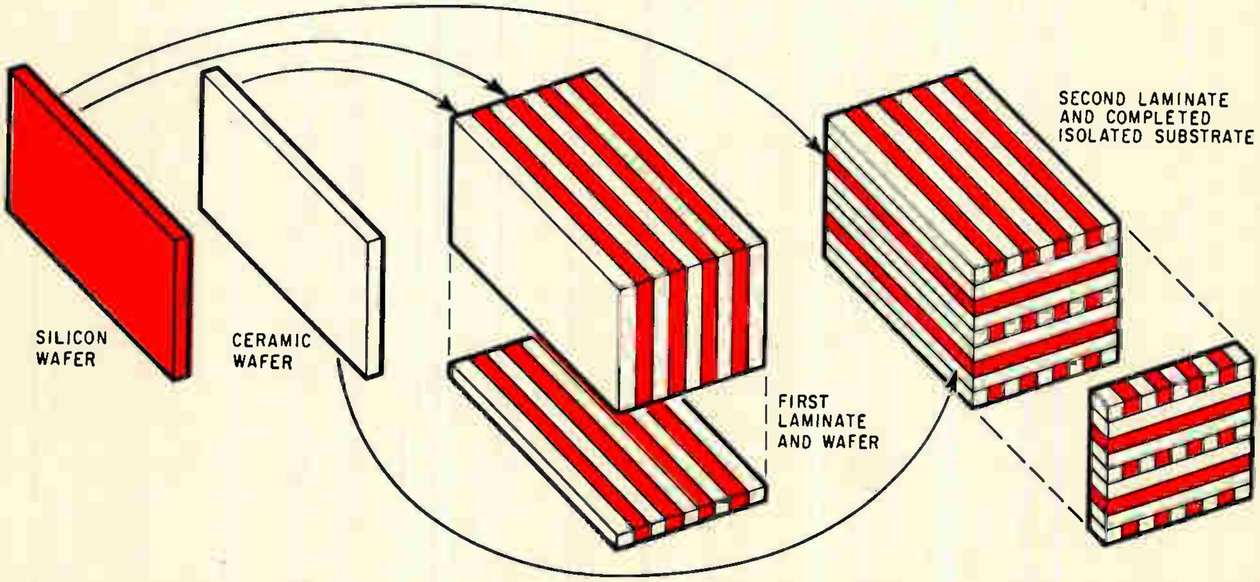
The glass-ceramic mixture is hot-pressed around the mesas and heat-treated to form a dense, coherent matrix. Finally, the handle wafer is etched away with hot, gaseous hydrochloric acid. Etching ceases automatically when the acid reaches the oxide layer protecting the mesas. The rest of the processing and interconnection metalization is conventional.

Isolated substrates can also be prepared much like multilayer sandwiches. Wafers of a ceramic such as fully crystallized Pyroceram (Corning) and single-crystal silicon are laminated, using silicon dioxide thermally grown on the silicon layers as the bonding medium. The laminate is sliced as illustrated below. If these slices are laminated and sliced again, substrates containing blocks of silicon in rows separated by a ceramic matrix can be prepared. Provided that the ceramic matches the expansion coefficient of silicon, the dielectric regions can be as large as desired and the silicon blocks can be any combination of p-type and n-type silicon of any desired resistivity.

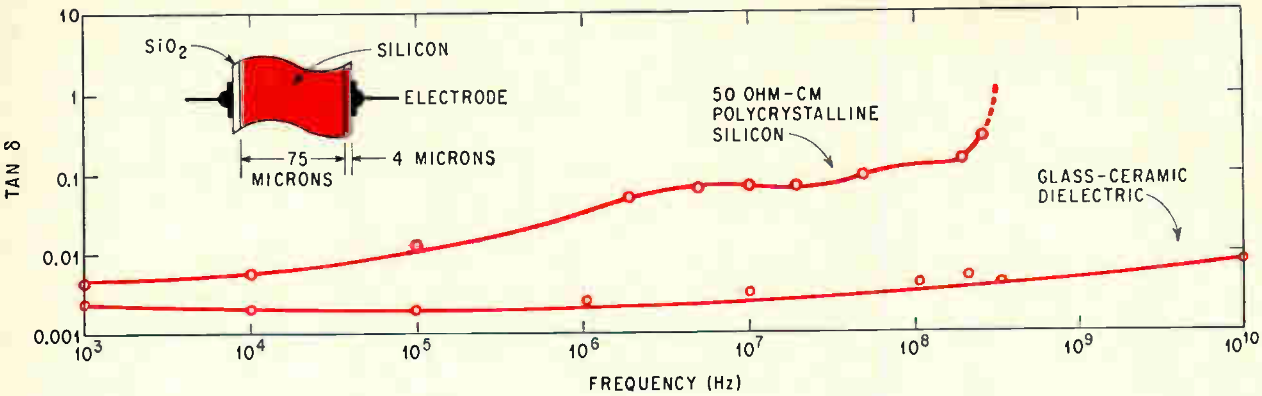
### Which dielectric?

Air is the superior isolation medium at low voltages. Its dielectric constant is only about 1, compared with about 4 to 6 for glass and ceramic. Since low dielectric constant means low capacitance, and since a major purpose of isolation is to minimize unwanted capacitance, air is preferred. However, air's breakdown strength is only about 10,000 volts per cm, approximately 100 times less than those of ceramic and glass. Therefore, if large voltage swings between adjacent devices have to be accommodated, ceramic or glass isolation may be preferable.

It's important to determine the electrical characteristics of any new compositions, such as the glass-mullite composite dielectric. Measured with a capacitance bridge and in a microwave cavity, this material shows a dielectric constant of 6 at frequencies from about 1 kilohertz to 9 gigahertz. Loss




**Layers of silicon** and ceramic are bounded together, then sliced and laminated again to form a sandwich matrix of isolated silicon blocks. This technique can be used when arrays of field-effect transistors are needed. Thicker ceramic wafers provide a broader substrate area for thin-film devices.




**Glass-ceramic dielectric** of the mosaic wafers has a low loss tangent at microwave frequencies. A conventional type of isolation, polycrystalline silicon refill, appears to be useless at about 250 Mhz. Refill is approximated by the sample configuration.

tangents rise gradually from 0.003 to 0.01 (graph shown above), demonstrating that the material is an excellent one for circuits operating throughout this frequency range.

A reference sample has also been evaluated through the same measuring technique. This sample, consisting of a 75-micron-thick wafer of polycrystalline 50-ohm-cm silicon with 4-micron layers of thermally grown silicon dioxide on each surface, approximates the polycrystalline silicon refill isolation used in some IC's.[2,3] It exhibited a loss tangent of only 0.001 at low frequency, but the losses were so high at about 250 Mhz that it appears to be of little value as an isolation medium near or above this frequency.

The choice of an isolation material thus depends on circuit characteristics. To date, the authors have concentrated on devising isolation techniques rather than new circuits. As test vehicles, replicas of commercial monolithic IC's—with dielectric isolation substituted for monolithic isolation—have been used for convenience.

An example is an r-f mixer circuit, shown on page 99, made in mosaic form. Preliminary measurements of the transfer admittance for this circuit have been made by RCA Victor Research Laboratories, Montreal, for circuits isolated with p-n junctions, polycrystalline silicon refill, and glass ceramic. The frequency at which the real part of this admittance, $G_{21}$, falls to 1 millimho is, respectively, 200 Mhz, 280 Mhz, and 300 Mhz. The increased frequency response of the polycrystalline silicon refill and the glass-ceramic refill is almost exactly that calculated, considering the lowered parasitic capacitances. This limited improvement is testimony to the skill with which the monolithic circuit's designers coped with parasitic capacitances and other design problems.

## Decal advantages

Aside from sharing the major isolation advantages, the alternate approaches each offer special advantages. Those apparent in the Decal integrated circuit at this stage of development include:

- Lower packaging costs. The circuits could be placed into a conventional IC package with bonded wire leads. However, bonding the tungsten leads directly to a fanned-out lead pattern printed on an inexpensive header or on a circuit board is a far more attractive approach. No further packaging is needed, because the isolation process has also hermetically sealed the circuits in glass.
- Closer spacing betwen these IC's on a circuit board. Isolation and the shorter lead lengths between circuits should lower power dissipation in computer systems and may even allow the use of simple wiring instead of transmission lines for interconnection.
- Optional glass substrate thickness. Therefore, the glass can be precisely polished down to the thickness needed for a microwave stripline circuit. As a ground plane for the tungsten interconnections, a conducting metal is simply deposited on the free surface of the glass. The dielectric properties of the glasses used are excellent for this application.
- Provision of interconnection pads anywhere on the exposed tungsten wiring of each circuit or circuit array, even in the middle of a circuit. The circuit designer has a new degree of freedom, and damage during the testing of circuits should be minimal since tungsten metalization isn't easily scratched or abraded by probing.
- Operation at higher power dissipation levels than possible with monolithic IC's. The transistors' active regions are only 10 to 15 microns from the free silicon surface, where the heat they produce can be removed by an appropriate heat sink. In contrast, heat must travel through as much as 125 microns of silicon in a conventional IC.

It isn't generally desirable to include both high-power devices and heat-sensitive devices in the same monolithic IC since heat given off by the high-power devices is transferred laterally through the silicon. Air and other dielectrics are poorer thermal conductors than silicon, and, in dielectrically isolated circuits, heat is more likely to be preferentially conducted from each island to the heat sink and is less likely to be conducted laterally from device to device.

In Decal circuits, power devices can safely be used with heat-sensitive devices. If necessary, the dielectric spacing can be increased to insure that heat flows to a heat sink rather than to adjacent devices.

### Active and passive arrays

Other isolation methods can afford the electrical advantages of hybrid integrated circuits without requiring the process of attaching device or IC chips to a previously prepared substrate carrying passive thin-film devices. Precision thin-film devices can be deposited on the dielectric alongside the silicon devices and both can be interconnected in a single metalization step.

Attempts to do this in conventional monolithic circuits, on the other hand, present many headaches. Good thin-films can be put on an oxide or glass layer over the silicon, but the device area is restricted to the size of the silicon chip or to the number of deposited glass layers that can be superimposed. In operation, the active and passive devices affect one another's performance, and parasitic capacitances may arise between the films, the silicon substrate and the devices.

When the thin-film parts and interconnection wiring can be spread over an isolation dielectric, however, these problems are minimized. The glass or ceramic is an excellent substrate, and thin-film resistors deposited on the isolation dielectric can have a temperature coefficient of resistance near zero, assuring stability in circuit operation. Thin-film capacitors whose capacitance is independent of applied voltage can also be prepared. (Diffused-junction capacitors used in monolithic IC's are voltage-dependent—the depletion region widens as applied voltage is increased, changing their capacitance.) Electrical isolation of both active and passive devices will permit voltage swings of 1,000 volts or more between neighboring components.

Variations of the checkerboard method can be used to make arrays of complementary devices. For example, pnp transistors can be prepared in one silicon wafer and npn transistors in a thicker wafer. The npn mesas are made high enough to extend through holes in the pnp wafer so that both sets of devices are coplanar when the glass is pressed into the interstices between the devices.

This method and the lamination technique described on page 103 are most suitable for orthogonal arrays of devices. Besides the isolation provided, their great advantage is that each type of device can be made by the process best suited for it. In conventional monolithic IC's, process compromises are needed if complementary devices are to be prepared, with the result that one or both types are not optimum.

The handle-wafer approaches are suitable for small arrays of devices whose size and shape—or both—are random. Isolation channels are only 10 to 20 microns deep and perhaps 20 to 40 microns wide. The densities of active devices are very high, even when complementary arrays are required.

If large areas of dielectric substrate are needed for the thin-film components, extra substrate areas can be provided around the periphery of the wafers during the glassing process. This is much less costly than increasing the dielectric area in the center of the wafer by cutting down on the number of silicon mesas or making the isolation channels wider, but it presumes that each circuit will have its share of the dielectric edge region.

The laminate construction doesn't waste silicon when a circuit requires large numbers of big or passive components. The separation between islands can be made as wide as desired by increasing the thickness of the ceramic wafers. Devices must, however, be made in rows because of the fabrication steps involved in preparing these substrates. Laminate substrates are especially suited to complementary arrays of metal oxide semiconductor field effect transistors. These can be prepared in high-resistivity silicon; they don't need an epitaxial layer, which would be difficult to provide on the laminate.

### References


1. D.A. Maxwell, R.H. Beeson, and D.F. Allison, "The Minimization of Parasitics in Integrated Circuits by Dielectric Isolation," IEEE Transactions on Electron Devices, ED-12, 20, 1965.
2. R.M. Warner Jr. and J.N. Fordemwalt, editors, "Integrated Circuits," McGraw-Hill Book Co., New York, 1965.
3. G.L. Schnable, A.F. McKelvey, and J.A. Hastings, "A Chemical Technique for Preparing Oxide-Isolated Silicon Wafers for Microcircuits," Electrochemical Technology, 4, 57, 1966 (also contains a survey of the literature on isolation techniques).
4. See, for example, T.V. Sikina, B.D. Joyce, C.C. Roe, F. Schliesing, and N. Formigoni, "A Novel Oxide Isolation Technique," International Electron Device Conference, Washington, D.C., Oct. 20-22, 1965.
5. A.I. Stoller and N.E. Wolff, "Isolation Techniques for Integrated Circuits," Second International Symposium on Microelectronics, Munich, Oct. 24-26, 1966. Proceedings to be published by R. Oldenbourg Press, Munich.



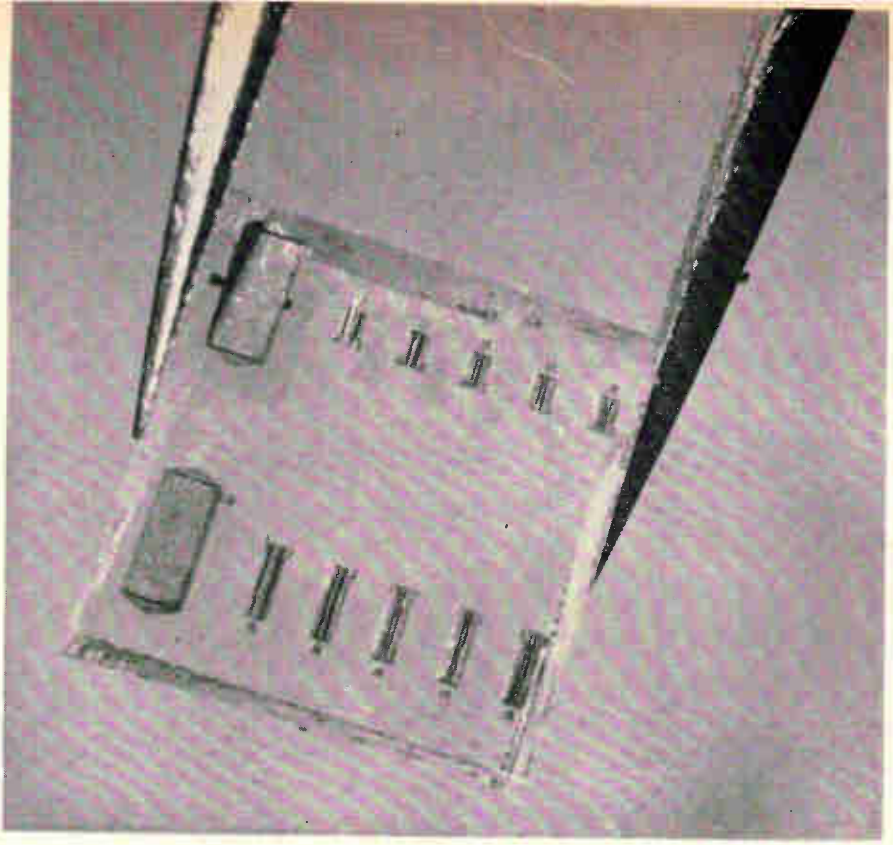
The authors

Arthur I. Stoller has won RCA Laboratories achievement awards for his work on magnetic materials and integrated-circuit processing. He was issued three patents in magnetics before switching to semiconductor processing in 1963, and now has three patents pending for integrated-circuit techniques.

James A. Amick was promoted in January to head of the materials processing group in the process research and development lab at RCA Laboratories. His Ph.D., from Princeton University, is in physical chemistry and his work, at present, is on chemical techniques to improve integrated circuits.

Nikolaus E. Wolff, like Amick, got his Ph.D. in chemistry at Princeton in 1952. He helped establish the process research and development lab in 1963 and this January was named the lab's associate director for process technology. His research includes electronic behavior of organic materials.

Stepping stone to silicon-on-sapphire integrated circuits is this group of 10 thin-film transistors and two capacitors, all MOS devices. To connect them, microstrip transmission lines would be formed on the ⅛-inch-square sapphire substrate.



Components

# Silicon-on-sapphire transistors point way to microwave IC's

On the road to their goal of integrated circuits isolated by sapphire, researchers have produced thin-film silicon transistors that operate at 4 gigahertz, and 8-Ghz transistors are in sight

By Rainer Zuleeg

Solid State Research Center, Hughes Aircraft Co., Newport Beach, Calif.

**Silicon-on-sapphire** technology has merits not shared by other dielectric isolation methods. Sapphire, a high-quality dielectric suitable for microstrip transmission lines, is a substrate for a thin film of silicon in which devices operating at frequencies well into the microwave region can be formed in large groups. The devices are isolated in this technique by etching the film—not as an extra process, but as one of the steps in a batch-fabrication process.

Microwave silicon-on-sapphire devices with useful operating frequencies as high as 4 gigahertz are being made experimentally, and, with continued improvement in processing techniques, useful power outputs at frequencies as high as 8 Ghz can be expected. Once these devices pass from experimentation to production, microwave integrated circuits can be made through the application of microstrip interconnections to the sapphire between the devices. Integrated sos circuits have already been made for high-frequency linear and high-speed nonlinear applications.

### Lateral devices

Although it's difficult at this time to weigh the economics of microwave sos circuits against the cost of making microwave IC's by other means, the future capabilities of sos circuits can be assessed by considering several devices being developed at the Solid State Research Center of the Hughes Aircraft Co. Intended primarily for linear applications, these devices include p-n junction diodes, bipolar transistors, metal-oxide semiconductor transistors and space-charge-limited triodes—MOS transistors with a recessed gate.

These are lateral devices, made in isolated islands in the silicon film. The cross-sections of the p-n junction areas are very small—typically one millionth of a square centimeter—so the parasitic capacitances of the devices are also extremely small. For example, p-n junction diodes have shown zero-bias capacitance of 0.05 picofarad. They have a typical switching or recovery time of 1 nanosecond.

One bipolar transistor has a current-gain-bandwidth product, $f_T$, of about 4 Ghz, and an amplification factor, $\alpha$, of 0.9. The maximum frequency of oscillation, $f_{max}$, of the space-charge-limited triodes made to date is approximately 4 Ghz, and the matched power gain is 12 decibels at 1 Ghz.

### Frequency response

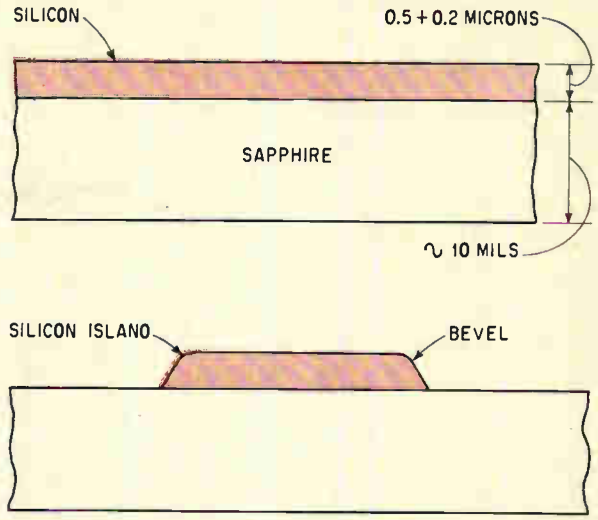
The frequency response of the triodes is being evaluated under contract from the National Aeronautics and Space Administration's Electronics Research Center in Cambridge, Mass. The study involves optimum control of the geometry with photolithographic etching techniques.

As the graph (next page) indicates, there is a consistent relationship between maximum frequency and $L_D$, the distance separating the source and the drain contact. The solid dots on the curve are measured values of experimental devices, while the circles indicate theoretical values of devices with an $L_D$ of 2 microns. The discrepancy between the two sets of values is of great importance in determining the highest frequency practical for sos transistors.

State-of-the-art photolithographic techniques allow junction diffusions and contact metalization precise enough to produce an $L_D$ as small as 4 microns. Triodes with that source-drain separation have a transconductance of 5 milliamperes per volt and a feedback capacitance of 0.3 pf at a drain voltage, $V_D$, of 10 volts and a drain current, $L_D$, of 10 milliamperes. Under these conditions, the maximum frequency of oscillation is 4 Ghz and the power gain at 1 Ghz is 12 db.

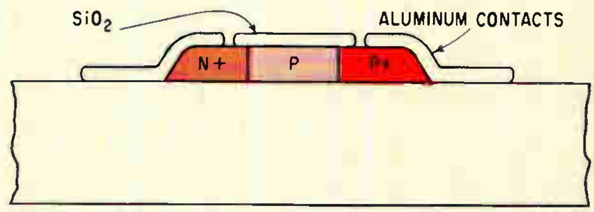
It can be predicted from transit-time effects in such triodes that $f_{max}$ will be proportional to $L_D^{-2}$ when $L_D$ is greater than 4 microns. This, in fact, was confirmed experimentally in the low-field region. The electrons are in thermal equilibrium

### Isolation steps



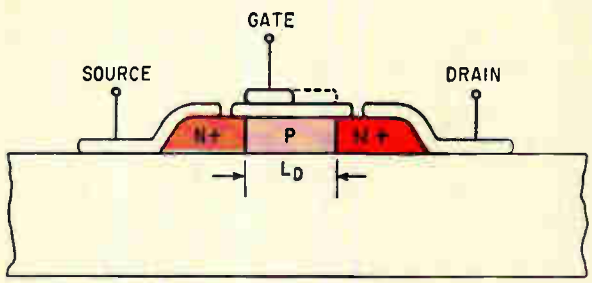

Thin film of silicon crystal, either n or p type, is grown heteroepitaxially on a sapphire substrate and is etched to form islands isolated on the sapphire. The bevel makes it easier to apply the thin-film contacts. Contacts can be extended into microstrip lines.

### Lateral diodes

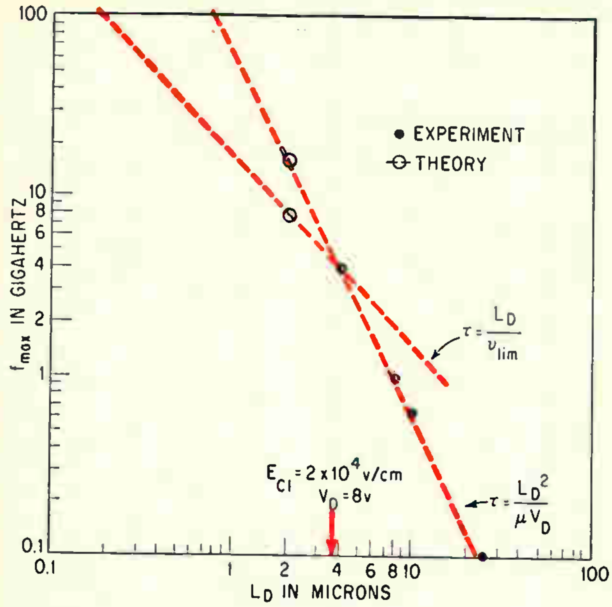



P-n junction diodes are formed by growing silicon dioxide on the silicon, diffusing to form $n^+$ and $p^+$ regions in the silicon, and metalizing contacts and interconnections of aluminum. Such diodes have a typical switching or recovery time of 1 nanosecond.

### MOS transistors




Transistors are made by growing silicon dioxide, diffusing the $n^+$ regions and growing the gate oxide. If the gate is full width (dotted line) the transistor will have the characteristics of a pentode; if the gate is recessed, the device will act as a triode.




**Thin-film triodes** with a source-to-drain separation, $L_D$, of 4 microns have a maximum frequency response of 4 Ghz. Halving the source-drain length again will probably extend the response to 8 Ghz rather than 16 Ghz because the critical field (arrow) is exceeded at this point in very small devices, and electrons reach their limiting velocity.

with the crystal lattice, and their transit time, $\tau$, is

$$\tau = \frac{L_D^2}{\mu V_D}$$

where $\mu$ is the mobility.

However, one cannot assume that reducing $L_D$ to 2 microns will produce triodes operating at 16 Mhz, as shown by the projection of the measured values on the graph. When the field, E, between source and drain electrodes reaches the critical value, $E_{ci} \cong 2 \times 10^4$ volts per centimeter, the electrons move at their limiting velocity, $v_{lim} \cong 8 \times 10^6$ centimeters per second. In a triode with an $L_D$ of 2 microns, this critical field is reached when $V_D$ equals 4 volts. Beyond this voltage, hot-electron behavior limits the maximum frequency response. This behavior, therefore, should theoretically limit $f_{max}$ to $L_D^{-1}$ in devices with very small source-drain lengths, since the transit time becomes $L_D/v_{lim}$.

A device with an $L_D$ of 2 microns, therefore, would have an $f_{max}$ of 8 Ghz, rather than 16 Ghz. One can therefore reasonably predict that improvements in photoligthographic techniques will make it possible to produce MOS transistors for integrated circuits operating at frequencies up to 8 Ghz.

## Integrated circuits

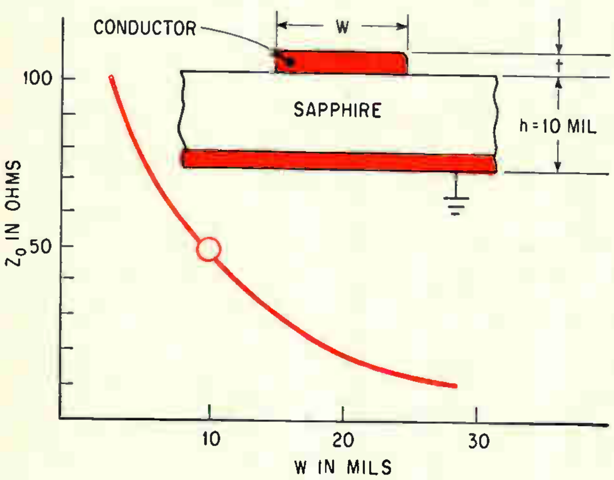
The diffusion and metalization process in fabricating SOS circuits are similar to those for conventional monolithic IC's. However, it has taken several years to refine device design and the process by which the film of silicon crystal is grown. The silicon film is grown by prolysis of silane ($SiH_4$). Pyrolysis is a thermal reduction process [see Electronics, Feb. 20, 1967, p. 174]. The growth must be heteroepitaxial, rather than epitaxial as in monolithic IC's, because there isn't a perfect match between the crystalline structures of silicon and sapphire ($Al_2O_3$).

In lower-frequency linear SOS circuits, as in conventional IC's, thin-film wiring applied to the top of the sapphire can be used to interconnect the devices. To produce microwave SOS circuits, appropriate devices will be interconnected with microstrip. This can readily be done by extending the contact metalization of the devices into conductor lines on the top of the sapphire and depositing a metal film on the bottom to provide a ground plane.

The design of the microstrip interconnection is straightforward because the sapphire substrate is a good dielectric. Its dielectric constant, $\epsilon$, is 11. The characteristic impedance, $Z_o$, is given in ohms by

$$Z_o = \frac{377h}{\sqrt{\epsilon}\, W\left[1 + \frac{2h}{\pi W}\left(1 + \ln\frac{\pi W}{h}\right)\right]}$$

W and h are defined in the sketch accompanying the graph at the left. Typically, $Z_o$ is 50 ohms for lines 10 mils wide on a 10-mil-thick sapphire substrate.

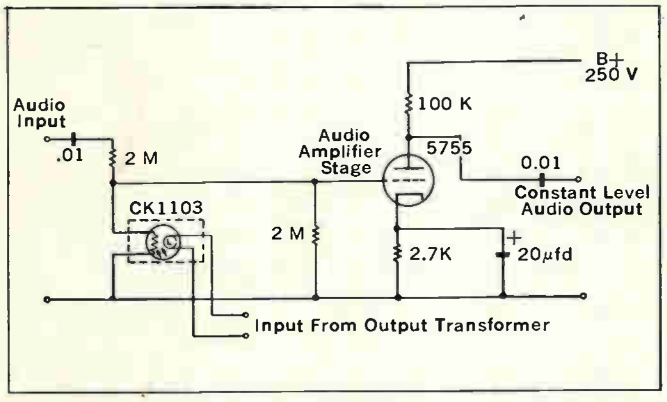



**Sapphire acts** as a high-quality dielectric for microstrip interconnections. Line impedance is typically 50 ohms when the sapphire is 10 mils thick and the conductor is 10 mils wide.

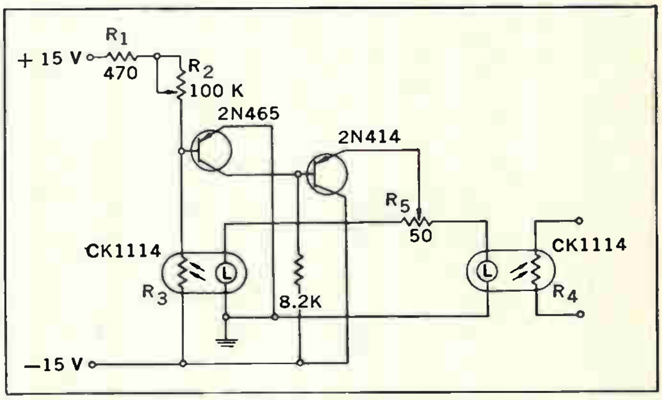
### The author

Rainer Zuleeg was born and educated in Germany. He came to the United States in 1953 and worked at the Washington Institute of Technology, and Sprague Electric Co., before joining the Hughes Aircraft Co. He recently left Hughes, where he was senior staff physicist, Solid State Research Center.

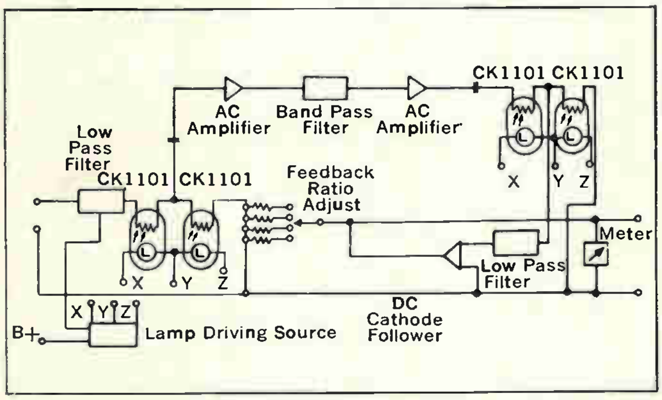
# 3 ways you can use the Raysistor® to improve your product, cut costs



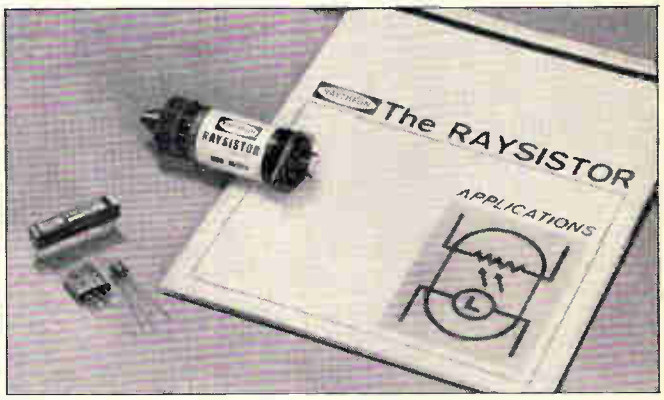

**1. Use the Raysistor®** as a simple remote or automatic volume control in SSB suppressed carrier receivers. Feeding part of the audio output into the control light source varies the resistance of the Raysistor's photocell, making it usable in place of a normal volume control.




**2. As a remotely controlled linear potentiometer.** The Raysistor can be used as a remotely controlled linear potentiometer when used in the circuit shown above. Here the Raysistor forms a voltage divider between the positive and negative voltages.




**3. As a photochopper stabilized D-C microvoltmeter.** Raysistors, used as photochoppers in both modulator and demodulator circuits, enable d-c levels to be measured to a fraction of a microvolt. They facilitate synchronous detection and demodulation with simple electrical coupling, have less noise than transistor choppers, while avoiding maintenance problems of mechanical choppers. Other photochopper applications: photochopper relay, series or shunt chopper, modulator circuit, and as a stabilizer to reduce long-term drift.




**Many more ways you can use the Raysistor.** Send for *The Raysistor Applications Manual* which describes ways you can use this unique optoelectronic component as a photochopper, variable resistor, solid-state switch, relay, voltage or signal isolator, nonlinear potentiometer, etc. For complete specifications and prices, call your Raytheon distributor or regional sales office. For a copy of this 28-page manual, circle the reader service card or write directly to *Raytheon Company, Components Division, Quincy, Massachusetts 02169.*

RAYTHEON

TALK TO RAYSISTOR SPECIALISTS DURING IEEE—RAYTHEON APPLICATIONS CLINIC, HAMPSHIRE HOUSE, MARCH 22.

**Industrial Components Operation—A single source for Circuit Modules/Control Knobs/Display Devices/Filters/Hybrid Thick-Film Circuits/Industrial Tubes/Optoelectronic Devices/Panel Hardware**


Circle 109 on reader service card

# All the CANNON® connectors made in the last 40 years would reach to the moon.

## In fact, some have.

ITT Cannon Electric has made more electrical connectors for more applications than anyone in the world. More than 40 years ago a specially designed CANNON Plug helped introduce talking pictures. Today, some of our connector designs rest on the moon.

Generation after generation of CANNON connectors have solved every conceivable electrical and electronic connection problem.

From the aircraft industry's infancy of the early thirties to the most modern military and commercial jet . . . to the challenge of outer space and the ocean's depths to the rapidly expanding needs of commercial and industrial electronics — CANNON connectors have always been first to meet the most exacting requirements, whether size, shape or environmental extremes.

Today, ITT Cannon Electric offers the broadest connector line available. You have a complete choice of standard, miniature, subminiature, microminiature — in cylindrical and rack/panel configurations—for every aircraft, ground support, satellite, marine, commercial, and industrial application.

*This is ITT Cannon Electric.*

When you need electrical connectors, an old standby or a breakthrough design, look first to the imaginative engineering of ITT Cannon, the world's most experienced manufacturer of electrical connectors. ITT Cannon Electric, 3208 Humboldt Street, Los Angeles, California 90031. A division of International Telephone and Telegraph Corporation.

CANNON® PLUGS

CANNON ITT

Circle 111 on reader service card

# Extending IC technology to microwave equipment

Three different technical approaches are already being used; one way to speed the use of IC's is to base system design on the assembly of similar transmit-receive modules

By Harold Sobol
RCA Laboratories, David Sarnoff Research Center, Radio Corp. of America, Princeton, N.J.

**The next area** likely to fall under the onslaught of integrated circuits is microwave equipment. Although the best crystal balls now available do not show IC's having a widespread impact on the microwave industry until the mid-1970's, progress is moving so fast that date may well be bettered. In some development laboratories, microwave circuits are already being built with so-called hybrid IC's, in which silicon chips, serving as transistors and diodes, are bonded to ceramic substrates. In others, monolithic techniques have been modified to produce microwave circuits. In still others, dielectric isolation with glass, ceramic, or sapphire promises interesting circuits for microwave equipment.

All the integrated circuits built so far are for applications that do not require high power at high frequencies. Also, building completed systems with IC's will be far more difficult than fabricating individual circuits.

Probably the worst obstacles to rapid acceptance of IC's in microwave equipment are the sheer mass of design, materials, and fabrication technique tradeoffs that have not yet been resolved.

One way of clearing the underbrush more rapidly, and at the same time improving cost effectiveness, appears to be basing system design upon the assembly of similar transmit-receive modules, as shown on pages 120 to 123. Output for each module would be only a few watts, sufficient for low-power systems. Modules could be combined for systems with outputs in the kilowatts range. This approach is also being investigated elsewhere under an Air Force contract (the program at the Radio Corp. of America is company funded).

The modules could be made in relatively high volume, one of the chief economic attractions of integrated circuit production—and a necessity. There are several prototype circuits for such modules. The prototypes are hybrid IC's, but much of the design work is applicable to monolithic or dielectrically isolated IC's. The modular concepts are being worked out in cooperation with the RCA Communications Systems division and other RCA product divisions [Electronics, Oct. 21, 1966, p. 114].

Many microwave functions, particularly those that dissipate little power, can now be accomplished with hybrid integrated circuits and a few with monolithic IC's. Receiving, signal control and signal processing functions are practical to integrate today, and these functions soon will be integrated in some systems. Transmitting circuits are more difficult, primarily because the power level is higher and fairly good amplification is needed without excessive losses.

The integrated microwave receiver shown on page 117 is an example of what can be accomplished today in the laboratory. Its dimensions are about 1 inch by 2½ inches, as indicated by the full-size reproduction of the metalization etching pattern used to define the transmission lines, electrodes of

**The author**

Harold Sobol heads the microwave integrated circuits group in the microwave research laboratory at RCA laboratories. Before joining RCA in 1962, he was with the International Business Machines Corp. and the University of Michigan, where he received his doctorate in 1959.

passive devices and active-device bonding pads. This receiver, a hybrid integrated circuit, contains a four-transistor intermediate-frequency strip with thin-film capacitors and resistors, a mixer, circulator, multiplier, and up-converter formed of microstrip transmission lines. It operates at a frequency of 9 gigahertz, in the microwave X band. This prototype will have a noise figure of about 12 decibels. Future models with tunnel diode amplifiers should have a noise figure of 6 or 7 db.

### Different definition

When a microwave engineer talks about an integrated component, he usually means a device or subsystem in a single package—for example, a traveling wave tube and its power supply. Therefore, microwave IC requires a more exact definition: a subsystem or function comprising a miniaturized planar circuit of solid-state devices. The definition covers monolithic, hybrid, and dielectrically isolated IC's.

The transistors and other active devices may be grown in a single-crystal, semiconductor substrate or attached as chips to another substrate. This eliminates component-package parasitics, like case capacitances and lead inductances, but may introduce other parasitics, such as capacitance between IC elements and the substrate. Like conventional integrated circuits, microwave IC's can be batch-fabricated.

Aside from these similarities, a microwave IC has little in common with the familiar digital IC. Operation is linear. Repetitive functions are few and large numbers of IC's need not be packed into a very small volume to build a system. Microwave frequencies also require propagating structures that offer shielding against spurious signals, prevent radiation of spurious signals to other circuits, keep losses low, and can be terminated in a way that keeps standing-wave ratios low. The propagation requirements usually call for a well-defined transmission line, such as microstrip (diagram, right).

### Hybrid or monolithic?

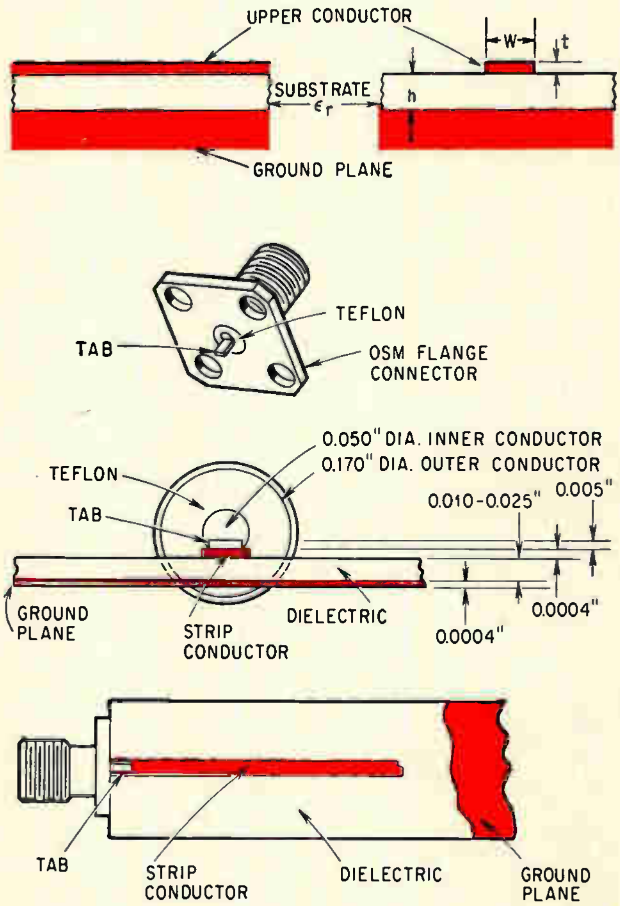
Both monolithic and hybrid IC's will probably be used in high-performance integrated microwave systems. It is also likely that standard components will be used, since high performance is unattainable in certain applications with IC's. Final power stages, stable local oscillator cavities, and diplexing with narrowly separated frequencies are among the continuing applications seen for conventional components.

Switches, mixers, transmit-receive switches, amplifiers, and circulators for microwave equipment have all been made as IC's.[1-8] In theory, most could be monolithic. In practice, however, hybrids have been more successful. The only microwave monolithic IC reported as yet is a transmit-receive switch for a phased-array radar.[1]

Mixers, diplexers and radio-frequency interconnections need some form of transmission line circuitry. The semiconductor substrate of a monolithic IC may be adequate at times as the insulating medium between the conductor and the ground plane. But silicon is a resistive insulator. Its quality factor, Q, is very low compared with the Q of dielectric materials. If the line must propagate energy at microwave frequencies with low losses, the insulator should be a good dielectric. Only hybrid integrated circuits provide a high-Q substrate of glass or ceramic at present.

Dielectrically isolated IC's show promise as an alternative in the future, particularly with the approach illustrated by the RCA Decal circuit described in the article on page 97. Another likely form of IC's is known as silicon-on-sapphire, although the technology is not yet sufficiently advanced to provide all needed types of devices. The SOS method is to deposit films of silicon on the sapphire substrate, form isolated active devices by etching and diffusing the film. Other devices can be formed in the silicon or other thin films deposited on the sapphire. [Editor's note: another company's work on SOS is described on page 106].

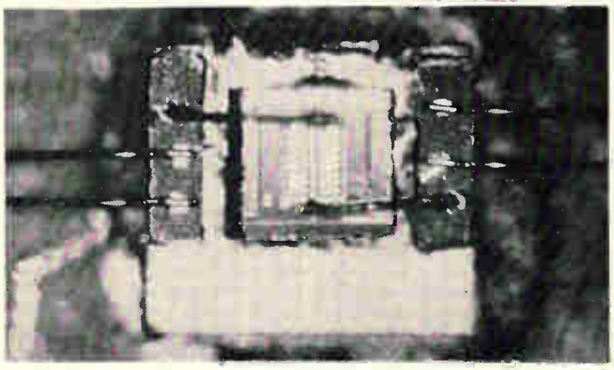
The ceramic substrate of the hybrid IC is more stable than a monolithic circuit's semiconducting substrate, since there are no carriers (mobile conduction electrons or holes) to be excited by light



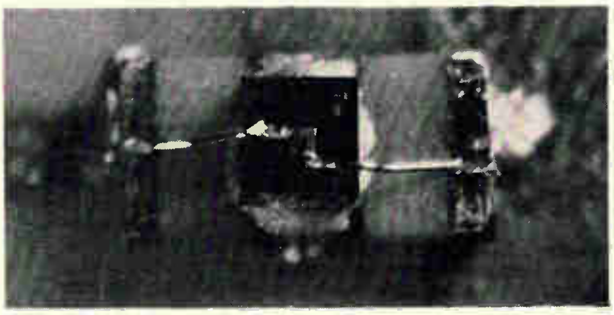

**Microstrip transmission line, shown in cross-section at the top can be extremely small. However, it must be coupled to relatively large external connections. Below it is a transition that joins the microstrip to a miniature coaxial connector.**

## Bits and pieces of integrated microwave circuits

Lumped inductor is part of the lumped-element amplifier. It's outside diameter is 0.040 inch.



Mount for an r-f transistor. The opening is 0.020 inch square. The leads to the mount are wires.



Another transistor mount. This one can be soldered directly to a microstrip transmission line.

or heat. Ceramic properties do not vary considerably during processing and circuit operation.

Hybrid circuits also allow the designer a wide choice of proven types of devices. In hybrid IC's passive devices are customarily thin films. Active devices can be planar or sandwich-type chips attached by beam-lead, flip-chip, or conventional bonding methods.

### Monolithic circuits

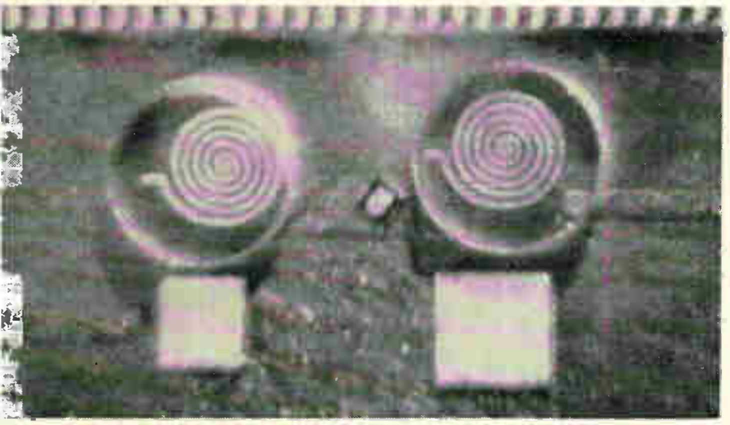
Microwave IC's cannot have low-resistivity semiconductor substrates. On such substrates, p-n junction isolation or conventional dielectric isolation is inadequate. Therefore, the most promising form of monolithic isolation is resistive, obtained by forming devices in thin epitaxial layers grown on a high-resistivity semiconductor substrate. If the substrate resistivity is not extremely high—usually about 1,000 ohm-centimeter—microstrip resonant structures and interconnections will be too lossy.

The devices must be planar. Active elements, such as transistors and diodes, are formed by diffusions in the epitaxial crystal. Passive elements, such as resistors and capacitors, may be diffused into the epitaxial layer or substrate, or deposited along with inductors as thin films on either an epitaxial layer or the substrate.

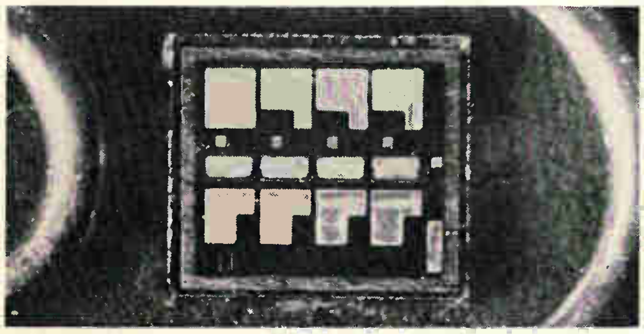
Manufacturing costs are inversely related to the number of IC's processed simultaneously. Cost is low if many monolithic IC's are made on a semiconductor wafer. However, if much of the semiconductor real estate is to be occupied by inactive devices, the hybrid approach may save money. Each decision requires a cost study that includes the savings resulting from producing large numbers of chip devices on a wafer versus the costs of attaching and wiring the chips to the hybrid IC substrate.

Generally, monolithic circuits should be considered if a large number of IC's can be made on a 1-inch wafer. This implies that if IC's for the lower microwave frequencies are to be monolithic, lumped elements will have to be used because of the relatively large size of distributed circuits. High-frequency circuits, on the other hand, can be distributed. The unloaded Q of monolithic circuits will be fairly low, compared with larger hybrids, because the monolithics are much smaller and have little volume available for energy storage. Low Q implies low performance in such factors as circuit efficiency, signal linewidth, and stability. Hybrids using small elements will, of course, have the same problem, as would the more compact forms of dielectrically isolated circuits.

The device needed will also determine whether the circuit can be monolithic. For several years to come, silicon will be the only practical semiconductor for monolithic IC's. Thus, the designer



Lumped elements of the type used in the 2-Ghz amplifier shown in color on page 119.



Wideband amplifiers are made 42 at a time on an inch-square sapphire wafer. Chip transistors will be added.

can consider circuits employing such silicon devices as transistors, p-i-n diodes, Schottky-barrier diodes, and possibly avalanche diodes.[2-4, 9]

Germanium, gallium arsenide and gallium antimonide are needed for low-noise tunnel-diode amplifiers, Gunn-effect devices, and high-frequency Schottky-barrier diodes. Since production of sophisticated planar circuits of germanium or intermetallic semiconductors are still beyond the state of the art, any circuit requiring the more advanced devices will be made for the time being as a hybrid IC.

## Microstrip transmission lines

Material, electrical, and processing aspects of integrated circuit technology are very tightly woven in microwave IC design considerations. The interrelationships are particularly apparent in microstrip transmission lines.

Microstrip is the basic element of a distributed passive circuit. It came into use 15 years ago as a lightweight means of microwave transmission. This form of waveguide's fundamental mode is a quasi TEM (transverse electromagnetic) mode with a fringe field bound to the main propagating mode but extending fairly far from the strip conductor. Discontinuities in either the main or fringe field may excite an undesirable radiation mode. Designers for the most part shunned microstrip with organic insulators because of fringe-field and radiation problems. Stripline was somewhat more popular because its construction, a strip conductor between two ground planes, reduces undesirable modes.

However, because of its planar geometry, microstrip is enjoying a resurgence in microwave IC's. When substrates have a relatively high dielectric constant, the fields stay close to the strip conductor. Although this doesn't eliminate the problems, it lessens them considerably. Microwave IC designers will have to learn to live with such external elements as shielding enclosures and posts to break up unwanted waveguide modes.

## Microstrip impedance

Accurate design data on microstrip was not available until recently. H.A. Wheeler derived, by conformal mapping analysis, a set of curves for a parallel-plate guide that is applicable to microstrip.[10, 11] Experimentally verified design data based on Wheeler's analysis was presented in 1966 by this writer and others.[12] Equations for characteristic impedance and wavelength have been fitted to the design curves. In these equations, terms are as defined as on page 118.

Characteristic impedance of unshielded microstrip line is given by

$$Z_o = \frac{377h}{\sqrt{\epsilon_r}\, W \left[1 + 1.735\epsilon_r^{-0.0724} \left(\frac{W}{h}\right)^{-0.836}\right]} \qquad (1)$$

and the wavelength for the line is given by

$$\lambda_g/\lambda_{TEM} = \left[\frac{\epsilon_r}{1 + 0.63\,(\epsilon_r - 1)\left(\frac{W}{h}\right)^{0.1255}}\right]^{1/2}; \quad W/h \geqq 0.6$$

$$\lambda_g/\lambda_{TEM} = \left[\frac{\epsilon_r}{1 + 0.6\,(\epsilon_r - 1)\left(\frac{W}{h}\right)^{0.0297}}\right]^{1/2}; \quad W/h \leqq 0.6 \qquad (2)$$

Equation 1 is accurate to within 1% for $W/h > 0.4$ and $\epsilon_r > 1$ and extremely accurate when $W/h > 0.1$. When $W/h < 0.4$ and $\epsilon_r > 1$, the accuracy is within 3%. Equations 1 and 2 apply when the conductor's thickness is essentially zero. If the thickness is finite, the effective width must be used in place of the width in equations 1 and 2.

$$W_{eff} = W + \Delta W \approx W + \frac{t}{\pi}\left(\ln\frac{2h}{t} + 1\right) \qquad (3)$$

In most cases three to five skin depths are sufficient for the upper conductor and for the ground plane. (At one skin depth, the current density is one neper less than the current density at the conductor surface.) The conductivities tabulated on page 123 are bulk values and skin depths are normalized to the square root of the frequency in gigahertz. Conductivity generally will be somewhat less in films several microns thick. Films only hundreds of angstroms thick have resistivities considerably higher than bulk values and, therefore, still lower conductivity. Exact values depend upon fabrication conditions and should be measured.

### Attenuation and loss

Attenuation due to conductor loss is given approximately by

$$\alpha_c = \frac{\sqrt{\pi f \mu}}{2 Z_o W}\left[\frac{1}{\sqrt{\sigma_1}} + \frac{1}{\sqrt{\sigma_2}}\right], \text{ nepers/meter} \quad (4)$$

In the limiting case, as impedance approaches a low value (when $W/h >> 1$), equation 4 becomes

$$\alpha_c \rightarrow \frac{\sqrt{\pi f \epsilon_o \epsilon_r}}{2h}\left[\frac{1}{\sqrt{\sigma_1}} + \frac{1}{\sqrt{\sigma_2}}\right] \quad (5)$$

so attenuation due to conductor loss tends to be inversely related to the height of the insulator. This suggests that low-loss lines require thick substrates. The dielectric constant factor, $\sqrt{\epsilon_r}$, in the numerator drops out when the loss per wavelength is being determined, because the wavelength is proportional to $1/\sqrt{\epsilon_r}$.

Attenuation due to losses in the insulating substrate is given by

$$\alpha_{d\ \mathrm{INS}} \approx \frac{\omega}{2}\left(\frac{\mu}{\epsilon'}\right)^{1/2}\frac{\epsilon''}{\epsilon'}\epsilon' \text{ nepers/meter} \quad (6)$$

The dielectric losses can be neglected for hybrid IC's on ceramic substrates because conductor losses usually predominate. When the substrate is a semiconductor, substrate losses are not negligible. The approximate losses for semiconductors is given by

$$\alpha_{d\ \mathrm{SEMICON.}} \approx \frac{1}{2}\frac{Z_o W}{\rho h} = \frac{188}{\sqrt{\epsilon_r}\,\rho}\;\frac{1}{1 + 1.735\,\epsilon_r^{-0.0724}\left(\frac{W}{h}\right)^{-0.836}} \text{ nepers/meter} \quad (7)$$

Calculated losses of lines on ceramic and silicon are tabulated on page 122. Ceramic-based lines A and B are assumed to have no dielectric loss. Conductor and substrate losses are included in the values for silicon substrates. Note that high resistivity markedly lowers the losses of silicon-based lines. The line materials and sizes are typical of microwave IC's.

### Quality factor

The Q attainable in microstrip resonators is an important circuit design consideration. If the microstrip is an open or shorted section, the unloaded quality factor, $Q_u$, of a quarter-wavelength resonator is

$$\frac{1}{Q_u} = \frac{1}{Q_d} + \frac{1}{Q_c} \quad (8)$$

If the conductors are all made of the same material, the conductor Q is

$$Q_c = \frac{1}{6}\frac{\lambda_{TEM}}{\lambda_g}\frac{W}{h} Z_o \sqrt{\epsilon_r}\, h \sqrt{F_{Ghz}}\,\sqrt{\sigma_c} \quad (9)$$

(Meter-kilogram-second units are used in the equation.) The Q of the substrate, $Q_d$, is approximately the Q of the dielectric; for semiconducting substrates, it is

$$Q_d \approx \omega \rho \epsilon_r \epsilon_o \quad (10)$$

Calculated Q values of quarter-wavelength, distributed resonators, in the table on page 122, show that microstrip resonators have lower Q's than conventional cavity resonators and that the penalty in performance is greatest in the monolithic IC type of microstrip. While the Q values can be raised by thicker substrates, this tends to increase IC size and thermal resistance. It may not be practical to make the monolithic IC substrates thicker.

At some point, the microstrip must be coupled to the outside world. The simple transition, on page 113, from microstrip to a 50-ohm miniature coaxial connector, works well up to 10 Ghz. It is convenient for testing prototype IC's individually; operational assemblies of IC's in a module would probably be interconnected by microstrip.

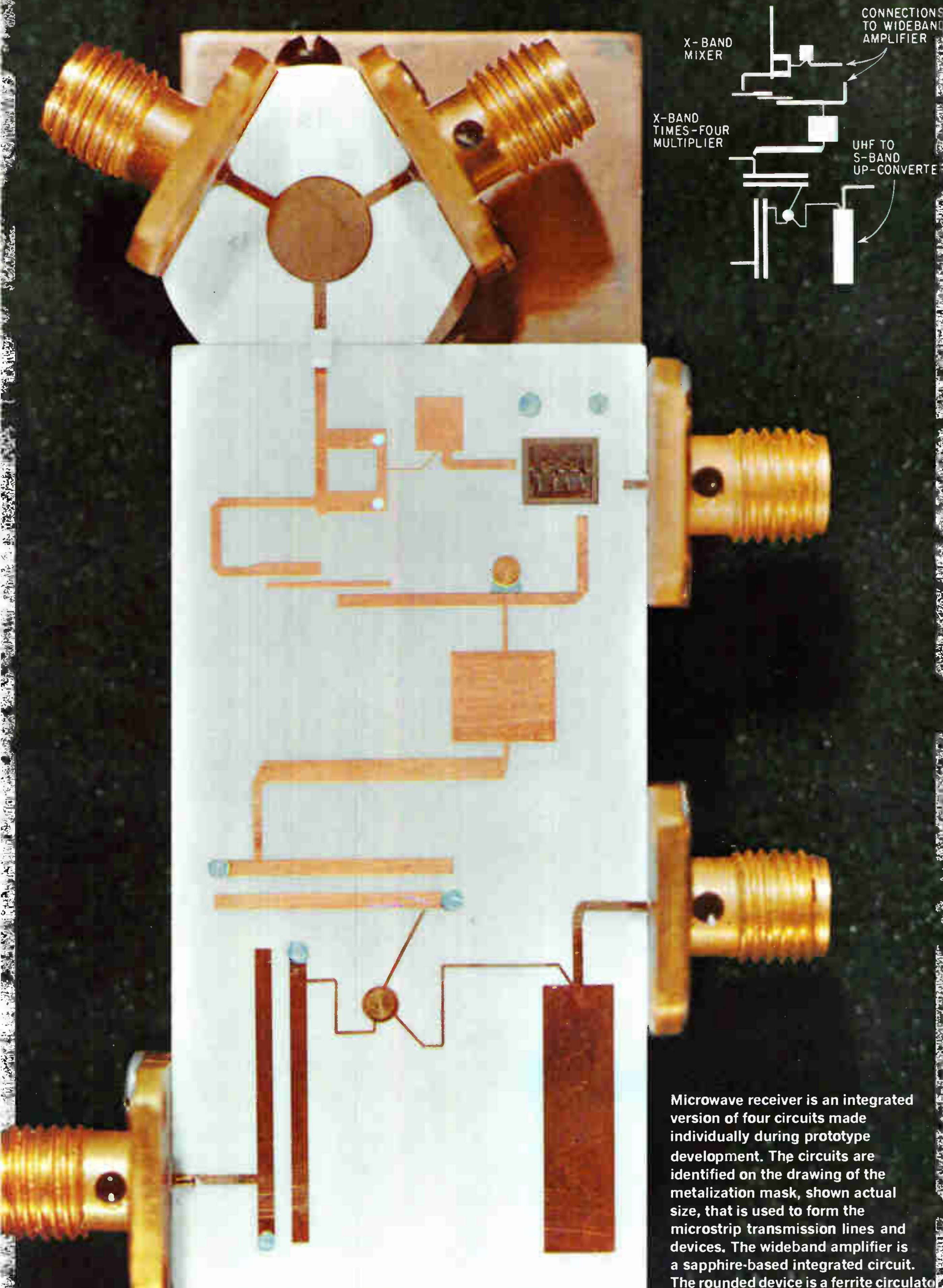
### Choosing the materials

The rules for selecting a microwave IC substrate are not the same as for choosing the substrate of a standard IC. The substrate is an integral part of the microstrip circuit and must have relatively low dielectric loss at microwave frequencies. Dielectric constant must not only be high, but homogeneous in each substrate and from batch to batch. Often, its thermal conductivity must be high, also, to prevent local overheating around power components. Thin-film conductors must adhere strongly to the substrate and, even if the substrate is only 10 to 50 mils thick, neither the substrate nor the conductors should be deformed by temperature cycling. The substrate surface must be free of pits for uniform transmission lines and short-free capacitors to be deposited.

If circuit temperatures vary widely, variation of characteristics with temperature must be studied. Many high-dielectric materials have relatively low Curie points, so temperature can strongly affect characteristics, particularly in microstrip circuits. For example, the approximate change in the resonance frequency of a quarter-wavelength microstrip resonator is given by

$$\frac{\Delta f}{f_o} \cong -\frac{1}{2}\frac{\Delta \epsilon}{\epsilon} \quad (11)$$

The equation is only an approximation, since the amount of fringe field depends on the dielectric constant. A temperature change from 0° to 100°C will change the dielectric constant of rutile about 10%. The equation shows the resonance frequency will change about 5%. The corresponding change in sapphire-based microstrip is less




Microwave receiver is an integrated version of four circuits made individually during prototype development. The circuits are identified on the drawing of the metalization mask, shown actual size, that is used to form the microstrip transmission lines and devices. The wideband amplifier is a sapphire-based integrated circuit. The rounded device is a ferrite circulato than 0.5%, making it a better choice than rutile in this respect, although its dielectric constant is lower (see table on p. 124). Temperature compensating systems might be used, but they may make the design too complex.

Substrate thickness is governed by a tradeoff between conductor Q and the maximum allowable thermal resistance of the substrate. A first-order approximation of thermal resistance for a device with square dimensions, W, is given by

$$R_{th} \approx \frac{h}{k\,W^2} \qquad (12)$$

This equation holds if the ground plane is in good thermal contact with a heat sink. Although the equation suggests the heat flow is a uniform cylinder, the flow tends to be conical. However, the equation illustrates that thickness, h, is limited by allowable thermal resistance. Minimum thickness is set by conductor attenuation, as noted in the discussion of equation 5.

When the conductor material (table, p. 122) forms part of the device metalization on a monolithic IC, the metal is usually aluminum or gold, which are compatible with most silicon devices. Restrictions on conductor Q partially determine the choice of conductors for hybrid IC's. Also, since at least three skin depths of conductor are desirable, film thickness must be increased with conductor resistivity. Greater care must be taken in microwave IC's than in conventional IC's to avoid nonuniformity in conductor linewidths, undercutting, nicks, and other flaws, since these can cause variations in the impedance of transmission lines.

Insulating films between two metal films are needed for capacitors, capacitive devices that block direct current (blockers), and sometimes for device passivation. The insulating film cannot be used as the dielectric of microstrip, because the line would be quite lossy—about 8 db loss for a 1-micron-thick film at 3 Ghz.

### Definitions of terms

- C = capacitance per unit length
- f = frequency in hertz
- h = thickness of dielectric substrate
- j = square root of −1
- k = thermal conductivity
- L = inductance per unit length
- l = length of line
- Q = quality factor
- $Q_c$ = Q of the conductor
- $Q_d$ = Q of the substrate
- $R_{th}$ = thermal resistance
- t = thickness of strip conductor
- W = width of conductor
- $W_{eff}$ = effective width of conductor
- $Z_o$ = characteristic impedance
- $\alpha_c$ = attenuation due to conductor loss
- $\alpha_d$ = attenuation due to losses in insulator
- $\beta$ = propagation constant equal to $\omega$ divided by velocity in the medium
- $\delta$ = skin depth
- $\epsilon$ = dielectric constant
- $\epsilon'$ = real part of the permittivity
- $\epsilon''$ = imaginary part of the permittivity
- $\epsilon_o$ = free space permittivity = $8.85 \times 10^{-12}$
- $\epsilon_r$ = relative dielectric constant of insulating layer
- $\lambda_{TEM} = \lambda_o/\sqrt{\epsilon_r}$
- $\lambda_g$ = guide wavelength
- $\lambda_o$ = free space wavelength
- $\mu = 4\pi \times 10^{-7}$
- $\omega = 2\pi f$
- $\rho$ = substrate resistivity in ohm-cm
- $\sigma$ = conductivity (of metal film)
- $\sigma_1$ = conductivity in $(\text{ohm-m})^{-1}$ of strip
- $\sigma_2$ = conductivity in $(\text{ohm-m})^{-1}$ of ground plane

## Lumped elements

Basic to the nondistributed passive circuit is the lumped element, a circuit element with dimensions so much smaller than a wavelength that distributed effects play no part in its operation. For example, in the limit of small length, l, a short-circuited transmission line becomes an inductance with a reactance

$$Z = j\,Z_o \tan \beta l \rightarrow j\sqrt{\frac{L}{C}}\;\omega\sqrt{LC}\,l = j\,\omega L l \qquad (13)$$

At microwave frequencies, lumped elements are minute. It has been more practical to build large distributed circuits of waveguides and coaxial cable—these circuits have higher Q because of the higher storage volume. But in integrated circuits, small is desirable because big is impractical.

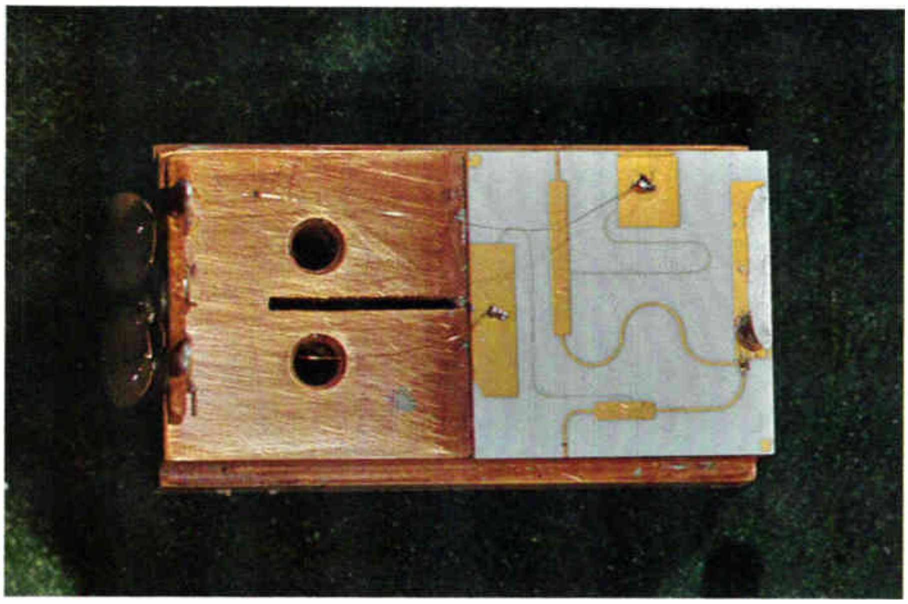
Minute planar lumped elements can be fabricated now with exacting precision as IC's. These are truly lumped elements. They satisfy the requirement that the phase shift over the element length approach zero because they are so short. On the other hand, however, the designer must try to circumvent the low-Q problem. If extra amplification stages don't help, the idea of using IC's for circuits requiring high Q's may have to be abandoned. Lumped elements in hybrid or monolithic IC's may be practical up to nearly 3 Ghz.

## Thin-film inductors

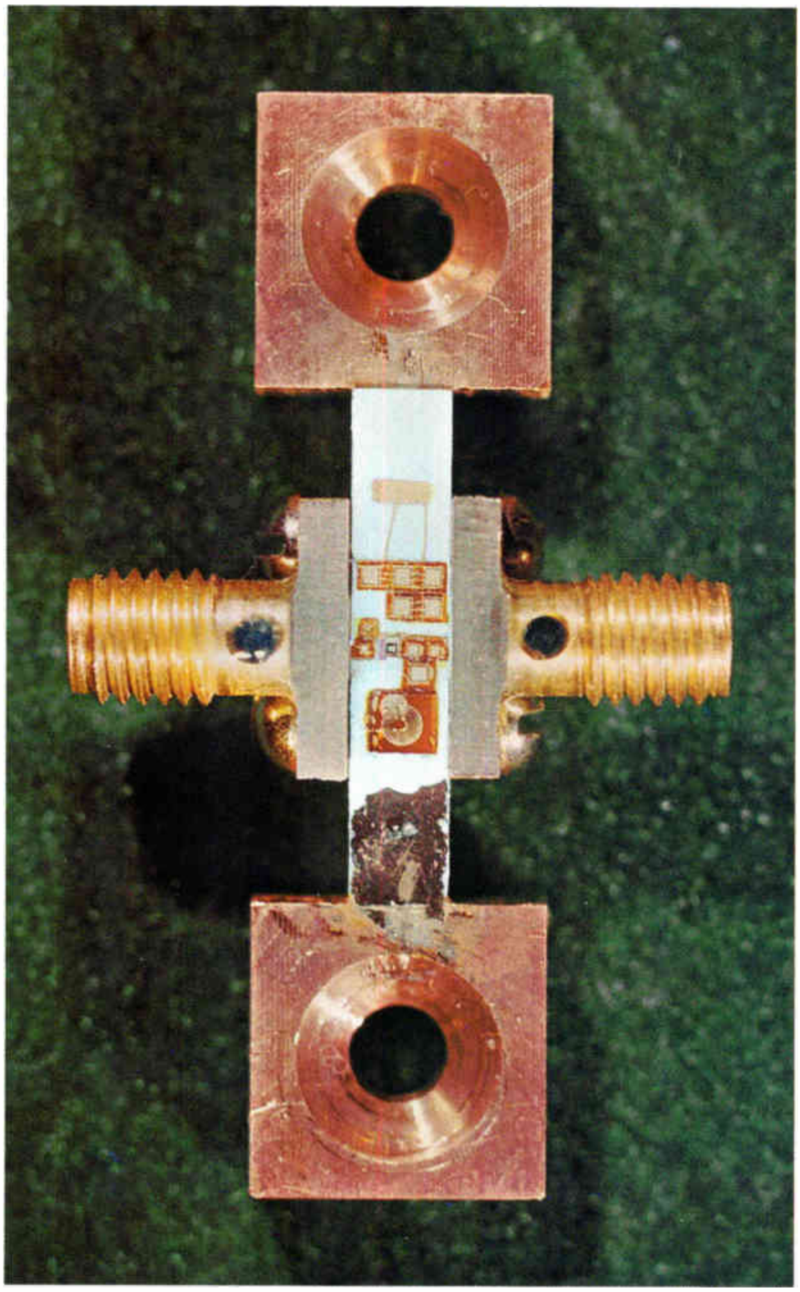
Lumped-element design is straightforward. Low-frequency formulas for inductance and capacitance apply well in microwave design, provided the elements are much smaller than the wavelength.

Inductors for low-frequency IC's must be large, a familiar IC problem. This is not troublesome at microwave frequencies, since only nanohenrys of inductance are needed rather than microhenrys. The microwave coil on page 114 is 0.040 inch in diameter and was deposited on a glass substrate. A layer of deposited silicon dioxide insulates the crossover from the coil. The inductance is 10 nh and the Q is 45 at 2 Ghz. A coil 0.060 inch in diameter has an inductance of 25 nh and a Q of 60 at 2 Ghz. Coils deposited on ceramic substrates have similar values.

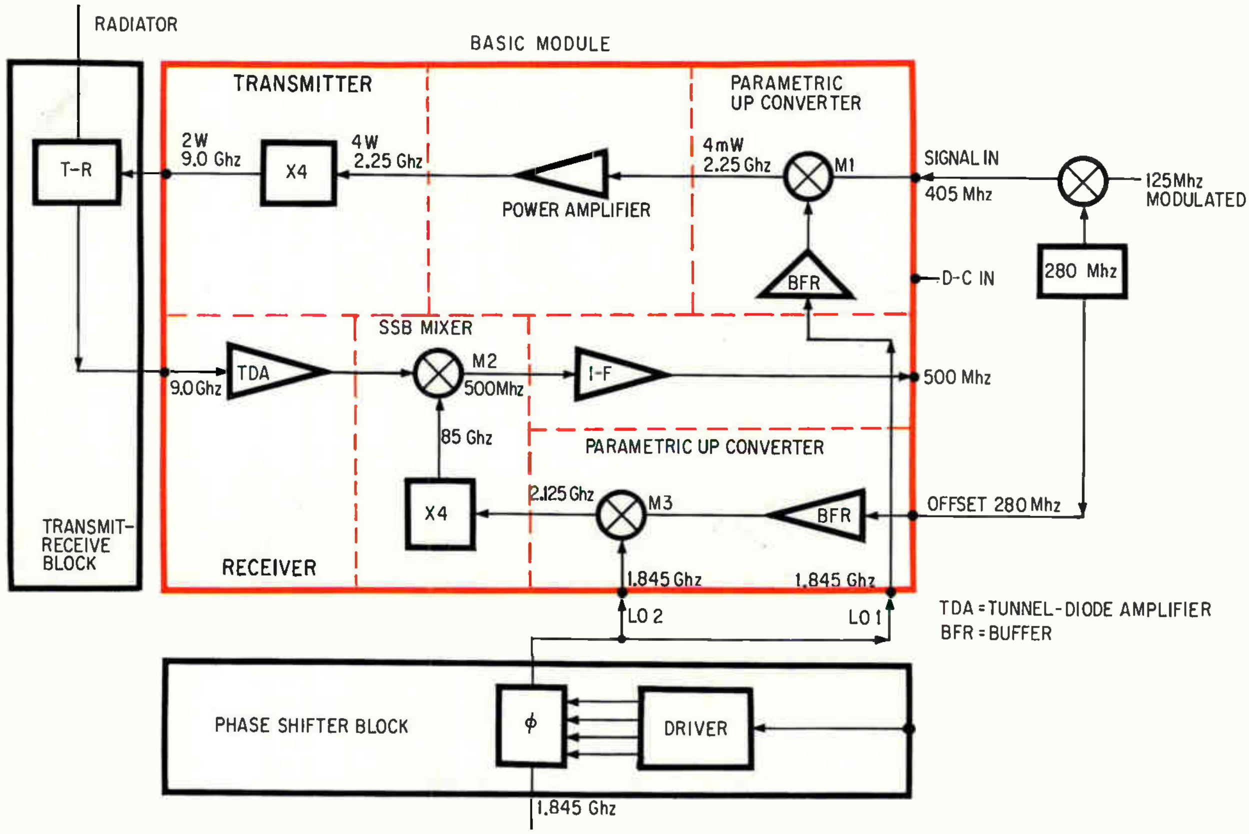
The inductances measured are within 10% of the calculated values for a low-frequency, flat-spiral coil. The Q is about one-third to one-half the value calculated, assuming that current flow on the upper and lower sides of the coil are equal and that the conductors have bulk resistivity. Both assumptions, however, are probably inaccurate. More



**Distributed-element amplifier**, on a substrate about 1 inch square, has a gain of 8 db and a power output of 20 milliwatts at 1.2 Ghz. Sections of microstrip handle the impedance transformation.



**Lumped element amplifier** will measure only about 0.1 inch square. This breadboard version's substrate is about ½ inch long. Used as a power amplifier at a frequency of 2 Ghz, it has an output of ½ watt with a gain of about 4 db. Its components are lumped inductors and capacitors.




**Basic microwave module,** the circuits within the red outlines, requires only the addition of a signal source, phase shifter and transmit-receive switch to make it a functioning unit.

study is needed in current flow, resistivity and the effect of having dielectric on one side of the coil.

Suitable coils will be extremely difficult to make on monolithic circuits. These coils are as large as conventional IC's, posing the real estate cost problem. Coil Q's tend to be lower when the substrate is silicon, and lower still when the silicon is low in resistivity. Increasing conductor thickness is unlikely to be of much help. A coil thickness of two or three skin depths gives a very high Q. Further thickness adds little to the Q and lowers the self-resonance frequency of the coil by adding to the interturn capacitance. Once again, the effect of lossy dielectric on one side of the coil must be analyzed.

The 10-nh coil and a 0.636-picofarad film capacitor form a simple LC resonator in about the same area as a simple digital IC—less than 2,000 square mils. The LC resonator's Q will be about 25 at 2 Ghz. In contrast, a microstrip resonator constructed from a 50-ohm line on a 25-mil-thick alumina substrate will have a Q of 120, but its area will be 15,000 square mils. Area versus Q is therefore another design tradeoff.

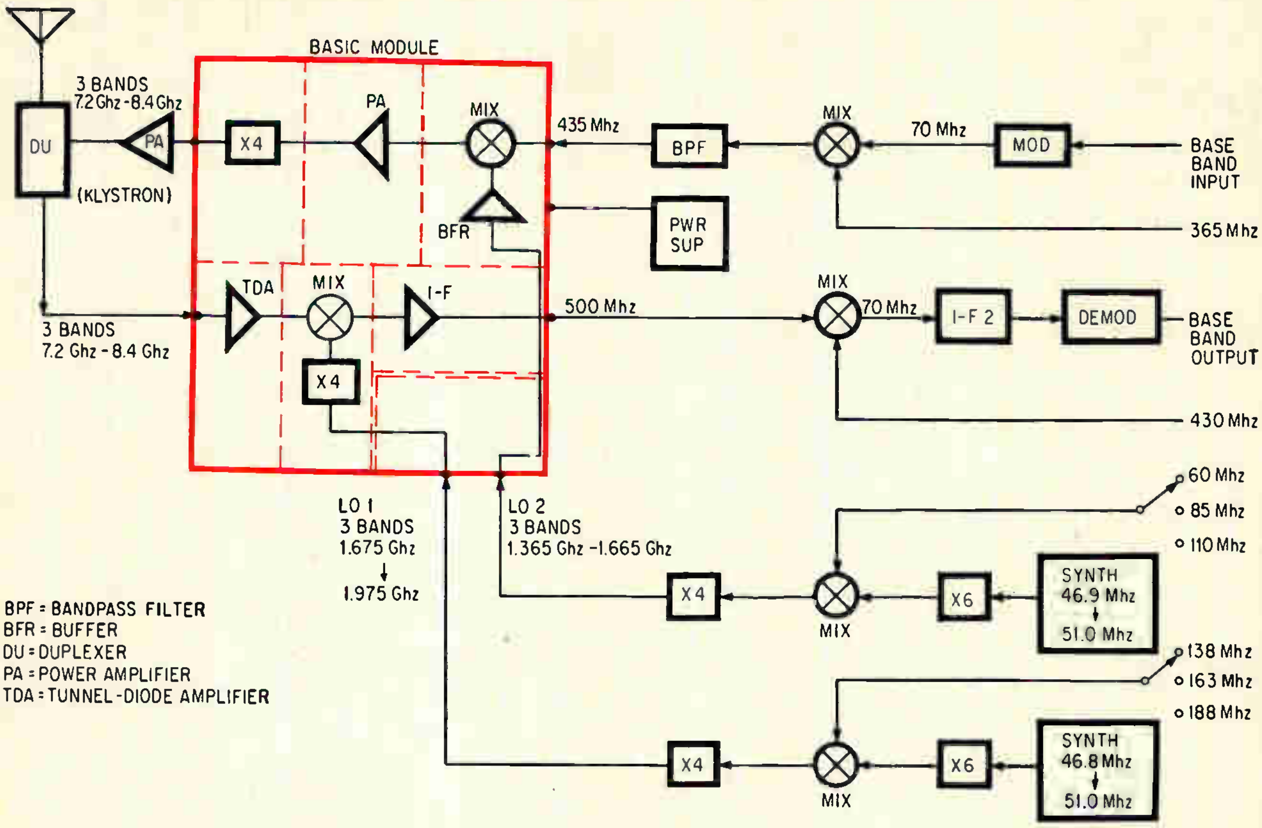
Developers of dielectric-isolated circuits suggest that this real estate problem may be overcome by providing a large dielectric area for thin-film components (see p. 105).

The high parasitic capacitances of diffused silicon capacitors and metal oxide semiconductor (MOS) capacitors tend to lower their maximum usable frequency. Furthermore, their parasitic reactances are higher and their Qs tend to be lower than thin-film capacitors. Therefore, thin-film capacitors are preferred.

Capacitors can be made with many types of dielectric materials. However, the Q's at microwave frequencies of many materials have not as yet been determined. But the data now available can be used in the low-frequency capacitance formulas to accurately predict microwave performance. RCA's evaluations show silicon monoxide has a Q of 30 at S band and silicon dioxide has a Q of 50. Other likely films are tantalum pentoxide ($Ta_2O_5$) and deposited or anodized alumina ($Al_2O_3$). Silicon dioxide film capacitance is 0.02 to 0.05 pfd per square mil and its breakdown is above 200 volts, so suitable microwave capacitors can be made. If low-loss electrodes are used, the capacitor's Q approaches the Q of the dielectric material; 15-pfd capacitors made at RCA with deposited layers of silicon dioxide as the dielectric have measured Q's of about 50 at 2 Ghz. Texas Instruments Incorporated has reported higher Q's for capacitors made of reactively sputtered silicon dioxide.

## Testing active devices

Microwave IC's can rarely be tuned, so operating impedances and all other characteristics of an active device should be known before it is put into a circuit. Tolerances must be held to a bare mini-




**Communications systems** would be made of one, or a few, modules supplemented by signal sources, modulators and demodulators that adapt the module operation to the specific system needs. With the klystron power amplifier, power could be boosted to the level required for troposcatter transmission.

mum. Only when the characteristics of large numbers of devices are close to the average can optimum circuits be obtained.

Devices may be passivated with a material like glass or plastic, but usually will be unpackaged. Package parasitics must be excluded in evaluating transfer functions, impedances, and other design parameters at the plane of the device. If the device has been studied in a package, the characteristics of the connections and package must be found and taken into account. However, it is preferable to test unpackaged devices.

