Electronic Design

VOL. 15 NO. 11

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MAY 24, 1967

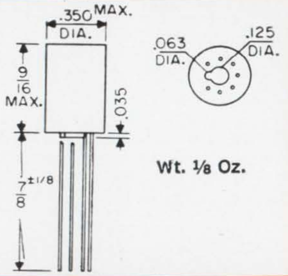
**Electrical brain stimulation** plays tricks on a monkey's eyes, can even modify his social behavior. Such studies will ultimately lead to better diagnosis and treatment of human ailments. Advances in miniaturization are bringing about button-sized implants which will further brain research. For details, see the report starting on p. 36.

PIONEERS IN MINIATURIZATION

# NEW

# DO-T200™ SERIES

## ULTRAMINIATURE TRANSISTOR TYPE AUDIO TRANSFORMERS



Wt. 1/8 Oz.

U. S. PAT. NO. 2,949,591; others pending.

This DO-T200 series of transistor transformers and inductors has been newly added to the UTC lines of stock items available for immediate delivery. These transformers provide the unprecedented power handling capabilities and the inherent reliability found only in the basic structural design of the UTC DO-T Family of miniature transformers. This reliability has been dramatically proven in the field.

Leads are 7/8″ long, .016 Dumet wire, gold plated, and may be either welded or soldered. They are uninsulated and are spaced on a .1″ radius circle, conforming to the termination pattern of the "TO-5" cased semiconductors and micrologic elements.

DO-T200 series of transformers are designed for Class R application. On special order they may be designed to Class S Specifications. No additional life expectancy is gained by using Class S insulation systems at Class R temperatures.

In pulse coupling impedance matching applications, (when measured with a 30 microsecond input pulse voltage wave), typical values for these transformers are: 5% or less droop, zero overshoot, and less than 10% backswing.

Special unit modifications, such as additions and deletions of leads, changed lead lengths, different impedance ratios and incorporation of electrostatic shields, etc., are available in these constructions.

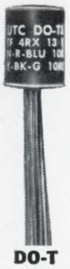
- **Manufactured and successfully tested to complete environmental requirements of MIL-T-27B**

- **Most Ruggedized MIL Structure, Grade 4, Metal Encased**
- **Immediate Delivery From Stock**
- **Full Conformance to MIL Mounting Requirements**
- **Solderable and Weldable Leads**
- **Hermetically Sealed**
- **Straight Pin Terminals**
- **Excellent Response**
- **High Efficiency**
- **Low Distortion**

| Type No. | MIL Type | Pri. Imp. | D. C. ma‡ in Pri. | Sec. Imp. | Pri. Res. | Mw Level | Application |
|---|---|---|---|---|---|---|---|
| **DO-T255** | TF4RX13YY | 1K/1.2K CT | 3 | 50/60 | 115 | 100 | Output or matching |
| **DO-T275** | TF4RX13YY | 10K/12K CT | 1 | 1.5K/1.8K CT | 780 | 100 | Interstage |
| **DO-T277** | TF4RX13YY | 10K/12K CT | 1 | 2K/2.4K split | 560 | 100 | Interstage |
| **DO-T278** | TF4RX13YY | 10K/12.5K | 1 | 2K/2.5K CT | 780 | 100 | Driver |
| **DO-T283** | TF4RX13YY | 10K/12K CT | 1 | 10K/12K CT | 975 | 100 | Isol. or Interstage or Pulse |
| **DO-T288** | TF4RX13YY | 20K/30K CT | .5 | .8K/1.2K CT | 830 | 50 | Interstage |
| **DO-T297** | TF4RX16YY | 200,000 CT | 0 | 1000 CT | 8500 | 25 | Input and Chopper |
| **DO-T200SH** | Drawn Hipermalloy shield provides 15 to 20 db shielding through side of case | | | | | | |

‡DCma shown is for single ended useage. For push pull, DCma can be any balanced value taken by .5W transistors. Where windings are listed as split, 1/4 of the listed impedance is available by paralleling the winding.

## THE DO-T FAMILY OF COMPONENTS



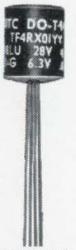
**DO-T**

**DI-T**

**DI-T200**

**PIL**

**PIP**



**DO-T400**

These items manufactured and successfully tested to complete environmental requirements of MIL-T-27B, Grade 4, Class R, Life X. Except **PIP**: to MIL-T-21038B, Grade 6, Class R, Life X. Grades 4 and Grades 6 of MIL-T-27B & MIL-T-21038B respectively, are identical.

**DO-T** Flexible leads. Freq range 300 CPS—10KC & up. Power up to ½ W. Size 5/16 dia x 13/32″ h. Wt approx 1/10 oz.

**DI-T** Flexible leads. Freq range 400 CPS—10KC & up. Power up to ½ W. Size 5/16 dia x ¼″ h. Wt approx 1/15 oz.

**DO-T200 Series.** See above

**DI-T200 Series** Straight pin gold plated. Dumet leads. Freq range 400 CPS—100KC. Power up to 500 mw. Size 5/16 d x 3/8″ h. Wt approx 1/15 oz.

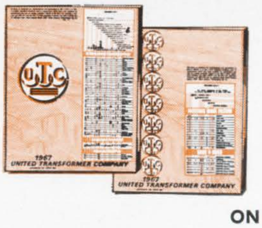
**PIL** Inductors range from .025 hy to .8 hy, DC 0 to 10 ma. Transformers from 500 ohms to 10,000 ohms impedance. Freq range 800 cps—250 KC; power up to 100 MW. Size 5/16 dia x 3/16″ h. Wt 1/20 oz.

**PIP (Pulse)** Flexible leads. Wide application pulse transformers, to MIL-T-21038B specifications. Size 5/16 dia x 3/16″. Wt 1/20 oz.

**DO-T400 (Power)** Flexible leads, power transformer. Power output 400 mw @ 400 cycles. Size 5/16 dia x 13/32″. Wt 1/10 oz.

## AND SPECIAL, CUSTOM BUILT COMPONENTS TO YOUR SPECIFICATIONS

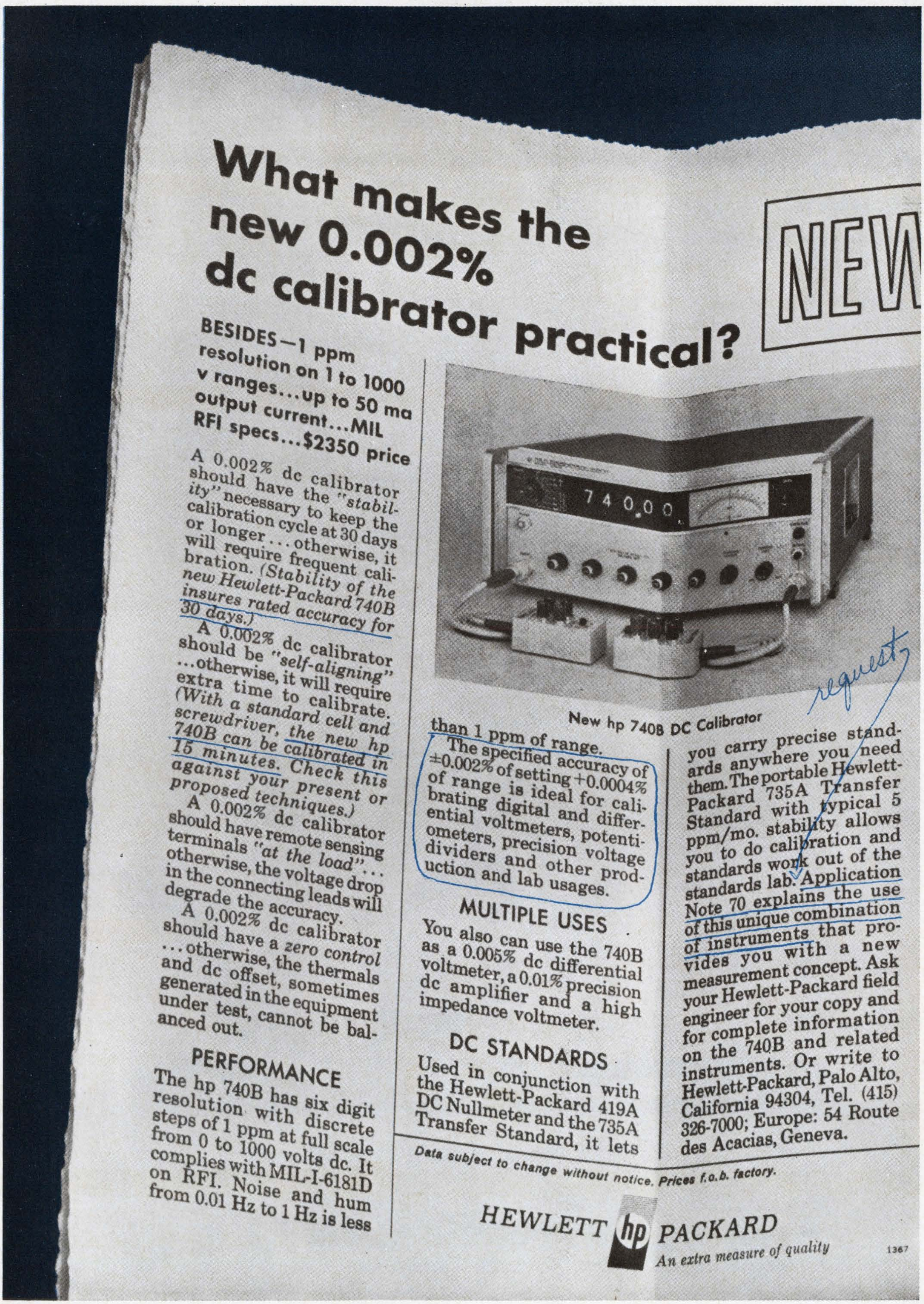
**Write for catalog of over 1,300 UTC TOP QUALITY STOCK ITEMS IMMEDIATELY AVAILABLE from your local distributor.**



# UNITED® TRANSFORMER CO.

*DIVISION OF TRW INC. • 150 VARICK STREET, NEW YORK, N. Y. 10013*

ON READER-SERVICE CARD CIRCLE 132



# What makes the new 0.002% dc calibrator practical?

NEW

**BESIDES—1 ppm resolution on 1 to 1000 v ranges...up to 50 ma output current...MIL RFI specs...$2350 price**

A 0.002% dc calibrator should have the *"stability"* necessary to keep the calibration cycle at 30 days or longer... otherwise, it will require frequent calibration. *(Stability of the new Hewlett-Packard 740B insures rated accuracy for 30 days.)*

A 0.002% dc calibrator should be *"self-aligning"* ...otherwise, it will require extra time to calibrate. *(With a standard cell and screwdriver, the new hp 740B can be calibrated in 15 minutes. Check this against your present or proposed techniques.)*

A 0.002% dc calibrator should have remote sensing terminals *"at the load"*... otherwise, the voltage drop in the connecting leads will degrade the accuracy.

A 0.002% dc calibrator should have a *zero control* ...otherwise, the thermals and dc offset, sometimes generated in the equipment under test, cannot be balanced out.

## PERFORMANCE

The hp 740B has six digit resolution with discrete steps of 1 ppm at full scale from 0 to 1000 volts dc. It complies with MIL-I-6181D on RFI. Noise and hum from 0.01 Hz to 1 Hz is less than 1 ppm of range.

The specified accuracy of ±0.002% of setting +0.0004% of range is ideal for calibrating digital and differential voltmeters, potentiometers, precision voltage dividers and other production and lab usages.

## MULTIPLE USES

You also can use the 740B as a 0.005% dc differential voltmeter, a 0.01% precision dc amplifier and a high impedance voltmeter.

## DC STANDARDS

Used in conjunction with the Hewlett-Packard 419A DC Nullmeter and the 735A Transfer Standard, it lets you carry precise standards anywhere you need them. The portable Hewlett-Packard 735A Transfer Standard with typical 5 ppm/mo. stability allows you to do calibration and standards work out of the standards lab. Application Note 70 explains the use of this unique combination of instruments that provides you with a new measurement concept. Ask your Hewlett-Packard field engineer for your copy and for complete information on the 740B and related instruments. Or write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

request

New hp 740B DC Calibrator

*Data subject to change without notice. Prices f.o.b. factory.*

HEWLETT hp PACKARD

*An extra measure of quality*

1367

ON READER-SERVICE CARD CIRCLE 2


Thanks
TRIGGER LEVEL
FUNCTION
TIME BASE – MULTIPLIER
100.000
CMC
RESET
COUNT GATE
MEMORY
POWER

# Electronic Design

VOL. 15 NO. 11
THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY
MAY 24, 1967

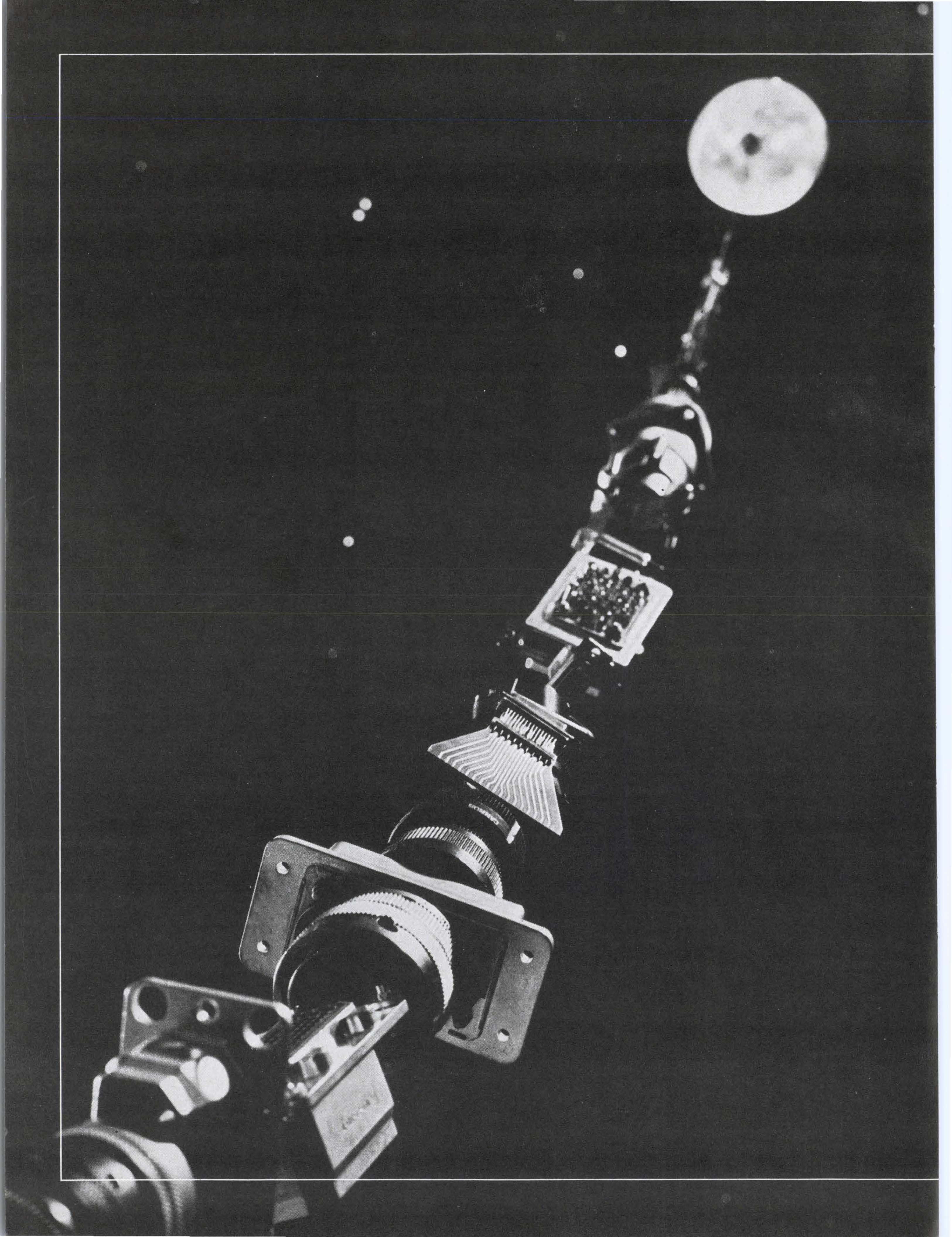
## NEWS

## TECHNOLOGY

## PRODUCTS

### Departments

**ELECTRONIC DESIGN** is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. Application to mail at controlled postage rates pending in St. Louis, Mo. Copyright © 1967, Hayden Publishing Company, Inc. 62,409 copies this issue.



# 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

ON READER-SERVICE CARD CIRCLE 4

# EIMAC now has three new miniature planar triodes for airborne and space applications

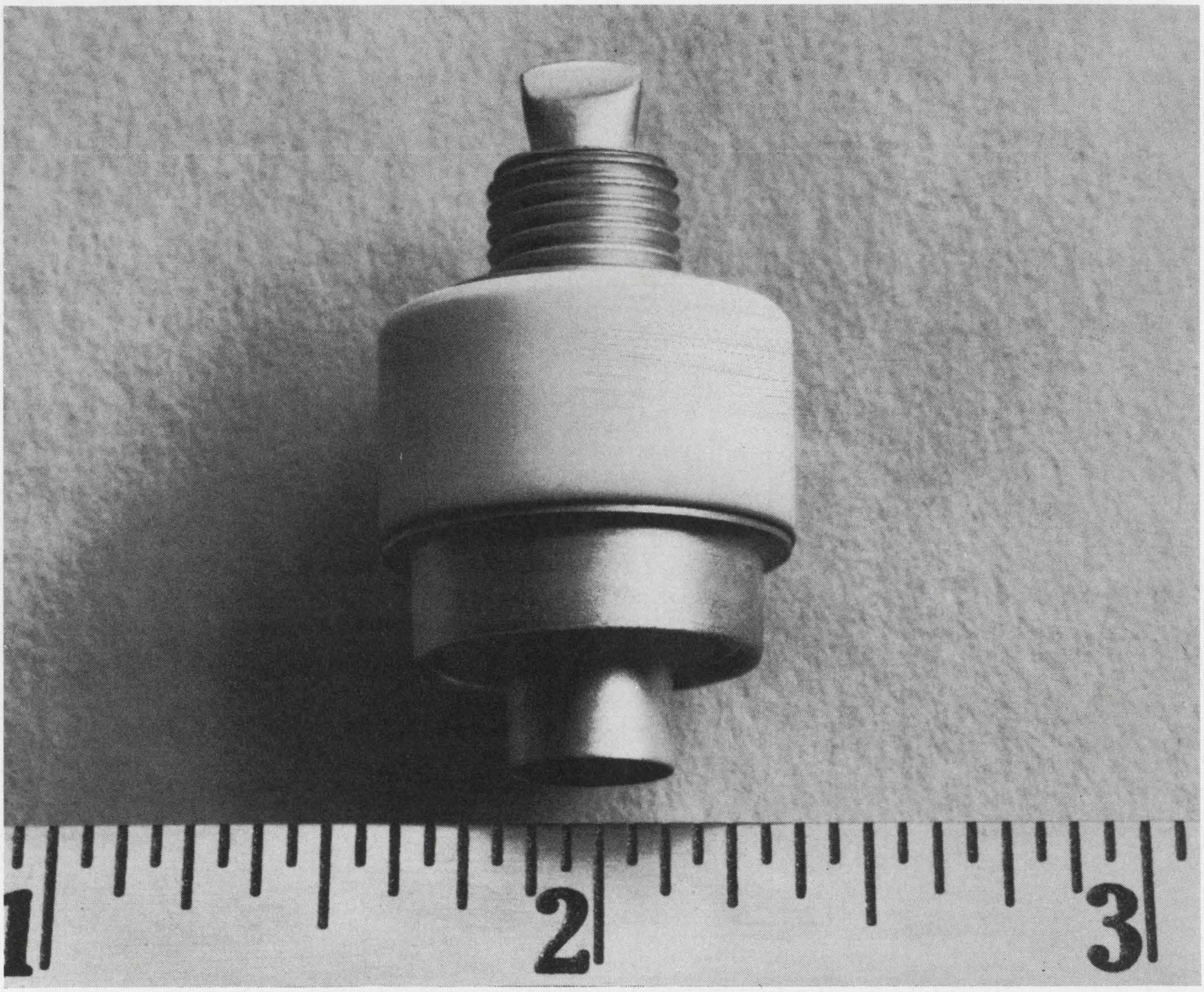
EIMAC's new line of miniature planar triodes is specifically designed for use in advanced airborne and space applications. They are rugged and reliable, and feature larger contact areas for improved electrical paths. EIMAC 8755, 8756, and 8757 triodes are miniaturized versions of the well-known 8533, 7815, and 7698 tubes. You're assured of excellent tube-to-tube uniformity because of our more than 20 years experience with planar triode design and manufacture. Cooling is by forced air or heat sink. All tubes have arc-resistant cathodes, and provide good high-frequency efficiency through S-band. Write Power Grid Tube Marketing for more details, or contact your nearest EIMAC distributor.