Two mounts useful for testing microwave transistors, because they introduce very little reactance at frequencies around 2 Ghz, are shown on page 114. The transistor chip—or monolithic IC containing the transistor—is bonded to the mount base plate with a high-temperature solder or eutectic alloy. Short lead wires are bonded to the chip's emitter and base pads and to the mount's corresponding lands. Then the mount is soldered, at a lower temperature, into the test circuit.

The typical amplifier transistor test circuit used by RCA has lines with 50 ohms impedance. Impedance-matching stubs are used to obtain the maximum gain or power from the amplifier. The stubs are removed and the impedances looking into the stub positions are measured and transformed back to the plane of the transistor to obtain both the input and required load impedances.

These tests point up the need for monolithic IC elements to be planar. Contacts will have to be made to the top of the IC during tests as well as during use. Microstrip conductor contacts will also have to be made to the top of the IC, since the bottom is reserved for the ground plane and the mounting.

## Integrated functions

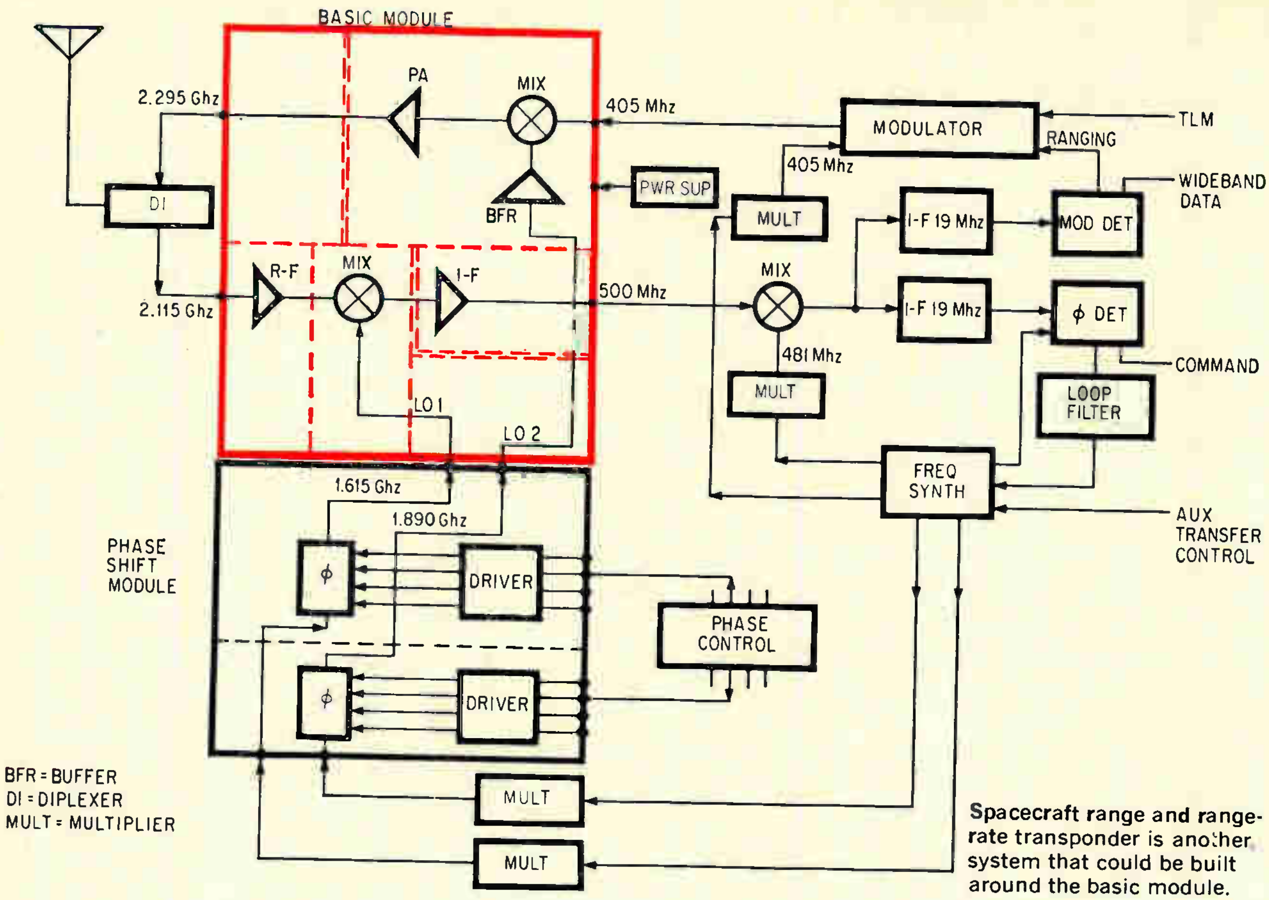
As a preliminary to construction of the integrated receiver shown on page 117, the following circuits of the receiver were first built as individual circuits and tested.

The prototype of the X-band balanced mixer has a noise figure of 9 db. The gain of the wideband amplifier is greater than 20 db over a range of 30 to 700 Mhz. The up-converter's gain at about 2 Ghz is 2 db. And the multiplier's peak efficiency is 25% at 9 Ghz.

The amplifier is attached to the integrated receiver's substrate as a two-level chip. The circuit's thin-film capacitors and resistors are made on a sapphire substrate and the active devices are chips attached to the substrate. The passive networks are made 42 at a time on a square inch of sapphire.

The upconverter and multiplier both contain microstrip coupled lines, demonstrating that microstrip can be used as such lines [Alfred Schwartzmann, of the RCA Communications Systems division, is preparing a paper on theory and design of coupled lines].

Besides the receiver circuits, lumped-element




Spacecraft range and range-rate transponder is another system that could be built around the basic module.

and distributed-element amplifiers (these are shown in color on page 119) have been made. One is a breadboard version that contains lumped inductors and capacitors; it's output near 2 Ghz is ½ watt and its gain is about 4 db. The thin-film equivalent of this circuit will have an area of about 10,000 square mils (about 0.1 inch square). Sections of microstrip handle impedance transformation in the distributed-element amplifier, which is about 1 inch square. At 1.2 Ghz, its output is 20 milliwatts and its gain is 8 db.

### Ferrite devices

While diodes can do the phase shifting and switching that are conventionally done by ferrite devices, ferrites are still required for nonreciprocal functions—those depending on the signal flow direction. Among these are isolators and circulators, necessary for practical tunnel-diode and parametric amplifiers.

Furthermore, if the system load varies, it is desirable to isolate the power-output stage, especially when the final stage is a muliplier chain. The load may vary in applications such as phased-array antenna where the elements are driven by separate sources. As the beam is steered the impedance of the elements vary and cause reflections that can upset the operation of the output stage.

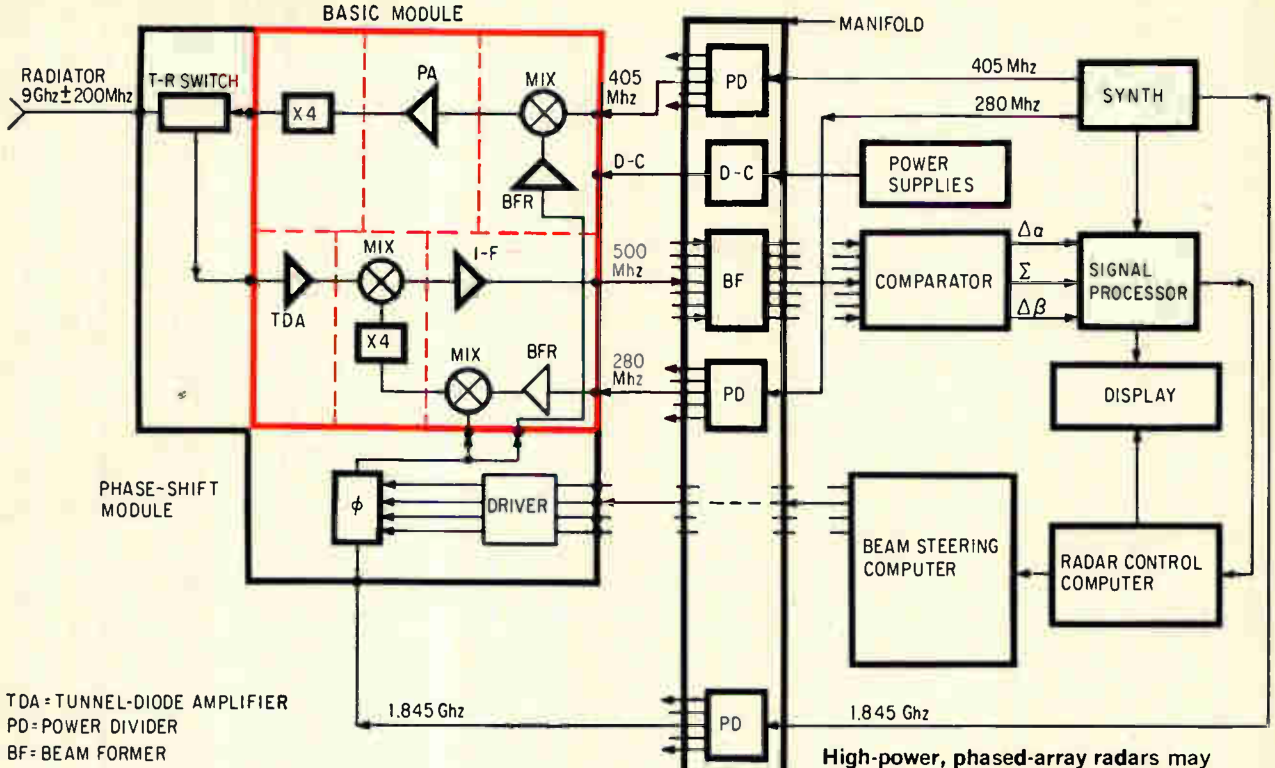
A microstrip junction circulator (shown on page 117) was made by mounting a ferrite cylinder in an alumina ceramic substrate and depositing the conductors on the substrate.[8] Permanent magnets, 0.1 inch or less thick, mounted near the ferrite provide the circulator's magnetic field. Performance at X band has been excellent: isolation above 40 db with insertion loss as low as 0.2 db have been measured. Methods of using latched circulators and other ferrite components in integrated circuits are under study.

The functional blocks described above and in the references can have low-power applications, primarily in the receivers, signal processing, and con-

**Losses of 50-ohm microstrip lines in microwave integrated circuits**

| Line | Conductor | Dielectric Material | Dielectric Thickness | $\epsilon_r$ | Losses, db/cm 2 Ghz | Losses, db/cm 10 Ghz | Q of $\lambda/4$ Resonator 2 Ghz | Q of $\lambda/4$ Resonator 10 Ghz |
|---|---|---|---|---|---|---|---|---|
| A | gold | ceramic | 10 mils | 9.9 | 0.098 | 0.22 | 48 | 106 |
| B | gold | ceramic | 25 mils | 9.9 | 0.039 | 0.088 | 120 | 265 |
| C | gold | silicon (150 ohm-cm) | 10 mils | | 1.3 | 1.44 | 2 | 9 |
| D | gold | silicon (1,500 ohm-cm) | 10 mils | | 0.24 | 0.38 | 14 | 50 |

No dielectric loss in lines A and B; conductor and substrate loss included for lines C and D




**High-power, phased-array radars** may be assembled by combining the outputs of many basic modules. One module is shown in color. Duplicates would be connected in a similar way to the manifold and their beam phases controlled by the computers. This is a pulsed radar system for point defense or for multimode aerospace applications. A similar design would be used for continuous-wave radar.

trol sections of a microwave system. But what of the transmitter? How much transmitter power can be achieved with solid state devices, integrated or not?

Conventional single-transistor output stages put out about 1 watt at microwave frequencies for instance, between 1 and 2 watts at 2 Ghz. This is ample for instrumentation, radio relays, altimeters, and other low-power applications, but far too low for most radar and space systems.

Tens of watts at 2 Ghz and greater than 1 watt at 10 Ghz can be obtained with lower frequency amplifiers followed by varactor frequency multipliers.

Bulk-effect and avalanche-transit-time devices will have to be reckoned with in the future as sources of high power. A Gunn-effect diode has reportedly produced 380 watts of pulse power at L band.[13] But further accumulation and evaluation of data on the control, modulation, phase locking, and possible amplification of such devices will be needed before they can be considered for use.

There is, of course, a way to get high power out of today's low-power devices—combine their outputs. If proper impedances are maintained, many devices can be physically tied together in series-parallel combinations. In one system, 64 transistors are combined to produce 1,200 watts at 300 Mhz.[14] Eight avalanche diodes have been combined in a hybrid ring arrangement at X band.[15]

Such combinations can be integrated by mounting the semiconductor devices on ceramic substrates that also carry microstrip or lumped-element impedance transformers. Probably, 50 to 100 devices can be put on substrates. Beyond this number, impedance matching becomes fairly difficult. At present, it isn't practical to make such IC's monolithic, since the circuit Q's needed are too high and the area occupied by the transformers is very large and wastes active material.

Combining outputs can be achieved in space by phased-array antennas that parallel the outputs of many sources in the radiated beam. This is the basis of the MERA (microelectronic radar array) study the Air Force has sponsored at Texas Instruments. The objective is to get a total of 600 watts of pulse power at X band from about 600 driven elements spaced one-half wavelength apart. Driver

**Skin depths of metal films**

| Metal | $\sigma$ (ohm − m$^{-1}$) | Normalized skin depth $\delta\sqrt{F_{ghz}}$(microns) |
|---|---|---|
| Ag | $6.17 \times 10^7$ | 2.03 |
| Cu | $5.8 \times 10^7$ | 2.09 |
| Au | $4.09 \times 10^7$ | 2.49 |
| Al | $3.72 \times 10^7$ | 2.61 |
| W | $1.78 \times 10^7$ | 3.76 |
| Mo | $1.76 \times 10^7$ | 3.8 |
| Pt | $0.94 \times 10^7$ | 5.2 |
| Cr | $0.77 \times 10^7$ | 5.75 |
| Ta | $0.64 \times 10^7$ | 6.26 |

**Dielectric substrate properties**

| Substrate material | tan δ (10 Ghz) | $\epsilon_r$ | k, watts/cm—°C |
|---|---|---|---|
| High quality $Al_2O_3$ | $2 \times 10^{-4}$ | 9.6–9.9 | 0.2 |
| Sapphire | $10^{-4}$ | 9.3–11.7* | 0.4 |
| Glass (7059) | $4 \times 10^{-3}$ | 5 | 0.01 |
| BeO | $10^{-4}$ | 6 | 2.5 |
| Rutile (amorphous) | $4 \times 10^{-4}$ | 100 | 0.02 |

* Varies with crystal orientation

elements will be integrated circuits. Besides the drivers, each array element can have an integrated receiver and controls.

## Building blocks

One can visualize sophisticated multifunction systems with many antenna beams—for instance, one system for both communications and radar.

While these schemes are technically feasible, cost effectiveness is a serious problem. One can hardly afford a 1,000-element array if each element's receiver and transmitter costs $100 to $1,000. The price range would have to be $10 to $100, with the lower price in large systems.

A price of only $10 for a microwave transmitter, receiver, and control seems incredible. It is impossible if the elements are custom built in the conventional way.

It could be practical, however, if universal building blocks can be made for both large and small systems. The variety of units would be less, but components could be manufactured in large quantities, thus cutting unit costs. Modularization, therefore, could provide microwave IC's with the cost effectiveness needed.

A possible form of module, on page 120, being studied by RCA can contain either hybrid or monolithic IC blocks. The choice depends on the factors already discussed and which IC technology is most suitable when and if they are produced.

Usually, the components will have fairly broad bandwidths, in line with the goal of volume production. Operating bandwidth will be defined as needed by adding filters to the basic block, while different-order microstrip multipliers will change the operating frequencies.

Different kinds of modules can be made from different block combinations. The blocks will be assembled by mounting them on a common, heat-sinking base plate. Interconnections, including microstrip, will be a printed overlay pattern. In addition, some blocks such as the intermediate-frequency and power amplifiers may be individually packaged and sold. The choice of blocks for a system and their mode of operation will have to be chosen carefully so that spurious responses do not exceed a system's specification.

How many modules with outputs of 1 to 2 watts can be used in a system? That depends on the allowable heat dissipation and the complexity and cost of the distribution network that communicates with the modules. As for total power, it seems feasible to achieve as much as 5 to 10 kilowatts by combining modules made with devices available today.

Only one or a few modules would suffice in a communication system or spacecraft transponder, such as shown in the conceptual diagrams on pages 121 and 122, or in an altimeter or telemetry system. With a klystron to boost the output power, a troposcatter system could be built.

With many identical transmit-receive modules linked to signal processing and control subsystems through a manifold, as shown on page 123, ground radar systems and such aircraft radar systems as fire control, terrain-avoidance and following, and mapping might be built.

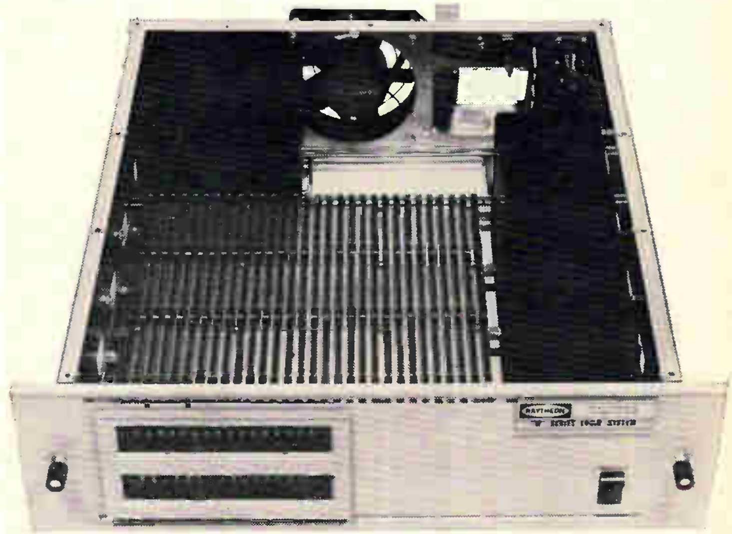
Before these concepts can be realized, over-all efficiency has to be boosted to 10%-25%, from the 1%-2% in conventional varactor-multiplier chains. Reproducibility and tuning problems exist, too, but these may be eased by the tendency of an array antenna to smooth out random deviations in the characteristics of the individual outputs as they are combined. However, if tuning is required, tuning varactors or tunable YIG filters will be needed. (YIG filters are frequency-selective devices made of yttrium-iron garnet.) To keep crosstalk between modules down to a tolerable level, shielding will have to be designed into antenna housing. Finally, device passivation and hermetic sealing suitable to the environments in which the systems will operate must be provided.

## References


1. Alfred Ertel, "Monolithic IC techniques produce first all-silicon X-band switch," Electronics, Jan. 23, 1967, p. 76.
2. A. Botka and W.J. Moroney, "High-Isolation, Fast Switching Integrated Microstrip RF Switches," International Solid-State Circuits Conference, Digest of Technical Papers, February 1967.
3. W.M. Portnoy and T.M. Hyltin, "An X-Band Balanced Mixer Integrated Circuit," op. cit.
4. C. Genzabella and C. Howell, "Integrated S- and X-Band Mixers," IEEE International Convention Record, Part 5, March 1966, p. 113.
5. A. Ertel, "A 9 Ghz Silicon Monolithic Integrated TR Switching Circuit," International Electron Devices Meeting, October 1966.
6. R.S. Engelbrecht and K. Kurohawa, "A Wideband Low-Noise Balanced Transistor Amplifier," Proceedings of the IEEE, March 1965, p. 237.
7. T.E. Saunders and P.D. Stark, "An Integrated 4 Ghz Balanced Transistor Amplifier," International Solid-State Circuits Conference, Digest of Technical Papers, February 1966.
8. Bernard Hershenov, "An X-Band Microstrip Circulator," Proceedings of the IEEE, December 1966, p. 20, 22.
9. K.D. Smith, "Generating power at gigahertz with avalanche-transit time diodes," Electronics, Aug. 8, 1966, p. 126.
10. H.A. Wheeler, "Transmission-Line Properties of Parallel Wide Strips by a Conformal-Mapping Approximation," IEEE Transactions on Microwave Theory and Techniques, May 1964, p. 280.
11. H.A. Wheeler, "Transmission-Line Properties of Parallel Strips Separated by a Dielectric Sheet," IEEE Transactions on Microwave Theory and Techniques, March 1965, p. 172.
12. H. Caulton, J.J. Hughes and H. Sobol, "Measurements on the Properties of Microstrip Transmission Lines for Microwave Integrated Circuits," RCA Review, September 1966, p. 377.
13. News item, Microwaves, November 1966, p. 12.
14. Electronics Newsletter, Electronics, Nov. 14, 1966, p. 25.
15. H. Fukui, "Frequency Locking and Modulation of Microwave Silicon Avalanche Diode Oscillators," Proceedings of the IEEE, October 1966, p. 1475.

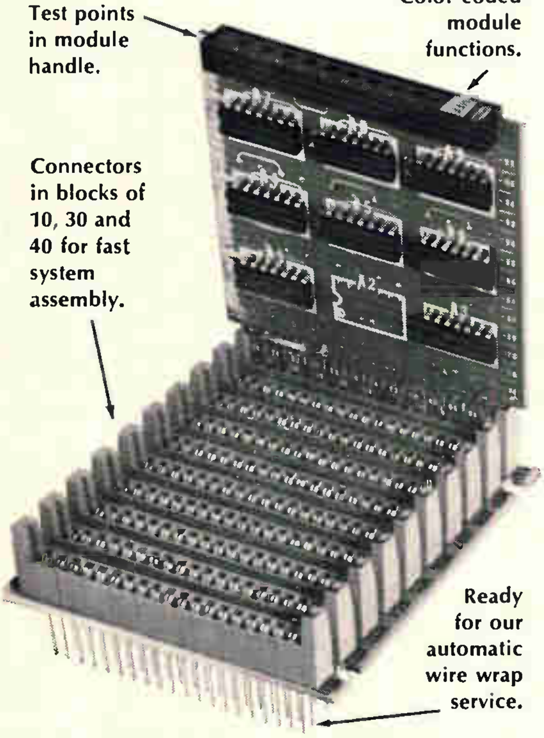
# The Unbeatable IC System:

## Your logic design and Raytheon Computer modules and hardware.



Indicator lights display system operation.

This case holds 120 modules. There's also one for 40; another for 400.



Test points in module handle.

Color-coded module functions.

Connectors in blocks of 10, 30 and 40 for fast system assembly.

Ready for our automatic wire wrap service.

Laminated power bus bars installed and wired in each module case. Reduces noise, eliminates power inter-connections, cuts hours from assembly and test time.

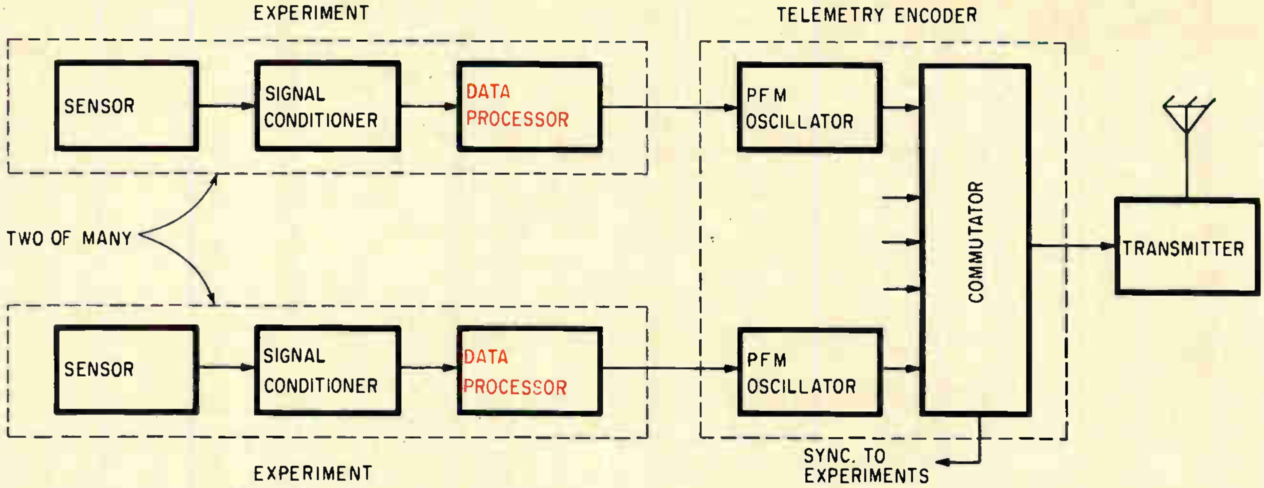
**Raytheon Computer's M-Series** — more than 30 modules— connectors, cases, power supplies and power distribution are so thoroughly engineered you can concentrate on logic and electronic design, not mechanical details. Every step— design, assembly, test, check-out, troubleshooting—is easier than you thought it could be.

**We'll even help you design your logic.** Call or write today for a visit from a helpful applications engineer or for the whole story in print. Ask for Data File M-136. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif., 92705, Phone: (714) 546-7160.

RAYTHEON



Circle 125 on reader service card




**A single channel encoder replacing multitudinous pulse-frequency modulated oscillators is a step in the right direction, but still requires the inefficient special-purpose processors.**

computer. This computer must find the sum of squares, perform logarithmic compression, and make logical decisions in addition to doing other calculations. Also planned for IMP-F is a magnetometer experiment that includes an autocorrelation function computer to perform multiplication and find sums of products.

These two systems point up the difficulties in designing, fabricating, and testing complex special-purpose data-processing hardware within the schedule constraints of a small satellite. From the experimenter's viewpoint, transferring these tasks to a general-purpose computer would be desirable. Specifically for the IMP-F, a general-purpose digital computer has been shown to be superior to separate hard-wired, special-purpose devices.[1]

## Four kinds of computation

Functions the computer must perform include removing redundancies, extracting parameters, and formatting and buffering data.

Redundancy removal doesn't destroy information; it merely recodes the data for transmitting fewer bits. An example is a recently developed method of encoding monotonic data.[2]

Parameter extraction, however, does not preserve all the data produced by an experiment sensor. Only the desired portions, or certain parameters dependent upon the data, are transmitted. Computations for the IMP-F experiments fall into this class. One form of parameter extraction is conversion to floating point format.

In present satellites, the wiring of the telemetry encoder system determines the format in which data is transmitted; a centralized computer could take over this format determination. The advantage here is flexibility; control of the telemetry format by a computer program would reduce wiring changes from spacecraft to spacecraft, provide a standardized vehicle for various experiments, and permit quick changes in the format any time before launch. If a ground command capability were included, the format could be changed after launch.

If an experiment fails, its slot in the format could be allocated to more data from other experiments. The format also could be changed to maximize the transmission of useful data if the desired spacecraft trajectory or orientation weren't achieved. Conceivably, the format could vary automatically in response to the spacecraft's environment.

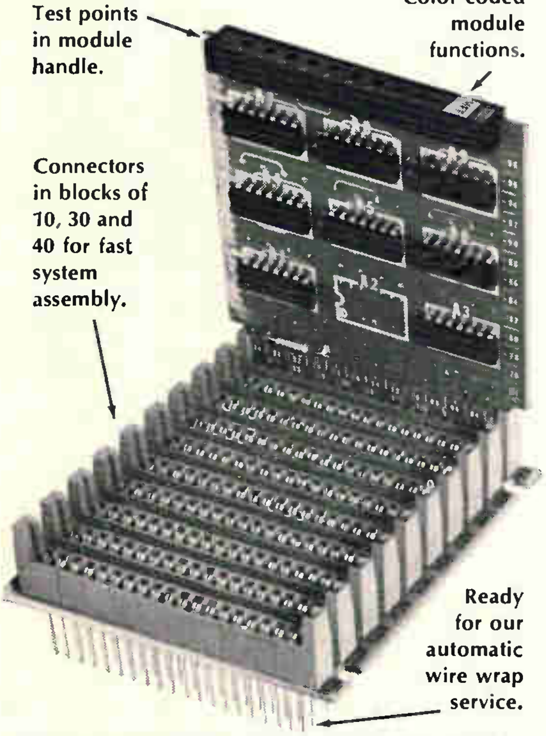
In planning a general-purpose space computer, more data-handling hardware has been assigned to the chore of buffering data than all the other functions combined. Most of the buffer memory is required because the satellite's spin rate is unrelated to the telemetry rate. Data from directional experiment sensors, collected at some point in the spacecraft's rotation, must be stored until it can be transmitted. For instance, the optical-aspect computer on board the IMP-D contains 225 bits of storage. Of these, 96 count pulses during a spin. The remaining 129 serve only one function: to store data until the telemetry system is ready to transmit it.

A digital computer contains, by its very nature, a memory—usually some magnetic device that occupies little volume, is lightweight, and consumes no power except when data is actually being transferred in or out of it. For the most part, small spacecraft haven't carried magnetic memories because other techniques are more economical in terms of size, weight, and power when only a few bits of memory are needed. However, when individual buffer memories are collected into a larger unit, magnetic memory becomes attractive—particularly when read/write and addressing circuits are already available. The computer memory can handle the buffer function at a small increase in size, weight, power, and complexity.

To use one centralized computer rather than a number of separate special processors is to put all the eggs in one basket. If the centralized computer fails, then the spacecraft fails. But continued production of a computer model will increase

# The Unbeatable IC System:

## Your logic design and Raytheon Computer modules and hardware.



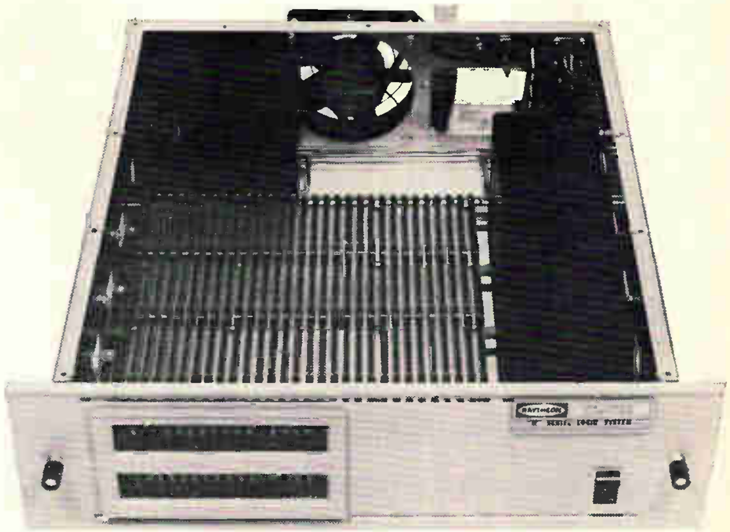
Test points in module handle.

Color-coded module functions.

Connectors in blocks of 10, 30 and 40 for fast system assembly.

Ready for our automatic wire wrap service.

Laminated power bus bars installed and wired in each module case. Reduces noise, eliminates power inter-connections, cuts hours from assembly and test time.



Indicator lights display system operation.

This case holds 120 modules. There's also one for 40; another for 400.

**Raytheon Computer's M-Series** — more than 30 modules— connectors, cases, power supplies and power distribution are so thoroughly engineered you can concentrate on logic and electronic design, not mechanical details. Every step— design, assembly, test, check-out, troubleshooting—is easier than you thought it could be.

**We'll even help you design your logic.** Call or write today for a visit from a helpful applications engineer or for the whole story in print. Ask for Data File M-136. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif., 92705, Phone: (714) 546-7160.

RAYTHEON



Circle 125 on reader service card

*"Why do more and more executives say MICHIGAN has more of everything?"*

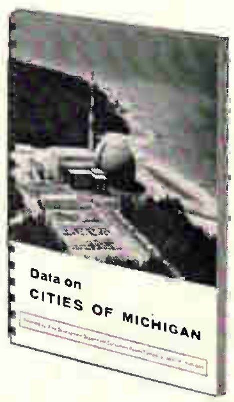
"...because Michigan backs you up with top-notch supporting industries in every growth field."

A significant part of Michigan's industrial strength lies in the variety, scope, and talents of its supporting industries. Hundreds of specialized firms are producing components and materials to meet the most critical precision requirements. Southern lower Michigan has 828 special tool and die shops, 237 machine tool accessory shops and 524 machine shops — all manned by a labor force with skills far above the national average. May we, in confidence, tell you more about your profit potential in Michigan? Write:

**Consumers Power Company**

*216 West Michigan Ave. Jackson, Michigan 49201 Area Code 517 - 788-0502*

*W. N. McClelland, Director of Area Development*




*Ask for your copy*

# Space for small computers

A general-purpose stored-program machine compact enough to squeeze into a research satellite could take over several tasks of special-purpose data processors and drain less power

By Rodger A. Cliff

Goddard Space Flight Center, National Aeronautics and Space Administration, Greenbelt, Md.

**One of the troubles** with small research satellites is space—or, rather, the lack of it—for data-handling equipment.

Because of the growing number of experiments called for aboard the tiny spacecraft, a single general-purpose computer is needed to replace the special-purpose digital equipment now included in individual experimental packages. But the biggest obstacle to be overcome is the limited power supply aboard spacecraft.

One such unit may be in the offing. Proposed is a stored-program computer that would eliminate the duplication of data-processing capability which results in wasted power, weight and space—all dear on satellites weighing 400 pounds or less. The organization, routines and programing have already been worked out.

Compared with the usual computer, it would have a small memory, few registers, few instructions, and short words—yet would be able to improve experimentation. With it, experiment packages need only contain sensors and signal conditioners. Data buffering and formatting, redundancy removal, and parameter extraction would be taken over by the multipurpose computer.

One of the stored-program computer's biggest advantages is flexibility. Significant changes in the data system in different satellites could be made in the program instead of by intricate wiring. However, a major constraint is that the computer's reliability must be very high.

As it flies, the spacecraft is stabilized by spinning it about the axis of highest moment of inertia. This spinning motion causes directional experiment sensors to scan circularly. Although this scanning motion isn't necessarily undesirable, experimental data is most meaningful when synchronized with the satellite's spin. The time-division-multiplex telemetry system's fixed commutation rate, too. is not related to the spin rate. A computer would considerably improve the data system's performance by synchronizing the experiments with the spacecraft's spin, or, if desired, provide data unrelated to spin.

Many experiments that measure random events —energetic particle experiments, for instance—produce raw data with a wide bandwidth, while information from other experiments may have less bandwidth but a higher average data rate. In either case, transmitting every scrap of raw data would severely burden the telemetry transmitter. Because of this, satellites often buffer and compress data with devices like logarithmic particle counters.

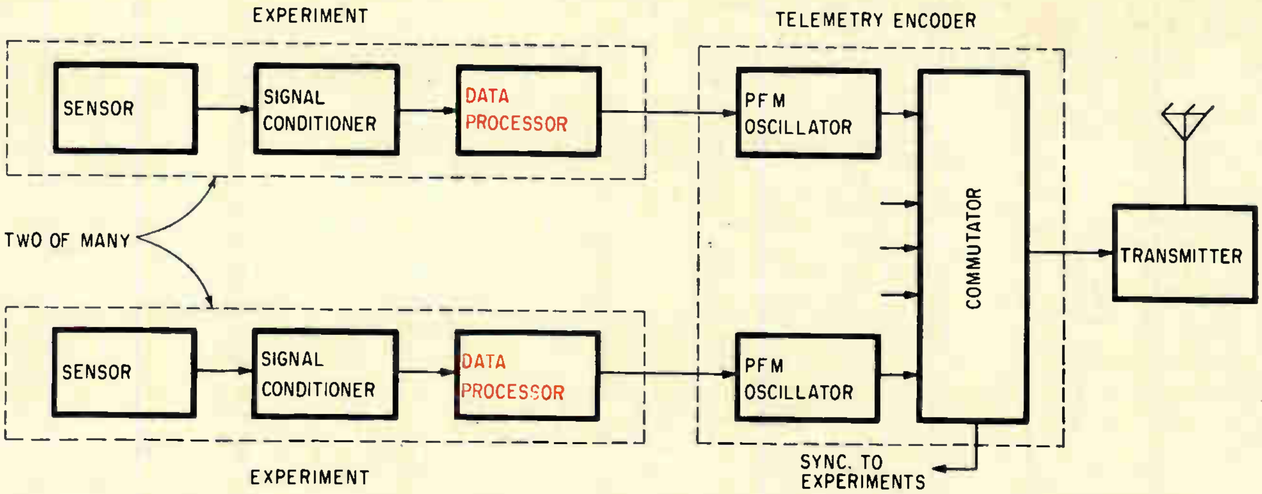
In applying a general-purpose computer to the spacecraft, two matters must be considered. First, the computer/spacecraft interface should be designed in such a manner that the two units can be operated and tested separately. Second, wherever possible, the computer should be compatible with such established hardware as channel encoders, commutators, etc.

### What the computer must do

The computations to be made aboard spacecraft are becoming more complex. For example, the sixth interplanetary monitoring platform, the IMP-F, will carry a plasma experiment requiring a statistics

**The author**

Rodger A. Cliff has been working on data-processing and compression methods at NASA's Goddard Space Flight Center since graduating from the Massachusetts Institute of Technology five years ago.




**A single channel encoder** replacing multitudinous pulse-frequency modulated oscillators is a step in the right direction, but still requires the inefficient special-purpose processors.

computer. This computer must find the sum of squares, perform logarithmic compression, and make logical decisions in addition to doing other calculations. Also planned for IMP-F is a magnetometer experiment that includes an autocorrelation function computer to perform multiplication and find sums of products.

These two systems point up the difficulties in designing, fabricating, and testing complex special-purpose data-processing hardware within the schedule constraints of a small satellite. From the experimenter's viewpoint, transferring these tasks to a general-purpose computer would be desirable. Specifically for the IMP-F, a general-purpose digital computer has been shown to be superior to separate hard-wired, special-purpose devices.[1]

### Four kinds of computation

Functions the computer must perform include removing redundancies, extracting parameters, and formatting and buffering data.

Redundancy removal doesn't destroy information; it merely recodes the data for transmitting fewer bits. An example is a recently developed method of encoding monotonic data.[2]

Parameter extraction, however, does not preserve all the data produced by an experiment sensor. Only the desired portions, or certain parameters dependent upon the data, are transmitted. Computations for the IMP-F experiments fall into this class. One form of parameter extraction is conversion to floating point format.

In present satellites, the wiring of the telemetry encoder system determines the format in which data is transmitted; a centralized computer could take over this format determination. The advantage here is flexibility; control of the telemetry format by a computer program would reduce wiring changes from spacecraft to spacecraft, provide a standardized vehicle for various experiments, and permit quick changes in the format any time before launch. If a ground command capability were included, the format could be changed after launch.

If an experiment fails, its slot in the format could be allocated to more data from other experiments. The format also could be changed to maximize the transmission of useful data if the desired spacecraft trajectory or orientation weren't achieved. Conceivably, the format could vary automatically in response to the spacecraft's environment.

In planning a general-purpose space computer, more data-handling hardware has been assigned to the chore of buffering data than all the other functions combined. Most of the buffer memory is required because the satellite's spin rate is unrelated to the telemetry rate. Data from directional experiment sensors, collected at some point in the spacecraft's rotation, must be stored until it can be transmitted. For instance, the optical-aspect computer on board the IMP-D contains 225 bits of storage. Of these, 96 count pulses during a spin. The remaining 129 serve only one function: to store data until the telemetry system is ready to transmit it.

A digital computer contains, by its very nature, a memory—usually some magnetic device that occupies little volume, is lightweight, and consumes no power except when data is actually being transferred in or out of it. For the most part, small spacecraft haven't carried magnetic memories because other techniques are more economical in terms of size, weight, and power when only a few bits of memory are needed. However, when individual buffer memories are collected into a larger unit, magnetic memory becomes attractive—particularly when read/write and addressing circuits are already available. The computer memory can handle the buffer function at a small increase in size, weight, power, and complexity.

To use one centralized computer rather than a number of separate special processors is to put all the eggs in one basket. If the centralized computer fails, then the spacecraft fails. But continued production of a computer model will increase reliability, and if the spacecraft/computer interface is properly designed, total failure of the computer need not mean total failure of all the experiments.

The argument against using a stored-program computer is that it's too complex and uses too much power. However, special-purpose data processing devices of great complexity and considerable power drain are already being built.

## Present-day systems

The requirements of the computer/spacecraft interface are pointed up by the data system for the first three IMP spacecraft. Data processing is performed in the experiments, except for accumulators in the telemetry encoder that count pulse data from certain experiments.

Inside the telemetry encoder are a number of pulse-frequency-modulation oscillators[3]—one for each experiment. Each oscillator encodes the output data from its associated experiment as a frequency; the commutator switches these frequencies in sequence to the transmitter and also supplies synchronization pulses for the experiments.

For experiments with analog outputs, the pfm oscillator is voltage-controlled. For experiments with digital outputs a digitally controlled oscillator produces a discrete frequency for each input state. In either case, the phase of the frequency output is uncontrolled and the frequency is only approximately determined. This sort of system is not optimum for a number of reasons.

Better performance can be achieved by using a phase-coherent digital pfm oscillator for all experiments. IMP-D has such an oscillator and others are planned for the fifth IMP, to be launched within the next few months, and the sixth and seventh in the series. The new oscillator[4] is more complex than the earlier models, and only one can be used. Data is commutated to the single oscillator, which then feeds the transmitter directly.

The biggest disadvantage of this method is that if the single oscillator fails, all data is lost. The advantages of the new oscillator are increased reliability and far fewer total components. Furthermore, the performance of the telemetry system using the new oscillator closely approaches the theoretical limits of pfm.

The data system used on IMP-D and slated for the others to follow, shown opposite, is similar to the system in the first three IMP craft except that the order of the pfm oscillator and commutator functions have been interchanged within the telemetry encoders. Although a pfm oscillator is used in this case, any type of channel encoder could be substituted (for instance, the pseudonoise pulse-code-modulation type). A channel encoder is any device that encodes data to combat noise in the communication channel.

Outside of channel encoding, everything the telemetry encoder does has been consolidated into the box labeled "commutator." Besides commutation, these functions include analog-to-digital conversion—necessary now that analog voltage-controlled oscillators are no longer used—accumulation of pulse data, and generation of synchronization pulses.

## Future IMP spacecraft

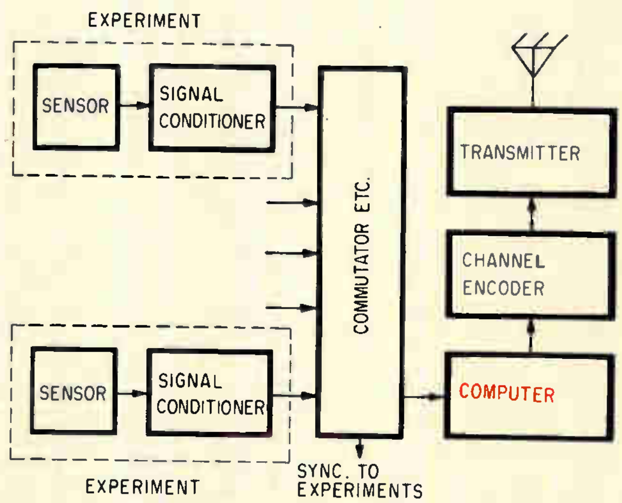
The next logical step in the improvement of the spacecraft data system is shown below. Again the block labeled "commutator," which also contains several other functions, has been moved to the left. Here the multiple data processors in the various experiments have been replaced by a single box labeled "computer." The channel encoder's only function is to prepare telemetry signals before transmission.

This basic configuration is proposed for future satellites. But there still is room for refinement. In a further improved data system using a centralized computers, shown on page 130, the two separate commutators perform the same function as the single one; they are identical except for their sources of synchronization.

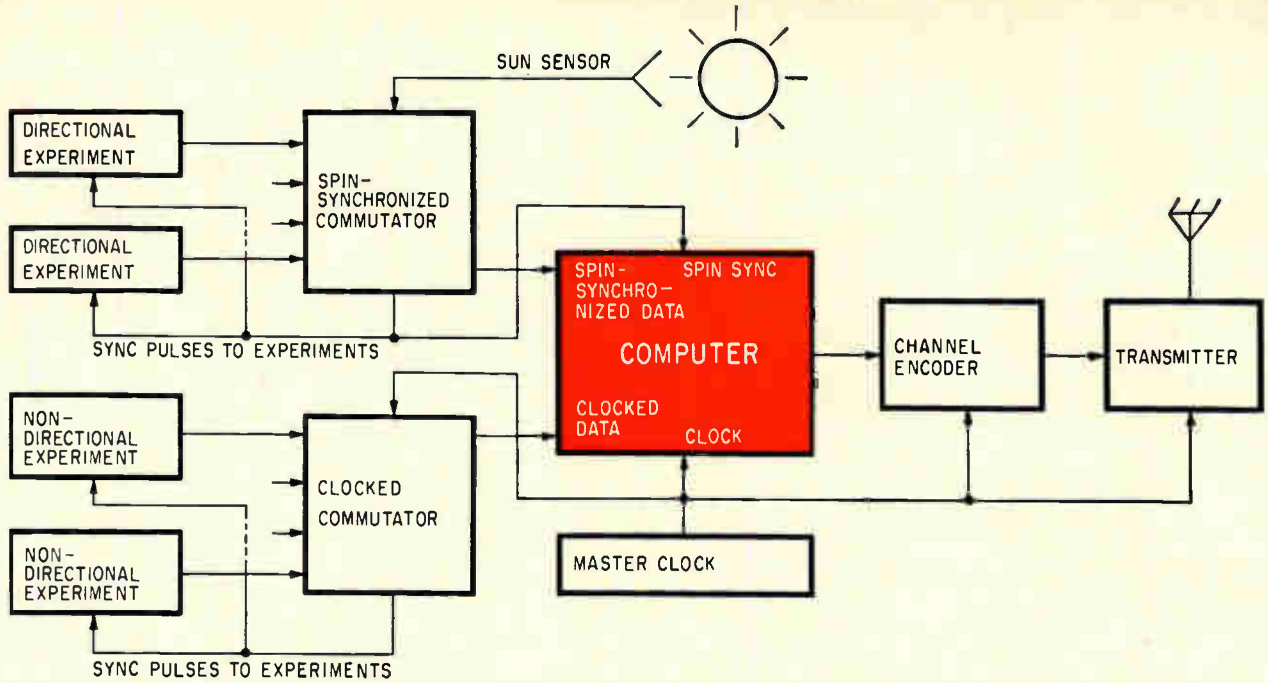
The clocked commutator, controlled by a fixed clock as usual, handles the data from experiments with nondirectional sensors, such as some micrometeorite detectors. It works in the same manner and has the same functions as the earlier commutators. Data from the clocked commutator goes to the computer for redundancy removal, data reduction and analysis, and formatting, before going on to the channel encoder.

The significant feature of this data system is the spin-synchronized commutator. Sun pulses from the optical aspect system do the synchronizing in each revolution of the spacecraft.

The system has many advantages for experiments with directional sensors, such as those measuring energetic particles. (Whether a given type of sensor is directional or nondirectional often depends on how the experiment is set up.) Such a sensor may accumulate data, say, only from 90° to 120° following a reference direction such as the line be-




A stored-program computer driven by the commutator can perform all the tasks required by the different experiments and make better use of the telemetry channel.




A computer driven by two commutators is still better scheme. One commutator is synchronized by a master clock and one is synchronized to the spacecraft spin rate.

tween the spacecraft and the sun. Currently, the sensor cannot accumulate any new data if the telemetry system hasn't yet read out data from the preceding revolution; the sensor sometimes remains idle for several revolutions before accumulating additional data. With a computer and its memory to serve as a buffer, data could be collected continuously even when the telemetry system lags behind in data transmission.

The system could also synchronize the operation of directional experiments for specific directions—toward the earth, moon, or sun, for example. The spin-synchronized encoder could complete one format for any given integral number of revolutions. For example, each of five directional experiments, all collecting large amounts of data during a single revolution, could utilize the full capability of the encoder and computer. In that case, five revolutions would be required to complete a format.

If the spin-synchronizing stimulus—in this case the sun—is lost, by eclipse, for instance, then the encoder should run free at its last synchronized rate before the stimulus was lost. Techniques for producing the synchronization characteristics have already been developed for the IMP series.[5]

A master clock would control all subsystems not spin-synchronized because a carrier-coherent telemetry system has better synchronization characteristics than a noncoherent system,[6] and because otherwise the computer would have to perform an unnecessary buffering function.

### The computer's characteristics

The vital characteristics of a multipurpose space computer of the type at top of page 131 are reliability, low power consumption, light weight and small size, in that order. Problem-solving power and flexibility are also important, but less so than in conventional computers.[7]

All power on a spacecraft comes from either batteries or solar cells, both of which are heavy. Heavier payloads cost more to launch, and high power drain can generate too much heat.

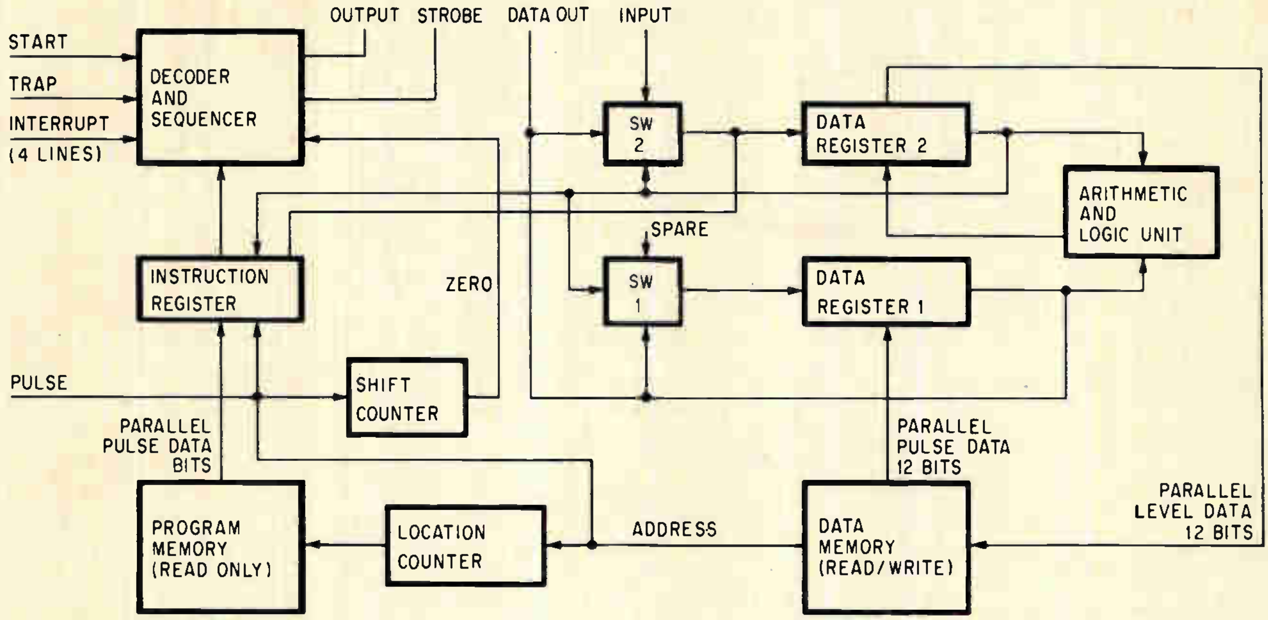
To keep the power drain down, the number of logic gates should be minimal. Many convenient features of ordinary computers—indirect addressing, index registers, floating-point hardware, and special instructions, for example—must therefore be eliminated. Lack of these features complicate the programing, though this isn't a serious drawback. Programing would be done infrequently and the data rate would be low enough to allow an inconvenient instruction set.

A suitable instruction set requires arithmetic and logical operations, data transfer operations, and control instructions. The number of instructions should be minimal.

Designing internal functions for serial operation can further reduce the number of gates.

The computer needs at least three one-word registers: one for the current instruction and two for the operands in such operations as addition. The choice of auxiliary functions for these registers can make for very simple data paths.

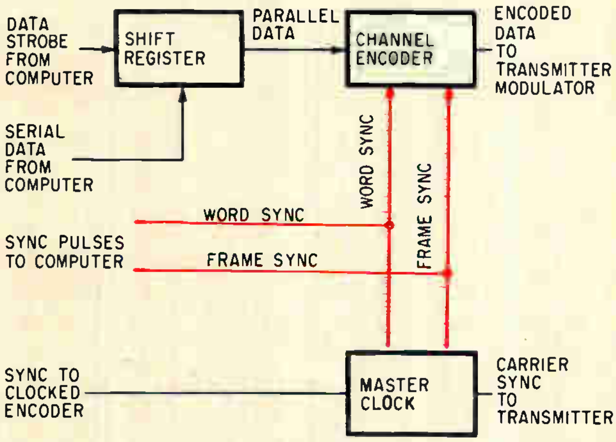
For highest reliability, the computer program must be protected from transient malfunctions. This is best with a read-only memory for the program and a read-write memory for data. The two-memory design also eliminates parallel gating of addresses and data otherwise required, and requires less power, at a small extra cost in components.




**Stored-program computer** for a small scientific spacecraft could process, compress, and buffer data from several experiments in preparation for telemetering. It is small, lightweight, reliable and consumes little power.

To reduce the number of gates, and consequently power drain, word length should be as short as possible, consistent with the ability to address any location in memory and to encode all operations in the instruction set. Twelve bits would probably be sufficient for this type of computer.

Because the computer's internal organization is serial and the encoder requires parallel data (diagram below), a shift register is needed to convert data from a serial to a parallel format. The register should be part of the channel encoder, because if it were in the computer, wiring would be necessary between the two units for each bit of parallel data. With the shift register in the channel encoder, only one data line and one strobe line are required in the interface, and the computer can be made compatible, through program changes, with spacecraft whose encoders have either more or fewer bits.




**Computer/encoder interface** contains a shift register for serial-to-parallel conversion, a word-sync line for relating word timing to the rf carrier, and a frame-sync line for identifying the various words.

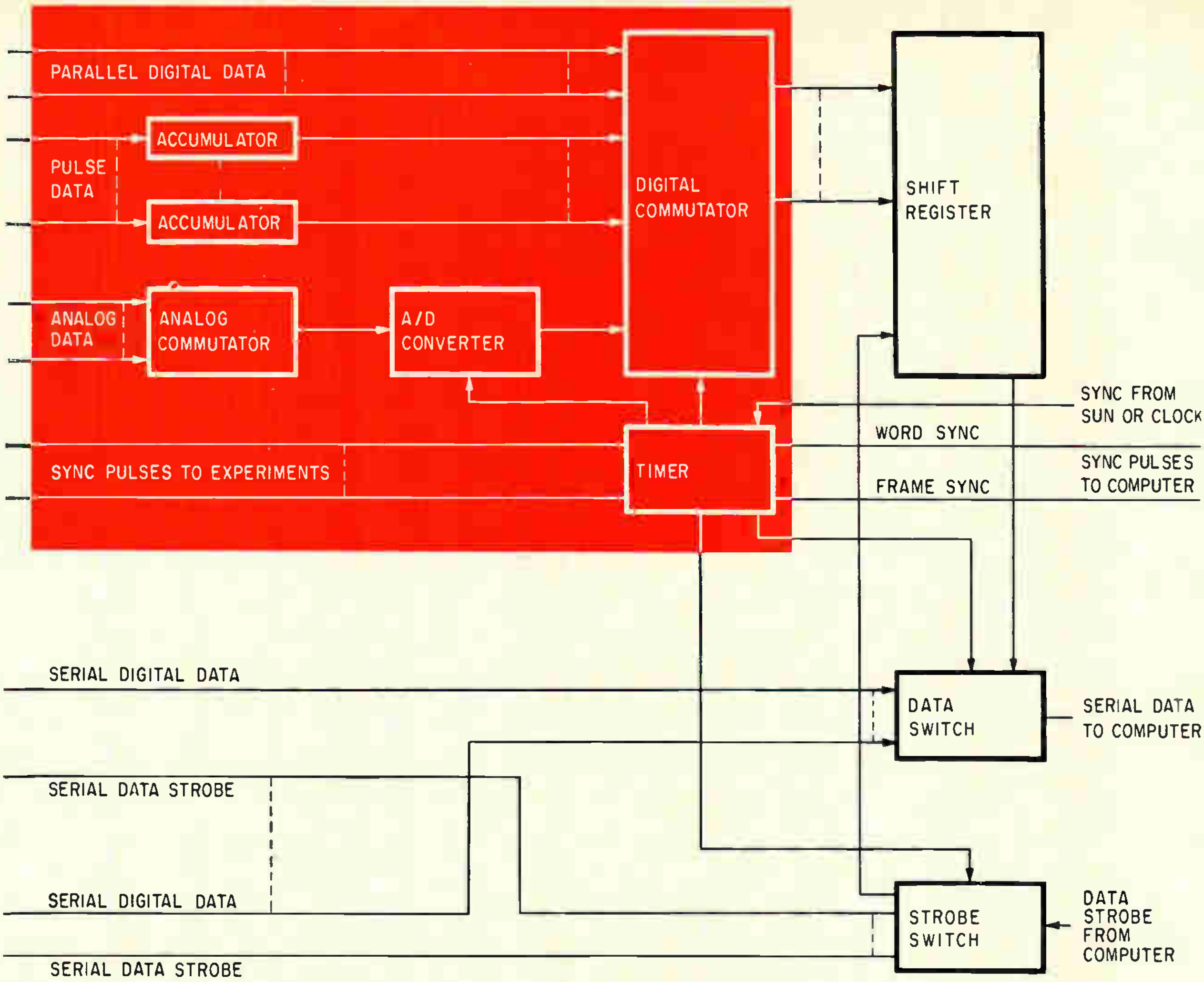
One word consists of all the bits that the channel encoder encodes at one time. Such a group of bits is often called a channel, though the meaning of the word here differs from its usage in "channel encoder" and "communications channel." In present pfm telemetry systems, one word is four bits. Increasing the word size will improve the theoretically attainable error rates at the expense of increased encoder and decoder complexity.[8]

The master clock generates both word and frame synchronization. Frame sync for the channel encoder could be generated by the computer from the channel sync, but if frame sync comes from the master clock, the channel encoder can continue to operate normally in the absence of the computer —for instance, when testing the spacecraft with the computer removed. This also makes catastrophic failure of the computer less likely during a mission. Frame sync from the master clock also keeps the computer synchronized with the channel encoder.

## Computer/commutator interface

In the diagram of the interface between the computer, and the two commutators on page 132, the usual commutator and related functions, similar to those now in spacecraft, are tinted. Added to these are the shift register, data switch, and strobe switch that make the commutator and the computer compatible. This shift register converts the parallel data output of the commutator into the serial data required by the computer. Including the shift register in the spacecraft, rather than in the computer, simplifies the interface.

Data is transferred from the commutator to the computer by strobe pulses fed through the strobe




**Computer/experiment interface** also has a shift register to convert parallel data into serial form. The tint outlines the commutator and related functions that are part of the conventional spacecraft equipment.

switch to the shift register. From there the data flows through the data switch to the computer. The strobe and data switches aren't required if all the data from the experiments passes through the commutator, but if serial information is produced in some experiments, it can be fed directly to the computer through these switches.

The accumulators, which count the pulses in their respective input data pulse trains, are usually included in the commutator rather than the experiment because only one wire is then needed to carry the data from experiment to commutator. These accumulators will still be used in computerized spacecraft, except, perhaps, when extremely slow counting rates can be handled directly by the computer.

The analog commutator, analog-to-digital converter, and the timer would perform the same tasks as they do in present spacecraft except that they would be in pairs, one of which in the computerized satellite would be synchronized to the spin rate rather than to a clock.

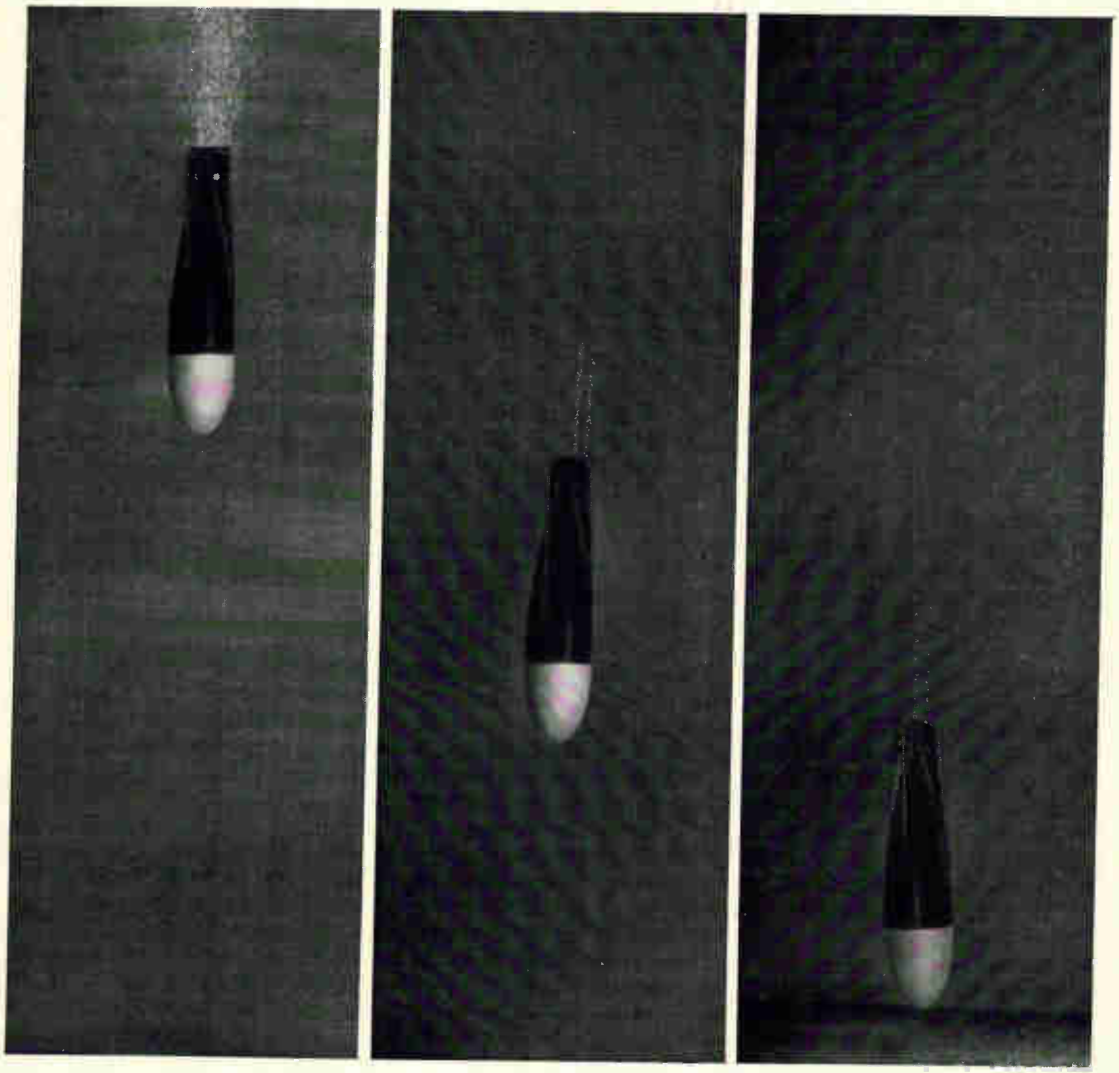
In present spacecraft the number of bits per word is the number of bits accepted at one time by the channel encoder. With a computer interposed between the commutator and the encoder, the best number of bits per encoder word would be the number per computer word.

The word sync and frame sync in the above diagram are generated in the spin-synchronized encoder's timing function. They signal the computer what data is available from the spin-synchronized encoder and when it is available.

## References


1. E.P. Stabler, "Telemetry Computer Studies," from "Final report of the Goddard summer workshop program in analysis of space data and measurement of space environments," NASA-GSFC Document X-100-65-407, 1965, p. A-1.
2. G.A. Gordon, "An Algorithmic Code for Monotonic Sources," op. cit., p. A-57.
3. R.W. Rochelle, 'Pulse-Frequency-Modulation Telemetry," NASA Technical Report R-189, January 1964.
4. Rodger A. Cliff, "Digital Oscillator," NASA-GSFC Invention Disclosure, 1963.
5. E.J. Pyle, "Aspect Determination System for the Super Interplanetary Monitoring Platforms," Master's thesis, University of Maryland, 1966.
6. T.V. Saliga, "Using carrier-coherent telemetering rates to improve synchronization," to be published.
7. Rodger A. Cliff, "A Stored-Program Computer for Small Scientific Spacecraft," NASA Technical Note TN-D-3640, October 1966.
8. J.P. Strong III and T.V. Saliga, "Comparison of Phase-Coherent and Non-Phase-Coherent Coded Communications," NASA Technical Note TN D3079, 1966.

# Parylene proves itself



# at 250 fathoms.

The Sippican Expendable Bathythermograph System accurately and rapidly measures and records the temperature of ocean waters down to depths of 1,500 feet. Heart of the system is an 8-inch probe, that carries, as its temperature-sensing element, a miniature-sized thermistor, shown on the left.

The protective coating for the thermistor had to be extremely thin (0.5 mil), yet had to be formed as a uniform, continuous, adherent layer, even around sharp corners.

Only BAKELITE parylene was able to meet these critical requirements and also provide the necessary dielectric and corrosion-preventing properties. The Sippican Corporation coated the thermistors under a parylene license from Union Carbide Corporation.

The ability of parylene to be vacuum-deposited in uniform micro-thin coatings is unmatched. True conformal coatings can be as thin as 0.002 mil or as thick as 3 mils or more... and they won't bridge, run, sag, bloom, blister, wrinkle or blush! As a conformal coating, parylene is a primary dielectric, an excellent moisture barrier, resists softening at high temperatures and its chemical resistance is outstanding.

With all of these special properties, parylene is recommended as conformal coatings on discrete components or high density circuity, for fast responding sensing probes, photo-cells or memory units.

This plastic is already used as ultra-thin pellicles for such applications as beam splitters in optical instruments and windows for nuclear radiation measuring devices.

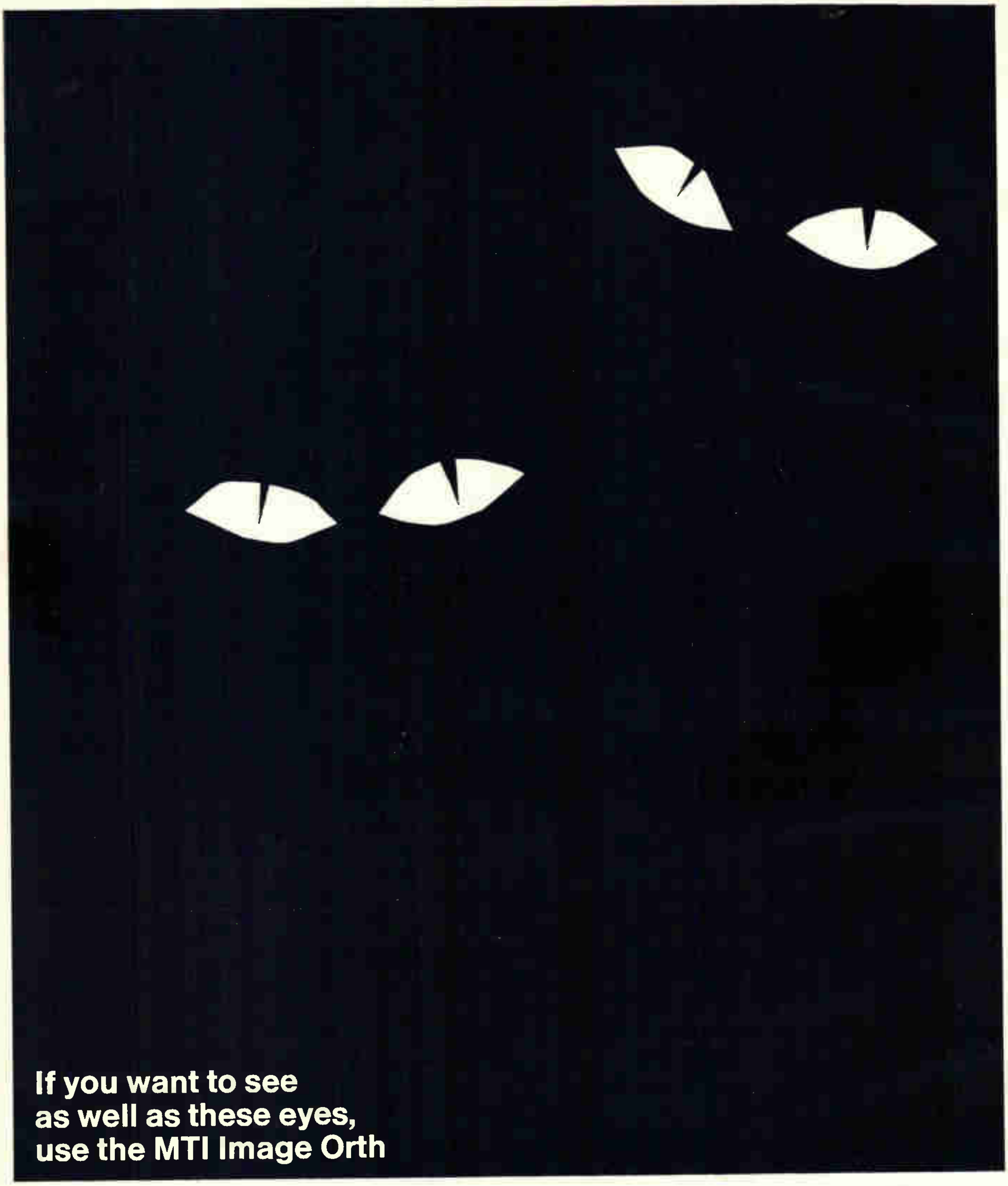
Thin coatings of BAKELITE parylene can even be used to increase the over-all heat transfer coefficient of desalination condenser tubes by promoting dropwise condensation.

Possibly your product could benefit from this new plastic. For more information, write to Dept. E-3, Union Carbide Corporation, Plastics Division, 270 Park Avenue, New York, N. Y. 10017.

UNION CARBIDE

PLASTICS

BAKELITE is a registered trade mark of Union Carbide Corporation.




Nocturnal animals see well in the dark. MTI Image Orthicon television cameras see almost as well.

We're specialists in low light level television equipment. In fact, the largest manufacturer in the world. And our equipment will pick up an image in near total darkness. A pin hole of light is more than enough. Or more specifically, at $1 \times 10^{-5}$ foot candles of ambient light (approaching total darkness).

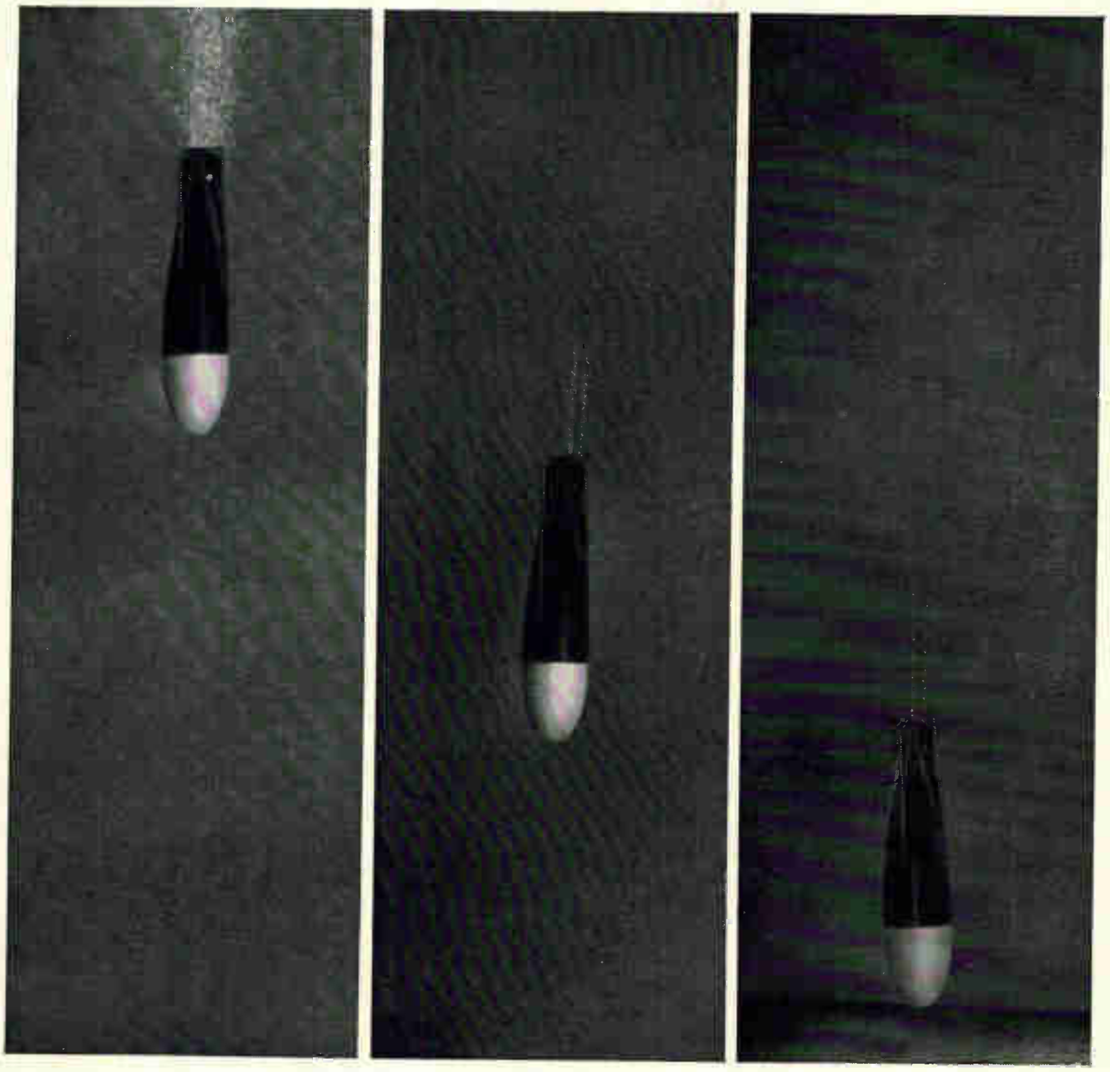
This is but one research application. The possibilities in all fields are endless, as research is discovering every day. If you have need — call us. We'll be there to help . . . quickly with quality.

**mti MARYLAND TELECOMMUNICATIONS, INC.**

York & Video Roads, Cockeysville, Md. 301-666-2727 World's largest manufacturer of low light level television cameras.

Circle 136 on reader service card

# Parylene proves itself



# at 250 fathoms.

The Sippican Expendable Bathythermograph System accurately and rapidly measures and records the temperature of ocean waters down to depths of 1,500 feet. Heart of the system is an 8-inch probe, that carries, as its temperature-sensing element, a miniature-sized thermistor, shown on the left.

The protective coating for the thermistor had to be extremely thin (0.5 mil), yet had to be formed as a uniform, continuous, adherent layer, even around sharp corners.

Only BAKELITE parylene was able to meet these critical requirements and also provide the necessary dielectric and corrosion-preventing properties. The Sippican Corporation coated the thermistors under a parylene license from Union Carbide Corporation.

The ability of parylene to be vacuum-deposited in uniform micro-thin coatings is unmatched. True conformal coatings can be as thin as 0.002 mil or as thick as 3 mils or more . . . and they won't bridge, run, sag, bloom, blister, wrinkle or blush! As a conformal coating, parylene is a primary dielectric, an excellent moisture barrier, resists softening at high temperatures and its chemical resistance is outstanding.

With all of these special properties, parylene is recommended as conformal coatings on discrete components or high density circuity, for fast responding sensing probes, photo-cells or memory units.

This plastic is already used as ultra-thin pellicles for such applications as beam splitters in optical instruments and windows for nuclear radiation measuring devices.

Thin coatings of BAKELITE parylene can even be used to increase the over-all heat transfer coefficient of desalination condenser tubes by promoting dropwise condensation.

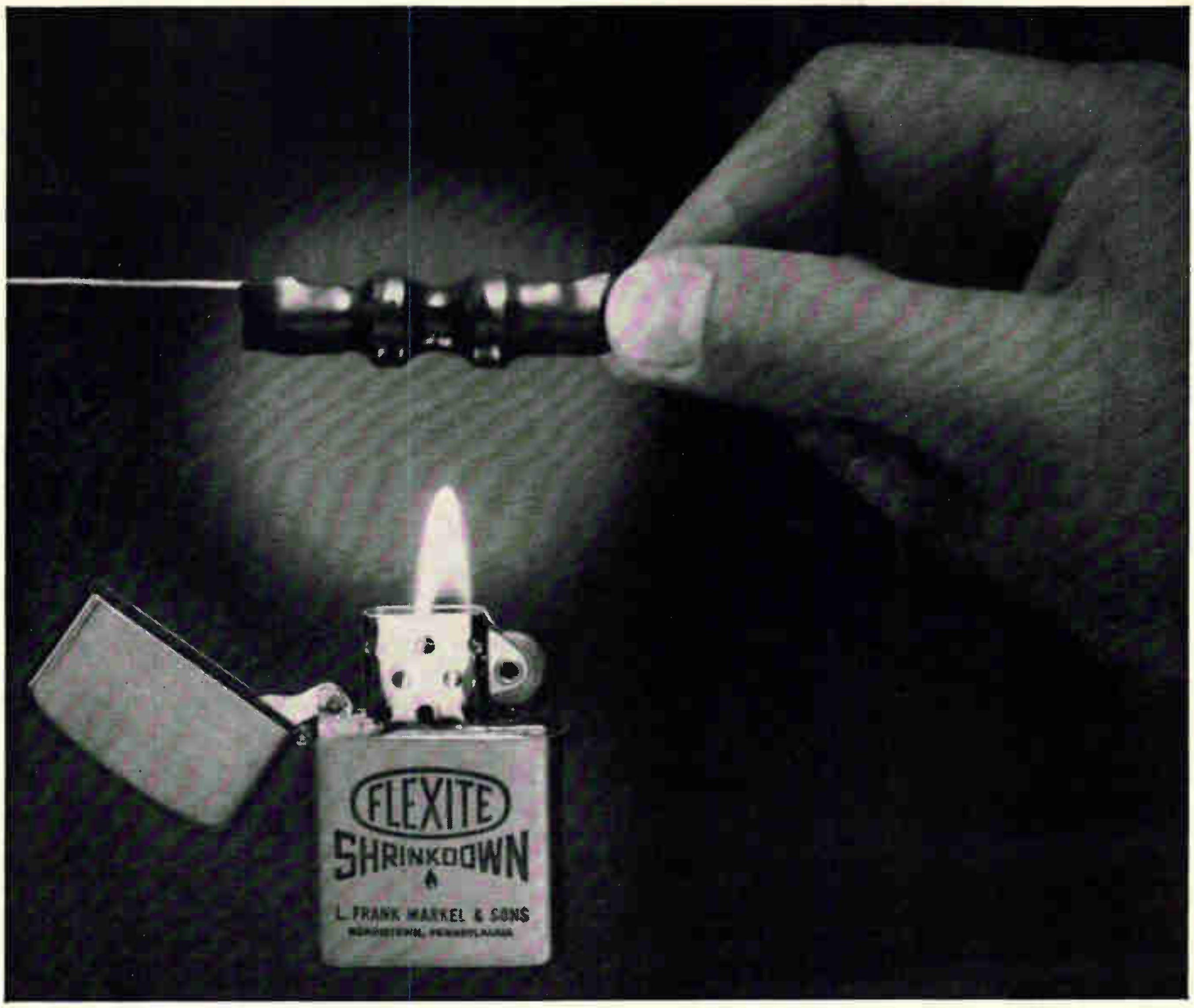
Possibly your product could benefit from this new plastic. For more information, write to Dept. E-3, Union Carbide Corporation, Plastics Division, 270 Park Avenue, New York, N. Y. 10017.

UNION CARBIDE
PLASTICS

BAKELITE is a registered trade mark of Union Carbide Corporation.



Circle 133 on reader service card




# Ingenious uses for a **hot idea!**

You design engineers are coming up with all sorts of ingenious uses for Flexite Shrinkdown plastic tubing.

Three years ago, Markel Shrinkdown was introduced as a better, more easily applied insulation for electrical components, connections and assemblies of irregular shapes. It still is . . . only more so!

But new uses, in countless applications, are being discovered every day. For instance: to bind things together—add strength and rigidity—seal against leaks—identify wires and parts—protect against abrasion, wear and breakage—resist corrosion, heat and moisture—keep out dirt, water, grease and chemicals—cover rough or sharp protrusions—prevent vibration—reduce noise—improve appearance—and so on ad infinitum.

Put your ingenuity to work. See where a skin-tight sheath of tough, flexible, heat-resistant plastic would improve performance, prolong life or cut the cost of your products.

There are four types of Shrinkdown to meet your requirements. One is of Teflon*, for use at temperatures up to 250°C. Two have shrinking temperatures under 200°F for use where higher heat would injure components. All have excellent electrical characteristics . . . meet military and commercial specifications. All shrink 50% in diameter—less than 10% in length.

To stimulate your thinking, we'll be glad to send you our "Hot Idea" experimental sample kit of Markel Flexite Shrinkdown Tubings. No cost—no obligation—just write.