CHARACTERISTICS

| TUBE TYPE | 8755 | 8756 | 8757 |
|---|---|---|---|
| Description | Miniature, high voltage pulse triode stable anode | Miniature, high current, stable anode | Miniature, high current, stable anode |
| Anode dissipation (watts) | 100 | 100 | 100 |
| Maximum Frequency (MHz) | 3000 | 2500 | 2500 |
| Transconductance (micromhos) | 30,000 | 25,000 | 30,000 |

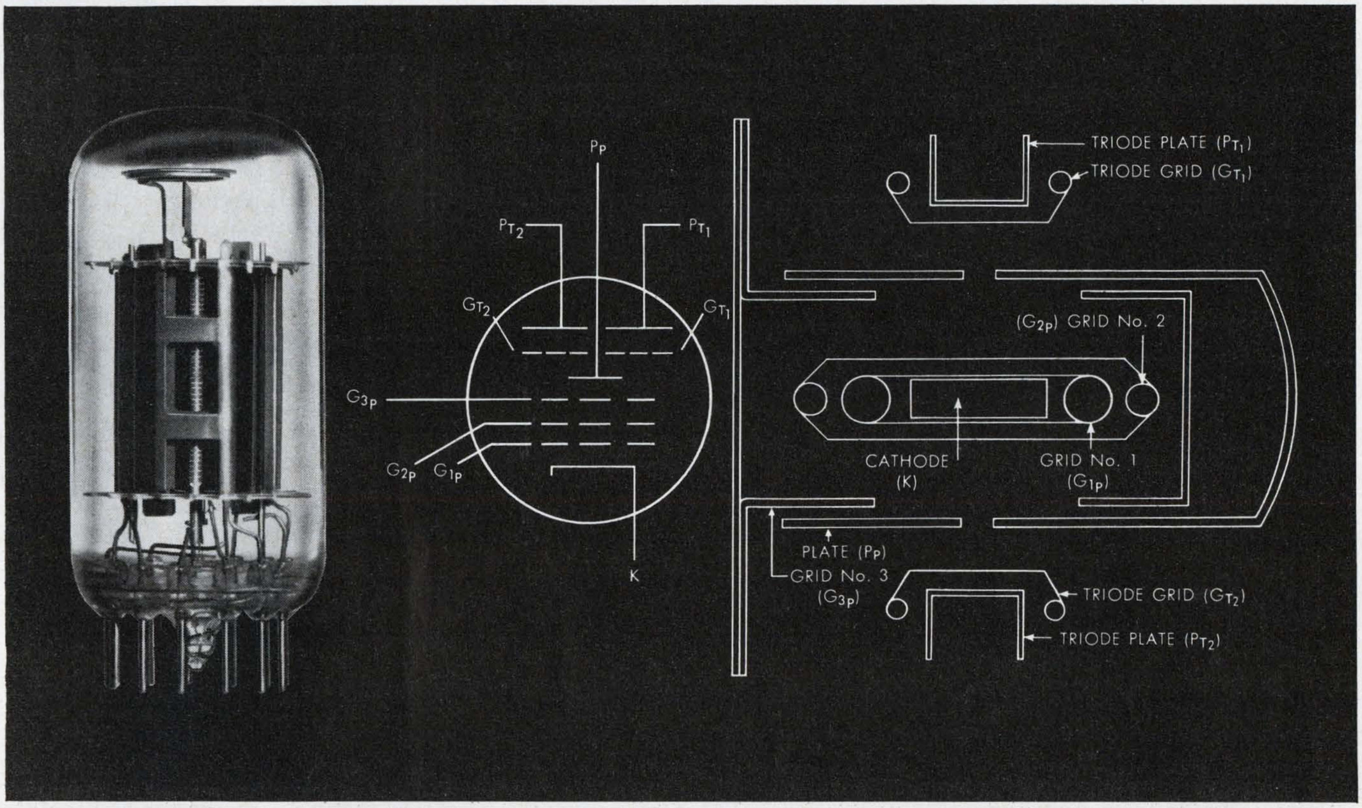
| TYPICAL OPERATION | 8755 | | 8756 | | | 8757 | |
|---|---|---|---|---|---|---|---|
| | grid pulsed | plate pulsed | CW | CW | grid pulsed | CW | CW |
| Frequency (MHz) | 1550 | 3000 | 500 | 2500 | 1100 | 500 | 2500 |
| Amplifier or Oscillator | AMP | OSC | AMP | OSC | AMP | AMP | OSC |
| Output Watts (minimum) | 2000 | 2500 | 40 | 17 | 1500 | 65 | 25 |

**EIMAC**
Division of Varian
San Carlos, California 94070



ON READER-SERVICE CARD CIRCLE 5

# RCA Engineers strive to give you better tube performance at lower cost



Never satisfied with existing performance, RCA Engineers are intent on improving receiving tube designs. For example, consider the unique RCA developmental A55280 tube—with three individually-controllable outputs from a single cathode in a pentode-triode-triode configuration. Far more significant to you than the development of this particular tube, however, is the dedication that lies behind it: a determined and continuing effort to give circuit designers products that provide ever better performance at the lowest possible cost.

For more information on RCA's developmental A55280, contact your nearest RCA District Office. For complete information on RCA's Commercial and Industrial Receiving Tubes, write RCA Commercial Engineering, Section E18DE, Harrison, New Jersey 07029.

**Advantages of RCA's developmental A55280 include:**

- Frame-grid pentode in series with two triodes . . . and all in one envelope
- Very high pentode-unit transconductance (45,000 μmho)
- Noise-immune sync automatically obtained from one of the triode units
- High-gain bandwidth product

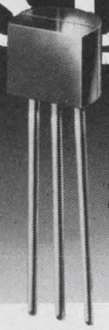
**RCA DISTRICT OFFICES**—OEM SALES: EAST, 2075 Millburn Ave., Maplewood, N. J. 07040, (201) 485-3900 • MID-ATLANTIC, 605 Marlton Pike, Haddonfield, N. J. 08034, (609) 428-4802 • MID-CENTRAL, 2511 East 46th St., Bldg. Q2, Atkinson Square, Indianapolis, Ind. 46205, (317) 546-4001 • CENTRAL, 446 East Howard Ave., Des Plaines, Ill. 60018, (312) 827-0033 • WEST, 6363 Sunset Blvd., Hollywood, Cal. 90028, (213) 461-9171 • INTERNATIONAL OPERATIONS, RCA International Division: Central and Terminal Aves., Clark, N. J. 07066, (201) 485-3900 • 118 Rue du Rhone, Geneva, Switzerland, 35 75 00.

**RCA Electronic Components and Devices, Harrison, N. J. 07029**

**The Most Trusted Name in Electronics**

ON READER-SERVICE CARD CIRCLE 6

# IF YOU CHECK THE PRICE OF OUR NEW PLASTIC UNIJUNCTION TRANSISTOR, YOU'LL FIND IT'S ONLY 40¢*



# If You Check What It Does, You'll Wonder Why.

Here's a new plastic unijunction transistor that's not only priced to extend the inherent economy of UJT circuitry but offers significant advantages in many existing and new consumer and industrial circuit designs!

For example, you can now select from *two* narrower-range eta spreads, reducing the necessity of tight-tolerance resistor/capacitor selection and *two* valley current characteristics allowing you wider latitude in sawtooth oscillator and frequency divider circuit design.

A low leakage current, resulting from the Motorola developed and patented oxide-passivated Annular† structure, reduces pulse width variations due to the undesirable charging current to the timing capacitor in oscillator circuits.

And low (2.5 V) typical emitter saturation voltage allows greater output to the following circuit stage, particularly in triggering applications.

Rugged Unibloc** unijunction packages are easy to plug into existing "base-one, emitter, base-two" metal TO-18 pin circles, too... *without* confusing lead-crossing common to other plastic units.

Use it in: ■ time delays ■ lamp dimmers & flashers ■ sawtooth generators ■ motor-speed controls ■ level sensing ■ temperature & process control ■ ring counters ■ military fuse circuits ■ regulator, motor & lamp operator circuits ■ pulse generators ■ photoelectric sensors ■ frequency dividers ■ TV deflection ■ automotive ignition ■ multivibrators ■ oscillators

Check the specs and prices — then contact your franchised Motorola distributor for evaluation units or your Motorola factory representative for production quantities. Write Box 955, Phoenix, Arizona 85001, for data sheets and two just-off-the-press unijunction technical publications!

**CHARACTERISTICS**

| Type | Peak Point Current (typ) | Emitter Reverse Current (typ) | Intrinsic Standoff Ratio ($\eta$) | | Valley Current (Min) |
|---|---|---|---|---|---|
| | | | Min. | Max. | |
| **2N4870** | 1 $\mu$A | 0.05 $\mu$A | 0.56 | 0.75 | 2.0 mA |
| **2N4871** | | | 0.70 | 0.85 | 4.0 mA |

*Large Volume. †Annular semiconductors are patented by Motorola Inc.
**Trademark of Motorola Inc.

*– where the priceless ingredient is care!*

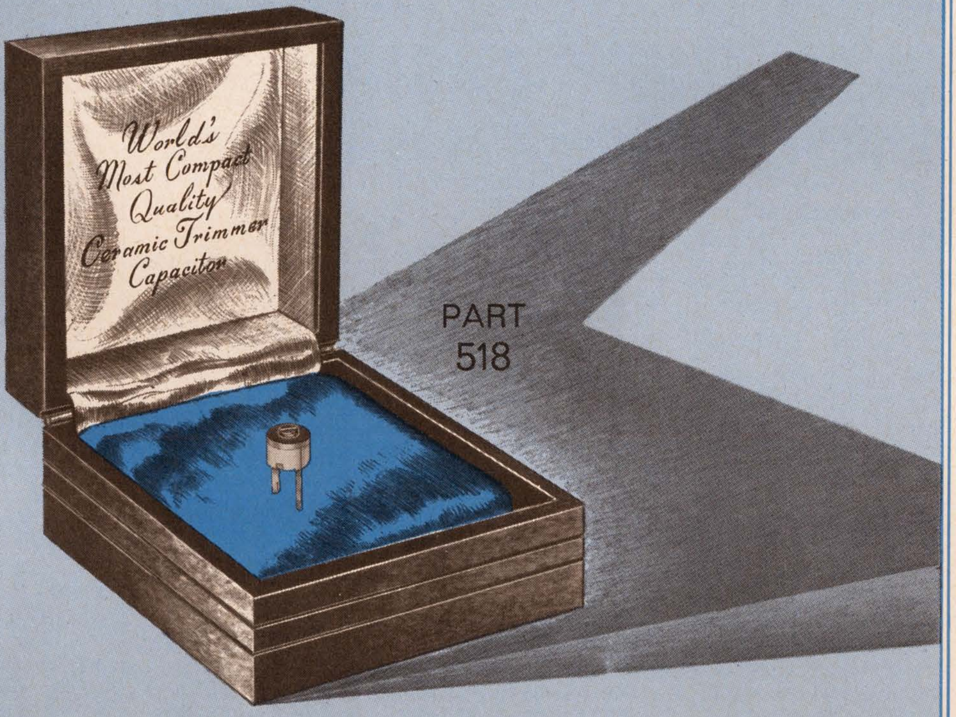
**MOTOROLA**
**Semiconductors**

ON READER-SERVICE CARD CIRCLE 7

# ANNOUNCING...

## *The WORLD'S most compact QUALITY*

# CERAMIC TRIMMER CAPACITOR



**AMAZING 5 to 25 pF. CAPACITANCE RANGE IN LESS THAN .007 CUBIC INCH**

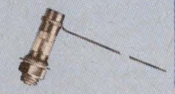
A precious jewel? Not at all . . . This is a new subminiature Ceramic Trimmer Capacitor. It represents the most significant development in variable capacitors in more than a decade . . . and again Erie leads the State of the Art. The tiny 518 occupies only .007 cubic in. . . . and has an incredible capacitance range of 5 to 25 pF. Operating temperature range: –55° C to 125° C. — Working voltage 100 WVdc to 85° C; 50WVdc to 125° C. The unit exhibits remarkable ruggedness, being a development from Erie's exclusive Monobloc Process®. The Monobloc rotor with its sealed electrode provides stability under extreme environmental conditions. The 518 permits rigid mounting in both printed circuit and point to point wiring applications. Tuning linearity is assured by precision lapped bearing surfaces.

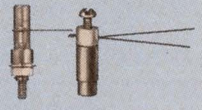
This compact little trimmer is the ultimate in volumetric efficiency . . . after all, it's only .218" in diameter — almost the size of a precious jewel.

**ERIE OFFERS THE MOST COMPLETE SUBMINIATURE TRIMMER CAPACITOR LINE IN THE INDUSTRY . . .**


CERAMIC


AIR


GLASS AND QUARTZ


PLASTIC

**ERIE**
**TECHNOLOGICAL**
**PRODUCTS, INC.**

ERIE

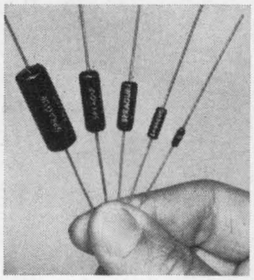
Erie, Pennsylvania

**Another Series of Components in Erie's Project "ACTIVE"**
**Advanced Components Through Increased Volumetric Efficiency**

ON READER-SERVICE CARD CIRCLE 8

# RESISTORS FOR PERSPICACIOUS DESIGN ENGINEERS

## FILMISTOR® PRECISION METAL-FILM RESISTORS



Extended-range Filmistor Resistors now give you dramatic space savings in all wattage ratings — 1/20, 1/10, 1/8, 1/4, 1/2, and 1 watt — with absolutely *no sacrifice in stability!*

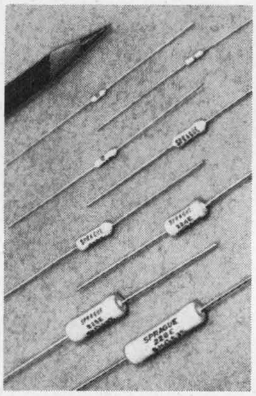
Filmistors offer extended resistance values in size reductions previously unobtainable. For example, you can get a 4.5MΩ resistor in the standard 1/4 watt size, which had conventionally been limited to 1 MΩ. Filmistor Metal-Film Resistors are now the ideal selection for "tight-spot" applications in high-impedance circuits, field-effect transistor circuits, etc.

Other key features are ±1% resistance tolerance, low and controlled temperature coefficients, low inherent noise level, negligible coefficient of resistance, and rugged molded case.

Filmistors *surpass* the performance requirements of MIL-R-10509E.

**Write for Engineering Bulletin 7025C**

## ACRASIL® PRECISION/POWER WIREWOUND RESISTORS



These silicone-encapsulated resistors combine the best features of both precision and power wirewound types, giving them unusual stability and reliability.

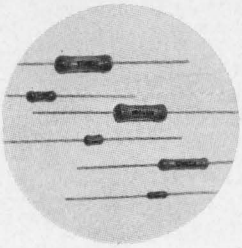
Acrasil Resistors are available with tolerances as close as .05%, in power ratings from 1 to 10 watts. Resistance values range from 0.5 ohm to 66,000 ohms.

Their tough silicone coating, with closely matched expansion coefficient, protects against shock, vibration, moisture, and fungus.

Acrasil Resistors meet or exceed the requirements of MIL-R-26C.

**Write for Engineering Bulletin 7450**

## BLUE JACKET® VITREOUS ENAMEL PRECISION/POWER WIREWOUND RESISTORS



Axial-lead resistors available in ratings from 1 to 11 watts, with resistance tolerances to ±1%. Non-inductive windings available to ±2% tolerance.

All welded end-cap construction securely anchors leads to resistor body. Vitreous coating and ceramic base have closely matched expansion coefficients.

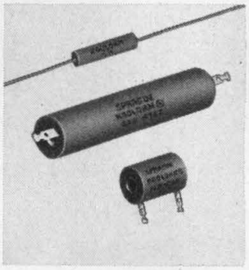
**Write for Engineering Bulletins 7410D, 7411A**

Tab-terminal Blue Jacket Resistors can be had in a wide selection of ratings from 5 to 218 watts, with several terminal styles to meet specific needs.

Tab-terminal as well as axial-lead Blue Jackets can be furnished to meet the requirements of MIL-R-26C.

**Write for Engineering Bulletins 7400B, 7401**

## KOOLOHM® CERAMIC-SHELL POWER WIREWOUND RESISTORS



Koolohm Resistors are furnished in axial-lead, axial-tab, and radial-tab styles, in a broad range of ratings from 2 to 120 watts. Both standard and non-inductive windings are available.

Exclusive ceramic-insulated resistance wire permits "short-proof" multilayer windings on a special ceramic center core for higher resistance values. The tough non-porous ceramic shell provides complete moisture protection and electrical insulation. Koolohms can be mounted in direct contact with chassis or "live" components.

Axial-lead Koolohm Resistors to MIL-R-26C are available in MIL styles RW55 and RW56.

**Write for Bulletins 7300, 7305, 7310**

## STACKOHM® POWER WIREWOUND RESISTORS

Sprague Stackohm Resistors are especially designed for equipment which requires power wirewound resistors of minimum height. Their flat silhouette permits stacking of resistor banks in close quarters.

Aluminum thru-bars with integral spacers act as mounting means and also conduct heat from within the resistance element. Resistance windings are welded to end terminations for maximum reliability. An outstanding vitreous coating protects the assembly against mechanical damage and moisture. Ceramic core, end terminations, and vitreous enamel are closely matched for coefficient of expansion.

Stackohm Resistors are available in both 10-watt and 20-watt ratings, and can be furnished with resistance tolerances as close as ±1%. Resistance values range from 1 ohm to 6000 ohms.

Both 10- and 20-watt types meet the stringent requirements of MIL-R-26C.

**Write for Engineering Bulletin 7430**

*Send your request to Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247, indicating the engineering bulletins in which you are interested.*

| | | | | |
|---|---|---|---|---|
| ON READER-SERVICE CIRCLE 821 | ON READER-SERVICE CIRCLE 822 | ON READER-SERVICE CIRCLE 823 | ON READER-SERVICE CIRCLE 824 | ON READER-SERVICE CIRCLE 825 |

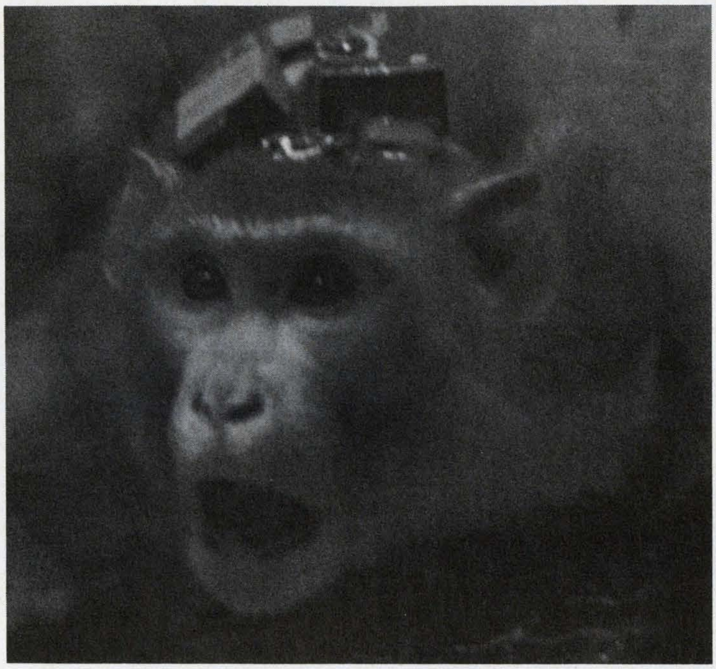
**SPRAGUE COMPONENTS**

RESISTORS
CAPACITORS
TRANSISTORS
THIN-FILM MICROCIRCUITS
INTEGRATED MICROCIRCUITS
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

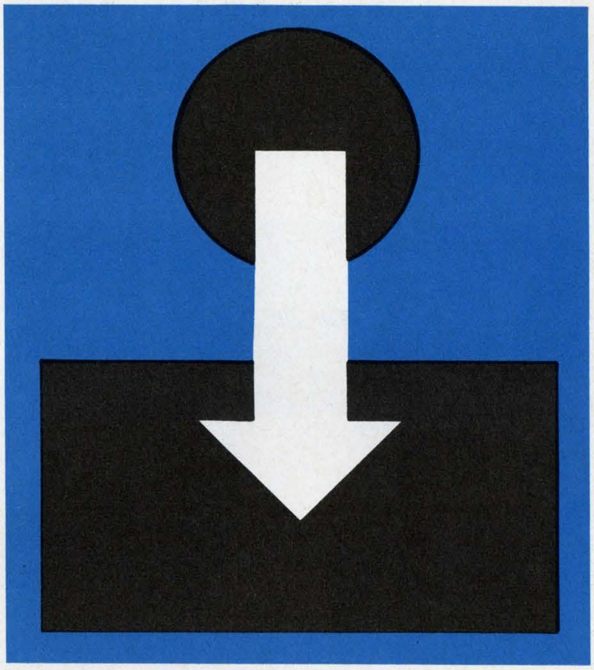
4SR-5145

**SPRAGUE®**
*THE MARK OF RELIABILITY*

# News



**Permanently implantable microcircuit stimulators** aid research into workings of the brain. Page 36



**'Macromodular' building blocks ease** the design of new computer setups. Page 50

**U.S. instrument makers take steps** to expand their market in Western Europe. Paris show points up the extent of their influence, now felt even by Polish manufacturers. Page 17

## Also in this section:

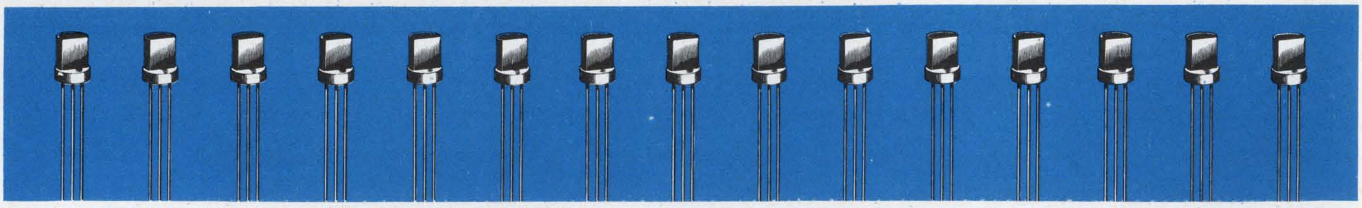
**Europe adopts coding system** for microelectronic devices. Page 21

**Pen and transparent tablet feed drawings** to computer. Page 26

**News Scope,** Page 13 . . . **Washington Report,** Page 29 . . . **Editorial,** Page 59

***First from Sprague Electric!***

# Do you use the 2N2222 for Industrial Amplifiers or for Switching?



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4SS-7121

ON READER-SERVICE CARD CIRCLE 9

# NASA invites industry to design for future

At a two-day briefing at the Massachusetts Institute of Technology, NASA put it on the line to industry: It needs new equipment and foresees millions of dollars' worth of potential business for communications, guidance and control manufacturers.

But the equipment must be reliable. Unless a system "can operate reliably over periods of years, encountering radiation fields and temperature extremes ranging from −200° to +1200°C," one NASA official indicated, it's no sale.

The U.S. space agency, in discussing its plans for the future, disclosed that not only was it envisioning a more ambitious assault on space; it also intends to direct more of its efforts toward solving civil-aviation problems.

To the 500 industry representatives at the briefing in Cambridge, Mass., earlier this month, NASA speakers pointed to these potential orders for space equipment:

- A threefold increase in the use of microcircuits in systems over the next five years.
- Miniature on-board computers.
- More powerful lasers in the visible region and improved optical and infrared filters, modulators and detectors.
- Better display techniques, including cathode-ray tubes, motion pictures as well as three-dimensional systems.

In civil aviation, NASA said it was particularly interested in areas that are not now being investigated by the Defense Dept. They include:

- Attitude control systems—probably "fly-by-wire" type.
- Display concepts and their integration with control systems.
- Approach and landing guidance.
- Aircraft collision-avoidance systems.

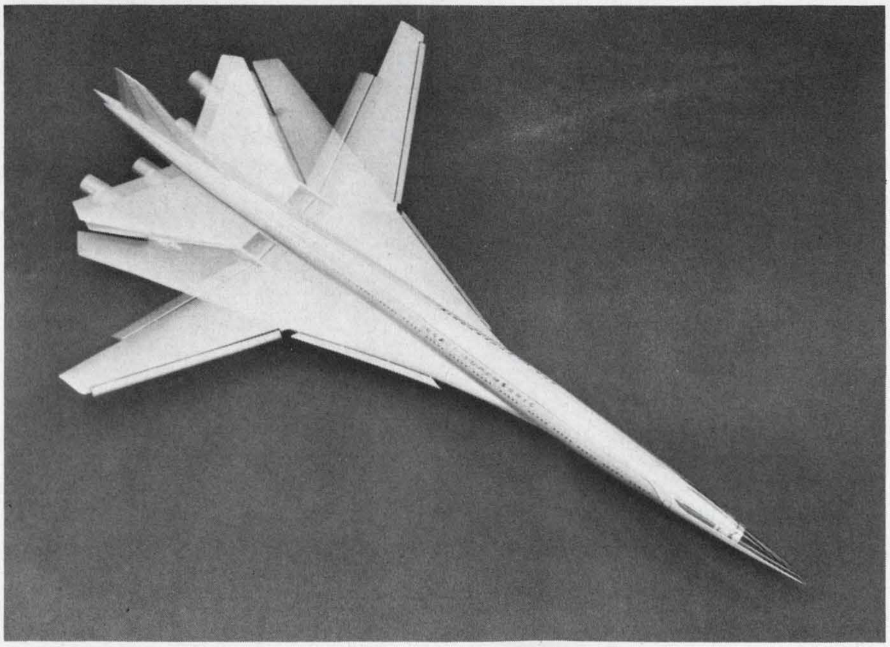
Dr. W. Crawford Dunlap, assistant director for components research at the NASA Electronics Research Center in Cambridge, noted that the Apollo program computer being built by United Aircraft was one of the most advanced microcircuit applications. Used for kick-stage guidance, the computer contains 5600 micrologic gates, equivalent to 39,000 discrete components. Dr. Dunlap said that by the year 2000, NASA would need a miniature, cognitive, multiprocessor computer capable of processing nearly all the raw data on a spacecraft. The computer for an unmanned planetary vehicle may have as many as $10^{10}$ logic elements and $10^9$ memory bits and still have a volume of one cubic foot.

Dr. Dunlap reported that the center had sponsored the development of a space-charge-limited, thin-film transistor to operate reliably in temperatures above 400°C. The device, developed by Hughes Research Laboratories of Malibu, Calif., is an analog of the vacuum tube. With the use of silicon-on-sapphire techniques, the device is not suited for really high temperatures, Dr. Dunlap said, but it is a step in the right direction and overcomes the 175°C limit for silicon monolithic structures.

Jack Fischel of NASA's Flight Research Center at Edwards, Calif., said that electrical "fly-by-wire" systems were the best means of controlling high-performance aircraft like the SST. These systems, he explained, use electrical signals originating at the aircraft's manual controls. The signals, transmitted over wires, actuate hydraulic or electric drive mechanisms at the rudder, ailerons or other control surfaces. Fischel said that the X-15 and several lunar-landing simulators had demonstrated the effectiveness of the concept.

The electronics industry must, he went on, provide reliable, low-cost, easily maintained systems for more exacting flight control. He also emphasized the need for new landing displays that could show several variables to the pilot at once.

"The need to improve and simplify pilot displays has been recognized for many years," Fischel said. "Anyone entering the cockpit of an aircraft would be awed by the array of single-parameter instruments. The lack of cockpit space, the increased information required by the pilot, has resulted in indicators being installed in window sills, on the cockpit ceiling, floor and, in some instances, behind the pilot. An obvious solution is the use of integrated displays."



**NASA proposes fly-by-wire control** and integrated displays for SST

## X-ray missile defense may get U.S. go-ahead

Is the United States pushing to deploy an antimissile defense system? Or does the Administration still believe, as Defense Secretary Robert S. McNamara has indicated in the past, that such a system would be of questionable military value? The questions are being asked anew in the light of recent Congressional testimony by the Pentagon's Director of Defense Research and Engineering, Dr. John S. Foster, Jr.

Dr. Foster has indicated that the U.S. is looking into the use of the enormous X-ray energy released by thermonuclear explosion to destroy incoming missiles. In heavily censored testimony, the defense official is said to have confirmed that such use of X-rays is a key element in the proposed Nike-X missile defense system.

An X-ray defense would make possible an "area defense," in which it would no longer be necessary to aim defense missiles directly at incoming warheads. Since the destructive effects of X-rays extend for miles in outer space, defensive missiles could be effective merely by firing them at high altitudes in the vicinity of intruding missiles.

Dr. Foster said that a nationwide defense system, costing as much as $20 billion, was not technically justified because changes in the enemy's offense could rapidly outdate it. He noted, however, that a "thin-defense" Nike-X system, costing $3 to $4 billion, could be effective against a Communist Chinese nuclear threat.

As reported in ELECTRONIC DESIGN last Feb. 15 (News Scope, ED 4, p. 13), modifications of U.S. ICBM offensive warheads has been under way for some time in the wake of speculation that the Soviet antimissile system is relying on X-ray to stop any incoming hardware.

However, Secretary McNamara is on record as saying that the enormous cost and questionable performance of any antimissile defense would make it impractical for a nation as large as the U.S. to build a fully effective system.

According to Dr. Foster's testimony, the Defense Dept. decided in 1964-65 to make a fundamental change in its approach to a ballistic-missile defense. Prior to that time the Pentagon had been developing the Nike Zeus missile for long range interception of attacking warheads. The Nike Zeus however suffered from two fundamental defects.

First, it had to be guided relatively close to its target to be able to destroy the warhead. Secondly, because of its interception requirement, it was incapable of handling a large-scale attack in which warheads were mingled with decoys.

As a result, Dr. Foster explained, the Pentagon shifted toward the concept of providing "area defense" by using larger warheads with X-rays which would have to be exploded only in the general vicinity of incoming warheads.

## French telemetry system checks car crash victims

In order to improve the chances of survival of persons injured in automobile crashes, doctors at Purpan Hospital in Toulouse, France, are using a new patient telemetry scheme.

The ambulance crew carries an FM/FM telemetry system with appropriate transducers. These are attached to the injured victim before he is removed from the automobile. The telemetered heartbeat, respiration and like parameters are monitored by a specialist back at the hospital. By this means, doctors can advise on the correct method of handling the patient in the hope of increasing his chances of survival.

The monitoring continues while the patient is in the ambulance, and correct equipment is therefore on hand when the patient is admitted to the hospital.

## Ford opens new lab for advanced research

The Philco-Ford Corp. has underlined electronics' growing role in the automobile industry by establishing a research facility in Blue Bell, Pa.

George C. Crowley, a corporation vice-president, has announced that the Automotive Electronic Development Laboratory will be equipped with the latest electronic apparatus and instrumentation.

The laboratory's function will be to undertake advanced research and development work aimed at the economic application to the automobile industry of innovations coming out of the Philco-Ford laboratories in Dearborn, Mich.

It is expected to work with a three-to-five-year lead time on the refinement of basic research for the solution of automotive problems. Its main responsibility will be to develop electronic controls, communications and entertainment devices for use in cars.

## U.S. contract shakeup follows Apollo fire

The first major reforms in the U.S. Moon-exploration program are being pressed by NASA in the wake of the Apollo spacecraft fire that killed three astronauts at Cape Kennedy last Jan. 27. The revisions call for:

- Less responsibility for North American Aviation, Inc., manufacturer of the capsule.
- New contracts to other companies to fill the void.

Testifying this month before the Senate Space Committee, NASA administrator James E. Webb said that the $2.8 billion Apollo contract with North American, along with $75 million in engineering changes, was being renegotiated.

The contract changes will bring the Boeing Co. into the program as checkout specialist for the spacecraft before it is launched. This role was formerly performed by North American itself.

In addition, Webb said, another contractor will take over preparation of the Apollo craft for missions after its first lunar landing.

And "other forms of contractor assistance" are being considered, the space administrator went on, to help North American with management and test procedures.

The changes followed blunt criticism in a report last month by a special board that investigated the Apollo fire. The board found "major deficiencies in design and engineering, manufacture and quality control" (see News Scope, ED 9, April 26, 1967, p. 13).

New from Ohmite! Convenient, plug-in, time delay relays for obtaining delays or intervals with accuracy and repeatability superior to pneumatic and geared devices. Dependability and long life are assured with maintenance-free, solid state timing circuits and rugged Ohmite electro-mechanical relays which serve as the power switching elements.

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ON READER-SERVICE CARD CIRCLE 10

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The instrument can function as a wave analyzer with bandwidth adjustable from 1% to 100%; as a flat or selective AC voltmeter with sensitivity ranging from 10 microvolts to 5 volts rms full scale; as a distortion analyzer to measure distortion levels as low as 0.1% (as low as 0.001% when used in conjunction with a second Model 110); as a low-noise amplifier (typical noise figure of 1 dB) with voltage gain ranging from 1 to $10^4$; as a stable general-purpose low-distortion oscillator providing up to 5 volts rms into 600 ohms, capable of being synchronized by an external signal; and as an AC-DC converter with ground-based output.

**Price:** $1195. Export price approximately 5% higher (except Canada).

For additional information, write for Bulletin T-140 to Princeton Applied Research Corporation, Dept. E P.O. Box 565, Princeton, New Jersey 08540. Telephone: (609) 924-6835.

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ON READER-SERVICE CARD CIRCLE 11

### At Mesucora 67

# Common Market lures U. S. instrument makers

## "Made in Europe" will be commoner on American units as tariffs tumble; even Poland follows U.S. lead

**Robert Haavind**
Managing Editor

**PARIS**

U.S. test equipment manufacturers, despite a powerful position in the European marketplace, are not standing pat. They are organizing to take fuller advantage of falling Common Market trade barriers.

The degree of their European involvement varies widely, as was evident from exhibits at the mammoth Palais de la Défense here, where Mesucora, a quadrennial European instruments and controls exhibition, was held April 14-21.

Three items at the show pointed up different facets of the situation.

First was a display of instruments shown by Metronex, the Polish export-import agency which controls all electronics goods moving into or out of this Eastern European nation. The labels on the equipment were in English, and English descriptions and specification sheets were available.

"A few years ago, German was usually used on instruments," a Polish representative explained, "But today, European engineers know English best."

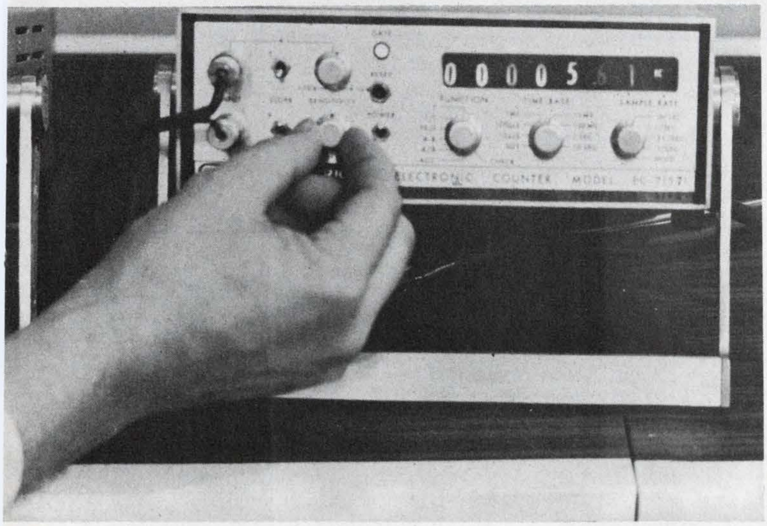
Many other aspects of European-designed equipment also followed patterns pioneered in the U.S. in the last few years—plug-ins, dual-trace capability in oscilloscopes, for instance. Even Eastern European nations must, somewhat apologetically, follow this trend in order to compete in the Western Europe market.

A second pointer was the fact that the John Fluke Manufacturing Co., Inc., of Seattle, plans to set up manufacturing facilities in Amsterdam next year. A Fluke representative pinpointed the reason: instruments shipped from the Netherlands to other members of the European Common Market next year will be subject to 5% duty; from the U.S., 25%. The pressure on instrument makers to "go European" is even stronger than on the component makers (see "Europe girds for battle with Goliaths of U.S.," ED 9, April 26, 1967, p. 24 ff), because the tariffs for their more complex equipment are higher. Although France is keeping U.S. instrument makers at arm's length, other Common Market nations—like Belgium and the Netherlands—are spreading the welcome mat.

A third indication came from a company which has probably gone furthest in integrating its efforts into the European scene: Hewlett-Packard Co. It was a new sound loudness analyzer completely designed by engineers at H-P's Böblingen, West Germany, plant. Another H-P instrument at the booth was a 10-Hz-to-1-MHz digital oscillator, completely designed in Japan by HP-Yokogawa.

Some European sales representatives accounted for American success here by pointing out that the much larger electronics industry in the U.S. allowed manufacturers to design for a sizable market. Since more units can be sold, development costs can be spread over a larger production run. But a second important factor was apparent at Mesucora: design innovation. The variety of instruments shown and use of the latest technology, such as microcircuits—both stood out in U.S. exhibits.

The former was evident in a Gertsch synthesized signal genera-



**A contrast in design** is evident in Aerometric's 10-MHz counter (above) and the Polish 10-MHz digital frequency time meter. The 8-digit version of the U.S. instrument sells for $1925. The Polish instrument, with markings in English, costs about $3000.

(**Mesucora 67,** *continued*)

tor, the model SSG-1. It covers 5 Hz to 500 MHz, in 1-Hz steps to 50 MHz and in 10-Hz steps thereafter. It is priced at $12,500.

"The total market for this kind of instrument in France might be 20 or 30, not enough to make it economically sound for a French manufacturer," explained Pierre Challande, sales engineer for SERIEL, the French representative for Singer Metrics, Gertsch's parent firm.

The microcircuit trend was noticeable among U.S. digital instruments. Linear circuits, however, are still usually implemented with discrete devices, because linear-microcircuit performance has not yet reached desired levels.

### Tiny 10-MHz counter

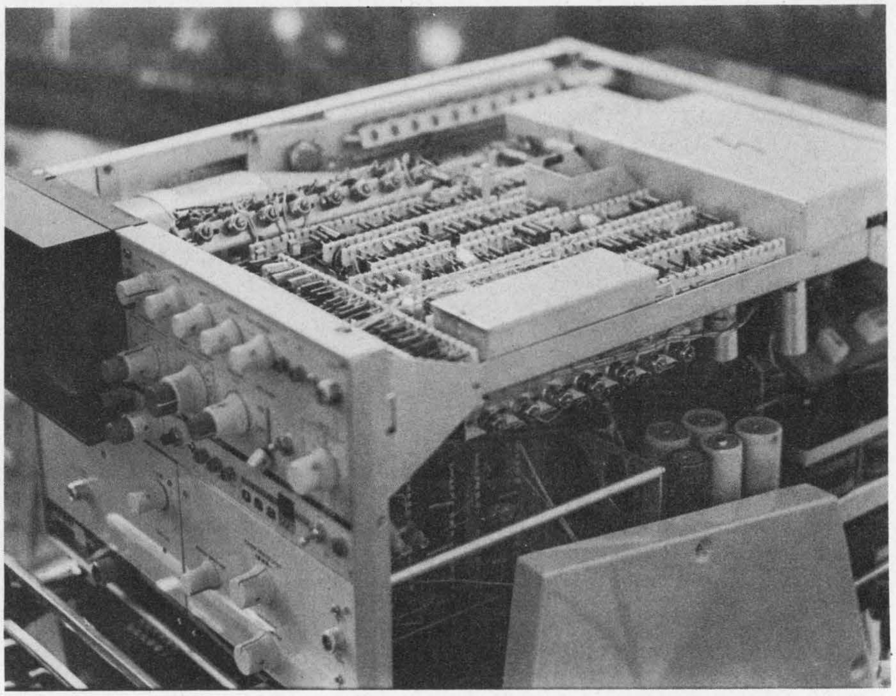
Aerometrics showed 0–10-MHz microcircuit counters that, it claims, are the smallest on the market. Prices range from $1250 for a four-digit model to $1925 for an eight-digit version in the EC715 series introduced by the Aerojet-General subsidiary.

Two of the units will fit side by side in a standard 19-inch rack, taking up 3-1/4 inches in height. Sensitivity is 100 mV rms. This instrument is about 80% IC. The power supply and some linear circuits are not integrated. It weighs seven pounds.

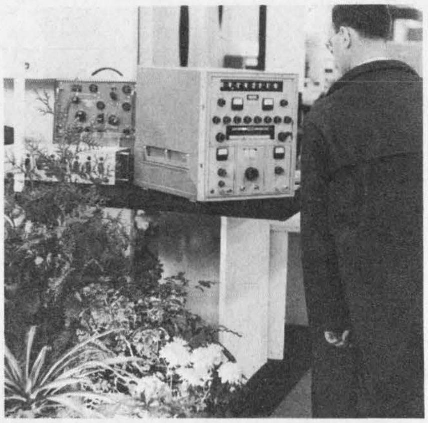
The Poles were also showing what they called a digital frequency time meter—the 55-pound Zopan type PFL-4, priced at about $3000. Over a glass of Polish vodka in a private room within the booth, the Polish representatives explained how difficult it was for them to move into world electronic-instrument markets.

"One of our biggest difficulties is your embargo. Many of the things we need are on the embargo list. We can get most of them—through contacts in Holland and Belgium—but it costs us about 40% more that way."

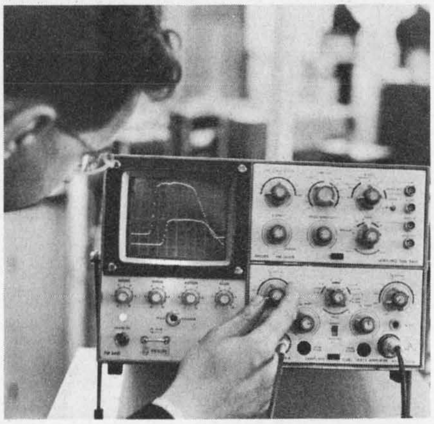
This was stated by one of the Polish representatives who did not wish to be identified. He also cited difficulties with Polish transistors. "We make only pnp transistors in Poland, and their quality is low," he said.



**Interior of a Polish 60-MHz oscilloscope** shows the large components and side-by-side packaging used. The OSA601 has passive devices suspended between two ceramic strips with slots for the leads to be soldered into.



**Floral display brightens the scene** as a visiting engineer inspects a new Gertsch synthesized signal generator. Booths at European shows include sections at the back where business can be transacted.



**One European manufacturer** that seems to run neck and neck with U.S. developments is Philips of Eindhoven, which introduced this 1-GHz two-channel sampling scope priced at about $4100.

The counter that was on display uses eight types of Polish transistors, one Soviet and one Dutch. It uses four Polish diodes and one Dutch. An eight-digit nixie readout uses Philips digit indicators.