*DuPont Trademark

MARKEL
SINCE 1922

**L. FRANK MARKEL & SONS**
Norristown, Pa. 19404 • Phone: 215/272-8960
**INSULATING TUBINGS AND SLEEVINGS**
**HIGH TEMPERATURE WIRE AND CABLE**



Circle 135 on reader service card→

*Model CFI-3*
*Transistorized Microwave RI/FI Meter*

*Model TR-3*
*Transistorized Microwave Receiver*

# *Third Lap ...and still miles ahead*

## These Modern Classics are now in their third generation.

For many years, the CFI and TR were the *only* transistorized, truly portable microwave receivers and RI/FI meters. They are still the best, by far. Why? For many reasons. Consider, for example:

- a *decade* of field experience... since the first CFI/TR was introduced in 1956.
- *dozens* of design improvements
- *three generations* of design refinement
- *unequalled* calibration stability and longevity
- Polarad's unique manufacturing and applications-engineering experience

Check the specification highlights given here. Then send for the full data on these rugged, thoroughly dependable, highly polished "instrumentation classics". Better yet, call PEI Sales at (212) EX 2-4500, and arrange for a prompt demonstration... *from stock.*

### *Specification Highlights*
### Model TR-3
### 0.95-21.0 GHz

Portable, compact, ruggedized, versatile, AM/FM/CW/MCW/PULSE

- AFC, AGC circuits
- Digital frequency dial
- Unidial® Tuning
- Output calibrated directly in db.
- Preselection on all tuning units

6 Plug-in Tuning Units Cover 0.95-21.0 GHz

Min. Sensitivity Ranges from —90 to —77 dbm (1 MHz BW)

Impulse bandwidth: 1 MHz, 5 MHz, wideband

Linearity: ±1 db over 70 db range

Meter Scales: μv, db above 1 μv/MHz, db above 1 μv/5 MHz, 0-70 db relative, 0-10 linear relative

Outputs: audio, AM/FM video, recorder

Image Rejection: 60 db minimum

12V DC or 115V/230V AC line operation

### *Specification Highlights*
### Model CFI-3
### 1.0-21.0 GHz

Full category A Air Force Approval per MIL-I-26600, MIL-1-6181 and MIL-STD826 to 10 GHz

Portable, compact, ruggedized. Combines an impulse calibrator, field-intensity meter, and calibrated antenna system.

Provides accurate measurements of frequency and absolute power level of conducted or radiated microwave energy.

UNIDIAL® tuning; direct-reading digital dial; ±1% frequency accuracy; output level direct-reading in db... no calculations or correction charts!

Calibrated AM, FM, CW, MCW, and Pulse Receiver; calibrated impulse Gen.; calibrated antenna system.

6 Plug-In Tuning Units Cover 1.0-21.0 GHz

Min. Sens. —90 to —77 dbm (1 MHz BW)

KS and KU band units have self-contained impulse calibrators

Maximum RF input: 3v

Image Rejection: 60 db

Impulse bandwidth: 1 MHz, 5 MHz, wideband

Signal Attenuation: 0-80 db in 1 db steps

Calibrating Signal: Impulse, 1 MHz to 21 GHz

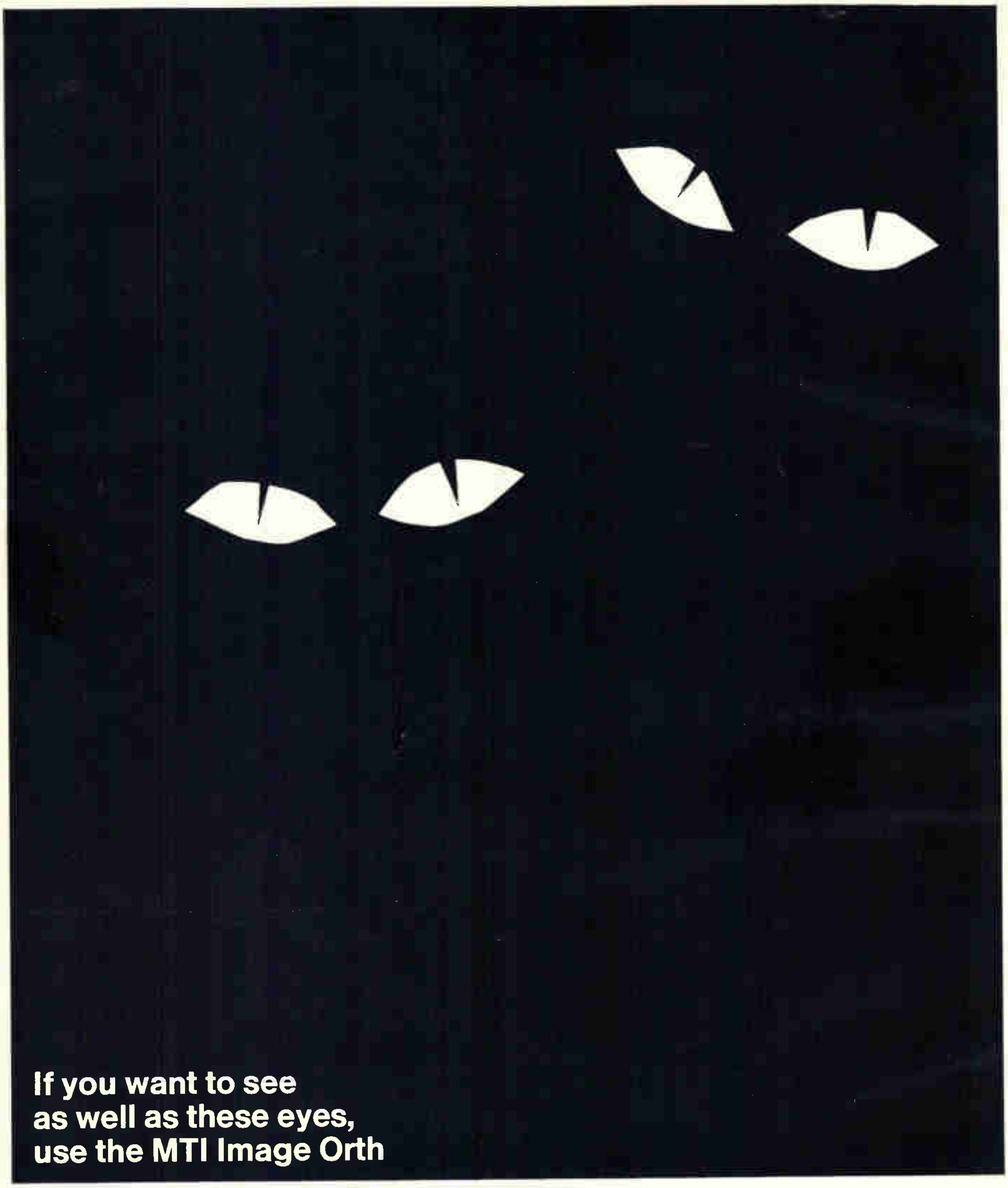
Meter Scales: μv, db above 1 μv/MHz, db above 1 μv/5 MHz, 0-70 db relative, 0-10 linear relative

Outputs: audio, AM/FM video, recorder

12V DC or 115V/230V AC line operation

POLARAD

**POLARAD ELECTRONIC INSTRUMENTS**
A Division of Polarad Electronics Corporation
34-02 Queens Boulevard/Long Island City, New York 11101
*World Leader in Microwave Instrumentation*




Nocturnal animals see well in the dark. MTI Image Orthicon television cameras see almost as well.

We're specialists in low light level television equipment. In fact, the largest manufacturer in the world. And our equipment will pick up an image in near total darkness. A pin hole of light is more than enough. Or more specifically, at $1 \times 10^{-5}$ foot candles of ambient light (approaching total darkness).

This is but one research application. The possibilities in all fields are endless, as research is discovering every day. If you have need — call us. We'll be there to help . . . quickly with quality.

**mti MARYLAND TELECOMMUNICATIONS, INC.**

York & Video Roads, Cockeysville, Md. 301-666-2727 World's largest manufacturer of low light level television cameras.

The Switch to IC's

# 1+1=10

In Application Note No. 8 we described the five basic building blocks of digital logic: flip-flops, inverters, AND gates, OR gates, and delays. Now let's see how these blocks are assembled into larger units to perform desired functions.

**BINARY ARITHMETIC:** Digital circuits use the binary system of counting because there are only two digits involved (1 and 0) and these are easily represented electrically. Table 1 shows the numbers 0-16 as they look in decimal and in binary, and some examples to illustrate that binary arithmetic follows the same rules you learned in school for decimal. Digital circuits simply give these rules electrical form.

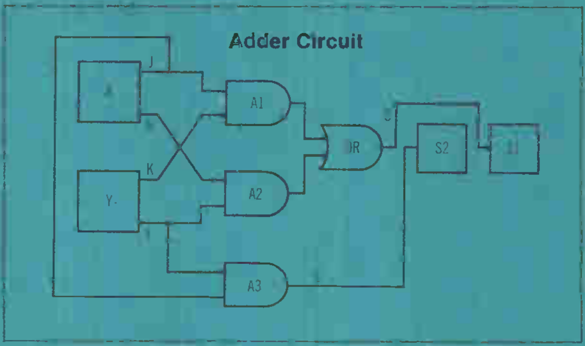
**TABLE 1**

| Decimal | Binary |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 10 |
| 3 | 11 |
| 4 | 100 |
| 5 | 101 |
| 6 | 110 |
| 7 | 111 |
| 8 | 1000 |
| 9 | 1001 |
| 10 | 1010 |
| 11 | 1011 |
| 12 | 1100 |
| 13 | 1101 |
| 14 | 1110 |
| 15 | 1111 |
| 16 | 10000 |
| etc. | etc. |

| Binary | Decimal |
|---|---|
| $100 + 101 = 1001$ | $4 + 5 = 9$ |
| $1001 - 11 = 110$ | $9 - 3 = 6$ |
| $100 \times 100 = 10000$ | $4 \times 4 = 16$ |
| $\frac{1000}{10} = 100$ | $\frac{8}{2} = 4$ |

**ADDER CIRCUIT:** Let's take a simple example and add two binary digits (bits for short) to arrive at their sum. Since we are dealing with binary digits, there are only four possibilities. When both digits are zero the sum obviously is zero. If either digit equals 1, the sum will be 1. And if both digits equal 1, the result will be 10, or 0 and 1 to carry over to the next binary position.

The diagram shows how this is implemented in hardware: X and Y are two flip-flops. Their outputs are fed into a pair of AND gates A1 and A2, so that each gate receives the J output of one flip-flop and the K output of the other. (You will recall that when the J output of a flip-flop is high, its K output is low, and when its K output is high the J ouput is low. Here we will consider the high J output to indicate that the flip-flop is in the "1" state, and a high K output to indicate that it is in the "0" state.) The output of both AND gates is fed into an OR gate. (You will also recall that an AND gate requires *all* inputs to be high to produce a high output, whereas an OR gate will produce a high output from *any* high input.) The output of the OR gate is the least significant bit of our sum and is connected to the SET input of flip-flop S1. The most significant bit of the sum, which is the carry-over bit, is handled separately by connecting the J outputs of X and Y to the inputs of a third AND gate A3, and connecting the output of A3 to the SET input of the S2 flip-flop. In our example, the results of the addition are




therefore stored in the sum register S1, S2. We could, of course, do a variety of other things with the results: display them, store them in core memory, drive an output line to a typewriter, card punch, or tape deck, etc. To simplify the diagram, we have excluded a third input to each of the three AND gates. This input would represent the "Add" command. What happens when the "Add" command triggers the circuit? If both X and Y are zero, nothing happens. If X=0 and Y=1, the AND gate A2 receives a high input from the J output of the Y flip-flop, and another high input from the K output of the X flip-flop. Consequently it will have a high output, triggering the OR gate, and setting S1=1. AND gate A3, on the other hand, receives a high input from Y, but a low input from X. Hence its output remains low and S2 remains 0 (0 + 1 = 1). The next case, X=1, Y=0, is identical, except that AND gate A1 gets the two high inputs and triggers the OR gate. The results are the same. Finally, when X=1, Y=1 A1 gets a high input from the X flip-flop, but a low input from the Y flip-flop; A2 gets a high input from Y, but a low input from X. Neither AND gate produces a high output and the output of the OR gate remains low (S1=0). A3, however, gets a high input from X and a high input from Y and generates a high output, setting S2=1, which corresponds to the arithmetic result we are seeking (1 + 1 = 10). Table 2 summarizes the four cases.

**TABLE 2**

| Case | A1 | A2 | OR | S1 | A3 | S2 | Sum |
|---|---|---|---|---|---|---|---|
| X=0, Y=0 | 0 | 0 | 0 | 0 | 0 | 0 | 00 |
| X=0, Y=1 | 0 | 1 | 1 | 1 | 0 | 0 | 01 |
| X=1, Y=0 | 1 | 0 | 1 | 1 | 0 | 0 | 01 |
| X=1, Y=1 | 0 | 0 | 0 | 0 | 1 | 1 | 10 |

**ADDING COMPLEXITY:** This adder circuit for adding two bits is in itself a building block: to add larger numbers you simply repeat the circuit for as many bits as you need. Many of today's large computers have registers of 36 bits, and you would have to repeat the circuit 36 times to add two of them together. You can begin to understand, then, why integrated circuits revolutionized the computer industry: implemented with discrete components, the circuitry would be massive, and expensive to assemble, check out and maintain. With integrated circuits it is almost as simple to build as to draw on paper: each of the components shown is available in integrated form, and some of today's integrated circuits perform complete functions such as counting or shifting, on a single silicon chip.

For additional integrated circuit applications circle Reader Service Number 480.

# Integrated Memory Logic

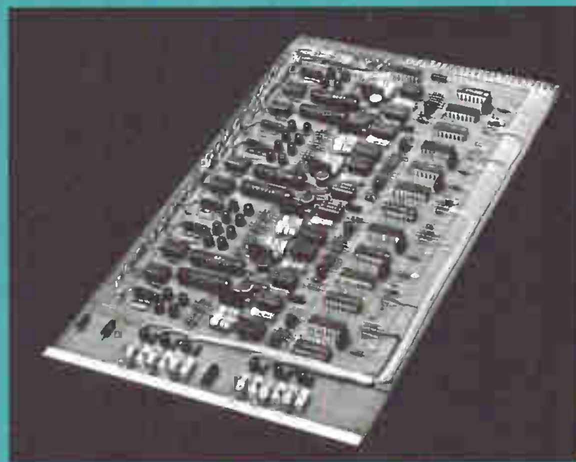
Computer memories are essentially arrays of magnetic cores, each core representing a single bit of information. The memory associated logic has the task of locating the single right core in the array, and either storing or retrieving information from it. Since most core memories have a destructive readout (the information stored in the core is erased as it is retrieved), the logic must also regenerate the same information and re-store it in the core. In modern computers all of this must be reliably accomplished at sub-microsecond speeds and at the least possible cost. The memory designer must also consider the size of his components: the more room is taken up by the logic circuitry, the less there is left for core storage.

Reliability, speed, small size and optimum cost were the design objectives of Standard Memories, Inc., of Santa Ana, California, for their new series of core memories. Named MICRA-STOR® (Magnetic Integrated Circuit Random Access STORe) memories, the new line is implemented with Fairchild Diode-Transistor Micrologic® integrated circuits (DTμL).

**DESCRIPTION:** The general logic organization is shown in the block diagram. Two registers, implemented with 9948 clocked flip-flops, are used to hold the address and the data to be entered or retrieved from memory. The contents of the address register are split up between the X drivers and the Y drivers which locate the word to be accessed.

During a "write" operation, the contents of the data register are transferred into the Z drivers and written into the accessed word. During a "read" operation, the accessed word is read through the sense amplifiers into the data register; from there it is simultaneously transmitted to the data output lines and to the Z drivers which restore it in memory. The X, Y and Z drivers are implemented with Fairchild 9932 buffers. The input logic is implemented with 9946 quad gates.

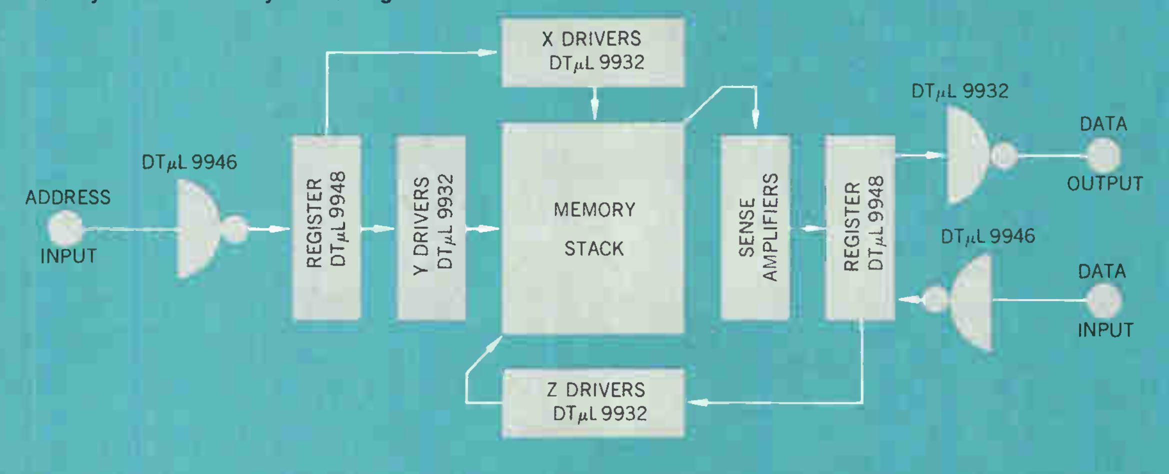
**MEMORY DESCRIPTION:** By using integrated circuits, Standard Memories achieved many attractive features in its MICRA-STOR series, including a reduction in panel height from 21" to 7" for a complete memory unit. The memory is offered in various sizes ranging from 256 words to a maximum of 16,384 words, with word sizes ranging from 6 to 36 bits. The memory has an access time of 800nsec. and a full cycle time of 1.75μsec. It is completely modular and mounts in a standard EIA (RETMA) relay rack.



Micra-STOR Circuit Board


Micra-STOR Memory Unit

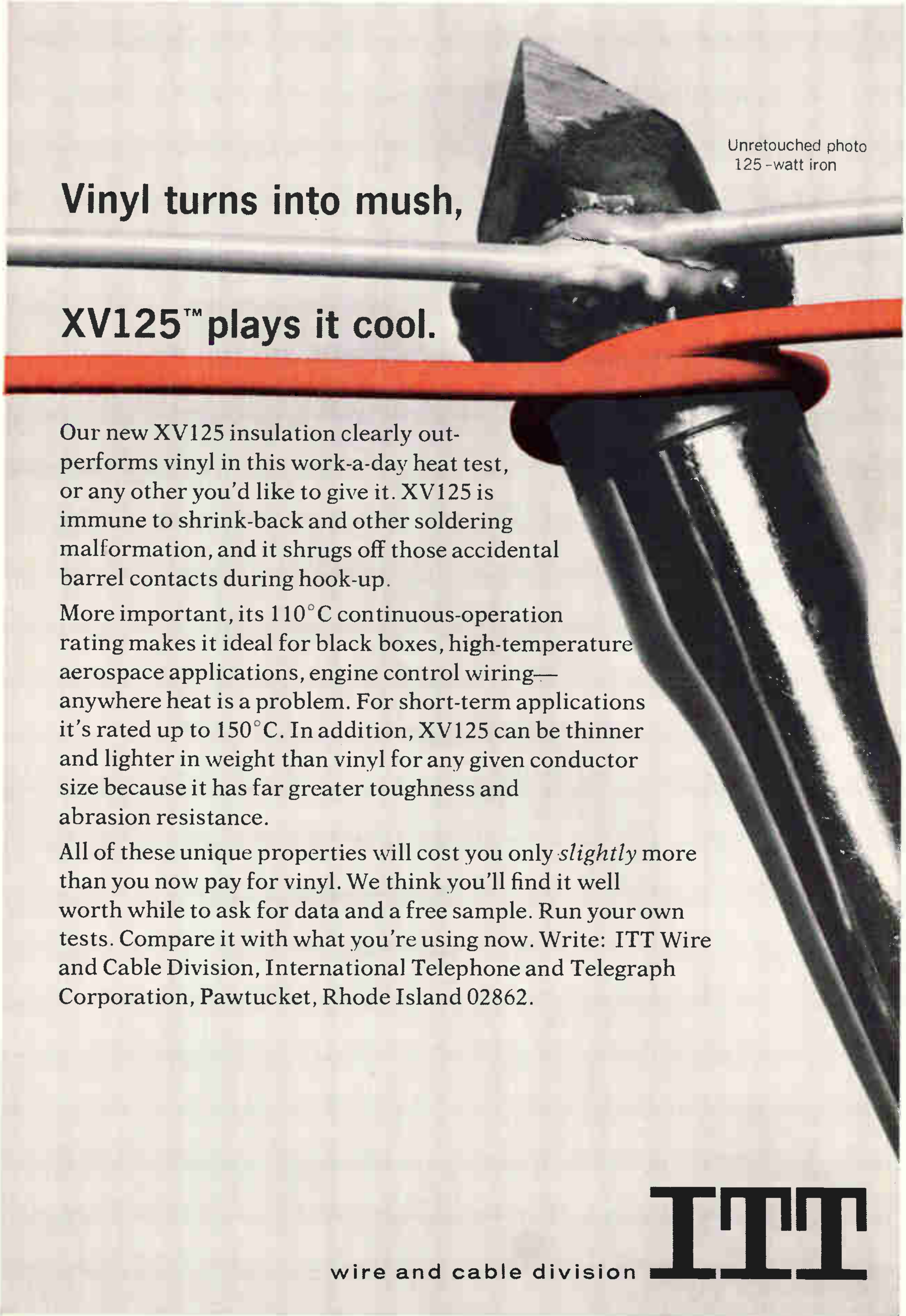
**Memory Control Circuitry Block Diagram**




FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR / A Division of Fairchild Camera and Instrument Corporation ■ 313 Fairchild Drive, Mountain View, California 94040, (415) 962-5011 ■ TWX. 910 379 6435

For additional integrated circuit applications circle Reader Service Number 480.

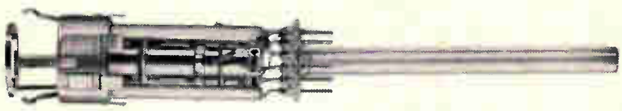

Unretouched photo
125-watt iron
Vinyl turns into mush,
XV125™ plays it cool.
Our new XV125 insulation clearly outperforms vinyl in this work-a-day heat test, or any other you'd like to give it. XV125 is immune to shrink-back and other soldering malformation, and it shrugs off those accidental barrel contacts during hook-up.
More important, its 110°C continuous-operation rating makes it ideal for black boxes, high-temperature aerospace applications, engine control wiring—anywhere heat is a problem. For short-term applications it's rated up to 150°C. In addition, XV125 can be thinner and lighter in weight than vinyl for any given conductor size because it has far greater toughness and abrasion resistance.
All of these unique properties will cost you only *slightly* more than you now pay for vinyl. We think you'll find it well worth while to ask for data and a free sample. Run your own tests. Compare it with what you're using now. Write: ITT Wire and Cable Division, International Telephone and Telegraph Corporation, Pawtucket, Rhode Island 02862.
wire and cable division
ITT

# Convergence Drift Minimized with Hitachi's Shielded Lens Electron Guns*

One of the main problems in the color TV industry has been the convergence of color images due to "drift". Hitachi's engineers have traced the main cause of convergence drift to the considerable electric charge (due to the high voltages required for color TV tubes) which accumulates on the inner wall of the tube neck. This electric charge results in distortion in the main lens formed by the third and fourth grids. Furthermore, the charge fluctuates from time to time causing convergence drift between the three colors (red, green and blue).

Hitachi has overcome the effects of the accumulated electric charge with their revolutionary shielded lens electron guns, keeping the electron beam steady — maximum convergence drift observed in actual use amounted to a mere 0.5 mm (one fourth of that experienced with conventional electron guns) which is negligible in TV reception. Hitachi's shielded lens electron guns, with rare-earth red phosphor, make possible steady, attractive color TV pictures. Find out more about them by contacting Hitachi, Ltd. **U.S.A. and Japanese patents applied for.*

Shielded lens electron gun



Ordinary type electron gun

## ELECTRICAL DATA

| | |
|---|---|
| Electron Guns, Three with Axes Tilted Toward Tube Axis | Red, Blue, Green |
| Heater Voltage | 6.3 V |
| Heater Current | 0.9 A |

## OPTICAL DATA

| | | |
|---|---|---|
| Screen, on Inner Surface of Faceplate: | Type | Aluminized, Tricolor, Phosphor-Dot |
| | Phosphor (Three Separate Phosphors, Collectively) | P22-Rare-Earth (Red), Sulfide (Blue, Green) Type |

## MECHANICAL DATA

| | | |
|---|---|---|
| Tube Dimensions: | Over-all Length | 445.0±10.0 mm |
| | Neck Length | 163.0± 5.0 mm |
| | Diagonal | 494.5± 3.0 mm |
| | Greatest Width | 433.0± 3.0 mm |
| | Greatest Height | 349.8± 3.0 mm |
| Minimum Screen Dimensions (Projected): | Diagonal | 448.0 mm |
| | Greatest Width | 383.0 mm |
| | Greatest Height | 296.0 mm |
| Weight (Approx.) | 10 kgs. | |

HITACHI COLOR PICTURE TUBE 490LB22
19″ rectangular (viewable diagonal 18″) glass picture tube with 90° deflection and 36.5 mm neck diameter.

**HITACHI**
Hitachi, Ltd. Tokyo Japan

HITACHI SALES CORPORATION: 333 N. Michigan Avenue, Chicago, Ill. 60601, U.S.A. Tel: 726-4572/4 / 666, 5th Avenue, New York, N.Y. 10019, U.S.A. Tel: 581-8844 / HITACHI, LTD., DUESSELDORF OFFICE: 4, Duesseldorf, Graf Adolf Strasse 37, West Germany Tel: 10846



Circle 141 on reader service card→

# A new kind of Leak Detector by Veeco— the fast, high sensitivity MS-12 Split Sector.

## See it at the IEEE show

**New York Coliseum, March 20 through 23**

Also visit our special on-floor Vacuum Applications Clinic. This is an unusual opportunity for you to meet with vacuum and leak detection specialists for informal technical discussions.

This 16′ x 20′ room is located in the Veeco Area—Booth 2A46 and adjacent space—which occupies the entire NW corner of the second floor.

*Veeco, the leader in leak detection for over twenty years, announces an important new advance—the MS-12 Split Sector Mass Spectrometer Leak Detector. The Split Sector is a new type of mass spectrometer tube used in the MS-12. It sequentially eliminates background and scattering in two stages of deflection. The increased helium signal-to-noise ratio results in higher sensitivity and faster pumping speeds, both at the same time. There are also many other new and unique features of self-protection, reliability, and maintainability that you will want, all in the smallest self-contained fully automatic system you can buy. Call or write for a descriptive brochure now.*

*Look at these features:*

- *$5 \times 10^{-12}$ atm cc/sec Minimum Detectable Leak at full pumping speed, and the pumping speed is* ***fast****.*
- *Direct readout in cc/sec.*
- *Exclusive new Vacguard protects system against atmospheric burst, virtually eliminates "catastrophic failure".*
- *Completely modular electronics; pull-out circuit board construction.*
- *Modular vacuum system; entire vacuum system lifts out on its own subframe; mech. pump subframe.*
- *Capable of detecting one part helium in 100,000,000 parts of air.*
- *Dual filament ion source.*
- *Self-cleaning internally baked out ion source.*

*Available in three models:*

- *MS-12AB-1 Bench model is the smallest fully automatic self-protected high-sensitivity leak detector available; 26″ w x 22″ h x 18″ d.*
- *MS-12AB-R Roll-around model offers compact mobility.*
- *MS-12AB-P "Sit-down" Production model (shown) is the most functional and reliable production leak detector available.*

Veeco® INSTRUMENTS INC. TERMINAL DRIVE, PLAINVIEW, NEW YORK 11803 • PHONE: 516-681-8300

# Here's how to get more cooling with less size and weight:

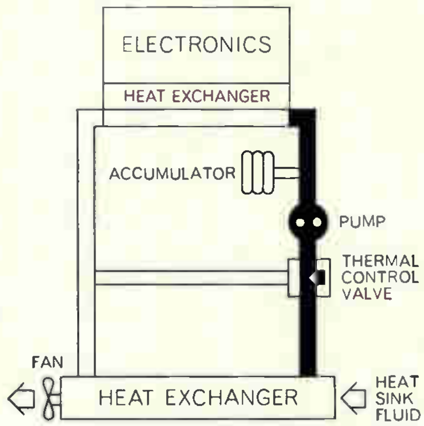
# Use Garrett-AiResearch "ICE".

The Garrett-AiResearch systems approach to "black box" cooling is called Integrated Cooling for Electronics ("ICE"). It can save you development dollars, cut system weight, and reduce circuit enclosure size.

Simply give us your circuit design heat transfer problem and we'll do the rest: trade-off studies, interface details, heat transfer system design, and manufacturing.

You'll get an optimized system with minimum power consumption for maximum cooling, and a compact, lightweight chassis with an integral or separate heat transport loop or heat pump.

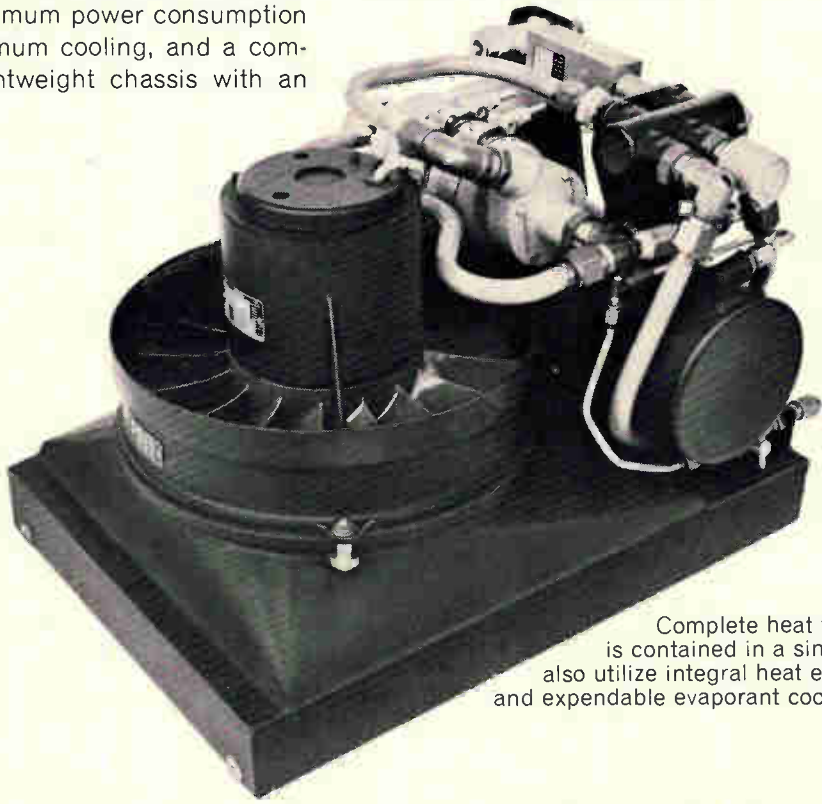
If you're developing electronics circuits for space vehicles, weapons systems, aircraft or ground communications, or other critical applications, call in AiResearch while your package is being conceived; we'll work with you to match an "ICE" system to your specific needs. Contact AiResearch Manufacturing Company, 9851 Sepulveda Blvd., Los Angeles, California 90009.



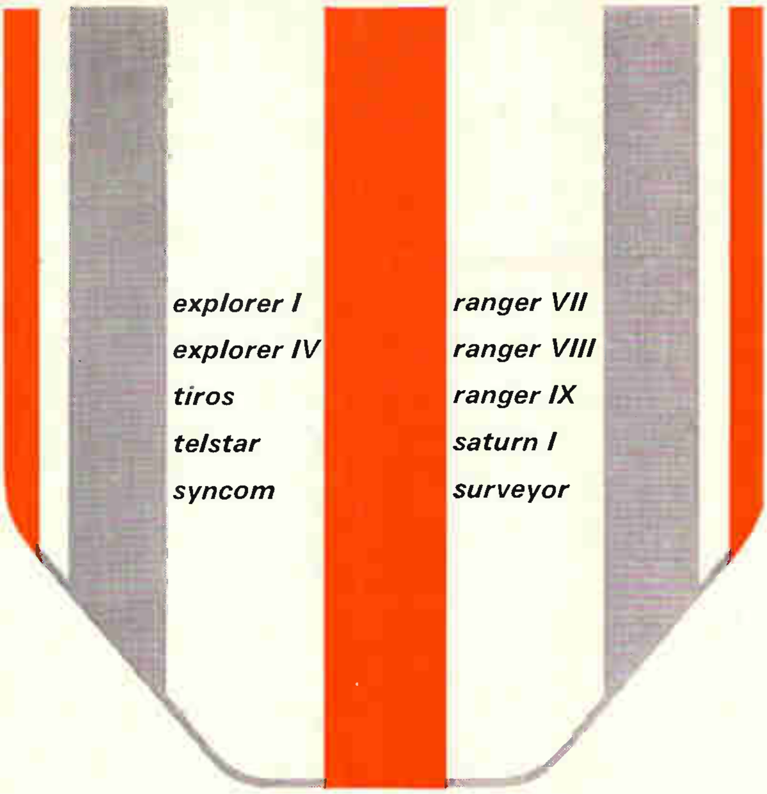

TYPICAL "ICE" SYSTEM SCHEMATIC

This AiResearch "ICE" system includes both the heat transport system and electronics enclosure with integrated heat exchanger.

**AiResearch Heat Transfer Systems**



Complete heat transport system (left) is contained in a single, compact unit. We can also utilize integral heat exchangers, heat pumps, and expendable evaporant cooling methods.

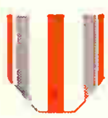



# the most honored resistor in the Space Program

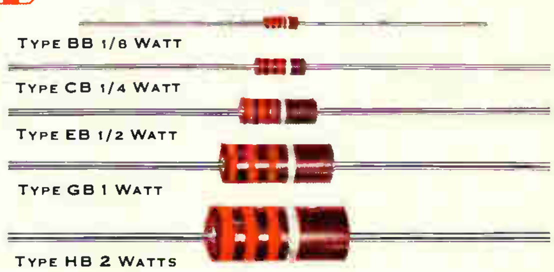
■ Allen-Bradley hot molded resistors were chosen to participate in these many history-making space projects for only one vital reason—a history of proven performance that dates back for more than a quarter of a century! A record more conclusive than any testing program could possibly provide!

The superiority of Allen-Bradley resistors is found in the exclusive hot molding process. Through the use of completely automatic machines—developed and used *only* by Allen-Bradley—there is obtained such uniformity of characteristics from resistor to resistor, year after year, that the resistors' long term performance can be accurately predicted. Furthermore, no Allen-Bradley hot molded resistor has ever been found to have failed catastrophically.

The widespread use of the Allen-Bradley hot molded resistors in these space programs should convince you that to include this plus value in the equipment which you produce gives it the mark of "extra quality." Let us tell you more about the complete line of Allen-Bradley electronic components. Please write for Publication 6024. Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., N.Y., N.Y., U.S.A. 10017.



HOT MOLDED FIXED RESISTORS are available in all standard resistance values and tolerances, plus values above and below standard limits. Shown actual size.

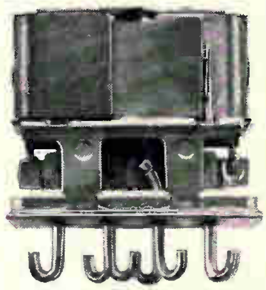



**ALLEN-BRADLEY**

QUALITY ELECTRONIC COMPONENTS

766-2ABJ

# 10 amp subminiature relays at less than a buck an amp



It's a new design. Not a short cut, but an instrumentation quality device that is built to MIL-R-5757.

(Seems we've built them so good, so long, we can't do it any other way, at any price.)

These 10 amp 2PDT relays come up to the 50 G shock and 15 G vibration specs and pass the 100 K life cycling test.

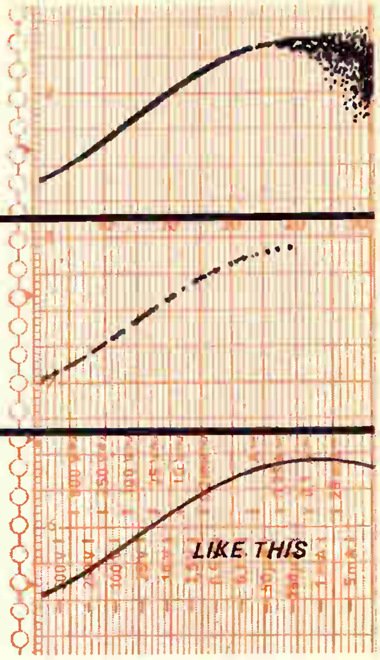
They just aren't built to go through all those extreme space environments, so why pay the missile price?

You get them by ordering our Series D. In several mounting and terminal configurations. And, of course, the under-a-buck-an-amp part does mean in quantity.

Get all the details by phoning us at Leach Corporation, Relay Division (213) 323-8221.

Or write: 5915 South Avalon Boulevard, Los Angeles 90003. Export is Leach International S.A.

**LEACH**




# NO BURNS
LIKE THIS

# NO BLANKS
LIKE THIS

# A PERFECT RECORD every time


## Simpson Multicorder®

### 22 SINGLE ELECTRICAL RECORDERS WRAPPED IN ONE
### STANDARD 3 CHART SPEEDS 1", 3", 12" PER HOUR

Impressions every 2 seconds. Additional speeds (30", 60", 90" per hour) with the optional gear unit Catalog #0682. This voltage-current recorder has a wide selection of ranges and functions to eliminate the need for separate recorders. The pressure-sensitive paper means that there is no conductive paper to burn, no ink to run dry. Meter movement features shock-proof **TAUT BAND SUSPENSION.** AC and DC indicating accuracy is ±1.5% FS; recording accuracy ±2.5% FS. These are just a few of the features that make the Simpson Model 604 Multicorder the most versatile and economical recorder on the market. For the full story, write for Bulletin 520.

**RANGES**

DC VOLTS: 0-0.1, 0.5, 2.5, 10, 25, 100, 250, 500 @ 20,000 Ω/V
AC VOLTS: 0-10, 25, 100, 250, 500 @ 5,000 Ω/V
DC MICROAMPERES: 0-50, 250
DC MILLIAMPERES: 0-1, 5, 25
DC AMPERES: 0-0.1, 0.25, 1.0
AC MILLIAMPERES: 0-0.2

**Multicorder Model 604..........$200.00**

ACCESSORIES
Gear Unit No. 6082 (30", 60", 90" per hour).....30.00
Chart Paper No. 02612, Per Roll................ 2.50
Ever-Redy Vinyl Carrying Case No. 02611.......25.00

Simpson
INSTRUMENTS THAT STAY ACCURATE

*Representatives in Principal Cities ... See Telephone Yellow Pages*

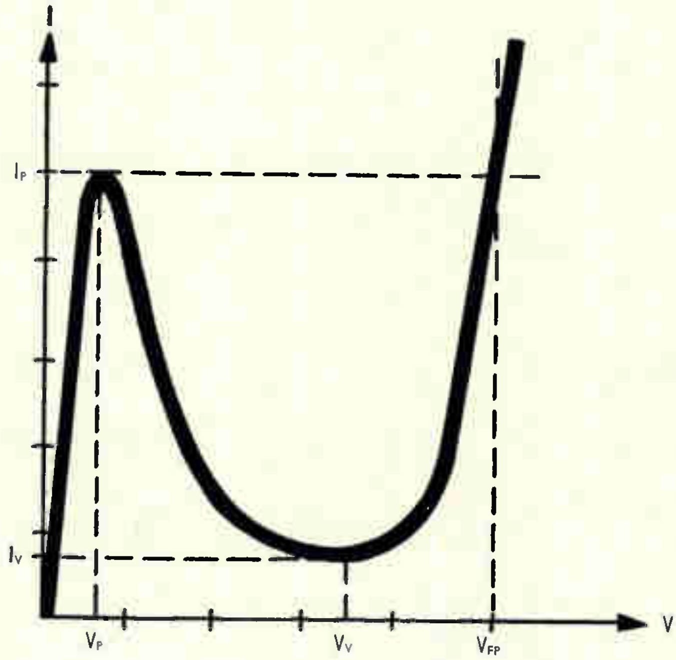
AGM DIVISION

**SIMPSON ELECTRIC COMPANY**
5202 W. Kinzie Street, Chicago, Illinois 60644 • Phone: (312) 379-1121
**Export Dept**: 400 W. Madison Street, Chicago, Illinois 60606, Cable, Simelco
**IN CANADA**: Bach-Simpson Ltd., London, Ontario
**IN INDIA**: Ruttonsha-Simpson Private Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT

ELECTRONIC INNOVATIONS IN ACTION

# Now tunnel diodes cost as little as 50¢




# Hadn't you better switch fast?

If tunnel diode performance at transistor prices sounds impossible, take another look at GE tunnel diodes.

Now you can get a typical switching speed of 1.5 nsec. or better in current ratings from 0.5 mA to 10 mA. Power dissipation is as low as 40 microwatts per unit.

All that performance can cost as little as 50¢.

And your circuits will benefit from greater packaging density, lower power consumption, and fewer components to perform a given function.

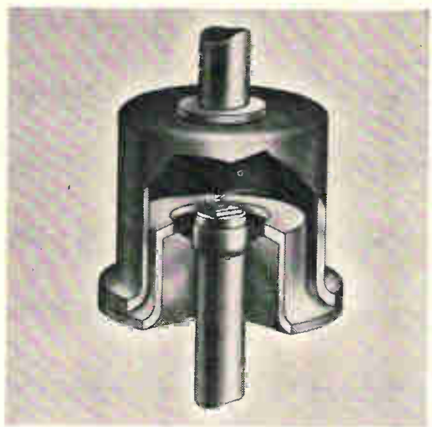
New General Electric tunnel diodes are available either in axial lead packages, or in pellet form for hybrid integrated circuits.

At the new low prices you can now use GE diodes in many new applications. Why not try them for current or time delay thresholding, high-speed logic circuits, high-frequency oscillators or amplifiers, UHF mixers, or sense amplifiers?

This is just one more example of the low-cost semiconductor leadership and total electronic capability GE offers you.

**For further details call your nearest GE engineer/salesman, or semiconductor distributor. Or write to Section 220-50, General Electric Company, Schenectady, N.Y. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y.**

**Actual size low-cost GE tunnel diode**

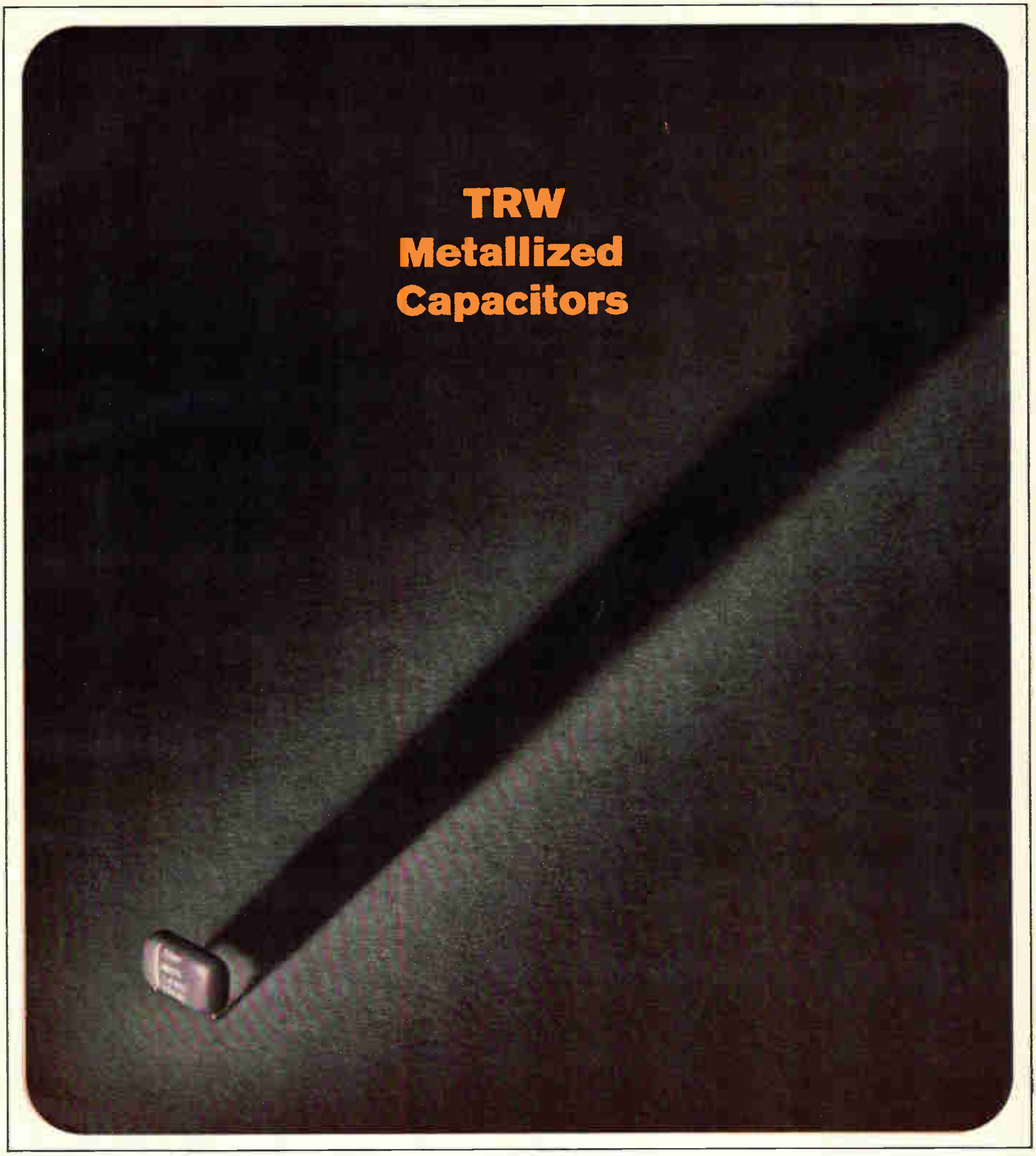


**Planar and thin film fabrication techniques, used to form the germanium tunnel junction, make lower prices possible.**

SEMICONDUCTOR PRODUCTS DEPARTMENT

**GENERAL ELECTRIC**

**DON'T MISS GE'S TWO IEEE SEMICONDUCTOR APPLICATION SEMINARS MARCH 21 AT THE BARBIZON PLAZA HOTEL**




## ...stand tall

Type X601PE Metallized Mylars typify TRW's stature in advanced metallized dielectrics.

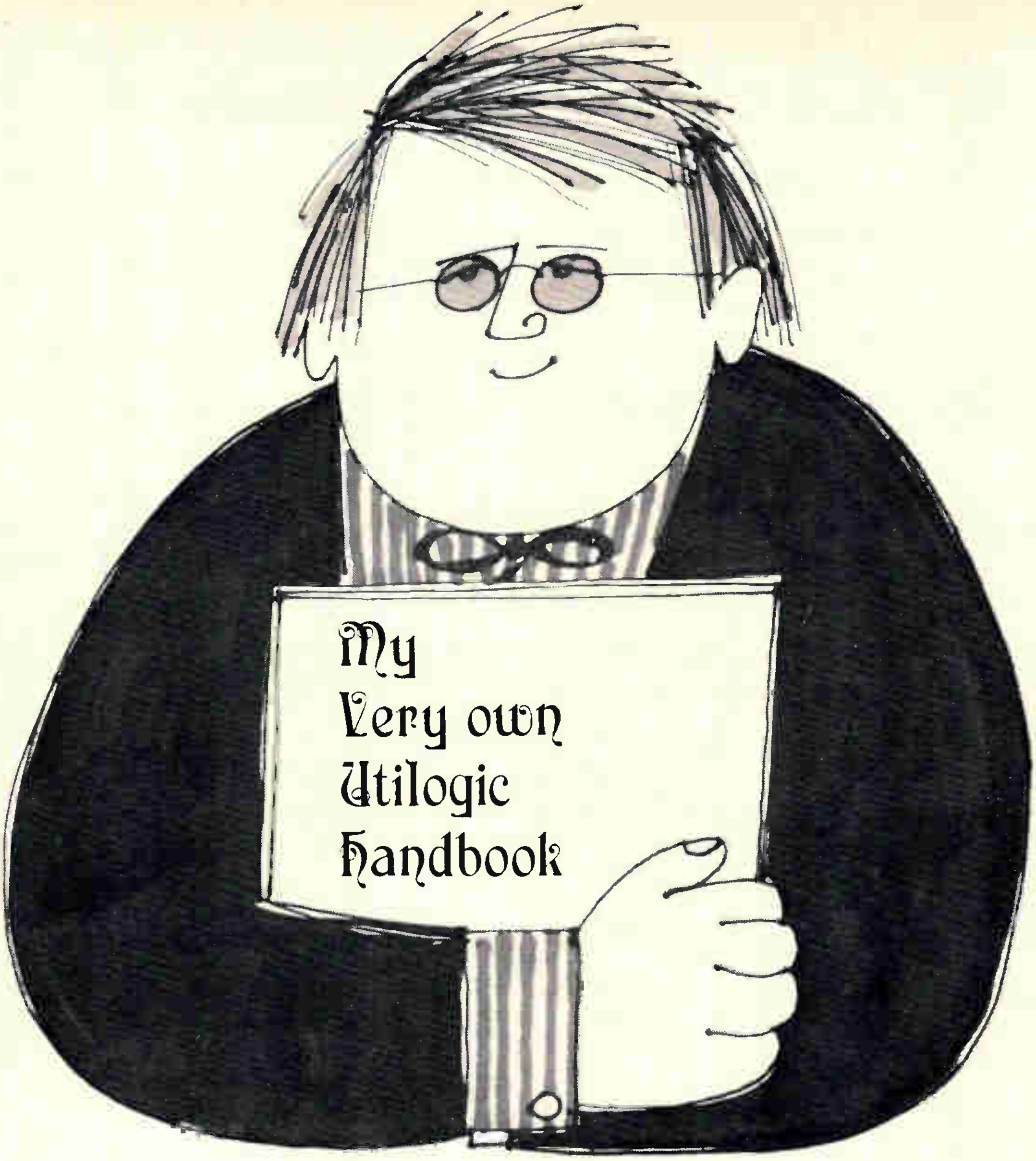
They're smaller and lighter... *metallized!* Tough and rugged... *epoxy sealed!* Ideal for printed circuits... *save space!*

TRW offers many additional styles and dielectrics for demanding Military and Industrial needs.

Product information is available from TRW Capacitor Division, TRW INC., Box 1000, Ogallala, Nebraska. Phone (308) 284-3611. TWX: 910-620-0321.

TRW

Circle 147 on reader service card




**Since 1 in 10 integrated circuits in use are our own UTILOGIC units, we thought the line deserved its own handbook. It's yours. Free.**

It's the first applications handbook of its kind. Make it your very own. It will give you 32 pages of everything you need to know about using UTILOGIC. Signetics introduced UTILOGIC in 1964: it was the first line designed specifically for the commercial and industrial market. Customers bought them by the millions. No wonder. The UTILOGIC series offers 800 mv minimum noise margins. fan-outs of up to 17 from Gates and J-K Binary and high capacitive drive capability. SU-element operation is guaranteed from −20° to +85° C, and LU-elements from +10° to +55° C. Send for your own UTILOGIC Handbook. Write: Signetics, 811 E. Arques Avenue, Sunnyvale, California 94086.

**SIGNETICS INTEGRATED CIRCUITS**

A SUBSIDIARY OF CORNING GLASS WORKS

**SIGNETICS SALES OFFICES:** Metropolitan New York (201) 992-3980; Upper New York State (315) 469-1072; Southwestern (214) 231-6344; Western Regional (213) 272-9421; Eastern Regional (617) 245-8200; Mid-Atlantic (609) 858-2864; Southeastern (813) 726-3734; Midwestern Regional (312) 259-8300; Northwestern (408) 738-2710.

**DISTRIBUTORS:** Compar at all locations listed below. Semiconductor Specialists, Inc. (312) 622-8860; Terminal Hudson Electronics (212) 243-5200; Wesco Electronics (213) 684-0880; Wesco Electronics (405) 968-3475.

**DOMESTIC REPRESENTATIVES:** Jack Pyle Company (415) 349-1266. Compar Corporation at the following locations: Alabama (205) 539-8476; Arizona (602) 947-4336; California (203) 245-1172; California (415) 697-6244; Colorado (303) 781-0912; Connecticut (203) 288-9276; Florida (305) 855-3964; Illinois (312) 775-5300; Maryland (301) 484-5400; Massachusetts (617) 969-7140; Michigan (313) 476-5758; Minnesota (612) 922-7011; Missouri (314) 428-5313; New Jersey (609) 429-1526; New Mexico (505) 265-1020; New York (518) 436-8536; New York (607) 723-8743; New York (716) 684-5731; New York (201) 471-6090; North Carolina (919) 724-0750; Ohio (216) 333-4120; Ohio (513) 878-2631; Texas (214) EM 3-1526; Texas (713) 649-5756; Washington (206) 725-7800.

**INTERNATIONAL SALES:** France, Germany, Italy, Belgium, Holland, Luxemburg, Spain — Sovcor Electronique, 11, Chemin de Ronde, Le Vesinet, (S.-&-O.) France. United Kingdom, Ireland, Sweden, Denmark, Norway, Switzerland, Austria, Portugal — Electrosil Ltd., Lakeside Estate, Colnbrook-By-Pass Slough, Buckinghamshire, Great Britain. Australia — Corning, 1202 Plaza Building, Australia Square, Sydney, N.S.W. 27-4318. Canada — Corning Glass Works of Canada, Ltd., Leaside Plant, Ontario, Canada (416) 421-150. Israel — Optronix, P.O. Box 195, Ramat-Gan, Israel 724-437. Japan — ASAHI Glass Co., Ltd. (IWAKI), Corning Products Sales Dept. No. 2, 3-Chome Marunouchi, Chiyoda-ku, Tokyo, Japan.

This is the new Tally System 800 for verification and duplication of perforated tape. We call it the "Super Dupe".

It duplicates perforated tape on a bit-for-bit basis at 120 characters per second.

It verifies two tapes bit-for-bit.

It verifies two tapes and duplicates a completely error free third tape.

It detects perforation bit errors as they happen.


The Tally System 800 verifies and/or duplicates perforated tapes from one through eight channels in any code structure at 120 characters per second.
It uses bit echo techniques to make sure that every error is caught on the character and eliminated by comparing each perforated bit with with each bit read by the master reader.
Its price is remarkably low and delivery amazingly good. If it's your kind of baby and you would like the full story, please write our man Crawford. Address Tally Corporation, 1310 Mercer Street, Seattle, Wash., 98109. Phone: (206) Main 4-0760. TWX 910-444-2039. In the U. K. and Europe, address Tally Europe, Ltd., Radnor House, 1272 London Road, London, S. W. 16, England.

TALLY

SEE US AT THE S.J.C.C.

# We don't think the film pots we made to someone else's requirements are good enough for you.

That's why Litton never has any off-the-shelf potentiometers.

Yet we make some of the most versatile precision film pots in the industry. Linear. Trigonometric. Logarithmic. Pressure-altitude. Impact-mach. Nonlinear empirical. And every one of them custom engineered to fit your specific requirements.

Litton conductive film pots can be provided readily in any mechanical angle—sector configurations or continuous rotation. In addition, they feature

- Infinite resolution
- Terminal conformity as low as ±0.01% depending upon size, resistance, and type of function
- A minimum temperature coefficient of −250 PPM/°C
- An ambient temperature range to +150°C
- Matching resistors and switches when specified
- Gold-plated slip rings and precious metal contacts to prevent oxidation, reduce noise and slip-ring wear
- Dimensionally stable housings to withstand shock and vibration, heat and cold, dust and humidity.

And *each* one is microscopically inspected, tested at every stage of production. What's more, our government-certified testing equipment allows simultaneous exposure to environmental extremes.

Send us your requirements or applications. We'll handle them—fast—at no cost or obligation. For more information, write or call: Litton Industries, Potentiometer Division, 226 East Third Street, Mt. Vernon, N.Y. 10550. Tel.: (914) 664-7733 TWX: (914) 699-4687 • Western Regional Office: Tel.: (213) 273-7015.

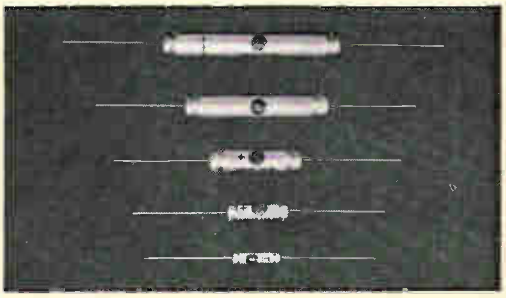
**LITTON INDUSTRIES**
POTENTIOMETER DIVISION

*A TECHNICAL DIGEST FOR INNOVATORS OF* ***MILITARY EQUIPMENT***

# *COMPONENT CAPSULES*

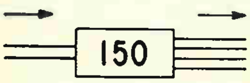
## Proved: In-circuit reliability for military uses

More than 20 million GE tantalum foil capacitors have already been applied. They are designed to withstand unsuspected voltage reversals and are self-healing. Low impedance circuits or catastrophic failures are no problem with GE tantalum foils. Ratings are available up to 450VDC, 0.15 to 3500 $\mu$f, —55C to 85C, or 125C with voltage derating. Circle **Number 90** for all the facts on these capacitors.



**GE tantalum capacitors**

## Unique: 2-input, 4-output AND circuit in a single relay




No other components are needed. Just a GE 150 4-pole Grid-space relay thanks to its unique magnetic circuit. The four outputs are switched simultaneously, yet completely independent from each other. And all input and output signals are electrically isolated. Save space. The relay measures just 0.320 by 0.610 by 0.610 inch. Save cost. All GE relay advantages—high power switching, high environmental capability, and GE's unique 150 design—are designed in especially for high performance, military type applications. Circle **Number 91.**

## Your choice: high-speed or high-voltage switching in this compact SCR

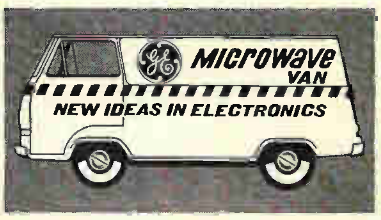
Take your pick.

**GE C141 high speed SCR's** (2N3654-8) are characterized for applications up to 25 kHz and feature a maximum turn-off time of 10 $\mu$ sec. They're ideal for converters and other high speed applications such as triggering a GE H1D1 laser diode.

**Actual size C141/C137 package**

**GE C137 high voltage SCR's** are rated up to 1200 volts repetitive peak with both high di/dt and high dv/dt capability . . . excellent for power switching from high voltage sources. Circle **Number 92** for more details on all SCR's available in this compact package from your GE salesman or distributor.

## Coming your way . . . GE's microwave van




**Be sure it visits your plant**

See eight interesting displays on new ideas in microwave active components . . . and see them right at your plant. "Live" or operating displays include: distance measuring equipment (DME), radar altimeter, spectrum analyzer, unit oscillator, and some very recent VTM developments.

Ask the questions you want answered about GE klystrons, ceramic gridded tubes, voltage tunable magnetrons, tunnel diodes, and other microwave devices you may use.

Circle **Number 93** for more information.

**WE MAY NOT OFFER EVERYTHING YOU WANT FROM ONE COMPONENTS SUPPLIER. BUT WE DO COME A LITTLE CLOSER THAN ANYONE ELSE.**

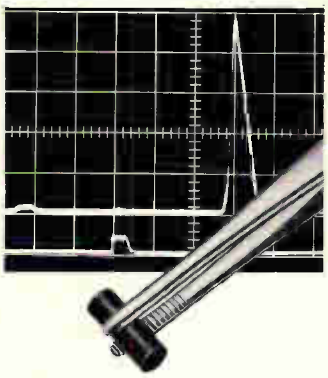
285-18

**GENERAL ELECTRIC**

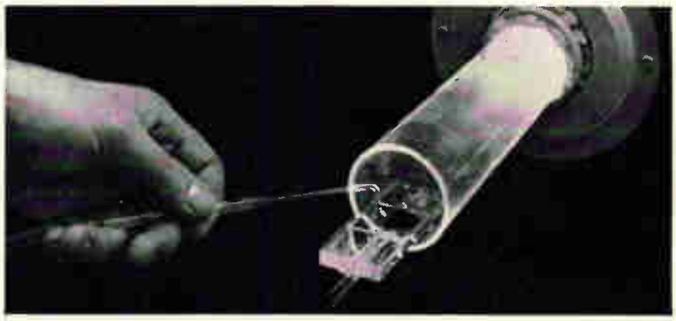
# Tomorrow's answers... through Sperry Research

*High purity of lithium niobate boules is maintained by meticulous control of temperature and withdrawal rate as well as microscopic precision in formulation.*

*Variable signal delay and trillion-fold amplification characterize the performance of experimental delay lines made with YIG rods as small as one half-inch long.*



*Headed for the diffusion furnace — insulation deposited on silicon wafer base provides a better diffusion mask and greater dielectric strength than oxide growth methods.*



## GROWING LASER EFFICIENCY —

A tenfold increase in crystal fluorescence . . . a tunable optical source that converts a laser beam of one color to any other color in the spectrum . . . such achievements are the result of significant advances in the art of crystal chemistry. Crystals like YAG (yttrium aluminum garnet), for example, are expected to provide new host crystals for high-energy, optically-pumped ion-host lasers. Lithium niobate will provide a new and efficient means for deflection, modulation and tuning of laser outputs. Sperry's staff of crystal technologists is, in fact, actively studying no fewer than forty-six different materials and using all of the principal crystal preparation techniques: Flux growth and flame fusion as well as the Czochralski and Bridgman processes. From this research will come materials for the next generation of electronic and optical devices.

## DELAYING ACTION —

A half-inch of YIG (yttrium iron garnet) and a unique parametric pumping technique have enabled Sperry physicists to demonstrate net gain amplification of delayed microwave signals at room temperature. Variable delay and signal amplification up to 20 db net gain from L to X-band are the latest results. Without getting tangled up in miles of coaxial cable, YIG delay lines hold a key to higher resolution, less costly, Doppler and pulse-compression radar and ECM systems. Other magnetic materials are also under study for microwave and computer applications.

## THICKSKINNED —

A new microelectronic insulating technology developed by Sperry scientists promises increased electrical stability in the newest breed of semiconductor devices and microcircuits. Reliable passivation isolates circuits from environmental deterioration without encapsulation. Insulation is deposited on the silicon base material, not grown by oxidation. Deposition is ten times faster at half the temperature required for oxide growth. Thickness can be precisely controlled in layers varying from angstroms to mils. Continuing studies are exploring possible use of this technique with other base materials, such as germanium, gallium arsenide, and indium arsenide.

## DC DOES IT —

Sperry scientists tucked a tiny, silicon planar epitaxial diode into a small, tunable, resonant cavity and reverse-biased it beyond breakdown. Applied dc inputs produced microwave outputs, either pulsed or cw. This experimental transit-time oscillator has displayed high spectral purity and easy tunability in octave bandwidths over the entire microwave frequency range. As potential replacements for conventional, low power microwave sources, such devices look especially suitable for future ground, air, or space-borne radar and communication receivers, beacons, and radar altimeters. Current experiments aim at pushing the frequency capability well up into the millimeter wave region.

☐ These are just a few of the many scientific achievements of Sperry Rand Research Center. Sperry can help you meet similar short- or long-term technological objectives through basic and applied research in a variety of scientific disciplines. We are currently engaged in intensive investigation and experimentation in the following areas:

**SOLID STATE SCIENCES**
Microelectronics
Microwave and optical signal processing
Microwave oscillators
Thin film techniques
Laser materials and techniques
Crystal chemistry
Magnetic phenomena

**PLASMA PHYSICS**
Microwave and optical devices
Re-entry plasmas
Energy conversion

**ATMOSPHERIC PHYSICS**
Environmental modeling
Active and passive radiometry
Laser atmospheric probing

**SYSTEMS RESEARCH**
Radar sciences
Human factors
Applied mathematics and control theory
Data processing techniques
Underwater communications and sonar

SPERRY
DIVISION OF SPERRY RAND CORPORATION

**SPERRY RAND RESEARCH CENTER • Sudbury, Massachusetts 01776**


Now the industry-accepted TTL has a double, pin for pin...
Westinghouse TTL. Available now.
The new direct replacement for industry-accepted SUHL II is here. Westinghouse TTL is a true mechanical and electrical replacement, pin for pin. Here's a second source TTL that can help keep your products competitive into the 1970's. □ Circuits now available in industry standard dual-in-line and flat packages include: 6G241 Dual NAND/NOR Gate; 6G221 Quadruple NAND/NOR Gate; 6F251 JK Flip-Flop, AND input; 6F261 JK Flip-Flop, OR input. □ For evaluation quantities, contact your Westinghouse Electronic salesman. Or phone Westinghouse at (301) 796-3666. Or write Westinghouse, Molecular Electronics Division, Box 7377, Elkridge, Maryland 21227.
You can be sure if it's Westinghouse
J-09141

# EIMAC has advanced power amplifiers for low power UHF-TV transmitters

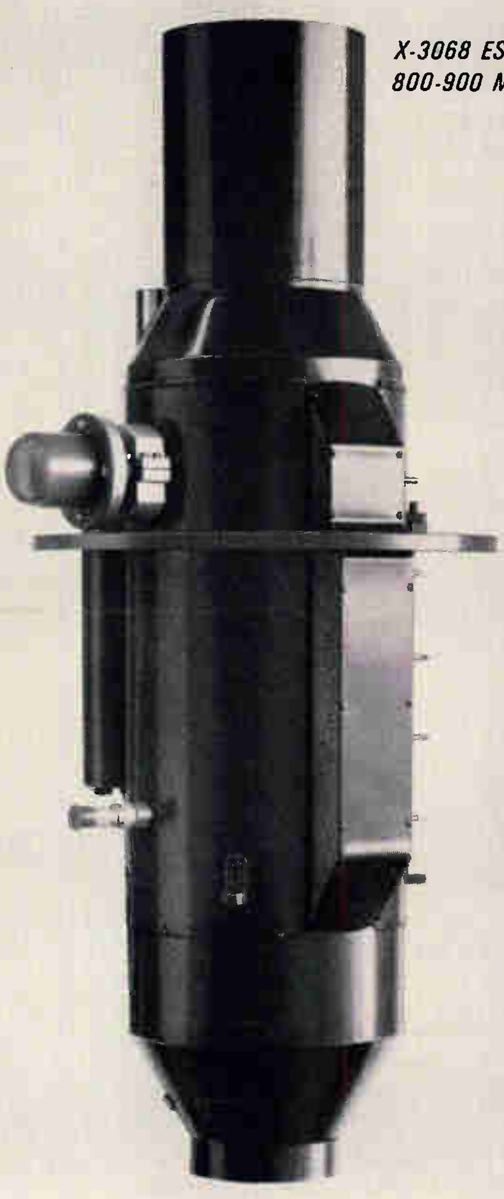
These power amplifier tubes are electrostatically focused klystrons (ESFK). They need no magnets. Our entire ESFK family offers you the best power-to-weight ratio of any power amplifiers. That means when you use one of our new ESFK's in your next design, your UHF-TV transmitter will be smaller—and easier to maintain. And since these tubes are air-cooled, they need less heat dissipation equipment, so your transmitter is less expensive to operate.

One example: the X-3068 amplifier. Note its 35 db gain with 36% beam power efficiency. At UHF frequencies, power outputs between 1 and 3 kilowatts are available.

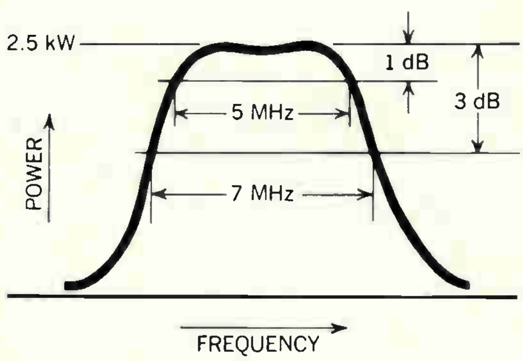
For S-band transmitter designs, check our X-3065. It offers 500 watts output yet weighs only 5 pounds and measures just 6 inches. And provides 30 to 40 db gain with efficiency between 35% and 45%; heat-sink or air-cooled.

We have spent more than ten years in advanced materials research, ceramic-to-metal technology, and beam focusing studies. To make an advanced power amplifier, it takes experience. You can count the number of experienced ESFK manufacturers on one finger.

**EIMAC**
Division of Varian
San Carlos, California 94070



*X-3068 ESFK*
*800-900 MHz*




RF OUTPUT POWER vs. FREQUENCY.
CAVITIES TUNED FOR BANDWIDTH.

| | |
|---|---|
| DRIVING POWER | 2 W |
| OUTPUT POWER | 2.5 kW |
| GAIN | 31 dB |
| 1 dB BANDWIDTH | 5 MHz |
| 3 dB BANDWIDTH | 7 MHz |

At IEEE Show:
Don't miss **The World of Varian** 3rd Floor, Coliseum

Circle 154 on reader service card

Circle 155 on reader service card→


# The wrapped tubular explosion!

When you think of wrapped mylar capacitors, you naturally think of Cornell-Dubilier. Over the years, our type WMF has become an industry standard.

But our wrapped mylars are just a small part of the biggest selection of wrapped tubular capacitors made. The CDE line also includes type MFP pressed mylars, military grade type CTM mylars, type MMW metallized mylars and two brand new types. WCR polycarbonates and MCR metallized polycarbonates.

All are SPRINT stock standards. All are available through CDE's Authorized Industrial Distributors.

CDE CORNELL-DUBILIER

# —STOCK STANDARDS—WRAPPED TUBULAR CAPACITORS—

## WMF — GENERAL PURPOSE MINIATURE

**STANDARD STOCK RATINGS** ‡ Tolerance ±20% or ±10%

| Cap. Mfd. | 100V DCW †Type WMF- | 100V DCW Size DxL (In.) | 200V DCW †Type WMF- | 200V DCW Size DxL (In.) | 400V DCW †Type WMF- | 400V DCW Size DxL (In.) | 600V DCW †Type WMF- | 600V DCW Size DxL (In.) |
|---|---|---|---|---|---|---|---|---|
| .001 | 1D1 | .156 x ½ | 2D1 | .156 x ½ | 4D1 | .156 x ⅝ | 6D1 | .170 x ¾ |
| .0012 | 1D12 | .156 x ½ | — | — | — | — | — | — |
| .0015 | 1D15 | .156 x ½ | 2D15 | .156 x ½ | 4D15 | .156 x ⅝ | 6D15 | .170 x ¾ |
| .0018 | 1D18 | .156 x ½ | — | — | — | — | — | — |
| .0022 | 1D22 | .156 x ½ | 2D22 | .156 x ½ | 4D22 | .156 x ⅝ | 6D22 | .187 x ¾ |
| .0027 | 1D27 | .156 x ½ | — | — | — | — | — | — |
| .0033 | 1D33 | .156 x ½ | 2D33 | .160 x ½ | 4D33 | .190 x ⅝ | 6D33 | .203 x ¾ |
| .0039 | 1D39 | .156 x ½ | — | — | — | — | — | — |
| .0047 | 1D47 | .156 x ½ | 2D47 | .170 x ½ | 4D47 | .200 x ⅝ | 6D47 | .234 x ¾ |
| .0050 | 1D5 | .156 x ½ | — | — | — | — | — | — |
| .0056 | 1D56 | .156 x ½ | — | — | — | — | — | — |
| .0068 | 1D68 | .175 x ½ | 2D68 | .200 x ½ | 4D68 | .250 x ⅝ | 6D68 | .265 x ¾ |
| .0082 | 1D82 | .175 x ½ | — | — | — | — | — | — |
| .01 | 1S1 | .200 x ½ | 2S1 | .230 x ½ | 4S1 | .300 x ⅝ | 6S1 | .290 x ¾ |
| .012 | 1S12 | .215 x ½ | — | — | — | — | — | — |
| .015 | 1S15 | .235 x ½ | 2S15 | .290 x ½ | 4S15 | .360 x ⅝ | 6S15 | .312 x ⅞ |
| .018 | 1S18 | .255 x ½ | — | — | — | — | — | — |
| .022 | 1S22 | .275 x ⅝ | 2S22 | .260 x ⅝ | 4S22 | .320 x ¾ | 6S22 | .335 x ⅞ |
| .027 | 1S27 | .300 x ⅝ | — | — | — | — | — | — |
| .033 | 1S33 | .300 x ⅝ | 2S33 | .270 x ¾ | 4S33 | 350 x ⅞ | 6S33 | .350 x 1 |
| .039 | 1S39 | .245 x ¾ | — | — | — | — | — | — |
| .047 | 1S47 | .265 x ¾ | 2S47 | .320 x ¾ | 4S47 | .400 x ⅞ | 6S47 | .415 x 1 |
| .050 | 1S5 | .265 x ¾ | — | — | — | — | — | — |

| Cap. Mfd. | 100V DCW †Type WMF- | 100V DCW Size DxL (In.) | 200V DCW †Type WMF- | 200V DCW Size DxL (In.) | 400V DCW †Type WMF- | 400V DCW Size DxL (In.) | 600V DCW †Type WMF- | 600V DCW Size DxL (In.) |
|---|---|---|---|---|---|---|---|---|
| .056 | 1S56 | .265 x ¾ | — | — | — | — | — | — |
| .068 | 1S68 | .280 x ¾ | 2S68 | .350 x ¾ | 4S68 | .390 x 1 | 6S68 | .500 x 1 |
| .082 | 1S82 | .270 x ¾ | — | — | — | — | — | — |
| .1 | 1P1 | .290 x ⅞ | 2P1 | .410 x ⅞ | 4P1 | .465 x 1 | 6P1 | .520 x 1⅜ |
| .12 | 1P12 | .315 x ⅞ | — | — | — | — | — | — |
| .15 | 1P15 | .335 x ⅞ | 2P15 | .500 x ⅞ | 4P15 | .515 x 1¼ | 6P15 | .625 x 1⅜ |
| .18 | 1P18 | .350 x 1 | — | — | — | — | — | — |
| .22 | 1P22 | .385 x 1 | 2P22 | .500 x 1⅛ | 4P22 | .565 x 1⅜ | 6P22 | .660 x 1⅝ |
| .27 | 1P27 | .380 x 1⅛ | — | — | — | — | — | — |
| .33 | 1P33 | .415 x 1⅛ | 2P33 | .550 x 1⅛ | 4P33 | .600 x 1⅝ | 6P33 | .687 x 2 |
| .39 | 1P39 | .460 x 1⅛ | — | — | — | — | — | — |
| .47 | 1P47 | .475 x 1¼ | 2P47 | .600 x 1¼ | 4P47 | .700 x 1⅝ | 6P47 | .855 x 2 |
| .50 | 1P5 | .500 x 1¼ | — | — | — | — | — | — |
| .56 | 1P56 | .525 x 1¼ | — | — | — | — | — | — |
| .68 | 1P68 | .570 x 1¼ | 2P68 | .650 x 1⅝ | 4P68 | .790 x 1¾ | 6P68 | .970 x 2 |
| .82 | 1P82 | .585 x 1⅜ | — | — | — | — | — | — |
| 1.0 | 1W1 | .625 x 1½ | 2W1 | .750 x 1¾ | 4W1 | .875 x 2 | 6W1 | 1.165 x 2½ |
| 1.25 | 1W1P25 | .690 x 1½ | 2W1P25 | 825 x 1¾ | 4W1P25 | .950 x 2 | 6W1P25 | 1.340 x 2½ |
| 1.5 | 1W1P5 | .770 x 1¾ | 2W1P5 | .900 x 1¾ | 4W1P5 | .975 x 2¼ | 6W1P5 | 1.275 x 3 |
| 2.0 | 1W2 | .955 x 1¾ | 2W2 | .980 x 1⅞ | 4W2 | 1.250 x 2¼ | 6W2 | 1.460 x 3 |
| 3.0 | 1W3 | 1.100 x 2 3/16 | | | | | | |
| 4.0 | 1W4 | 1.250 x 2.500 | | | | | | |

† Order by complete type no.; e.g, WMF1D68 Type numbers listed are ±10%; Available to 1.0 mfd in ±20% tolerance. To specify ±20% add —20

## MFP — FLAT MYLAR* WRAP

**STANDARD STOCK RATINGS** ‡ Tolerance ±20% or ±10%

| Cap. Mfd. | 100V DCW †Type MFP— | 100V DCW L x W x T (Inches) | 200V DCW †Type MFP— | 200V DCW L x W x T (Inches) | 400V DCW †Type MFP— | 400V DCW L x W x T (Inches) | 600V DCW †Type MFP— | 600V DCW L x W x T (Inches) |
|---|---|---|---|---|---|---|---|---|
| .01 | ★ | | ★ | | ★ | | 6S1 | .750 x .343 x .218 |
| .015 | ★ | | 2S15 | .500 x .312 x .187 | 4S15 | .625 x .437 x .312 | 6S15 | .875 x .343 x .218 |
| .022 | 1S22 | .625 x .343 x .218 | 2S22 | .625 x .343 x .218 | 4S22 | .750 x .375 x .250 | 6S22 | .875 x .406 x .281 |
| .033 | 1S33 | .625 x .312 x .187 | 2S33 | .750 x .343 x .218 | 4S33 | .875 x .406 x .281 | 6S33 | 1.000 x .406 x .281 |
| .047 | 1S47 | .750 x .312 x .187 | 2S47 | .750 x .375 x .250 | 4S47 | .875 x .500 x .343 | 6S47 | 1.000 x .468 x .343 |
| .068 | 1S68 | .750 x .343 x .218 | 2S68 | .750 x .437 x .250 | 4S68 | 1.000 x .437 x .312 | 6S68 | 1.000 x .562 x .406 |
| .1 | 1P1 | .875 x .343 x .218 | 2P1 | .875 x .500 x .312 | 4P1 | 1.000 x .531 x .375 | 6P1 | 1.375 x .593 x .406 |
| .15 | 1P15 | .875 x .406 x .250 | 2P15 | .875 x .562 x .375 | 4P15 | 1.250 x .562 x .406 | 6P15 | 1.375 x .687 x .531 |
| .22 | 1P22 | 1.000 x .468 x .281 | 2P22 | 1.125 x .562 x .406 | 4P22 | 1.375 x .625 x .500 | 6P22 | 1.625 x .750 x .531 |
| .33 | 1P33 | 1.125 x .500 x .312 | 2P33 | 1.125 x .625 x .500 | 4P33 | 1.625 x .656 x .500 | 6P33 | 2.000 x .781 x .562 |
| .47 | 1P47 | 1.250 x .531 x .375 | 2P47 | 1.250 x .656 x .500 | 4P47 | 1.625 x .781 x .593 | 6P47 | 2.000 x .937 x .718 |
| .68 | 1P68 | 1.250 x .687 x .468 | 2P68 | 1.625 x .718 x .531 | 4P68 | 1.750 x .875 x .687 | 6P68 | 2.000 x 1.062 x .843 |
| 1.0 | 1W1 | 1.500 x .718 x .500 | 2W1 | 1.750 x .812 x .625 | 4W1 | 2.000 x .937 x .750 | 6W1 | 2.500 x 1.250 x 1.062 |
| 1.25 | 1W1P25 | 1.500 x .718 x .562 | 2W1P25 | 1.750 x .960 x .687 | 4W1P25 | 2.000 x 1.062 x .843 | 6W1-P25 | 2.500 x 1.437 x 1.218 |
| 1.50 | 1W1P5 | 1.750 x .843 x .656 | 2W1P5 | 1.750 x 1.000 x .781 | 4W1P5 | 2.250 x 1.062 x .843 | 6W1P5 | 3.000 x 1.406 x 1.093 |
| 2.0 | 1W2 | 1.750 x 1.062 x .843 | 2W2 | 1.875 x 1 062 x .843 | 4W2 | 2.250 x 1 312 x 1.125 | 6W2 | 3.000 x 1 593 x 1.281 |

★ Covered by Parent Case size. Use next higher voltage for same case size. † Order by complete type no.; e.g., MFP1S22. ‡ Type numbers listed are ±20%; to specify ±10% add —10 to type no.