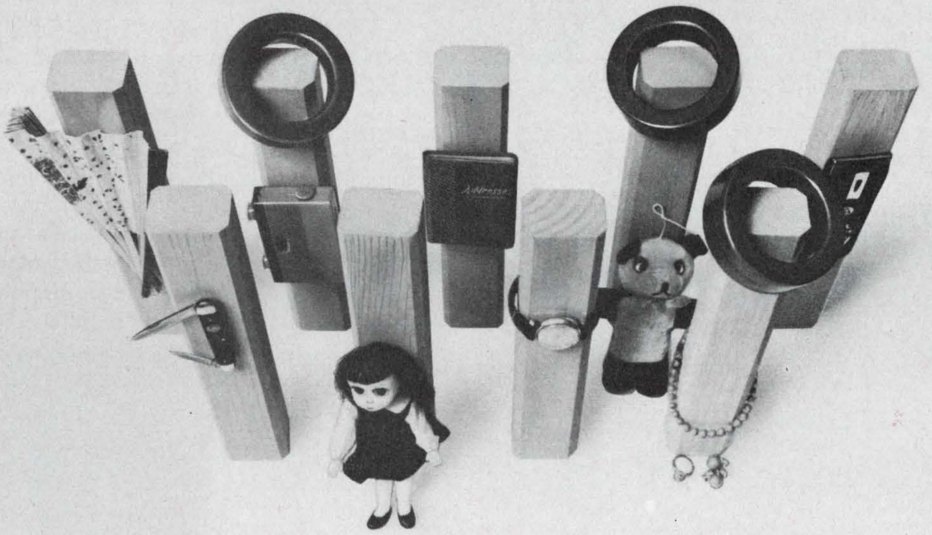
The Poles were also showing a 60-MHz oscilloscope, type 0SA601, which sells for about $3000. It comes with a carrying cart and plug-ins, including a sampler that covers 0-1 GHz. Triggering to 100 MHz is possible in the real-time scope by means of tunnel-diode circuitry. The 95-pound instrument uses large components, soldered side by side between two ceramic pieces. In view of the handicaps faced by Polish designers, both instruments are a credit to their ingenuity.

The representative explained also that the Poles would not sell instruments unless they were able to make a profit.

"The vodka," he commented, "is one thing we make better than the Russians." And it was good. ■ ■

# you get a choice,

# not a challenge



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| SPRAGUE TYPE | Case And Configuration | Dielectric | Temperature Range | Military Equivalent | Eng. Bulletin |
|---|---|---|---|---|---|
| 680P | hermetically-sealed metal-clad tubular | metallized Metfilm* 'A' | −55 C, +85 C | no specification | 2650 |
| 431P | film-wrapped axial-lead tubular | metallized Metfilm* 'E' (polyester film) | −55 C, +85 C | no specification | 2445 |
| 155P, 156P | molded phenolic axial-lead tubular | metallized paper | −40 C, +85 C | no specification | 2030 |
| 218P | hermetically-sealed metal-clad tubular | metallized Metfilm* 'E' (polyester film) | −55 C, +105 C | CH08, CH09 Characteristic R | 2450A |
| 260P | hermetically-sealed metal-clad tubular | metallized Metfilm* 'K' (polycarbonate film) | −55 C, +105 C | no specification | 2705 |
| 121P | hermetically-sealed metal-clad tubular | metallized paper | −55 C, +125 C | no specification | 2210C |
| 118P | hermetically-sealed metal-clad tubular | metallized Difilm® (polyester film and paper) | −55 C, +125 C | CH08, CH09 Characteristic N | 2211D |
| 143P | hermetically-sealed metal-clad "bathtub" case | metallized paper | −55 C, +125 C | no specification | 2220A |
| 144P | hermetically-sealed metal-clad "bathtub" case | metallized Difilm® (polyester film and paper) | −55 C, +125 C | CH53, CH54, CH55 Characteristic N | 2221A |
| 284P | hermetically-sealed metal-clad rectangular case | metallized paper | −55 C, +105 C | no specification | 2222 |
| 283P | hermetically-sealed metal-clad rectangular case | metallized Difilm® (polyester film and paper) | −55 C, +125 C | CH72 Characteristic N | 2223 |
| 282P (energy storage) | drawn metal case, ceramic pillar terminals | metallized paper | 0 C, +40 C | no specification | 2148A |

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## FM unit monitors whirling turbine

A self-contained transmitter the size of a shotgun shell broadcasts the condition of turbochargers spinning at 100,000 revolutions per minute.

The FM station, built by the Schwitzer Div. of Wallace-Murray Corp., Indianapolis, is said to be the world's smallest. It is mounted on the hollow impeller shaft of the supercharger and is used to relay signals from strain gauges on the impeller blades.

Schwitzer laboratory technicians developed the tiny transmitter when they found that the former method of picking up the strain gauge signals by commutation was no longer practical. Electrical impulses were picked up directly from contacts on the shaft at speeds to 50,000 rpm but were unable to keep up at the higher speeds.

The miniature transmitter is powered by the same battery as that used to power an electric wristwatch. Schwitzer says that the milliwatt output power is modulated by the output signals from the strain gauges. The strain gauges are cemented to selected locations on the impeller blades. The receiver can interpret variations to indicate impeller stress. ■ ■

**Tiny FM transmitter** mounted on a turbocharger impeller is able to relay strain gauge signals when the shaft is rotating at 100,000 rpm.

# Europe adopts integrated-circuit coding scheme

## Thirty-eight firms agree on code to be used for ICs; U.S. sticks to 6N numbers

European manufacturers have begun using a new, meaningful coding system to identify microelectronic devices. The system is similar to coding schemes already in use in Europe for tubes, transistors and diodes.[1]

The system was developed by the Association Internationale à But Scientifique, Pro Electron, headquartered in Brussels, Belgium. Members of the organization include 38 European semiconductor manufacturers, including all the major ones of France, the Netherlands and West Germany, according to Jan Haantjes, director of the organization. The first meeting was held in Brussels last Feb. 21 and was attended by representatives from Belgium, France, Italy, the Netherlands, Spain, Sweden, the

## New code for integrated circuits.

FAA101*

| **The first two letters:**<br>Family, respectively solitary type | **Third letter:**<br>Group of circuit functions | **Two first figures:**<br>Running serial number | **Third figure:**<br>Temperature range |
|---|---|---|---|
| **Family types:**<br>FA, FB, . . .<br>GA, GB, . . ., etc.<br>**Solitary types:**<br>T followed by letter **A**, which may change to **B**, **C**, etc., if running serial number is exhausted. | **A** Linear amplification.<br>**B** Frequency conversion/demodulation.<br>**C** Oscillating/generating (continuous).<br>**D** Multiple of dissimilar linear networks.<br>**G** Multiple of noninterconnected discrete devices when belonging to a family of networks.<br>**H** Logic.<br>**J** Storage (continuous).<br>**K** Timing (including temporary storage).<br>**L** Digital level conversion.<br>**Y** Miscellaneous. | 10-99 | 1) 0° to +75°C.<br>2) –55° to +125°C.<br>0) Other temperature ranges. |

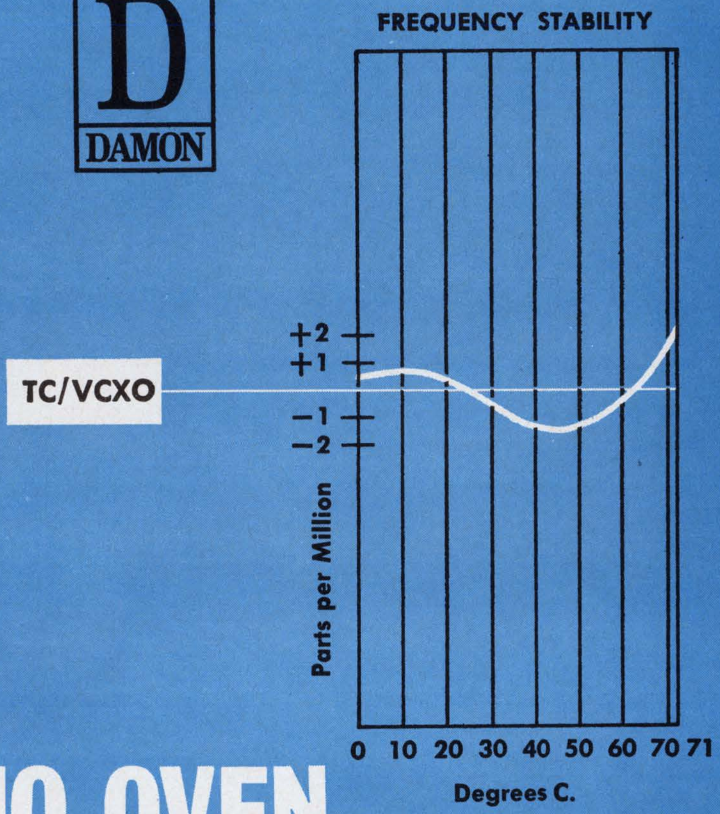
*Linear amplifier, the first device in the FA series, for use in a temperature range from 0 to 75°C.

## Special code for Zener diodes.

BZY99 - C4V7R*

| Basic part of the type designation | Letter indicating the nominal tolerance of the Zener voltage in % | Typical Zener voltage in volts | Polarity |
|---|---|---|---|
| Assigned in accordance with the code described in Table 1. | A 1%<br>B 2%<br>C 5%<br>D 10%<br>E 15% | The typical Zener voltage is related to the nominal current rating for the whole range. The letter V is used in place of the decimal point when this occurs. | Normal polarity, which is with cathode connected to case, and symmetrical executions are not specially indicated. Reverse polarity, which is with anode connected to case, is indicated by the letter R. |

*Silicon voltage reference diode for use in professional equipment. Second group says this is a 4.7-volt, 5% tolerance device with reverse polarity (anode connected to case).



(**coding scheme,** *continued*)

United Kingdom and West Germany. The group will continue to use the tube, semiconductor and diode coding developed previously by the now dissolved Association Pro Electron of Luxembourg.

Many characteristics of the tube coding scheme used in Europe for the past 30 years have been carried over into the codes for semiconductor devices. For example, a small-signal diode is always identified by the second letter "A", whether it is a semiconductor type or a high-vacuum or gas-filled tube. The first letter tells which of these it is.

The basic principles of coding are similar for all devices in the European system. The first letter—or in the case of integrated circuits, two letters—indicates the category and group, series or family of devices. The second, or third, letter indicates the circuit function of the device. In some cases additional information is coded in, or a serial number is added to identify specific devices.

The new integrated circuit code is shown in the table. A comparison with Table 1, for discrete semiconductor devices, shows the similarity between the systems. The following example will help to clarify the system and illustrate some of its present limitations.

A device designated "FYH121" is a digital logic microcircuit (from the "H") in the "FY" family. It will work compatibly with other "FY" devices. That is, it will use the same supply voltages, work with the same input and output levels, operate at the same speed, etc. It is the third device in the series (series numbers go from 10-99, therefore the "12" gives this information). The "1" at the end indicates that it operates over a temperature range of 0°–75°C.

The logic type—DTL, RCTL, $E^2CL$—is not given by the code. Haantjes says that there is some interest among European semiconductor makers in adding this information, and a means to do so may be developed.

At present six manufacturers have already started using the new code and the remaining 32 manufacturers in the organization intend

# Table 1. Designation code for semiconductor devices.

AA100*

| **First letter:**<br>Distinguishes between junction and nonjunction devices and gives an indication of the material. | **Second letter:**<br>Indicates primarily the main application, respectively main application and construction if a further differentiation is essential. | **Serial number:** |
|---|---|---|
| **Junction devices:**<br>**A** Devices with one or more junctions, using material with a band gap of 0.6 to 1.0 eV, such as germanium.<br>**B** Devices with one or more junctions, using material with a band gap of 1.0 to 1.3 eV, such as silicon.<br>**C** Devices with one or more junctions, using material with a band gap of 1.3 eV and more, such as gallium arsenide.<br>**D** Devices with one or more junctions, using material with a band gap of less than 0.6 eV, such as indium antimonide.<br>**Nonjunction devices:**<br>**R** Devices without junction, using materials such as those employed in Hall generators and photoconductive cells. | **A** Detection diode, high-speed diode, mixer diode.<br>**B** Variable-capacitance diode.<br>**C** Transistor for af applications (thermal resistance between crystal and mounting base more than 15°C/W).<br>**D** Power transistor for af applications (thermal resistance between crystal and mounting base equal to or less than 15°C/W).<br>**E** Tunnel diode.<br>**F** Transistor for RF applications (thermal resistance between crystal and mounting base more than 15°C/W).<br>**G** Multiple of dissimilar devices.†<br>**H** Field probe.<br>**K** Hall generator in an open magnetic circuit, e.g. magnetogram or signal probe.<br>**L** Power transistor for RF applications (thermal resistance between crystal and mounting base equal to or less than 15°C/W).<br>**M** Hall generator in a closed, electrically energized magnetic circuit, e.g., Hall modulator or multiplier.<br>**P** Radiation-sensitive device.<br>**Q** Radiation-generating device.<br>**R** Electrically triggered controlling and switching device having a breakdown characteristic (thermal resistance between the crystal and mounting base more than 15°C/W).<br>**S** Transistor for switching applications (thermal resistance between crystal and mounting base more than 15°C/W).<br>**T** Electrically, or by means of light, triggered controlling and switching power device having a breakdown characteristic (thermal resistance between crystal and mounting base equal to or less than 15°C/W).<br>**U** Power transistor for switching applications (thermal resistance equal to or less than 15°C/W).<br>**X** Multiplier diode, e.g. varactor, step recovery diode.<br>**Y** Rectifying diode, booster diode, efficiency diode.<br>**Z** Voltage reference or voltage regulator diode. | Three figures for semiconductor devices designed for use primarily in consumer goods.<br>One letter and two figures for semiconductor devices designed for use primarily in professional equipment. |

*Germanium small-signal diode (either detection, high speed or mixer) for use in consumer equipment.

†A multiple device is defined as a combination of similar or dissimilar active devices, contained in a common encapsulation that cannot be dismantled, and of which all electrodes of the individual devices are accessible from the outside.
Multiples of similar devices as well as multiples consisting of a main device and an auxiliary device are designated according to the code for discrete devices described above.
Multiples of dissimilar devices of other nature are designated by the second letter G.

# Special code for rectifiers and thyristors.

BYY99-100R*

BTY99-100R

| Basic part of the type designation | Rated maximum value of the repetitive peak reverse voltage in volts | Polarity |
|---|---|---|
| Assigned in accordance with the code described in Table 1. | In case of thyristors the rated maximum value of the repetitive peak reverse voltage in volts or the repetitive peak off-state voltage, whichever value is lower. | Normal polarity, which is with cathode connected to case, and symmetrical executions are not specially indicated.<br>Reverse polarity, which is with anode connected to case, is indicated by the letter R. |

*Silicon diodes, a rectifier in the case of the "BY" and a thyristor in the case of the "BT," for use in professional equipment. Both have 100-volt PRV and reverse polarity.

(**coding scheme,** *continued*)

to adopt it as they go into off-the-shelf microcircuit production, according to Haantjes.

European engineers and European representatives of U.S. firms expressed mixed feelings about the new coding system.

Interviews at the International Electronic Components Exhibition, held in Paris April 5-10, indicated that the European design engineer appreciates the meaningful coding of devices. Several years of using the U.S. system, however, has accustomed him to dealing with the serial registration numbering of devices. He feels that the much better data supplied by U.S. firms than European or Japanese suppliers, particularly in the form of application notes, partly compensates for the system's shortcomings. He would welcome the application of the European code to U.S. devices, but a still different code would lead to too much confusion.

European representatives of U.S. firms are generally satisfied with JEDEC numbers, 1N and 2N designations: there has been little recoding of devices for the European market. The fine job done by JEDEC in getting uniformity of characteristics for devices with the same type number from different manufacturers was praised. Two devices with the same numbers from two different European manufacturers may be quite different, they said.

Meanwhile, the EIA committees on microelectronics have settled on the 6N system for all integrated devices. There has been considerable agitation over the past year for at least the addition of a 7N designation for nondigital microcircuits, according to C. E. Coon, EIA staff engineer for active devices. Contacted in Washington, he said that this possibility was rejected early this month. Among the many reasons for this, he explained, is the problem of where to put devices such as A-D converters and future LSI chips that include both analog and digital circuits. The decision was reached by the EIA's MED-2 committee (Microelectronic Devices) and approved by the seven member MED Engineering Panel. This panel, which includes representatives of manufacturers of semiconductors, parts and government products, voted unanimously against expanding the 6N system, according to Coon.

The formation of the newly constituted Pro Electron group in Brussels was undertaken for two main reasons. When the Luxembourg group was started, it was split into founding members and normal members. Since the founding members carried more weight in the organization, manufacturers who joined later were dissatisfied with their weaker position. The new group has only normal members, all with an equal voice in decisions. The previous organization registered only devices from member companies, so some European devices went unregistered. The new Brussels group will register devices from nonmember firms as well. The address of the new organization is:

Association Internationale à But
Scientifique, Pro Electron,
10, Avenue Hamoir,
Brussels 18,
Belgium. ■ ■

**Reference:**

1. W. A. Rheinfelder, "Why Not Sensible Coding for Transistors?" ELECTRONIC DESIGN, XII, No. 23 (Nov. 9, 1964), 64-69.

---

# Air Force gyro: a nimble thimble

**The DART gyro** for aerospace use.

The Air Force has developed a hardy gyro the size of a thimble.

The gyro is relatively insensitive to shock, yet it can measure a wide range of angular velocities from one revolution an hour to 78 a minute. It is for use in stabilizing aircraft, missiles and spacecraft.

Called DART (Dual Axis Rate Transducer) the new gyro is a result of collaboration between the Air Force's Materials Laboratory and its Flight Dynamics Laboratory.

The heart of the DART is a half-inch sphere, filled with mercury, and an assembly of piezoelectric crystal sensing rods. When the vehicle accelerates, the mercury presses against the rods and a voltage appears across their length. The sphere rotates on ball bearings at 24,000 rpm. This rotation is sustained by a tiny electric motor, mounted in the gyro case. ■ ■

## On the beam at Expo

**An infrared light beam** carries data between an IBM System/360 computer in the Canadian Government pavilion at Expo 67 and a receiving unit and graphic display terminal (above) in the Man the Producer pavilion half a mile away. The path of the beam has been simulated by photographic retouching.

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| 1208 | 6.95 to 11.0 |
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| 1509 | 10.0 to 15.5 |
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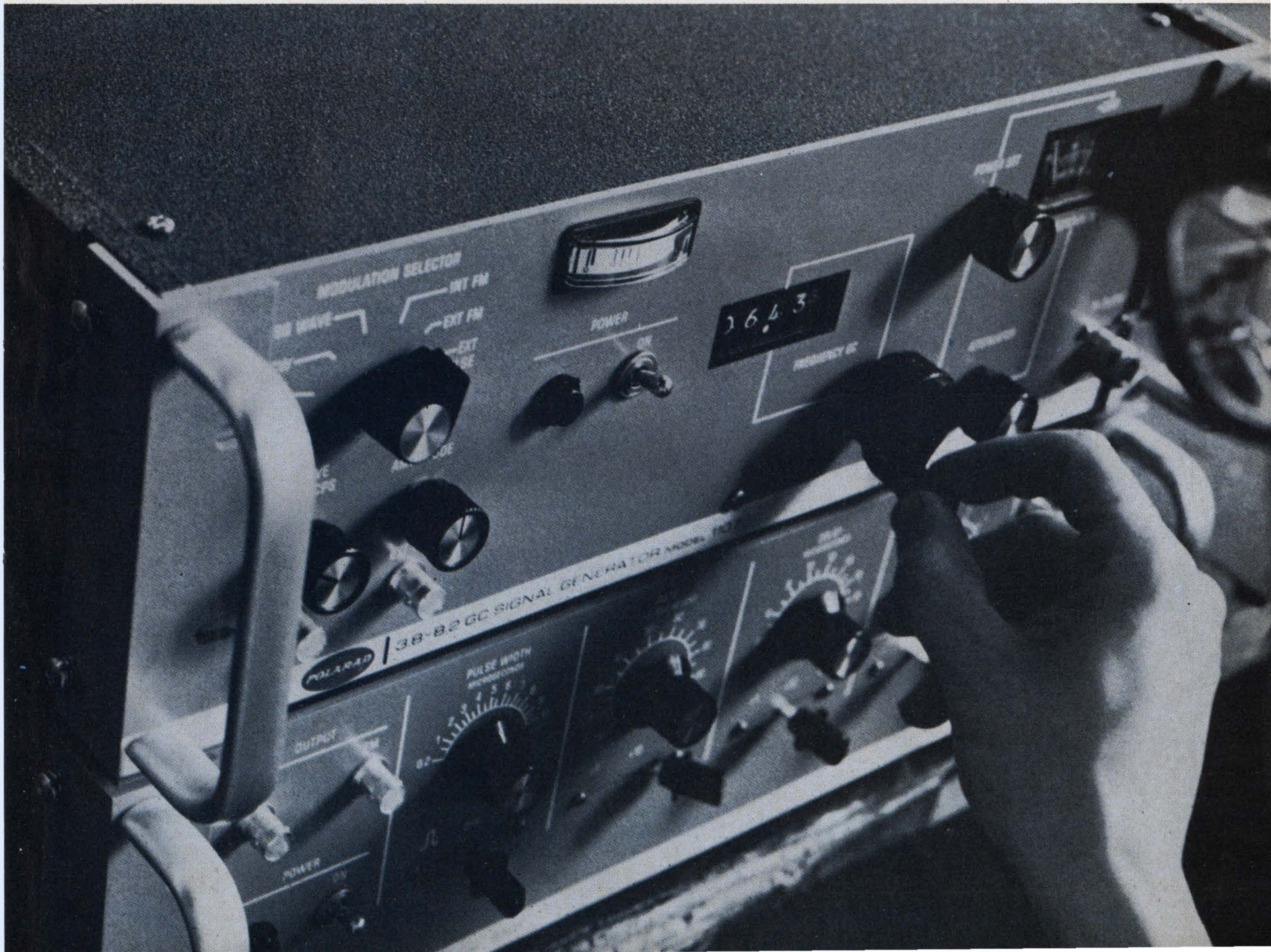


# Input for a computer: A pen and transparent table

Hand-drawn information can be converted easily for computer storage and processing with a new computer input system. The operator merely marks the information with an electronic pen on a transparent conductive plate, and the system converts the result to digital and analog signals.

Reported to operate more simply than other graphic input devices, it depends on phase detection to convert the written information to electronic data.

A development of the Applied Research Laboratory of Sylvania's Electronic Systems Div., Waltham, Mass., the electronic "note pad" permits the operator to work directly on an oscilloscope face or to trace directly over maps or drawings. The transparent tablet eliminates the guess work in locating precise coordinates. The ball point pen can make permanent copies on translucent paper.

The Rand tablet, another input device, uses an opaque surface that cannot be used for tracing. If a correction on a CRT face is desired, the operator must, by trial and error, find the corresponding point on the display before he can make the change.

The light pen, on the other hand, calls for more complex circuitry than either the Rand or Sylvania tablet, and it does not give the operator a copy of his drawing.

The writing area in the Sylvania system is a conductive surface with ac fields across the x (horizontal) and y (vertical) directions. As the pen passes over the writing surface, its position is sampled 200 times a second, by measurement of the phase of the x and y signals corresponding to the pen's position.

Sylvania engineers say that the phase-detection technique is less susceptible to error than earlier voltage-gradient-surface stylus and capacitance-surface stylus techniques. They say that pen movements as small as 0.003 inch can be measured.

In addition to the x and y measurements, the system has a z-axis capability. Variations in the height of the pen above the tablet will produce differences in the z digital output that can be used to introduce additional data to the computer.

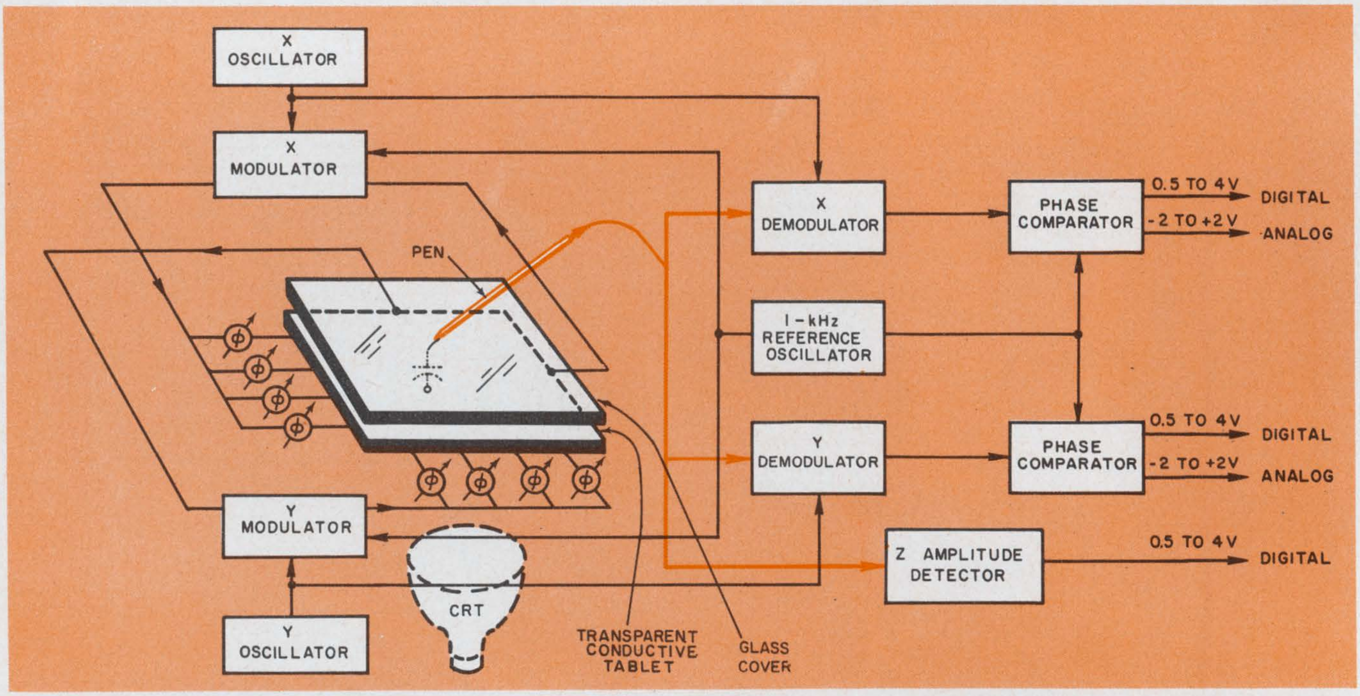
Sylvania says its system can be used with military command and control equipment, machine-aided design displays, training devices and for the reduction and processing of maps and charts.

The system has a transparent conductive film that is sandwiched between transparent glass sheets. Signals of about 100 kHz are introduced across the 11-by-11-inch writing surface at points along the edges of the tablet.

Time-varying modulating signals of 1 kHz are impressed on the 100-KHz signal at the input points. Coordinate information at any point on the surface is obtained by detecting the phases of the signals at that point. Signals are sensed by the pen through its capacitive coupling with the tablet surface.

Both digital and analog outputs are available simultaneously from the x and y axes; only digital information is available from the z axis.

Digital output in x and y, encoded as 12-bit words, are updated every 5 ms. Three bits of z-axis information are available. ■ ■



**Computer graphical input system** uses an electronic pen and a transparent conductive tablet. The pen makes capacitive contact with the conductive layer, and its coordinates are sampled 200 times a second by means of a phase detection technique. Both analog and digital output are available.

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# Semiconductors

## NEW IDEAS IN APPLICATION AND DESIGN

### ■ ACCURACY UP, RFI DOWN WITH GE'S NEW LOW-COST A-C POWER CONTROL MODULE

"Zero-voltage switching" is the key. GE's new S200 synchronous switch power control provides much lower RFI levels than are possible with electromechanical thermostats or phase-controlled semiconductors. And it has high accuracy with control point repeatability better than ±0.5% of sensor resistance. Keys to this high performance are a monolithic integrated firing circuit and a Triac power control device. Its user need only provide power, a resistive load (such as a resistance heater), a variable resistance sensor and a reference control resistor.

Potential uses include any resistive load application where a-c power control is needed. S200 power control modules are available in ratings of 10 and 15 amps RMS, at 120, 240 and 227 volts RMS, 50 to 60 Hz, for controlling resistive loads up to 4150 W. Use with General Electric's new Man-Made® diamond thermistor permits sensing and control of temperatures to 450 C. Housing dimensions of the S200 power control module are roughly $1\frac{1}{16}$ by $2\frac{1}{8}$ by $3\frac{1}{8}$ inches.

Circle **Number 811** for full details on these new GE power control modules.

### ■ NEW ECONOMY POWER TRANSISTOR

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  20 min. at 400 mA, 1 V
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- $V_{CE(SAT)}$... 0.05 typical
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Other characteristics closely match those of the 2N3414-17.

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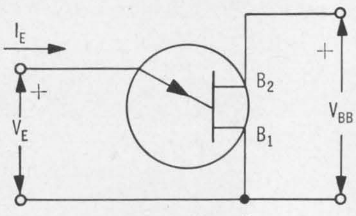
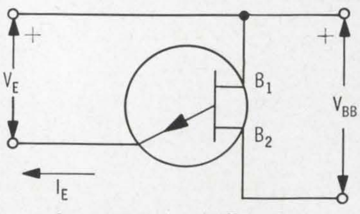


Standard unijunction



Complementary unijunction

### Introducing the Complementary UJT for Improved Stability and Accuracy in Oscillator and Timer Circuits

It's an entirely new kind of unijunction called the D5K. General Electric's D5K has superior temperature stability and product uniformity through utilization of planar processing techniques. Its characteristics are like those of a standard unijunction transistor except that the currents and voltages applied to it are of opposite polarity.

With GE's D5K you can build oscillator and timer circuits with better than 0.5% accuracy from —40 to +120C. Its intrinsic stand-off ratio ($\eta$) is just 0.58-0.62 or ±3%. You save test costs by determining your best compensating resistor for temperature stability **at room temperature.** And the D5K gives you a low base 1 to emitter voltage drop at high current . . . permits generation of high output pulses with low base-to-base voltages.

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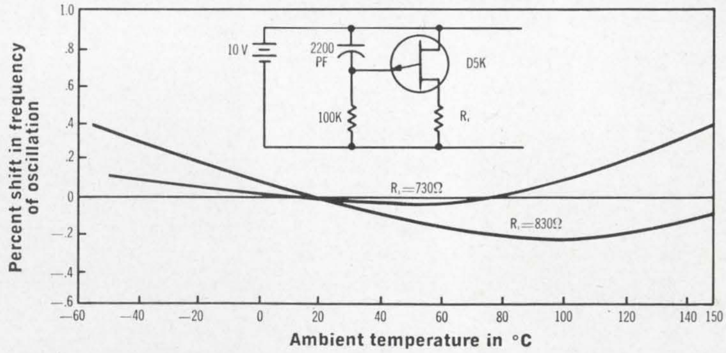

**Frequency stability demonstrated by relaxation oscillator test circuit (CUJT only subjected to temperature change.)**

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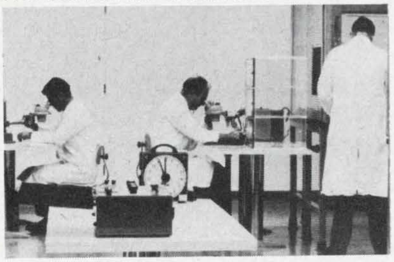
**GENERAL ELECTRIC**

220-55

# Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR



The search for talent is chronic

## Hiring of aliens urged

Is there a shortage of scientists and engineers in the United States? Acting Commerce Secretary Alexander Trowbridge says there is. As a result, Senator Warren G. Magnuson (D-Wash.) has introduced a bill that would permit the Commerce Dept. to hire aliens in scientific or technical capacities when U.S. citizens with the needed skills could not be found.

Trowbridge has told Magnuson that a number of times Commerce Dept. agencies engaged in scientific or technical work "have found that the only persons qualified and available for certain highly specialized positions are not citizens of the United States." In general, only U.S. citizens can be paid with Federal funds, although many exceptions are made.

A significant assertion by Trowbridge—one that swings considerable weight in recurrent argument over whether there is a shortage of scientists and engineers—is this passage from his letter to Magnuson: "The need to utilize the services of these talented foreigners is due in part to the general shortage of scientists and engineers in this country."

But more important to the Commerce Dept. right now is "the fact that some of the department's technical programs are outside the popular, or currently fashionable, areas of modern science, and therefore are not particularly attractive to American students and scientists." Trowbridge cites as an example the difficulty that the National Bureau of Standards has had for several years in recruiting physicists trained in atomic spectroscopy. The lack of trained Americans, combined with the increasing demands on the bureau for precise data on atomic properties obtainable only through spectroscopic studies, have created a near crisis, according to Trowbridge. He points out that the information is essential in interpreting astrophysical data associated with the space program; in measuring and understanding plasmas in thermonuclear fusion research, and in furthering our grasp of rocket propulsion. Yet, he says, present law prohibits hiring atomic spectroscopists from Sweden, where large numbers have been trained.

The Acting Secretary says similar problems exist in applied mathematics and numerical analysis, and in such undertakings as the Weather Bureau's atmospheric ozone study program and the Bureau of Standards' oceanography program. He says the requested law would not jeopardize U.S. scientists and engineers, because it would require an unsuccessful search of the various talent rosters before an alien could be hired. Further, Trowbridge points out, such organizations as the Smithsonian Institution, NASA, the Defense Dept. and Agriculture Dept. already have authority to hire non-citizen scientists and engineers under compelling circumstances.

The bill (S. 1663) has White House support. However, a staff member of the Senate Commerce Committee, which will conduct the hearings, wondered aloud what the State Dept. would have to say about its "brain drain" implications.

## Computer supply setup criticized

The Army's new computer-based Pacific supply system is largely useless at present, the General Accounting Office has concluded after a year's review. The watchdog arm of Congress says, however, that it's the Army supply system—not the computers—that is at fault. Comptroller General Elmer B. Staats says he is not recommending abandonment of the computers, because "they are essential for effective management of large inventories and great numbers of supply transactions." However, he reports, they won't do the Army any good until the basic supply system and the data fed to the computers are improved.

These conclusions represent a major rewrite of the General Accounting Office report from its draft form, which did not differentiate as clearly between computer failings and Army failings. In its earlier form, computer industry representatives in Washington felt, the report could have given large computer-based systems a black eye and might have cost the industry several years in its efforts to win new Government business. Investigators found two chief reasons behind the alleged failure of the Pacific system. One is that "inventory procedures were not adequate to insure accuracy of inventory and warehouse location records." The other is that "management practices led to excesses of some supply items and critical shortages of others." The report says the Army failed to prepare for installation of its computers by correcting long-standing supply-management problems and by adapting the operation to data processing. Even after more than a year of operation with the computers, the Government study team found, a large percentage of Pacific supply transactions could not be processed routinely by computers; they still had to be researched, edited and reprocessed manually, just as in the old days.

Under a contract to scrutinize the system and suggest changes, the Computer Science Corp. made some short-term improvements. However, according to the Comptroller General, the Army found it was in such bad shape that it had to rewrite its contract with Computer Science, at a cost of $1.6 million, to redesign the entire system. The system consists of four computer sites. Three batteries of computers are at each. At the Army's Pacific headquarters in Hawaii, the groupings are: IBM 7010-100K/7010-80K; IBM 1460/1401C/1401E; IBM 1302-2/1302-2/1302-1. At other points, the computers used, all IBM, are 7010, 1460, 1302-2 and 1410 in groupings less sophisticated than those on Hawaii. The annual rental fee for the supply system is about $2.5 million. In addition, General Accounting Office figures, the Army owns and maintains equipment that would amount to about $600,000 in annual rental at current rates.

## Needed: A sonic boom silencer

Transportation Secretary Alan Boyd has indicated a sometimes-overlooked role for the electronics industry in the planned SST (supersonic transport) development program. The ultra-high-speed craft obviously will require new navigation and collision-avoidance electronics that the industry already has discussed. But Boyd is publicly indicating research programs in the offing, aimed at reducing sonic boom. A Federal Aviation Administration official admits that the FAA has no concrete ideas on how such an apparent natural phenomenon as a sonic boom might be curtailed, but he assumes early approaches will center on electronics. At the very least, he told ELECTRONIC DESIGN, the mere studying of sonic booms will be an electronics research project.

## Electronic maintenance codified

The struggle of maintenance departments to keep up with galloping progress in electronic equipment is no less a problem for Government than it is for industry. Various approaches of Government agencies to meet this problem have been brought together in one publication that the Commerce Dept. is offering to industry. Ten maintenance concepts, described as new, have been analyzed for the Army by E. L. Shriver and R. C. Trexler of the Human Resources Research Office of George Washington University.

The research team attempted to identify the common elements of the 10 maintenance concepts and to indicate which aspects of each might be combined to fit new situations. One common element discovered was that of having experts generate trouble-shooting strategy rather than attempting to give each maintenance trainee sufficient technical background to generate his own strategy. According to the researchers, all of the concepts can reduce trouble-shooting time and can result in a higher degree of success in finding the causes of trouble, compared with conventional approaches.

In the Human Resources Research Office publication, an analysis of a system is followed by samples of the instructions and graphics used in the system. The publication, "A Description and Analytic Discussion of Ten New Concepts for Electronics Maintenance," is available at $3 (65¢ in microfiche) from the Commerce Dept. Clearinghouse, Springfield, Va. 22151. Order AD-647-229.

Among the concepts discussed are FORECAST, JOBTRAIN and MAINTRAIN, developed by the Human Resources Research Office; BAMAGAT, the trademark of a system developed by the Hughes Aircraft Co. and MDS (Maintenance Data System), which is under development by Bell Telephone Laboratories.

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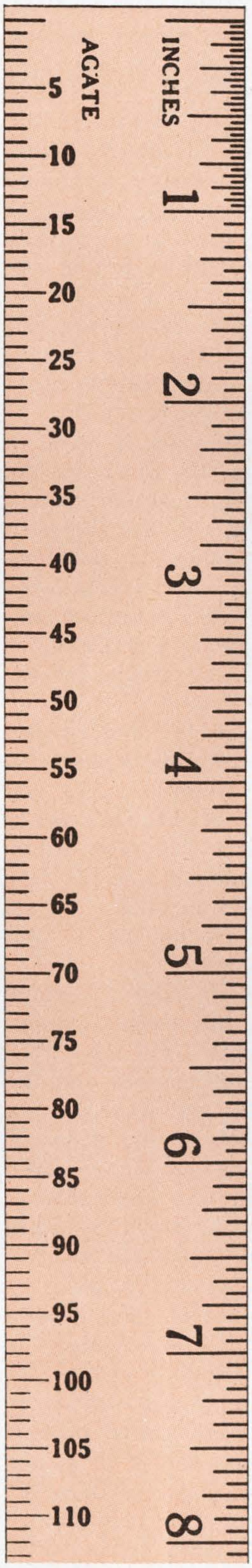

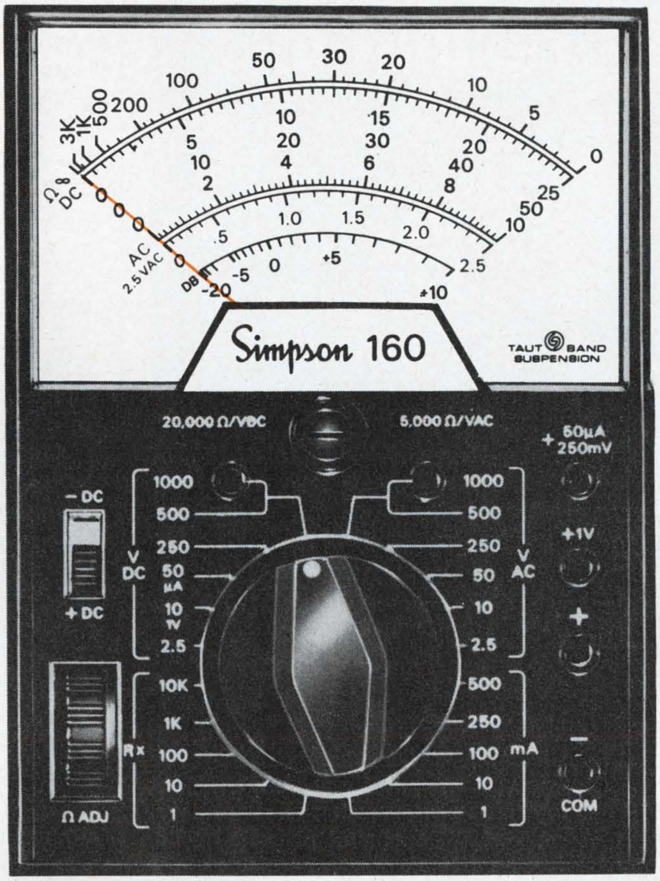

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DC MICROAMPERES: 0-50

DC MILLIAMPERES: 0-1, 10, 100, 500

DB: −20 to +10, −8 to +22, +6 to +36, +20 to +50

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WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT

ON READER-SERVICE CARD CIRCLE 17

# Rugged mirrors lift $CO_2$ laser's output

A multilayer film deposited on germanium makes almost lossless, rugged reflectors for $CO_2$ laser systems.

Philip Heinrich, president of Laser Optics, Inc., Danbury, Conn., where the new coating technique was developed, says that lasers that formerly delivered 100 watts now put out 150 to 170 with the new reflectors.

He declined to reveal the material of the film, except that it is an unusual one, and "competitors would not be able to analyze it readily."

Vacuum evaporation is used to deposit the film. He considers the control of the critical parameters during deposition the key factor in achieving the improved performance. His list of factors includes the temperature of the germanium substrate, the evaporation rate and the composition of the residual background gases.

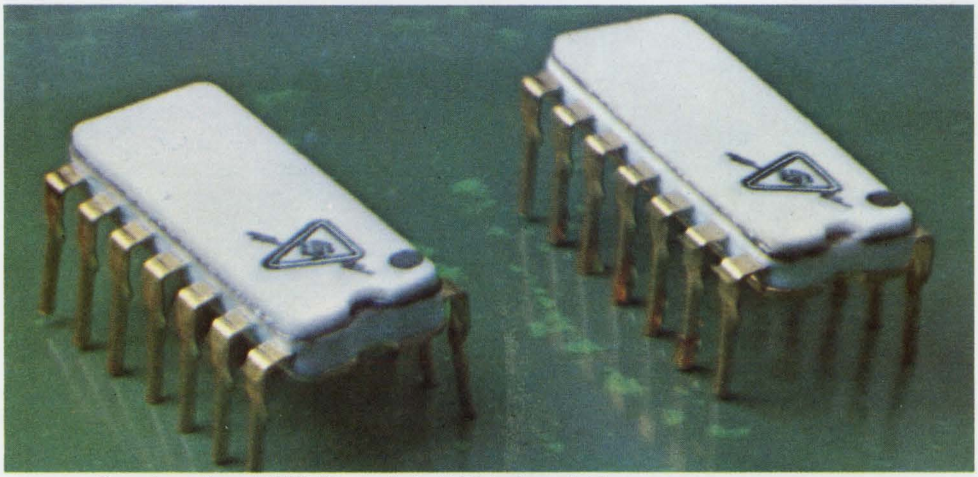
"Our aim was to combine low loss with durability and stability in the reflectors," Heinrich says, "and we did it. The loss of the mirrors is about 0.3%, and they are waterproof, resist acids and tolerate wide temperature ranges—like from room temperature to 250°C and back in 15 seconds."