## MMW — MINIATURE MYLAR WRAP — METALLIZED

**STANDARD STOCK RATINGS** Tolerance ±20%

| Cap. Mfd. | 200V DCW Type† MMW— | 200V DCW D x L (Inches) | 400V DCW Type† MMW— | 400V DCW D x L (Inches) | 600V DCW Type† MMW— | 600V DCW D x L (Inches) |
|---|---|---|---|---|---|---|
| .01 | ★ | | 4S1 | .180 x 9/16 | 6S1 | .200 x ¾ |
| .015 | ★ | | 4S15 | .180 x 11/16 | 6S15 | .250 x ¾ |
| .022 | ★ | | 4S22 | .210 x 11/16 | 6S22 | .300 x ¾ |
| .033 | 2S33 | .180 x 9/16 | 4S33 | .250 x 11/16 | 6S33 | .370 x ¾ |
| .047 | 2S47 | .200 x 9/16 | 4S47 | .300 x 11/16 | 6S47 | .325 x 1 1/16 |
| .068 | 2S68 | .200 x 11/16 | 4S68 | .350 x 11/16 | 6S68 | .400 x 1 1/16 |
| .1 | 2P1 | .240 x 11/16 | 4P1 | .325 x 1 | 6P1 | .450 x 1 1/16 |
| .15 | 2P15 | .280 x 11/16 | 4P15 | .375 x 1 | 6P15 | .475 x 1¼ |

| Cap. Mfd. | 200V DCW Type† MMW— | 200V DCW D x L (Inches) | 400V DCW Type† MMW— | 400V DCW D x L (Inches) | 600V DCW Type† MMW— | 600V DCW D x L (Inches) |
|---|---|---|---|---|---|---|
| .22 | 2P22 | .340 x 11/16 | 4P22 | .400 x 1¼ | 6P22 | .575 x 1¼ |
| .33 | 2P33 | .390 x 11/16 | 4P33 | .450 x 1½ | 6P33 | .560 x 1¾ |
| .47 | 2P47 | .370 x 1 | 4P47 | .520 x 1½ | 6P47 | .675 x 1¾ |
| .68 | 2P68 | .420 x 1 | 4P68 | .625 x 1½ | 6P68 | .800 x 1¾ |
| 1.0 | 2W1 | .500 x 1 | 4W1 | .675 x 1¾ | 6W1 | .950 x 1¾ |
| 1.5 | 2W1P5 | .540 x 1¼ | 4W1P5 | .825 x 1¾ | | |
| 2.0 | 2W2 | .620 x 1¼ | 4W2 | .950 x 1¾ | | |

★ Use next higher voltage rating. † Order by complete type number; e.g., MMW2S33.

## MCR — FILM WRAP METALLIZED POLYCARBONATE

**STANDARD STOCK RATINGS** Tolerance ±20%

| Cap. Mfd. | 200V DCW †Type MCR— | 200V DCW Size D x L (In.) | Lead Size | 400V DCW †Type MCR— | 400V DCW Size D x L (In.) | Lead Size | 600V DCW †Type MCR— | 600V DCW Size D x L (In.) | Lead Size |
|---|---|---|---|---|---|---|---|---|---|
| .01 | 2S1 | .150 x 9/16 | 24 | 4S1 | .200 x 9/16 | 24 | 6S1 | .245 x ¾ | 24 |
| .015 | 2S15 | .175 x 9/16 | 24 | 4S15 | .200 x 11/16 | 24 | 6S15 | .295 x ¾ | 24 |
| .022 | 2S22 | .185 x 9/16 | 24 | 4S22 | .225 x 11/16 | 24 | 6S22 | .350 x ¾ | 24 |
| .033 | 2S33 | .215 x 9/16 | 24 | 4S33 | .260 x 11/16 | 24 | 6S33 | .420 x ¾ | 22 |
| .047 | 2S47 | .240 x 9/16 | 24 | 4S47 | .320 x 11/16 | 22 | 6S47 | .375 x 1 1/16 | 22 |
| .068 | 2S68 | .215 x 11/16 | 24 | 4S68 | .375 x 11/16 | 22 | 6S68 | .435 x 1 1/16 | 22 |
| .1 | 2P1 | .275 x 11/16 | 24 | 4P1 | .345 x 1 | 22 | 6P1 | .525 x 1 1/16 | 22 |
| .15 | 2P15 | .310 x 11/16 | 22 | 4P15 | .400 x 1 | 22 | 6P15 | .565 x 1¼ | 22 |
| .22 | 2P22 | .370 x 11/16 | 22 | 4P22 | .425 x 1¼ | 22 | 6P22 | .670 x 1¼ | 22 |
| .33 | 2P33 | .430 x 11/16 | 22 | 4P33 | .465 x 1½ | 22 | 6P33 | .670 x 1¾ | 22 |

| Cap. Mfd. | 200V DCW †Type MCR— | 200V DCW Size D x L (In.) | Lead Size | 400V DCW †Type MCR— | 400V DCW Size D x L (In.) | Lead Size | 600V DCW †Type MCR— | 600V DCW Size D x L (In.) | Lead Size |
|---|---|---|---|---|---|---|---|---|---|
| .47 | 2P47 | .370 x 1 | 22 | 4P47 | .550 x 1½ | 20 | 6P47 | .775 x 1¾ | 18 |
| .68 | 2P68 | .450 x 1 | 22 | 4P68 | .650 x 1½ | 20 | 6P68 | .925 x 1¾ | 18 |
| 1.0 | 2W1 | .530 x 1 | 22 | 4W1 | .725 x 1¾ | 18 | 6W1 | 1.125 x 1¾ | 18 |
| 1.5 | 2W1P5 | .575 x 1¼ | 20 | 4W1P5 | .865 x 1¾ | 18 | — | — | — |
| 2.0 | 2W2 | .650 x 1¼ | 20 | 4W2 | .990 x 1¾ | 18 | — | — | — |
| 3.0 | 2W3 | .700 x 1½ | 18 | 4W3 | 1.062 x 2¼ | 18 | — | — | — |
| 4.0 | 2W4 | .745 x 1¾ | 18 | — | — | — | — | — | — |
| 5.0 | 2W5 | .825 x 1¾ | 18 | — | — | — | — | — | — |

† Order by complete type number; e.g., MCR2S22

## WCR — FILM WRAP POLYCARBONATE

**STANDARD STOCK RATINGS** Tolerance ±10%

| Cap. Mfd. | 100V DCW †Type WCR— | 100V DCW Size (D x L (Inches) | Lead Size | 200V DCW †Type WCR— | 200V DCW Size (D x L (Inches) | Lead Size |
|---|---|---|---|---|---|---|
| .001 | 1D1 | .200 x 15/16 | 24 | 2D1 | .200 x 15/16 | 24 |
| .0022 | 1D22 | .220 x 15/16 | 24 | 2D22 | .220 x 15/16 | 24 |
| .0033 | 1D33 | .260 x 15/16 | 24 | 2D33 | .260 x 15/16 | 22 |
| .0047 | 1D47 | .290 x 15/16 | 24 | 2D47 | .290 x 15/16 | 22 |
| .0068 | 1D68 | .340 x 15/16 | 24 | 2D68 | .290 x 15/16 | 22 |
| .01 | 1S1 | .235 x ¾ | 24 | 2S1 | .290 x 15/16 | 22 |
| .015 | 1S15 | .245 x ¾ | 24 | 2S15 | .320 x 15/16 | 22 |
| .022 | 1S22 | .295 x ¾ | 22 | 2S22 | .385 x 15/16 | 22 |
| .033 | 1S33 | .345 x ¾ | 22 | 2S33 | .465 x 15/16 | 22 |
| .047 | 1S47 | .395 x ¾ | 22 | 2S47 | .405 x 1 5/16 | 22 |

| Cap. Mfd. | 100V DCW †Type WCR— | 100V DCW Size (D x L (Inches) | Lead Size | 200V DCW †Type WCR— | 200V DCW Size (D x L (Inches) | Lead Size |
|---|---|---|---|---|---|---|
| .068 | 1S68 | .415 x ⅞ | 22 | 2S68 | .485 x 1 5/16 | 22 |
| .1 | 1P1 | .450 x 1 | 22 | 2P1 | .585 x 1 5/16 | 20 |
| .15 | 1P15 | .525 x 1⅛ | 20 | 2P15 | .700 x 1 5/16 | 18 |
| .22 | 1P22 | .590 x 1⅛ | 20 | 2P22 | .675 x 1⅞ | 18 |
| .33 | 1P33 | .645 x 1⅜ | 20 | 2P33 | .815 x 1⅞ | 18 |
| .47 | 1P47 | .735 x 1⅝ | 18 | 2P47 | .950 x 1⅞ | 18 |
| .68 | 1P68 | .765 x 1⅞ | 18 | 2P68 | 1.000 x 2⅜ | 18 |
| 1.0 | 1W1 | .925 x 1⅞ | 18 | — | — | — |

† Order by complete type number; e.g., WCR1D22

* DuPont T.M.

THE LARGEST SELECTION OF WRAPPED TUBULAR CAPACITORS MADE

CDE CORNELL-DUBILIER

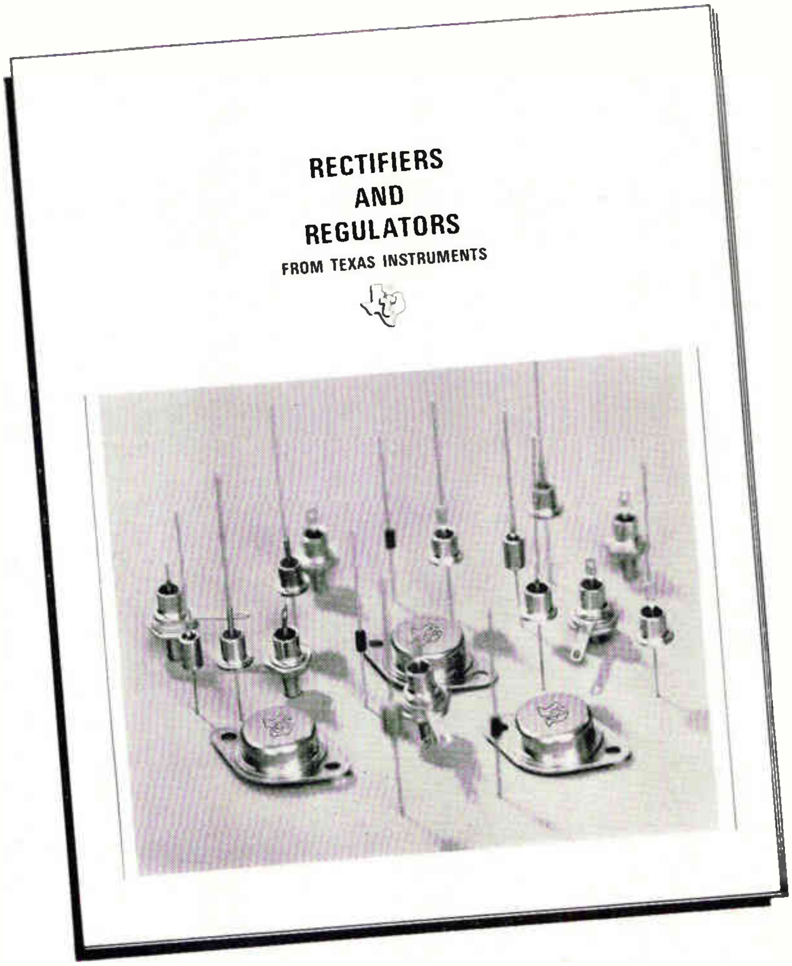
AVAILABLE FROM ALL CDE AUTHORIZED INDUSTRIAL DISTRIBUTORS

**Broad selection**

**Superior construction**

**Competitive prices**

**and fast delivery**




# ... four good reasons to call WEATHERFORD for TI rectifiers and regulators

You'll benefit in many ways when you order TI rectifiers and regulators from us. Our large stocks and personalized service mean fast delivery. Our prices — of course — are competitive.

In addition, you can get the exact performance you require from TI's broad selection. The TI line is shown in a new product bulletin.

This new bulletin (shown above) also describes the superior construction features that make TI rectifiers and regulators exceptionally reliable.

In addition, other new bulletins on TI power semiconductors are available for the asking. Circle the appropriate numbers on the Reader Service card for the bulletins you want.

- **Number 201 for TI Rectifiers and Regulators (shown above)**
- **Number 202 for Epitaxial Planar Power Transistors**
- **Number 203 for Regulator Interchangeability**
- **Number 204 for Transistor Interchangeability**

## R. V. WEATHERFORD CO.

NOW WITH CUSTOMIZED COMPONENTS
WEATHERFORD SERVICE PLUS

**DISTRIBUTORS OF ELECTRONIC COMPONENTS AND EQUIPMENT**

**ANAHEIM, CALIFORNIA**
1651 State College Blvd.
714-532-6741
714-547-7521

**GLENDALE, CALIFORNIA**
6921 San Fernando Road
213-849-3451

**PALO ALTO, CALIFORNIA**
3240 Hillview Drive
Stanford Industrial Park
415-321-5373

SALES OFFICES

**Albuquerque, N.M.**
505-298-5593

**Phoenix, Arizona**
602-272-7144

**Pomona, California**
714-966-8461 714-623-1261

**San Diego, California**
714-278-7400

←Circle 156 on reader service card

# THE NEW GENERATION


# SILVERLINE T.M.*

## *a new, superior line of Clifton Synchros*

**• Higher Accuracy. 5′ standard • Outstanding Repeatability of Calibration Pattern • Stability of Calibration over Temp. • 150°C Standard Operating Temp.**

Keeping pace with the developing aerospace field, Clifton announces SILVERLINE, a new, superior line of standard synchros. ☐ These units, a natural evolution from our present line of quality synchros, embody certain new manufacturing techniques and space age materials. The result is a standard synchro which outperforms present synchros in four distinct ways shown above. ☐ SILVERLINE synchros are in the field now. Call your local Clifton Sales Office for price, delivery and further information.

cppc CLIFTON
DIVISION OF LITTON INDUSTRIES

*Trademark of Clifton Division of Litton Industries

Circle 158 on reader service card

# Probing the News

Computers

## Computer firms stalked by their own shadow

They hope for a technological respite in which to recoup their investments, but are forced to press for new hardware

By Wallace B. Riley
Computer editor

**Time and technology** wait for no one, not even for those computer manufacturers who see a moratorium ahead in computer design—a pause that would enable them to recoup their heavy investments in the design and software of present systems.

One company that has been losing money steadily on its computer business—along with most of its competitors—while turning out machines by the hundreds is the General Electric Co.

Marketing men for GE's computer department in Phoenix, Ariz., contend that the operation will soon show a profit because computer technology has settled down. The rentals the company receives on installed machines can put it well into the black before those machines become obsolete, a company official asserts.

Other marketing men in the industry have voiced similar opinions in recent months [Electronics, Jan. 9, p. 145]. However, the new developments in memories and integrated circuits point to another round of hardware design.

### 1. Large-scale problems

Large-scale integration—the fabrication of many circuits on a single chip—is already pushing new computers onto the drawing boards. The commitment has been made in military and aerospace computers, and the bellwether of the commercial computer business, the International Business Machines Corp., is making LSI plans [Electronics, Feb. 20, p. 123]. Even GE's computer department has engineers plotting the use of such techniques.

Because of packaging constraints, the first commercial LSI computers are going to have internal wiring organizations that differ from the layouts in conventional machines. This situation will necessitate redesign outlays but isn't likely to render obsolete the basic software that has been laboriously developed. The big challenge is to reduce per-circuit costs while stepping up processing capacity.

But another goal, paradoxically, is to cut the user's software expenses—in ways that will increase the manufacturer's design costs and probably boost his software costs at the outset. GE estimates that the user spends 75 cents of every computer dollar on software, programing, and operation—an overhead that has caused some businesses to lose instead of profit by computers. A manufacturer's software expenses are pegged at 30% to 40% of total system cost.

Officials at GE consider the manufacturer's cost a positive problem—one caused by a surge of new computer applications—and contend that it's being solved by development of software libraries and applications packages.

**Firmware.** Nevertheless, engineers are starting to show in their work on small, high-speed memories—both magnetic and LSI—that hardware embellishment is an attractive way to reduce software. The new catchword is "firmware"—defined by Ascher Opler, executive director of Computer Usage Education Inc., as a collection of microprograms in a control memory. Such a collection combines hardware with the programs and routines—software—that utilize computer capabilities. According to Jack Peterson, director of technology at Scientific Data Systems Inc., firmware permits the building of program subroutines into read-only memories. These require careful software preparation. But once the software becomes hardware, the user has fewer programing chores and the speed and efficiency of the machine is improved.

Dan Cota, also of SDS, doubts firmware will become elaborate. "People won't pay for hardware that performs trivial functions like finding a square root. Software for such things was perfected years ago; and complex functions, like a hardware compiler for Fortran, just don't make sense."

Such firmware, however, is slated for military computers where a premium is put on high speed in a small package. The Autonetics division of North American Aviation Inc., for one, intends to use LSI look-up tables—memories that provide answers to recurrent prob-

NEW! DIGITAL PANEL METERS
0.1% ACCURACY


Shown ⅔ actual size

DIGIMETER
MODEL DM-25
$260
OEM discounts available

For every application where a conventional panel meter is inadequate
- AC or DC measurements
- Single or multiple ranges
- 1 uA to 1,000 A. full scale
- 10 mV to 10,000 V. full scale
- Other functions & ranges to order

Send for detailed literature

ABBEY ELECTRONICS CORP. AEC

2 Sixth St., New Hyde Park, L. I., N. Y. 11044
516 CH 8-8060

Circle 259 on reader service card

UNIVERSAL CALIBRATOR
Model MC-10

Fast, accurate calibration of panel meters, multitesters, oscilloscopes, vtvm's, other measuring instruments. Full accuracy without correction curves. Meter indicates directly the % Error in device under test. All solid-state. Meets MIL specs for temperature, humidity, vibration, shock, RFI.

AC & DC VOLTAGE: ±0.2%, 0-1000 volts in 1 millivolt steps, 0-20 mA load
AC & DC CURRENT: ±0.2%, 0-1 ampere in 1 microamp steps, 0-1 volt burden
RESISTANCE: ±0.1%, 0-1,000,000 ohms in 1 ohm steps

Send for detailed literature

ABBEY ELECTRONICS CORP. AEC

2 Sixth St., New Hyde Park, L. I., N. Y. 11044
516 CH 8-8060

lems—as a supplement to logic in airborne navigation and radar signal-processing computers.

Looking farther ahead, researchers such as Jack Goldberg of the Stanford Research Institute project functional memories that will require no external programing. Built-in LSI logic would enable the units to handle such data manipulations as associating, comparing, sorting, and coding; to perform matrix and vector operations; to prepare compiler programs; or to act as executive controls for multiprocessor systems.

"No one needs the increased speed badly enough to spend the money now," Goldberg says, adding that the economic tradeoffs between such liberal use of circuitry and more conservative organizations are still unclear. But he thinks the built-in logic will be used in systems that must make "life or death" decisions at the fastest possible speed.

**Reconfiguration.** Goldberg's own project at Stanford is a study of a reconfigurable system—one that won't stop when circuits fail, but will reorganize itself so that data bypasses the failed circuits.

A co-worker of Goldberg's, Sven Mahlstrom, is designing LSI arrays whose logic functions could be rearranged—not to reduce programing, but to allow the volume production of arrays for limited numbers of computers. [Electronics, March 6, p. 45].

Autonetics is toying with an approach that harks back to the early concept of computers as fairly intelligent machines rather than programed idiots. The approach combines the reconfiguration idea with another popular concept: the self-organizing system. If this method pans out, it would boost the volume of standard LSI arrays that could be used for special-purpose computers, and could also minimize programing.

The computer might be built in three parts, each composed of LSI arrays. Processing would be done in a general-purpose section with enough circuitry to handle a variety of problems. This kind of design is common in commercial computers but uncommon in special-purpose units. The central section would be a matrix of switching circuits, such as a diode array, while the third section would analyze input data to determine how it should be processed and would set up the processor through the switching matrix.

"We don't know if it can be done," says Richard Platzek, scientific adviser at Autonetics, "but it could solve custom-design problems and provide commonality in arrays usage." Multiprocessor designs may evolve from the concept, he adds.

One application under study is automated lie detectors, or polygraphs. Initial research on the learning process is being done by a psychologist, Platzek explains, since the machine would have to learn a subject's response pattern as he answers questions, and analyze the waveforms to determine if he has guilty knowledge. The way a seemingly innocuous question affects a person's breathing, for example, provides a clue to his knowledge of the answer.

## II. Spend to save

Commercial computer makers buy the firmware approach up to a point, but their interest in reconfiguration schemes remains academic—a word that was used to table the concept by Rex Rice of Fairchild Camera & Instrument Corp.'s Semiconductor division. He prefers firmware that's really firm.

Read-only control memories are used in several late-model computers to store rules for routing data when the machines receive instructions. Some allow the units to run programs written for a different type of computer. If the memories were electrically alterable, one memory would provide a computer with a library of such microprograms.

Reconfiguration, Rice asserts, would prevent the user from ever knowing what state the machine is in and would compound the software problem. More practical methods of using hardware to reduce software are available, he says, citing a paper that L.C. Hobbs, a consultant, gave at last year's Fall Joint Computer Conference.

Hardware, Hobbs held, could replace software for such functions as input-output control and editing, scheduling and storage allocation, and interrupt procedures, as well as conversions, scaling, lookup

 Circle 160 on reader service card 

tables, and data transfers within the computer. He went so far as to say that it would be cheaper to custom-design LSI computers than to provide general-purpose machines plus software. This would reverse the prevailing situation in the commercial computers field.

**Wrong tree.** Rice adds that designers who only want to reduce circuitry costs with LSI are barking up the wrong tree. Even if the arrays cost nothing, he says, they could only pare the cost of a typical general-purpose computer by 1.5%. The cost of silicon in a computer is so negligible, he contends, that the amount of circuitry could be doubled and total cost reduced.

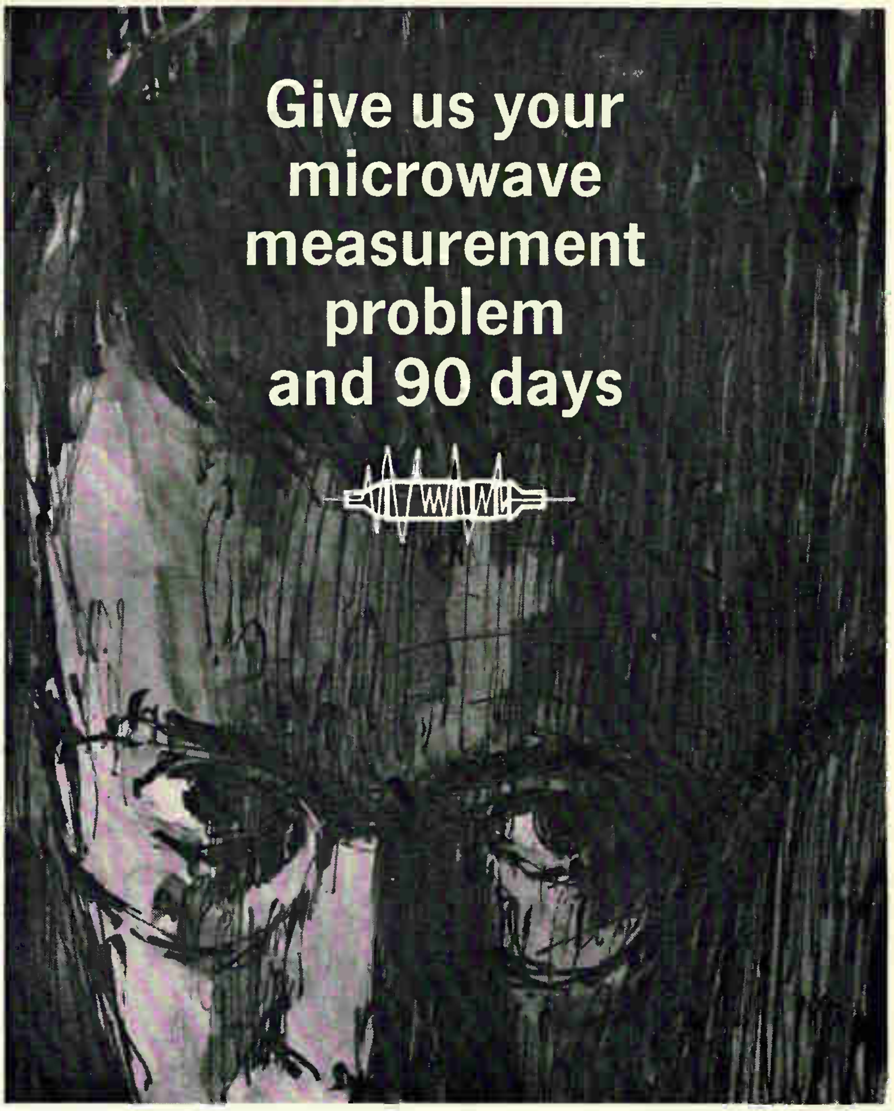
His figures are based on user expenses, about one-third of which go for problem-solving, another third for operations and housekeeping, and the balance for rental. Doubling the amount of circuitry, Rice calculates, would cut the first two expense categories in half—partly by eliminating such operations as language translation and punched-card preparation, and partly by increasing the capability of a system occupying a given facility. The doubling would also provide encoding and buffering circuits that would permit users at remote terminals and displays to time-share the computer.

The effect upon the manufacturer's cost would be trivial, Rice continues, because that part of the pie is further subdivided into circuit, design, software, servicing, and other expenses. The manufacturer may even find that the added circuit cost can be offset by a reduction in field servicing and in the software he supplies the user.

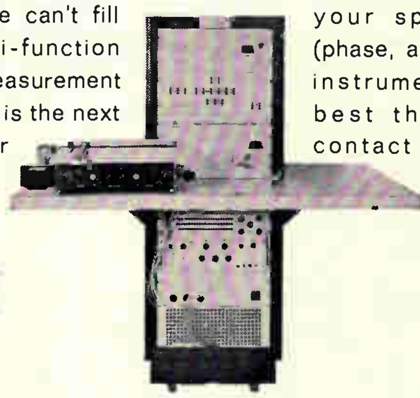
### III. Blinders at GE

But the resistance to change is summed up in a remark by a GE spokesman. "You need four- or five-year-old machines to make money, because of rental arrangements." The company could get its computer operation into the black now if it sold its rented machines, he says, but it can "turn the profit corner soon" without that maneuver.

The reason given is that GE has been making a full line of computers for more than two years. There has been nothing basically new in




**We'll probably give you the answer off the shelf,** with 60 days to spare; but if your problem is really out of the ordinary, we'll build you something like the ETS-24. ☐ That's one below. Designed for a video detector production line, the ETS-24 Test Set automatically measures and records noise output, tangential sensitivity, and detected pulse height in less than one minute — sweeping across more than an octave. (Accuracy: tangential sensitivity, 0.8 db; video output voltage, 2%.) Two of these sets are in New Hampshire right now, testing 500 units a day each. Rantec designed, built, and delivered them in 90 days. ☐ Producing precise microwave test equipment is one of our specialties; delivering it fast is another. If we can't fill your specs from our standard line of multi-function (phase, amplitude, impedance) and time-delay measurement instruments, our quick-response design service is the next best thing. ☐ Write us your requirements, or contact the nearest office listed below.

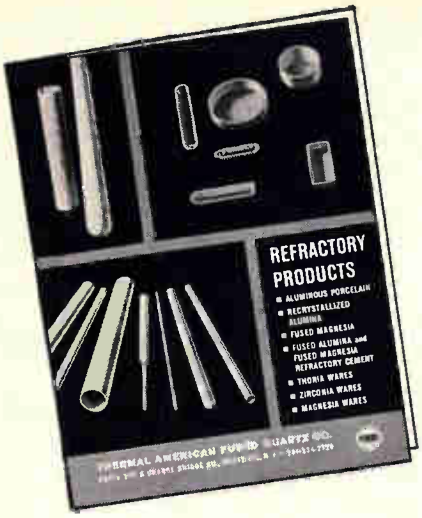


rantec®
A DIVISION OF EMERSON ELECTRIC

*See us at the IEEE Show — Booth 2J09*

Rantec Home Office: 24003 Ventura Blvd., Calabasas, Calif. 91302 • (213) 347-5446 • TWX 910-494-1218
Eastern Regional Office: 910 Fox Chase Rd., Rockledge, Phila., Pa. 19111 • (215) 728-7500 • TWX 510-665-4176
Northeastern Dist. Office: 1762 Mass. Ave., Lexington, Mass. 02173 • (617) 861-0502 • TWX 710-320-0203

Circle 161 on reader service card




# FREE

## SELECTOR CHART FOR REFRACTORIES

This Free New Selector Chart / Brochure describes a line of crystalline oxide refractory and insulating ware for use by industry and laboratories. These new products are designed for high resistance to heat, low reaction with metals and chemicals, low porosity and high thermal conductivity. The Selector Chart provides instant technical, mechanical and application data for apparatus made of Aluminous Porcelain, Recrystallized Alumina, Thoria, Zirconia and Magnesia. Write for your copy today.

57

VITREOSIL VITREOUS SILICA

THERMAL AMERICAN FUSED QUARTZ CO.
RT. 202 & CHANGE BRIDGE RD.
MONTVILLE, NEW JERSEY
ZIP CODE 07045


computer technology for three years, the official says, and the basic hardware concepts should remain stable for another five to 10 years.

Shipments of the company's Model 600 multiprocessors began two years ago. The latest, the 645's, are developmental time-sharing systems with such features as small, solid-state associative memories. One has gone to Bell Telephone Laboratories and another to the Massachusetts Institute of Technology for its multiple-access computer project.

Third-generation machines are either being built or designed by all the major computer companies.

The 600's are backed up by the 200 series, of 1960 vintage, and the three-year-old 400's. A best seller is a late-model 200—the 265. This is a 235 refitted with a Datanet 30 communications system that allows the computer to be used by 35 to 40 terminals. The Phoenix plant, which has a work force of 6,000, is crammed with computers being built or updated.

The company is now concentrating on rounding out its software collection for these systems and improving their components, memories, and peripheral equipment. Engineers at the Phoenix plant are redesigning the computers, for example, so that integrated circuit logic can be substituted for the transistor circuits that are now used in all the company's business computers. "It will be a one-for-one logic replacement," says Robert Patrow, manager of planning in the manufacturing department.

At GE's process-control computer plant, also in Phoenix, the manager, R.C. Berendson, also thinks computer design is stabilizing. "The time between process-control computer series has been about 18 months in the past," he says, "but we hope this one will last us four or five years." He is referring to the 4020, an integrated-circuit computer in production for about a year. As of January, 82 of these were sold and they now account for 90% of GE's process-control sales.

Berendson, too, is stressing software development. "Almost any manufacturer can compete on hardware," he says. "The real problem is to reduce software costs." To do this, routine program sections, such as typewriter input, are being standardized and a new process-control language is being developed.

Despite the official silence at GE, design studies of LSI computers are already being made. "If you plan on making 1,000 computers, you better plan on LSI or you are in trouble," remarks W.H. Howe, a consultant in the computer department.

Redesign is necessary, he points out, because LSI efficiency requires a repartitioning of the logic to achieve larger circuit groupings. "For example, if a machine has eight registers you look for flip-flops and gates around the register, and the LSI design becomes almost synonomous with a small memory." If only a small number of machines—say 100 in three years—is to be built, he continues, LSI can be made economical by directing system design toward memory-organized data paths and table lookup rather than logic.

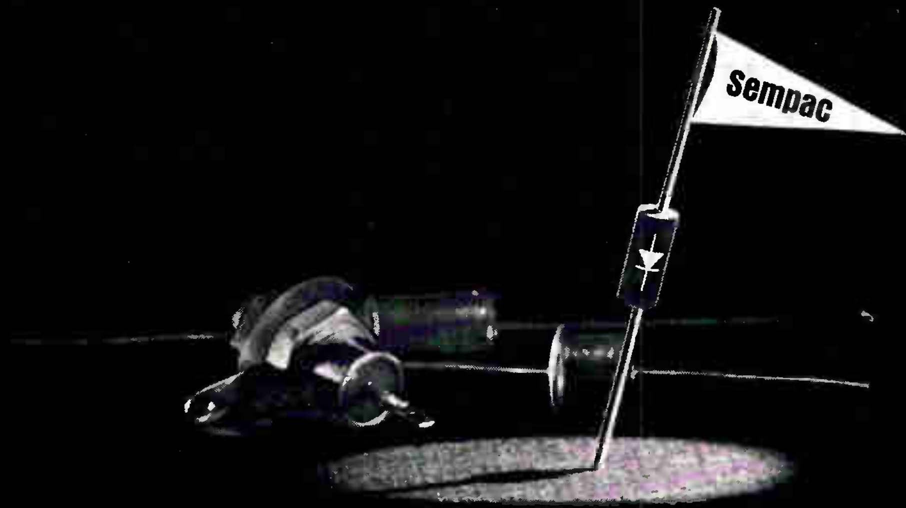
### IV. Howe's way

Howe is urging a reversal of the standard method of driving logic signals through circuitry—driving one circuit with another. He proposes transmitting low-level signals and putting metal-oxide semiconductor amplifiers on the receiving array. This technique, he says, would minimize noise and power-dissipation problems, and cost to "next to nothing." Voltages could be dropped from about 5 volts to 50 millivolts if 50-ohm transmission lines were used.

"I think all the sweat about power drivers will become academic," Howe says, referring to efforts to lower or dissipate driving power in LSI arrays. An MOS-bipolar combination in arrays, already under development by semiconductor manufacturers, would need only microwatts of power, he contends.

Multilayer boards are essential for interconnection of arrays, he goes on, to provide a fixed transmission media. He expects clock cycles to jump to around 200 megahertz, compounding present problems of synchronizing logic operations [Electronics, Nov. 1, 1965, p. 88]. Delays can be adjusted, Howe believes, by fabricating the equivalent of microwave delay lines—

N5198
N5199
N5200
N5201




# The NEW CHAMP
## 3 amp 55°C / No heat sink

6 amps if mounted per MIL-STD-750A

Semtech's multi-purpose, high current, axial lead, silicon rectifiers are designed to eliminate packaging problems associated with lead mounted metal cans and stud rectifiers.

Packaged in fully insulated "SEMPAC" cases the units are light weight, small (.375" long x .195" diameter), and easy to install.

Available in PIV ratings from 50 to 600 volts with a low reverse current of 10μA @ 25°C, an average rectified current of 3 amps at 55°C. NO HEAT SINKING required and a one cycle surge rating of 300 amps.

Equal area heat sinking is provided on both sides of the silicon junction with *Tungstaloid* pins which match the thermal expansion characteristics of the silicon. The junction, *Tungstaloid* pins and solid silver (.40") leads are bonded above 900°C.

No solders or whiskers are used in the construction of the rectifiers.

For more information contact your nearest representative and ask for Technical Bulletin No. E44. Economically priced, the units are available in large quantities.

**SEMTECH CORPORATION**

**Western Office:** 652 Mitchell Road, Newbury Park, California, (805) 498-2111/from L.A. (213) 628-5392/TWX 805-499-7137
**ional Offices—Central:** 140 North La Grange Road, La Grange, Illinois (312)-352-3227 **Eastern:** 71 West 23rd St., New York, N.Y. (212) 989-7550/TWX 212-640-5060
**European Sales:** Bourns A G, Alpenstrasse 1, Zug, Switzerland (042)4 82 72/73

# Here's a Great New Way to Buy Silicon DC Power Modules

MODEL
LC322
5" x 5" x 7"

## *Introducing ERA's All-New, Wide-Range, Variable, 71°C, All-Silicon, Fully Repairable DC Power Modules at Exceptionally Low Prices*

ERA's new Value-Engineered DC Transpac® power modules provide, for the first time, all-silicon, high performance DC power in a wide range, variable, *low cost* module.

All units can be set to desired voltages by a simple external tap change and users will find that a single model can serve many voltage requirements. Stocking problems are reduced to a minimum and power module obsolescence is practically eliminated.

| Output Voltage (DC) | Current 71°C | Size WxDxH (inches) | Weight (lbs.) | Model | Price |
|---|---|---|---|---|---|
| 4-32 | 0-750 MA | 4 x 4 x 6½ | 6.2 | LC32P7 | $ 89.00 |
| 4-32 | 0-2 amps | 5 x 5 x 7 | 8.5 | LC322 | $115.00 |
| 4-32 | 0-5 amps | 6¾ x 8½ x 7¼ | 16.8 | LC325 | $179.00 |
| 4-32 | 0-10 amps | 8¾ x 9½ x 7½ | 29.0 | LC3210 | $215.00 |
| 30-60 | 0-1 amp | 5 x 5 x 7 | 8.5 | LC601 | $145.00 |

Over-Voltage Protector Option: Add $35.00 to above prices and Suffix V to Model No. (i.e. LC325V, etc.).

### SPECIFICATIONS

**Input:** 105-125 VAC, 50-400 cps
**Ripple:** Less than 800 microvolts RMS or .005%, whichever is greater
**Line Regulation:** Better than ±0.01% or 5 mv for full input change
**Load Regulation:** Better than 0.05% or 8 mv for 0-100% load change
**Voltage Adjustment:** Taps/screw driver adjustment
**Short Circuit Protected:** Automatic recovery
**Vernier Voltage:** External provision
**Transient Response:** Less than 50 microseconds
**Operating Temperature:** —20°C to +71°C free air, full ratings
**Maximum Case Temperature:** 130°C
**Temperature Coefficient:** Less than 0.01% per degrees C or 3 millivolts
**Long-Term Stability:** Within 8 millivolts (8 hours reference)
**Remotely Programmable**

WRITE TODAY FOR CATALOG #147

**ELECTRONIC RESEARCH ASSOCIATES, INC.**

Dept. E-3, 67 Sand Park Road, Cedar Grove, N. J. 07009 • (201) 239-3000

SUBSIDIARIES: ERA Electric Co. • Advanced Acoustics Co. • ERA Dynamics Corp. • ERA Pacific, Inc.


meandering etched wiring paths in the multilayer board.

The ways LSI will be used military computers will largely determined by the Air Force's yea old "computer on a slice" proje A total of $4.5 million is being spe to see how many circuits can put on a chip and how LSI logic a memory should be partitioned. this amount, $2.9 million is Force money and the rest is bei invested by the three contracto according to the project office Howard Steenbergen and Rob Werner of the Microelectron Laboratory at Wright-Patters Air Force Base.

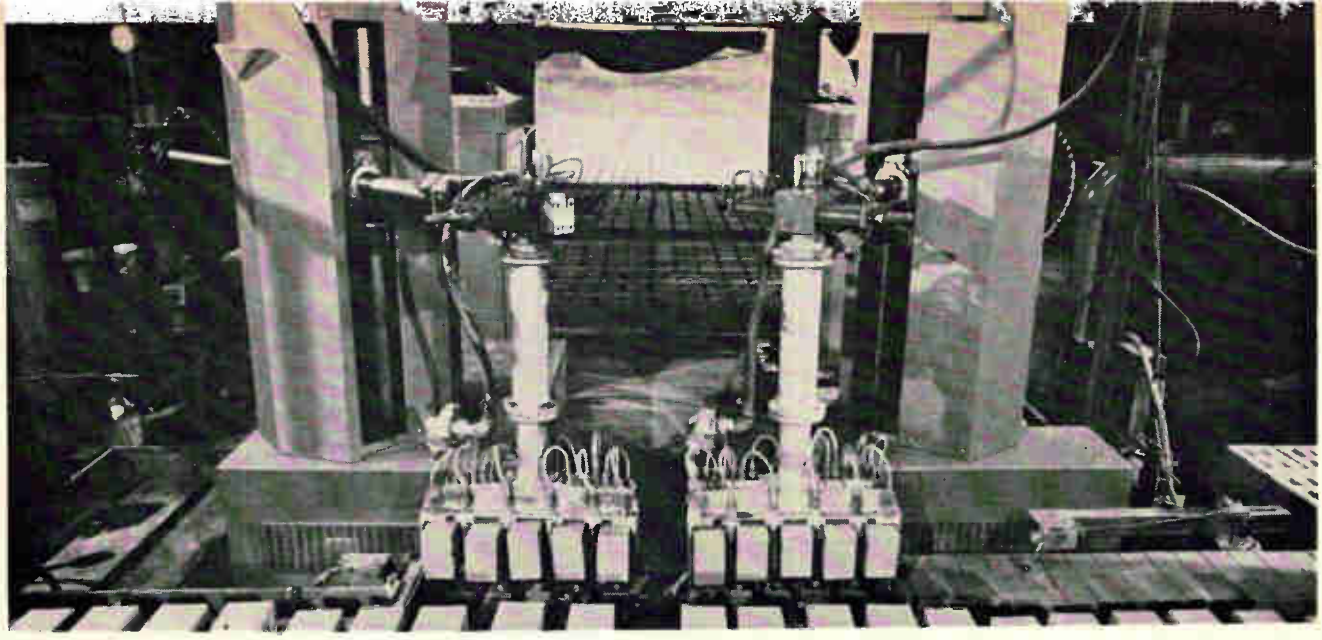
Texas Instruments Incorporat is building a radar computer [Ele tronics, Feb. 20, p. 143] with polar IC's and a discretionary w ing approach, the Radio Corp. America is making a navigation a guidance computer with fixed-w ing bipolar logic and a comp mentary MOS memory, and t Philco-Ford Corp. is making inertial-guidance computer w MOS arrays.

The units are being built to d termine the usefulness of each ty of approach, but they will be wor ing systems for the Air Force they prove successful. The syste designs are being kept loose explore the different process tec nologies.

Up to about 500 circuits will put into each LSI array, with t average about 150 to 200. Initial the goal was up to 1,000 circu per chip, but partitioning studi have shown this kind of crowdi won't be necessary.

One of the most important fin ings to date is that LSI memori aren't going to scramble their co tents if system power fails. Th volatility problem was once co sidered a major stumbling blo to the use of LSI for computer me ories.

Integrated circuits are still vol tile, but complementary MOS c cuitry requires only tiny amour of standby power to overcome cu rent leakage; this can be provid readily by a small battery in th computer. Leakage is only in th microampere range, because wh complementary devices are plac in series in the memory circuits, least one device in each circuit always cut off.



Industrial electronics

# Robots are ready to grapple with dirty jobs in factories

The machines, basically mechanical arms linked to memories, are about to shed their science-fiction image for production-line roles; even labor unions don't begrudge them their dull and dangerous tasks

By Alfred Rosenblatt
Industrial electronics editor

**They aren't taking over**—yet—but robots are ready to step into places on production lines around the world. After about five years of being little more than experimental curiosities, the machines—basically mechanical arms with a memory—seem past the evaluation stage and in line for an increasing number of industrial applications.

Within five years there should be at least 5,000 robots working tirelessly in various U.S. industries, according to Joseph F. Engelberger, president of Unimation Inc., one of the two major domestic manufacturers of robots. Right now, there are only about 75 handling on-line production tasks.

Samuel Z. Shoshan, marketing manager of the Versatran division of the American Machine & Foundry Co., the other major maker, predicts that within 20 years there will be as many as 50,000 robots at work in this country.

"Most of the companies that first tried the robots were worried sick over union objections," concedes Jule F. Harrah, sales manager for Unimation. "However, the great surprise has been that there have been no objections at all."

**Hazardous duty.** This is because the robots are designed for jobs that humans would rather not do, Harrah explains. They're working in hot and hostile environments, reaching into high-temperature glazing kilns or molten-metal forging machines, and handling dull repetitive jobs humans are glad to be rid of.

A spokesman for the United Steel Workers of America remarks: "In general, we don't oppose the use of these devices. We don't believe anyone can stand in the way of this kind of progress."

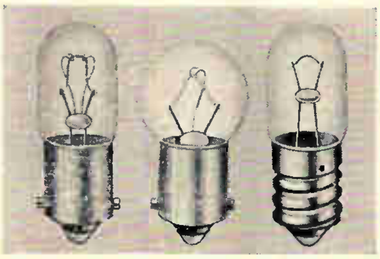
This kind of progress is finding its way into electronics plants. One manufacturer of television tubes has used a machine to transfer tube face plates from one conveyor belt to another. Other applications under investigation include the use of robots to pick up and insert components into x-ray test devices. Robots may also be used to install electron guns in the necks of tv tubes.

But the machines have enjoyed their widest acceptance in heavy industry. They are being used in forging, die casting, plastics molding, spot welding, paint spraying, and kiln loading. Roughly half of them are toiling in some area of the metalworking field or related industries.

Among the corporations that have purchased one or more indus-

## Miniature Indicator and Panel Lamps

**For better, more readable light**



Superior bulbs for aircraft, automotive and other instrumentation, as well as commercial radio and television applications. Design volts from 2.0 to 28.0. Candlepower to 6.0.

*For complete information, write:*
Hudson Lamp Company
526 Elm St., Kearny, N. J. 07032

Circle 500 on reader service card

## Sub-Miniature Lamps

**Space-savers for aircraft and indicator applications.**

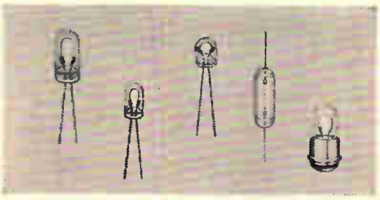
Sophisticated bulbs available in a wide range of base styles including the well-known "Tu-Pin" (originated by Hudson) for transistor and soldered connection sockets and fast plug-in on printed circuit boards.

*For complete information, write:*
Hudson Lamp Company
526 Elm St., Kearny, N. J. 07032

Circle 501 on reader service card

## Micro Miniature Lamps

**Lifes from 25,000 to in excess of 100,000 hours**



The ultimate in miniaturization in lamps for electronic applications, including transistorized circuitry, punch-card readers, computer tape readouts and photoelectric logic systems. Wire terminal or sub-midget flanged bases. Sizes from .093 dia., as short as .0145 in.

*For complete information, write:*
Hudson Lamp Company
526 Elm St., Kearny, N. J. 07032


trial robots for evaluation are the Corning Glass Works, the Ford Motor Co., the Chrysler Corp., the General Motors Corp., and the Chambersburg Engineering Co., a metalworking concern.

### I. Image problem

Industrial robots essentially are designed to transfer materials from one place to another. Some companies, sensitive to the name robot and its pejorative connotations, have taken to calling these machines "universal transfer devices."

The word robot is from the Czech *robota*—for compulsory service or work. It came into the English language during the 1920's with the production of Karel Capek's play, R.U.R. (Rossum's Universal Robots), a drama dealing with a revolt of efficient but insensitive automatons in a futuristic state.

Working industrial robots are analogous to their literary forebears only insofar as they can do useful jobs. They have no intelligence enabling them to make decisions affecting their own actions. Strictly materials handlers, the machines differ radically from the discriminating, artificial intelligence systems now under investigation at such places as Stanford University and the Massachusetts Institute of Technology.

**Modifying claws.** Industrial robots have an easily programed memory that directs a movable arm through a servoed, hydraulic control system. Various kinds of fingerlike mechanical grippers can be placed at the end of the arm, depending upon the shape of the object to be transferred. Vacuum cups to hold onto the delicate glass of television tubes are also available.

Depending on their options, the robots cost anywhere from $17,500 to $25,000, with up to 40% of this price going for electronics. Most are transistorized, although some tubes are still used in the higher-powered circuits. In the near future, silicon integrated circuits will probably be introduced into as much of the digital circuitry as possible to reduce costs.

Those marketing the machines are still a pretty select group—AMF's Versatran division, Unimation, a joint venture of Pullman Inc. and the Condec Corp.; and the Autobot Co. of Katonah, N.Y. Guest Keen & Nettlefold Ltd., a British concern, has been licensed by Unimation to sell machines in Western Europe, and Hawker Siddely Dynamics Ltd., another British company, has an agreement to market AMF's devices.

Once placed in position on a production line, the mount and memory unit of a contemporary robot are stationary; only the arm moves. However, unlike special-purpose tools designed to go through a prescribed series of motions to accomplish a single task, the robot has some flexibility because of its programable memory. The memory can move the arm through an infinite number of points.

Unimation and Versatran robots get on-the-job training. After an operator uses an auxiliary teaching control to guide the unit through the desired sequence of work positions, the motions are stored in the memory and the robot is turned loose to operate as directed.

### II. Controls

Arms are controlled to work either continuously through all points in a programed path—as in an application where paint must be sprayed uniformly over a large surface—or from one point to the next, with tasks to be performed only at the points themselves.

Unimation makes only a point-to-point machine, called the Unimate, while AMF offers Versatran robots in either point-to-point or continuous-path versions. Most applications will probably involve the less complex point-to-point design.

Unimate is a larger machine than the Versatran models. It weighs about 3,500 pounds, has a 7½-foot reach, and can carry a 25-pound payload at top speed, swinging through a 220° arc in two seconds. Its memory and arm are part of a single unit. The arm can come back to the same position with a repeatability within 50 mils.

Versatran comes in two parts—a 300-pound memory and control console, and a 1,300-pound arm unit. Pivoting on a radius about half as long as Unimate's, Versatran has a normal payload of 20 pounds. Its positioning repeatability is 125 mils; swing speed is roughly comparable to the Unimate's. Both machines can lift

 Circle 502 on reader service card 

# An Ace on every Mission

Mark up another score when a Licon® environment-free sealed switch is specified. You get the same reliability and long life on a light plane panel as you do when you've got a hot jet dropping its landing gear or dropping its ordnance. A whole line of military approved and performance tested switches are detailed in this new book. **Take a look at it.** Send for your copy now.

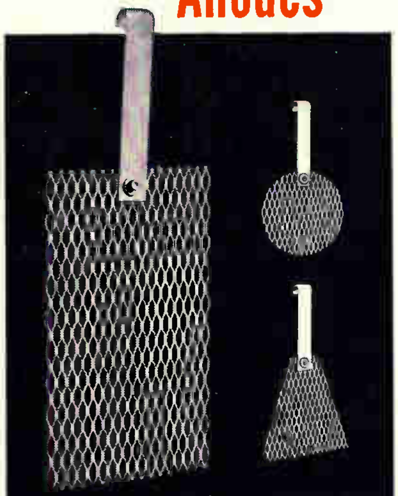
***Strike hard with LICON... fastest growing full-line switch supplier***

**itw LICON**
DIVISION ILLINOIS TOOL WORKS INC.
6615 WEST IRVING PARK ROAD – CHICAGO, ILLINOIS 60634
*"Remember, you're never more than a few feet away from a product of ITW"®*

A McDonnell Phantom photo

Exclusive Bishop Process adds years of service life to

**Platinized Titanium Anodes**



*Bishop Platinized Titanium Anodes can be custom-made to specifications for superior plating.*

**BISHOP PLATINIZED TITANIUM ANODES,** the top-quality anodes available today, give you . . .

- **LONGER LIFE WITH MAXIMUM CONDUCTIVITY** (100 microinches of highest quality platinum distributed uniformly over Titanium)
- **PURITY OF DEPOSIT** (no binder to dissolve, no contaminates to codeposit with the gold)
- **CORROSION RESISTANCE** (impervious to action of acids, alkalies and cyanide solutions)
- **VERSATILITY** (available in expanded mesh or new closed mesh for increased surface area)
- **CHOICE OF TABS** (welded or bolted . . . two tabs on sizes 6 in. and larger give maximum contact and stability)
- **CHOICE OF SIZES** (order any size or save by selecting regular 6 in. x 12 in., 6 in. x 18 in., 4 in. x 12 in., or 4 in. x 18 in. sizes)
- **RENEWAL** (Bishop will replate *any make anode* with required amount of platinum)

*Bishop Platinized Titanium Anodes are recommended and supplied by:*

**AMERICAN CHEMICAL AND REFINING CO., INC.**
Waterbury, Connecticut

*We also manufacture Precious Metal plating solutions and reclaim them. For technical bulletins, write to:*

**J. BISHOP & CO.**
**PLATINUM WORKS**
Chemical Products Division/Platinum Chemical Department
**MALVERN, PENNSYLVANIA 19355**
*Tel: (215) 644-3100*
*A Johnson, Matthey Associate*

more weight at slower speeds.

The memory techniques used in the two machines differ markedly. Unimate stores information on a specially designed magnetic drum. The Versatran point-to-point machine stores analog position information in a bank of potentiometers, while the continuous-path model uses magnetic-tape storage.

**Commands.** Data is stored in Unimate's drum as a flux polarity, so the drum remains stationary while being read. Readout is nondestructive. Eighty bits of information, read in and out in parallel, contain sufficient information to move the arm through five axes of motion. There are also enough bits to control or sense external operations that must go on at the same time the robot is doing its primary work. The arm is positioned in space around three axes of motion, while the grippers' wrist-like motion swivels around two more axes.

Digital shaft encoders on each motion axis sense the arm's position. When their readout is compared to the position specified on the drum, the difference generates an error signal that is amplified and fed to servo-valves driving hydraulic actuators. When the five servoloops have reduced position errors to zero, and all auxiliary functions have been completed, the drum is indexed one step by a stepper motor and the next memory readout is compared with the output from the encoders. Two hundred sequential commands can be stored on the drum.

The Versatran point-to-point machine stores information in a bank of 36 potentiometers. Three axes for positioning the arm are under servocontrol so that there are three potentiometers for each point. Twelve points can be specified at a single control console.

Phase-discriminating circuitry compares the phase of an a-c signal across each potentiometer with the phase across 400-cycle resolvers on each axis, and an error signal activates hydraulic valves until the arm is in its commanded position. Commands for the grippers—open, close, swivel up, swivel down, and pause for external signals—are programed on a matrix pin board for each point.

The continuous-path Versatran uses five-channel magnetic tape to store pulse-width modulated signals fed from resolvers. Two separate tape decks are used; one rewinds while the other moves, at either 7½ or 15 inches per second, controlling the motion of the robot.

### III. Prospects

Versatran is developing a modified memory for its point-to-point machine, according to Shoshan. It has only 18 potentiometers, but one set of three can be used to specify the same point more than once. Perhaps borrowing a bit from Unimate, this new Versatran stores sequence steps mechanically on a drum. Raised tabs placed in slots along the drum close switches that call in combinations of potentiometers. The memory will be expandable in modules of 18 potentiometers.

Integrated circuits will undoubtedly by introduced into the robots in the near future. With the speed of the IC's, separate logic boards for each axis in a digitally controlled robot, for example, won't be needed. Instead, a single board will be time shared for all axes.

**Eyes, maybe.** Even further in the future, are refinements that will enable a robot to move about the factory floor and, in a rudimentary way, see. Two-armed robots are also a possibility.

Versatran's Shoshan also sees such innovations as a central computer station to control several robots, or the use of robots as automatic tool changers on numerically controlled machinery. Modularized units are also a possibility, he says, with basic subsystem kits being used to modify robots for additional or more complex tasks.

To ease any worries about clanking monsters, Maurice J. Dunne, Unimation's chief engineer, notes that "in anything we add to the robot, we're going to stick with what's already available and not mix in any science fiction."

"We would like the robot to be able to pick up a part that hasn't been oriented properly by special fixtures," Dunne says. "Probably it will use some sort of mechanical feelers or even an optical pattern-recognition scheme. Our interest now is to keep up with the field and see how we can tie a development in when it's far enough advanced."

MILGRAY

# RED-TAG SERVICE

**Should we have made it green?**

Some of our own people had misgivings about our red-tag idea. "Bad move!" they said. "Play it cool with Green for Go" they argued. "Red isn't a starter, but a stopper!"

And that decided it.

Because *nobody* around Milgray stands still when your orders arrive. *All your orders are handled with red-tag urgency.*

Routine requirements for in-stock items are shipped the same day. And, when you need it, we can ship emergency orders for any in-stock quantities within 45 minutes.

But probably most important of all, we like to think of the red tag as a constant reminder to ourselves . . . that the best way for Milgray to stay in the black is to see lots of red.

MILGRAY

MILGRAY / NEW YORK / 160 VARICK ST. / N. Y., N. Y. 10013 / 212-YU 9-1600 / NEW JERSEY 201-HE 2-4300 / TWX 710-581-5808 / TELEFAX-FQF
MILGRAY / DELAWARE VALLEY / 2532 N. BROAO ST. / PHILA., PA. 19132 /215-BA 8-2000 / CAMDEN, N. J. 609-WO 6-7750 / TWX 710-670-3400
MILGRAY / WASHINGTON / 5133 LAWRENCE PLACE / HYATTSVILLE, MARYLANO 20781 / 202-864-6330 / BALT. 301-727-1870 / TWX 710-826-1127
MILGRAY / CLEVELAND / 1821 EAST FORTIETH STREET / CLEVELAND, OHIO 44103 / AREA CODE 216 881-8800 / TWK 810-421-8573
MILGRAY / INTERNATIONAL / 160 VARICK ST. / NEW YORK, N. Y. 10013 / TWX 710-581-5808 / TELEFAX-FQF / CABLE-MILGRAYEL-NEW YORK
ENTERPRISE AND ZENITH NUMBERS IN LEAOING INOUSTRIAL AREAS



Circle 327 on reader service card


## *Total Systems Responsibility*

Look to COMCOR . . . to accept total responsibility in designing and building the world's largest hybrid computer systems — similar to the one shown below, now under construction for Lockheed Missiles & Space Company, Sunnyvale, California.

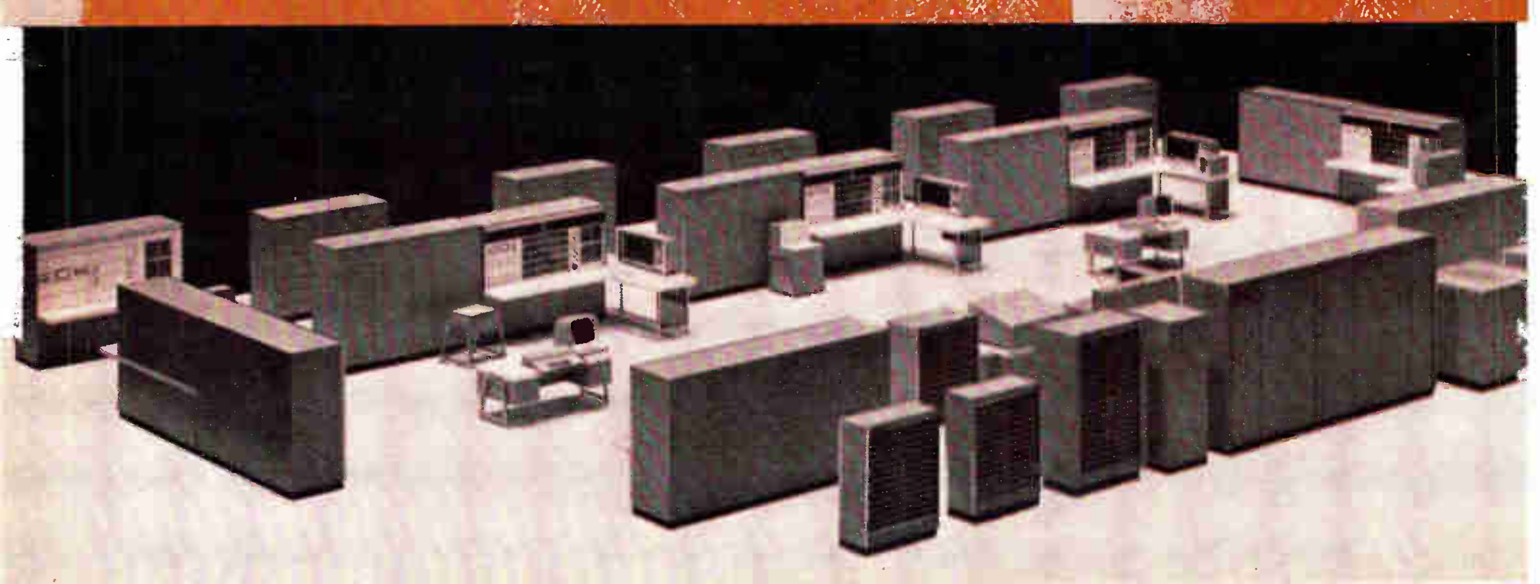
Look to COMCOR . . . mathematicians, applications engineers, logic designers, analog and digital specialists, programmers, and software people; experts with the knowledge to assume complete systems responsibility from logic design, through critical interfacing, to final assembly.

Look to COMCOR . . . backed by the corporate facilities of Astrodata, renowned for its leadership in large complex computer systems.

Look to COMCOR . . . whose precise combination of talents and facilities has made it responsible for the majority of large hybrid computer systems in existence today.

**COMCOR INC.**

A Subsidiary of Astrodata, Inc.
*1335 South Claudina Street / Anaheim, Calif. 92803*

# No wane in brain drain

## Stepped-up overseas recruitment by U.S. electronics firms has provoked angry reaction in European capitals

**Much to the dismay** of Europe, talent-hungry American electronics firms, scrambling for engineers, are stepping up their overseas recruitment efforts with measurable success.

With almost 5,000 foreign engineers flocking to U.S. shores last year, compared with 3,400 in 1965, an alarm has been sounded that is being heard on both sides of the Atlantic. A nationwide sampling indicates that the electronics specialists are coming in at a faster pace than the engineering group as a whole.

In London, in Bonn, and in other Western European capitals, officials are growing more and more concerned about the incursions of American recruiters. The clamor could result in governmental action to halt the exodus of skilled personnel. The repercussions are being felt in Washington, too. Congress is now weighing possible legislation aimed at easing Europe's increasingly serious plight.

Despite the uproar in official circles, European engineers—particularly Britain's prized electronics specialists—are increasingly more receptive to the attractive propositions being put to them by representatives from a swarm of American companies.

**Some of the 100-odd U.S. firms recruiting abroad**

- Admiral
- Ampex
- Avco
- Bell Aerosystems
- Bell Aerospace
- Bendix
- Boeing
- Components Corp. of America
- Conductron
- Data-Control Systems
- Douglas Aircraft
- Fairchild
- General Dynamics
- General Electric
- General Precision Equipment
- Honeywell
- Lenkurt Electric
- Lockheed
- National Company Inc.
- Philco-Ford
- Radio Corp. of America
- Sangamo Electric
- Sprague Electric
- United Aircraft
- Westinghouse
- Xerox

### I. Domestic shortage

While U.S. firms are somewhat reluctant to discuss overseas recruitment, most agree on the reason for it: an acute shortage of engineers. According to a recent Government manpower survey, U.S. industry will require 69,000 engineering graduates of all types annually through 1976. But, the study shows, colleges are only turning out 35,000 each year.

"We recruit abroad because the labor market here doesn't supply what we need," says Robert Conboy, technical employment manager at the Xerox Corp. "Demand is far greater than the supply."

Just back from a successful recruiting trip to London, Walt Kelly, employment manager at the General Electric Co.'s Communications Products division in Lynchburg, Va., says: "I hired 10 in 1962 and went back again last month for telecommunications engineers. Out of 35 interviews, I made 11 offers and got seven new employees. With talent scarce, I'm going to Germany, too."

Another who has recently returned from London is Joseph J. Simms, employment manager at Philco-Ford's Western Development Labs in Palo Alto, Calif. He interviewed 52 prospects, offered jobs to 21, and expects 16 or 17 to say yes. "We have very exact requirements and are hiring in the fields of microwave, circuit design, display, logic design, computer programing, and digital systems," he says.

While most firms are concentrating on Britain in their recruiting efforts, others are turning to the Continent. The Avco Corp.'s Electronics division recently hired 25 European engineers. Says Herman Burgett, the division's industrial relations director: "We went to England, Denmark, Sweden, and Holland looking for electronics engineers in communications, radar, space, and infrared because we can't find enough here."

Stockholm, Stuttgart, Zurich, Milan, Paris, London, and Glasgow were on the recent itinerary of Don Maguire, employment manager at the Lenkurt Electric Co., a subsidiary of the General Telephone & Electronics Corp. Seeking engineers experienced in pulse-code modulation and telecommunications, he hired 11 of 130 applicants. Lewis Corwin, the General Dynamic Corp.'s personnel director, who also has hired in Britain, has even turned to South America in search of talent.

**Costs less.** Some companies claim hiring abroad saves money. "We feel that it's less expensive to go to England than recruit from the East Coast," says John Doolittle, personnel manager at the Ampex Corp., Redwood City, Calif. "We set a limit on what we're going to pay. The people over there are very anxious to get here so they'll accept our relocation offer."

Don Clement, professional placement manager at Avco's Lycoming division, Stratford, Conn., agrees: "In most cases it's cheaper to get a foreign engineer to Connecticut than to bring [in] a guy from California." He has hired 100 European engineers in the past year.

Charles Maynard, professional employment supervisor at the Westinghouse Electric Co.'s defense and space center, believes that the European is better equipped, technically. "The engi-

←Circle 170 on reader service card

neers are of a very good quality. They seem to be a bit more specialized than the American engineer and the ones at a bachelor [degree] level are a bit better educated."

### II. Methods of recruiting

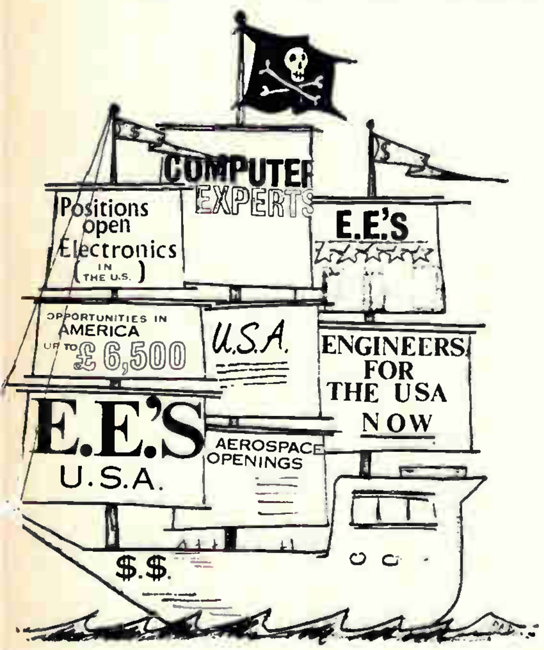
Companies use a number of methods in recruiting overseas.

Some, including the Radio Corp. of America, have used the do-it-yourself approach. Xerox also has tried going it alone. Last year, the company placed advertisements in the British press before sending its recruiting team to London. But, says Conboy, "we only got 16 last year. Since we need more this time, we're using an agency when I go again in April."

Most firms are turning to professional employment agencies in their search for talent, but not all for the same reasons. Many firms, for example, are concerned about possible adverse publicity because of their overt raids. This is particularly true of companies selling consumer goods in foreign markets. Another reason: most firms in the highly competitive electronics and aerospace fields want no publicity about any corporate activity.

Perhaps the major reason for the use of employment agencies is that they perform an essential function economically by screening out persons the companies wouldn't be interested in hiring.

Two agencies finding favor with electronics firms are Careers Inc., New York City, and Interstate Staffing Inc., Bala-Cynwyd, Pa.




William A. Douglass, Careers Inc.'s president, has recruited about 500 engineers from overseas in less than two years. Dubbed "Mr. Drain Brain" by the British press, he admits to being responsible for routing some of Britain's most promising talent into American hands. Douglass is just back from London, where, together with 20 representatives of U.S. firms, he contacted 1,400 engineers and technicians. Of these, he estimates 50 will be hired. This was his seventh trip abroad, with number eight coming up next month.

Interstate Staffing, founded by Adam C. Sugalski early in 1965, is also active overseas. "We recruit for 64 clients," says Sugalski. "We have placed over 60 engineers from England since November and have as many pending. We differ from Careers in that we research and then send out personal letters to prospective recruits." Sugalski is just back from a London trip on which he squired recruiters from four U.S. companies. Next month he is off to London, Montreal, and Toronto.

Another indirect overseas recruiting approach is taken by such firms as Texas Instruments Incorporated and the International Telephone & Telegraph Corp. They seek engineers through their foreign subsidiaries or divisions. Says E.A. Smith, manpower administrator and manager of college relations for IT&T: "We don't engage in the brain drain. We transfer employees. I would say that we send as many over as we bring here." Marvin Berkeley, TI's corporate personnel director, claims much the same situation prevails at his company.

### III. Foreign reaction

The increased defection rate among Britain's engineers has stirred heated debate in Parliament and angered Britain's man in the street. A special committee, headed by E.F. Jones, Mullard Ltd.'s managing director, was created by Parliament last fall to look into the over-all problem of the emigration of scientists, technologists, doctors, and other skilled personnel, in hopes of coming up with a way to stem the exodus.

A move calling on the government to encourage talented Britons to stay at home was defeated recently in the House of Commons, because, as one Member put it, "you can't create a fence around us." He said an answer must be found that coincides with the "spirit of confidence in the future of Britain."

A proposal that has already gained some favor takes the form of an indenture system. An engineer whose education is subsidized by the British government would be required to work for a certain number of years in the United Kingdom. Any overseas firm wanting him would have to make a cash settlement with the government covering the remainder of his obligation.

**Advertising ban.** In Germany, advertising for engineers by foreign firms or agencies has been banned in a move aimed directly at American recruiters. While recruiting in Switzerland, Avco's Clement received a phone call ordering him out of the country because "it's illegal to advertise for talent in Swiss papers." Clement demanded a copy of the law. When he didn't get it, he stayed on.

Some European firms have indicated that they may turn the tables on American companies by launching a recruiting drive on this side of the Atlantic. The Marconi Co. is now seriously weighing a campaign aimed both at hiring U.S. nationals and luring back expatriate Britons. Other firms are staying in touch with engineers who went to the U.S. in hopes of getting them back when and if they decide to leave their present jobs.

The alarm is mounting, since the drain no longer can be dismissed as quantitatively small even if qualitatively significant. What was a trickle a decade ago has turned into a flood.

Answers to the problem are also being sought in the U.S. The immigration law of 1965 eliminated the national-origins quota, making entry into the nation much easier for skilled professionals. And the annual influx of professionals has soared by more than 60% in the past decade, to 30,039 last year. Some U.S. legislators have become increasingly concerned about the losses experienced by the nation's friends and allies in Europe.

Last fall, Minnesota's Demo-

## Following the sun

"The thought of going back fills me with horror—not about the working conditions, but the living conditions," says John Orchard, a senior staff engineer with the Lenkurt Electric Co.'s advanced development department in San Carlos, Calif.

Six years ago, Orchard, then a research engineer with the Telephone Section of the British Post Office, decided he was just about fed up with his native England. After 15 years with the department, he lacked neither money nor opportunity. But he thought he could be much happier in America. "I liked my work, but couldn't take the climate any more," he says. "Weather is important to me."

A specialist in network and design theory, he had no problem landing another job. He accepted an offer from Lenkurt, a division of the International Telephone & Telegraph Corp.

Orchard, his wife, and his son came to the U.S. But the transition wasn't easy. "During the first two years we were undecided whether to stay or to return to England," he recalls. "I was used to the atmosphere of my government job, which had relatively few pressures and much freedom, similar to a university. The people I was working with were more academic, a much different type than I found in the U.S."

After two years, Orchard quit and returned with his family to their native West Bromwich; but it didn't take. "Forty-eight hours after I was home, I realized I had made a mistake, and had to return to the U.S.," he says. "Just the train ride from the airport was enough to make me realize and compare the living conditions to America."

A month later, he was back with Lenkurt in California. Orchard admits it took him four years to make the adjustment. Although salaries are much higher in the U.S., Orchard wouldn't urge others to do the same unless they know what they're doing. He says, "The changes and adjustments you'll have to make are much greater than you think."

His biggest adjustment, says Orchard, was in coping with the emphasis on money. "People are less willing to trust you here," he says. "Insurance on my car was impossible to get. I had to have several letters backing me up from England. Shortly after we arrived here, a minor auto accident required some hospital treatment for my wife. It was hard getting admitted until they knew they were going to get their money."

Orchard, speculating on a shortage of engineers in Britain, believes the "brain drain" will continue. The only way Britain can stop the emigration of engineers, he says, is "to grow technologically and to raise the standard of living. You have to make the grass greener on your side of the fence."

cratic Sen. Walter F. Mondale proposed a bill calling for a comprehensive program to assist foreign countries in their efforts to reduce the drain. The bill, imaginatively titled "The International Brain Drain Act," died in the Senate Foreign Relations Committee.

Hearings are now under way in Washington on the problem. Conducted by the Senate Judiciary Committee's immigration and naturalization subcommittee, the hearings could determine whether Mondale will push for his bill's passage in this session of Congress.

### IV. Land of opportunity

Job challenge is a key reason for emigration, but status, money, and standard of living are high on the list. Interstate Staffing's Sugalski says British firms aren't spending enough on research and development, causing many specialists to feel their potential growth is stunted and forcing them to look across the seas. British firms, including the General Electric Co. (not related to the American company of the same name), Marconi, Mullard, and Elliott-Automation Ltd. bear out this contention. All agree that the principal motives aren't a higher standard of living and higher real income, but improved opportunities and a desire to broaden technical experience.

Money is also a great inducement. The average annual salary of a British engineer with five years experience and a college degree is about $6,000. In the U.S., an inexperienced engineer right off the college campus with a B.S. starts at about $7,200. With the higher salaries, Britons can achieve a higher standard of living in the U.S. at less cost than in England. Says Ampex's Doolittle: "Engineers are available over there because the economy and environment in England aren't good right now."

**Where the jobs are.** Geography also plays an important part in a man's willingness to move. Frank Morgan, personnel director at the Sparton Corp. of Jackson, Mich., cites his experience. "Our overseas recruiting program failed. We sent B.C. Passman, an Englishman, over to try to drag a whole boatload of his fellow countrymen back with him. We advertised extensively, but we didn't net one warm body. Our failure lies mainly in our location. Since we are in the military business and near Detroit, an electronics engineer feels out of place."

Assimilation isn't a real problem for Britons, and there isn't a language barrier. Avco's Clement says, "These new men have been good for the company. They have introduced different approaches. In turn, they have had no social problems, and I have heard no complaints from them."

American corporations are helpful in settling their new employees. Time off with pay to house-hunt is a common occurrence. One company has established a sort of buddy system; they assign an already established British family to look after a newcomer.

**Double standard.** Resolution of the brain drain problem is a long way off and much seems to depend on whose ox is being gored. A recent headline for a London Times editorial warned, "Alarming Loss of Talent." Meanwhile, the newspaper is busily selling American companies on the benefits of placing recruitment ads.

## To: The wizards at Hoffman, the quiet, reliable semiconductor house.

We just might spend about a nickel more for your splendid commercial 1 watt microglass zeners than we do for those comparatively clumsy cans we've been using. Send us one to abuse cruelly.

**Hoffman** SEMICONDUCTOR
HOFFMAN ELECTRONIC PARK
EL MONTE, CALIFORNIA 91734

NAME ____________________

COMPANY ____________________

ADDRESS ____________________

____________________ ZIP ____________

(If you will be so kind as to attach the coupon to your letterhead, it will aid us in discouraging impostors, rascals, free-loaders and hobbyists who make artistic earrings.)


Hipernom meets the requirements of Federal Standard No. 222

# It can keep your costs competitive in the 1970's.

Westinghouse Hipernom's high permeability lets you use thinner, lighter shielding against magnetic fields from DC to 10,000 Hz. That means easier fabrication, less material per shield.
So if you use magnetic shielding materials, be sure to use Hipernom.
Its premium performance gives you the shielding you need at the lowest possible cost. And cuts needless weight from your products.
Along with Hipernom, you get the services of the largest group of metallurgists specializing in magnetics. For 50 years, Westinghouse research has led in this field. You get the benefit. Want specific details? Call Bob Carroll at 412-459-9400.

**Free 36-page book on magnetic shielding.** It's a complete seminar in practical, easy-to-use form...tells you everything you must know to design and evaluate magnetic shielding. The only book of its kind. For your free copy, write for "Shielding Book." Address Westinghouse Metals Division, Box 868, Pittsburgh, Pennsylvania 15230.

You can be sure if it's Westinghouse

J-05014

Circle 175 on reader service card

# *CONSIDER COLORADO / INDUSTRIAL COLORADO*

***. . . where research and education set an accelerated pace . . .*** Innovating for industry. Providing information and qualified personnel. Through government, university and private sources.

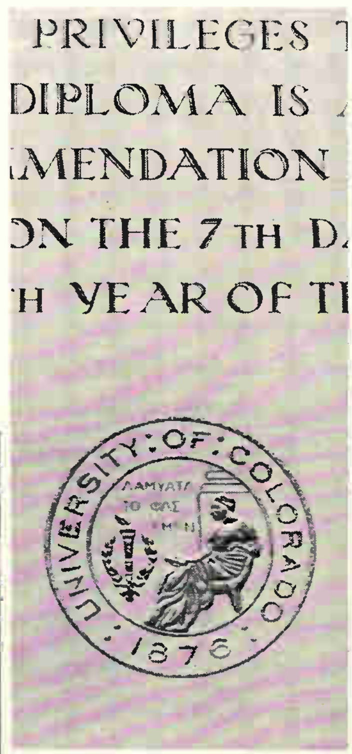
Consider basic and applied research being conducted in Colorado by over 100 organizations. More than 3,500 graduate scientists directing the activities of thousands of specialized personnel to gather, correlate and apply data about everything from marketing to missiles, from the arctic to aerospace.

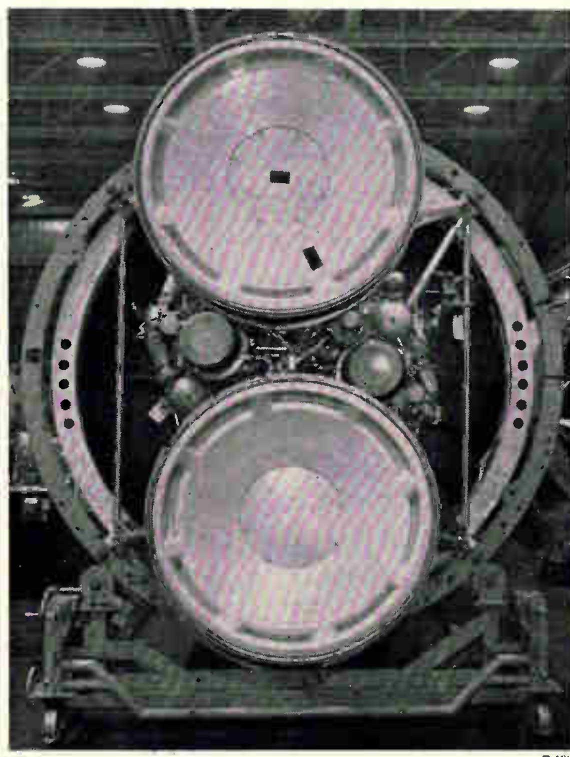
Consider Colorado's scientific and academic community. Fifth ranking state for percentage of scientists in its population. 10.7% of the population in the 25 and older age group with 4 years of college, the highest percentage in the nation. A professional atmosphere and a pleasant and varied "living" environment that attracts and holds scientists, engineers and technical administrators. A recent survey of graduating college students points up the desirability of locating in Colorado by ranking Denver among the top 3 major U. S. cities preferred for living.

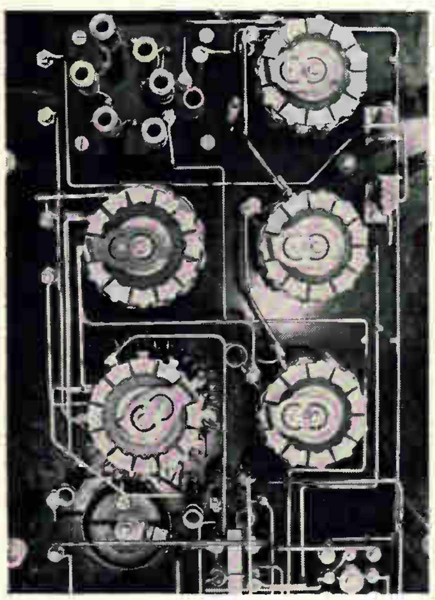
Consider the excellence of Colorado's education system. 16 colleges and universities. 6 junior colleges. Per capita spending for institutions of higher learning ranks the State fourth in the nation. 23% of the State's annual budget earmarked for education.

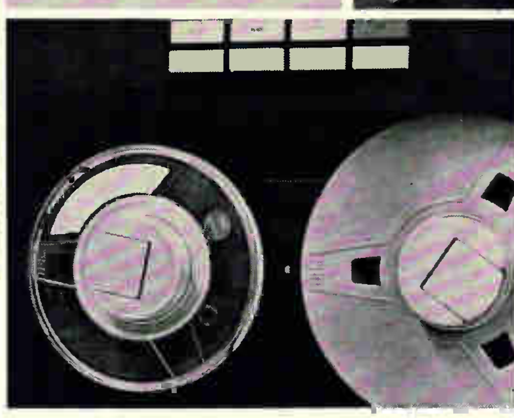
If a burgeoning scientific and academic community would be an asset to your business, consider Industrial Colorado for your expansion or relocation.

*A well-educated population, numerous centers of basic and applied research, and a desire to find practical applications for new discoveries characterize Colorado. Write for a complimentary copy of Industrial Colorado, a revised-to-the-minute, factual 74 page spiral-bound portfolio. It covers 11 important considerations pertinent to plant expansion or relocation in any part of the State. Address inquiries to Dwight E. Neill, Director, Division of Commerce and Development, 17 State Services Building, Denver, Colorado 80203.*





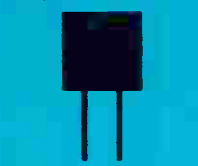


# SELECTION is only ONE reason it pays to specify

ATTACK INDIVIDUAL MISTAKES
ZERO DEFECTS PROGRAM

# AEROVOX PRECISION RESISTORS
## WIRE-WOUND / METAL-FILM / CARBON-DEPOSITED

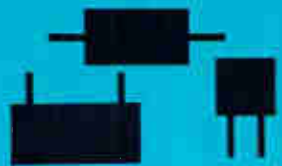
**WIRE-WOUND**



Established Reliability
Series ER 300 and 600

Molded high reliability units in all axial and radial lead styles.

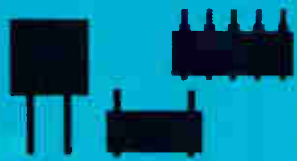
**WIRE-WOUND**



Epoxy cast
Series CE 200
Molded
Series CE 300 & 600

Units to MIL-R-93C. Choice of wire leads or lug terminals in radial and axial styles.

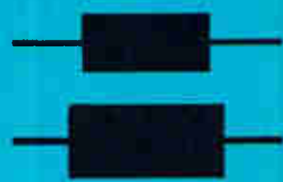
**WIRE-WOUND**



Printed wiring
Series CE 400
Ceramic
Series CE 500

Units for pc boards and for commercial computer and other industrial requirements.

**WIRE-WOUND**



Industri-Line
Series CE 700 Molded

High quality units for commercial and industrial applications.

**METAL-FILM**

Molded
CPFM Series

RN55, 60, 65, 70 & 75 to MIL-R-10509F.

**METAL-FILM**

Conformal coated
Series CPFX

RN50, 55, 60, 65, 70 & 75 sizes to MIL-R-10509F.

**CARBO-FILM**

Molded
Series CPM
Ceramic
Series CPC

RN55, 60, 65, 70, 75 & 80 case sizes.

**CARBO-FILM**

Conformal coated
Series CPX
Special coating
Series CP-W65

Epoxy coated and painted units in rating from 1/10 to 2 watts.

Aerovox offers you the widest selection of precision resistors in wire-wound, metal-film and carbon-deposited constructions. They meet applicable military specifications and come in a full range of sizes, values, and case styles. You can now *select* the unit that best fits your *need* . . . the established reliability type, the mil approved unit, or the economy priced commercial version for that less critical application.

Along with this wide selection of types and sizes, Aerovox has maintained an enviable reputation for more than two decades for quality precision resistors providing superior performance and incorporating all the latest advances in the state-of-the-art; Metal-Film and Carbo-Film types are available from stocking Aerovox Distributors throughout the country in MIL-BELL and commercial stock values. Send today for your free copy of our new PRECISION RESISTOR CATALOG.

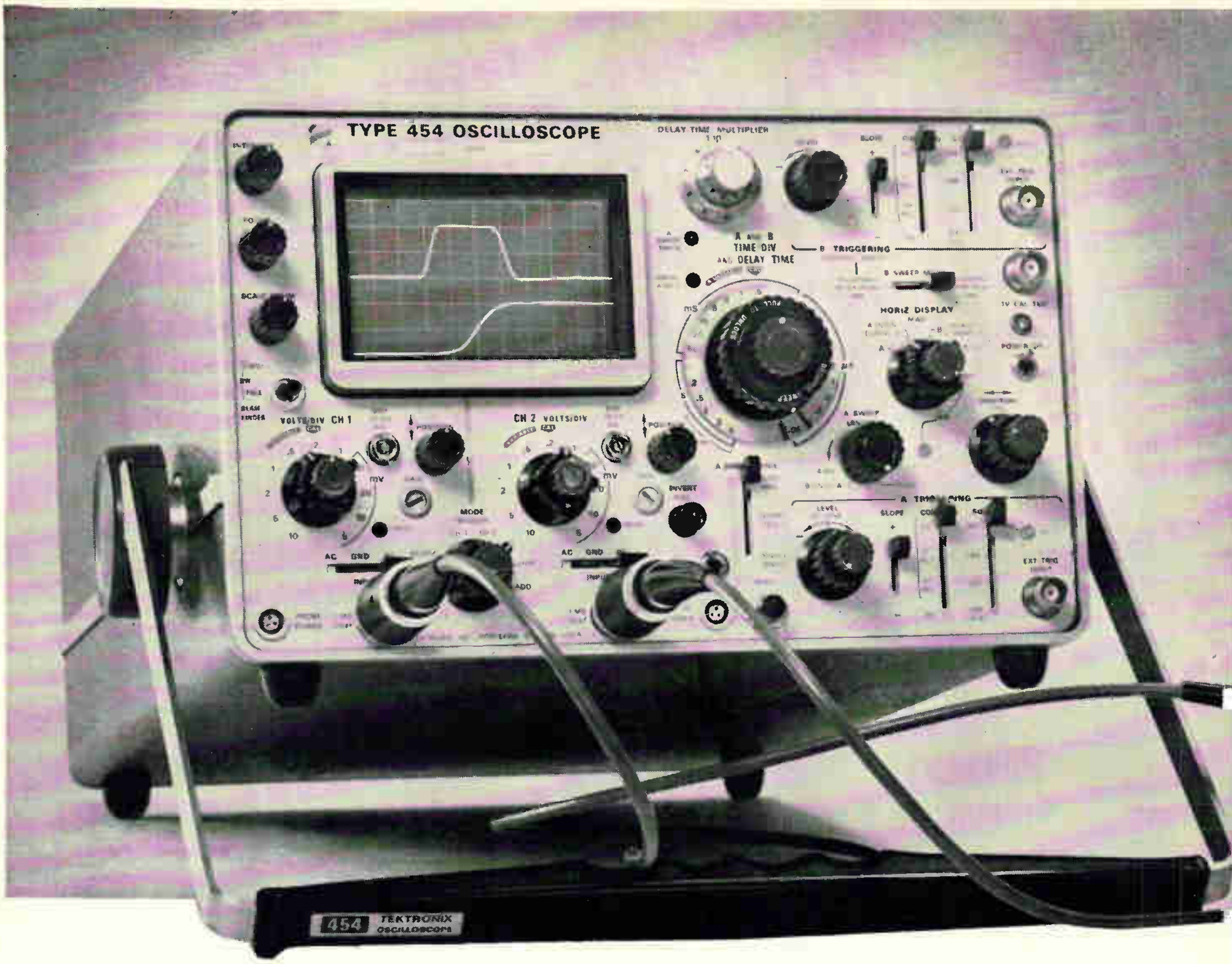
See AEROVOX IEEE Booths 3J-13, 15

AEROVOX Hi-Q ®

**AEROVOX CORPORATION**
OLEAN, NEW YORK
BURBANK, CALIFORNIA



Circle 177 on reader service card




# the NEW TEKTRONIX TYPE 454 advances

## All new performance from probe tip to CRT

**new probes** Two miniature P6047 10X Attenuator Probes are included with the Type 454 to provide DC-to-150 MHz bandwidth and 2.4-ns risetime performance where you use it—at the probe tip. They have an input resistance of 10 MΩ and an input capacitance of 10.3 pF. The optional P6045 FET Probe features unity gain with 10 MΩ input resistance and 4 pF input capacitance. With the Type 454, the P6045 provides a system risetime of 2.7 ns and bandwidth of DC-to-130 MHz from 20 mV/div to 10 V/div without signal attenuation. Probe power is provided by a front panel jack.

**new vertical** The Type 454 features a new dual-trace vertical system with DC-to-150 MHz bandwidth and 2.4-ns risetime capabilities. The instrument delivers this performance either with or without the P6047 Probe. Dual-trace vertical deflection factor is from 5 mV/div to 10 V/div. The Type 454 also can make 1 mV/div single trace measurements and 5 mV/div X-Y measurements.

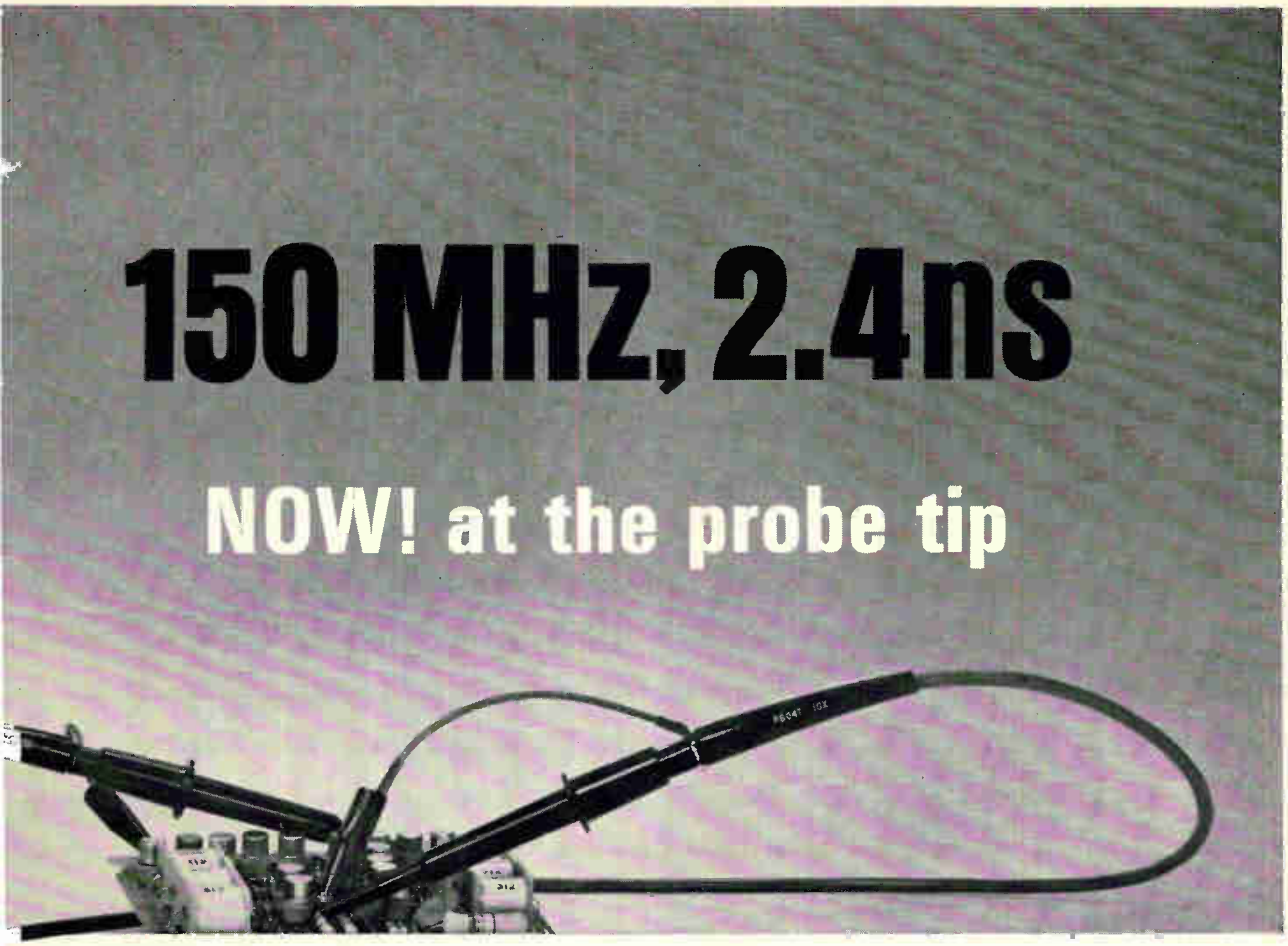
| *Deflection Factor** | *Risetime* | *Bandwidth* |
|---|---|---|
| 20 mV to 10 V/div | 2.4 ns | DC to 150 MHz |
| 10 mV/div | 3.5 ns | DC to 100 MHz |
| 5 mV/div | 5.9 ns | DC to 60 MHz |

***Front panel reading. Deflection factor with P6047 is 10X panel reading.**

**new horizontal** The Type 454 has triggering, sweep speeds and sweep delay capabilities which are compatible with the high performance of the vertical system. It can trigger to above 150 MHz internally, and sweep speeds up to 5 ns/div are provided on both normal and delayed sweeps. The calibrated sweep range is from 50 ns/div to 5 s/div, extending to 5 ns/div with the instrument's X10 magnifier. Calibrated delay range is from 1 μs to 50 seconds.

**new CRT** The Type 454 features a new CRT with distributed vertical deflection plates and a 14-kV accelerating potential. It has a 6 by 10 div (0.8 cm/div) viewing area, a bright P-31 phosphor and an illuminated, no-parallax, internal graticule. The CRT has high writing rate capabilities which complement the 150-MHz-2.4-ns vertical performance and the 5-ns/div horizontal performance of the Type 454.

**new Scope-Mobile® cart** The Type 454, as well as the Type 453 oscilloscope and the Type 491 Spectrum Analyzer, may be mounted on the new Type 200-1 Scope-Mobile Cart. Friction locks permit the instrument to be tilted at any angle from 0° to 60°. Also available as an optional accessory is a collapsible viewing hood.




# your ability to make measurements

**new camera** A new high-writing-speed camera, the Type C-40, is now available for use with the Type 454. The camera can utilize Polaroid† 10,000 speed film, and has an 80-mm f/1.3 lens with a 1:0.5 object-to-image ratio that records up to three photos on a single piece of film. Both the Type C-40 and the Type C-30 (with variable object-to-image ratio) cameras mount directly on the Type 454.

*†Registered Trademark Polaroid Corp.*

The Type 454 weighs 31 lbs. and has the rugged environmental characteristics required of a portable instrument. A rackmount, the 7-inch-high Type R454, also is available with the same high performance features.

For further information about the Type 454 oscilloscope, or about the new Tektronix DC-to-100 MHz *plug-in* oscilloscope, the Type 647A, contact your nearby Tektronix field engineer, or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

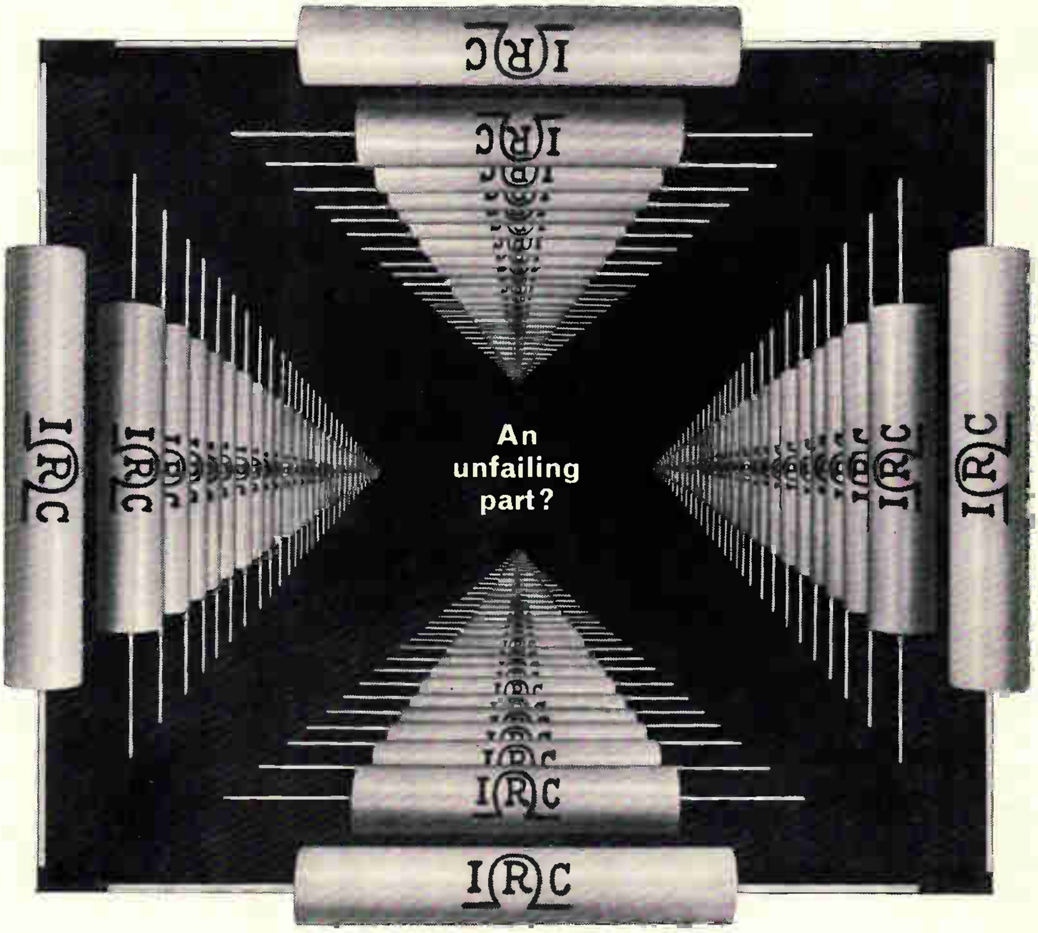
| | |
|---|---|
| Type 454 (complete with two P6047 Probes and accessories) | $2550 |
| Type R454 (complete with two P6047 Probes and accessories) | $2635 |
| P6045 FET Probe (010-0204-00) | $ 275 |
| C-30 Camera | $ 390 |
| C-40 Camera | $ 540 |
| Type 200-1 Scope-Mobile® Cart | $ 60 |
| Collapsible Viewing Hood (016-0083-00) | $ 7.50 |

U.S. Sales Prices FOB Beaverton, Oregon

TEKTRONIX®

*Research and development*

*... part of the Tektronix commitment to progress in the measurement sciences*

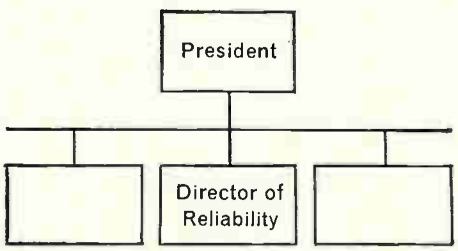



Nobody makes parts that absolutely won't fail. Not yet, anyhow. In a sense, reliability only provides a measure of how close you are to perfection.

But we're working toward it. And we have been since 1956 when we established the discipline structure that led to the production of our first Minuteman resistor.

We are tough on ourselves, too. Our Director of Reliability carries his concern into everything from basic design through final inspection. The result of discipline and concern is product homogeneity and predictable performance—time after time . . . in resistors, in potentiometers and in semiconductors.

We don't have infinite reliability yet. What we do have is the widest choice of reliability levels to match your present cost and performance needs. At IRC reliability begins with front door management, not back door selection. Questions on reliability get top management attention by writing to our Director of Reliability.

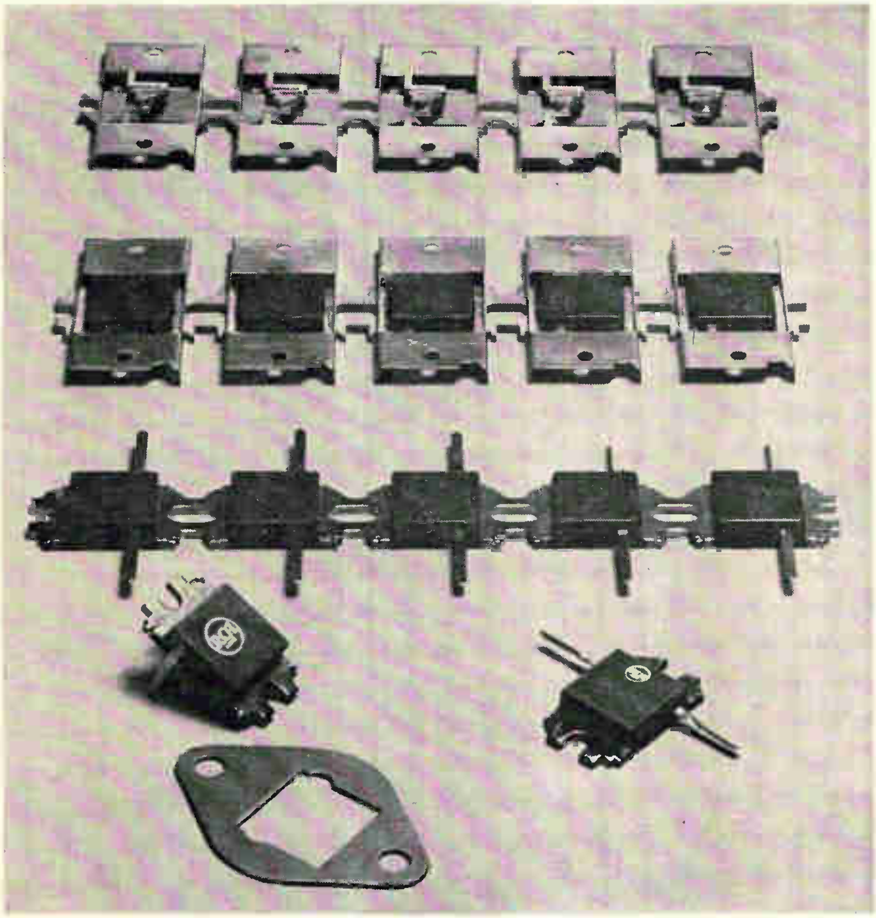



IRC, Inc., 401 N. Broad St., Philadelphia, Pa. 19108

IRC

# Watts up in silicon power transistors

Lower-cost plastic packaging, automated production, and 83-watt rating seen swaying amplifier designers



**Silicon power transistors** have yet to dislodge germanium types from the amplifier power stages in stereo consoles, tape recorders, and other consumer audio equipment —except in high-priced hi-fi amplifiers.

But the industrial semiconductor department of the Radio Corp. of America expects price-conscious designers to change their minds about silicon-transistor applications when they see eight new, under-a-dollar units at the IEEE show. Four are rated at 83 watts and four at 37.5 watts. The low price is the result of plastic packaging and automated production.

The 83-watt units (2N5034-2N5037) are four versions of a single device, with two voltage ratings and two lead configurations. The base and emitter leads will plug into a TO-3 socket and an adapter is available to match the collector lead to the TO-3's mounting holes.

These transistors are available in production quantities. Prices range from 75 to 95 cents, depending on specifications and quantities.

The four 37.5-watt types will be

## New products in this issue

available in production quantities in about six months and will cost 30 to 50 cents each. These units will fit directly into TO-66 sockets.

The wattage ratings given by RCA are of the commonly used infinite heat-sink type. Of course, the units cannot deliver such high powers. Under normal conditions, the output of the 83-watt units can be as high as 50 watts and that of the 37.5-watt types can be 20 watts.

The silicon chips in the plastic packages are the same as those RCA puts into hermetically sealed packages for types 2N3055 and 2N3054.

The 83-watt transistors are packaged in strips of five, and the 37.5-watt types in strips of eight. After chips have been positioned on copper headers, internal leads are dropped into position and automatically soldered. Lead frames are clamped to the base metal, units are encapsulated in silicone plastic, and the metal frames are stamped to form the package leads.

The chip and lead surfaces are coated with a special material to increase their adherence to the plastic. Because expansion coefficients of metals and the plastic differ by about 10, a good bond is essential to prevent moisture creeping into openings caused by thermal expansion. As another precaution against separation, the plastic and the metal base are dovetailed.

### Specifications

| | | | |
|---|---|---|---|
| Model number | 2N5036<br>2N5037 | | 2N5034<br>2N5035 |
| Power rating | | 83 watts | |
| Collector-emitter sustaining breakdown voltage | | | |
| $I_c$=100 ma, $V_{be}$=—1.5v | 70 v | | 55 v |
| Collector-emitter reverse current | | | |
| $V_{ce}$=65 v, $V_{be}$=—1.5 v | 1 ma | | |
| $V_{ce}$=50 v, $V_{be}$=—1.5 v | | | 1 ma |
| Collector saturation voltage | | | |
| $I_c$=3 a, $I_b$=0.3 a | 1 v | | |
| $I_c$=2.5 a, $I_b$=0.25 a | | | 1 v |
| Current gain, ($h_{fe}$) | | | |
| $I_c$=2.5 a, $V_{ce}$=4 v | 20-70 | | |
| $I_c$=3 a, $V_{ce}$=4 v | | | 20-70 |
| Gain-bandwidth product | | | |
| $I_c$=1 a, $V_{ce}$=4 v | | 1 Mhz | |

Industrial Semiconductor Department
Radio Corp. of America, Somverville, N.J.
Circle 349 on reader service card.

## IC's boost range of selective voltmeter

**As commercial communications** carrier systems creep to higher and higher frequencies, the test equipment needed to measure performance parameters must become more and more precise, since the instruments cover more octaves and more dynamic range. The Sierra Electronic division of the Philco-Ford Corp., a subsidiary of the Ford Motor Co., has turned to frequency counting with a new digital integrated circuit for a selective voltmeter that operates from 100 kilohertz to 33.5 megahertz—well past the top of the high-frequency range.

The instrument comes in three parts: a tuning unit, containing a crystal to generate the prime and offset frequency necessary to heterodyne the prime down to an intermediate frequency of 40 Mhz, plus logic circuitry in the counter; a signal generator to supply r-f power; and a level meter. The latter is calibrated in dbm, since the purpose of the instrument is to measure loss and voltages are meaningless unless impedances are known.

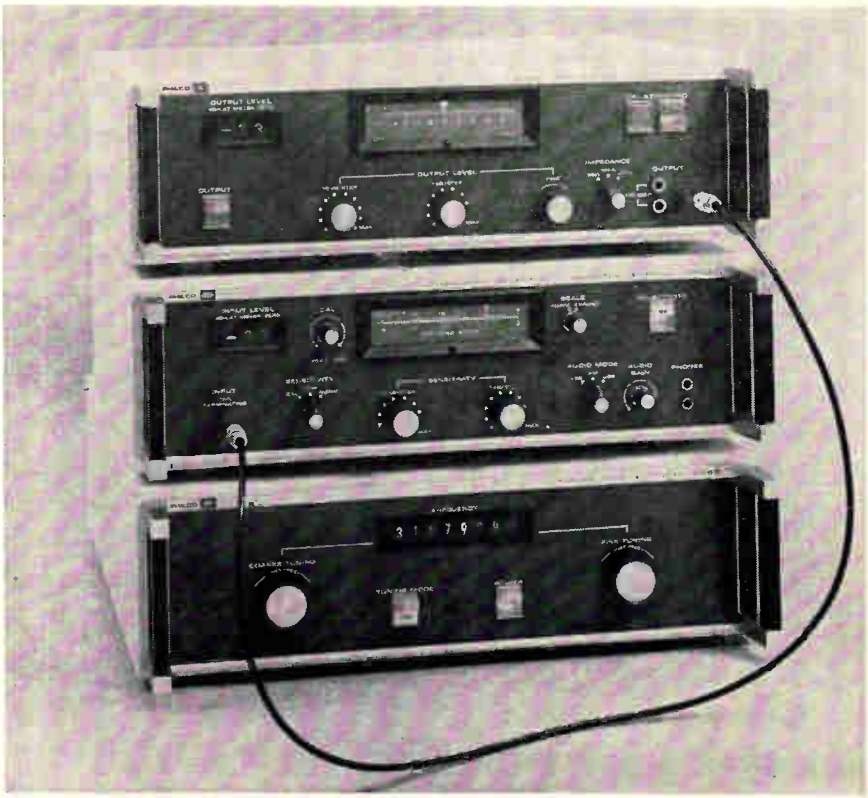
Basically, the unit takes one signal from the tuning unit, routes it through two paths to the level meter, and compares the results. One path goes directly from the tuning unit to the level meter; the other goes to the signal generator and then through the system being tested before going to the meter.

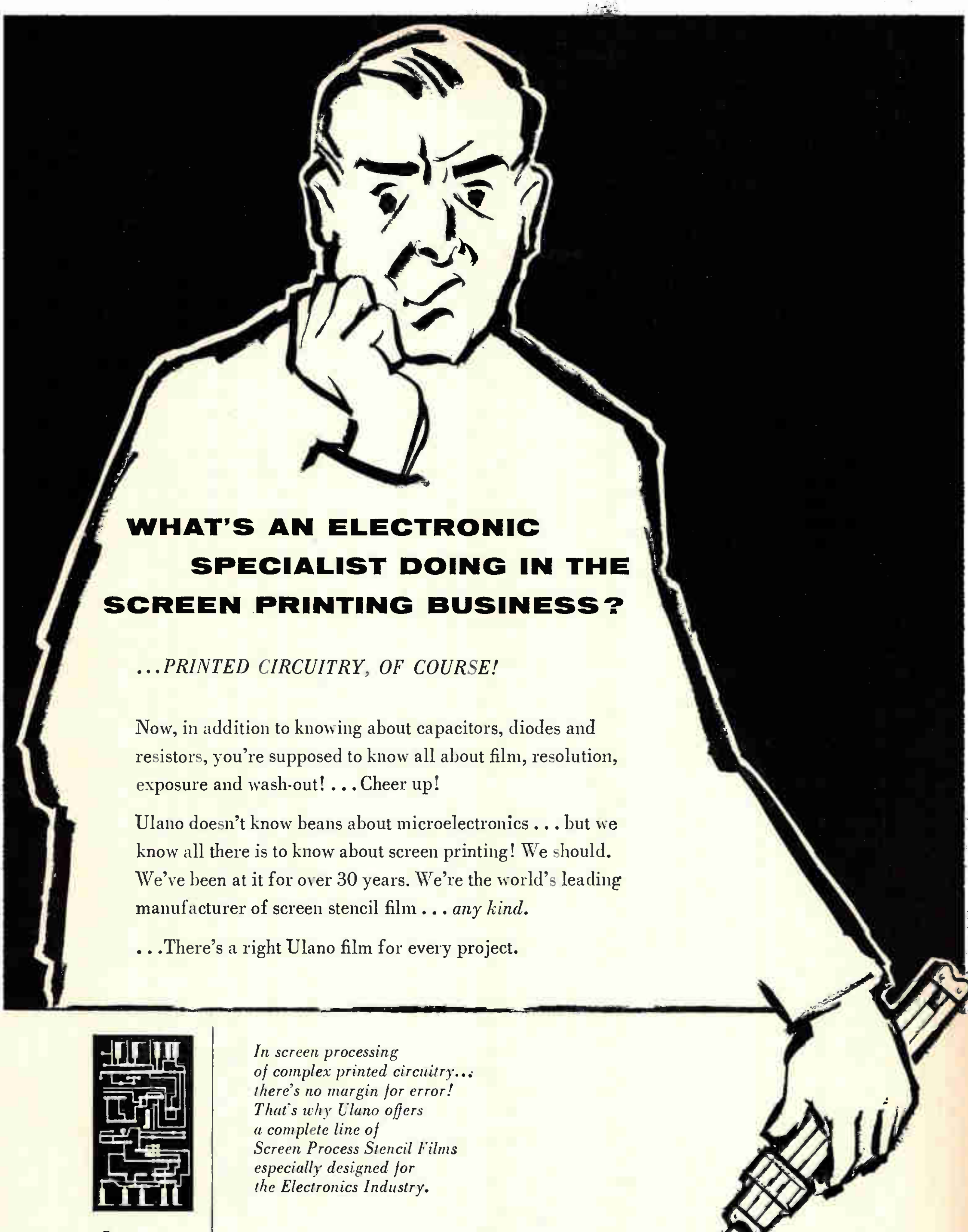
For accurately determining the frequency, the tuning unit uses a counter based on a 200-Mhz flip-flop developed by Motorola Semiconductor Products Inc. Discrete components are used in the i-f and analog circuitry, high-power stages, and voltage regulators.

### Specifications

| | |
|---|---|
| **Frequency** | 1 khs to 35.5 Mhz |
| **Stability** | |
| Short term (1 hour) | 1 part in $10^8$ |
| Long term (1 week) | 1 part in $10^7$ |
| **Sensitivity** | −120 dbm at 75 ohms impedance (greater than 1 mv) |
| **Level measurement capability** | ±0.5 db |
| **Power generator stability** | ±0.01 db |
| **Attenuator step resolution** | 1 db |
| **Availability** | July |

Sierra Electronic Division, the Philco-Ford Corp., 3885 Bohannon Drive, Menlo Park, Calif. 94025 [350]






*In screen processing of complex printed circuitry... there's no margin for error! That's why Ulano offers a complete line of Screen Process Stencil Films especially designed for the Electronics Industry.*

ulano T.M.

610 DEAN STREET, BROOKLYN, N.Y. 11238

NEW YORK • CALIFORNIA • CHICAGO • ZURICH

In Europe: ULANO A. G., Untere Heslibachstrasse 22, Kusnacht 8700, Switzerland

***Write on your letterhead for special electronic test kit** (no charge) **No. 5948.***

Circle 183 on reader service card

# LC Filters?

# We'll try anything!

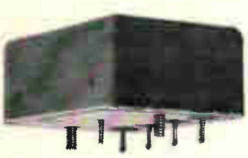
If you have a tough, tricky or unusual problem in LC filters, try Bulova first! Bulova has built a reputation for being willing to "try anything". Even jobs that other companies "can't be bothered with"!

Are we crazy? Like foxes! Fact is, we can do things others can't—and that's the way we win friends and customers!

We'll custom-design units to solve your unique problems. We'll supply prototypes when you need them—in 2 weeks or less! We'll schedule production units to meet your schedule —and give you solid proof we can do it!

And what a range! High pass, low pass, band pass, lumped constant delay lines, IRIG filters—you name it! Frequencies from DC to 50MHz! Sharpest shape factors! Just tell us your requirements—when you need it —and let us tackle it. Our hot engineering group will show you why you should "Try Bulova first"!

For more information, write to us at Dept. E-25.



# Try Bulova First!

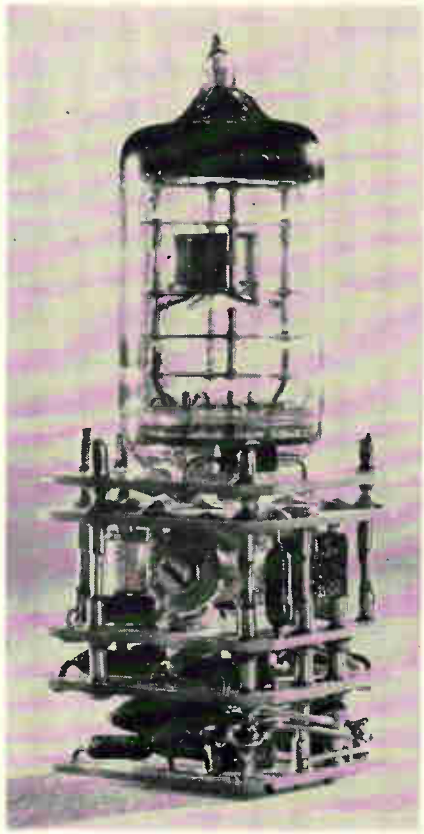
**FREQUENCY CONTROL PRODUCTS**

ELECTRONICS DIVISION
OF BULOVA WATCH COMPANY, INC.

61-20 WOODSIDE AVENUE
WOODSIDE, N.Y. 11377, (212) DE 5-6000




# IC heater stabilizes crystal



**An unusual miniature oscillator** uses an integrated circuit to stabilize the temperature of its crystal assembly for ambients of —55° to +90°C. The oscillator can be preset and supplied at any frequency between 10 and 15 megahertz. Since only 500 milliwatts are consumed at the worst-case ambient of —55°C, applications in airborne equipment and manpack receivers are possible.

In this first model of a projected series, developed by the Marconi Co., the crystal assembly requires minimum heating to stabilize temperature. The assembly consists of a quartz crystal $\frac{3}{16}$ inch in diameter, a thermistor, and a sensitive IC amplifier as the heating element. All are housed in a TO-5 transistor can. The IC heater is possible because of the crystal's low thermal capacity. An evacuated glass envelope contains the transistor can to insulate the heater from the temperature.

Temperature is controlled by a thermistor bridge. When the operating temperature decreases, the change in thermistor current is sensed by the IC amplifier. Current through the heater then increases to compensate for the lower outside temperature.

Two precautions are taken against thermal loss. First, the wires connecting the crystal to the oscillator circuit are fine-drawn platinum, providing low electrical resistance and high rigidity, and reducing heat loss from the evacuated temperature chamber. Second, the mounting structure has a long conduction path between the transistor can and the glass envelope.

The oscillator circuit is built up on printed-circuit boards with the glass envelope fitted on top. Adjustment of oscillator frequency to compensate for long-term aging effects can be made by tuning a trimmer. The entire assembly is fitted in a 3 by 1 by 1 inch aluminum rectangular case that bolts to the chassis of the equipment. Output and input connections are made through terminals suitable for p-c board mounting.

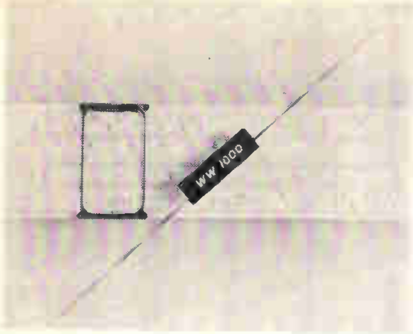
**Specifications**

| | |
|---|---|
| **Frequency** | Preset between 10 and 15 Mhz |
| **Stability** | |
| **long term** | ± 5 parts in $10^6$ in six months |
| **short term** | 1 part in $10^8$ averaged over 1 second |
| **Temperature range** | —55° to +90°C |
| **Frequency adjustment** | Covers 10 years aging |
| **Output** | 1 volt peak-to-peak into 50 ohms |
| **Warm-up time** | 90 seconds from —55°C to within ±5 parts in $10^6$ of required frequency |
| **Power consumption** | 500 mw max. at —55°C |
| **Supply voltage** | 12 volts ± 5% d-c |
| **Size** | 1 x 1 x 3 in. |

The Marconi Co., Chelmsford, England
**[351]**

# Fixed-slider variable resistor

A wirewound device provides ±20% variations in nominal resistance as it slides along a center




lead that is attached to a multi-fingered fixed wiper and is insulated on one side. The resistance element consists of fine wire closely wound on a metal mandrel. High-density winding and the design of the wiper afford high resolution with the wirewound element.

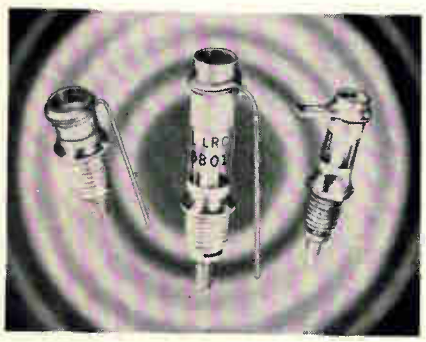
Good stability and temperature coefficient capabilities of 20 ppm per °C result from the plastic housings, power dissipating properties, and Polyimide insulation on the mandrel.

The variable resistor exceeds the requirements of MIL-R-27208A as regards load life and response to shock, moisture, and vibration. Models are designated by wattage ratings: WW1000 is 1 watt, WW500 is ½ watt, and WW250 is ¼ watt; all are rated at 70°C. Nominal resistances are from 10 ohms to 250,000 ohms.

The WW1000 measures 3/16 x 5/16 x 1 in.; the WW500 is 0.750 in. in length, and the WW250 is 0.535 in. in length.

Radio Products International, 1501 So. Hill St., Los Angeles, 90015. [352]

## Trimmer capacitors of metalized glass



Spring-compensated torque control is featured in the Permtork series of metalized glass miniature trimmer capacitors. This permits a


# Improve your dc potential for diodes, resistors, photomultipliers and such, with this handy...


## it's stable, low cost and very easy to use

You're looking at a standout in general purpose dc voltage sources that supplies stable, low noise voltages in 1-volt steps from 0 to 1200 volts—accurate to 1%. Rated for 10 milliamperes current, the Keithley 240A smoothly recovers from no-load to full-load within 35 milliseconds.

It has built-in overload protection which limits output current to less than 13 milliamperes. Reset is automatic and fast—within ¼ second after removal of overload. And it has such features as a variable trim potentiometer; outputs at both front and rear; and provision for remote programming.

When it isn't busy in other applications, the 240A is a convenient general purpose supply for capacitor leakage tests, radiation detectors and semi-conductor testing. It's an ideal companion to your Keithley Electrometer or Picoammeter.

Best of all, the Keithley 240A High Voltage Supply is an economical $345. Only $15 more buys a kit for conversion to rack mounting. For free, you can get our 240A technical engineering note. A demonstration, too. Both are yours when you write or call.

- **0.02% stability per 8 hours**
- **1 millivolt rms noise**
- **0.005% line and load regulation**

KEITHLEY INSTRUMENTS
12415 Euclid Ave. • Cleveland, Ohio 44106
EUROPE: 14 Ave. Villardin, 1009 Pully, Suisse




Circle 185 on reader service card

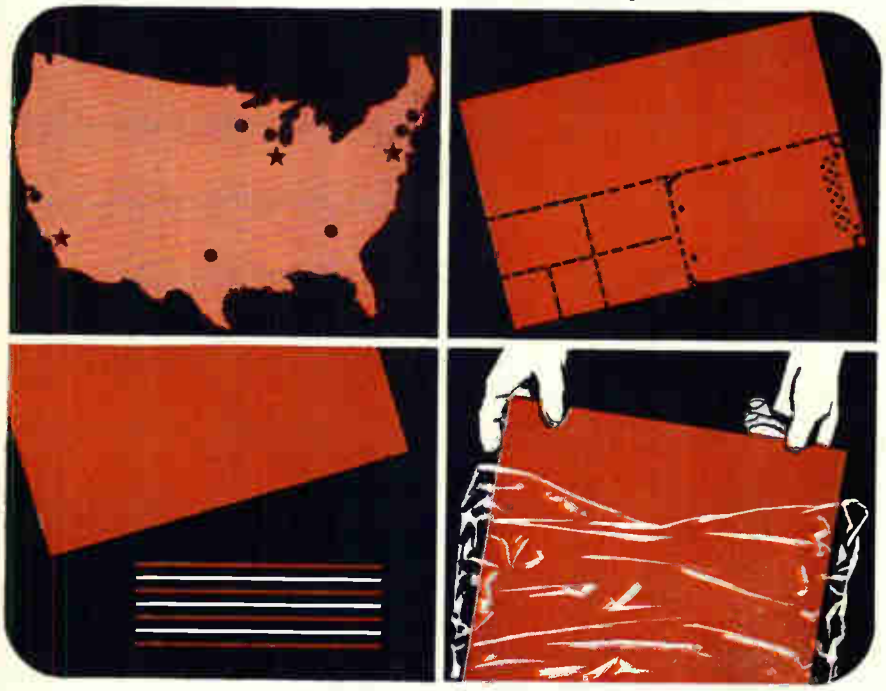
# Glass-Epoxy copper-clad

**through TAYLOR'S TOTAL RELIABILITY PLAN:**

**Raw materials, panels or punched blanks to your reliability requirements. You get what you order from a fully integrated source.**

FAST DELIVERY from two fully equipped plants — one at Valley Forge, Pa., the other at La Verne, Calif. Or from warehouses in Chicago, Ill. and other key locations.

. . . FULL SIZE SHEETS, CUT-TO-SIZE PANELS or PUNCHED BLANKS to satisfy fabricating and processing requirements. Ease of fabrication is a plus value in printed circuit production.



. . . STANDARD AND ULTRA-THIN FORMS. Standard sheets in all grades. Ultra-thin sheets and multilayer prepregs in GEC 500 (G-10) and Fireban 600 (G-10, FR-4).

. . . WHITE GLOVE HANDLING in atmosphere-controlled white rooms, careful processing, extremely tight quality control and special packaging assure top performance.

Taylor's copper-clad has proven total reliability demonstrated by an ever increasing number of major OEM's and commercial etchers. This acceptance substantiates our claim for unsurpassed quality, ease of fabrication and delivery to your scheduled requirements. Let us demonstrate this reliability to you. Ask for a sample (give grade designation and copper combination) and a copy of Bulletin GB-2.

Tc ...your assurance of quality

**Taylor copper-clad**

TAYLOR CORPORATION • Valley Forge, Pa. 19481

Phone: 215-666-0300 TWX: 215-666-0659

West Coast Plant: La Verne, Calif.

Also manufacturer of Taylor laminated plastics, Taylorite® vulcanized fibre and Tayloron® prepregs



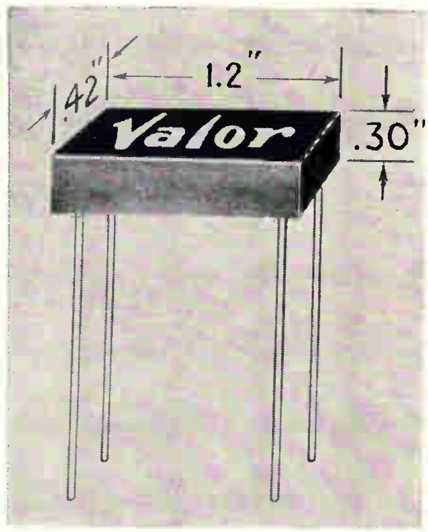

greater number of adjustments than previously available in low-cost glass trimmers, according to the manufacturer. There are only four parts in the complete assembly.

The ¼-in. devices are available in five sizes, to meet or exceed environmental requirements of Mil-C-14409. Capacitance ranges in the models are 1 to 5, 1 to 10, 1 to 15, 1 to 20 and 1 to 30 picofarads. The design is also available in 3/16-in. diameter with values up to 1 to 10. The Q factor of the trimmers is guaranteed as 500 minimum at 50 Mhz. Operating temperature range is $-55°$ to $+125°$ C. Temperature coefficient of capacitance is $\pm 50$ to $\pm 100$ ppm/° C, depending on the capacitance range.

Price is approximately $2 to $3 per unit in small quantities; 75 cents to $1.10 in volume production. Small lots are available from stock; production quantities, in 3 to 4 weeks normal delivery.

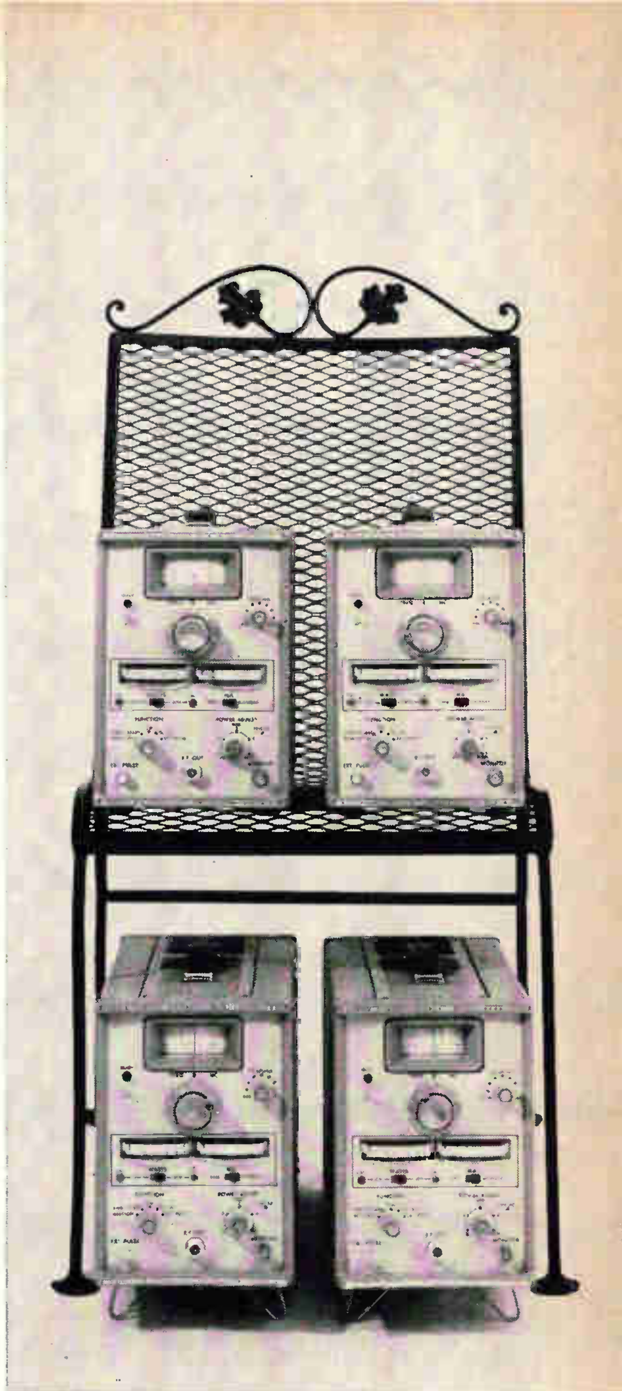
LRC Electronics, Inc., 901 South Ave., Horseheads, N.Y., 14845. [353]

## Delay lines shrunk to fit small spaces




Designed for use in radar, computers, instrumentation equipment and p-c boards, a series of delay lines has been miniaturized to fit installations where space and reliability are prime critical factors.

While variations in size and operational characteristics are available on order, typical delay lines



## A high-power signal generator

## ...Four others from Sierra

Wavering signals may cut the ice in certain Alpine applications. But there's no place for them in the r-f test and measurement laboratory. There you'll want rock-steady signals from a stable source of r-f power — the kind of performance you'd get with a Sierra Series 470A High-Power Signal Generator.

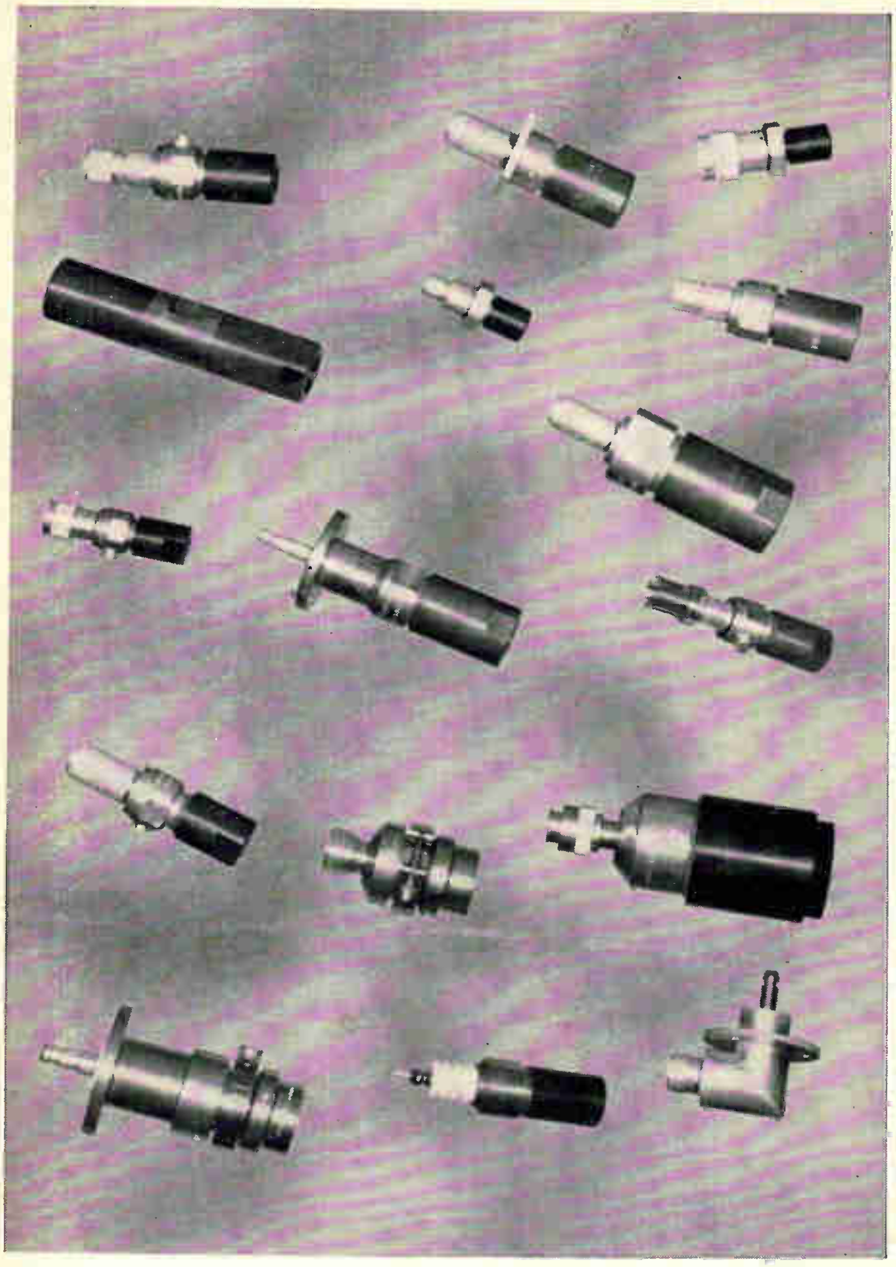
The four Sierra 470A's deliver signals at selectable frequencies through 2.5 GHz with ultra-reliable all-solid-state circuits. (Exception: The final output tube, a standard type, that can be changed in 30 seconds.) Power outputs range from around 70 watts at 400 MHz to 15 watts at 2.5 GHz. You can monitor power output plus grid and cathode currents on direct-reading front-panel meters. All units incorporate automatic no-load, underload protection. Prices are lower than you might expect at $2,495 (for coverage of 200–500 MHz or 470–1000 MHz), $2,775 (1000–1800 MHz), and $3,300 (1800–2500 MHz).

One call to Sierra will produce an echoing avalanche of relevant data and information. Or write Sierra/Philco, 3885 Bohannon Drive, Menlo Park, California 94025.

PHILCO Ford

PHILCO-FORD CORPORATION
Sierra Electronic Operation
Menlo Park, California • 94025

Circle 187 on reader service card




# Connectors for semi rigid coax? Yes. All sizes, all interfaces!

Here is an all new series of connectors ideal for Phelps Dodge or any other make of semi-rigid coaxial cable ready for delivery from stock.

This new design incorporates a captivated collet holding mechanism providing positive holding capability with best possible electrical contact. VSWR is low, and the maintenance of cable pressures up to 30 psi are guaranteed when properly installed. And, best of all, these new connectors are immediately available off-the-shelf in all sizes, all interfaces, from ¼" to ⅞" in Type N, HN, UHF, C, BNC, TNC, GR and Splice. Other interfaces and sizes are available on request.

Other important features include a ⅛" NPT threaded gas port which is provided for the attachment of pressure lines or gages and a conventional "O" ring gasket gas and moisture seal. A special epoxy barrier around the base prevents electrolysis.

Can we tell you more? *Write for Bulletin WH, Issue 4.*

**PHELPS DODGE** ELECTRONIC PRODUCTS NORTH HAVEN, CONNECTICUT


## New Components

are 0.30 in. high, 0.42 in. wide and 1.2 in. long. They provide a delay time of 200 nsec, a risetime of 65 nsec and an impedance of 1,000 ohms.

With No. 22 pure nickel leads, units are packaged in molded cases of diallyl phthalate and meet all requisites of MIL-D-23859 specifications.

Valor Electronics Inc., 13214 Crenshaw Blvd., Gardena, Calif., 90249 **[354]**

## Tiny chip resistors rated to 250 kilohms

Subminiature chip resistors that are suited for integrated circuits or in printed circuitry feature solderable terminations, and can also be mounted directly on a ceramic p-c board by heat sink attachment.

The resistors measure as small as 0.010 x 0.110 x 0.010 in. They have a resistance range of 100 ohms to 250 kilohms with temperature coefficient ±150 ppm.

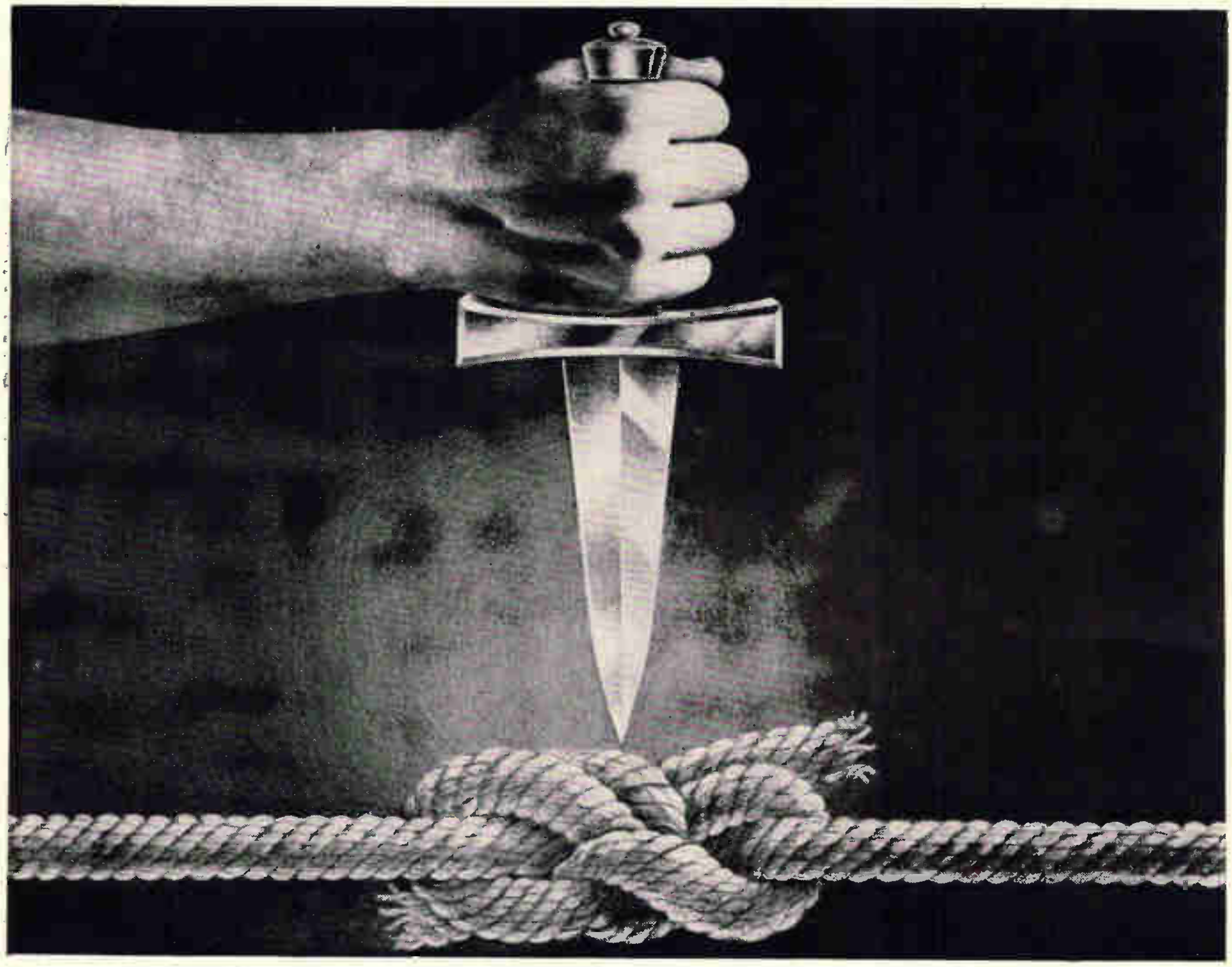
Mepco Inc., Columbia Road, Morristown, N.J. **[355]**

## Tiny relay offers high reliability

Half-crystal case size relays enclosed in a high-impact plastic dust cover are designed for plug-in or p-c board soldering, with terminals arranged on a 0.200-in. grid. Intended for commercial applications requiring high performance in minimum space, the HP series is suited as a high reliability relay for tv cameras, desk-top computers and other products employing high-density circuits.

Design advantages include a

# the simplest solution !

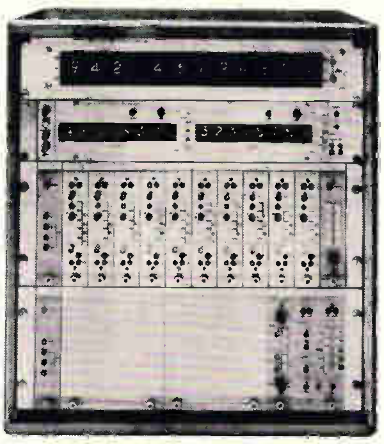


## SEN 300 COUNTING EQUIPEMENT

with integrated circuits

## 100 Mhz

Unlimited applications • Up to 1000 channels • Scalers with visual display • Modular scalers • Automatic readout of the system: from the simplest printers to the most sophisticated output device



SEN

SOCIÉTÉ D'ÉLECTRONIQUE NUCLÉAIRE — 31, AV. ERNEST-PICTET — 1211 GENEVA 13 — SWITZERLAND



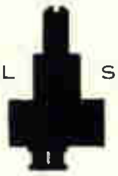
Circle 189 on reader service card

Waters

INDUSTRIAL JP/2C

JP/2C

only a half-inch (d)

ACTUAL  SIZE

and a half-ounce

but... what a pot for performance

When paramount performance in restricted space is the trimmer-pot problem, the JP/2C could well provide an easy answer! Built to Waters exceptional standards, this petite pot in the 50 ohm to 10K ohm range has every fine characteristic developed at Waters to insure accurate resistance control throughout a phenominally long operational life. Available down to 10 ohms and up to 20K ohms as optional features.

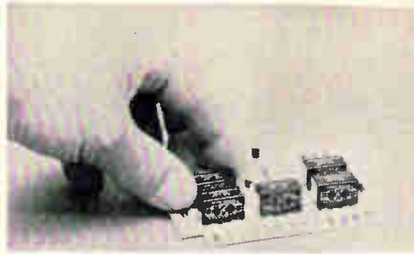
**Need a Particular Pot?**

If you have a worthwhile need for the potentiometer that doesn't exist . . . Waters has the engineering know-how and shop facilities to fulfill that need. Like to talk it over?

WATERS MANUFACTURING INC.
WAYLAND, MASSACHUSETTS

EXPORT
Charles H. Reed, Export Director
Waters Manufacturing, Inc.
Wayland, Mass. 01778 U. S. A.

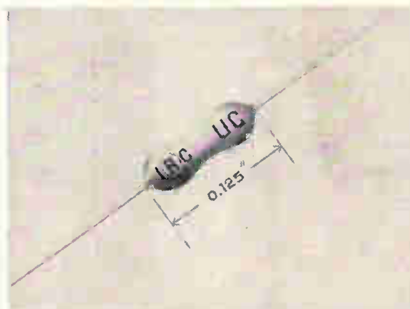


high-torque motor structure, dpdt gold-plated silver contacts rated low level to 2 amps at 30 v d-c resistive, 0.5 amp at 120 v a-c. Coils are rated for continuous duty with an operate time of 5 msec maximum and a release time of 3 msec maximum, both at nominal coil voltage and 25° C. Coil voltages of 6 v, 12 v, 24 v, 36 v and 48 v are available.

Potter & Brumfield, Princeton, Ind., 47570. [356]

## Metal film resistor in a small package




Bridging the gap between available discrete resistors and micro-circuitry is a new metal film resistor that satisfies the requirements of MIL-R-10509, and is believed to be the smallest commercially available. The UC resistor measures 0.125 in. long and 0.047 in. in diameter. It has No. 30 Awg (0.010 in.) gold-plated dumet leads.

Resistance values range from 50 ohms to 10 kilohms, with initial tolerances of ±1, ±2 or ±5%. Rated 1/20 watt at 100° C, these resistors are available with temperature coefficients of ±50 or ±100 ppm/° C.

Price is 67 cents each in lots of 1,000; delivery, 8 weeks.

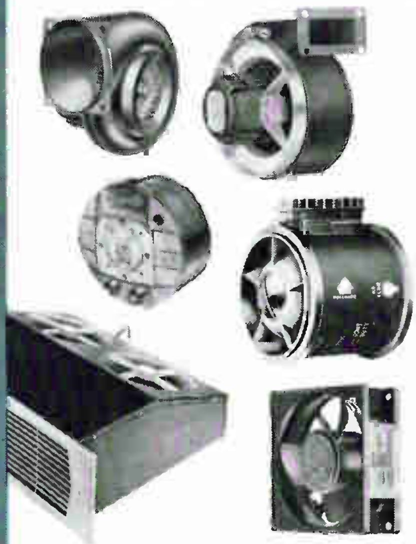
IRC, Inc., 401 N. Broad St., Philadelphia, Pa., 19108. [357]

# behind the Rotron trademark

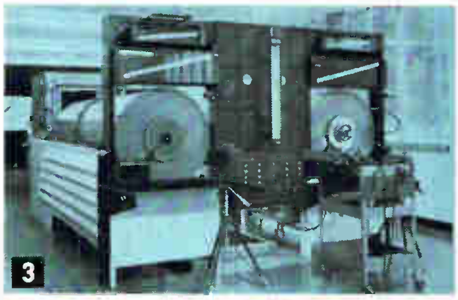
Advancing the state of the cooling art has been the direct accomplishment of Rotron's research and engineering staff which today represents a reservoir of knowledge and skills that is of incalculable value to the industries and the people the company serves.

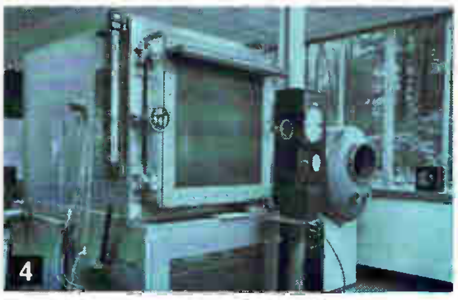
Rotron has complete laboratory facilities located in Woodstock, New York, Burbank, California and Breda, The Netherlands where customers' prototypes may be tested and evaluated, at no charge or obligation, to determine the proper cooling device to meet the requirements. Upon completion of the evaluation, standard units will be recommended or one will be custom designed.

Nothing is left to chance at Rotron.








1 CHEMICAL & MATERIALS LABORATORY — Basic material analysis to insure proper selection of the most appropriate plastics, metals, finishes, and insulations.

2 ELECTRO-MAGNETICS LABORATORY — Extensive investigation and experimentation for the development of motors, which are specifically matched with an air impeller to provide integrated units to meet particular application requirements.

3 AERODYNAMICS LABORATORY — Air flow test chamber (designed in accordance with Air Moving and Conditioning Association Bulletin No. 210) for measurement of air system impedance of actual prototype equipment, or simulated assemblies.

4 ENVIRONMENTAL LABORATORY — Necessary testing in all atmospheres, high pressures, low pressuers, various conditions of humidity and corrosive elements to insure optimum performance of fan and blowers in any environment.

ROTRON ® ROTRON mfg. co., inc.
WOODSTOCK, NEW YORK • 914-679-2401
West Coast: Rotron/Pacific, Burbank, Calif.
Canada: Aerovox Canada Ltd., Hamilton, Ont.
Rotron Europa N.V. Breda, The Netherlands

See Rotron at IEEE Booths 3B-19 and 21.

Circle 191 on reader service card

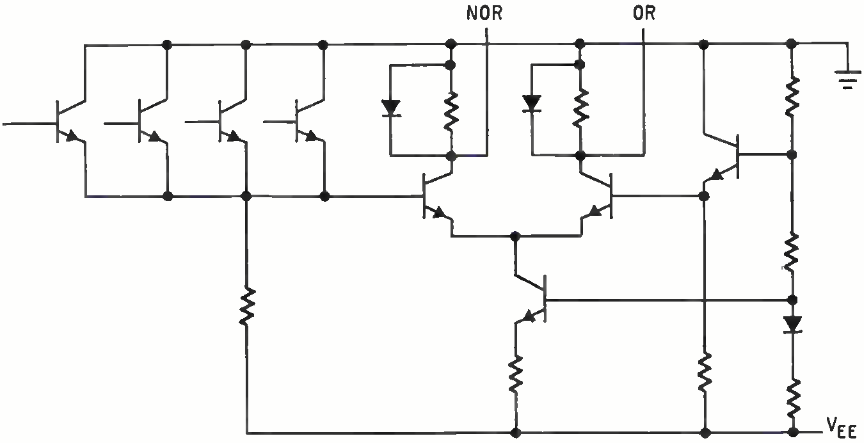

DISPLAY TIME
DC RANGE
FUNCTION
TIME BASE
FILTER
INPUT
POWER
VOLTS
CHASSIS
OHMS
OVERLOAD
VOLTS
OHMS
FUNCTION
RANGE

We make our digital volt meters with integrated circuits. They do more and sell for less. We make a model for every price range. One is for you. Made to measure.

FAIRCHILD

INSTRUMENTATION

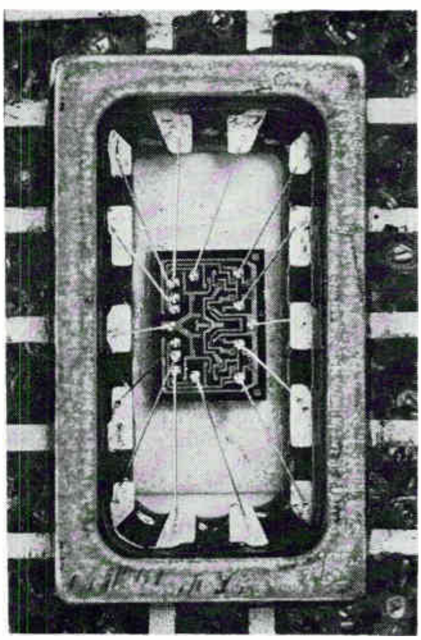
# One-upping emitter-coupled logic




**From its very name,** one might suspect that emitter-emitter coupled logic might be superior to ordinary emitter-coupled logic. And it is, says the Westinghouse Electric Corp.'s Molecular Electronics division, which has just started to market integrated circuits that have emitter-to-emitter input coupling. The E²CL line has typical switching speeds of 2 to 3 nanoseconds with a fan-out of 3, compared to the 5 nsec that have been achieved with ECL counterparts.

Among the advantages claimed are these:

- The emitter-follower input provides high input impedance and high fan-out. A fan-out up to 10 is possible at some sacrifice in speed. The speed degrades about 0.5 nsec for each additional gate beyond the specified fan-out of 3.
- The reference source is built into the circuit, improving temperature stability.
- Only one power supply is needed.
- System power dissipation is reduced because the emitter-follower is located at the output.
- Noise pickup is reduced because one logic level is tied to ground.
- Output impedance is virtually constant for both directions of logic swing, facilitating line termination.



Conventional ECL circuits, on the other hand, are subject to noise disturbance, particularly at high temperatures and may result in poor circuit matching due to floating logic levels. If matched to low impedances, conventional circuits will display high power dissipation.

Like emitter-coupled logic, E²CL operates in the current mode and provides both OR and NOR outputs where appropriate. The E²CL concept was developed by Britain's Mullard Ltd., which built the first circuits using discrete components. Westinghouse was the first company to build integrated E²CL circuits.

According to the company, about 10 devices are planned for the line. So far, six—all in ceramic flat-packs—have been made:

- Dual 4-input NOR-OR gate with 75 ohms internal termination.
- Single, 6-input line driver with clamped output, a catching diode at the collector.
- Dual 3-input NOR-OR gate with 75 ohms termination available but not connected.
- Single 8-input NAND-AND-OR (collector OR-ing internal).
- Single 6-input, double output NOR-OR gate.
- Single 8-input NAND-AND-OR gate with clamped output.

**Specifications**

| | |
|---|---|
| Propagation delay per gate | 2 nsec with fanout of 3 |
| Clock frequency | 100 Mhz |
| Line impedance | 75 ohms |
| Output capacitance | 5 pf max. |
| Noise margin | 150 mv min. |
| Power dissipation | 60 mw per gate |
| Input resistance | 2 kilohms |
| Input capacitance | 3 pf |
| Input current | 50 μa max. |
| Supply voltage | 4 v |
| Operating temperature range | —55° to +125°C |

Westinghouse Molecular Electronics Division, Box 7377, Elkridge, Md. 21227 **[361]**

# High-voltage, low cost, with silicon rectifier

A family of HVM (high voltage module) devices makes available a standard, low-cost silicon rectifier for end uses previously served by more expensive special units. They have peak reverse voltage ratings from 2,000 to 6,000 v at 250 ma; and in typical noncompensated diode strings, prv ratings up to 150,000 v can be achieved.

The HVM contains a modified version of the same basic diode diffused silicon cell employed in the manufacturer's Glass-Amp devices. Eight cells are connected in series in the module, which is encapsulated in high thermal conductivity epoxy. Insulating spacers are molded into the package to facilitate cooling when the modules are assembled in arrays. Leads can be welded and soldered, allowing maximum circuit assembly flexibility. The module measures ⅝ x ⅜ x ¼ in.

Applications include high voltage series strings for cathode-ray tubes, photomultipliers, vidicon power supplies, and other higher power applications such as welders, X-ray units, electron microscopes, electrostatic precipitators, and microwave ovens.

Because the devices promise


# The DVM's:

### Fairchild 7200:

A full 5-digit meter made for precision measurements in the laboratory or on the production line. It operates to a high standard of accuracy, with 10$\mu$V resolution, and excellent short and long term stability. The principle of operation is based on a new concept where high accuracy and long term stability are achieved by a digital time base memory (Pat. Pend.). The basic unit provides DC voltage measurements, DC ratio measurements, and counting functions to 1MHz. Optional plug-in cards or modules provide AC measurement, frequency measurement, resistance measurement, and other capabilities. Basic unit price is $3500.00.

### Fairchild 7100A:

A full 4-digit meter with extensive capabilities for laboratory and production line measurements. The 7100A measures voltage, resistance and ratio, with AC capabilities optionally available in a plug-in unit. It features guarded construction, 10$\mu$V resolution, 0.01% performance, and excellent stability. Price is $2075.00.

### Fairchild 7000:

A small, half-rack size, portable, medium price 4-digit meter, the 7000 features 0.01% accuracy. The basic unit provides DC voltage measurements, with provisions for adding AC voltage, resistance and current measurements as well as autoranging and BCD output. The front panel of the instrument controls all measurement functions, so that capabilities may be added simply by plugging in a circuit board. Basic unit price is $1150.00.

### Fairchild 7050:

This low-cost, accurate, 3-digit instrument is intended primarily as a replacement for analog-type meters and panel indicators in such applications as production testing, general testing, quality assurance, servicing and the like. Basic features include DC volts and resistance, full scale readout of 1500, input impedance greater than 1000 megohms, floating input, and readout storage (non-blinking display). Price is $299.00

**Where to get them:** For immediate assistance or for the name and address of the representative in your area, contact any of these Fairchild Instrumentation Field Sales Offices:

**U.S.A.**

4546 El Camino Real
Los Altos, California 94022
(415) 941-3111

5410 West Imperial Boulevard
Los Angeles, California 90045
(213) 678-3166
TWX: 910-328-6177

50 Jericho Turnpike
Jericho, L. I., New York 11753
(516) 333-9311
TWX: 510-222-4479

2105 Gulf-To-Bay Boulevard
Suite #4
Clearwater, Florida
(813) 446-4619
TWX: 810-866-0436

8517 39th Avenue, North
New Hope, Minnesota
(612) 544-5220

113 Gentry Road
*Hoffman Estates*
Roselle, Illinois 60172
(312) 894-2060

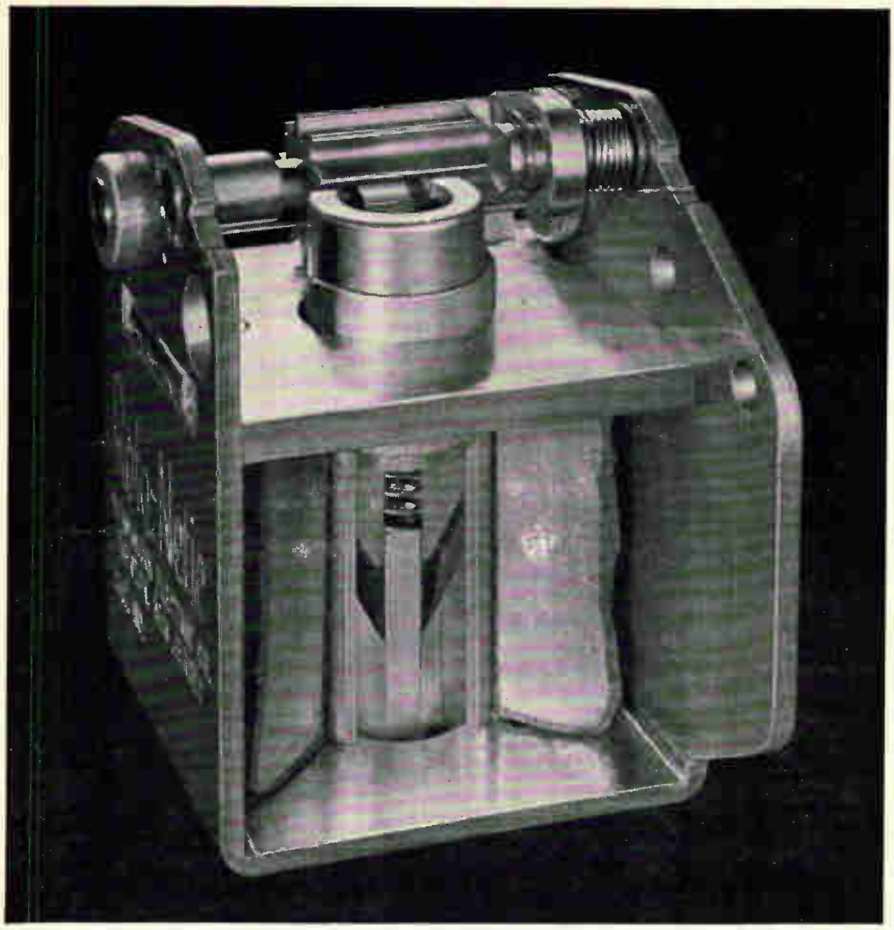
**EUROPE**

FAIRCHILD INSTRUMENTATION LTD.
Grove House, 551 London Road
*Isleworth*, Middlesex, England
Tel: 560-0838
TELEX: 24693

Grunwalderstrasse 99
Munich 90, West Germany
Tel: 49 18 47
Cable: FAIRINTA MUNICH

FAIRCHILD
INSTRUMENTATION

FAIRCHILD INSTRUMENTATION / A Division of Fairchild Camera and Instrument Corporation ▪ 475 Ellis, Mountain View, California 94040, (415) 962-2011 ▪ TWX: 910-379-6944



## Nobody ever built a stepping motor this way before.

## Or sold one for so little.*

A stepping motor has always been a rotary motor that steps. With all the design and manufacturing difficulties that implies. Precision bearings, dynamic balance, and the like. Incremental rotation calls for detents, springs, balls. Or magnetic braking. Then there's the axial thrust problem. Not surprisingly, you pay a lot of money for a rotary motor that steps.

Our picture shows a stepping motor that is not a rotary motor. It's a solenoid in disguise. A spring-loaded armature actuates a ratchet and pawl mechanism. Mechanically, that's all there is to it.

But functionally, there's a great deal more. For example, there's a double-ended shaft that lets you choose the direction of output rotation. An output torque of 0.1 inch-pounds. A ten-step star wheel (very handy for decade functions). A standard stepping speed of 600 steps/min.

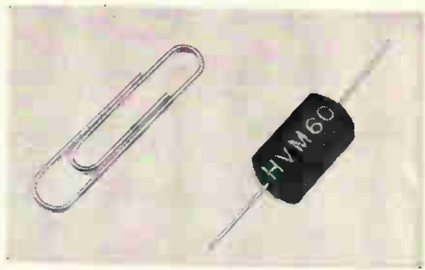
There's still more, but we'll save it until you ask—either for Bulletin 701, which is free, or for a sample motor, which costs ten dollars. If you'd like the sample, please let us know whether you want the 12 VDC or 115 VAC model. Heinemann Electric Company, 2600 Brunswick Pike, Trenton, N.J. 08602.

*$8, to OEM's, in quantities of 100 to 499.

HEINEMANN

3657

## New Semiconductors




longer life, higher reliability, greater resistance to shock and vibration, and smaller size, the HVM's may replace many conventional h-v tubes. In addition, the unit reduces circuit complexity and cost, since it eliminates filament supplies.

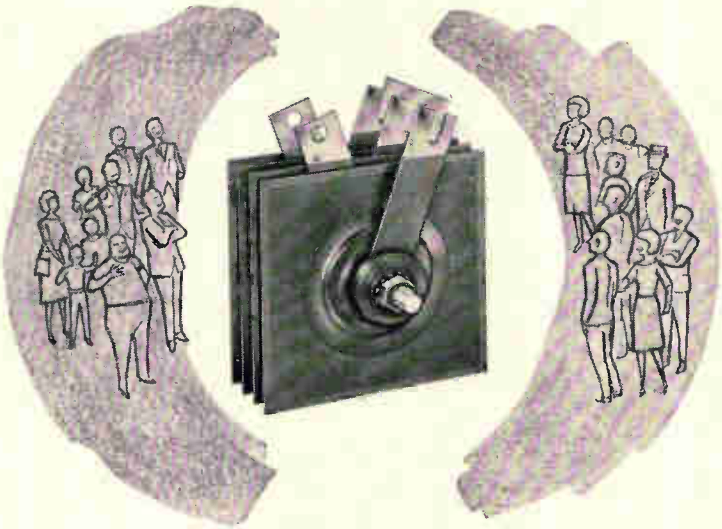
The HVM's are available for less than 50 cents per kv in large quantities.

General Instrument Corp., Microelectronics Division, 600 W. John St., Hicksville, N.Y., 11802. [362]

## Voltage regulator in a monolithic chip

Development and production of what is claimed to be the industry's first monolithic voltage regulator is announced. The device is adjustable over a 2- to 30-v output voltage range and can handle output currents up to 5 amps by the addition of external transistors. It can be used either as a linear, dissipating regulator or a high efficiency switching regulator with essentially the same performance in either application.

Flexibility of the LM-100's design satisfies the demands of a broad market, with applications in virtually all types of electronic equipment, according to the man-



# Uni-sel for the "IN" Crowd

## SYNTRON'S UNI-SEL SELENIUM RECTIFIER VIRTUOSO PAR EXCELLENCE!

In the crowded electronics industry, Uni-Sel Selenium Rectifiers solo with current ratings up to four times those of other 45-volt cells, double those of 33-volt high density cells. Operate at higher current density with smaller physical size.