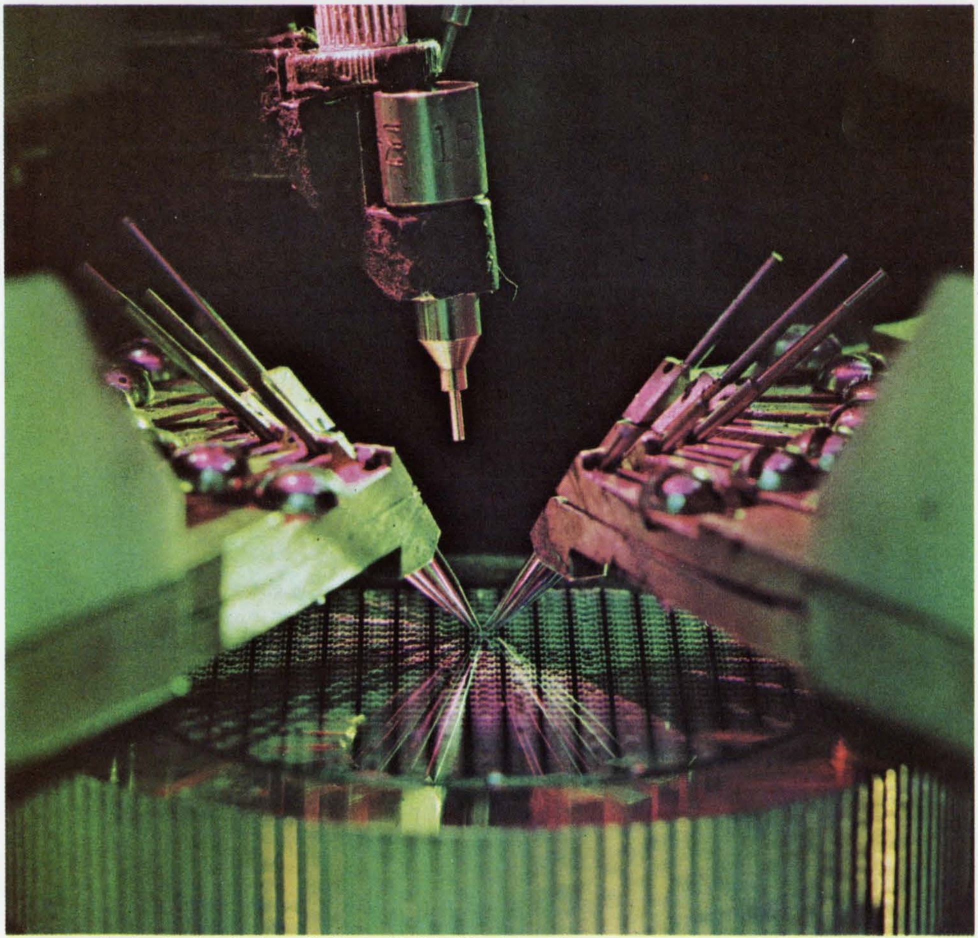
The technique is said to combine the two major advantages of conventional mirror coatings: the ruggedness of germanium and the low loss of NaCl and BaFl. But in conventional designs, the losses of germanium hover around 2%, and NaCl and BaFl are water-soluble, so that on a humid day, the failure of an air-conditioner can be ruinous.

Encouraged by its success with the $CO_2$ laser, Laser Optics is working on a reflecting system for ruby lasers. As radar or range finders, ruby lasers should provide high pulse rates and high power levels, but the high energy densities and the resulting rapid temperature rise (several hundred °C in $10^{-6}$s) explode the available film systems. Heinrich's aim is to find materials for lasers that have up to 50 MW output power and 10 or more pulses per second. ■ ■

Integrated Circuit IDEAS
SYLVANIA
Electronic Components Group

## Sylvania's ceramic-pack ICs, for unexceeded reliability


Ceramic-packaged SUHL ICs use fastest TTL logic available.


Mechanized wafer-level testing with this 14-point probe.

**Sylvania's ceramic-packaged TTL integrated circuits provide greater reliability and higher performance levels.**

Ceramic packaging offers the finest environmental protection for integrated circuits. Therefore, the ICs operate at peak design efficiency since the package insures that the circuits are never exposed to moisture or other performance degrading environments. Also, consistent reliable operation under varying temperatures is assured because all parts of Sylvania's package, including the IC chip, have matched temperature coefficients of expansion.

But reliable operation depends on more than an excellent package; a good logic approach, a properly designed semiconductor chip, precisely controlled manufacturing, proper testing, quality auditing and a continuous reliability improvement program assure high reliability.

All Sylvania integrated circuits

*(Continued)*

### This issue in capsule

(Continued)

go through extensive testing during and after manufacturing. Once packaged, they are thermally and mechanically stressed, then tested for hermeticity. After a high-temperature stabilization period, they are ready to be tested for static and dynamic characteristics by "MR. ATOMIC", Sylvania's automatic IC tester.

Additional quality checks on each IC lot supplement the 100 percent testing program.

Typical of the continuing effort devoted to reliability improvement is an extensive wire bonding program just completed. The result was an improved ultrasonic bonding process. In the first tests of this new technique, over 1200 ICs were subjected to accelerated temperature cycling from −65°C to 200°C for 400 cycles. The result: out of 16,800 connections, only one bond on one circuit failed. That's high reliability!

CIRCLE NUMBER 300

## You can customize SUHL performance by tailoring the supply voltage

Designers can't always use ICs at their rated supply voltage. Here's what you gain (and lose) when SUHL™ circuits are not operated at their nominal value.

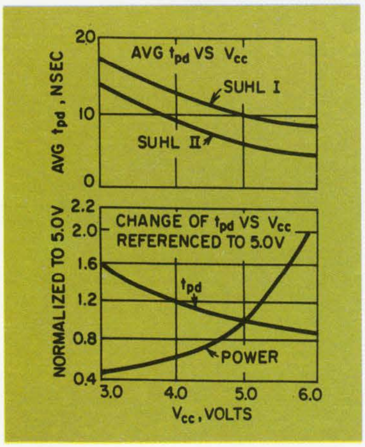
SUHL integrated circuits by Sylvania provide maximum speed, highest noise immunity, greatest fan-out with a minimum of power. To accomplish this, a 5.0 volt nominal power supply is needed for proper drive to the outputs in the "0" state and for a high logic "1" for negative noise immunity.

SUHL devices are designed for power supply variations of ±10% retaining good circuit performance over the range of 4.5 to 5.5 volts.

Below 4.5 V the performance, speed and noise immunity are degraded, particularly at low temperatures. Supplies larger than 5.5 volts may be used with a resultant increase in speed and an increase in negative noise immunity, but this causes a disproportionate increase in power consumption. Supply voltages greater than 6.0 V are not recommended for normal operation. The increased power causes an internal temperature rise of about 0.3°C/mW in free air. This temperature rise degrades the positive noise immunity about 4mW/°C, or 1.2mV/mW. A higher power supply of 6.0 would normally have a tolerance of ±10% which would cause even greater degradation.

The degradation is not in the junctions or in reliability, but in a heating effect which restricts logical performance. This is the reason for the maximum supply voltage rating of 8.0 V and a maximum operating supply voltage of 4.5 to 6.0 V. At 8.0 V, the circuits are not destroyed but probably won't operate logically.

The best results are obtained by keeping within the optimum design value for the power supply, 5.0 to 5.25 volts.



CIRCLE NUMBER 301

## If the problem can be solved with flip-flops, Sylvania has the solution

What can designers do with Sylvania's line of TTL flip-flops? They can implement just about any circuit function calling for flip-flops.

Because Sylvania has the most flexible line of TTL flip-flops, designers are finding it easier to solve a host of circuit problems. They can choose from many flip-flop types—SR, two-phase SR, single-phase SRT, J-Ks with AND inputs, J-Ks with OR inputs, dual J-Ks with common or separate clocks. Frequency ratings for these units are as high as 50 MHz. All these flip-flops are available in military or industrial versions, packaged in the TO-85 flat pack or in Sylvania's dual-in-line plug-in pack.

Here are a few typical applications for SUHL™ flip-flops.

The lowest power approach to flip-flop register applications is offered by Sylvania's set-reset SF-10 series (Figure 1). The SF-10 units are useful for a variety of register applications where high speed word transfer is required. In the method illustrated in Figure 1, the reset line clears the central register and permits the clock line to transfer word information from the buffer register.

The SF-20 series of SR clocked flip-flops are particularly useful for application in dual rank or 2-phase systems or as half shift registers. Figure 2 gives the interconnections for a dual rank shift register.

How a synchronous binary counter can be implemented with the SF-30 series of single-phase SRT flip-flops is shown in Figure 3. The SF-30 devices are particularly useful in applications requiring a simple ac coupled flip-flop.

The advantages of multiple J and K inputs are seen in the synchronous binary counter of Figure 4 which uses only four SF-50 series J-K flip-flops. Because gating is internal, this circuit has no external gate delays and counts at 14 MHz. The counting rate can be upped to 38 MHz by using SF-200 flip-flops which otherwise display the same functional characteristics.

Figure 5 shows how OR input J-Ks can be used for parallel to serial conversion. The flip-flops are Sylvania's SF-60 series (14 MHz) or SF-210 (38MHz).

Dual J-Ks with separate clock input terminals for each flip-flop are used in the *high-speed* ripple-type binary counter of Figure 6. This configuration offers both minimum wiring and minimum package count.

You can choose 35 MHz (SF-100 series) or 50 MHz (SF-120 series) devices for this application. These same dual J-K devices are also excellent for systems where multiple J-K flip-flops are needed for separate, unrelated processing activities.

The way that the SF-110 (35 MHz) and SF-130 (50 MHz) dual J-Ks with a common clock can be used in a semi-ripple counter is seen in Figure 7. Decoding rate of this circuit is 25 MHz.

These are just a few of the circuit problems which can be solved effectively and efficiently with the wide range of flip-flops in completely compatible SUHL I and SUHL II.

CIRCLE NUMBER 302

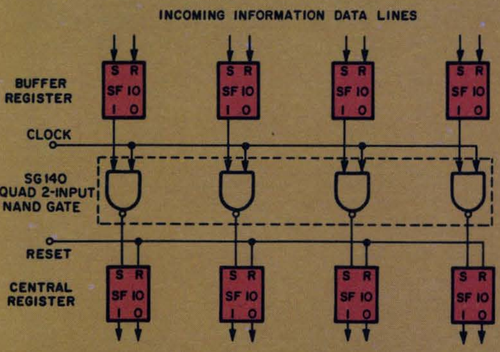


Fig. 1—Flip-flop register application.

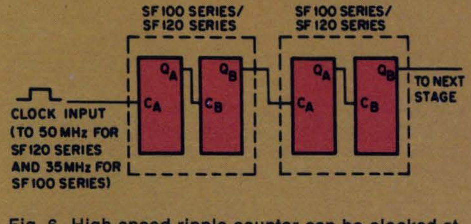


Fig. 6—High-speed ripple counter can be clocked at up to 50 MHz.

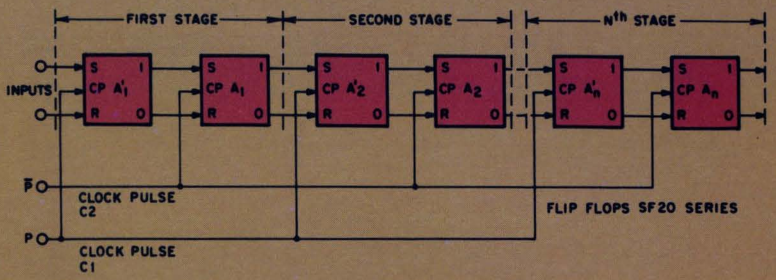


Fig. 2—Shift register—dual rank.

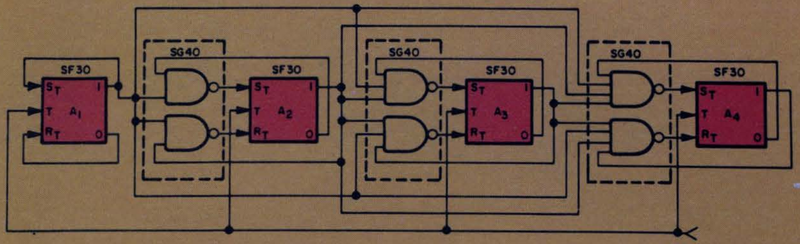


Fig. 3—Synchronous binary counter with SRT flip-flops.

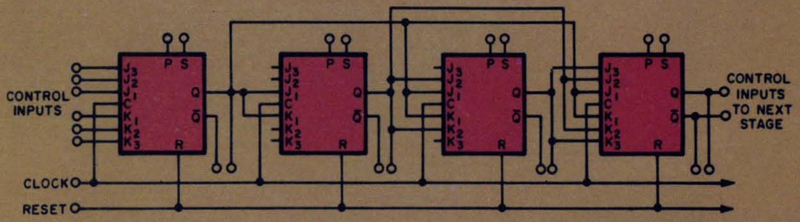


Fig. 4—Synchronous binary counter takes advantage of multiple J and K inputs.

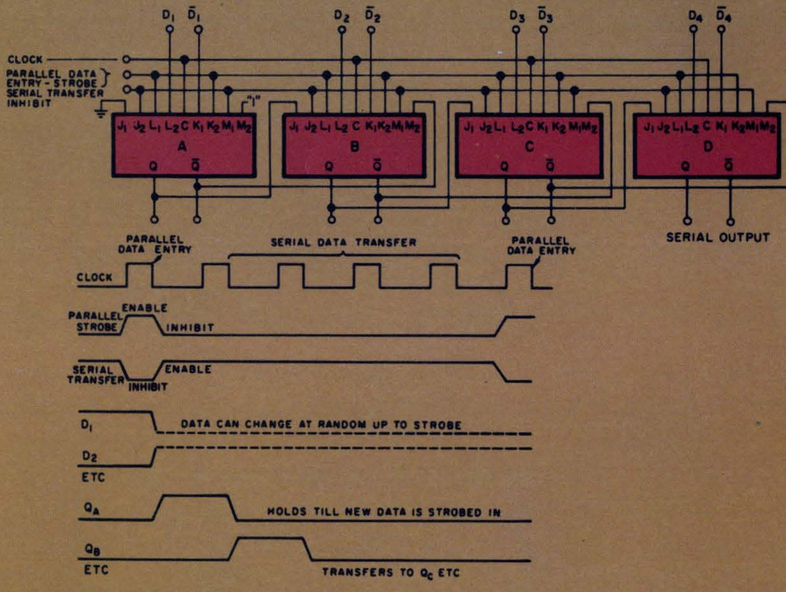


Fig. 5—In parallel to serial converter data is inserted through one set of 0Red inputs on each flip-flop.

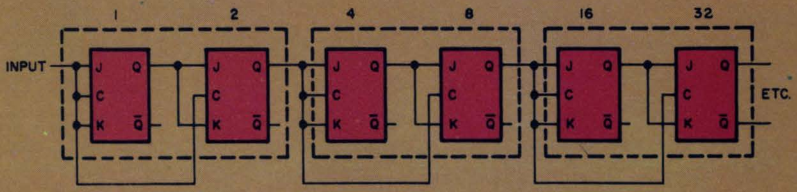


Fig. 7—Semi-ripple counter employs dual J-Ks with common clock.

# 380 circuit types in industry's largest TTL line

| SUHL I TYPICAL CHARACTERISTICS (+25°C, +5.0 Volts)<br>Function | Type Nos. | $t_{pd}$ (nsec) | Avg. Power (mw) | Noise Immunity +(volts) | – | **Military (–55°C to +125°C) Prime FO | Std. FO | **Industrial (0°C to +75°C) Prime FO | Std. FO |
|---|---|---|---|---|---|---|---|---|---|
| **NAND/NOR Gates** | | | | | | | | | |
| Dual 4-Input NAND/NOR Gate | SG-40, SG-41, SG-42, SG-43 | 10 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Single 8-Input NAND/NOR Gate | SG-60, SG-61, SG-62, SG-63 | 12 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Expandable Single 8-Input NAND/NOR Gate | SG-120, SG-121, SG-122, SG-123 | 18 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Dual 4-Input Line Driver | SG-130, SG-131, SG-132, SG-133 | 25 | 30 | 1.1 | 1.5 | 30 | 15 | 24 | 12 |
| Quad 2-Input NAND/NOR Gate | SG-140, SG-141, SG-142, SG-143 | 10 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Triple 2-Input Bus Driver | SG-160, SG-161, SG-162, SG-163 | 15 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Triple 3-Input NAND/NOR Gate | SG-190, SG-191, SG-192, SG-193 | 10 | 15 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| **AND-NOR Gates** | | | | | | | | | |
| Expandable Quad 2-Input OR Gate | SG-50, SG-51, SG-52, SG-53 | 12 | 30 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Expandable Dual Output, Dual 2-Input OR Gate | SG-70, SG-71, SG-72, SG-73 | 12 | 20/gate | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Exclusive-OR with Complement | SG-90, SG-91, SG-92, SG-93 | 11 | 35 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Expandable Triple 3-Input OR Gate | SG-100, SG-101, SG-102, SG-103 | 12 | 25 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Expandable Dual 4-Input OR Gate | SG-110, SG-111, SG-112, SG-113 | 12 | 20 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| **Non-Inverting Gates** | | | | | | | | | |
| Dual Pulse Shaper/Delay-AND Gate | SG-80, SG-81, SG-82, SG-83 | 11 | 30/gate | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Dual 4-Input AND/OR Gate | SG-280, SG-281, SG-282, SG-283 | 11 | 38/gate | 1.0 | 1.5 | 10 | 5 | 8 | 4 |
| **AND Expanders** | | | | | | | | | |
| Dual 4-Input AND Expander | SG-180, SG-181, SG-182, SG-183 | <1 | 0.9/gate | 1.1 | 1.5 | | | | |
| Dual 2 + 3 Input AND/OR Expander | SG-290, SG-291, SG-292, SG-293 | 7 | 15/gate | 1.0 | 1.5 | | | | |
| **OR Expanders** | | | | | | | | | |
| Quad 2-Input OR Expander | SG-150, SG-151, SG-152, SG-153 | 4 | 20 | 1.1 | 1.5 | | | | |
| Dual 4-Input OR Expander | SG-170, SG-171, SG-172, SG-173 | 3 | 5 | 1.1 | 1.5 | | | | |
| **Flip-Flops** | | | | | | | | | |
| Set-Reset Flip-Flop | SF-10, SF-11, SF-12, SF-13 | 20MHz* | 30 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Two Phase SR Clocked Flip-Flop | SF-20, SF-21, SF-22, SF-23 | 20MHz* | 30 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Single Phase SRT Flip-Flop | SF-30, SF-31, SF-32, SF-33 | 15MHz* | 30 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| J-K Flip-Flop (AND Inputs) | SF-50, SF-51, SF-52, SF-53 | 20MHz* | 50 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| J-K Flip-Flop (OR Inputs) | SF-60, SF-61, SF-62, SF-63 | 20MHz* | 55 | 1.1 | 1.5 | 15 | 7 | 12 | 6 |
| Dual 35MHz J-K Flip-Flop (Separate Clock) | SF-100, SF-101, SF-102, SF-103 | 35MHz* | 55/FF | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Dual 35MHz J-K Flip-Flop (Common Clock) | SF-110, SF-111, SF-112, SF-113 | 35MHz* | 55/FF | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| SUHL II TYPICAL CHARACTERISTICS (+25°C, +5.0 Volts) | | | | | | | | | |
| **NAND/NOR Gates** | | | | | | | | | |
| Expandable Single 8-Input NAND/NOR Gate | SG-200, SG-201, SG-202, SG-203 | 8 | 22 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Quad 2-Input NAND/NOR Gate | SG-220, SG-221, SG-222, SG-223 | 6 | 22 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Dual 4-Input NAND/NOR Gate | SG-240, SG-241, SG-242, SG-243 | 6 | 22 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Single 8-Input NAND/NOR Gate | SG-260, SG-261, SG-262, SG-263 | 8 | 22 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| **AND-NOR Gates** | | | | | | | | | |
| Expandable Dual 4-Input OR Gate | SG-210, SG-211, SG-212, SG-213 | 7 | 30 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Expandable Quad 2-Input OR Gate | SG-250, SG-251, SG-252, SG-253 | 7.5 | 43 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Expandable Triple 3-Input OR Gate | SG-300, SG-301, SG-302, SG-303 | 7 | 36 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Expandable Dual Output Dual 2-Input OR Gate | SG-310, SG-311, SG-312, SG-313 | 7 | 30/gate | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| **AND Expanders** | | | | | | | | | |
| Dual 4-Input AND Expander | SG-180, SG-181, SG-182, SG-183 | <1 | 0.9/gate | 1.1 | 1.5 | | | | |
| **OR Expanders** | | | | | | | | | |
| Quad 2-Input OR Expander | SG-230, SG-231, SG-232, SG-233 | 2 | 28 | 1.0 | | | | | |
| Dual 4-Input OR Expander | SG-270, SG-271, SG-272, SG-273 | 2 | 6.7 | 1.0 | 1.5 | | | | |
| **Flip-Flops** | | | | | | | | | |
| Dual 50 MHz J-K Flip-Flop (Separate Clock) | SF-120, SF-121, SF-122, SF-123 | 50MHz* | 55/FF | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| Dual 50MHz J-K Flip-Flop (Common Clock) | SF-130, SF-131, SF-132, SF-133 | 50MHz* | 55/FF | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| 50MHz J-K Flip-Flop (AND Inputs) | SF-200, SF-201, SF-202, SF-203 | 50MHz* | 55 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |
| 50MHz J-K Flip-Flop (OR Inputs) | SF-210, SF-211, SF-212, SF-213 | 50MHz* | 55 | 1.0 | 1.5 | 11 | 6 | 9 | 5 |

| FUNCTIONAL ARRAYS, TYPICAL CHARACTERISTICS (+25°C, + 5.0 Volts)<br>Function | Type Nos. | $t_{pd}$ (nsec) | Avg. Power (mw) | Noise Immunity +(volts) | – | **Military (–55°C to +125°C) Prime FO | Std. FO | **Industrial (0°C to +75°C) Prime FO | Std. FO |
|---|---|---|---|---|---|---|---|---|---|
| Full Adder | SM-10, SM-11, SM-12, SM-13 | sum 22 carry 10 | 90 | 1.0 | 1.0 | 20 | 10 | 20 | 10 |
| Dependent Carry Fast Adder | SM-20, SM-21, SM-22, SM-23 | sum 22 carry 10 | 125 | 1.0 | 1.0 | 20 | 10 | 20 | 10 |
| Independent Carry Fast Adder | SM-30, SM-31, SM-32, SM-33 | sum 22 carry 10 | 125 | 1.0 | 1.0 | 20 | 10 | 20 | 10 |
| Carry Decoder | SM-40, SM-41, SM-42, SM-43 | 2 | 25 | 1.0 | 1.0 | | | | |
| Decade Frequency Divider | SM-50, SM-52 | 30 MHz | 120 | 1.0 | 1.0 | 15 | | 15 | |
| Four Bit Storage Register Bus Transfer Output | SM-60, SM-61, SM-62, SM-63 | 20 | 30/bit | 1.0 | 1.0 | 20 | 10 | 20 | 10 |
| Four Bit Storage Register Cascade Pullup Output | SM-70, SM-71, SM-72, SM-73 | 20 | 30/bit | 1.0 | 1.0 | 20 | 10 | 20 | 10 |
| 16-Bit Scratch Pad Memory | SM-80, SM-81, SM-82, SM-83 | 25 | 250 | 1.0 | 1.0 | 40 | 20 | 40 | 10 |

*Minimum toggle frequency **Minimum fan-out

CIRCLE NUMBER 303

# The performance you ask for, assured by MR. ATOMIC

IC users expect to get the performance they specify. This means every IC made by Sylvania undergoes extensive dynamic testing before delivery.