241

Send catalog data about
Syntron Uni-Sel Rectifiers

Name/Title ____________________

Company ____________________

Street ____________________

City, State ____________ Zip ______

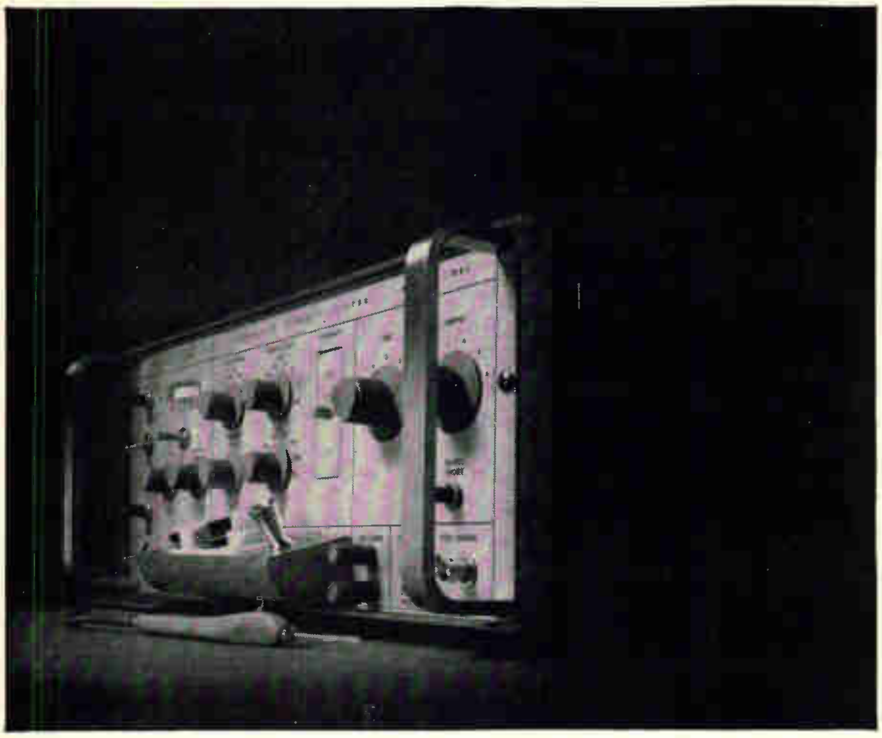
Just out!
New catalog with full information on Silicon Diodes and Assemblies.

SYNTRON

**SYNTRON COMPANY**

241 LEXINGTON AVE. • HOMER CITY, PA. 15748
TELEPHONE 412—479-8011
Sales Representatives Coast-to-Coast

67R6



**NEW! DYNAMIC IC TESTER**
**simulates actual in-circuit conditions.**

**The MONITOR Model 851 dynamically tests all commonly used integrated circuit types and package configurations.**

**It makes a full operational check on an IC in less than 15 seconds, at the actual in-circuit pulse rates, logic levels, and voltages called for by your system. The Model 851 is a complete, portable package (even includes a vacuum pickup for flatpack handling). All you need is a scope. It is obsolescence-proof, via interchangeable IC adapter sockets and test program plugs.**

**But the real clincher is the price: $1,920.**
**Descriptive literature? Get in touch with us.**

MONITOR SYSTEMS INC. A subsidiary of Epsco, Inc.

Fort Washington, Pa. 19034 □ Phone 215-646-8100 TWX 510-661-1520

3596

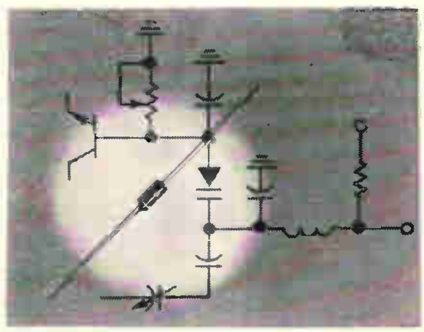


ufacturer. In addition to the usual advantages of small size and high reliability, the monolithic approach provides the equipment manufacturer with the opportunity of using a standard voltage regulator design for a wide range of performance requirements.

The device features regulation better than 1% for widely varying load and line conditions. Temperature stability is better than 1% over the full military temperature range. As a linear regulator the design provides current limiting, excellent transient response and unconditional stability with any combination of resistive or reactive loads. As a switching regulator, the circuit will operate at frequencies up to 100 khz with an efficiency of 85%. The monolithic chip contains a temperature-compensated voltage reference, an error amplifier and a series pass element capable of handling output currents to 10 ma. The addition of a single transistor increases the output to 200 ma. A second transistor will raise the output to 5 amps. The output voltage is set at the desired value by an external voltage divider.

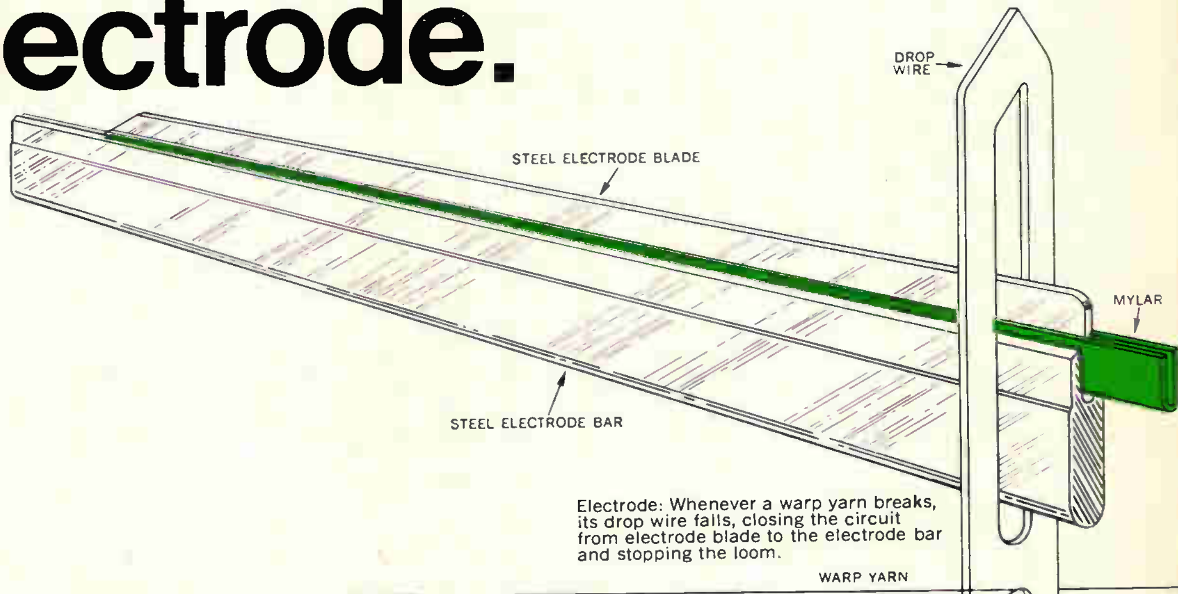
National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif.. 95051. [363]

## Silicon diodes cover 6.8 to 100 pf range



Voltage-variable capacitance diodes feature a high Q and high tuning ratio. The MV1720 through MV1750 series of silicon Epicaps cover a capacitance range of 6.8 to 100 picofarads with a capacitance tolerance of 10% and a re-

# Humidity can't faze this electrode.




Electrode: Whenever a warp yarn breaks, its drop wire falls, closing the circuit from electrode blade to the electrode bar and stopping the loom.

# It's insulated with Mylar.®

MYLAR* replaced paper as insulation in this K-A Electrode Switch — a vital part of textile looms that prevents mis-weaving by stopping the loom when a thread breaks. Paper was previously used as insulation, but the required high humidity in weaving rooms often caused electrical failures and needless stoppages. Then Marion Industries, Inc., a division of Draper Corporation, switched to insulation of MYLAR, and the electrical failures were practically eliminated. MYLAR offered a new kind of reliability to Marion and its customers. Specifically, better resistance to moisture, abrasion and puncture, plus improved dielectric strength. (MYLAR also resists most chemicals and withstands temperatures from −60°C. to +150°C.)

MYLAR may do even more for you. It can lower insulation costs because less MYLAR is required for a given insulation value. The high cut-through resistance and lasting durability of MYLAR enable you to use thinner gauges. You can replace heavier, bulkier insulation materials such as rubber, paper and resins with thinner, flexible MYLAR . . . save on weight, size and cost of your components, even make significant design improvements in your product.

MYLAR has paid off for Marion Industries and the textile industry. Find out how it can do the same for you. Mail the coupon today for a complete "Fact File" on MYLAR. Or write: Du Pont Company, Room 4992C, Wilmington, Delaware 19898.

*Du Pont's registered trademark for its polyester film.

DU PONT MYLAR®

Du Pont Company
Room 4992C,
Wilmington, Delaware 19898

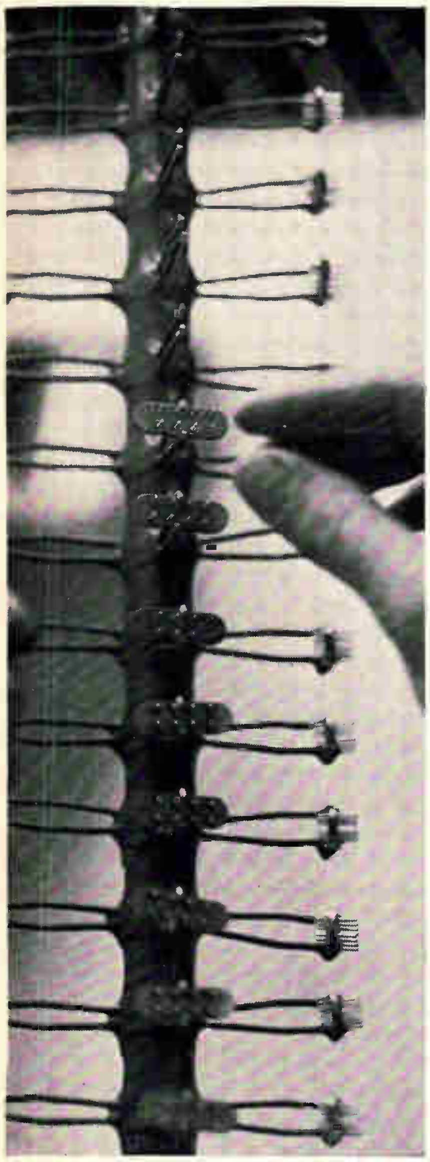
I'd like to know more about MYLAR. Please send me a complete Fact File.

Name ____________

Address ____________

Company ____________

City ________ State ________ Zip ______



# Pick a header... standard or custom

Then call Atlas—where reliability is a reality—whether you need custom headers to your drawings or any of more than 150 configurations of single-pin terminals for off-the-shelf delivery.

At Atlas a tape-programmed, six-head drilling machine reduces tooling time and total cost. An electron-beam welder bonds delicate parts with precision. And Helium Mass Spectrometers check for possible leakage.

In-house facilities such as these make it possible for us to manufacture and test to your specifications or MIL specs. For you that means unmatched quality and reliability. Challenge us today. Phone 215 666-0700. Or send for complete information.

**ATLAS**
**CHEMICAL INDUSTRIES, INC.**
**Aerospace Components Division**
**Valley Forge, Pa. 19481**



verse breakdown voltage of 30 volts.

These epitaxial, passivated diodes are suitable for high quality tuning applications in the vhf and uhf regions, providing solid state reliability and flexibility when replacing mechanical tuning. The devices' high Q allows tuning circuits to have sharp selectivity as a result of optimized resistivity profile. Tuning ratio, directly related to the tuning range capability of a voltage-variable capacitor, is obtained by the careful doping control.

The MV1720 has a nominal diode capacitance of 6.8 pf at a reverse bias voltage of 4 v d-c at a frequency of 1 Mhz. The tuning ratio is a minimum of 2.7 to 1 with a minimum Q of 500 as measured at 50 Mhz with 4 volts of reverse bias. The MV1750 has a nominal diode capacitance of 100 pf with a minimum tuning ratio of 3.2 to 1 and a minimum Q of 250.

The diodes are in a DO-7 glass package with the manufacturer's Ramrod construction and are priced at $4.90 each in lots of 100 to 999.
Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz., 85001. [364]

## Operational amplifier enclosed in a TO-5 can

An integrated circuit operational amplifier has been constructed on a single monolithic silicon substrate. Compensation may be applied externally to control stability.

Input drift of the model 1812 is limited to ±25 μv/°C over the temperature range of −55° to +125°C. Open loop gain is typically 86 db with a gain bandwidth product in excess of 10 Mhz. Input impedance is 500 kilohms with a 4 μv rms of noise. Output is 10 v peak-to-peak into 1,000 ohms. Power required is ±12 v d-c at 5 ma.

The amplifier is enclosed within a TO-5 transistor can with twelve 0.017-in.-diameter leads.

Price is $45, with delivery from stock.
Fairlane Electronics Inc., Box 335, Long Valley, N.J., 07653. [365]

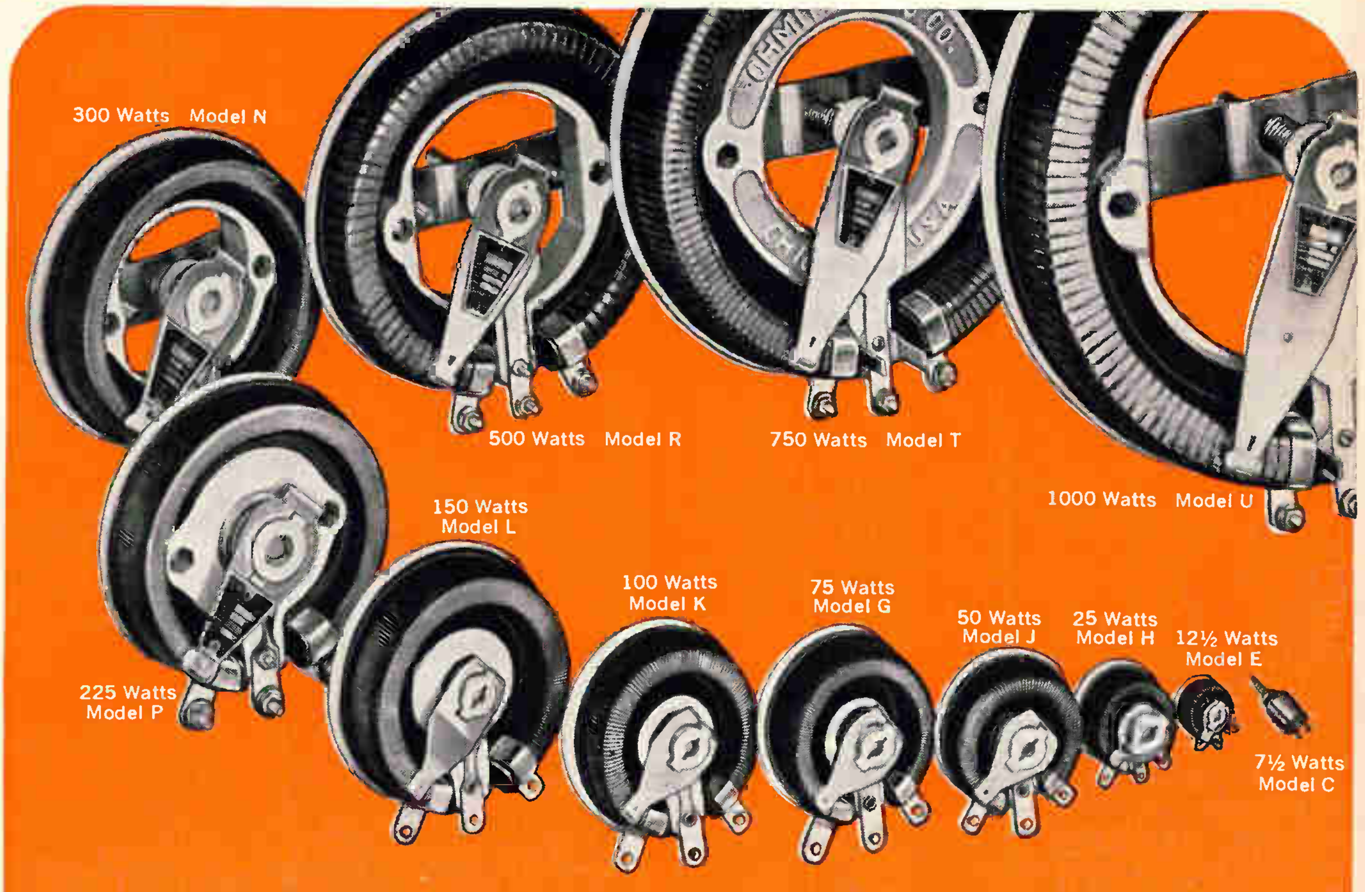


# Solve Your Special Purpose Filter, Transformer, Inductor and other Wire Wound Component Problems at SIE!


Dresser SIE now offers a complete engineering and manufacturing service to fill all your needs for special purpose wire wound components for your ordnance, aircraft, aero space and siesmic applications.

*Send your specifications today to the address below for complete information.*

**DRESSER**
**SIE**
**INC.**
INDUSTRIAL PRODUCTS GROUP
P.O. Box 2928/Houston, Texas 77001
one of the DRESSER Industries




# if it's a rheostat, you can get it from Ohmite

Need a miniature 7½-watt rheostat? Or something at the other extreme, say, 1000 watts? Ohmite makes all 12 basic sizes. With these as a starting point, you can branch out into literally hundreds of electrical, mechanical, and motor-driven variations . . . too many to even begin listing here.

Ohmite is the *only* rheostat supplier who can fill 100% of your requirements (plus many you probably will never run into).

*As Near As Your Distributor*—There are thousands of stock Ohmite rheostats in distributors' inventories from coast to coast backed up by the world's largest factory stock. So if you need standard rheostats in a hurry, you'll find Ohmite units are the easiest and quickest to lay your hands on . . . no matter where you are located . . . no matter what size you need.

*Motor-Driven Rheostats:* Technically, these are classified as specials. But Ohmite makes so many of them that some models are practically standard.

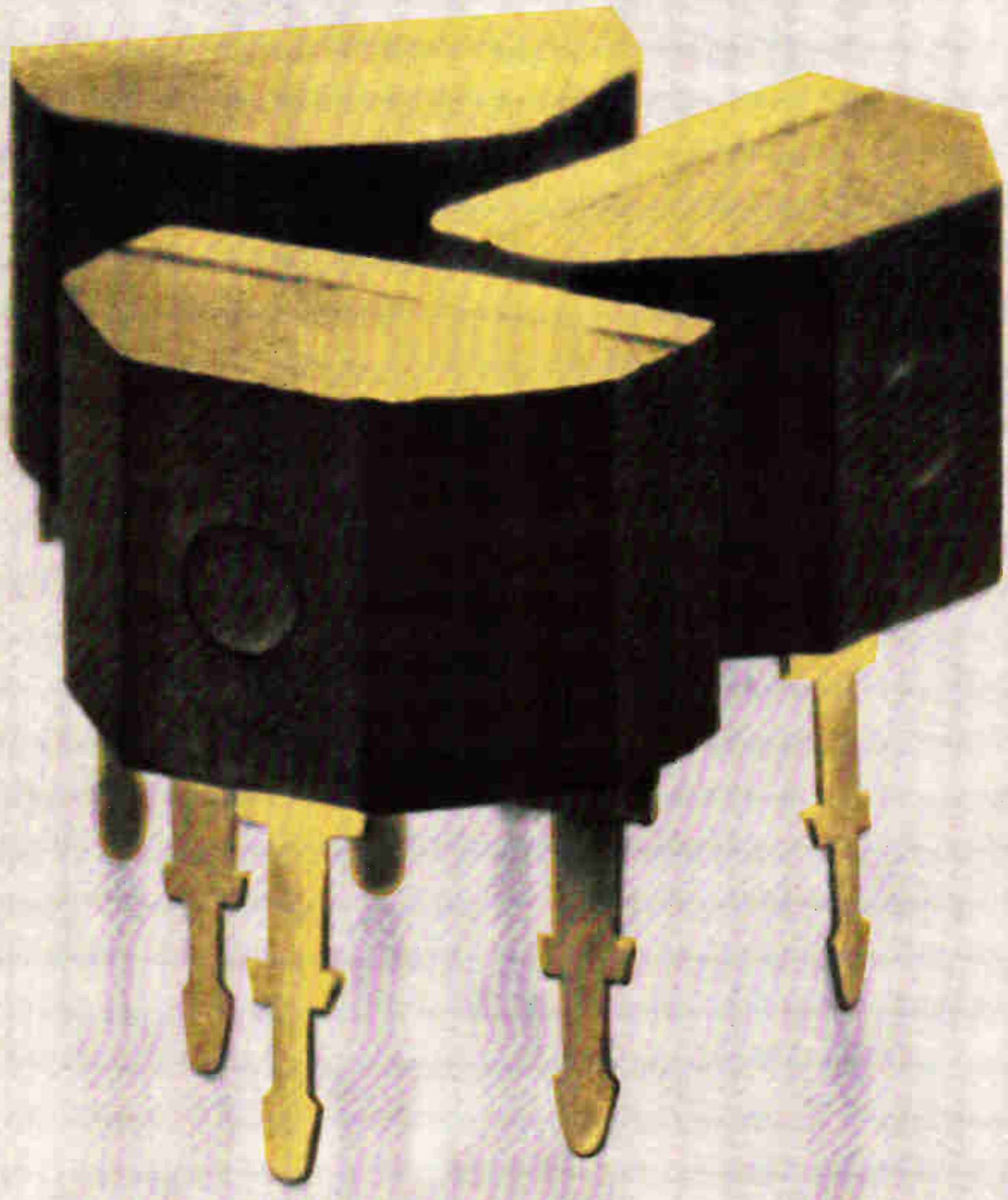
*"Way Out" Specials?* No matter how unusual your requirement, contact the factory. For over 30 years, Ohmite has been solving tough rheostat problems. Maybe yours is even among them.

*Write for Big New Catalog 200.*

**OHMITE**
MANUFACTURING COMPANY
3510 Howard Street, Skokie, Illinois 60076
Phone (312) ORchard 5-2600

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • TANTALUM CAPACITORS • TAP SWITCHES • RELAYS • R.F. CHOKES • SEMICONDUCTOR DIODES

# Now–the autosert
# A New Transistor Configuration That Permits Automatic Insertion Into All Standard PC Boards



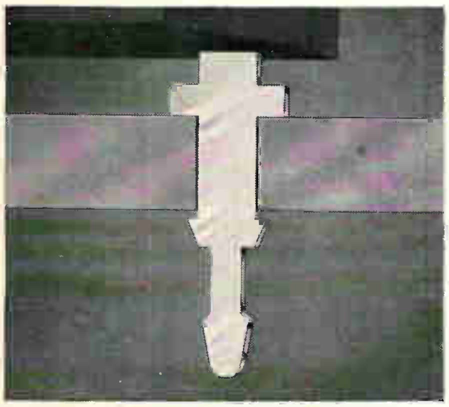

One of today's major unsolved problems in mass-producing electronic circuit boards is automatic insertion of transistors into the boards.

To solve this problem, the transistor should have rigid leads and a shape conducive to mechanized handling; it must fit the industry's standard circuit board hole-pattern and when inserted, it would have to snap in and seat so firmly that no other support is required.

The new Amperex **autosert** provides all these advantages for automatic (as well as high speed manual) insertion—at plastic transistor prices— without compromise in performance or reliability.

Instead of flexible wire leads, the **autosert** is terminated in three rigid alloy leads .008" thick, that snap—that's right, snap-into the circuit board holes.

Its unique shape mechanically keys the lead arrangement; the leads are spaced on a 200 mil pin circle eliminating the possibility of solder-bridging. Once inserted into the board, the **autosert** sits firmly on its own stand-off, its depth of penetration controlled by its rigid leads.



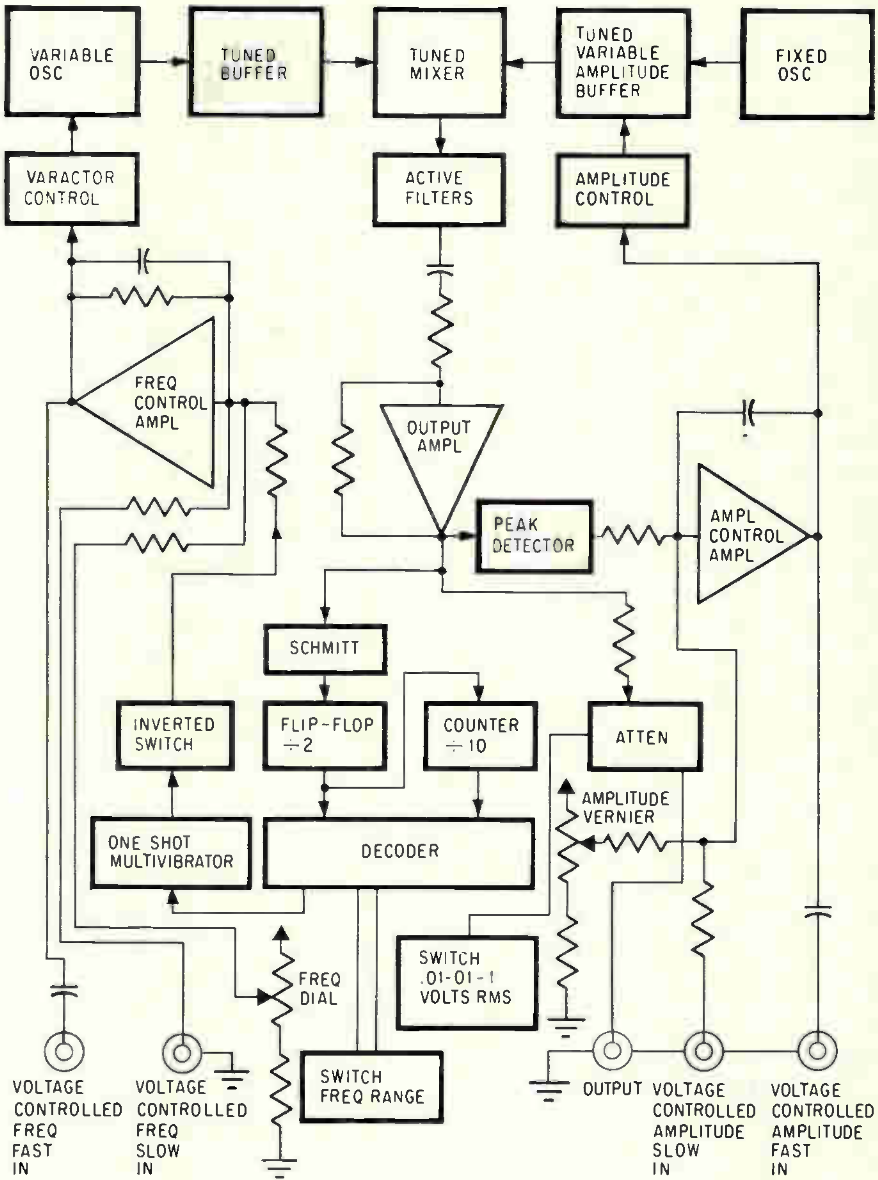
Transistors now available in the new **autosert** configuration are the RF amplifier types A494 and A495, for AM/FM radio, TV video drivers, sound IF's and sync circuits, CB and mobile communications receivers and types A747, A748 and A749 for general purpose and low level audio-frequency applications.

For additional information, write:
Amperex Electronic Corporation,
Semiconductor & Receiving Tube Division,
Dept. 371, Slatersville, Rhode Island 02876.

**Amperex**®
TOMORROW'S THINKING IN TODAY'S PRODUCTS



# Low-cost signal source, simply done




**With most** a-m/f-m signal generators selling for upwards of $1,400, many users would cast quizzical looks at any instrument that purports to do as much at only a fraction of the cost. But any lingering doubt that such a device actually exists is now being effectively dispelled.

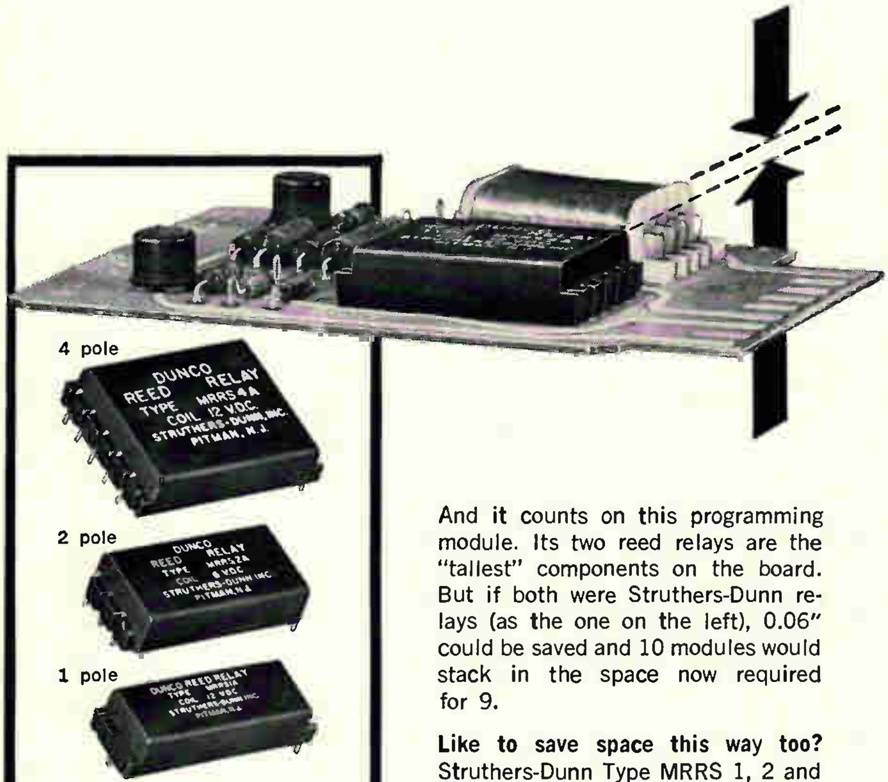
Making its bow at the IEEE show is a signal generator from Wavetek priced at $595. Although its 100-kilohertz to 12-megahertz frequency range isn't as broad as those of the costlier units, the company feels this is outweighed by remote control capabilities not found on other instruments.

In its efforts to keep the cost down on its model 501, Wavetek turned to simplified control circuitry. Because digital techniques were employed, off-the-shelf IC's were used instead of more expensive circuits fabricated with discrete components.

Two oscillators comprise the instrument's main components. Frequency modulation and sweeping is done on a variable-frequency oscillator spanning the range from 58 to 59.9 Mhz, while a fixed-frequency oscillator—operating at 70 Mhz—accepts the amplitude mod-

←Circle 256 on reader service card

# SAVING .06"+ WHERE IT Counts!




**Dunco**
**LOW PROFILE REED RELAYS**

And it counts on this programming module. Its two reed relays are the "tallest" components on the board. But if both were Struthers-Dunn relays (as the one on the left), 0.06" could be saved and 10 modules would stack in the space now required for 9.

**Like to save space this way too?** Struthers-Dunn Type MRRS 1, 2 and 4 pole reed relays are available in single and dual-coil models. They're magnetically shielded and encapsulated into rigid homogenous structures. Detailed information is contained in Data Bulletin MRR-3A. Write:

S-D **STRUTHERS-DUNN, INC.**
PITMAN, NEW JERSEY 08071

COMING TO IEEE? SEE US AT BOOTHS 4J 25-27




ulation. Inserting the modulation in a narrow range of higher, premixer frequencies makes it easier to control the output signal.

The outputs of the oscillators are combined in a mixer to develop a difference signal which is then filtered and amplified to function as the output. Tuned buffer amplifiers between the oscillators and the mixer reduce harmonic distortion, thus simplifying the filtering requirements. Control circuitry keeps the output's amplitude and frequency constant for given panel settings or applied control voltages.

The output frequency is swept by applying a ramp voltage to the "slow" frequency-control terminal and setting the main tuning dial at its lowest value. A ramp input from zero to 5 volts will then control the frequency over the range selected, either from 100 khz to 1.2 Mhz or from 1.0 Mhz to 12 Mhz. By applying a similar signal to the "slow" amplitude-control terminal, the output amplitude can be swept from zero to 1 volt in three steps—to 0.01, to 0.1, and to 1 volt root-mean-square.

Any waveform can modulate the output. To use a modulation frequency above 5 khz, the control signal must be applied to the "fast" terminal to bypass the frequency-control amplifier. Below that frequency, the "slow" control terminal can be used.

After the output signal is amplified, a peak generator sends pulses that are summed in a control amplifier along with the analog input from the input terminal. A control circuit then varies the output amplitude from the fixed oscillator buffer amplifier. This signal is nulled when the amplitude reaches the desired value.

The amplifier is also sampled by a Schmitt squaring circuit. The output of the circuit is divided by two in the 100-khz to 1.2-Mhz range, and by 20 in the 1 to 12-Mhz range. Divide-by-two is done by a flip-flop and the additional divide-by-10 by a counter. A front-panel switch controls a decoder that selects the correct rate for frequency ranging. The decoder drives a bistable multivibrator which controls a set of inverted switches that provide pulses to the frequency-control amplifier. This amplifier sums the pulses with the analog-frequency-control input signal and drives a varactor-diode frequency control network to change the frequency of the variable oscillator.

The amplitude is constant within 0.01% over the instrument's entire range. Frequency is accurate within 1% of the setting, and the voltage-to-frequency linearity is 0.2% on the slow range. The company supplies linearity curves for the fast range.

Wavetek, 8159 Engineer Rd., San Diego, Calif. 92111 [371]

## Pressure transducer provides 1-v output

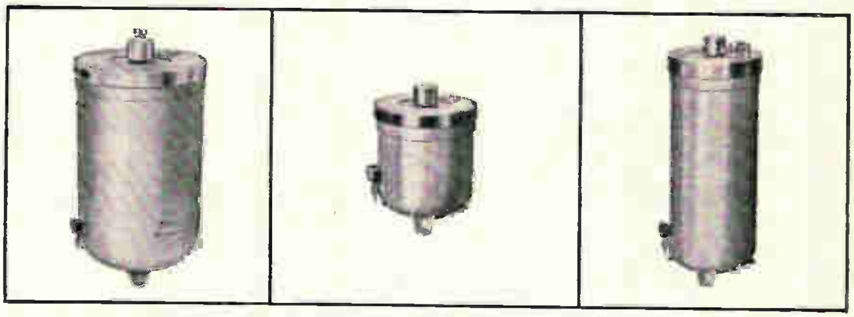
A semiconductor strain-gauge pressure transducer that provides an unamplified 1-volt output is intended for both airborne and industrial uses. It will measure and monitor air, fuel, lubricants, hydraulic fluids, and corrosive gases and liquids.

Model 3508-14 operates in the pressure range of 0 to 50 psi through 0 to 3,000 psi absolute or gauge. It will withstand 50 g vibration, 200 g acceleration and 400 g shock. Compensable temperature range is −20°F to +250°F.

The basic model weighs less

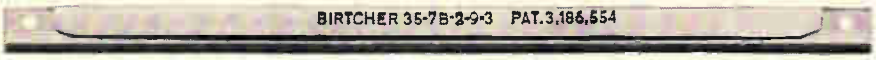

LAPP GAS FILLED CAPACITORS ARE DESIGNED FOR

HIGH VOLTAGE
HIGH CURRENT
HIGH CAPACITANCE
APPLICATIONS



These uniquely designed Lapp Gas-Filled Capacitors are completely unaffected by atmospheric or dust conditions. They are precision built and of extra strong construction to assure years of accurate, trouble-free operation. ■ Lapp Gas-Filled Capacitors are available in either fixed or variable models. All are equipped with an external safety gap to protect against internal flashover on excess voltage peaks. Capacitance available up to 30,000 mmf, safety gap settings up to 85 kv peak and current ratings up to 400 amps at 1 mc. ■ Write for Bulletin 302 . . . get our complete Gas-Filled Capacitor story. Lapp Insulator Co., Inc., Radio Specialties Division, 203 Sumner St., LeRoy, N.Y. 14482.

Lapp

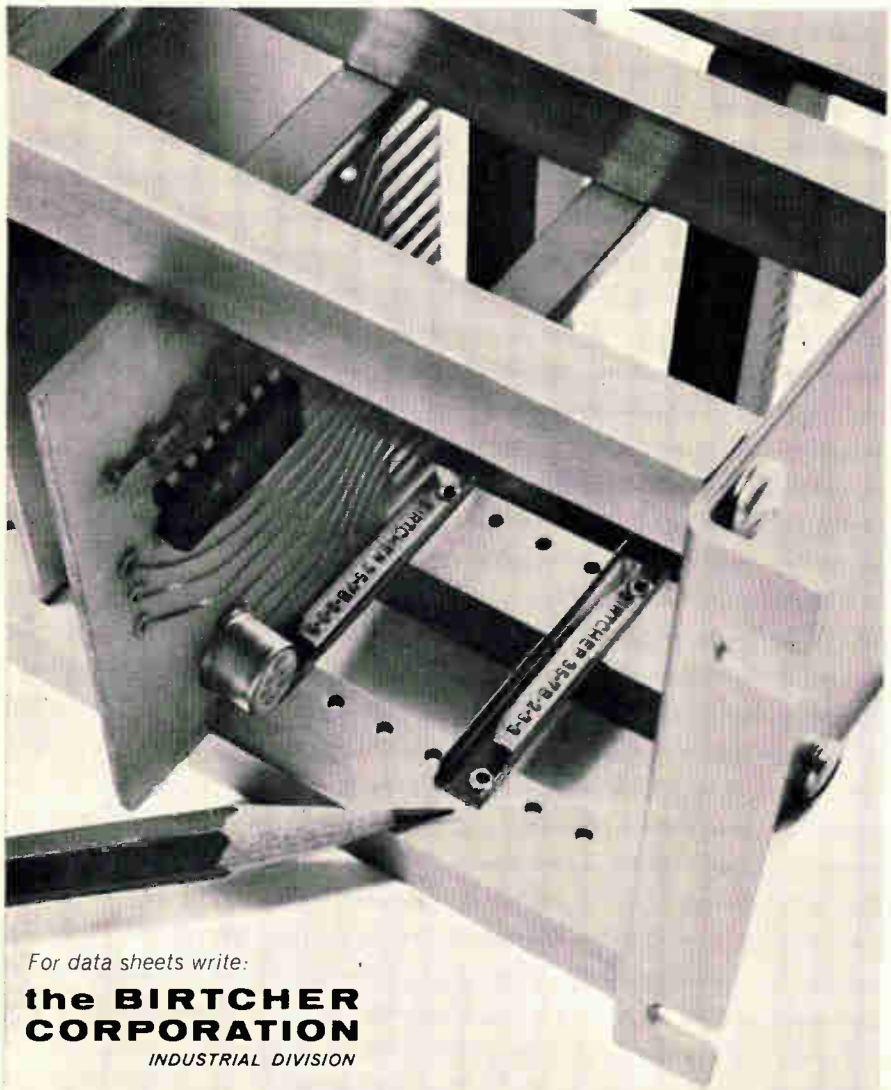



Shown actual size


# PCB RETAINERS FOR MICROMIN AND IC APPLICATIONS—THE BIRTCHER 35-7 SERIES PCB-TAINER



offers you these advantages: LOW PROFILE—takes up only 1/8″ of board space. SMALL CROSS-SECTION—allows 1/4″ board spacing; offers minimum impedance to air flow. PROVEN CONFIGURATION—same spring retention, shock protection of standard size 35-1 series. WIDE SIZE RANGE—available for 1/32″ and 1/16″ boards; lengths from 1″ to 6″ in 1/2″ increments. CONDUCTIVITY—standard beryllium copper unit provides thermal contact for heat sinking, electrical contact for grounding. EASY MOUNTING—fastens with .062″ rivets. Available in choice of materials and finishes from any of the distributors listed opposite. Also available: component kit for complete miniature rack assembly shown; assemble your rack to your own requirements for card height, length, and spacing.



*For data sheets write:*

**the BIRTCHER CORPORATION**

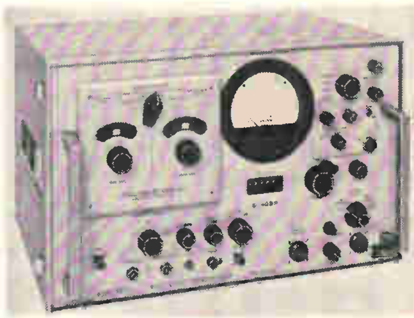
*INDUSTRIAL DIVISION*

745 Monterey Pass Road • Monterey Park, California 91754 • (213) 268-8584




than 2.5 oz. It is available for absolute or gauge pressure measurement with a variety of electrical connectors, pressure fittings, case configurations and mounting styles to meet individual applications.
Servonic Instruments Inc., 1644 Whittier Ave., Costa Mesa, Calif. [372]

## Instrument scans noise, field intensity



Automatic scanning is featured in a solid state noise and field intensity meter. The instrument is designed to meet the requirements of all applicable federal and military standards and specifications.

The Empire model NF-315A automatically scans between any portion of the 20 hz to 15 khz frequency range. Upper and lower limits of the sector to be scanned are selected remotely, or by means of a front panel scan limit control. This permits continuous spectrum scanning or single sweep, upward or downward in frequency.

Operation of the NF-315 is simple and fast. Three separate, calibrated scales are provided: peak, average, and rms. Simple calibration checks may be performed in the field, using built-in frequency and amplitude calibrators, and recalibration may be performed without disconnecting input terminals; however, highly stabilized circuits eliminate the necessity of recalibration when tuning to new frequencies.

Performance characteristics include: 180-db signal range; 0.005 $\mu$v sensitivity; greater than 70-db spurious response rejection; and high resistance to shock, vibration and temperature extremes. Up to eight hours of continuous, portable operation is made possible by built-in rechargeable batteries.

The Singer Co., Metrics division, 915 Pembroke St., Bridgeport, Conn., 06608. [373]

## Transducer senses linear motion

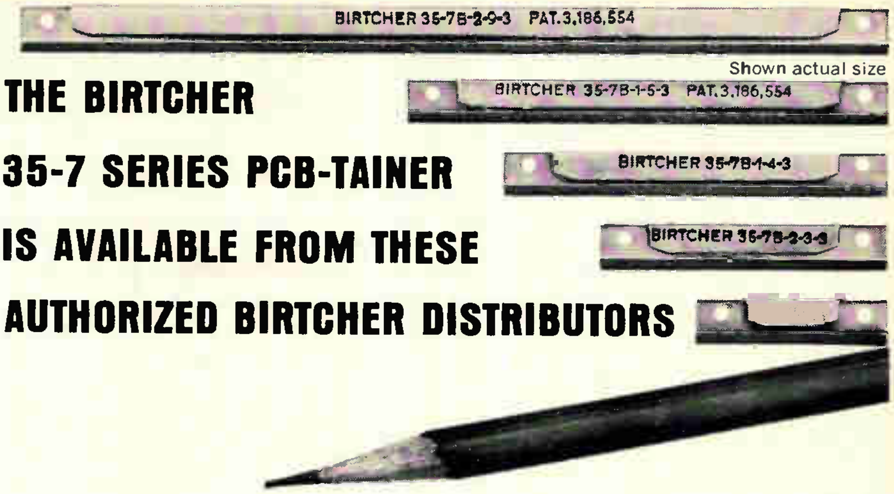

Conversion of motion to linear d-c output from 6-v d-c input is achieved by a linear variable differential transformer. Besides measuring, detecting, and controlling linear motion from a d-c supply, the unit can also be used for force and pressure measurement.

Model 7304 is 0.812 in. long by 0.750 in. in diameter. The core is 0.300 in. long, and extensions are available. Range is ±0.050 in. with linearity of ±0.25% one side of null, ±0.5% through null. Output at 0.050 is 2 v d-c with a load of 10,000 ohms. The maximum null position shift with temperature is 0.00025 in. per 100°F change. Output change with temperature is ±1% per 100°F change.

Pickering & Co., 101 Sunnyside Blvd., Plainview, N.Y., 11803. [374]

## Phase angle standard affords high precision

A self-calibrating technique has resulted in the development of what is termed the only known primary phase measurement instrument. This unit, model 312, is a primary phase angle standard,


Shown actual size

**THE BIRTCHER 35-7 SERIES PCB-TAINER IS AVAILABLE FROM THESE AUTHORIZED BIRTCHER DISTRIBUTORS**

**ALABAMA**
Cramer Electronics, Inc.
Huntsville 35801
Tel. 205-536-4493

**ARIZONA**
R. V. Weatherford Company
Phoenix 85009
Tel. 602-272-7144

**CALIFORNIA**
Fortune Electronics, Inc.
Redwood City 94063
Tel. 415-365-4555

Hollywood Radio & Electronics, Inc.
Menlo Park 94025
Tel. 415-322-3431
TWX: 910-373-1260

Hollywood Radio & Electronics, Inc.
Hollywood 90027
Tel. 213-466-3181
TWX: 910-321-4135

Santa Monica-Bell Electronics Corp.
Gardena 90247
Tel. 231-321-5802
TWX: 213-327-0070

Zack Electronics
Palo Alto 94301
Tel. 415-326-5432

**COLORADO**
Newark/Denver
Electronic Supply Corp.
Denver 80222
Tel. 303-757-3351
TWX: 910-931-0479

**CONNECTICUT**
Cramer Electronics, Inc.
Hamden 06514
Tel. 203-288-7771

**FLORIDA**
Airwork Corp.
Miami 33148
Tel. 305-885-2401
TWX: 810-848-7641

Cramer/Florida Inc.
Fort Lauderdale 33307
Tel. 305-566-7511

**ILLINOIS**
Airwork Corp.
Elk Grove Village 60007
Tel. 312-437-3740
TWX: 910-222-2052

Semiconductor Specialists
Chicago 60666
Tel. 312-279-1000
TWX: 910-254-0169

**IOWA**
Iowa Radio Supply Co., Inc.
Cedar Rapids 52402
Tel. 319-364-6154

**KANSAS**
Radio Supply Co., Inc.
Wichita 67201
Tel. 316-267-5214 also 5216

**MARYLAND**
Car-Lac Electronic
Industrial Sales, Inc.
Baltimore 21218
Tel. 301-889-3540

Cramer/Washington
Rockwell 20850

**MASSACHUSETTS**
Cramer Electronics, Inc.
Newton 02164
Tel. 617-969-7700

**MICHIGAN**
Semiconductor Specialists
Detroit 48240
Tel. 313-255-0300

Semiconductor Specialists
Dearborn Heights 48127
Tel. 313-271-4240
TWX: 810-221-7443

S. Sterling Company
Southfield 48076
Tel. 313-442-5656 also 357-3700
TWX: 313-357-4615

**MINNESOTA**
Lew Bonn Company
Minneapolis 55404
Tel. 612-339-9461
TWX: 612-321-1075

Semiconductor Specialists
Minneapolis 55423
Tel. 612-866-3434
TWX: 910-576-2959

**MISSOURI**
Electronic Components
for Industry Company
St. Louis 63144
Tel. 314-647-5505
TWX: 314-556-0584

Interstate Industrial Electronics
St. Louis 63116
Tel. 314-353-8313

Semiconductor Specialists
St. Louis 63134
Tel. 314-521-8866

Walters Radio Supply, Inc.
Kansas City 64111
Tel. 816-531-7015

**NEW JERSEY**
R. P. Luce & Company
Short Hills 07078
Tel. 201-379-6600
TWX: 710-983-4431

**NEW MEXICO**
Kierulff Electronic Company
Albuquerque 87108
Tel. 505-268-3901

**NEW YORK**
Car-Lac Electronic
Industrial Sales, Inc.
Bellmore 11710
Tel. 516-221-1441

Cramer/Eastern, Inc.
Syracuse 13211
Tel. 315-455-6641

Cramer/Esco, Inc.
Elmhurst 11369
Tel. 212-478-4000

R. P. Luce & Company
New Hyde Park 11040
Tel. 516-437-4550

Summit Distributors
Buffalo 14202
Tel. 716-884-3450

**OHIO**
Cramer/Tri-States
Cincinnati 45241
Tel. 513-563-0570

Pioneer Standard Electronics, Inc.
Srepco Electronic Division
Dayton 05404
Tel. 513-224-0871
TWX: 513-944-0430

Pioneer Standard Electronics, Inc.
Srepco Electronic Division
Cleveland 44103
Tel. 216-432-0010

Semiconductor Specialists
Dayton 45415
Tel. 513-278-9455

**OKLAHOMA**
Radio, Inc.
Tulsa 74119
Tel. 918-587-9124

Radio, Inc.
Oklahoma City 73102
Tel. 405-235-1551

**PENNSYLVANIA**
Semiconductor Specialists
Pittsburgh 15218
Tel. 412-351-3611

**TEXAS**
Adleta Electronics Company
Dallas 75201
Tel. 214-742-8257

Busacker Electronic
Equipment Company
Houston 77019
Tel. 713-526-4661

Scooter's Radio Supply Company
Ft. Worth 76101
Tel. 817-336-7448

Southwest Electronics, Inc.
Houston 77027
Tel. 713-666-2401
TWX: 910-881-1794

**UTAH**
W. H. Bintz Company
Salt Lake City 84110
Tel. 801-363-5821

**WASHINGTON**
Seattle Radio Supply, Inc.
Seattle 98121
Tel. 206-624-2341

Seattle Radio Supply, Inc.
Yakima 98902
Tel. 509-457-5123

**WASHINGTON, D.C.**
Capitol Radio Wholesalers, Inc.
Washington, D.C. 20009
Tel. 202-232-6000

**EXPORT AGENT**
Frazar & Hansen, Ltd.
San Francisco 94111
Tel. 415-981-5262

**CANADA**
Lake Engineering Company, Ltd.
Scarborough, Ontario
Tel. 416-751-5980

*—distributors of the complete Birtcher line of electronic retention/cooling devices: tube clamps, Kool Klamps®, heat radiators, transistor clips, PCB Tainers®*

Circle 207 on reader service card


*where industry is never blocked...*

How did Louisiana remove the stumbling blocks to profit? With its progressive **Right-To-Profit Laws.** They protect industry, large and small, from unfair taxation and excessive government regulation.

The **Right-To-Profit Laws** are a major reason why over a billion dollars worth of new industry has located in Louisiana in the last two years. This is the greatest growth period in the State's history.

For information on The Right-To-Profit Laws—and the other factors in Louisiana's industrial renaissance—write to W. T. Hackett, Department of Commerce and Industry, Room 214, Capitol Annex, Baton Rouge, Louisiana 70804.

LOUISIANA

The Right-To-Profit State



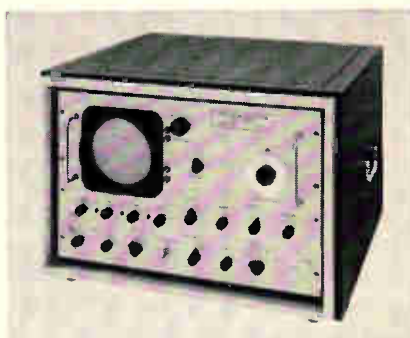

built with solid state devices, which operates over the frequency range from 4 khz to 500 khz.

The instrument produces very precise phase shifts over a 360° range and measures the phase shift through an unknown device or between two signals. Absolute accuracy is ±0.05° from 4 khz to 10 khz, ±0.02° from 10 khz to 50 khz; with slightly decreasing accuracy to 500 khz. Output impedance is 1.6 ohms.

The unit is entirely self-contained, including the tuned null detector. Price is $3,450; delivery, 1 week.

Dytronics Co., 4800 Evanswood Drive, Columbus, Ohio, 43224. **[375]**

## Spectrum analyzer covers 0 to 50 khz



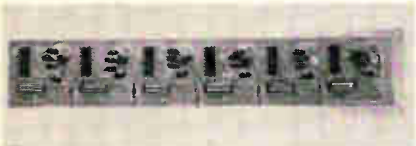
Using a comb of frequencies for accuracy measurements, a sonic spectrum analyzer covers the 0 to 50 khz range with a frequency accuracy to better than 10 hz. Model SS50-S is a valuable tool in the field of vibration, noise, distortion, and harmonic analysis.

Specifications include 50-$\mu$v to 500-v input sensitivity, 60-db dynamic range, and four internal markers at 50 khz, 5 khz, 1 khz, and 500 hz.

Delivery is 30 to 45 days after receipt of order.

Probescope Co. Inc., 211 Robbins Lane, Syosset, N.Y. [376]

## Timer measures pulses on a continuous basis



A system that measures the time between input start and stop pulses on a continuous basis has been introduced by Nanofast Inc. Outstanding features are the 10-nanosecond resolution and the continuity with a repetition rate up to 50 khz.

Included is a 100-khz preset counter which provides an output and resets the unit optionally when the measured time equals the preset value. The timing range of the 535-7C system is 10 nsec to 0.1 sec.

Applications include sonar phase measurements, high repetition rate and continuous laser systems, ballistic and shock wave measurements, and geophysical analysis systems.

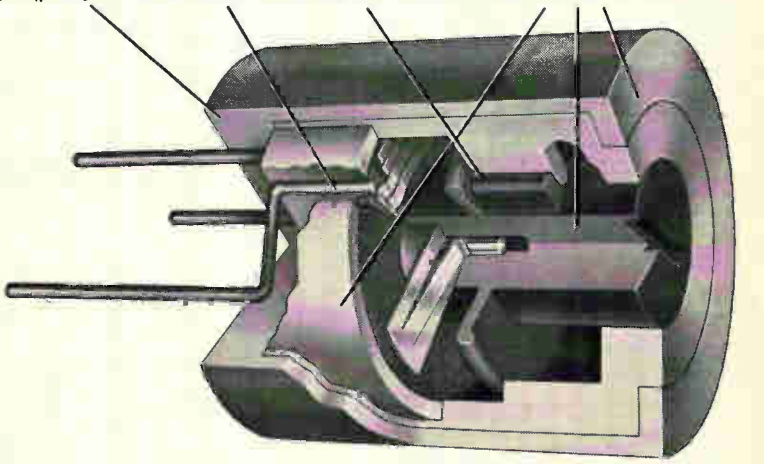
Nanofast Inc., 416 West Erie St., Chicago 10, Ill. [377]

## Generator produces clean square waves

A solid state generator is claimed to produce exceptionally clean square waves from 1 hz to 10 Mhz. Square-wave rise and fall times are less than 5 nsec. Overshoot, preshoot and ringing are less than 5%. There is no sag, and jitter is less than 0.2% of waveform period at any repetition rate.

Model 211B takes half the width of a 7-in.-high space when rack-mounted. Weight is 9 lbs.

The unit supplies 5-v pulses into a 50-ohm load. A second output, matched for 600 ohms, supplies 30 v peak into 600 ohms or 60 v open-



Actual Size

NEW! UNIQUE! A REVOLUTIONARY BREAKTHROUGH IN TRIMMER DESIGN!

(An exaggeration? Check the features!)

Look at the many quality features and outstanding performance characteristics we've packed into this tiny 11/32-inch-diameter industrial trimmer. ■ A unique, molded, seamless housing that virtually eliminates leakage. ■ A simplified design that greatly enhances reliability. ■ A unit with only two electrical joints that minimize the possibility of catastrophic termination failure. ■ An exclusive molded construction technique that provides a pin-pull-strength many times greater than that of comparable units. ■ A multi-finger wiper that covers a large element area to provide "redundant" positive contact and reduced noise (CRV). ■ A non-metallic housing that reduces the likelihood of voltage breakdown. ■ Plus, exceptional product quality and uniformity that are consistently maintained through the use of unique, semi-automatic final assembly equipment specially designed and developed by Spectrol.

All of these superior features are offered in Spectrol's highly reliable, industrial, cermet trimmer—the Model 53. Yet, this trimmer sells for less than comparable competitive units. This user-designed Model 53—developed in cooperation with one of the nation's largest computer manufacturers—is available in round top-adjust and cubic side-adjust versions. For complete specs, circle the reader service card.

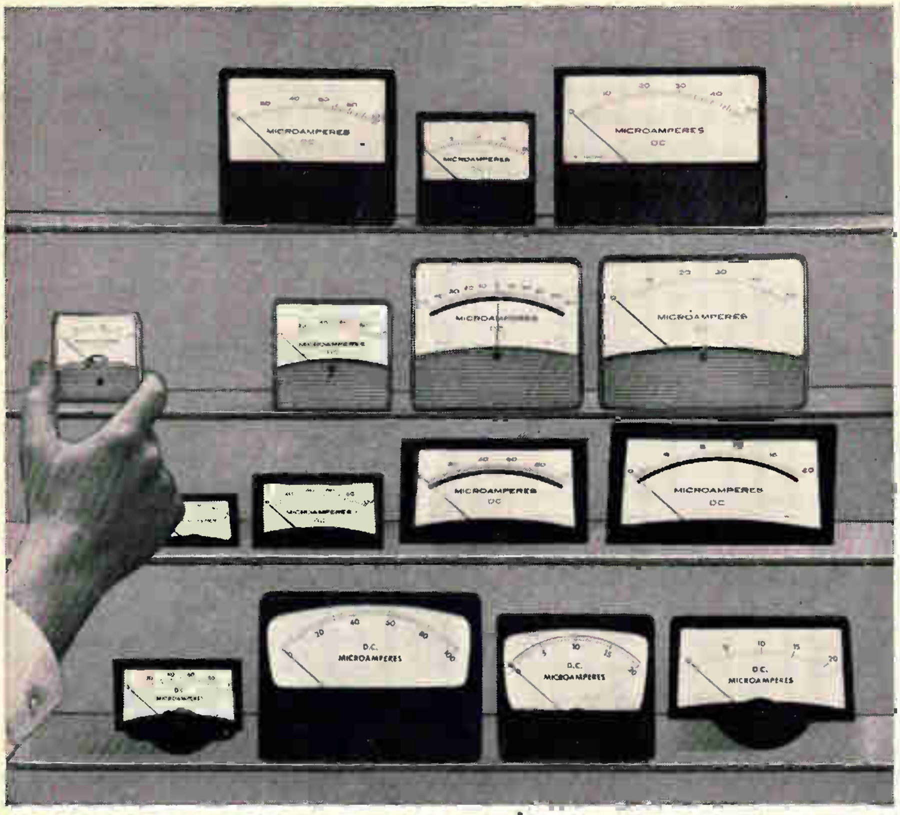
*See us at IEEE Booth 4K04-4K06*

Spectrol

*Better Components for Better Systems*

SPECTROL ELECTRONICS CORPORATION 17070 E. GALE AVE. CITY OF INDUSTRY, CALIF. 91745 PHONE: (213) 964-6565 TWX: (213) 686-6780

Circle 209 on reader service card



# Off-the-Shelf Only from api

- 1% tracking
- taut-band
- no extra charge
- 20 to 100 $\mu a$

There's extra value, but no extra cost, in API's line of DC panel meters in the 20 to 100 microampere ranges. Tracking of $\pm 1\%$ is standard. Frictionless taut-band construction produces meters that are the most accurate, sensitive to smaller signals, vibration-proof and durable.

No other manufacturer offers these bonus features at firm catalog prices.

*15 Models in Stock*

You'll get off-the-shelf delivery of the economically priced Panelist, Stylist and black phenolic meters shown above. Choose from these full-scale DC ranges:

**Microamperes:** 0-20, 0-50, 0-100
**Millivolts:** 0-5, 0-10

If ultra-precision tracking is the least you'll settle for, API offers 0.5% tracking at reasonable cost. This "super-calibration" is another API exclusive, again backed by published prices.

**Ask for Bulletin 47.**

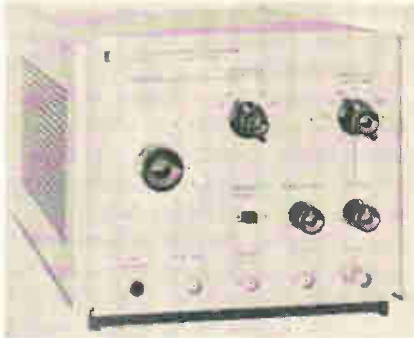
*Also stocked nationally by Allied Electronics and Newark Electronics.*

**See these instruments at IEEE Booth 2-G-39.**

**api INSTRUMENTS CO.**

*CHESTERLAND, OHIO 44026* (CLEVELAND-216) 729-1611 • TWX: 810-427-9230



circuited. Both output waveforms are d-c coupled negative-going, but differ in time phase by 180°.

Price is \$375; delivery is from stock.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif., 94304. **[378]**

## Multipoint recorder packaged compactly

Capable of measuring 2, 3, 4, 6, or 12 inputs, a compact multipoint recorder has a full 6½-in. scale. The face area of the instrument is approximately 2½ times smaller than a conventional 12-point unit which uses a 12-in. chart. Two of the series RD5 recorders can be mounted side by side in a standard 19-in. panel.

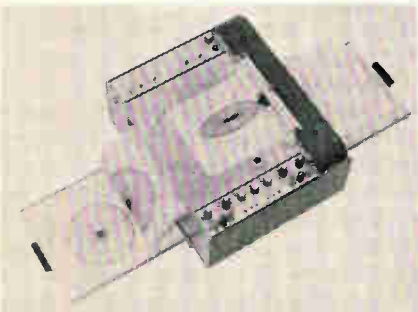
The user has a choice of three printout configurations: dots with a printed number every 25th dot, all dots with numbers, or just dots. A screwdriver adjustment changes the type of printout.

A removable flip-out chart transport allows a new chart to be preloaded in a spare transport for immediate use. Less than 15 seconds is required to exchange chart transports. An automatic print head lifter eliminates tearing of charts. The chart transport can be tilted 45° to double as a writing platen.

The slide-out chassis of the multipoint recorder has solid state circuitry. A zener diode constant voltage reference power supply is used for continuous reference. The fully shielded and guarded measuring circuit eliminates stray signal pickup and provides precision measurement of the input variable. Common mode and series mode rejection are high.

Barber-Colman Co., Rockford, Ill., 61101 [379]

## X-Y recorder uses fan-fold paper



Consecutive records without individual hand loading of sheets are possible with an x-y recorder that uses fan-fold paper. The paper may be loaded or unloaded in mid-record and each record can be torn out as an individual sheet at the perforations. Both forward and reverse advance is inherent and can be controlled automatically by programing. Each record is capable of automatic advance when the extreme margin is reached.

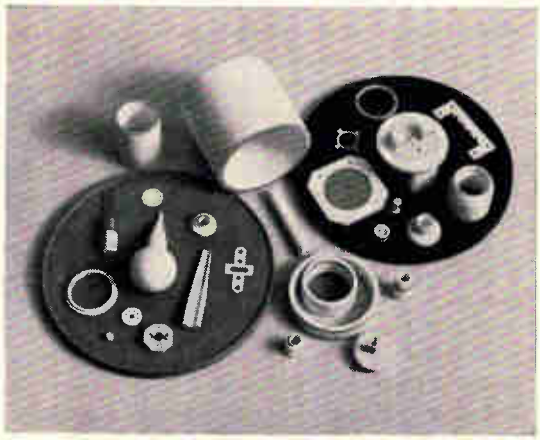
Model 6420 has a slewing speed of 15 in./second with 18 calibrated d-c voltage ranges (continuously variable in between) for each axis. English or metric scaling can be accomplished by a front panel switch.

Input impedance is 1 megohm on all ranges, fixed and variable. The recorder has two independent servo drives for the X and Y axes with an accuracy of ±0.2% full scale and a repeatability of ±0.1% full scale.

Price is $2,450; availability, 30 days after receipt of order.

Houston Omnigraphic Corp., 4950 Terminal Ave., Bellaire, Texas, 77401. [380]


# Now Silk City Offers Complete Ceramic Production Facilities From Development Through Volume Production



## Major Ceramic Services Offered By Silk City

**PROTOTYPE DEVELOPMENT**

In the development of precision prototypes for the electronic industry, we are equipped to offer multi-shaped parts and varied-ceramic formulations to meet every possible design and economy requirement. We produce precision ceramics that are machined from alumina, die formed, isostatic pressed, extruded, molded or cast. Materials range from high-aluminas through forsterite.

**PRECISION MACHINING**

Where the tolerance or surface finish is extremely critical, we are skilled and equipped to provide the necessary ceramic machining. We offer a complete range of grinding, polishing, lapping and ultrasonic machining.

**METALIZING AND PLATING**

We offer prototype development or volume production of metalized and plated ceramics for use in hermetic seals and other sub assemblies. Both high and low temperature metalizing are available. We prepare surfaces for customer brazing or numerous other sealing requirements.

**SUB ASSEMBLIES**

We produce complete sub assemblies to customer specifications, as well as provide a capability to design parts to meet your requirements. Final assembly includes brazing of ceramic to ceramic and metal to ceramic for either mechanical or hermetic seals.

**SHORT PRODUCTION RUNS**

After prototypes have been developed and approved, we are staffed and equipped to carry the item through to a test production run or fill initial stock orders. You are assured precision products that meet the highest quality standards.

**VOLUME PRODUCTION**

With the addition of our new plant in Hendersonville, North Carolina, we are now prepared to handle your full production requirements. Our present equipment will produce ceramic parts with diameters ranging from a fraction of an inch up to 15 inches.

**We invite your inquiry!**

## SILK CITY INDUSTRIAL CERAMICS
INCORPORATED

*Subsidiary of Basic Incorporated*

221 Seventh Avenue • Hawthorne, New Jersey 07507
Phone 201-427-4211

CSC

OFFERING A COMPLETE CERAMIC SERVICE FROM PROTOTYPE THROUGH PRODUCTION

# *Like so many TV stars we got our start in radio.*


Show business has been good to us.

Like true troupers we started on the road—in car radios.

Now we're in television. We produced the first practical silicon power transistors for big screen TV horizontal and vertical sweep circuits. This development helped make big-screen solid state TV possible (in black and white and color). Several major TV set manufacturers are using them.

Today, our high voltage silicon power transistors are making high-energy circuits simpler, more reliable and less expensive. They are available in production quantities for consumer, industrial and military applications.

We'd like to help you solve your power semiconductor problems.

**DELCO RADIO**

Division of General Motors, Kokomo, Indiana

**FIELD SALES OFFICES**

| UNION, NEW JERSEY** | DETROIT, MICHIGAN | SANTA MONICA, CALIFORNIA** | SYRACUSE, NEW YORK | CHICAGO, ILLINOIS** | General Sales Office: |
|---|---|---|---|---|---|
| Box 1018 Chestnut Station | 57 Harper Avenue | 726 Santa Monica Blvd. | 1054 James Street | 5151 N. Harlem Avenue | 700 E. Firmin, Kokomo, Ind. |
| (201) 687-3770 | (313) 873-6560 | (213) 393-1465 | (315) 472-2668 | (312) 775-5411 | (317) 459-2175 |

**Office includes field lab and resident engineer for applications assistance.

GM

MARK OF EXCELLENCE

# DELCO RADIO
## SEMICONDUCTOR DISTRIBUTORS

**EAST**
Baltimore, Md. 21201—Radio Electric Service Co.
5 North Howard Street/(301)-539-3835
Binghamton, N. Y. 13902—Federal Electronics, Inc.
P. O. Box 1208/(607)-748-8211
Clifton, N.J. 07015—Eastern Radio Corporation
312 Clifton Avenue/(201)-471-6600
Newton, Mass. 02195—Greene-Shaw Company
341 Watertown Street/(617)-969-8900
New York, New York 10036—Harvey Radio Co., Inc.
2 West 45th St./(212)-582-2590
Philadelphia, Penn. 19123
Almo Industrial Electronics, Inc.
412 North 6th Street/(215)-922-5918
Pittsburgh, Penn. 15206—Radio Parts Company, Inc.
6401 Penn Ave./(412)-361-4600
Woodbury, L. I., N. Y. 11797
Harvey Radio Company, Inc.
60 Crossways Park West/(516)-921-8700

**SOUTH**
Birmingham, Ala. 35233
Forbes Distributing Company, Inc.
2610 Third Avenue, South/(205)-251-4104
Miami, Florida 33142—Mountain Electronics
Division of Mountain National Co.
3730 Northwest 36th St./(305)-634-4556
Richmond, Va. 23220—Meridian Electronics, Inc.
1001 West Broad Street/(703)-353-6648
West Palm Beach, Fla. 33402—Mountain Electronics
Division of Mountain National Co.
1000 N. Dixie Highway/(305)-833-5701

**MIDWEST**
Chicago, Ill. 60630—Merquip Electronics, Inc.
4939 North Elston Avenue/(312)-282-5400
Cincinnati, Ohio 45237—United Radio, Inc.
7713 Reinhold Drive/(513)-761-4030
Cleveland, Ohio 44125
The W. M. Pattison Supply Co.
Industrial Electronics Division
4550 Willow Parkway/(216)-441-3000
Indianapolis, Ind. 46225
Graham Electronics Supply, Inc.
122 South Senate Avenue/(317)-634-8486
Kalamazoo, Mich. 49006—Electronic Supply Corp.
P. O. Box 831/(616)-381-4626
Kansas City, Mo. 64111—Walters Radio Supply, Inc.
3635 Main Street/(816)-531-7015
Minneapolis, Minnesota 55413
Northwest Electronics Corporation
336 Hoover St.. N. E./(612)-331-6350
St. Louis, Mo. 63144
Electronic Components for Industry Co.
2605 South Hanley Road/(314)-647-5505

**WEST**
Albuquerque, N. M. 87103
Sterling Electronics, Inc.
1712 Lomas Blvd., N. E./(505)-247-2486
Dallas, Texas 75201—Adleta Electronics Company
1907 McKinney Ave./(214)-742-8257
Denver, Colo. 80219—L. B. Walker Radio Company
300 Bryant Street/(303)-935-2409
Houston, Texas 77001—Harrison Equipment Co., Inc.
1422 San Jacinto Street/(713)-224-9131
Los Angeles, Cal. 90015—Radio Products Sales, Inc.
1501 South Hill Street/(213)-748-1271
Los Angeles, Cal. 90022—Kierulff Electronics, Inc.
2585 Commerce Way/(213)-685-5511
Oklahoma City, Oklahoma 73102—Radio, Inc.
903 North Hudson/(405)-235-1551
Palo Alto, Cal. 94303—Kierulff Electronics, Inc.
3969 East Bayshore Road/(415)-968-6292
Phoenix, Ariz. 85005—Sterling Electronics, Inc.
1930 North 22nd Ave./(602)-258-4531
San Diego, Cal. 92101—Milo of California, Inc.
2060 India Street, Box 2710/(714)-232-8951
Tacoma, Wash. 98402—C & G Electronics Company
2502 Jefferson Ave./(206)-272-3181
Tulsa, Oklahoma 74119—Radio, Inc.
1000 South Main Street/(918)-587-9124

**CANADA**
Scarborough, Ontario—Lake Engineering Co. Ltd.
123 Manville Rd./(416)-757-3253

GM
MARK OF EXCELLENCE

DELCO RADIO
DIVISION OF GENERAL MOTORS • KOKOMO, INDIANA




## Memory testing made easy

**Complexity has been** a continuing problem with memory testers. They are designed typically by engineers for engineers, rather than for technicians. To overcome this, Honeywell Inc.'s Computer Control division is introducing a simpler general-purpose system designed specifically with the novice technician in mind. The new unit, Model 3602, tests submicrosecond core memories during development and production. It can be programed either to stop when an error is detected or to produce an error-count pulse and continue.

Able to be used on systems with full-cycle speeds ranging from 400 nanoseconds to 500 milliseconds, the unit can test memories that perform faultlessly when continuously cycling but which may generate errors when long idle periods occur between cycles. The 3602 can test memories with access times as low as 100 nsec; it performs an error check and generates a new address in 200 nsec.

Priced at $19,500, the 3602 is the least expensive memory tester on the market. According to Honeywell, competitive systems are priced upwards of $40,000.

The unit's control panel and set-up procedure have been kept simple. It can be operated in various modes that transfer test words either in or out of the memory, complement them (change 1's to 0's or vice versa), or check for errors in various combinations. Individual data bits can be selected to complement, check normal or bypass error. Error checking may be made on either load or unload cycles, or both.

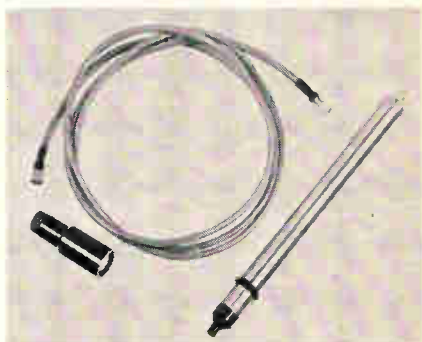
The 3602 memory tester is scheduled to be unveiled at the Spring Joint Computer Conference next month.

**Specifications**

| | |
|---|---|
| Address capacity | 65,536 addresses |
| Word length | 40 bits |
| Cycle time | 400 nsec to 500 msec; 200 nsec for error check and address generation; 150 nsec for data generation |
| Outputs | |
| Delay | 0 to 100 msec |
| Width | 20 nsec to 100 msec |
| Address and data | |
| Risetime | 50 nsec |
| Failure | 30 nsec |
| Input data and address | |
| Maximum amplitude | 6 v |
| Minimum swing | 2 v |
| Dimensions | 56 x 26 x 27 in. |
| Weight | 250 lbs. |
| Price | $19,500 |
| Delivery | 30 days |

Honeywell Inc., Computer Control division, Old Connecticut Path, Framingham, Mass. 01701 **[381]**

## A light pen that's really light



By using a phototransistor as the light sensing element, a new light pen eliminates the usual cumber-

**PACKAGING ENGINEERS** | **CIRCUIT DESIGN ENGINEERS** | **MANUFACTURING ENGINEERS**

## THE JOHN FLUKE MFG. CO., INC.
### Mountlake Terrace, Washington

### FLUKE
Developer and builder of precision laboratory instruments ranging from DC Calibrators to Frequency Synthesizers is currently seeking highly qualified individuals to assume major responsibilities in several Engineering areas. There are new positions created as a result of continuing growth and increased customer demand for our products.

### MOUNTLAKE TERRACE
is located twenty minutes north of Seattle, the cultural and commercial hub of the Pacific Northwest. We are within an hour's drive of major winter and summer recreation areas. Our schools, from kindergarten through graduate studies, are among the best in the nation.

### SENIOR ENGINEER SPECIAL PRODUCTS
- Assume special product project responsibility for instruments in the areas of FREQUENCY SYNTHESIZERS, COMPARATORS, DISTRIBUTION AMPLIFIERS and VLF RECEIVERS.
- Design and/or supervise the design of, new instruments, with emphasis on Frequency Synthesis Techniques.
- Consult with Sales Engineers and customers in defining customer instrument requirements.

* BS/MSEE with 3 years minimum experience in time and frequency instrument design.

### SENIOR ENGINEER DIGITAL CIRCUITRY
- Initiate and assume product responsibility for Digital Circuit Design.

* BS/MSEE with a minimum of three years Instrument Design experience with thorough knowledge of Logic Circuit Application and Feedback Amplifier theory. Capability in high performance analog to digital circuit design plus supervisory experience preferred.

### PACKAGING ENGINEER
- Assume responsibility for defining electro-mechanical design parameters for instruments in the 10 to 1000 MHZ region.
- Analyze design requirements for internal RF shielding.
- Design chassis envelop, RF circuit layout and associated module enclosures.

* BS/MS in EE or ME with five years related experience and thorough understanding of RF shielding techniques.

### PRODUCT ENGINEER MANUFACTURING ENGINEERING
- Work with Design Engineers in initial design stages to assure quality, reliability and producibility of new instruments.
- Evaluate new instruments relative to electrical characteristics, component requirements and economy of design.
- Prepare manufacturing documentation.

* BS in EE or related field plus several years experience in Circuit Design or Manufacturing Engineering in an electronic manufacturing facility.

- Starting salaries for these positions are open. Benefits include liberal insurance, profit sharing and educational support plans.

To investigate these opportunities, send your resume to:

**Ron Elarth**
**JOHN FLUKE MANUFACTURING CO., INC.**
**P.O. Box 7428 Seattle, Washington**
*AN EQUAL OPPORTUNITY EMPLOYER*



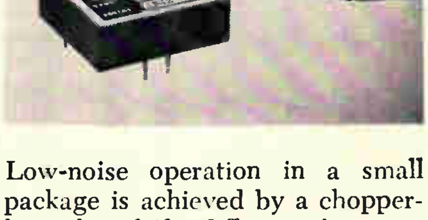

some fiber-optic bundle. The unit is light in weight, has a lightweight cable, high sensitivity, and broad spectral response. Also, it doesn't require high voltages for a photomultiplier.

The LP-200 light pen features a touch-sensitive actuator, that, unlike the usual mechanical shutter or microswitch, has no moving parts. To let the LP-200 see light, the operator has only to touch a metallic band placed where the index finger falls naturally during operation.

The improved spectral response of the unit permits use of the device with orange phosphors such as those used on the P-25 cathode-ray tube. Of the several different tips provided, one views fields as small as 0.100 in. across on crt displays in which symbols are very dense; with a telescopic tip, the pen can be aimed at larger areas from distances of approximately 1 foot. Other tips can be used for viewing large-screen projection displays.

Spectral response is 4,200 to 7,000 angstroms; radiant sensitivity, $10^{-5}$mw/cm$^2$ at 7,000 angtroms; background tolerance, $10^2$ mw/cm$^2$ (direct sunlight); output, 10$\mu$sec positive-going pulse, 0 and —10 v nominal; delay time, 3 $\mu$sec typical; cord length, 3 ft; size, ½ in. diameter x 6 in. long; power requirement, —20 v at 20 ma; temperature range, 0° to 55°C.
Information Control Corp., Abacus division, 138 Nevada St., El Segundo, Calif., 90245 **[382]**

## Operational amplifier uses no choppers



Low-noise operation in a small package is achieved by a chopperless, low-drift differential operational amplifier. The leading feature of the KM-53 is voltage-offset drift vs temperature of 1 $\mu$v/1°C maximum, over a temperature range of $-55°$ to $+125°$C. The unit is vacuum encapsulated for excellent reliability.

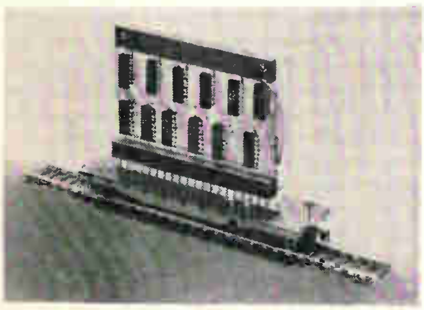
The amplifier is designed for low-drift applications such as strain-gauge amplifiers, analog computer functions, high-gain low-drift servo preamps, ultrastable null detectors for galvanometers, voltage comparators, instrumentation amplifiers, and automatic test equipment.

Typical input impedance for the unit is 100 megohms common mode. Gain is greater than 100,000 full load and full power output is greater than 30 khz ±11 v d-c at 5 ma.

The unit is packaged in the company's flatpack case style F which measures only 1.12 in. square by 0.40 in. thick.

K&M Electronics Corp., 102 Hobart St., Hackensack, N.J., 07601. [383]

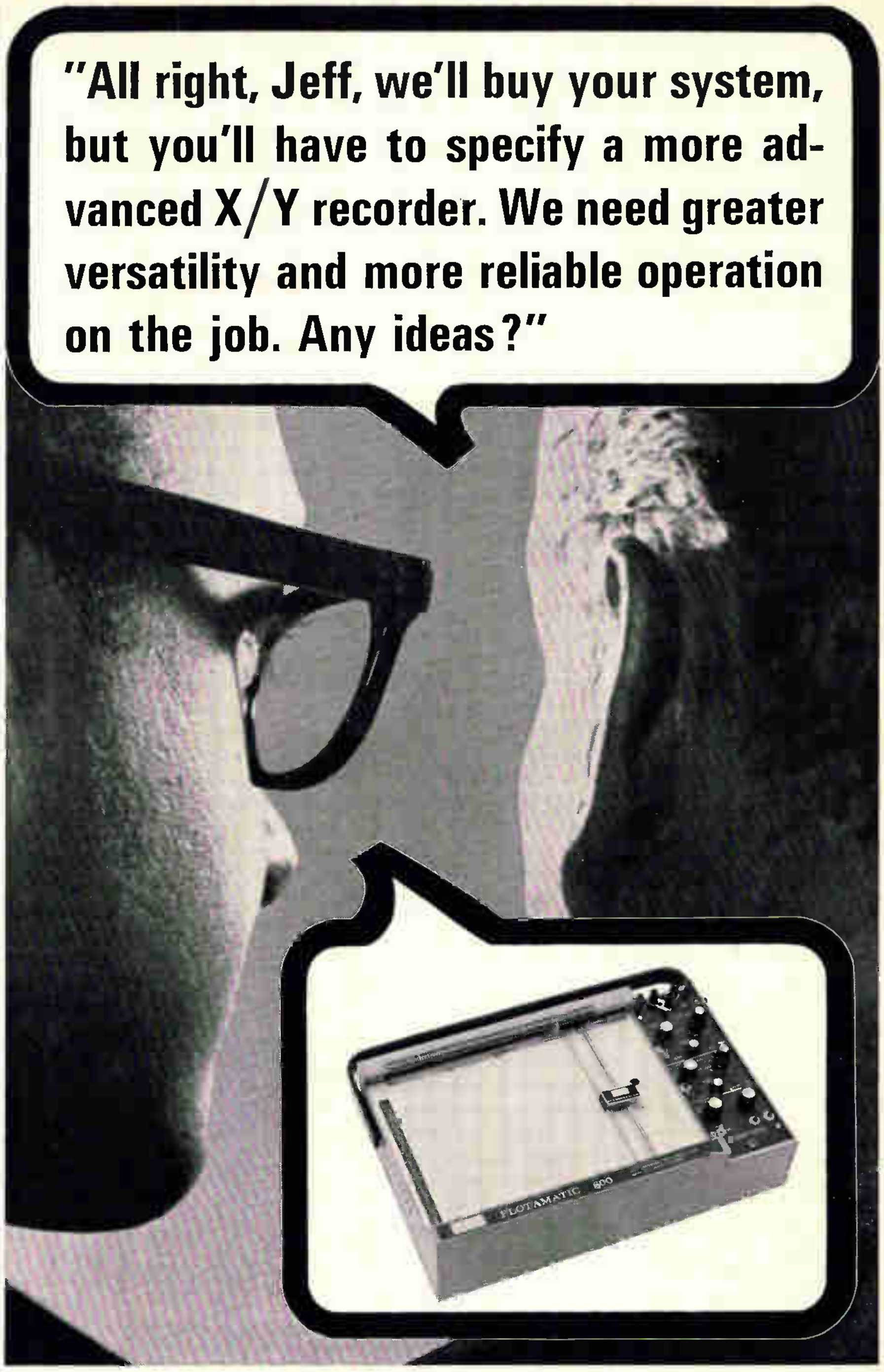
## Dual in-line DTL and TTL cards



Two series have been added to the MoniLogic line of integrated-circuit logic cards. The dual in-line diode-transistor-logic (DTL) and transistor-transistor-logic (TTL) cards are called Series 8D and 8T, respectively. Savings afforded by the use of dual in-line IC's can run as high as 40%, according to the manufacturer.

The new series are completely compatible with the rest of the line, which currently numbers some 140 different cards. Such features of the earlier cards as top-mounted test points and gold-plated spring-pin connectors have been retained. The cards are designed to fit into Monipak files, which hold 16 to 32 cards each, depending on the model.

Monitor System Inc., Fort Washington, Pa., 19034. [384]


"If you like, Craig, I'll give you the system with the latest X/Y recorder on the market: The PLOTAMATIC® built by Bolt Beranek and Newman's Data Equipment Division. Other users swear by them. The PLOTAMATIC has a paper hold-down system that always works, never gets dirty, and yet allows you to adjust the paper for proper alignment after it's mounted. Input resistance is greater than one megohm, independent of gain setting. Accuracy and input versatility are as good as anything on the market, and you don't have to buy time base if you don't want it. No high voltages to produce RFI problems, either. Just between us, Craig, I think our people are in a rut with those X/Y recorders we've been using. They use them out of habit, and aren't up on the latest the market has to offer."

BBN's PLOTAMATIC line includes a variety of 8½" x 11" and 11" x 17" X/Y recorders for virtually every application. Keep up with the market—write us for a catalog.

bbn BOLT BERANEK AND NEWMAN INC
DATA EQUIPMENT DIVISION
2126 SOUTH LYON ST., SANTA ANA, CALIF. 92705 (714) 546-5300

## Amplifier for high power coherent system

**High-gain,** crossed-field amplifier tubes deliver 1 megawatt peak power (3.5 kw average) over a 5.45 to 5.825 Ghz band. The SFD-231 amplifier, designed for pulsed coherent and frequency-agile systems, will amplify a signal without adding significant phase noise or phase distortion. Pulse width is 10 μsec. Duty factor is 0.0035 maximum.

The 57-lb liquid-cooled tube is suited for use in battlefield transportable radar, instrumentation radar systems, and applications where weight and size are at a premium. It is also suitable for shipboard radar and could be installed in large airborne systems. Dimensions are 11x13x9 in.

Existing magnetron radar systems can be simply converted to coherent operation because this tube's voltage and current requirements and physical size are almost the same as those of magnetrons operating at the same power and frequency level. In addition, no x-ray shielding is required as in high power klystrons or traveling wave tubes.

Power requirements are generally lower than those of comparable amplifiers, and efficiency is 45%. Peak anode voltage is 37 kv, and peak current is 60 amperes. Gain is 17 db.

The tube's cold cathode uses no heater power, a feature which reduces power requirements. Moreover, power is not needed to establish the magnetic field; a permanent package (Alnico 5) is built into the tube.

The output connector mates with a slightly modified UG-148 B/U waveguide flange.

S-F-D Laboratories, Inc., a subsidiary of Varian Associates, 800 Rahway Ave., Union, N.J., 07083. [391]

## Microwave diodes switch in 1 nsec

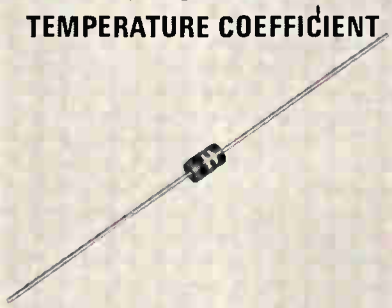
Low capacitance and good resistance values are featured in a series of fast switching microwave diodes. Type MO-2800D of the series makes possible the design of switches through the 8-Ghz range with a minimum number of diodes. The result is high isolation-to-in-


**CERAMAG® FERRITE MATERIALS CONSISTENT IN PERFORMANCE, QUALITY**

- Select from over 30 grades.
- Available in toroids; cup, insert and thread cores; bobbins; sleeves; transformer cores; deflection yokes; and rectangular solids.
- A wide range of sizes held to exact tolerances.
- Maximum permeability and high Q.
- Tooling available for hundreds of parts.
- Offers the advantage of complete moldability.
- Write for bulletin.

STACKPOLE CARBON COMPANY
Electronic Components Division
St. Marys, Pa. 15857

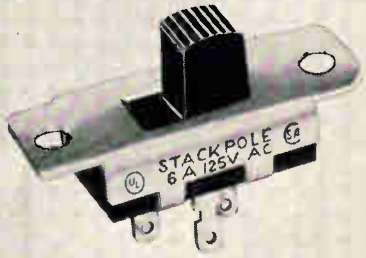
**CERAMIC CAPACITORS WITH SUPERIOR TEMPERATURE COEFFICIENT**



- Available in range of 0.1 to 10 picofarads.
- Tolerances of 5%-10%-20%, at rated working voltage of 500V DC.
- Temperature coefficient is ± 2% for values of 0.1 to 5.1 pf over a temperature range of -55° C to 85° C.
- Only ± 3% temperature coefficient for values of 5.1 to 10.0 for temperatures ranging from -55° C to +85° C.
- Power factor less than 1% at 1 megacycle at less than 80% RH.
- Write for bulletin.

STACKPOLE CARBON COMPANY
Electronic Components Division
St. Marys, Pa. 15857

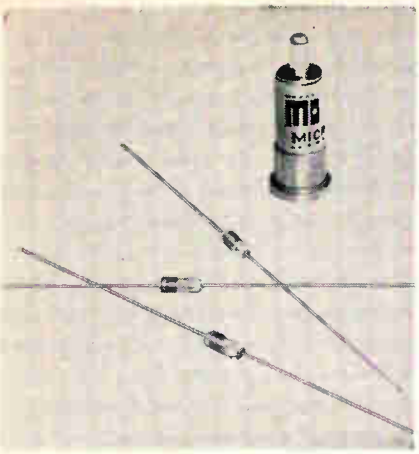
**UNEXCELLED QUALITY FOR LESS THAN 4¢**




- Rated from 1 to 10 amps with full UL AND CSA approval.
- 7960 slide switch combinations — 23 basic types.
- New rugged solder lug terminal, designed for use with quick connectors.
- Uniform quality assured by automated assembly.
- Electro-silver plated terminals and contacts—shorting and non-shorting.
- Phenolic or nylon triggers in a variety of colors.
- Write for engineering bulletin.

STACKPOLE CARBON COMPANY
Electro-Mechanical Products Division
Johnsonburg, Pa. 15845


 Circle 216 on reader service card    Circle 261 on reader service card    Circle 262 on reader service card



sertion loss ratios.

Specifications include a forward switching time of 1 nanosecond maximum; total capacitance, 0.07 picofarad maximum; voltage breakdown, 80 v minimum; and dynamic forward impedance, 80 ohms maximum.

The diode package is suitable for stripline applications.

Alpha Industries, Inc., Micro Optics division, 381 Elliot St., Newton Upper Falls, Mass., 02164. [392]

## Coaxial diode switch operates at 200 nsec

Designed for fast switching, a coaxial spdt diode switch is suited for antenna lobing in compact commercial transponder systems.

The MA-8306-2L24S is a lightweight unit which operates in the 1.02 to 1.1 Ghz frequency range with a switching speed of 200 nsec. Peak power is 2.5 kw; average power, 25 w. Isolation is 25 db and insertion loss is 0.5 db. Replaceability of diodes assures optimum performance for each specific switching circuit.

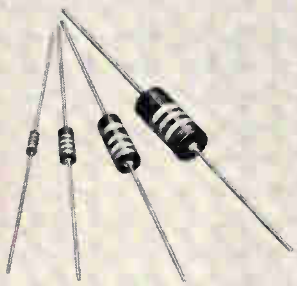
Microwave Associates, Inc., Burlington, Mass. [393]

## Transistor amplifiers cover 1 to 3 Ghz

Microwave transistor amplifiers are available with low noise figures, high gain, optimally-flat response characteristic, low intermodulation distortion, and replaceable transistors.

The model MTA-2350-15W operates from 2 to 2.7 Ghz and is flat to ±0.5 db. Maximum noise figure is 5.6 db. Another unit, the MTA-2250-15 operates at 2.2 to 2.3 Ghz. is flat to within ±0.25 db, and has a maximum noise figure of 5.2 db. All models have intermodulation distortion under —75 dbm when measured with two input signals at —30 dbm. Input signal level at the 1-db compression point is —16 dbm. Maximum r-f input power is


**GUARANTEED UNIFORMITY IN ELECTRICAL, PHYSICAL CHARACTERISTICS**

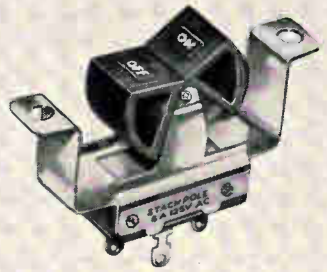


- Available in 2, 1, ½ and ¼ watt sizes.
- Uniform from resistor to resistor, order to order.
- 100% tested for resistance value.
- Same day shipment on 9 orders out of 10.
- Solderability, load life and humidity-temperature characteristic checked.
- Impregnated to assure moisture resistance.
- Write for literature.

STACKPOLE CARBON COMPANY ®
Electronic Components Division
Kane, Pa. 16735

Circle 263 on reader service card

**UNIQUE DESIGN ADDS VALUE AND APPEAL**

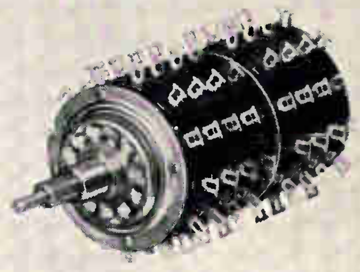


- 23 rocker switch configurations, including 2-3 positions, spring return and center-off.
- Variety of rocker designs available in a spectrum of colors and hot-stamped lettering.
- 1 to 10 amp UL AND CSA ratings at 125V and 250V.
- Solder lug, space saver, quick-connect or printed circuit terminals.
- Field-proven quality same as famous Stackpole slide switches.
- Prices start at less than 15¢.
- Write for engineering literature.

STACKPOLE CARBON COMPANY ®
Electro-Mechanical Products Division
Johnsonburg, Pa. 15845

Circle 264 on reader service card

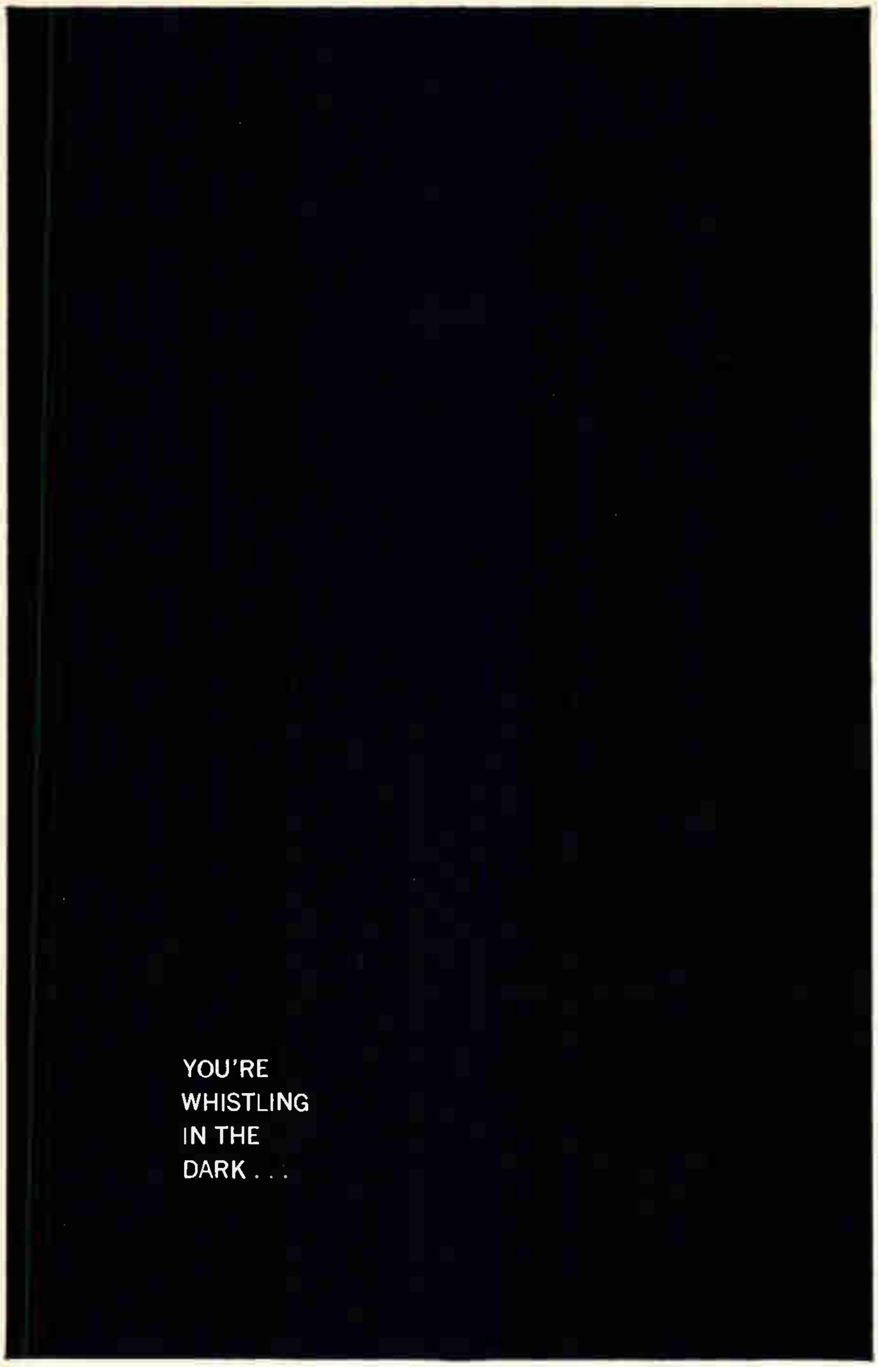
**DUST-FREE CONSTRUCTION AT NEW LOW COST**



- Environment-proof rotary switch design guards against contact contamination.
- Four struts guarantee rigidity and contact alignment.
- 15°, 30°, 60°, and 90° indexing angles available as standards.
- Solder or quick-connect terminals molded permanently into position minimize production damage.
- Free-floating, solid silver alloy wiper underwrites uniform low contact resistance.
- A pole can be made shorting, nonshorting, or both shorting and nonshorting all on the same deck.
- Write for bulletin.

STACKPOLE CARBON COMPANY ®
Electro-Mechanical Products Division
St. Marys, Pa. 15857

Circle 217 on reader service card

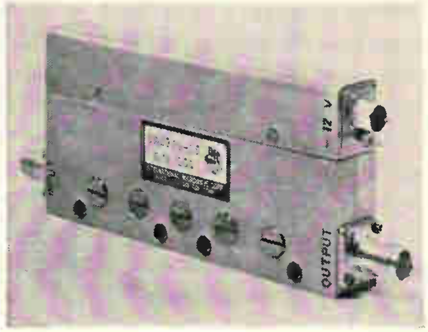



**. . . if you think that heart disease and stroke hit only the other fellow's family. No one is immune.** Protect the hearts you love. For authoritative information, ask your Heart Association. For medical advice see your doctor. To safeguard your family . . .

**GIVE...**
**so more will live**
**HEART**
**FUND**

*Contributed by the Publisher*

## New Microwave




5 watts peak. Gain stability from $-55°$ to $+85°C$ is better than 0.03 db/°C. Other models are available in octave band (1 to 2 Ghz), 1.435 to 1.535 Ghz, or any frequency to 3 Ghz, with gains of 15, 25, or 30 db.

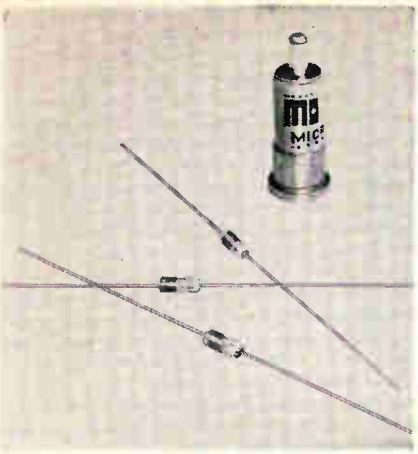
Price is available on request. Delivery takes 30 to 45 days after receipt of order.

International Microwave Corp., River Road, Cos Cob, Conn., 06807. [394]

## Microwave switches operate above 12 Ghz


Two solid-state switches that use p-i-n diodes for switching elements are claimed to be the first to operate between 12 and 18 Ghz. They have applications as pulse modulators, and power levelers in a wide variety of r-f test and simulator circuits.

Models 3560 and 3561 have low insertion loss (1.5 db), high isolation (50 db) and low vswr (1.6) in the on condition. Switching is accomplished by changing bias levels on two p-i-n diodes that shunt the transmisison line. Full isolation between input and output is obtained with bias currents on the order of 50 ma. The switches are available



sertion loss ratios.

Specifications include a forward switching time of 1 nanosecond maximum; total capacitance, 0.07 picofarad maximum; voltage breakdown, 80 v minimum; and dynamic forward impedance, 80 ohms maximum.

The diode package is suitable for stripline applications.

Alpha Industries, Inc., Micro Optics division, 381 Elliot St., Newton Upper Falls, Mass., 02164. [392]

## Coaxial diode switch operates at 200 nsec

Designed for fast switching, a coaxial spdt diode switch is suited for antenna lobing in compact commercial transponder systems.

The MA-8306-2L24S is a lightweight unit which operates in the 1.02 to 1.1 Ghz frequency range with a switching speed of 200 nsec. Peak power is 2.5 kw; average power, 25 w. Isolation is 25 db and insertion loss is 0.5 db. Replaceability of diodes assures optimum performance for each specific switching circuit.

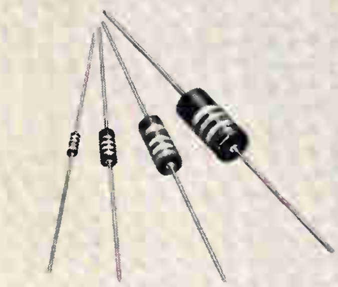
Microwave Associates, Inc., Burlington, Mass. [393]

## Transistor amplifiers cover 1 to 3 Ghz

Microwave transistor amplifiers are available with low noise figures, high gain, optimally-flat response characteristic, low intermodulation distortion, and replaceable transistors.

The model MTA-2350-15W operates from 2 to 2.7 Ghz and is flat to ±0.5 db. Maximum noise figure is 5.6 db. Another unit, the MTA-2250-15 operates at 2.2 to 2.3 Ghz. is flat to within ±0.25 db, and has a maximum noise figure of 5.2 db. All models have intermodulation distortion under −75 dbm when measured with two input signals at −30 dbm. Input signal level at the 1-db compression point is −16 dbm. Maximum r-f input power is


GUARANTEED UNIFORMITY IN ELECTRICAL, PHYSICAL CHARACTERISTICS

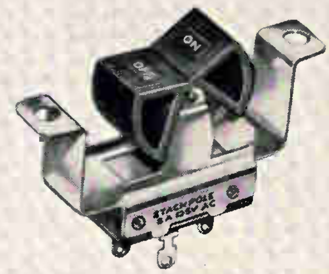


- Available in 2, 1, ½ and ¼ watt sizes.
- Uniform from resistor to resistor, order to order.
- 100% tested for resistance value.
- Same day shipment on 9 orders out of 10.
- Solderability, load life and humidity-temperature characteristic checked.
- Impregnated to assure moisture resistance.
- Write for literature.

STACKPOLE
CARBON COMPANY ®
Electronic Components Division
Kane, Pa. 16735

Circle 263 on reader service card

UNIQUE DESIGN ADDS VALUE AND APPEAL

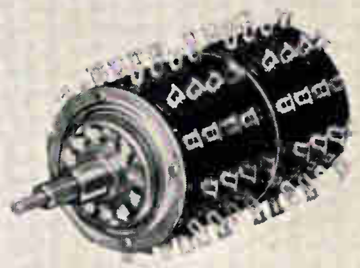


- 23 rocker switch configurations, including 2-3 positions, spring return and center-off.
- Variety of rocker designs available in a spectrum of colors and hot-stamped lettering.
- 1 to 10 amp UL AND CSA ratings at 125V and 250V.
- Solder lug, space saver, quick-connect or printed circuit terminals.
- Field-proven quality same as famous Stackpole slide switches.
- Prices start at less than 15¢.
- Write for engineering literature.

STACKPOLE
CARBON COMPANY ®
Electro-Mechanical Products Division
Johnsonburg, Pa. 15845

Circle 264 on reader service card

DUST-FREE CONSTRUCTION AT NEW LOW COST



- Environment-proof rotary switch design guards against contact contamination.
- Four struts guarantee rigidity and contact alignment.
- 15°, 30°, 60°, and 90° indexing angles available as standards.
- Solder or quick-connect terminals molded permanently into position minimize production damage.
- Free-floating, solid silver alloy wiper underwrites uniform low contact resistance.
- A pole can be made shorting, non-shorting, or both shorting and non-shorting all on the same deck.
- Write for bulletin.

STACKPOLE
CARBON COMPANY ®
Electro-Mechanical Products Division
St. Marys, Pa. 15857

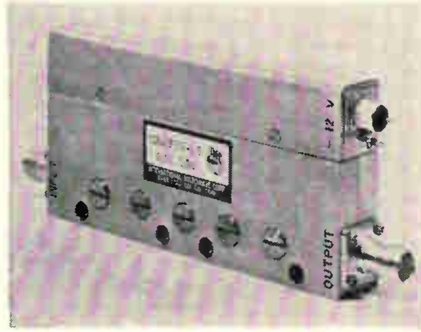
Circle 217 on reader service card


**. . . if you think that heart disease and stroke hit only the other fellow's family. No one is immune.** Protect the hearts you love. For authoritative information, ask your Heart Association. For medical advice see your doctor. To safeguard your family . . .

**GIVE...**
**so more will live**
**HEART FUND**

*Contributed by the Publisher*

## New Microwave

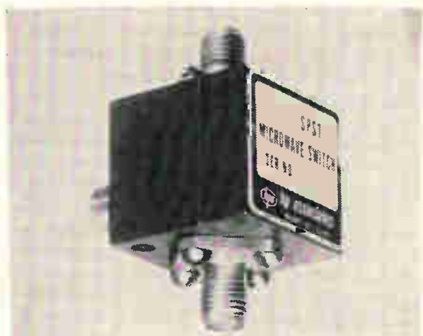



5 watts peak. Gain stability from −55° to +85°C is better than 0.03 db/°C. Other models are available in octave band (1 to 2 Ghz), 1.435 to 1.535 Ghz, or any frequency to 3 Ghz, with gains of 15, 25, or 30 db.

Price is available on request. Delivery takes 30 to 45 days after receipt of order.

International Microwave Corp., River Road, Cos Cob, Conn., 06807. [394]

## Microwave switches operate above 12 Ghz




Two solid-state switches that use p-i-n diodes for switching elements are claimed to be the first to operate between 12 and 18 Ghz. They have applications as pulse modulators, and power levelers in a wide variety of r-f test and simulator circuits.

Models 3560 and 3561 have low insertion loss (1.5 db), high isolation (50 db) and low vswr (1.6) in the on condition. Switching is accomplished by changing bias levels on two p-i-n diodes that shunt the transmisison line. Full isolation between input and output is obtained with bias currents on the order of 50 ma. The switches are available with either bias polarity. Harmonics and spurious are at least 40 db below fundamental output level.

The shunt-connected silicon p-i-n diodes and the bias control network are integrated into a 50-ohm microwave structure to achieve broad bandwidth. Allowable power dissipation is 1¼ watts at 25°C. Input, output, and bias connectors are OSM types.

Type 3560 is turned on by a negative voltage; type 3561, by a positive voltage. Otherwise the switches are identical.

Price is $325 each in quantities of 1 to 9; $308.75 each in quantities of 10 to 24; and $292.50 each in quantities of 25 to 99.

HP Associates, 1501 Page Mill Rd., Palo Alto, Calif., 94304. **[395]**

## Boosting power capacity of junction circulator

Application of a high-power ferrite material makes possible a junction circulator that can handle 5 kilowatts c-w at 2.4 to 2.5 Ghz. This is reportedly about 10 times the capability of previous units. The necessary electrical symmetry is provided by a Y-junction.

Previous devices for this power level required a 4-port phase-shift circulator involving two sections of waveguide between two hybrid junctions. The new unit is about a quarter of the size.

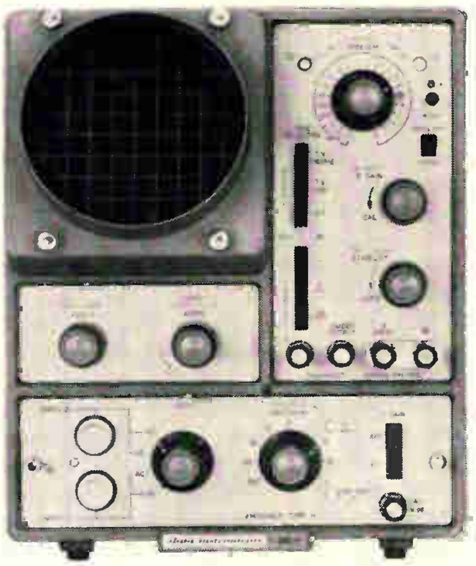
The unit, model 336359, has an insertion loss of 0.2 db max, an isolation of 20 db minimum, and a vswr of 1.2 maximum. Waveguide size is WR-340.

Average unit price is $700, depending on quantity. Availability is 90 days.

Litton Industries, Airtron Division, 200 E. Hanover Ave., Morris Plains, N.J., 07950. **[396]**


# Takes what hurts out of Megahertz

$23 a MHz*



*
Main Frame $420
25MHz Amplifier $160

Is your budget too tight for your bandwidth? Here's quick and permanent relief—Data Instruments S43A. Everything about this instrument is designed for sophisticated requirements—except the price. The main frame including the time base and horizontal amplifier is $420. Six vertical amplifiers ranging in price from $85 to $170 give the unit broad operating capabilities—Bandwidths to 25MHz with a risetime of 14 nsec. And sensitivities to 100μv/cm. Narrow band and wide band amplifiers are also available as well as an envelope monitor with a tuned bandwidth to 32MHz.

The 4 inch, flat-faced PDA tube provides accurate and unambiguous viewing. It is available in a variety of phosphors and has a removable graticule with controlled edge lighting. An extremely reliable time base provides sweep speeds to .5μsec/cm in 22 precisely calibrated ranges with single shot and lockout. It also has neon indication when the time base is armed. It features rock steady triggering in a number of modes and the horizontal amplifier provides 10X expansion to 500KHz.

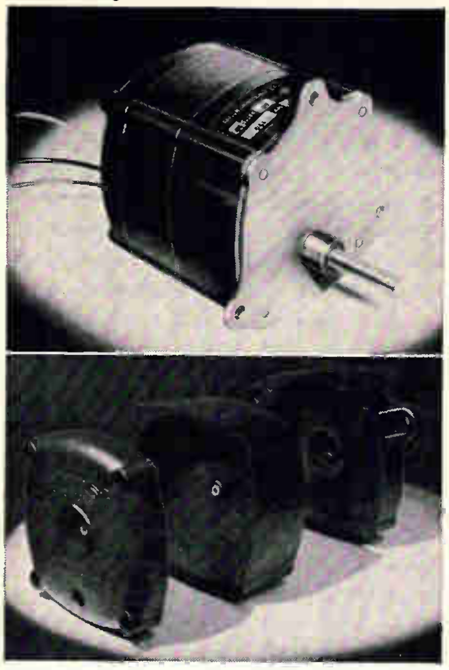
For those who want even more performance there is the D43A. This is a double beam scope giving two simultaneous 25MHz traces on a 4 inch tube. The main frame is $515, and it accepts the same vertical amplifiers as the S43A. Each instrument is fully guaranteed for one year, and field and factory servicing are provided.

If your budget is pinching you (and even if it isn't) why not arrange for a demonstration of the S43A? We have a man in your area and it doesn't hurt to look. At $23 a MHz it doesn't hurt at all.

***data instruments***

**Data Instruments Division • 7300 Crescent Boulevard, Pennsauken, N.J. 08110**

*Fiberfil High-Performance FRTP's In Action*



Polycarbafil Instrument Motor Housing molded for Hurst by Lenco, Inc., Jackson, Mo.

# A better motor housing at lower cost with Polycarbafil®

**Hurst Mfg. Corp., Princeton, Indiana chose fiberglass reinforced polycarbonate.**

For the new Model GA 600 inch-ounce, Synchronous Hysteresis Instrument Motor, Hurst chose Polycarbafil (fiberglass reinforced polycarbonate). Hurst research and tests proved that the FRTP adds performance characteristics for the user. It has lighter weight, reduced noise level, high impact strength, dimensional stability and heat resistance. Flexural and Tensile strength of Polycarbafil is higher than many common aluminum alloys. The company found that they gained a cost advantage because the Polycarbafil housing needs no finishing and painting, as aluminum housings would.

**Compare Physical Properties**

| Property | Unit | Unreinforced Polycarbonate | Polycarbafil G-50/20 |
|---|---|---|---|
| Tensile Strength @ 73°F. | PSI | 8,000 | 18,500 |
| Flexural Strength @ 73°F. | PSI | 13,500 | 25,000 |
| Coef. Linear Thermal Expansion | °F./In./In. | 3.75 x $10^{-5}$ | 1.07 x $10^{-5}$ |
| Heat Distortion Temp. @ 66 PSI | °F. | 285 | 308 |
| Water Absorption 24 Hrs. | % | 0.15 | 0.4 |

Polycarbafil is just one of several fiberglass reinforced thermoplastics pioneered and patented by Fiberfil. Only Fiberfil can give you complete technical data, practical experience and a full line of reinforced materials. Send for your free copy of the FRTP engineering manual.
Fiberfil Div., Rexall Chemical Co.
Evansville, Indiana 47717

FIBERFIL

**Fiberglass Reinforced Thermoplastics ®**

## New Production Equipment

### High-speed prober for testing IC's

**An automatic,** multihead prober tests integrated circuits, thin films and transistors during the manufacturing stage. The PR-85 accommodates up to 20 test probes. Either a single IC or up to nine conventional transistor dice may be probed simultaneously. Each prober head is adjustable to cover an area of 9 x 9 mm.

Once the machine has been set to probe a device, it can operate automatically, thus freeing the operator for other tasks.

To facilitate testing, particularly of partial or broken wafers, an edge-sensing probe can be fitted in place of one of the test probes. The edge sensor detects an absence of silicon beneath the probes, initiates a control movement to bring the probes on to the next row of devices, and reverses the machine. This saves the time that would otherwise be wasted probing areas of no interest.

Another feature that can be added is a marker pen to automatically apply a distinctive colored mark to any circuit or dice that receives a fail indication from the associated test unit. This pen would also take the place of one of the test probes.

Vacwell Engineering Co., Willow Lane, Mitcham, Surrey, England. [401]

### Carbide dies are used to produce IC frames

New carbide dies make possible the production of precise, subminiature frames for integrated circuits by stamping at rates of up to 200 pieces per minute. In their first application, the dies were used to make IC frames of 0.010-in.-thick Kovar, a soft magnetic material with high nickel and manganese content.

All die sections are precision-ground to a tolerance of ±10 millionths (0.000010) of an inch to provide detail without fitting operations and also to assure maximum part accuracy.

The manufacturer will supply carbide IC-frame dies to electronic parts stampers, or will build the dies and manufacture finished parts to blueprint specifications.

Hydro-Cam Engineering Co., 1900 E. Maple Road, Troy, Mich., 48084. [402]

### Machine polishes wafers and crystals

Designed for finishing semiconductor wafers and electronic crystals, an automatic machine can polish up to 100 1-in.-diameter wafers at a time.

The Model PA818 is powered by a ¾-horsepower motor with continuous variable speed control up to 175 rpm. The 18-in. stainless steel wheel rests on a heavy duty 8-in. thrust bearing. The polishing wheel will accommodate four 6¾-in.-diameter pressure plates that can be independently driven to accelerate the polishing action.

The polishing wheel, abrasive feed system, and all accessories can be taken apart and cleaned in minutes. The machine can also be adapted to lapping with an interchangeable, serrated cast-iron wheel with conditioning rings.

Geoscience Instruments Corp., 435 E. Third St., Mount Vernon, N.Y., 10553. [403]

## Transistor leads shaped automatically

Automatic cutting and forming of transistor lead wires is performed by a rugged, production line machine that can process 2,500 transistors per hour with manual feeding and is adaptable for high-speed feeding.

The standard model H-132 handles transistors with three leads on 0.1 and 0.2 in. lead circle diameters. Location of cutoff and forming dies are independently and continuously variable with a lead screw. This arrangement permits simple cutoff of the lead wires or cutoff plus a stand-off length to provide spacing between the transistor and the p-c board.

Use of one of the stand-off configurations eliminates the need for transistor pads and can save up to

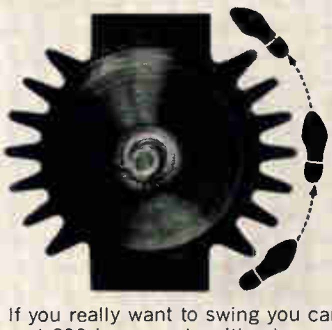

**4 ways to beat a hot system**
**1. Centrifugal Blowers**
**2. Propeller Fans**
**3. Vaneaxial Fans**
**4. Tubeaxial Fans**

Learn about them from a 12 page booklet called the "Airmover Selector." It has a technical information section to aid you in your choice of airmovers. On the remaining pages we have plugs for our products which help pay the cost of free booklets. Or a better bargain is our 136 page catalog given free when you meet with our technical sales reps. For very quick service contact: IMC Magnetics Corp., Eastern Division, 570 Main Street, Westbury, N.Y. 11591. Phone 516 334 7070 or TWX 516 333 3319. For the "Airmover Selector" write: Marketing Division at the same address, or circle the Bingo number below.

IMC

Circle 280 on reader service card

**This is our 3 step.**
**Give us a call and see all the steps in our routine.**



If you really want to swing you can also step 4, 8, 12, 24, 48, and 200 increments without gears.

Or to Indicate, Measure and Control using flag and remote angle indicators, synchros, resolvers, steppers, or solenoids. They are in stock at IMC Magnetics Corp., Western Division. For quick service contact the Applications Section at Western Division, 6058 Walker Ave., Maywood, Calif. 90270. Phone 213 583 4785 or TWX 910 321 3089.

If you need data sheets for references or consideration for future projects, write IMC's Marketing Division at 570 Main Street, Westbury, New York 11591.

IMC




Circle 221 on reader service card

# Coaxial Cables do double duty with POMONA BNC Adaptors

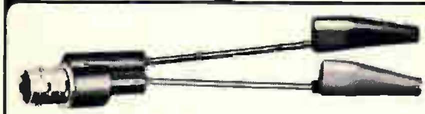
You can increase the flexibility and utility of your laboratory test equipment—and reduce the quantity and variety of coaxial cables—by using BNC Adaptors from Pomona Electronics.

**MODEL 1269**
BNC Receptacle to Double Banana Plug

**MODEL 1296**
Binding Posts to BNC Plug

Select from these popular adaptors to cover most of your needs . . . or choose from ten different combinations listed in our General Catalog, sent free upon request.

**MODEL 1645**
BNC Receptacle to Shielded Banana Plugs



**MODEL 2631 "BREAKOUT"**
BNC Receptacle to Minigator Clips

*Select from these popular adaptors to cover most of your needs . . . or choose from ten different combinations listed in our General Catalog, sent free upon request.*

**POMONA**
**ELECTRONICS CO., INC.**
1500 East Ninth Street, Pomona, California 91766
Telephone (714) 623-3463


## Production Equipment

$30 per 1,000 components by reducing material and handling costs.

Model H-132 handles both metal and plastic transistors and accommodates bent lead wires.

Heller Industries Inc., 30 N. 15th St., East Orange, N.J., 07017. [404]

### Punched cards set markings on wire

A numerically controlled wire marking machine automatically processes wire for electrical and electronic assembly. Moved by punched-card control, the WMM-103 unwinds the wire, measures it, marks it with up to 12 characters from heated type wheels, cuts and coils it, and deposits it in a work pan.

The machine can work with wire gauges ranging from No. 24 to No. 10 with any standard insulation. The basic machine contains 12 type wheels, each with letters A to Z, numerals 0 through 9, three graphic symbols, and one blank or space. Three type-wheel sets cover the full range of gauges, and a wheel set can be replaced in less than 1 minute.

Marking is done by pressing an electrically heated type wheel against a foil and applying it to the insulation on the wire. The temperature of the wheels is automatically controlled at any level up to 800°F. The machine holds up to 1,000 ft. of marking foil.

Depending on the punched-card program, the wire can be marked in one of three ways: on 2-in. cen-


## Compact electronics package?

# COOL IT...

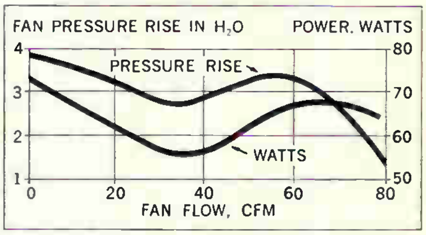
...with a small size, long life, high output AiResearch fan.

Garrett-AiResearch special purpose fans are individually designed and custom built to deliver more flow and greater pressure rise with a minimum envelope size.

Take a typical AiResearch small size fan: computer-optimized for required performance under all operating environments; our own motor, engineered and manufactured for a perfect match to its fan; and up to 40 percent more airflow than any other ventilating fan of similar input, size, and weight.

Next time you need a ventilating fan for a very special airborne or ground electronics enclosure specify AiResearch. Available for high temperature and cryogenic applications, with flow rates and power requirements as specified.

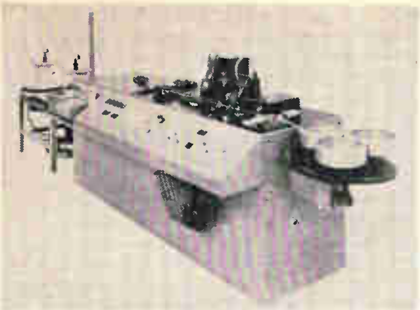
AiResearch Manufacturing Division, Torrance Facility, 2525 190th Street, Torrance, California 90509.




**AIRESEARCH SPECIAL PURPOSE FANS**
GARRETT




Circle 265 on reader service card



ters over the entire length of the wire; on 2-in. centers on the leading and trailing ends (up to 36 inches); and on 2-in. centers on the ends and on 15-in. centers over the remainder of the wire. The machine works on 115 v, 60 hz, and requires 100 psi air at 5 cfm.

Production rates vary with the type of wire marking done. With 8 markings per 40-ft. lengths of wire handled in lots of 10, the machine can process 108,000 ft. in an eight-hour shift. In addition to six extra type wheels, optional equipment includes a cardsorter that permits the processing of all wire of one gauge in sequence, and devices to sort the marked wire.

The basic 12-type-wheel machine is priced at $35,000; with all the optional gear the price is $50,000.
Giannini Controls Corp., 1600 S. Mountain Ave. Duarte, Calif., 91010 [405]

## Component transport facilitates testing

A handler of both axial and radial lead components delivers them to as many as 10 different test stations, and then to a series of up to seven ejection stations for sorting.

The CH-3 component transport consists of 24 spring-loaded jaws for holding the components mounted around the periphery of a 12-in. diameter wheel. The index time for the wheel is 0.125 second. External contact closures are used to supply the advance and ejection commands.

The transport can be used with a variety of automatic component test systems from the manufacturer, or separately with other types of instrumentation.

Price is approximately $2,500; availability is 90 days.
Optimized Devices Inc., Pleasantville, N.Y. [406]


VACTEC

Type O CdS Cells
*Fastest at Low Light Levels*

The response time of any photocell slows proportionately as the light level decreases. But Vactec delivers a rapid response time even at low light levels.

At .01 ft. candles, for example, Vactec Type O material provides a rise time of 780 milliseconds with a delay time of only 90 milliseconds. And you also get the temperature stability provided only by CdS material. Even if yours is a higher light level application, isn't it reassuring to know there is a supplier whose cells are capable of such a high level of performance?

Five new materials ranging from Cadmium Sulfide to Cadmium Selenide are now available. Write for new Bulletin PCD-4 today!

VACTEC INC.

2423 Northline Industrial Blvd.
Maryland Hts., Mo. 63042
AC 314, HE 2-4200

See Vactec's listing in EBG under "Semiconductors," and in EEM, Sec. 3700.

Circle 266 on reader service card

RFI/EMI Detection

with CEI's Ultra-Sensitive New VLF-LF Receiver

CEI's new Type 355 Receiver is designed for RFI and EMI detection, covering the 1 kHz to 600 kHz frequency range in a single band. Selectable IF bandwidths (1 kHz, 6 kHz, 20 kHz, 50 kHz) assure detection of both wideband and narrowband signals.

All solid state, the Type 355 is unusually sensitive, with an excellent noise figure and high image and IF rejection. A modified version is also available, Type 355-1, which provides X-Y outputs to record on an X-Y plotter. For complete specifications, please contact:

CEI

COMMUNICATION ELECTRONICS INCORPORATED
6006 Executive Blvd., Rockville, Md. 20852 · Phone (301) 933-2800 · TWX: 710-824-9603





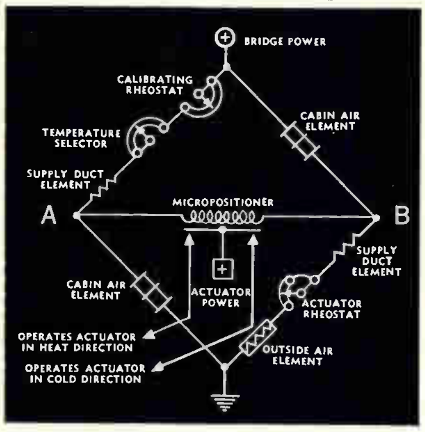
Circle 223 on reader service card

THE MARK OF QUALITY
BARBER COLMAN

# *Ultra-sensitive relays*

## HELPFUL DATA FOR YOUR CIRCUITRY IDEA FILE

The circuit drawing below indicates just one of the hundreds of ways many manufacturers utilize Micropositioner® polarized relays to solve complex control problems.




TEMPERATURE CONTROL

One of the most common applications of the Barber-Colman Micropositioner is in Wheatstone Bridge control circuits. In the above diagram of a temperature control application, the bridge arms incorporate temperature-sensitive transducers.

The Micropositioner is a polarity sensitive relay, so the direction of current flow in AB will close one or the other of its contacts from the normally floating neutral position. This causes a reversible control valve actuator to make desired temperature corrections in the supply air. A rheostat coupled to the actuator provides position feedback.

The same technique can control cycling (on-off) of an electrical heater. By using potentiometers or fixed resistors, the basic Wheatstone Bridge circuit adapts to positioning and synchronizing controls, or to automatic impedance test instruments.

**BARBER-COLMAN MICROPOSITIONER® POLARIZED D-C RELAYS**

Operate on input power as low as 40 microwatts. Available in null-seeking and magnetic-latching "memory" types of adjustment. Also transistorized types with built-in preamplifier. Write for our latest catalog with full information on polarized relays.

BARBER-COLMAN COMPANY
Electro-Mechanical Products Division
Dept. O, 12129 Rock Street, Rockford, Illinois

## New Materials

### Corrosion-free curing of silicone rubber

**Two new single-component** RTV (room-temperature vulcanizing) silicone rubber materials—a clear conformal coating and a high-strength sealant—are cured by a system that doesn't give off corrosive by-products. Previously available materials of this type, according to the producer, gave off a small amount of acetic acid during the cure, and this acid by-product could cause corrosion of copper during the curing period under humid conditions.

The conformal coating (illustrated), designated 3140RTV is a clear, self-leveling, fluid material with a viscosity of 660 poises. It cures on exposure to moisture vapor in the air to form a dry surface in about two hours. Typical thickness of the clear rubber, when applied by a single dipping operation, is about 25 mils.

The material was designed for use as a protective coating or encapsulant for p-c assemblies, electronic components, and connectors. The clear material allows easy component identification, inspection, and repair.

The noncorrosive elastomer, called 3145RTV adhesive/sealant, is a high-strength grey material supplied in a toothpaste-like consistency. It has excellent heat stability even by silicone rubber standards and can withstand long-term exposure at 200° to 250°C, and short-term use at 300°C. Tensile strength of the rubbery sealant is about 800 psi; elongation, about 675%; tear strength, 125 ppi.

This material can be used to seal electronic assembly enclosures, bond wires and terminals, insulate repairs and splices in silicone rubber-insulated wires or units, and mount electronic components.

The new materials both have excellent electrical properties over a wide range of temperatures and frequencies, along with a high degree of resistance to moisture, ozone, and weathering.

Dow Corning Corp., Midland, Mich. [407]

### Metalizing preparation for seal fabrication

A metalizing preparation is useful for the fabrication of reliable, high temperature, metal-ceramic seals. Called Molytite, it contains a reactive molybdenum alloy that forms a eutectic phase at the ceramic-metal interface during the firing process. The metalization leads to a fine, dense, metallic structure, uniformly bonded to the ceramic body, with interdiffusion occurring. The result is a strong bond and a hermetic seal.

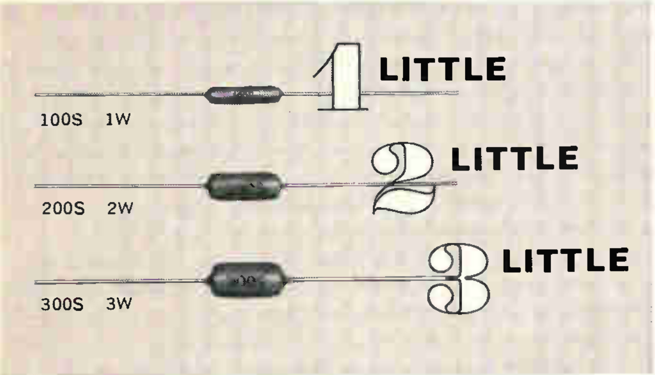
Molytite also permits good nickel plating required in the production of brazed seals. The Molytite process minimizes, in general, the critical controls required in preparing high quality metalized ceramics. Darkening of ceramic body, for example, is eliminated.

The new preparation can be used with both beryllia and alumina ceramics in the manufacture of ceramic tube structures, headers, ceramic packaging assemblies, and envelopes. Applications extend to ceramic receiving tubes, high-powered transmitting tubes, and special tubes such as klystrons, magnetrons, TR tubes, traveling-wave tubes, x-ray tubes, waveguide windows, and microwave diode packages.

Price is $45 per lb.

Transene Co., Route One, Rowley, Mass., 01969. [408]

# Good News for Packaging Engineers




Sage delivers the smallest 1, 2 and 3 watt resistors available—Specially designed for uniform length fit in .4 inch "Cordwood" circuit modules.

ACTUAL SIZE

## Check these outstanding features

| Resisance Range: | | (1W) | (2W) | (3W) |
|---|---|---|---|---|
| Regularly wound ...... | .05Ω to | 13KΩ | 18KΩ | 23KΩ |
| Non-inductively wound .. | .5Ω to | 3.0KΩ | 3.9KΩ | 5.3KΩ |

**Tolerance:** 5% to .05%.

**Standard TC:** As close as 10 ppm/°C.

**Construction:** All welded, silicone coated for temperature endurance beyond 275°C. Solderable or weldable leads.

SAGE backs up its resistor products with far more design and performance data than you customarily see from other manufacturers. Make us prove it by asking now for your copy of Catalog R-66.


**SAGE ELECTRONICS CORP.**

BOX 3926

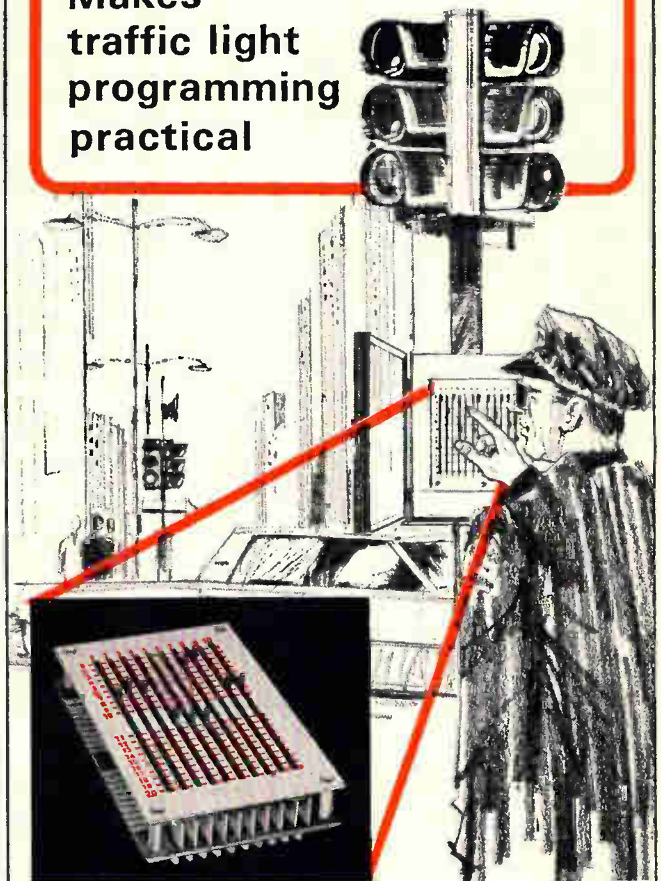
ROCHESTER, N. Y. 14610

Phone 716:586-8010

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

# VERSATILE, EASY-TO-USE SELECTOR SWITCH

**Makes traffic light programming practical**



**New Cherry Selector Switch permits continual re-programming of traffic lights to fit traffic changes**

Now—a manual switching device, human-engineered for rapid finger-tip selection of light sequence and timing. Patrolman can quickly program lights for varying traffic conditions.

The Cherry Selector Switch can be installed *quickly* because no soldering is required. And there's no jungle of wires to confuse you or cause problems. It is available in various sizes—from 100 to 2784 positions. **Write today for full details.**

**CHERRY® ELECTRICAL PRODUCTS CORP.**

1656 Old Deerfield Road Highland Park, Illinois 60035

**spec the switch to fit the job!**

Here's a ½" diameter rotary switch that lets you fit the switch to the job — not vice versa.

The new Daven series "X" will switch currents up to 2 amps. It's available in 1 to 4 poles per deck. Single pole decks have up to 12 positions shorting.

Write, phone or TWX for Bulletin SWSM 267. We build switches like no one else can.

**DAVEN** McGRAW EDISON

DIVISION OF THOMAS A. EDISON INDUSTRIES
GRENIER FIELD, MANCHESTER, N.H. 03103
(603) 669-0940 • TWX 603-623-4938

*See this and other new products at IEEE Booth #3K03.*


# New Books

## Package deal

Electronic Digital Systems
R.K. Richards
John Wiley & Sons, Inc., 637 pp., $15

Almost all of R.K. Richards' extensive knowledge of the computer field seems to be assembled in this massive tome. The style resembles that of a handbook, with most subjects broken up into discrete concepts, each described in a paragraph or short section. But the book is really a package deal, with the attendant advantages and disadvantages: some parts of the package are interesting and illuminating, while other sections are dull and rambling, describing all possible variations on a theme.

The first half of the book can be recommended as an interesting and extensive survey of computers. The highlight here is a 183-page chapter on stored programs. It describes every imaginable computer system hardware concept, including accumulators, microprogramers, list processors, etc. Another chapter is devoted to software and stresses higher languages. While it does not match the level of the hardware chapter, it is still quite good.

The rest of the book is an attempt to cover all other types of digital systems and related topics, but the author's specific interests are overemphasized. Data transmission and telephone systems for example, receive detailed treatment, but digital control systems are just barely mentioned.

There are a few serious omissions. The discussion of automatic programing does not include Fortran, and the chapter on digital systems and thinking devotes more space to game rules than to machine thinking. It is also unfortunate that the author did not take advantage of his knowledge of systems, programing, and communications to thoroughly discuss time-sharing and related topics.

The knowledge required of the reader varies from section to section. The description of one-address instructional formats is elementary, but that of multiprograming on an interrupt basis is quite advanced. In discussing the theory of digital systems, the author reviews sequential logic but assumes that the reader knows combinational logic.

In summary, the book may be useful for browsing and its extensive bibliographies may be helpful, but it is not the ideal book for educating oneself on any specific subject.

Marvin F. Heilweil
International Business Machines Corp.
Hopewell Junction, N.Y.

## Guide to waves

Advances in Microwaves, Vol. 1
Edited by Leo Young
Academic Press, 400 pp., $17.50

Following the format of the publisher's other "Advances in" annuals, this first volume in the microwaves series contains six long articles.

Topics include the design and fabrication of the disk-loaded waveguide that serves as the accelerating structure in the Stanford two-mile linear accelerator, optical waveguides, directional couplers, and the application of Lie algebraic theory to microwave networks.

The authors are expert in their areas, and they emphasize practical design considerations.

## Basic circuits

Directory of Electronic Circuits: with a Glossary of Terms
Matthew Mandl
Prentice-Hall, Inc. 226 pp., $10

An electronics engineer will know how most of these circuits work; he could even design them from scratch if he had to. Nonetheless, the directory is worth having on the shelf for occasional reference.

There are descriptions of more than 150 of what the author feels are the most-used circuits in all branches of electronics—communications, computers, and industrial control. There's a schematic for each circuit, of course, and the way it works is analyzed. Where necessary, component values and design equations are included. Most of the circuits use transistors, but tube circuits are included—sometimes just for comparison, but also for special applications.

Categories into which the cir-

# 500,000 Bits/Second PCM SYSTEMS

**710 PCM SYSTEMS** require as little as 26 cubic inches and weigh as little as 30 ounces. Space and weight are saved in Type 710 Microcircuit PCM Systems because they use MEMA.*

- Provides up to 256 channels of high, low and/or digital inputs.
- FET analog input gates.
- Offset and scatter below ±25 microvolts.
- Backcurrent below ±0.1 microampere.
- NRZ 10-bit word output.
- Sample rates from 1 to 50,000 words.

*Micro Electronic Modular Assemblies, a high density integrated circuit packaging concept developed by TELEDYNE, INC.

For complete information on Teledyne Telemetry components and systems contact:

TELEDYNE TELEMETRY
A TELEDYNE COMPANY
9320 Lincoln Boulevard
Los Angeles, California 90045
Phone (213) 670-7256
TWX: 910 328 6529

Circle 267 on reader service card

# April in Paris is electronic.

# Let Air France turn you on.

**April 5-10** International Exhibition of Electronic Components.

**April 10-15** International Conference on Electronics and Space.

**April 14-21** MESUCORA (Measurement and Automation).

We'll see you in the air and at the shows. We're happy to be the official carrier once again, and look forward to jetting you to Paris. At the shows, our Welcome Service will be on hand to give you any assistance you may need.

*Festival in the sky* stereo, and movies by In-Flight Motion Pictures, available at nominal cost.

For free brochures, mail the coupon to Air France, Overseas Trade Show Department, Box 707, New York, N.Y. 10011.

I *am* interested in: ☐ International Exhibition of Electronic Components. ☐ International Conference on Electronics and Space. ☐ MESUCORA (Measurement and Automation).

Name

Company

Address

City State Zip

E-4

*a Votre Service*
AIR FRANCE
THE WORLD'S LARGEST AIRLINE

Circle 227 on reader service card

# Now! Select from the most complete line of Vinylon Filament Non-Linting Uniform and Gloves in the world. See the comparison table below.

Comparison Table :

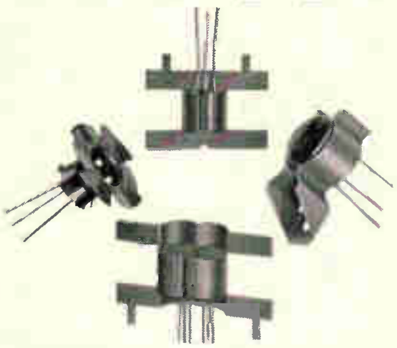
| Type of Fabric | Voltage of Static Charge |
|---|---|
| Taffeta (Vinylon-F) for this new products | 70 V. |
| Nylon Taffeta on the market | 3100 V. |

Vinylon-F NON-LINTING UNIFORM AND GLOVES ARE WIDELY USED not only in the precision machinery industry, where complete dust control is required for quality control, but also in other places where management can be effectively carried out only by preventing dust from being generated through replacement of the conventional white robes with this new product. *Details please write us*

**INDUSTRIAL AGENCIES OF JAPAN LTD.**
C.P.O. Box 2014 Tokyo, Japan
Cable Address: ARKENIAJ TOKYO
Tel: 861-4631 — 5
*manufacturer*
*FIRST NON-LINTING UNIFORM CO., LTD.*
*Tokyo, Japan*

Circle 268 on reader service card

# NEW!



**Heat Dissipators and Retainers for Plastic and Epoxy Transistors**

3 new series for RO-97A, RO-97 and X-20 devices. Maximum dissipating efficiency; added operating and safety margins. Reduce harmful effects of heat during production soldering. Cost less than a nickel in quantity. Send for data. IERC, 135 W. Magnolia Blvd., Burbank, California 91502.

ierc
SEMICONDUCTOR HEAT DISSIPATORS

*A corporate division of Dynamics Corp. of America*

# ADVANCED DEVELOPMENT ENGINEER

This promotional opportunity has been created in our Advanced Development Laboratory.

Microwave engineer, with experience in solid state and stripline design, is needed to perform research and development tasks. This individual will support company-funded research programs and advanced technology.

Salary open. BS degree required. MS degree desirable.

Please submit your resume to Mr. George W. Leesch, Manager, Industrial Relations, Mail Zone 7-32, 3090 Pacific Highway, San Diego, California 92112.

**GENERAL DYNAMICS**
*Electronics Division*
*San Diego Operations*
An Equal Opportunity Employer




cuits are grouped include amplifiers, bridges, demodulators, gates, oscillators, filters—both attenuators and pads—power controls and supplies, servo- and synchromechanisms, and pulse modifiers. A glossary of electronics terms is included, as well as an appendix containing unit values and conversions, common equations, color codes, and commercial spectrum designations.

Engineers may find this volume a helpful gift for their technicians. Some technicians, on the other hand, may think it appropriate for their engineers.

## Recently published

**Characteristics and Limitations of Transistors, Richard D. Thornton et al, John Wiley & Sons, 180 pp., $4.50 clothbound, $2.65 paperbound**

Volume four in a series prepared by the Semiconductor Electronics Education Committee deals with the physical processes which affect actual transistors—knowledge needed mainly by the designer who wants to minimize cost, improve reliability, or advance the state of the art.

**Dictionary of Electrotechnology—German/English, Eduard Hoehn, Barnes & Noble, 705 pp., $22.50**

In addition to translating German technical terms, the author has included words covering the commercial, financial, and legal aspects of the electronics industry. This adds to the book's bulk and price, but may save the novice translator some frustrating moments.

**Transformers for Electronic Circuits, Nathan R. Grossner, McGraw-Hill Book Co., 321 pp., $14**

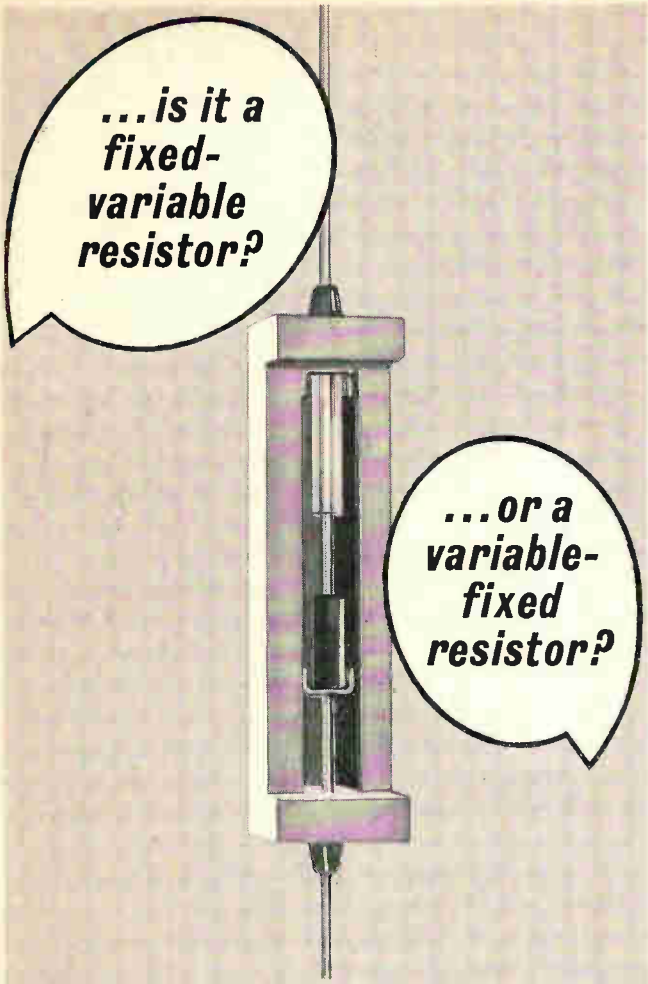
The author, a transformer designer, gives basic principles to guide engineers in specifying and selecting both power and pulse transformers. He includes such recent advances as conductive heat shields and evaporative cooling, and notes new core materials.

**On-Line Computing: Time-Shared Man-Computer Systems, edited by Walter J. Karplus, McGraw-Hill Book Co., 336 pp., $14.50**

A collection of articles, the volume goes beyond such obvious topics as system analysis and design, graphic input-output hardware, and various applications. It also spells out the economics of a time-shared system, sociological considerations, and the limits of man's physiological and psychological adaptability. Included is an actual user's manual, intended to serve as a guide in preparing operating instructions for such systems.

**Electronic Structure of Molecules, Raymond Daudel, Pergamon Press, 233 pp., $8**

Wave mechanics methods are applied to the following classes of molecules: diatomics, small molecules, saturated hydrocarbons, conjugated molecules, and those of biochemical interest—in the absence of external fields.




## neither...it's a

## varizistor

Thousands of engineers have seen and tested the VariZistor. They've moved the body up and down the center lead and marvelled at how easily the resistance can be adjusted to ±20% of the nominal value, with unbelievable resolution ... in increments as low as .0001 ohms! They've put it in circuits and noted the tremendous stability provided by the thin-film, metal-deposited resistance element. Then they've cranked up the current and found that the VariZistor easily carried over five times the rated capacity! They even subjected it to high impact shock test up to 1000 G's, with no adverse effect.

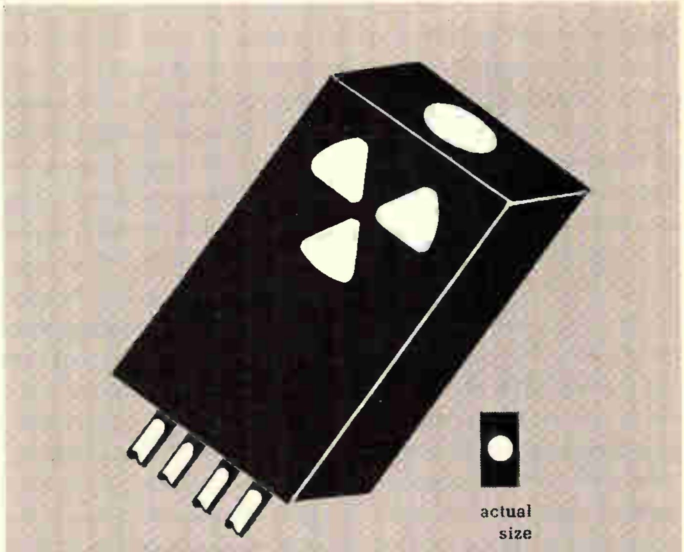
Once the elation of discovery wore off, they realized what the VariZistor could do for them! It replaces complicated networks, balances bridge circuits, reduces circuit costs by eliminating expensive matched components, such as zener diodes. Just think of the design possibilities!

Recently one of the leading electronic design news magazines put the VariZistor in a class by itself, so take your choice: fixed-variable, variable-fixed, or just VariZistor. Either way, try a VariZistor yourself and find out. Write today for literature and information on how to receive free test samples.

*Radio Products International* RPI

1501 So. Hill Street, Los Angeles, California 90015
**VariZistor** manufactured by **VACCO ELECTRONICS**
a division of VACCO INDUSTRIES

**SEE THE VARIZISTOR AT THE IEEE SHOW—BOOTH 4E 3941**




# NEW Microminiature "BITE"* Indicators

## Continuously monitor circuit and system performance.

**BITE . . . Built-In Test Equipment is now required by DOD on avionic equipment down to the module level where possible. These indicators give a visual indication if circuit or system performance falls below design parameters.*

Now you can design a microminiature indicator into any electrical or electronic circuit to alert operators if equipment performance is faulty or below desired operational levels. Even if the failure is transient, the indicator continues to register the fault by means of magnetic latching until a reset signal is applied to the terminals. Normal appearance of the case is black. If a fault develops, the windows show white in sharp contrast to the case.

### TYPICAL APPLICATIONS

In-flight monitoring of 400 cycle alternators.

Voltage sensors to determine if voltage variations exceed an allowable excursion range.

Servo loop in aircraft control system. Indicator has a built-in time delay. When a control signal is applied to the system, the indicator detects any failure to respond within 10 milliseconds, after which the time delay triggers the BITE indicator to signal failure.

Ground-support computer equipment. Indicator continuously monitors the complement of the output code and signals if an erroneous code is generated.

### GENERAL SPECIFICATIONS

These units measure only .7" x .2" x .4", a volume of only .056 cu. in. Operating range is 17-29 VDC. Response is to a pulse width as low as 15 milliseconds; special units will respond in 5 microseconds. They can be supplied with internal switching so power is used during indication transfer only. Several variations are available: Units utilizing a 4 volt fault signal; round types; pop-up indicators; and units with special interface circuitry. All meet the applicable requirements of MIL-E-5400H (ASG) Class 1-A Equipment.

**SEND FOR TECHNICAL DATA**

THE A.W. HAYDON COMPANY

232 North Elm Street
Waterbury, Conn. 06720
4060 Ince Boulevard
Culver City, Calif. 90231

Timing & Stepper Motors • Electromechanical & Electronic Timing Devices & Systems

**when special cables**

**short-circuit your production**

**call Columbia Wire!**

When immediate delivery of special cables—any type up to 2" in diameter—will keep your production running smoothly and profitably, call Columbia Wire. Chances are we have the know-how and facilities for producing it for you . . . fast!

Try us and see.

Write for our fully illustrated catalog

Columbia
WIRE PRODUCTS COMPANY
2850 Irving Park Rd. • Chicago, Ill. 60618

## Technical Abstracts

### Printed resistors

Thin film resistors using conventional circuit board substrates

Leo E. Thomas, Cinch-Graphik division, and Dennis Flammang and L.H. Barnette, Jr., Exploratory Development Laboratory, United Carr Inc., Cambridge, Mass.

If a printed circuit board assembly requires more than one resistor per square inch of board area. it may be cheaper to build thin-film resistors on the board itself instead of using discrete resistors. The film resistors, made of nickel alloy, are suitable for such applications as computer load resistances and read-only memories.

The film resistors can range in value from 10 ohms to 150,000 ohms, with tolerances as tight as 5%. Temperature coefficient is typically +80 parts per million, and drift is only 2% after 5,000 hours at 75° C and power dissipation of 2 watts per square inch. The drift compares favorably with the drift of discrete metal-film and carbon composition resistors.

The base material of the boards is unclad phenolic or glass-epoxy laminate. This is plated with nickel-phosphorous alloy to the thickness needed for the required sheet resistivity. After a resistivity test, the resistor pattern is etched. The resistors are insulated with epoxy solder resist screen-printed onto the film except where electrodes are to be plated on the resistors.

Copper is then deposited over the entire board by electroless deposition and electroplating. After the electrodes and the printed wiring are formed by etching the copper, the wiring is plated with nickel, gold, or tin-lead. The insulation applied to the nickel film resistors allows the wiring to cross over the resistors. Other components can then be assembled to the boards by standard techniques.

The authors provide a nomograph for designing resistors with a typical film—one that is 600 angstroms thick with a sheet resistivity of 50 ohms per square. The nomograph gives the resistor dimensions as functions of resistance value and voltage drop. Design formulas for meander or serpentine resistors, a shape that reduces the area needed, and for calculating power dissipation, are also given. Some of the design can be done by computer.

Presented at the National Electronic Packaging and Production Conference, Long Beach, Calif., Jan. 31-Feb. 2.

### Valuable scratch

A new magnetic read-only memory

E.B. Barcaro, D.T. Best, and J.S. Zajaczkowski, Univac division, Sperry Rand Corp., Blue Bell, Pa.

A read-only memory has been designed that overcomes drawbacks of some previous designs. It provides high density of information and fast operation. Also, when necessary, the data can be changed manually in a few minutes.

The read-only memory is built from plated wires similar to those used in the read-write memory in the Univac 9000 series computer [Electronics, May 30, 1966, p. 36; June 27, 1966 p. 50]. But in the read-only memory each wire has a scratch down its entire length that establishes an air gap in the plating; the data is stored as magnetic dipoles in a sheet of magnetic material placed against the array of parallel plated wires. Magnetic flux from the dipole enters the plating on the wire and follows the low-reluctance path around the wire rather than the high-reluctance path through the air gap. Parallel conducting strips on a substrate are on the opposite side of the array from the magnetic sheet.

To read data from the memory, a current is passed through one of the conducting strips. The magnetic field associated with the current causes the flux around the plated wire to acquire a longitudinal component. The shift generates a pulse in the wire beneath the plating; the pulse is picked up by sense amplifiers. Any word can be read out in less than a microsecond.

To change the data, the magnetic sheet is replaced with another sheet. Data is recorded with a ring-type magnetic head and can be handled at 50 bits per inch both ways, producing a density of 2,500 bits per square inch; the plated wires and the conducting strips are both spaced 1/50 inch apart. A

**NEW from Cramer**

# ADJUST-A-LOK STOOLS

*Adjust to every worker like fine tools!*

Cramer Adjust-A-Lok is immediately adjustable to any workers height. Just release the safety stop, and lift or lower. It can be done just that quick. Since fatigue is a critical factor in efficiency of seated workers, it's just good economics to provide tools that minimize fatigue. With Adjust-A-Lok every worker can find his own most comfortable and efficient level. 6 seat styles and 5 base types provide 30 available models. For more information: write V. P. Sales, Cramer Industries, Inc., 625 Adams, Kansas City, Kansas 66105.

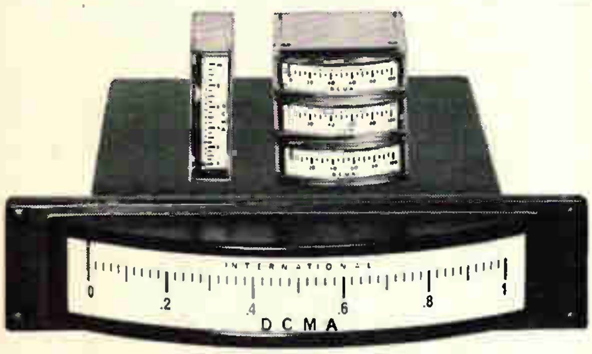
**Industrial supplier inquiries invited**

**CRAMER**
CRAMER INDUSTRIES INC. • KANSAS CITY, KANSAS
A Subsidiary of U S M Oil Co.

*Cramer—The leader in style and quality.*

Circle 270 on reader service card






## The long and short of it in stackable edgewise meters

Our stackable panel meters are the best bet yet for comparative readout or cramped panel areas.

We make them in four sizes (nominal 1½", 2", 4¼", and 6") in both horizontal and vertical styles. Whatever size or shape you need, there's probably an International stackable edgewise to fill the bill.

All our stackable meters are magnetically shielded. You can stack them together, on any kind of panel, without interference or calibration change. Each one, but the smallest, is available with optional internal illumination. And to improve readability still further, our 2" and 4¼" units have a parallax-defeating bi-level scale as standard.

Inherent in our stackables is the space-saving advantage of all our edgewise meters: you get the scale length of a front-reading meter in about one-third the panel area.

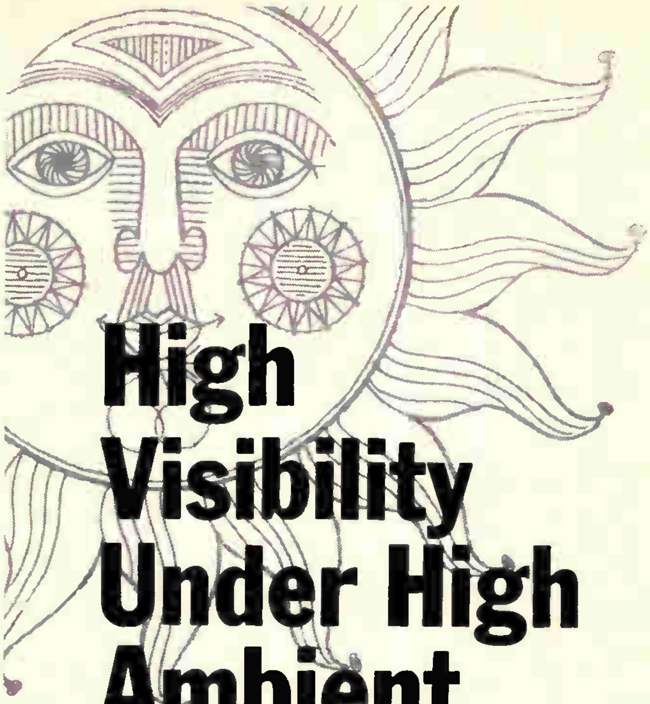
You'll find more details in our new edgewise meter catalog, Bulletin 391. Write for a copy.

***international instruments inc.***
8703 Marsh Hill Road • Orange, Connecticut 06477

SA3193

Circle 271 on reader service card





# High Visibility Under High Ambient Light


Where digital readout recognition must be under high ambient light conditions, the Tung-Sol readout provides unmatched clarity and visibility. The Tung-Sol unit was designed for aircraft applications where ambient light reaches extremely high levels.

The Tung-Sol design embodies subminiature incandescent lamps combined with special light piping that achieves a bright, sharp character of unmistakable clarity.

Tung-Sol digital readouts are easy to install and require very little hardware. They are extremely rugged and long-lived. Nevertheless, they are designed to be easily replaced. More than half-a-century of experience in the manufacture of light source devices assures product reliability of the highest order.

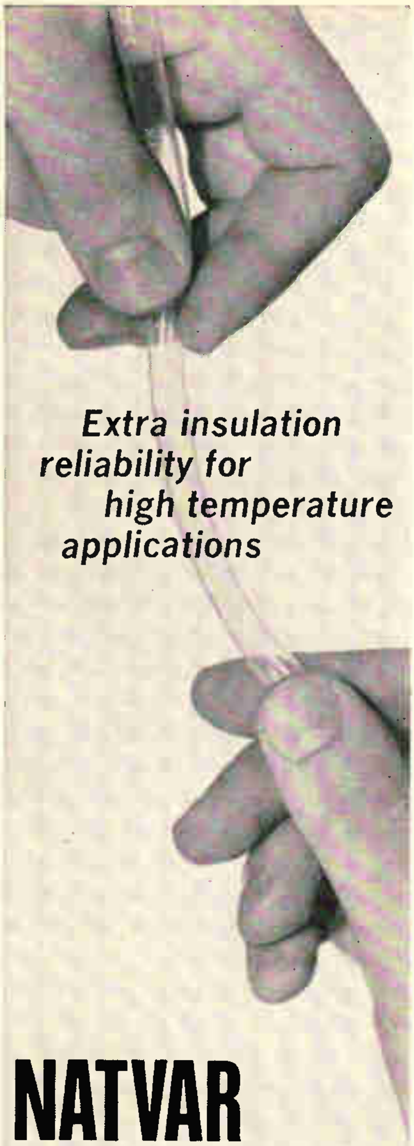
For more information, write describing your application. Tung-Sol Division, Wagner Electric Corporation, One Summer Avenue, Newark, N.J. 07104. TWX: 710-995-4607.

**TUNG-SOL®**

**HI-OPTICS DIGITAL READOUT**

**The most thoroughly engineered readout on the market**

Circle 231 on reader service card




# NATVAR 400 Vinyl Tubing

Here's an insulation you can rely on when the heat's on. Because Natvar 400 vinyl tubing has excellent thermal life. In fact, it's U.L. recognized for 105°C continuous operation. Besides that, it has exceptional resistance to oils.

Use Natvar 400 high temperature vinyl tubing to insulate leads . . . terminations . . . wiring . . . electronic equipment . . . oil filled transformers . . . harnesses.

Available in a wide range of sizes and colors—in continuous lengths or cut pieces. Send for FREE samples and complete technical data.

***NATVAR CORPORATION***
*P. O. Box 67, Rahway, New Jersey 07065*




memory containing 50,000 bits would measure only 4 by 5 inches and would be perhaps an inch thick, not including drive and sense circuitry.

Presented at the International Solid State Circuits Conference, Philadelphia, Feb. 15-17

## Cell for acceleration

A high-speed associative memory
A.W. Bidwell and W.D. Pricer
International Business Machines Corp.
Poughkeepsie and East Fishkill, N.Y.

Two associative memories that can be used in a full-scale computer with no penalty in speed or cost have been built and tested. The memory cell from which they are built may become the basis for large-scale associative memories.

The first was installed in a System 360 Model 40 whose memory is divided into segments or pages to permit time-sharing. Because this computer is smaller than most time-shared systems, very efficient page allocations among users is necessary. The 64-word-by-16-bit memory translates the program address within the page into the actual address in main memory. It also keeps track of page utilization so that inactive pages are reallocated. Interrogation time is 70 nanoseconds. The memory is described in detail in Proceedings of the IEEE, December 1966, p. 1,774.

This memory was so successful that the basic cell from which it was built was used in a small 8-by-9 laboratory model repackaged with special drive and sense circuits.

The basic cell contains two cross-connected transistors, with their emitters connected to the base of one transistor in a current-switch OR gate. All the cells in a single word are connected into this OR gate, whose reference transistor is at the input to the sense amplifier. The sense amplifier therefore generates an output pulse whenever one or more bits in the word being read out do not match the reference word. For a perfect match there is no output. Detecting a match or a mismatch by a signal or no signal is more reliable than looking for the difference between two signals.

Presented at the International Solid State Circuits Conference, Philadelphia, Feb. 15-17.


***New! From MESON! New!***

# ELECTRONIC TIME DELAY RELAY

- High Accuracy, ± 10%
- Repeatability, ± 3%
- Fast recycling time — .05 sec. max.
- Input — 115 VAC
- Up to 180 sec. delay, fixed or variable with external variable resistor.

Only $6.91 in 100 lots

***IMMEDIATE DELIVERY!***

Order one for test at $8.80. Your MONEY BACK if not satisfied!

MESON
ELECTRONICS CO. INC.
380 Cottage St., Rochester, N.Y. 14611
Phone (716) 235-7070

Circle 272 on reader service card

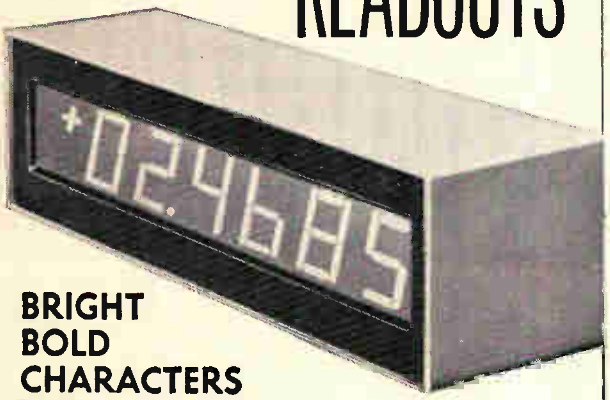

**HANIBAL GLASS, INC.**
1639 E. EDINGER AVE., SANTA ANA, CALIF. 92705 • (714) 542-4794
PRODUCING OVER 200,000,000 PARTS PER MONTH FOR THE SEMICONDUCTOR INDUSTRY.