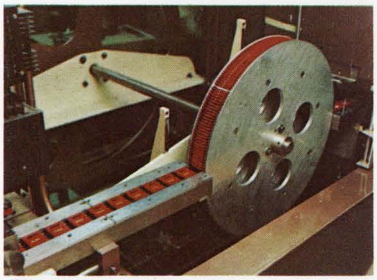
At Sylvania, a unique IC tester called MR. ATOMIC permits comprehensive and accurate testing of every integrated circuit produced, and it does this with complete assurance that each individual test has been precisely performed. Hence, all possibility of human error has been eliminated.

MR. ATOMIC (Multiple Rapid Automatic Test Of Monolithic Integrated Circuits) includes four temperature controlled dc test chambers, one each for +75°C, 0°C, +125°C, and −55°C, as well as a 25°C switching station. This tester features automatic mechanical feed and precise control by a digital process computer and magnetic drum memory.

Prior to testing, individual circuits in special plastic pallets are stack-loaded into MR. ATOMIC'S dispensing rack, which automatically dispenses a new circuit to the tester every two seconds. As each IC enters the first control chamber (75°C ambient temperature), it is automatically inserted into a large rotary holding device which moves the circuit to the test position. Holder and chamber are designed to insure that the time required for the IC to travel the 180 degrees to the test position is such that the entire device (chip, case and junction) has stabilized at the test temperature.

The test probe block for the IC package is arranged so that two probes make contact with each lead on the package. One probe performs the actual testing; the other is a sensing probe which allows MR. ATOMIC to determine that electrical contact has indeed been established with each lead. Any IC failing the contact sensing test at any test station is automatically sorted into a special bin for retesting.

Once electrical contact has been verified for all 14 leads, up to 100 parameters are checked at the rate of 17 milliseconds per test. The result of each test is stored in the computer memory for use in final circuit sorting.



Fifth testing station tests 30 switching parameters at 25°C.

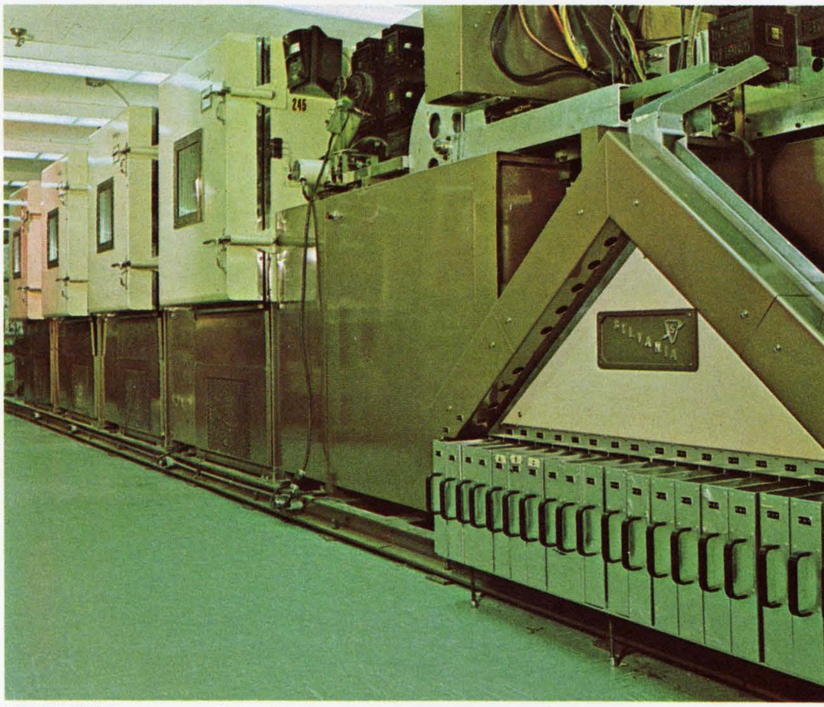
After the first chamber tests are completed, each IC is fed automatically to the second, third and fourth chambers where it is tested at 0°C, +125°C, and −55°C respectively. Again, the result of each test at each temperature is stored in the computer memory.

After completion of the dc tests, the IC moves to the fifth test station where dynamic switching tests are performed at 25°C. Here, as in dc testing, the integrated circuit is "worst case" tested for switching performance. Rise time ($t_r$), fall time ($t_f$), turn on delay ($t_{on}$), and turn off delay ($t_{off}$) are verified to the specification for each IC.

In this test, each input is individually checked through its appropriate gate structure for all parameters. *Each* input is verified; i.e., it is more than testing just one input of a multiple input gate and then assuming that all other inputs will function identically.

After each integrated circuit emerges from the switching test station, the complete history of that integrated circuit's electrical performance, stored in the computer memory, is reviewed and a decision made on sorting it. The package then is automatically placed into one of 20 sort bins where it is stored for packaging for shipment.

CIRCLE NUMBER 304



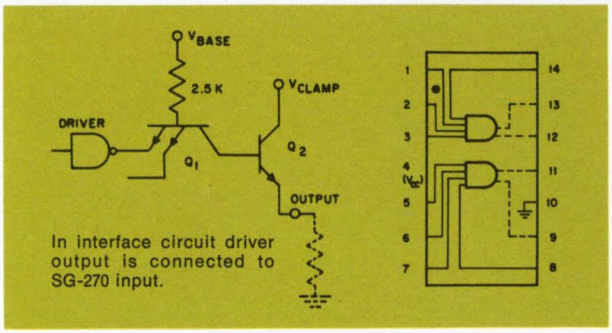
MR. ATOMIC tests each Sylvania IC in four temperature-controlled chambers.

# You can overcome IC interface problems this simple way

There's no need to give up the superior performance of SUHL™ circuits due to logic interface problems. Simple circuits overcome most of these problems.

Often, system requirements make it necessary to interface SUHL devices with other types of logic or other types of circuit functions. This is easily done.

One technique for interfacing SUHL circuits with RTL or other logics with similar restrictions is shown in the Figure. Here, the driving gate (or gates) is connected to the input of an SG-270 dual 4-input OR expander.



In interface circuit driver output is connected to SG-270 input.

When the driver output is at logic "0", $Q_2$ is OFF and the output is at logic "0" (or ground). As the

(Continued)

driver gate output goes to logic "1" (3.2V), the emitter of $Q_2$ follows. When the input of $Q_1$ gets to $V_{clamp} + V_{BE}$ of $Q_2$, the collector-base and base-emitter of $Q_2$ become forward biased and the output is essentially $V_{clamp}$. Further increases in the input have no effect on the output emitter of $Q_2$.

Impedance of the load determines the current in $Q_2$. This current should be no greater than 10 mA, as the transistor is designed to operate at a nominal value of about 5 mA.

To get sufficient drive at the base of $Q_2$, the current through the base resistor of $Q_1$ should be calculated for a beta of 5 for the temperature range of −55°C to +125°C, or a beta of 8 for 0°C to +75°C.

Base drive can be adjusted by the $V_{base}$ supply. For 1 mA drive to the base of $Q_2$:

$$V_{base} = V_{clamp} + 2\ V_{BE} + (2.5\ K\Omega \times 1\ mA)$$

$$\text{or,}\quad V_{base} = V_{clamp} + 2\ V_{BE} + 2.5\ V$$

Since the voltage on the load will be $V_{clamp}$ and the input must rise to $V_{clamp} + V_{BE}$, the maximum clamp voltage using a 5-V supply would be 2.5 volts. When higher clamp voltages are desired, a resistor is tied from the driver gate output to the B+ supply.

CIRCLE NUMBER 305

# An accurate 1-Hz generator doesn't need to be expensive

Here's how to build an inexpensive 1-Hz generator with an accuracy of better than 0.1% and which uses the power line frequency as its input.

A 1-Hz generator can be made with four Sylvania ICs: one SM-50 decade frequency divider and three SF-50 J-K flip-flops. The circuit uses the 60-Hertz line frequency as a P.R.R. control. Since power companies hold the power line frequency between 59.95 and 60.02 Hertz, this results in an accuracy of better than 0.1%.

In the circuit (Figure 1) the 60-Hertz line frequency is fed into the SM-50 and divided by ten. The resulting 6-Hz signal is put into three SF-50s connected in a synchronous divide-by-six configuration, giving an output of 1 pulse per second.

Because there is an emitter-follower on the SM-50 chip, the 60-Hertz sine wave can be fed directly into the SM-50. Output of the emitter-follower, which is essentially a rectified half-sine wave, serves as the input to the divide-by-ten circuit. The output of the SM-50 is compatible with the circuits in the SF-50 and with the other devices in the SUHL family.

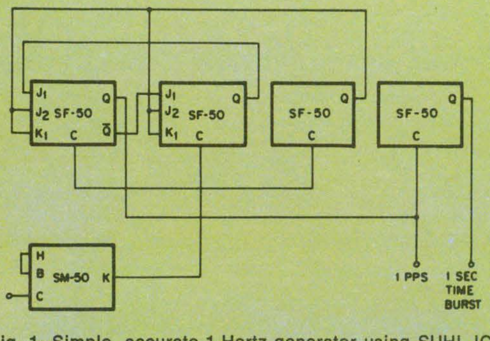


Fig. 1—Simple, accurate 1-Hertz generator using SUHL ICs.

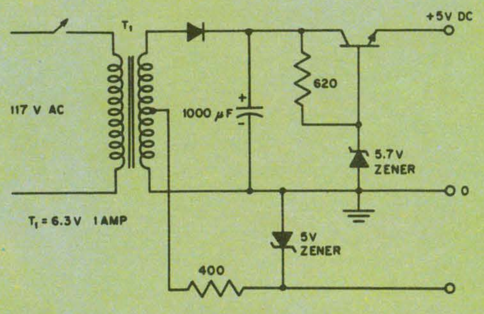
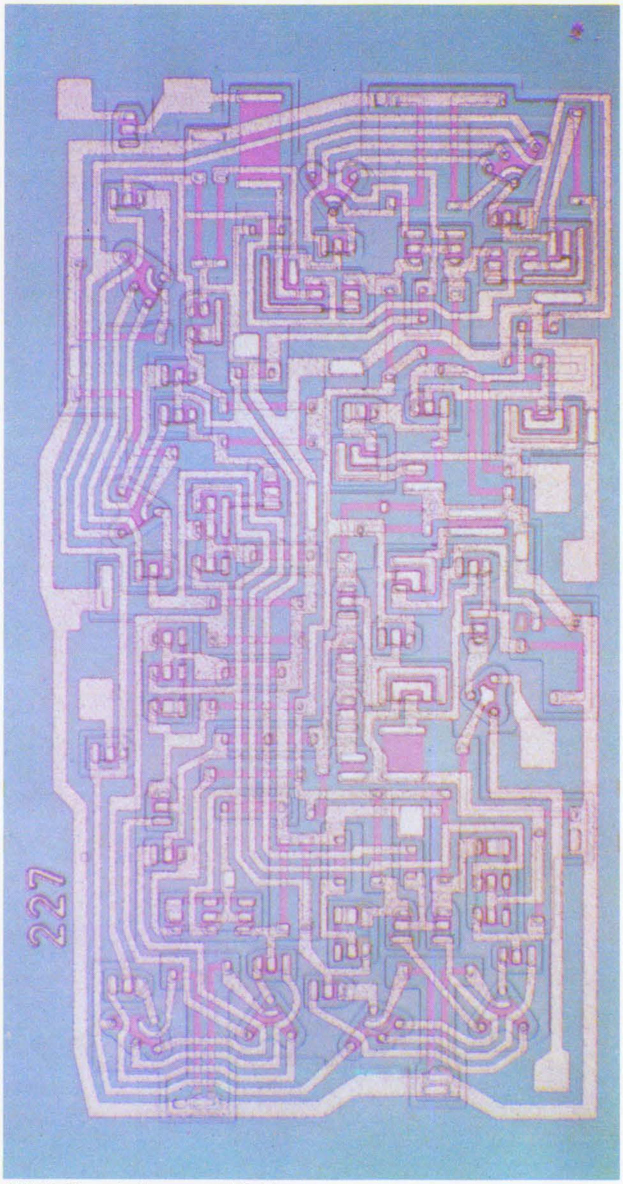


Fig. 2—Power source for low-frequency generator.



SM-50, Decade Frequency Divider

When a one second time burst is desired, output of the divide-by-sixty goes into another SF-50. This produces an output voltage which will be ON for one second and OFF for one second.

With proper gating, the basic circuit can be used to make an accurate timer. The time-burst configuration can be used to open and close a gate to a counter so that accurate counts per second can be made, such as is used in frequency counting.

Figure 2 gives the details of a simple power supply to power this 1-Hz generator circuit.

CIRCLE NUMBER 306

# How to error-check with SUHL NAND/NOR gates

When processing binary data, it's important that errors be immediately detected. The practical way to detect such errors is to use IC gates for parity checking.

Parity checking can insure that errors do not creep into information being processed in a computer or being transferred from a computer to other equipment. Essentially an error detection method, parity checking is based on checking the total number of 1s present in a computer word at various stages within the computer or after data is transferred. This is done by including an extra binary digit (parity bit) in the word so that the total number of 1s in the computer word (including the parity bit) is always odd or always even.

If a system uses ODD parity checking, then an error is indicated any time there is a single error or an odd number of errors in a computer word. In Figure 1, Row 1 shows an 8-bit word having ODD parity, there are five 1s. In Row 2, there is a change of one bit (the 8th bit went from "1" to "0"). Now there is an even number of 1s and an error signal would be produced by the ODD parity checker. Row 3 has an odd number of errors (bit positions 8, 6, & 5) are different from the original word). In this case, an error signal would be produced by the ODD parity checker because, again, there is an even number of 1s.

| | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| 1. Original word | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 2. Single error | **0** | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 3. ODD # of errors | **0** | 1 | **1** | **1** | 1 | 0 | 1 | 1 |

Fig. 1—Eight-bit data word showing parity checks.

In a similar manner, in an EVEN parity checker the total number of 1s in a computer word (including the parity bit) is always EVEN. Thus, EVEN parity is the complement of ODD parity.

How parity checking is implemented with SUHL devices is shown in Figures 2 & 3. Figure 2 shows the ease of implementing ODD/EVEN parity checking with only 1¼ SG-140 packages for 2 bits. Each SG-140 has four 2-input NAND/NOR gates. With the units shown, the typical propagation delay for EVEN parity is 36 nsec; for ODD parity, 48 nsec.

An 8-bit binary ODD/EVEN parity checker consisting of 7¼ SG-140 packages is outlined in Figure 3. An advantage of this method is that only the uncomplemented inputs are necessary, and wiring interconnects are straight forward and repetitive.

CIRCLE NUMBER 307

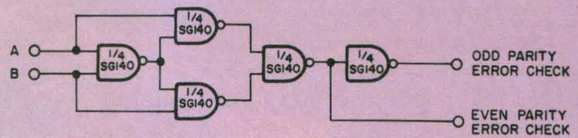


Fig. 2—ODD/EVEN parity checking for two bits.

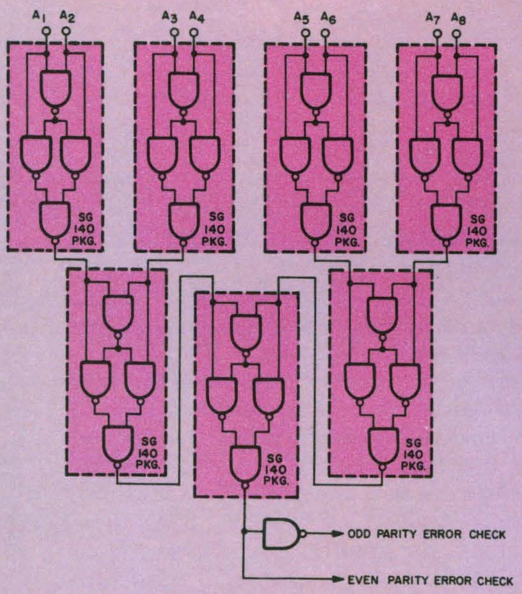
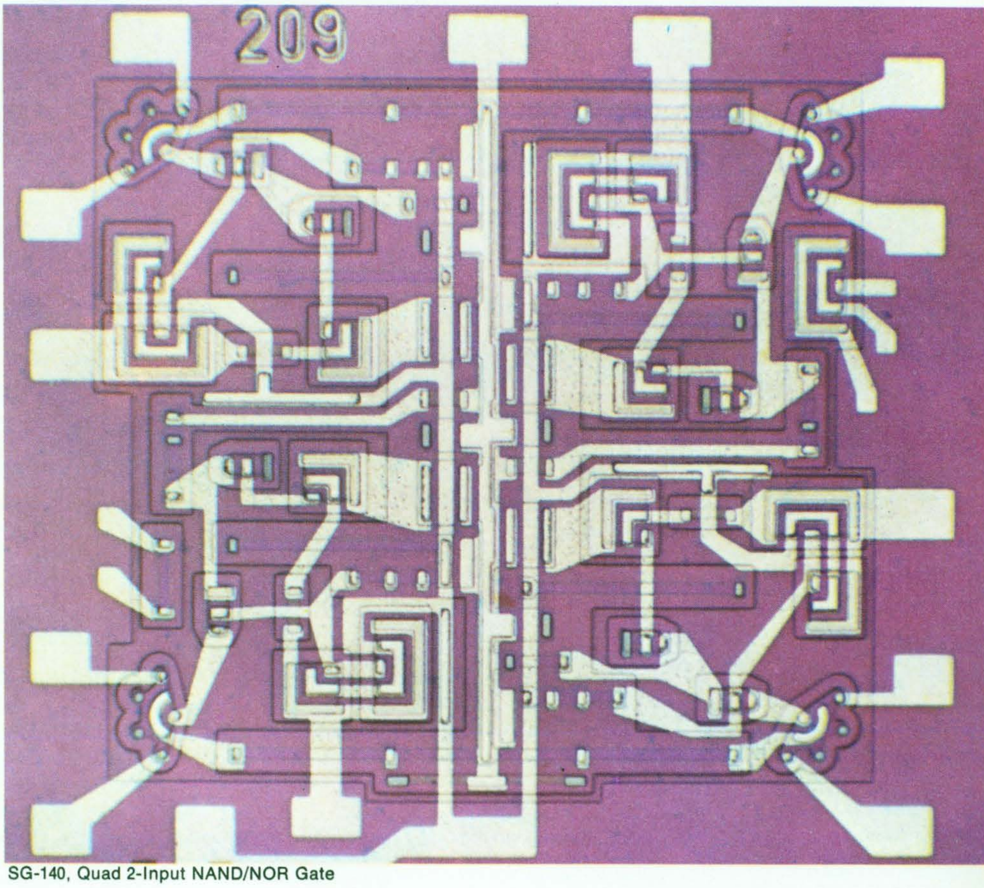


Fig. 3—Parity checking for 8-bit binary word which includes the parity bit.