Circle 273 on reader service card

# DIALIGHT READOUTS




**BRIGHT BOLD CHARACTERS WITH MAXIMUM RELIABILITY**

Need more data? Ask for Catalog L-181.

Modular Display

**$4.75**
per digit
1000 lot quantities

DIALCO®
*Foremost Manufacturer of Indicator Lights*
**DIALIGHT** CORPORATION
60 STEWART AVE., BROOKLYN, N.Y. 11237 Area Code 212 497-7600

Circle 274 on reader service card



**Visit our Booth 4J36 IEEE Show**


# 2" BLOWERS a.c. or d.c.

Globe's 2" diameter VAX-2 vaneaxial blowers give you substantial amounts of cooling air in a rugged, compact, lightweight package. Check over these versatile blowers.

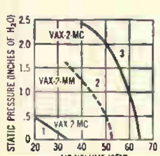
VAX-2-MC. Designed for 50 cfm. @ 2.1" $H_2O$ back pressure, unit operates on 200 v.a.c., 400 cycle, 3-phase or 115 v.a.c., 400 cycle, 1-phase. Variable speed high altitude units available. Length is 1½"; weight is 5 oz. Flange mounting. MIL specs.

VAX-2-MM. Designed for 37 cfm. @ 1.5" $H_2O$ back pressure, unit operates on 26 v.d.c., but other versions may be wound for up to 115 v.d.c. operation. Length is 2"; weight is 5 oz. Flange mounting. Designed for MIL specs. Also smaller and larger blowers available. Request Bulletin VAX-2.

**Globe Industries, Inc., 2275 Stanley Avenue, Dayton, Ohio** 45404, U.S.A., Tel. 513 222-3741

24 HOUR delivery on many units

GLOBE



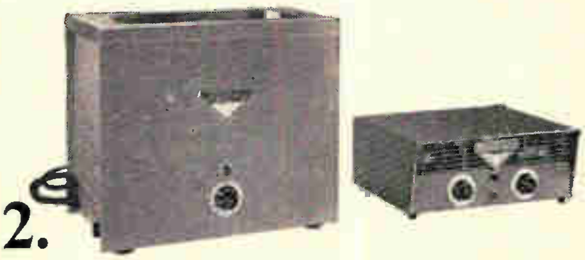

1. VAX-2-MC P/N 19A1150 200 v.a.c., 400 cps (low speed)
2. VAX-2-MM P/N 19A907 26 v.d.c.
3. VAX-2-MC P/N 19A774 for 200 v.a.c., 400 cps or 19A790 for 115 v.a.c., 400 cps

Circle 275 on reader service card



# See, there's a Blackstone ultrasonic unit for every precision cleaning need:

**1. Blackstone VRO.** Makes it easy to put vapor rinse and ultrasonic cleaning at every work-station. Requiring no water, drains or hood because of a built-in refrigeration system, the VRO runs on 110 volts, delivers 21,000 cycles, ± 1 Kc., controls particulate matter to 1 micron, and has jet spray plus solvent vapor rinsing. To assure long, trouble-free life, the lead zirconate titanate transducer is mechanically held by a retainer which is silver-brazed to the bottom of the 4" x 4" x 3" deep 316L stainless steel tank.



**2.**

**Blackstone HT Series.** Provides the right combination of tank size, power output and temperature to meet daily "on-the-bench" cleaning needs. Tank sizes can be furnished with 72, 144 and 216 square inch cleaning area capacities. Power outputs can be 100, 200, 300 and 500 watts and can be controlled from 0 to 100% for maximum cleaning efficiency without affecting the part to be cleaned. Temperature is thermostatically controlled from ambient to 190°F.

**3.**

**Blackstone VR Series.** Great where cleaning needs vary from day-to-day. Available with two ultrasonic tanks of either 5, 10 or 20 nominal gallon capacities, you can attack contaminants with a combination of solvents such as DuPont "Freon"® TF and "Freon"® T-WD602. Includes a third tank for vapor and spray rinsing. By changing sequences and solvent combinations, you can handle almost any cleaning problem on a moment's notice.

AUTHORIZED SALES AGENT DUPONT FREON® Fluorocarbon SOLVENTS

**Give us a sample of your work. We'll process anything you're cleaning and make recommendations — at no charge, of course.**

**BLACKSTONE ULTRASONICS, INC.**
1400 Howard Street • Sheffield, Pa.

See us at A-Booth #1 Institute of Electronic and Electrical Engineers Show, March 20-23, 1967

Circle 233 on reader service card

# WORLD WIDE

BADALONA FACTORY

TUDELA FACTORY

# FROM SPAIN

electronic components

# PIHER

**CARBON FILM RESISTORS • CERAMIC CAPACITORS**
**CARBON POTENTIOMETERS • SILICON EPITAXIAL TRANSISTORS**

Large and up to date facilities provided with very modern equipment allow us to produce a wide range of components and guarantee:

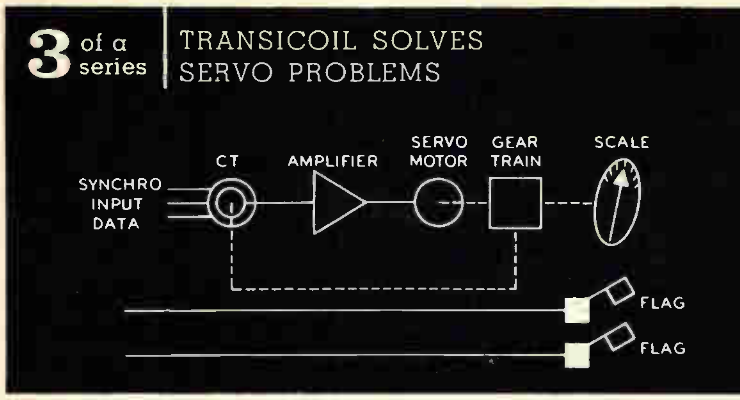
- CONSTANT QUALITY
- SHORT DELIVERY TIME
- LOWER PRICES THAN INTERNATIONAL LEVELS

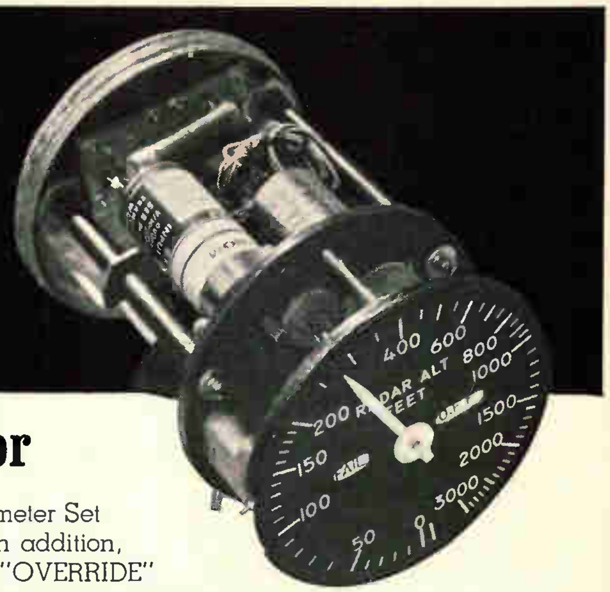
PIHER SA

Riera Canado, s/n. - Apartado, 53 - Phone 280 03 06 - Telex 05792 - BADALONA (Spain)

REPRESENTATIONS IN:
U. S. A. - Canada - Great Britain - France - Germany - Australia - Italy - Portugal - Netherland - Belgium
Finland - Sweden - Norway - Denmark - Colombia - Uruguay - Republic South Africa - Switzerland.

VISIT OUR STAND IN THE "SALON DES COMPOSANTS ELECTRONIQUES" PARIS APRIL 5–10, 1967




# Transicoil radar height indicator

Transicoil designed this instrument for the APN-120 Radar Altimeter Set aboard A3J aircraft. It provides a visual display of altitude. In addition, two Weston meter movements warn of "OFF", "FAIL", and "OVERRIDE" conditions. ■ Altitude data transmitted from a CX in the radar altimeter is fed to a matching CT in this assembly. A miniaturized servo, using size 8 components and transistorized amplifier drives the CT to a null, and exhibits this output as a pointer position on an altitude scale. ■ Pictured above without case, the unit is hermetically sealed in a 3¼" instrument can per AN-5727. All wiring is terminated at AN connectors at the rear of the can. ■ Transicoil offers an unusual capability for combining servo components into operating servo systems. Write for our 16-page brochure, SERVO ASSEMBLIES. It describes many of our standard and special-purpose units.

**Weston Instruments, Inc., Transicoil Division, Worcester, Pa. 19490.**

**WESTON®** *prime source for precision . . . since 1888*

Circle 276 on reader service card




# Great editorial is something he takes to work

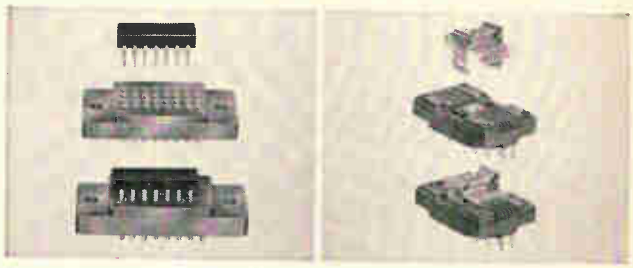
(What a climate for selling!)

**Electronics**

A McGraw-Hill Market-Directed Publication
330 West 42nd Street, New York, N.Y. 10036



# New CAMBION® integrated circuit sockets and holders...



## Make integrated circuits easier to handle

CAMBION integrated circuit sockets and holders are designed to accept all in-line IC packages, with up to 32 pin capability. Socket jacks, with cage or flat spring inserts, are engineered to survive thousands of insertion/extraction cycles. The reverse ends of both jack styles (flat or round pins) are available with solder terminal, solder pot, Wire-Wrap* or pin/plug.

CAMBION flat pack holders, with either round pin/plug or Wire-Wrap contacts, can accept any standard flat microelectronic package with 14 pin configuration. These flat pack holders are easy to handle, precision crafted, and provide reliable electrical contact.

**Send for our latest Fact-pak on CAMBION IC sockets and holders. It's FREE!** Cambridge Thermionic Corporation, 402 Concord Avenue, Cambridge, Massachusetts 02138. Phone: (617) 876-2800. In Los Angeles, at 8703 La Tijera Boulevard 90045. Phone: (617) 491-5400.

® REG. U.S. PAT. OFF.
*T.M. GARDNER DENVER CO. REG. U.S. PAT. OFF.

CAMBRIDGE THERMIONIC CORPORATION
**CAMBION®**

Standardize on CAMBION . . . 21,541 guaranteed electronic components

# We thought of putting a false bottom on it.

We toyed briefly with the idea of making our PVB (Potentiometric Voltmeter-Bridge) bigger than it had to be. We were worried about the skeptics who wouldn't believe we could combine seven high-accuracy measurement functions in a portable case the size of a typewriter.

But we resisted temptation. We designed the PVB as compact as solid-state technology permits. And we said to the skeptics, "Seeing is believing. If you don't think that one $750 instrument can deliver 0.02% accuracy or better on voltage, resistance, current and ratio measurements—just watch."

The skeptics watched and they became believers. They passed the word along to friends and made the PVB one of our best sellers. (If word hasn't reached you yet, write us direct.) They showed us this instrument has more uses than even *we* knew—including potentiometric temperature measurement, checking of dc power supplies, measuring pH and calibration applications galore.

We should have known that false bottoms went out with the bustle. ESI, 13900 NW Science Park Drive, Portland, Oregon 97229.

Electro Scientific Industries esi®

## New Literature

**Low-pressure transducers.** Robinson-Halpern Corp., 5 Union Hill Road, West Conshohocken, Pa., 19428. A four-page technical bulletin deals with low-pressure transducers that are used where a high degree of precision and reliability are required. [439]

**Digital coupler.** Cohu Electronics Inc., Box 623, San Diego, Calif., 92112. Photographs, charts, and diagrams are included in a data sheet on the 490 series digital coupler. [440]

**Thick-film technology.** E.I. duPont deNemours & Co., Wilmington, Del. 19898, has published an illustrated booklet that discusses thick-film technology as applied to the manufacture of integrated circuits, circuit elements, and packages for active devices. [441]

**Shielding alloy.** Westinghouse Electric Corp., Materials Manufacturing division, Blairsville, Pa., 15717. Brochure TD52-161 describes Hipernom alloy for magnetic shielding and laminations. [442]

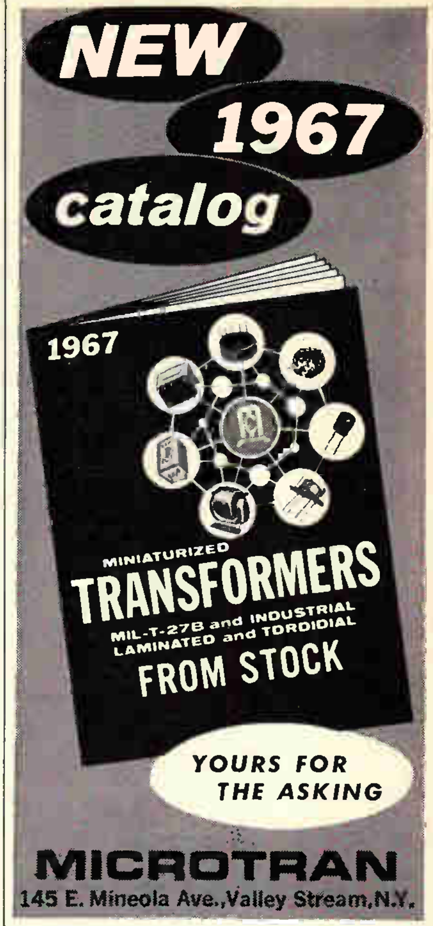
**Data transmission modem.** Rixon Electronics Inc., 2120 Industrial Parkway, Montgomery Industrial Park, Silver Spring, Md., has available a bulletin describing the PM-24 data set, a four-phase modem for data transmission at 2,400 and 1,200 bits per second. [443]

**Precious metals and alloys.** Semi-Alloys, Inc., 20 N. MacQuesten Pkwy., Mount Vernon, N.Y., 10550. Technical bulletin No. 89 lists all the purities available in gold and gold alloys, silver and silver alloys, and platinum. [444]

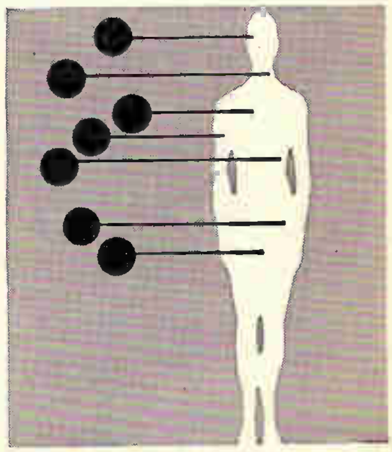
**Double balanced mixer.** Relcom, 2164 East Middlefield Road, Mountain View, Calif., 94040. A comprehensive data sheet on the performance parameters of the model M1 double balanced, broadband mixer includes a problem-solving application aid which gives complete data on harmonic intermodulation signals in easy-to-use chart form. [445]

**Flexible circuit designers' guide.** Taylor Corp., Valley Forge, Pa., 19481. A four-page designers' guide gives conductor and dielectric properties for Monotherm laminates for flexible circuits. [446]

**Log i-f amplifiers.** RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N.Y., 11735. Bulletin LA-101 lists a line of standard log amplifiers including Mil grade, economy, tube and solid state models with center frequencies from 5 to 200 Mhz and bandwidths from 2 to 100 Mhz. [447]




Circle 277 on reader service card



**Know the seven danger signals that may mean cancer.**

**1.** Unusual bleeding or discharge. **2.** A lump or thickening in the breast or elsewhere. **3.** A sore that does not heal. **4.** A change in bowel or bladder habits. **5.** Hoarseness or cough. **6.** Indigestion or difficulty in swallowing. **7.** Change in a wart or mole. None of these is a sure sign of cancer. But if one lasts more than 2 weeks, see your doctor at once. It's worth it in peace of mind alone.

**American Cancer Society**®

THIS SPACE CONTRIBUTED BY THE PUBLISHER

# ELECTRONIC ENGINEERS

**OPPORTUNITY:** Expanding product design and development activities have created openings for qualified Electronic Engineers interested in working in unique and challenging programs.

**ASSIGNEMENT:** Project responsibility for guiding new concepts through evaluation, design, prototype and test phases to production follow-up. Active participation in instrumentation design & development.

**REQUIREMENTS:** 2-5 years experience in one or more of the following discipline:

- Solid state circuit design including analog, pulse, digital, power supply, sensor, and servo;
- high voltage pulse and steady state circuit design;
- instrumentation packaging concepts.
- BSEE Degree

**BENEFITS:** Outstanding individual growth opportunities. Excellent salary and benefit programs

Submit resume in confidence to

**PHYSICS INTERNATIONAL COMPANY**

2700 Merced Street
San Leandro, California 94577
(415) 357-4610

An Equal Opportunity Employer


*ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.*
*NEW YORK, N. Y. 10036: P. O. Box 12*
*CHICAGO, Ill. 60611: 645 N. Michigan Ave.*
*SAN FRANCISCO, Cal. 94111: 255 California St.*

### POSITION VACANT

**Teaching—Unusual opportunity to develop** strong electrical section of recently established Engineering Science Dept. in an outstanding Liberal Arts College for men. Write to, Director, Engineering Science, Rockhurst College, 5225 Troost Ave., Kansas City, Mo. 64110.


# YOU'RE HIRED!

Do you need electronics engineers or technical management men? Electronics magazine is the way to recruit them. Electronics is designed specifically for the working engineer. 68,000 subscribers and an additional 133,000 pass-along readers turn to it to keep up with their industry. You can find the man that meets your qualifications with an advertisement in the Employment Opportunities Section.

For rates & information write: Electronics, a McGraw-Hill Publication. Classified Advertising Division, Post Office Box 12, New York 10036.



# The engineers we're looking for probably aren't looking.

They're doing well where they are. They're well paid, they're ambitious and they're growing. Fast.

That's why Loral Electronic Systems is the sort of company they *ought* to be working at. Because we're successful, ambitious and growing fast, too. Things move ahead quicker. So do our people.

Right now, we're a state-of-the-art contributor to the country's defense programs in avionic systems. Our particular areas are anti-submarine warfare, electronic warfare, and navigation and display.

In these areas, we're already a major factor. And there will soon be challenging new ones for the right men to work on.

That's where you could come in. We're busy. There's a lot of good work to be done. There's no giant-company red tape to hold you back. And the road to management is open.

So even if you're not actually looking, get in touch with us anyway. We'll not-look together.

Send a resume to Mr. George Conn, Loral Electronic Systems, 825 Bronx River Ave., The Bronx, N.Y. 10472.

Immediate openings for systems, project, and design engineers in all disciplines.

**LORAL ELECTRONIC SYSTEMS**
A Division of Loral Corporation
An Equal Opportunity Employer


# SEARCHLIGHT SECTION

- CLASSIFIED ADVERTISING • BUSINESS OPPORTUNITIES
- USED OR SURPLUS EQUIPMENT


RADAR AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS 3 & 10 CM. SCR 584 AUTOTRACK RADARS. M-33 RADAR TPS-1D SEARCH. APS-45 TPS-100 HT. FINOERS. WX RADARS. FPN-32GCA. APS-10 APS-15B APS-27 (AMTI) SEARCH. APN-102 DOPPLER. DOZENS MORE. CARCINOTRONS. PFN'S. .25-.5-1-2-3-6 MEGAWATT PULSE MOOULATORS. CAVITIES. PULSE TRANSFORMERS. IF STRIPS. WAVEGUIOE. BENDS 200 MC. 1 KMC. 3 KMC. 6 KMC. 9 KMC. 24 KMC. RF PKGS.

**RADIO RESEARCH INSTRUMENT CO.**
550 5TH AVE., NEW YORK 36, N. Y. JU 6-4691

CIRCLE 966 ON READER SERVICE CARD

*New* **VACUUM PENCIL**

$7.50 ea.

for picking up miniature parts

Selected Distributorships available.

**PHILIP FISHMAN COMPANY**
7 CAMERON ST., WELLESLEY, MASSACHUSETTS

CIRCLE 967 ON READER SERVICE CARD


# PROFESSIONAL SERVICES


**Donald C. Harder., Inc.**
*Magnetic Component Engineers*
Reactors—Transformers—Filters
Serving the Research Laboratory
2580 K Street, San Diego, Calif. 92102
Phone (714) 239-8021



**YOUR IDEAS** may be worth a Million Dollars, but . . . if they stay in your head they're not worth a nickel! Now through membership in the International Idea Club, Inc. you can sell your ideas and get maximum cash rewards. Legally protected, your ideas are consistently exposed to interested parties. Send only $1.00 today for big illustrated book "Millions For Your Ideas", showing how you can profit by membership in one of the nation's most dynamic organizations. International Idea Club, Inc., Dept. E-3, 135 Columbus Ave., Boston, Mass. 02116

CIRCLE 968 ON READER SERVICE CARD


7283940563498217890456372712345092718
8394056349821789045637271234509271890
1890991728394056349821789045637271234

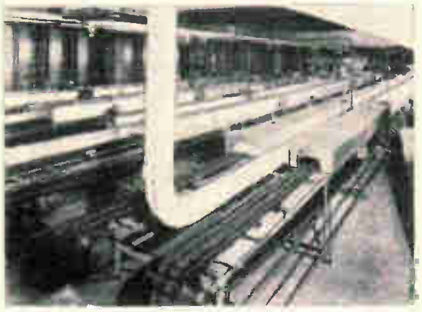
*PLEASE USE BOX NUMBER*

*when answering classified advertisements in Electronics. It is the only way we can identify the advertisement you're answering.*

9917283940563498217890456372712345092
2839405634982178904563727123450927189
0456372712345092718909917283940563498

# WORLD WIDE

BADALONA FACTORY



TUDELA FACTORY

# FROM SPAIN

electronic components

# PIHER

**CARBON FILM RESISTORS • CERAMIC CAPACITORS**
**CARBON POTENTIOMETERS • SILICON EPITAXIAL TRANSISTORS**

Large and up to date facilities provided with very modern equipment allow us to produce a wide range of components and guarantee:

- CONSTANT QUALITY
- SHORT DELIVERY TIME
- LOWER PRICES THAN INTERNATIONAL LEVELS

PIHER SA

Riera Canado, s/n. - Apartado, 53 - Phone 280 03 06 - Telex 05792 - BADALONA (Spain)

REPRESENTATIONS IN:
U. S. A. - Canada - Great Britain - France - Germany - Australia - Italy - Portugal - Netherland - Belgium
Finland - Sweden - Norway - Denmark - Colombia - Uruguay - Republic South Africa - Switzerland.

VISIT OUR STAND IN THE "SALON DES COMPOSANTS ELECTRONIQUES" PARIS APRIL 5–10, 1967

# Newsletter from Abroad

**March 20, 1967**

**Color-tv apathy in U.S. stimulates small sets in Japan**

The disappointing outlook for color-television set sales in the United States this year already has triggered repercussions in Japan.

**Apparently because of export-order cancellations by U.S. buyers, the Sanyo Electric Co. found itself with excess production capacity and** rushed into the home market this month with a 16-inch vacuum-tube set that retails at $397 list price. The going list price for a "low-cost" 19-inch set is currently about $450.

**Suppliers report that Sanyo hurriedly changed specifications for components in tuned circuits where Japanese and U.S. standards differ.** Sanyo, soon to gear up to turn out 30,000 color-tv sets monthly, undoubtedly made the switch in an effort to recoup the lost export business.

Meanwhile, the Matsushita Electric Industrial Co. has quietly started a production run on 16-inch hybrid color sets for export to America. The hybrids have transistorized radio-frequency and intermediate-frequency stages in both the video and sound channels, advantages for export since they make for small receivers and thus lower shipping costs.

The Tokyo Shibaura Electric Co. also produces a 16-inch hybrid, for the Sears Roebuck Co. **Other major Japanese color-tv manufacturers, seemingly, will stand pat with 19-inch sets until 15-inch color tubes become available in Japan starting in July.**

**Plessey set to tap automation market in Russia**

Some whopping Russian orders for computers and automation equipment seem in the offing for the Plessey Co. during the next few months.

**The British firm this month put itself on the inside track for upcoming Russian business through an agreement to exchange technical information with the USSR State Committee on Science and Technology.**

Although the pact covers only swaps of know-how, Plessey sees it as a forerunner to Soviet buys of a broad range of electronic equipment including computers, automation equipment, and communications gear. **Plessey now looks like the leading contender for a contract to automate** the vast operations of Gosstroy, the state committee that controls construction throughout the Soviet Union. Foreign computer experts say that complete automation for the far-flung government agency would require upwards of $500 million in equipment.

**Dutch may buy antisub missile from Australians**

Australia's Ikara antisubmarine missile may become a top seller in Western Europe.

**The Australian Department of Supply, which recently started producing the missile-torpedo, expects a major order for it soon from the Royal Netherlands Navy.** West Germany also is taking a hard look at the weapon, and Britain already has placed a $17 million order. Hawker Siddeley Dynamics Ltd. of Britain is handling the Australian missile in Western Europe.

The Ikara's performance is classified, **but its range is perhaps 25 miles, considerably better—the Australians maintain—than the U.S. Navy's current antisubmarine rocket.** The Ikara, named after a weapons thrower used by Australian aborigines, starts its attack run as a guided missile. It then plops into the sea and under sonar control either from a destroyer or a helicopter homes on a submarine.

# Newsletter from Abroad

**Philips' profits continue to slide**

Another poor year for profits seems in store for Philips Gloeilampenfabrieken NV, squeezed both by sagging consumer markets in Western Europe and costly startups in color television and business computers.

Sales last year soared to $2.3 billion, compared with $2.1 billion in 1965, but profits fell about 10%. **The decline will almost certainly continue this year, largely because returns on color tv and computer investments won't start coming in until 1968, at the earliest.**

Also clouding the picture is the problem of large inventories, now running close to $890 million—about 39% of last year's sales. To whittle this down, the company may have to cut prices and turn to expensive sales gimmicks. It now is selling black-and-white tv sets in Belgium on a six-month free trial basis and with a five-year guarantee.

Philips lopped off 3,500 workers from its Dutch payroll of 87,000 last year and will let another 2,500 go by June. But the cutback doesn't figure to check the slide in profits.

**Medical electronics exhibit in Moscow reveals Soviet lag**

Western experts are now convinced the Soviet Union is well behind the West in medical electronics.

Paradoxically, this lag became evident during an exhibit of X-ray equipment held with little fanfare this month in Moscow by Philips Gloeilampenfabrieken NV. **Russian specialists who turned up for the show disclosed, for example, that there's no domestic production of videotape recorders for X-ray diagnosis. Nor do the Soviets have transistorized closed-circuit television equipment for use with X-ray units.** And although the Russians are known to have developed sophisticated miniature image-intensifiers for their space program, none of these devices have been made available to medical institutes.

Philips specialists also got a look at leading Soviet medical centers while the exhibit was running and came back with the impression that production of advanced medical electronics hardware is practically nonexistent in the country.

**GE regains hold on Spanish firm**

The General Electric Co. has cut itself in for a larger share of the mushrooming electronics market in Spain. After three years of negotiations, the company now has a go-ahead from the Franco government to boost its holding in GE Espanola.

**The increased equity will return to GE the majority control it had when the Spanish firm was founded in 1929.** GE was later forced by the Franco government to sell off part of its holding and become a minority shareholder. Other big stockholders in GE Espanola are Alsthom, a leading French heavy electrical equipment producer, and Compagnie Francaise Thomson Houston-Hotchkiss Brandt.

**IBM and CDC at Leipzig Fair**

Western computer manufacturers and their potential customers behind the Iron Curtain expect U.S. restrictions on sales of sophisticated electronics hardware to Soviet bloc countries to soon be eased. **Anticipating freer trade, both the International Business Machines Corp. and the Control Data Corp. for the first time showed third-generation computers at this year's Leipzig Spring Fair.** IBM, particularly, has high hopes for East European markets, where French and British computer makers already have made considerable headway.

# Electronics Abroad

Volume 40
Number 6

## Japan

### Surprise package

As they boarded a jet bound for New York last week, a pair of engineers from the Hayakawa Electric Co. on their way to the annual convention of the Institute of Electrical and Electronics Engineers carried with them two small, ordinary-looking plastic cases. Inside the cases: prototypes of an electronic calculator built around metal-oxide-semiconductor integrated circuits that Hayakawa plans to put on the market late this summer.

Hayakawa showed an experimental desk calculator designed with monolithic silicon transistor-transistor logic circuits last fall [Electronics, Nov. 14, 1966, p. 345]. But in a surprise move, the company—the top producer of desk calculators in Japan—has switched to metal oxide semiconductors for its first commercial integrated circuit calculator.

The sole IC calculator on the horizon in the United States—Victor Comptometer Corp's Victor 3900—also has metal-oxide-semiconductor IC's. But the semiconductor company that will produce the machine for Victor, the Philco-Ford Corp., has had all sorts of teething troubles with the calculator and won't have it in mass production before this summer, more than a year behind Victor's original schedule [Electronics, March 6, p. 231].

**Modernization.** But Hayakawa has managed to skirt a number of the problems that Victor and Philco-Ford encountered. Victor's calculator crams the equivalent of 21,000 discrete components on 29 integrated circuits. Hayakawa's machine has 50 IC packages for arithmetic and control, plus 43 discrete silicon transistors and 200 germanium diodes to drive a display of Nixie-like indicator tubes.

What's more, the Japanese calculator has only five types of metal-oxide-semiconductor packages. The IC part of the machine includes 10 dual eight-bit shift registers, 10 quadruple flip-flops, 20 quadruple dual-input gates, five quintuple inverters, and five general-purpose circuits that can be connected to perform a variety of logic functions. Clock frequency for the logic circuits is 50 kilohertz. Hayakawa and the two semiconductor makers that will supply the circuit packages deliberately kept the degree of integration moderate so that yields would be economic and the packages suitable for other, larger calculators.

**Display.** For the readout, Hayakawa opted for ½-inch diameter Nixie-like tubes. Rather than the conventional simultaneous display for all 12 tubes, the readout is time-sequential with each tube "on" for 80 microseconds and then "off" for about 1,000 microseconds. The on-off switching is fast enough to give the calculator user the impression that the tubes are continuously lit.

But the sequential display cuts down considerably on the number of components needed for the tube-driving circuits. In a simultaneous display, 10 complete driving circuits are required for each digit displayed. For a 10-digit calculator, then, 100 separate circuits are needed. The sequential display—each digit position lit in turn—needs only 20 circuits, 10 for common cathode connections among the 0's, 1's, 2's, 3's etc. and 10 more for the anodes for each digit position. To light the numeral "5", say, in the tube that shows the tenth significant digit, the driving circuits switch on the "5" common cathode connection but the "5" glows only in the tenth tube since it is only one whose anode circuit is on at the same time. The driving circuits for decimal points are separate. Almost all the power consumed by the calculator—6 watts—goes for the display circuits.

**Calculating.** Hayakawa Electric Co. plans to put desk calculator with metal-oxide-semiconductor logic circuits on the market late this summer. The company had prototypes on its stand at the IEEE convention.

**Shrinking.** The prototypes Hayakawa will show at the IEEE convention this week are, roughly, 12 inches from front to back, 10 inches wide and 2.5 inches high. All the electronics are mounted on two 8.2-inch by 4.75-inch printed circuit boards. Improved layouts on the boards will make the commercial versions about 20% smaller than the prototypes.

The production versions will be lighter, too. Largely through a slimming down of the carrying case, the commercial calculator will weigh just 9 pounds, compared to 11 for the prototype. By contrast, Hayakawa's current small calculator weighs in at 29 pounds.

And Hayakawa has in mind improved display tubes. The tubes now in use require between 170 and 190 volts. In the works are 25-volt tubes that will lower the power consumption and make for longer life for the transistors in the driving circuits.

## France

### Lightening the load

Although the thousands of would-be subscribers who have to wait a year or more to get a telephone won't believe it, France may be the first country to use laser transmission links for telephone service.

Next month, Laboratoire Central de Télécommunications will start experimental telephone transmission by pulse code modulation over a laser link in a Paris suburb. The company, a subsidiary of the International Telephone and Telegraph Corp. and an important supplier of advanced equipment to the government-run phone network, sees the experiment as a forerunner to the establishment of short-range optical systems that could ease the load on overworked carrier equipment in existing exchanges.

Many telecommunications equipment producers around the world have laser transmission experiments under way. Most, though, have as their eventual goal long-distance trunk transmission with thousands of channels. Laboratoire Central's experimental system will handle just 25 channels.

**Back-and-forth.** In its experiment, the French company will send both data and telephone calls over a link a mile and a half long. The receiver and transmitter will be mounted on the same tower and the outgoing beam bounced back to the receiver by a reflector mounted on a second tower three-fourths of a mile distant.

The laser for the transmission system is a helium-neon type with a visible beam of 6,328 angstroms wavelength and a power of 30 milliwatts. It will be set up at the bottom of the transmitter tower and aimed at the second tower periscope fashion.

Reflected back from the second tower, the beam will pass through a pair of lenses and an interferential filter with a bandwidth of 35 angstroms centered on 6,328 angstroms. Then it will be picked up on a photocathode 0.1-inch in diameter.

**Ultrasonic.** To modulate the beam, Laboratoire Central will use an ultrasonic Brillouin-scattering device operating at a frequency of 250 megahertz. The device is a fused silica cube with a disk of X-cut quartz 30 microns thick and 5 millimeters in diameter bonded to it. The modulated beam is only 5 mm in diameter, so small that an insect flying through it would disrupt transmission. The beam is enlarged optically to 5 centimeters width before it is reflected off the periscope-like transmitter mirror.

For telephone transmission, the input to the modulator will come from a pulse-code-modulation signal generator. For data transmission, which Laboratoire Central is investigating for the French Defense Ministry, a special encoder will be used.

### Color tube time

It's been a long time coming, but the maskless color-television tube that the Compagnie Française de Télévision has had in the works for three years now seems definitely headed for the market.

This month, the company closed a \$4 million deal with the Soviet Union covering licenses and know-how for a pilot plant to build the maskless tube. The target date for starting production—of several thousand tubes annually—is 1969.

By then, the French most likely will be turning out the tubes in volume. Two major tube producers reportedly are well along in talks to set up a joint color-tube plant. The two, the Compagnie des Lampes and La Radiotechnique S.A., a subsidiary of Philips Gloeilampenfabrieken, are thinking in terms of a 200,000-tube output by 1969

**Confident.** Henri de France, inventor of the Secam color-tv system and scientific adviser to Compagnie Francaise de Television, says the company's maskless color tube is "practically ready" for production.

and something like 500,000 tubes yearly by 1971 or 1972. And Henri Peyrolles, general manager of Compagnie Française de Télévision, says the Russians will start building—within two or three years—a full-scale plant capable of producing a million tubes annually.

**Cautious.** With its prediction now that the maskless tube will be in production in about two years, Compagnie Française de Télévision has turned conservative. When they first showed the prototype tube nearly two years ago, company officials claimed it would be ready for volume production within a year. But so far, only 50 tubes have been produced in a pilot run by CSF-Compagnie Générale de Télégraphie sans Fil, one of the parent companies of Compagnie Française de Télévision.

CFT won't give details on the troubles it's run into readying the tube for the production line.

However, one engineer reports the production version will retain the same basic design of the tube conceived by Henri de France, inventor also of the Secam color-tv system. In this tube, a wire grill replaces the shadow mask and brightener electrodes on the outside of the tube control the speed of electrons emitted from three guns, one for each primary color [Electronics, May 3, 1965, p. 157]. But CFT says the tube has been considerably improved during the preparation phase. The contrast ratio has been lifted from 40 to 50 in the first tubes to between 180 and 200. And the definition was increased 20% by narrowing the color phosphor stripes from 0.33 millimeter to 0.27 mm.

## Soviet Union

### Color to come

The word from the Kremlin long has been that the Soviet Union would have color television on a big scale in time for next November's celebration of the 50th Anniversary of the Bolshevik Revolution. Now it seems that the anniversary color programs will be seen on only a few hundred receivers strategically placed throughout the country.

Like the French, the Russians are using the Secam color system and counting heavily on a maskless picture tube for priced-right color sets. But the tube won't be forthcoming before 1969 [see related story above]. Meanwhile, the Russians are restricting themselves to small-scale production of sets using shadow-mask picture tubes.

**Well grounded.** But if they won't be ready to flood the country with color sets for the jubilee, the Soviets will make good essentially on their promise to have countrywide colorcasts by then. Work is going full blast on a half-dozen ground stations to relay broadcasts from Moscow to ground stations in the far corners of the country via the three Molnya-1 communications satellites put into orbit in 1965 and 1966. Already, television programs have been relayed between Moscow and Vladivostok.

And all indications are that the Soviets will have a noteworthy innovation in television transmission when their communications satellite network goes into service. Putting to work an idea proposed 20 years ago by the Radio Corp. of America but still not used commercially in the United States, the Russians will transmit the audio signals in the video channel. In conventional broadcasting, there's a separate carrier for sound.

In the single channel scheme, called time diplexing, the audio information is inserted during the short interval (about 1.5 microseconds) between the end of the video information for one line and the synchronizing pulse for the start of the next line. With the sound diplexed into the video, a single transmitter can handle the complete tv signal. The Russians admit that the fidelity of the diplexed sound will be poor at the outset but claim they'll be able to improve it.

Time diplexing for tv satellite transmission was tried experimentally by the Bell Telephone Laboratories with Telstar 2 in 1963. Bell is still developing time diplexing equipment but has not yet offered it for use by broadcasting networks. Current network practice in the U.S. is to feed video information to stations over microwave links and the sound separately by coaxial cable.

## South Africa

### Hard times

Consumer electronics producers in South Africa can trot out a compendium of woes that would make marketing men in any other "developed" country shudder.

This month, the South African radio and audio industry started to clamor for increased tariff protection against imports, largely from the U.S., West Germany and Japan. But even if the government does raise the tariff wall—and there are no signs yet that it will—the industry's outlook will still be bleak.

**Slim pickings.** The ruling National Party won't allow television, and so consumer electronics makers have as their mainstay a meager domestic market for radio sets—around 100,000 a year—and phonographs.

And the dozen-odd South African electronics firms, along with 10 subsidiaries of foreign companies, hold only some 40% of this market. Companies based in neighboring Rhodesia, where British and United Nations economic sanctions against the breakaway Ian Smith regime have spurred local electronics output, surprisingly account for between 30% and 40% of South African radio-set sales. The rest of the market is accounted for by imports from the U.S., Japan and Germany.

**Good neighbor.** In South Africa's current climate of sympathy toward Rhodesia, both in government and business, there's no chance of throttling imports from there. South African manufacturers would like to see imports from elsewhere slowed to a trickle, but with an arbitrary tariff rise the government would invite retaliation.

What's more, the industry can't turn to its natural export market—the developing African countries—for a lift. The government has made it a criminal offense to supply equipment or know-how to any country hostile to South Africa or its apartheid policy. This shuts out South African products from most other countries in Africa.

With the outlook so bleak, a state of near-torpor seems to have settled in on the South African consumer electronics industry. At the Johannesburg radio and audio trade fair last month—the first ever held in the country—only half the South African-owned companies in the field bothered to exhibit. The other half apparently felt the state of the market didn't warrant spending money on promotion.

## Great Britain

### Through thick and thin

In their rush to achieve volume production of monolithic integrated circuits, Britain's major semiconductor makers have largely neglected thick-film hybrid IC's. Spotting an opening for a smaller company in the mushrooming—

but highly competitive—IC market, Welwyn Electric Ltd. is readying an automated production line to turn out 100,000 hybrid circuits a week.

Welwyn figures that when the line is running at full tilt a year or so from now, it will be able to produce logic gates selling at about 50 cents each. The firm expects the devices to be snapped up, particularly by industrial controls makers. Although the hybrids are slow compared to monolithic circuits, the low-cost thick film circuits can handle enough power to directly drive relays and silicon controlled rectifiers. And the hybrids operate at 12, 24, or 50 volts, much higher than monolithics' level. The high voltage levels, relatively immune to noise interference, are a big advantage in industrial controls.

**Bright prospects.** Welywyn, in fact, estimates that by 1970 hybrids will have a 30% share of a total British IC market of $55 million. The government agency charged with fostering technological advances in Britain, the National Research Development Corp., also sees a bright future for hybrids; the agency is providing most of the $2 million needed to finance Welwyn's automated production facilities. Eventually Welwyn will add a second line to boost its capacity to 200,000 thick-film hybrids a week. The concern will also produce thin-film resistance networks.

**Fired on.** To turn out logic gate circuits, Welwyn's line will feed alumina substrates about 1 inch square and 0.030-inch thick into a printing machine that lays down the passive elements and interconnections. The printed film components will then be baked on in an automatic furnace, with temperature controlled to within 1°C across the bond. The yield through this stage is expected to reach 80%, and there should be few rejects in subsequent operations.

After baking, the resistances will be automatically adjusted to a tolerance of 1% and the semiconductor chips will be soldered onto the substrate. The leads will then be fitted and the circuit encapsulated in a semiautomatic operation.

Welwyn will run go-no-go tests on the circuits at the outset but later will switch to a computer-controlled test setup to check parameters. The firm estimates the stability of the hybrid circuits at better than 2% over 2,000 hours at temperatures ranging from —55°C to 125°C.

## Lighting up

Nothing would bring greater joy to Britain's red-eyed civil air traffic controllers, so far condemned to work in darkened rooms, than a bright radar display of the aircraft they keep track of.

But the advent of bright displays at civil airports in the United Kingdom seems about 18 months off. The Board of Trade, which recently took over responsibility for air traffic control from the now-defunct Ministry of Aviation, currently is evaluating bids for the first installations.

Two bright display systems are slated to go into the control tower at London Airport and about 30 to the nearby area control center at West Drayton. Eventually, the Board of Trade expects there'll be about 90 bright displays at British civil airports.

**Competitors.** Two systems are in the running for the Board of Trade's business. One is the scan-conversion system, used at major airports in the U.S. In this system, information stored in a radial raster by a normal radar plan position indicator is converted into a television raster and then displayed on a tv screen. The Royal Aircraft Establishment at Farnborough has had such a system, built by the Raytheon Co., under evaluation for two and one-half years.

The second system in contention is based on a direct view storage tube. At a conference on air traffic control systems engineering and design held last week by the Institution of Electrical Engineers in London, an engineer of the Marconi Co., described an 11-inch direct view bright cathode ray tube.

**Two guns.** In the tube, the bright image comes from stepping up both the stream of electrons that excite the phosphors on the screen and the light-conversion efficiency of the phosphors themselves. To do this, two guns are used, a writing gun and a flood gun.

The writing gun works very much like the gun in a conventional crt except that the stream of electrons it puts out strikes a storage mesh instead of the phosphors. Because the phosphors themselves do not store information, high-efficiency, short-persistence phosphors can be used for the viewing screen.

The screen is lit by the flood gun, whose electron stream is collimated so that it approaches the storage mesh orthogonally and uniformly. The charge on the mesh allows the flood gun electrons to pass through and strike the screen continuously but only where information has been written in.

## Around the world

**Saudi Arabia.** Oil-rich Saudi Arabia has under way an ambitious program to expand its radio and television broadcasting network during the current fiscal year. Upwards of $26.5 million will be spent for transmitters and studio equipment. The strengthened transmitter facilities will bring within range of Saudi broadcasts all the emirates in the Arabian Gulf.

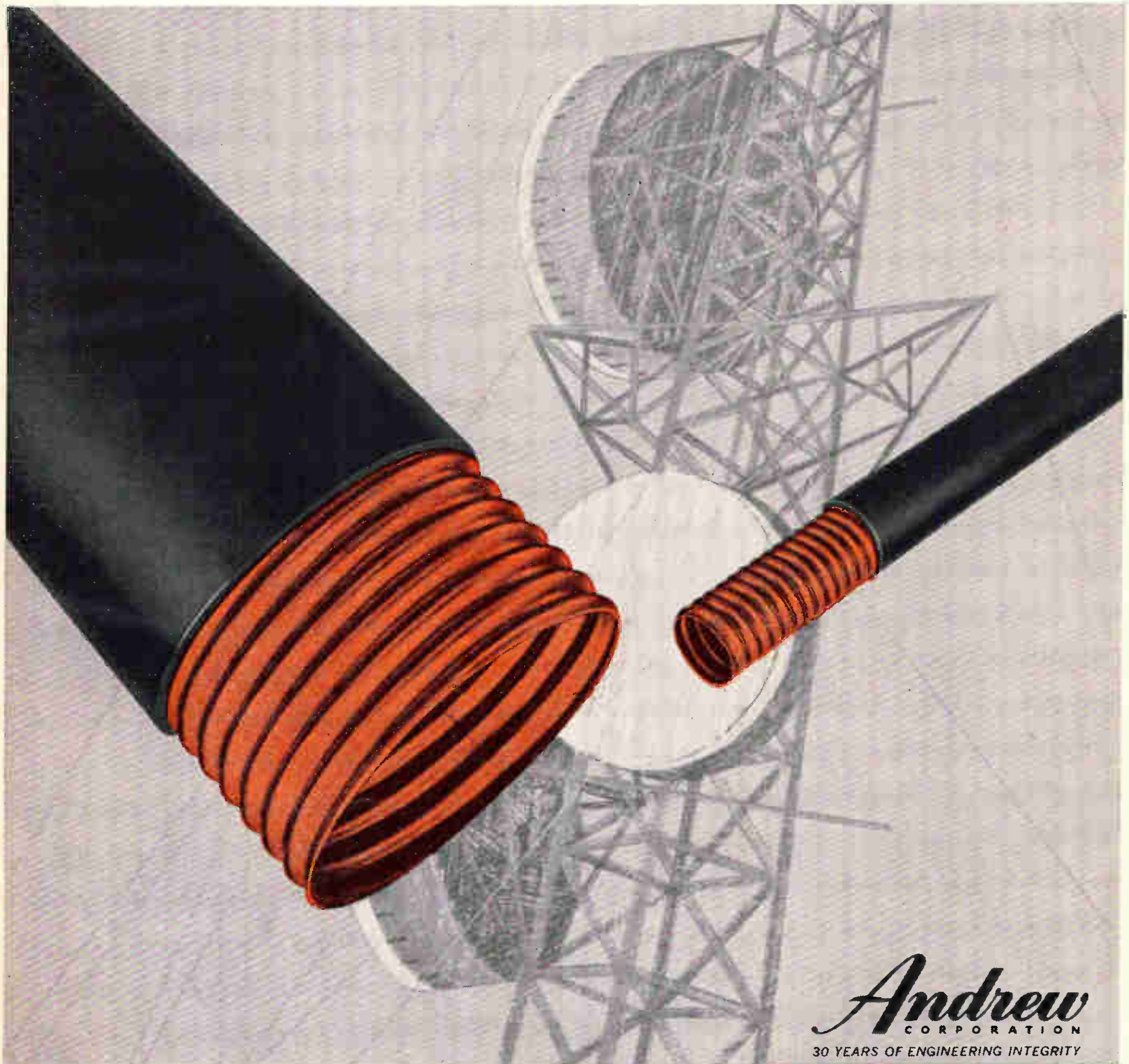
**Japan.** The Murata Manufacturing Co. introduced this week at the annual convention of the Institute of Electrical and Electronics Engineers experimental versions of ceramic filters that operate at frequencies of 10.7 and 4.5 megahertz. The filters are designed to replace coupling transformers in intermediate-frequency amplifiers and discriminators in television sets and frequency-modulation radios.

**Poland.** Four new transmitters and 42 relay stations slated for construction this year will bring to 86% the portion of the Polish population within receiving range of television broadcasts. Sales of tv sets for 1967 are expected to rise sharply to 500,000 units. This will push the total number of sets in service past the 3-million mark.

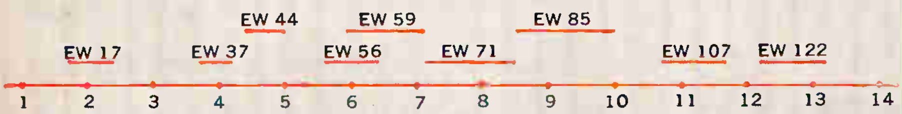
now in 9 sizes

# HELIAX® elliptical waveguide covers the microwave spectrum

With the addition of two new sizes, flexible HELIAX elliptical waveguide is available for all microwave communication bands from 1.7 to 13.2 GHz. The continuous single lengths of HELIAX waveguide assure reliable system performance, with electrical characteristics better than conventional rigid waveguides at less cost. ■ Investigate HELIAX Elliptical Waveguides for your next microwave system whether it be for a short haul installation or a long high density system. ■ Write for specifications—Andrew Corporation, P.O. Box 42807, Chicago, Illinois 60642. 2-67




9 SIZES OF ELLIPTICAL WAVEGUIDE




Standard or Tuned Connectors to Fit Standard Waveguide Flanges.

**IN EUROPE: Andrew Antennas Systems, Lochgelly, Fife, Great Britain**

# Electronics advertisers

March 20, 1967

## Classified Advertising

F.J. Eberle, Business Mgr.



■ For more information on complete product line see advertisement in the latest Electronics Buyers' Guide

□ Advertisers in Overseas Advertising Section following Newsletter from Abroad

## Advertising sales staff

**Frank E. LeBeau [212] 971-6464**
Advertising sales manager
Wallis Clarke [212] 971-2187
Assistant to sales manager
Donald J. Austermann [212] 971-3139
Promotion Manager

**Atlanta, Ga. 30309:** Michael H. Miller, 1375 Peachtree St., N.E. [404] TR 5-0523
**Boston, Mass. 02116:** William S. Hodgkinson McGraw-Hill Building, Copley Square [617] CO 2-1160
**Chicago, Ill. 60611:** Robert M. Denmead, J. Bradley MacKimm, Ralph Hanning, 645 North Michigan Avenue, [312] MO 4-5800
**Cleveland, Ohio 44113:** William J. Boyle, 55 Public Square, [216] SU 1-7000
**Dallas, Texas 75201:** Richard P. Poole, 1800 Republic National Bank Tower, [214] RI 7-9721
**Denver, Colo. 80202:** Joseph C. Page, David M. Watson, Tower Bldg., 1700 Broadway, [303] 255-5484
**Detroit, Michigan 48226:** Ralph Hanning 856 Penobscot Building [313] 962-1793
**Houston, Texas 77002:** Kenneth George, 2270 Humble Bldg., [713] CA 4-8381
**Los Angeles, Calif. 90017:** Ian C. Hill, John G. Zisch, 1125 W. 6th St., [213] HU 2-5450
**Minneapolis, Minn. 55402:** J. Bradley MacKimm, 1104 Northstar Center [612] 332-7425
**New York, N.Y. 10036** 500 Fifth Avenue Donald R. Furth [212] 971-3615 James R. Pierce [212] 971-3616 Stanley J. Kail, Jr. [212] 971-3617
**Philadelphia, Pa. 19103:** Warren H. Gardner, Jeffrey M. Preston, 6 Penn Center Plaza, [215] LO 8-6161
**Pittsburgh, Pa. 15222:** Warren H. Gardner, 4 Gateway Center, [412] 391-1314
**Portland, Ore. 97204:** James T. Hauptli, 218 Mohawk Building, 222 S.W. Morrison Street, Phone [503] 223-5118
**Rochester, N.Y. 14534:** William J. Boyle, 9 Greylock Ridge, Pittsford, N.Y. [716] 586-5040
**St. Louis, Mo. 63105:** Robert M. Denmead The Clayton Tower, 7751 Carondelet Ave. [314] PA 5-7285
**San Francisco, Calif. 94111:** James T. Hauptli, 255 California Street, [415] DO 2-4600
**London W1:** John W. Patten, Edwin S. Murphy Jr., 34 Dover Street, Hyde Park 1451
**Milan:** Robert M. Saidel 1 via Baracchini Phone: 86-90-656
**Frankfurt/Main:** Gerd Hinske, Dieter Rothenbach, Elsa-Brandstroem Str. 2 Phone: 72 01 81
**Geneva:** Michael R. Zeynel, 1, rue du Temple Phone: 31 95 60
**Paris VIII:** Denis Jacob, Kenneth Davey, 17 Avenue Matignon Phone: 359 6637
**Tokyo:** Nobuyuki Sato, 1, Kotohiracho Shiba, Minato-Ku [502] 0656
**Osaka:** Ryoji Kobayashi 163, Umegae-cho Kita-ku [362] 8771

## Business department

**Wallace C. Carmichael, Manager** [212] 971-3191
**Stephen R. Weiss, Production Manager** [212] 971-2044
**Thomas M. Egan,** Assistant Production Manager [212] 971-3140
**Dorothy Carmesin, Contracts and Billings** [212] 971-2908

## Circulation and research

**Milton Drake, Manager** [212] 971-3485
**Isaaca Siegel, Assistant Circulation Manager** [212] 971-6057
**David Strassler, Assistant Research Manager** [212] 971-6058
**Chloe D. Glover, Research Associate** [212] 971-6057

## Electronics buyers' guide

**George F. Werner, General Manager** [212] 971-2310
**Regina Hera, Directory Manager** [212] 971-2544
**Thomas M. Egan, Production Manager** [212] 971-3140

# Learn why

Please send me a FREE copy of "Transistor characteristics related to circuit performance," along with detailed specifications on ITT strip line transistors.

Name .................................. Title ..................

Company ......................................................

Address ......................................................

City ........................ State ................. Zip ........

## ITT's exclusive strip line packaging makes VHF/UHF transistor circuits work better


The strip line package reduces or eliminates many of the difficulties that were formerly inevitable when working with high-power VHF-UHF transistors.

Consider these advantages: strip line configuration simplifies final tune-up by virtually eliminating instability; low-inductance package means easier matching to driver stages and broad bandwidth. For 400 MHz application, you may select the 3TE440 (15 watts output) or the 3TE450 (4 watts output).

For full details fill in the coupon above. Or see for yourself — sample quantities are available off the shelf from your ITT distributor or factory representative.

ITT
SEMICONDUCTORS

ITT SEMICONDUCTORS IS A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, 3301 ELECTRONICS WAY, WEST PALM BEACH, FLORIDA.
FACTORIES IN WEST PALM BEACH, FLORIDA; PALO ALTO, CALIFORNIA; LAWRENCE, MASSACHUSETTS; HARLOW AND FOOTSCRAY, ENGLAND; FREIBURG AND NURENBERG, GERMANY

# Electronics reader service

## Use these handy post cards for more detailed information on: products advertised, new products, new literature.

Circle the number on the Reader Service post card that corresponds to the number at the bottom of the advertisement, new product item, or new literature in which you are interested.

Please print clearly. All written information must be legible to be efficiently processed.

If someone has beaten you to the post cards, you may obtain the needed information by writing directly to the manufacturer, or by sending your name and address, plus the Reader Service number, to Electronics Reader Service department.

All inquiries from outside the U.S. that cannot reach Electronics before the expiration dates noted on the Reader Service post card, must be mailed directly to the manufacturer. The manufacturer assumes all responsibilities for responding to inquiries. Electronics merely provides and clears requests for information from inquirer to manufacturer.

Correct amount of postage must be affixed for all mailings from outside the U.S.

### To subscribe to or to renew Electronics

Fill in the "For Subscriptions" area on the card if you desire to subscribe to or renew your present subscription to Electronics. Send no money. Electronics will bill you at the address indicated on the Reader Service post card.

### Multi-product advertisements

For information on specific items in multi-product advertisements which do not have a specific Reader Service number indicated write directly to manufacturer for information on precise product in which you are interested.

---

6 Please Print Clearly — March 20, 1967 Card Expires May 20, 1967 — 14

Name ______ title ______

Company ______

Address ______ zip code ______

City ______ state ______

For Subscriptions
☐ new ☐ renewal
☐ 3 years $16.00
☐ 1 year $8.00

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 39 | 58 | 77 | 96 | 115 | 134 | 153 | 172 | 191 | 210 | 229 | 248 | 267 | 286 | 305 | 324 | 343 | 362 | 381 | 400 | 419 | 438 | 457 | 476 | 495 | 514 | 962 |
| 2 | 21 | 40 | 59 | 78 | 97 | 116 | 135 | 154 | 173 | 192 | 211 | 230 | 249 | 268 | 287 | 306 | 325 | 344 | 363 | 382 | 401 | 420 | 439 | 458 | 477 | 496 | 515 | 963 |
| 3 | 22 | 41 | 60 | 79 | 98 | 117 | 136 | 155 | 174 | 193 | 212 | 231 | 250 | 269 | 288 | 307 | 326 | 345 | 364 | 383 | 402 | 421 | 440 | 459 | 478 | 497 | 516 | 964 |
| 4 | 23 | 42 | 61 | 80 | 99 | 118 | 137 | 156 | 175 | 194 | 213 | 232 | 251 | 270 | 289 | 308 | 327 | 346 | 365 | 384 | 403 | 422 | 441 | 460 | 479 | 498 | 517 | 965 |
| 5 | 24 | 43 | 62 | 81 | 100 | 119 | 138 | 157 | 176 | 195 | 214 | 233 | 252 | 271 | 290 | 309 | 328 | 347 | 366 | 385 | 404 | 423 | 442 | 461 | 480 | 499 | 518 | 966 |
| 6 | 25 | 44 | 63 | 82 | 101 | 120 | 139 | 158 | 177 | 196 | 215 | 234 | 253 | 272 | 291 | 310 | 329 | 348 | 367 | 386 | 405 | 424 | 443 | 462 | 481 | 500 | 900 | 967 |
| 7 | 26 | 45 | 64 | 83 | 102 | 121 | 140 | 159 | 178 | 197 | 216 | 235 | 254 | 273 | 292 | 311 | 330 | 349 | 368 | 387 | 406 | 425 | 444 | 463 | 482 | 501 | 901 | 968 |
| 8 | 27 | 46 | 65 | 84 | 103 | 122 | 141 | 160 | 179 | 198 | 217 | 236 | 255 | 274 | 293 | 312 | 331 | 350 | 369 | 388 | 407 | 426 | 445 | 464 | 483 | 502 | 902 | 969 |
| 9 | 28 | 47 | 66 | 85 | 104 | 123 | 142 | 161 | 180 | 199 | 218 | 237 | 256 | 275 | 294 | 313 | 332 | 351 | 370 | 389 | 408 | 427 | 446 | 465 | 484 | 503 | 951 | 970 |
| 10 | 29 | 48 | 67 | 86 | 105 | 124 | 143 | 162 | 181 | 200 | 219 | 238 | 257 | 276 | 295 | 314 | 333 | 352 | 371 | 390 | 409 | 428 | 447 | 466 | 485 | 504 | 952 | 971 |
| 11 | 30 | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 486 | 505 | 953 | 9 |
| 12 | 31 | 50 | 69 | 88 | 107 | 126 | 145 | 164 | 183 | 202 | 221 | 240 | 259 | 278 | 297 | 316 | 335 | 354 | 373 | 392 | 411 | 430 | 449 | 468 | 487 | 506 | 954 | 97 |
| 13 | 32 | 51 | 70 | 89 | 108 | 127 | 146 | 165 | 184 | 203 | 222 | 241 | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 431 | 450 | 469 | 488 | 507 | 955 | 97 |
| 14 | 33 | 52 | 71 | 90 | 109 | 128 | 147 | 166 | 185 | 204 | 223 | 242 | 261 | 280 | 299 | 318 | 337 | 356 | 375 | 394 | 413 | 432 | 451 | 470 | 489 | 508 | 956 | 97 |
| 15 | 34 | 53 | 72 | 91 | 110 | 129 | 148 | 167 | 186 | 205 | 224 | 243 | 262 | 281 | 300 | 319 | 338 | 357 | 376 | 395 | 414 | 433 | 452 | 471 | 490 | 509 | 957 | 97 |
| 16 | 35 | 54 | 73 | 92 | 111 | 130 | 149 | 168 | 187 | 206 | 225 | 244 | 263 | 282 | 301 | 320 | 339 | 358 | 377 | 396 | 415 | 434 | 453 | 472 | 491 | 510 | 958 | 9 |
| 17 | 36 | 55 | 74 | 93 | 112 | 131 | 150 | 169 | 188 | 207 | 226 | 245 | 264 | 283 | 302 | 321 | 340 | 359 | 378 | 397 | 416 | 435 | 454 | 473 | 492 | 511 | 959 | |
| 18 | 37 | 56 | 75 | 94 | 113 | 132 | 151 | 170 | 189 | 208 | 227 | 246 | 265 | 284 | 303 | 322 | 341 | 360 | 379 | 398 | 417 | 436 | 455 | 474 | 493 | 512 | 960 | 9 |
| 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 | 247 | 266 | 285 | 304 | 323 | 342 | 361 | 380 | 399 | 418 | 437 | 456 | 475 | 494 | 513 | 961 | 9 |

---

2

First class
Permit no. 42
Hightstown, N. J.

**Business reply mail**
No postage stamp necessary if mailed in the United States

Postage will be paid by

**Electronics**
**Reader service department**
**Box 444**
**Hightstown, N.J. 08520**

---

6 Please Print Clearly — March 20, 1967 Card Expires May 20, 19

Name ______ title ______

Company ______

Address ______ zip code ______

City ______ state ______

For Subsc
☐ new ☐
☐ 3 year
☐ 1 year

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 39 | 58 | 77 | 96 | 115 | 134 | 153 | 172 | 191 | 210 | 229 | 248 | 267 | 286 | 305 | 324 | 343 | 362 | 381 | 400 | 419 | 438 | 457 | 476 |
| 2 | 21 | 40 | 59 | 78 | 97 | 116 | 135 | 154 | 173 | 192 | 211 | 230 | 249 | 268 | 287 | 306 | 325 | 344 | 363 | 382 | 401 | 420 | 439 | 458 | 477 |
| 3 | 22 | 41 | 60 | 79 | 98 | 117 | 136 | 155 | 174 | 193 | 212 | 231 | 250 | 269 | 288 | 307 | 326 | 345 | 364 | 383 | 402 | 421 | 440 | 459 | 478 |
| 4 | 23 | 42 | 61 | 80 | 99 | 118 | 137 | 156 | 175 | 194 | 213 | 232 | 251 | 270 | 289 | 308 | 327 | 346 | 365 | 384 | 403 | 422 | 441 | 460 | 479 |
| 5 | 24 | 43 | 62 | 81 | 100 | 119 | 138 | 157 | 176 | 195 | 214 | 233 | 252 | 271 | 290 | 309 | 328 | 347 | 366 | 385 | 404 | 423 | 442 | 461 | 480 |
| 6 | 25 | 44 | 63 | 82 | 101 | 120 | 139 | 158 | 177 | 196 | 215 | 234 | 253 | 272 | 291 | 310 | 329 | 348 | 367 | 386 | 405 | 424 | 443 | 462 | 481 |
| 7 | 26 | 45 | 64 | 83 | 102 | 121 | 140 | 159 | 178 | 197 | 216 | 235 | 254 | 273 | 292 | 311 | 330 | 349 | 368 | 387 | 406 | 425 | 444 | 463 | 482 |
| 8 | 27 | 46 | 65 | 84 | 103 | 122 | 141 | 160 | 179 | 198 | 217 | 236 | 255 | 274 | 293 | 312 | 331 | 350 | 369 | 388 | 407 | 426 | 445 | 464 | 4 |
| 9 | 28 | 47 | 66 | 85 | 104 | 123 | 142 | 161 | 180 | 199 | 218 | 237 | 256 | 275 | 294 | 313 | 332 | 351 | 370 | 389 | 408 | 427 | 446 | 465 | 4 |
| 10 | 29 | 48 | 67 | 86 | 105 | 124 | 143 | 162 | 181 | 200 | 219 | 238 | 257 | 276 | 295 | 314 | 333 | 352 | 371 | 390 | 409 | 428 | 447 | 466 | 48 |
| 11 | 30 | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 4 |
| 12 | 31 | 50 | 69 | 88 | 107 | 126 | 145 | 164 | 183 | 202 | 221 | 240 | 259 | 278 | 297 | 316 | 335 | 354 | 373 | 392 | 411 | 430 | 449 | 468 | 48 |
| 13 | 32 | 51 | 70 | 89 | 108 | 127 | 146 | 165 | 184 | 203 | 222 | 241 | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 431 | 450 | 469 | 4 |
| 14 | 33 | 52 | 71 | 90 | 109 | 128 | 147 | 166 | 185 | 204 | 223 | 242 | 261 | 280 | 299 | 318 | 337 | 356 | 375 | 394 | 413 | 432 | 451 | 470 | 4 |
| 15 | 34 | 53 | 72 | 91 | 110 | 129 | 148 | 167 | 186 | 205 | 224 | 243 | 262 | 281 | 300 | 319 | 338 | 357 | 376 | 395 | 414 | 433 | 452 | 471 | 4 |
| 16 | 35 | 54 | 73 | 92 | 111 | 130 | 149 | 168 | 187 | 206 | 225 | 244 | 263 | 282 | 301 | 320 | 339 | 358 | 377 | 396 | 415 | 434 | 453 | 472 | 4 |
| 17 | 36 | 55 | 74 | 93 | 112 | 131 | 150 | 169 | 188 | 207 | 226 | 245 | 264 | 283 | 302 | 321 | 340 | 359 | 378 | 397 | 416 | 435 | 454 | 473 | 4 |
| 18 | 37 | 56 | 75 | 94 | 113 | 132 | 151 | 170 | 189 | 208 | 227 | 246 | 265 | 284 | 303 | 322 | 341 | 360 | 379 | 398 | 417 | 436 | 455 | 474 | |
| 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 | 247 | 266 | 285 | 304 | 323 | 342 | 361 | 380 | 399 | 418 | 437 | 456 | 475 | |

## All Electronics editorial matter available in reprint form:

For reprints of special reports and feature articles see list on right side of this page. Send your order to Electronics Reprint Department at the address indicated. To expedite mailing of your order for single reprints please send cash, check or money order with your order.

**Warning:** The Post Office now requires your **ZIP CODE** on all mail. Please include your **ZIP CODE** number when filling out your reply card.

3

First class
Permit no. 42
Hightstown, N. J.

**Business reply mail**
No postage stamp necessary if mailed in the United States

Postage will be paid by

**Electronics**
**Reader service department**
**Box 444**
**Hightstown, N. J. 08520**

Please Print Clearly

e

March 20, 1967 Card Expires May 20, 1967 **14**

pany ______ title ______

re ss ______

______ state ______ zip code ______

For Subscriptions
☐ new ☐ renewal
☐ 3 years $16.00
☐ 1 year $8.00

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 39 | 58 | 77 | 96 | 115 | 134 | 153 | 172 | 191 | 210 | 229 | 248 | 267 | 286 | 305 | 324 | 343 | 362 | 381 | 400 | 419 | 438 | 457 | 476 | 495 | 514 | 962 |
| 1 | 40 | 59 | 78 | 97 | 116 | 135 | 154 | 173 | 192 | 211 | 230 | 249 | 268 | 287 | 306 | 325 | 344 | 363 | 382 | 401 | 420 | 439 | 458 | 477 | 496 | 515 | 963 |
| | 41 | 60 | 79 | 98 | 117 | 136 | 155 | 174 | 193 | 212 | 231 | 250 | 269 | 288 | 307 | 326 | 345 | 364 | 383 | 402 | 421 | 440 | 459 | 478 | 497 | 516 | 964 |
| | 42 | 61 | 80 | 99 | 118 | 137 | 156 | 175 | 194 | 213 | 232 | 251 | 270 | 289 | 308 | 327 | 346 | 365 | 384 | 403 | 422 | 441 | 460 | 479 | 498 | 517 | 965 |
| | 43 | 62 | 81 | 100 | 119 | 138 | 157 | 176 | 195 | 214 | 233 | 252 | 271 | 290 | 309 | 328 | 347 | 366 | 385 | 404 | 423 | 442 | 461 | 480 | 499 | 518 | 966 |
| | 44 | 63 | 82 | 101 | 120 | 139 | 158 | 177 | 196 | 215 | 234 | 253 | 272 | 291 | 310 | 329 | 348 | 367 | 386 | 405 | 424 | 443 | 462 | 481 | 500 | 900 | 967 |
| | 45 | 64 | 83 | 102 | 121 | 140 | 159 | 178 | 197 | 216 | 235 | 254 | 273 | 292 | 311 | 330 | 349 | 368 | 387 | 406 | 425 | 444 | 463 | 482 | 501 | 901 | 968 |
| | 46 | 65 | 84 | 103 | 122 | 141 | 160 | 179 | 198 | 217 | 236 | 255 | 274 | 293 | 312 | 331 | 350 | 369 | 388 | 407 | 426 | 445 | 464 | 483 | 502 | 902 | 969 |
| | 47 | 66 | 85 | 104 | 123 | 142 | 161 | 180 | 199 | 218 | 237 | 256 | 275 | 294 | 313 | 332 | 351 | 370 | 389 | 408 | 427 | 446 | 465 | 484 | 503 | 951 | 970 |
| | 48 | 67 | 86 | 105 | 124 | 143 | 162 | 181 | 200 | 219 | 238 | 257 | 276 | 295 | 314 | 333 | 352 | 371 | 390 | 409 | 428 | 447 | 466 | 485 | 504 | 952 | 971 |
| | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 486 | 505 | 953 | 972 |
| | 50 | 69 | 88 | 107 | 126 | 145 | 164 | 183 | 202 | 221 | 240 | 259 | 278 | 297 | 316 | 335 | 354 | 373 | 392 | 411 | 430 | 449 | 468 | 487 | 506 | 954 | 973 |
| | 1 | 70 | 89 | 108 | 127 | 146 | 165 | 184 | 203 | 222 | 241 | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 431 | 450 | 469 | 488 | 507 | 955 | 974 |
| | 2 | 71 | 90 | 109 | 128 | 147 | 166 | 185 | 204 | 223 | 242 | 261 | 280 | 299 | 318 | 337 | 356 | 375 | 394 | 413 | 432 | 451 | 470 | 489 | 508 | 956 | 975 |
| | | 72 | 91 | 110 | 129 | 148 | 167 | 186 | 205 | 224 | 243 | 262 | 281 | 300 | 319 | 338 | 357 | 376 | 395 | 414 | 433 | 452 | 471 | 490 | 509 | 957 | 976 |
| | | 73 | 92 | 111 | 130 | 149 | 168 | 187 | 206 | 225 | 244 | 263 | 282 | 301 | 320 | 339 | 358 | 377 | 396 | 415 | 434 | 453 | 472 | 491 | 510 | 958 | 977 |
| | | 74 | 93 | 112 | 131 | 150 | 169 | 188 | 207 | 226 | 245 | 264 | 283 | 302 | 321 | 340 | 359 | 378 | 397 | 416 | 435 | 454 | 473 | 492 | 511 | 959 | 978 |
| | | 75 | 94 | 113 | 132 | 151 | 170 | 189 | 208 | 227 | 246 | 265 | 284 | 303 | 322 | 341 | 360 | 379 | 398 | 417 | 436 | 455 | 474 | 493 | 512 | 960 | 979 |
| | | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 | 247 | 266 | 285 | 304 | 323 | 342 | 361 | 380 | 399 | 418 | 437 | 456 | 475 | 494 | 513 | 961 | 980 |

First class
Permit no. 42
Hightstown, N. J.

**Business reply mail**
No postage stamp necessary if mailed in the United States

Postage will be paid by

**lectronics**
**eader service department**
**ox 444**
**ightstown, N.J. 08520**

Bulk reprints of editorial matter can be ordered from current or past issues. The minimum quantity is 100 copies. The higher the quantity ordered, the more economical the cost per copy. Prices quoted on request.

To order reprints or for further information, please write to: **Electronics Reprint Department, 330 West 42nd Street, New York, N.Y. 10036.**

Prices for the below listed reprints unless otherwise specified are 1-10 copies 50¢ each; 11-24 copies 35¢ each; 25-99 copies 25¢ each; price for 100 or more is 20¢ each.

**You may order any of the below listed reprints by key number.**

Key no. **R-01** **Computer-aided Design: Part I, The Man-machine Merger.** 16 pages. $1.25.

Key no. **R-02** **Vietnam Communications Network Growing Into Southeast Asia's Best.** 3 pages. 25¢.

Key no. **R-03** **Sense Amplifier Fits Any Product.** 6 pages. 25¢.

Key no. **R-04** **Multilayer Circuit Boards: Sharpening An Imperfect Art.** 7 pages.

Key no. **R-05** **Topology Cuts Design Drudgery.** 12 pages. 50¢.

Key no. **R-06** **Report on Japanese Technology: Sony.** 20 pages. 50¢.

Key no. **R-07** **European Electronics Markets 1967.** 22 page forecast report with 4 page foldout chart. $1.00.

Key no. **R-08** **U.S. Electronics Markets 1967.** 26 page forecast report with 6 page foldout. $1.00.

Key no. **R-09** **1966 Electronics Index to Technical Articles and Authors.** Free.

Key no. **R-90a** **Communications Satellites. Parts I and II.** 42 pages. $1.25

Key no. **R-88** **Belting Out Plastic Transistors On Mechanized Assembly Lines.** 8 pages. 25¢

Key no. **R-87a** **The Packaging Revolution in Microelectronics. Parts I through VI.** 64 pages. $2.00.

Key no. **R-86a** **Computer Time Sharing. Parts I and II.** 32 pages. $1.00.

Key no. **R-79** **MOS Integrated Circuits.** 12 pages.

Key no. **R-78** **The Overlay Transistor.** 15 pages.

Key no. **R-75** **Biotelemetry.** 2 part series, 16 pages.

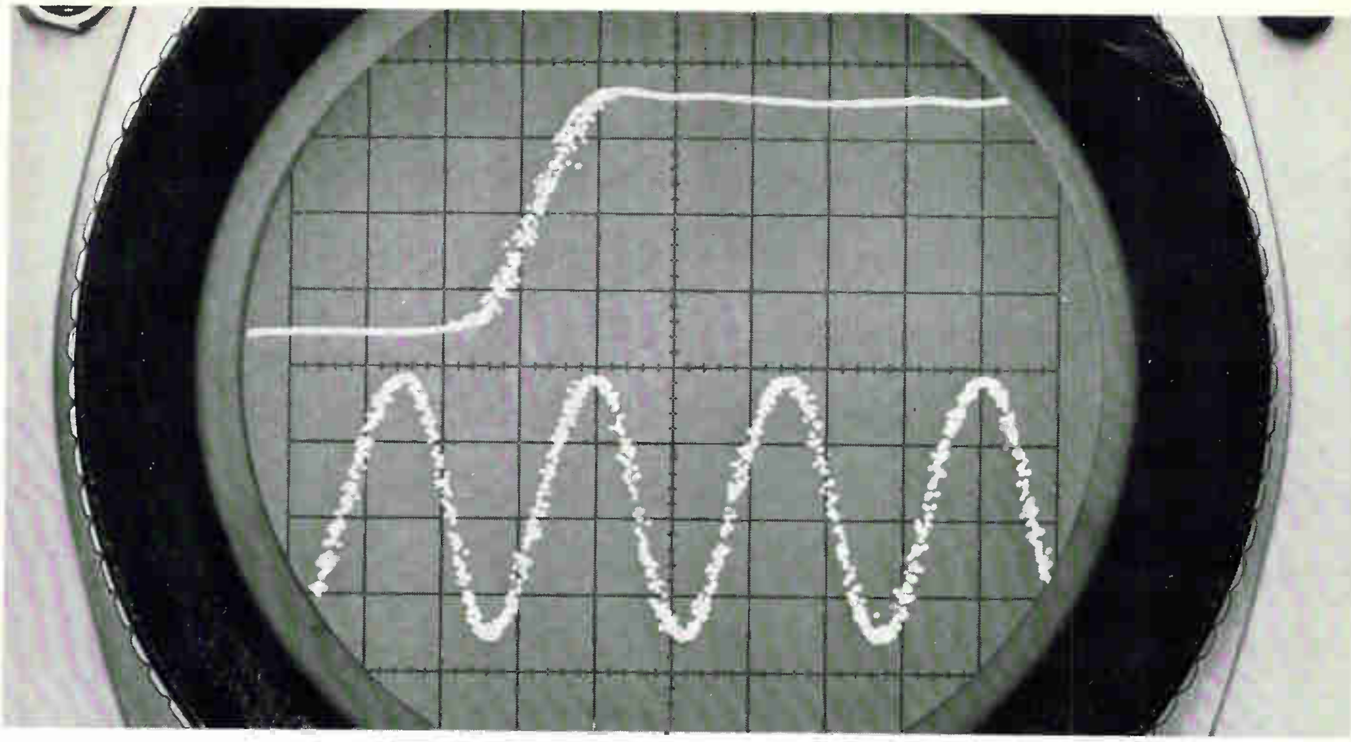
Key no. **R-74** **Unijunction Transistors.** 24 pages.

Key no. **R-64** **Field Effect Transistors. Parts I, II, and III.** 64 pages. $1.00.

Key no. **R-63** **Silicon Power Transistors.** 8 pages. 25¢.

Key no. **R-60** **Transistor Heat Dissipators.** 32 pages.

Key no. **R-31** **Electromagnetic Spectrum Chart.** (22" x 30" foldout chart). $1.00



*Put this new design window in your lab*

# SEE WAVEFORMS TO 12.4 GHz & BEYOND

For the first time, you can directly see 12.4 GHz phenomena, 28 psec rise time pulses, delayed sweep displays, and 40 psec TDR. And, for an encore, this new sampling scope system gives you less than 20 psec jitter for sharp displays, automatic triggering for fast easy trace set-up, and remote samplers which monitor fed-through signals with minimum loading. Time difference between channels is less than 5 psec for accurate phase measurements. You can build your system around the field-proven 140A mainframe (or the stop-action 141A with variable persistence and storage) using these all solid-state plug-ins:

**NEW DUAL-CHANNEL 1411A VERTICAL AMPLIFIER** functions with any of three dual-channel remote samplers, with sensitivities to 1 mv/cm: (1) Model 1430A with 28 psec rise time for optimum pulse response; (2) Model 1431A, DC to 12.4 GHz with an extremely flat bandwidth and low VSWR (1.4:1 to 8 GHz, 2:1 at 12.4 GHz); and (3) Model 1432A with 4 GHz bandwidth, 90 psec rise time. Additional versatility is provided by front panel recorder outputs, and A vs. B mode for accurate phase measurements. Price of the 1411A Vertical Amplifier: $700. Samplers: $3000 for 1430A and 1431A; $1000 for 1432A.

**NEW 1425A TIME BASE & DELAY GENERATOR,** first with delayed sweep sampling, gives sharp, jitter-free magnification of complex signals or long pulse trains. It provides maximum sweep speeds of 10 psec/cm, triggering to 1 GHz and delay times as long as 5 ms. Straightforward control nomenclature and layout make it easy to use. So does automatic triggering, push-button return to X1 magnification and an intensified dot which locates the expansion point for you when setting up a magnified trace. $1600.

Also available: Model 1410A Vertical Amplifier with 1 mv/cm at 1 GHz ($1600), 1104A/1106A Countdown for triggering to 18 GHz ($750), and 1105A/1106A 20 psec Pulse Generator ($750). Mainframe prices: 140A, $595; 141A, $1275. With the versatile hp 140 Scope System, you get *better performance in any direction:* 20 MHz wideband • TDR • high-sensitivity with no drift • variable persistence and storage – *and sampling.*

Get complete specs on the new hp sampling oscilloscopes. Write or call Hewlett-Packard, Palo Alto, California, 94304. Phone (415) 326-7000. In Europe: 54 Route des Acacias, Geneva.

087/11

HEWLETT hp PACKARD

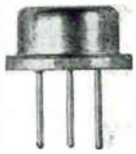
*An extra measure of performance*

Circle 901 on reader service card

40378
7A RMS current, 200V
(Surge current = 80A)
(2-lead TO-5)

2N3228
5A RMS current, 200V
(Surge current = 60A)
TO-66

2N3528
2A RMS current, 200V
(Surge current = 60A)
TO-8



# These 3 RCA SCR's sell for only 98¢* each

## ... and offer circuit capability of devices that cost many times more!

ONLY FROM RCA... one low price plus a choice of current ratings *and* packaging... for a broad range of 120-V line-operated control circuits. For low-current power control without use of a heat sink, ask for the 2N3528... for medium-power loads with the lowest dollars per kilowatt ratio, ask for the 2N3228... and for a really small package adaptable to semi-automatic or batch mounting, ask for the 40378. They all offer cost and performance advantages that should be built into *your* control circuits!

400-volt versions of these SCR's are also available for as little as $1.40*. Your RCA Field Representative will be happy to give you more details. *And ask him, too, about RCA's special heat-sinking techniques for TO-5 packages which gives you the power-handling capability of a press-fit without the added cost.* For additional technical data, write RCA Commercial Engineering, Section RN3-3, Harrison, N.J. 07029.

See your RCA Distributor for his price and delivery.

**Prices in quantities of 1,000 and up*

RCA Electronic Components and Devices

RCA

**The Most Trusted Name in Electronics**

**See Us at IEEE, Third Floor Booths 3 C01 – 3 C10**

Circle 902 on reader service card