SG-140, Quad 2-Input NAND/NOR Gate

ENGINEERING MANAGER'S CORNER

# Good specification sheets can both simplify and maximize IC utilization

You're cheating yourself if you're using inadequately specified integrated circuits.

Let's take a closer look at the problem. First of all, say that an IC spec sheet's purpose in life is to transmit technical information about a particular circuit to all parties who will be involved in its usage and application.

Next, add to this basic description certain other essentials:

☐ **It must be readable, i.e., well organized and written in the simplest appropriate style.**

☐ **It must be easy to understand, i.e., all technical data presented in an orderly manner, with all information in logical groups.**

☐ **It should provide the greatest number of guarantees over the broadest range of practical considerations, i.e., give realistic results of product tests. By keeping within practical limits, the user may be assured of the results as stated on the sheet.**

While the specification sheet should be descriptive, the description is of the greatest practical benefit to the user when it relates to and assists in the actual use of the circuit in a system. A specification can be quite elaborate, yet be unrelated to the end application.

The specification sheet wil provide the packaging engineer with package dimensions, thermal characteristics, conductivity, orientation. It provides the logic designer a description of the logical operation and rules for applying that particular logic element. Application notes also give ideas on optimizing logic capability.

The specification provides all details on the circuit and pertinent standards. For component engineers the sheet offers a description of the circuit, its operation and parameters—as well as information on how these parameters are effected by pertinent conditions (capacitance, frequency and temperature).

The actual "specification of electrical characteristics" portion of the spec sheet is generally the most difficult portion for the manufacturer to provide. Often it gets the greatest amount of his consideration, and also the user's. It's here that parameter limits and conditions of measurement are specified.

Parameters, limits, and conditions must be derived from:

☐ **Circuit analysis and calculations**

☐ **Product distribution**

☐ **Application or system requirements**

A good specification is a combination of these criteria. All are valid and necessary and effect the acceptability of the product, either by limiting its usefulness or its cost. The electrical specification should be developed under conditions that duplicate those of the circuit's eventual application.

Sylvania integrated circuits specifications combine all these criteria to provide well defined circuit input, output, and transfer characteristics which are directly translatable into system parameters and design rules. Parameters are not only specified over the temperature range, but are verified by actual testing at specified temperatures before shipment.

To make it easier to use the product and maximize the utility of the circuits, all Sylvania specifications provide circuit and logic diagrams plus a description of the circuit function and its operation. In addition, to assist you in using the circuits under conditions other than those specified, (data such as typical characteristics vs. temperature, power supply, loading, etc.) are specified. Our specification sheet also assists in system design by giving applications ideas which we feel highlight the circuit's special capabilities.

SUHL circuits make system design easy, and SUHL specification sheets make it easy to use SUHL.

JOHN RIENZO

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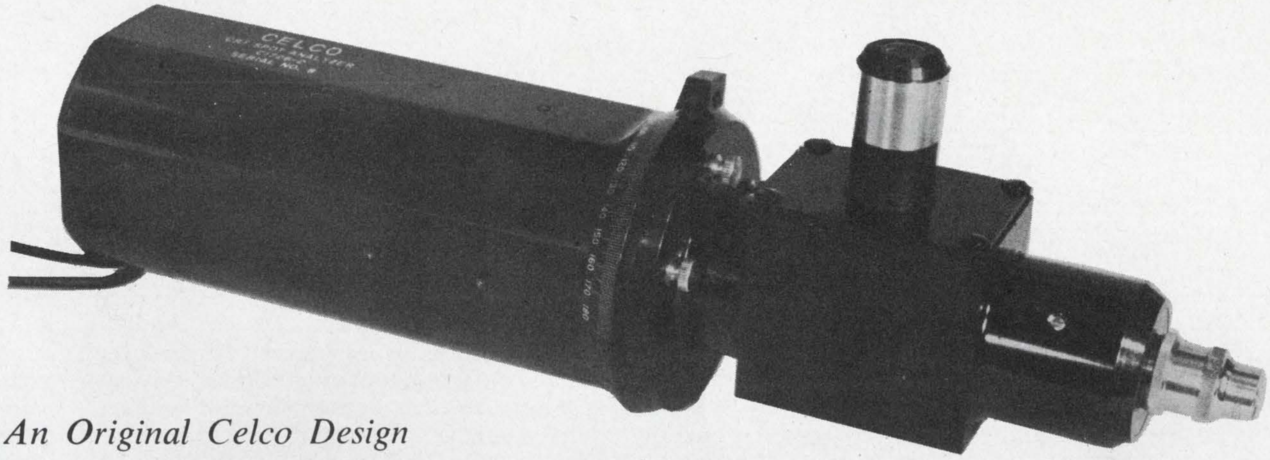
**Celco**

# TWO-SLIT SPOT ANALYZER

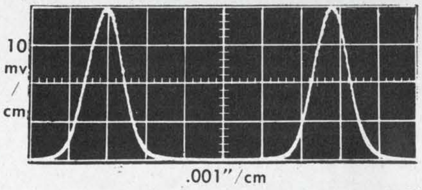
## FOR DETERMINATION OF CRT SPOT CHARACTERISTICS



*An Original Celco Design*

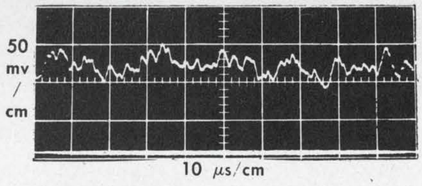
## SPOT MEASUREMENTS ON 5″ HIGH RESOLUTION CRT

Spot Diameter at 2″ to Left of Center

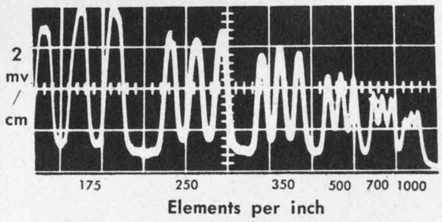


Half Amplitude Spot Diameter = .001″

Phosphor or Face Noise



Contrast Ratio Bar Chart



- SPOT SIZE AND PHOSPHOR NOISE
- GAUSSIAN SPOT — HALF AMPLITUDE POINTS
- SPATIAL FREQUENCY DISTRIBUTION
- MODIFIED LINE WIDTH — SINGLE SLIT
- SINE WAVE RESPONSE
- ABBERATION MEASUREMENT
- CONTRAST RATIO METHOD
- LINEARITY DETERMINATION

The CELCO Two-Slit Spot Analyzer is a complete system for measuring spot characteristics on the face of high resolution Cathode Ray Tubes under dynamic conditions and without the customary dependence on operator decisions. This device, calibrated in our laboratories, enables the user to make spot size measurements using a standard oscilloscope for the read-out of half amplitude points or other resolution references.

The Analyzer lens systems focuses the CRT spot on a pair of slits mounted in the goniometer and the unmodulated spot is scanned across the calibrated slits. Variations in light output are picked up by the photo-multiplier and this output fed to an oscilloscope. A pair of Gaussian distribution curves are presented on the face of the scope using an appropriate time base as determined by the analyzer calibration. The slits may be rotated to examine the spot for astigmatism or other abberations.

Spot sizes of .0002″ to .020″ can be measured using various lenses, slits and bar charts.

This versatile instrument has become an invaluable aid in research and development as well as in production testing and inspection of CRT's. Phosphor research, phosphor characteristics and other photoelectric measurements may be carried out. Ask our engineering staff for full details.

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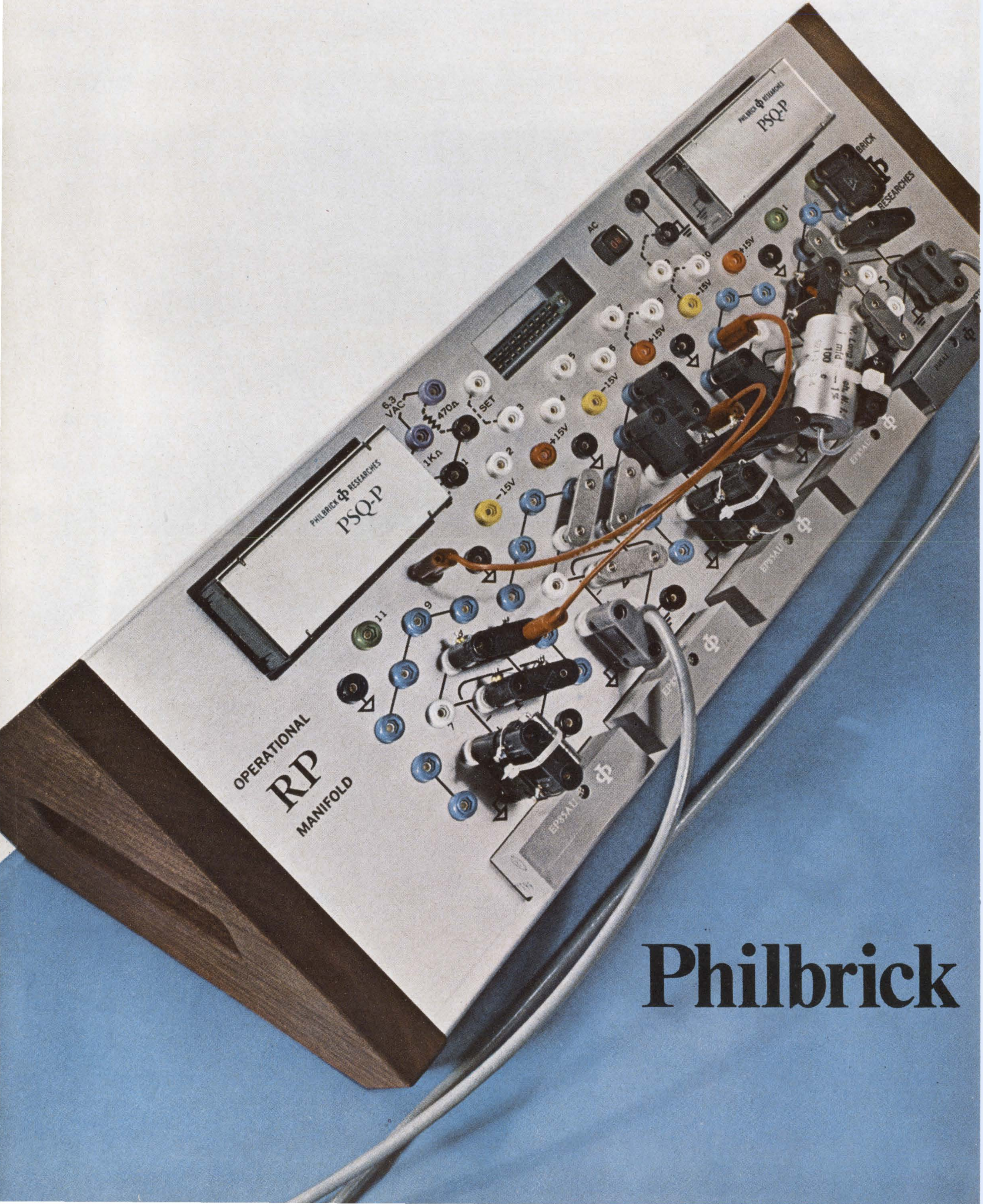
ON READER-SERVICE CARD CIRCLE 19


OPERATIONAL
RP
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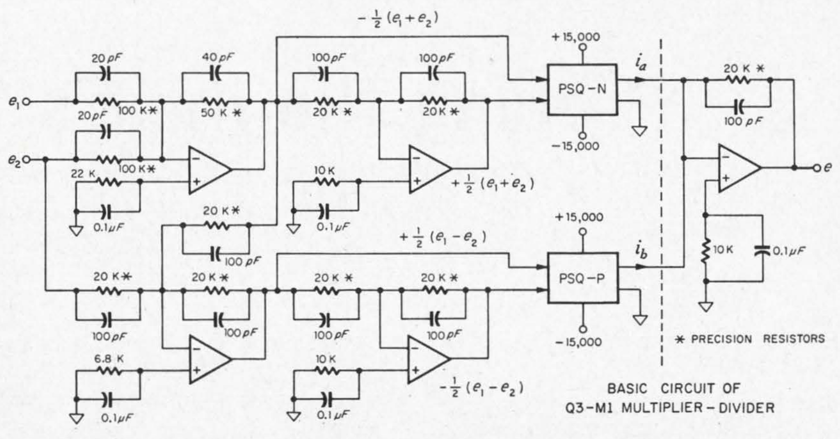
PHILBRICK RESEARCHES
PSQ-P
6.3 VAC
470Ω
1KΩ
SET
AC
+15V
−15V
EP85AU

# Philbrick



RP USED AS A 5-AMPLIFIER MULTIPLIER

Model RP is an all-in-one analog instrument. With it you can assemble operational amplifier circuits in *minutes* instead of hours or days. It's ideal for experimentation, simulation and instruction in the practical application of solid-state analog circuitry. The RP combines the convenience and freedom of old-fashioned breadboards with a technique that provides logical organization, shielding, grounding, isolation and stabilization to temporary or experimental circuits. Philbrick Operational Manifolds make it easy to build stable operational amplifier circuits that are free of "bugs," "strays" and other parasitic happenings.

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Mounted on the front panel of the RP Operational Manifold are 106 tip jacks, spaced ¾″ apart in a pattern of equilateral triangles. They accommodate standard twin-tip plugs and are used for mounting passive components, shorting bars and as terminations for shielded input and output cables. Jacks are color-coded. Functional interconnections are printed on the panel.

The 5-amplifier multiplier-amplifier circuit diagram shown above is typical of the many analog circuits that can be constructed on the RP Operational Manifold. Virtually all of the 125 circuits described in Philbrick's Applications Manual for Operational Amplifiers can be assembled quickly and easily on the instrument. The RP is not limited to use as a breadboard for experimental circuits. It may also be used for permanent or semi-permanent circuits that must be built to seemingly impossible schedules.

The RP Manifold is sturdily built, attractively packaged and wired to Philbrick's usual high standard of quality. The simple, clear-anodized sheet-aluminum enclosure provides effective shielding and a firm base for the solid mounting of electrical components. It is available in a style for rack-mounting or with hardwood ends for bench use.

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A 4-color, 6-page brochure contains more detailed information on the Philbrick RP and MP Operational Manifolds. For your copy, phone your nearest Philbrick engineering representative or get in touch with Philbrick Researches, 47 Allied Drive at Route 128, Dedham, Massachusetts 02026. Phone (617) 329-1600.

**PHILBRICK**

# Operational Manifold–

## the most sophisticated and economical way to breadboard operational amplifier circuits

ON READER-SERVICE CARD CIRCLE 20

# Probing the mind's 'computer'

Medical scientists seek to modify behavior by planting permanent microcircuit stimulators in the brain.

**Richard N. Einhorn**
News Editor

At hospitals and medical schools across the United States, scientists are using electrical impulses to gain new insights into that most marvelous of all computers, the human brain. Through electrical stimulation they are laying bare the fears, the motivations, the social adjustments and the learning processes.

This work with humans has been going on for 15 years, and microminiaturization, integrated circuitry, telemetry and other electronic advances promise to help accelerate it. New types of power supplies are urgently needed.

Thus far the work with humans has been with the ill—epileptics, Parkinson's disease sufferers, persons seeking relief from intractable pain and, in some cases, schizophrenics and other psychotics. Using electrode implants in the brain as a diagnostic tool, neurosurgeons have evoked in patients sensations of pleasure or pain, recall of long-forgotten experiences, and hallucinations, depending on how the electrodes were positioned.

One neurosurgeon recounts: "A patient even reached out from the operating table to catch the flitting butterfly created in his brain by the play of electrons."

All of the work so far has been in the realm of diagnosis and research. No cures have resulted from electrical stimulation of the brain, though that is the ultimate goal of clinicians. The most promising results to date have been the temporary relief of pain and the control of involuntary movements for a while.

The research, the progress, make many people uneasy. They accept the necessity of implanting electronic cardiac pacemakers, and they know that scientists are working on artificial organs, but the brain is something else again. Every sensation, every emotion, every concrete or abstract thought, every artistic impulse that man experiences depends upon the workings of his brain.

Like atomic energy, it raises a spate of ethical questions: Have the doctors the right to evoke artificial responses in people they are treating? Is nothing sacrosanct? Will the biomedical engineer become the liberator or the unwitting jailer of humanity?

Yet the work was bound to happen. Experimental work with animals had been going on fairly quietly for nearly a century. With their fine electrical pointers inserted in the depths of the brain, neurophysiologists (specialists in the mechanisms of the nervous system) have discovered such specialized structures as pain and pleasure centers, memory banks, automatic regulators of blood pressure, respiration and the flow of digestive juices, and many other bodily functions most people never even stop to think about. In one series of experiments each eye of a monkey reacted differently to light of the same intensity (see cover photo).

At a session of this spring's IEEE International Convention in New York, Prof. José M. R. Delgado of the Yale University School of Medicine called upon the electronic designer to add his skills to the interdisciplinary research on the brain. He described his own work and that of others and mentioned some of the limitations in present equipment: awkward hard-wire connections to the brain, bulky electronics, the inadequacy of present batteries.

Dr. Delgado predicted that microminiaturization and integrated circuit technology would soon make possible a stimulator "small enough to be implanted as a button in the skull, completely underneath the skin." It would operate without batteries, avoiding both toxic reactions and the need for surgery to replace them. The device would both receive and transmit electrical information over a telemetry link: stimulating waveforms with exactly controllable parameters in, EEG (electroencephalographic) signals out.

This stimulator would be a boon both to scientific investigation of the animal brain and to the art of diagnosing and treating human ills.

For legal and moral reasons, experiments purely for the sake of knowledge are not performed on humans. However, starting about 1952, neurosurgeons began to apply some of the experience gained with animals to hospital patients. They used implanted electrodes to pinpoint sites in the brain where epileptic seizures took place. Once this was determined, only the bare minimum of tissue was destroyed by surgery to eliminate the seizures.

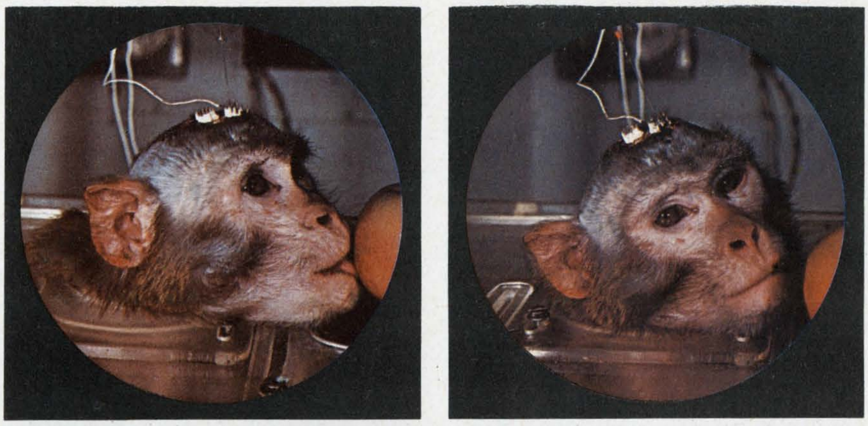
### Telemetry link sought

Early this spring Dr. Delgado visited Prof. Wen H. Ko, director of the Microelectronic Laboratory for Biomedical Sciences at the Case Institute of Technology in Cleveland. The neurophysiologist and the electronics expert had at least one interest in common—the telemetry of biological information.

Dr. Delgado had a problem, and he stated it something like this: "I want a completely encapsulated signal generator the size of an aspirin tablet. It must be batteryless, yet draw its power without leads that pierce the skin."

As the Yale professor spoke, Ko listened intently. He was used to being asked for state-of-the-art information on medical electronics.

Dr. Delgado continued: "My system must be activated by a telemetry link, you know."



**Electrical pulse to inhibitory** center in brain causes monkey to lose interest in fruit it contemplates so fondly.

**Radio-controlled stimulator** weighs 28 grams, consumes 1.2 mA and operates at 100 MHz. Leads run to electrodes.

**Monitoring signals from the brain** is valuable with or without stimulation. Here monkey undergoes EEG reading.

(**brain stimulation,** *continued*)

But there was more, much more, to his problem. Every pulse had to be exactly controllable in current amplitude, polarity, duration and frequency. The intended application: electrical stimulation of the brains of monkeys in a large cage or in a large outdoor compound.

"Do you think this is feasible?" Dr. Delgado asked.

Ko told him, in effect: "Engineering-wise, everything can be done, but not right away."

In a recent interview, the Case professor explained his reply.

"The design of a pulse generator the size of an aspirin tablet has been accomplished—for example, at our laboratory," he told ELECTRONIC DESIGN.

As for powering the brain stimulator without batteries or external leads, Ko noted: "At Tokyo in 1965, I discussed some of my results on the radio pulsing of power to implants. At Case we have transmitted about 50 mW maximum over half an inch in muscle, using a coil about an inch in diameter.

"Another way of powering it might be to implant biological power sources, such as piezoelectric crystals, in body cavities. However, these are a long way off, because there are still many problems to be solved."

As for the telemetry link:

"There are many ways you can telemeter medical information," Ko said. "If you are interested in EEG signals from the brain, first you transmit from the brain to the outside. Then you use a relay transmitter hanging on the animal's collar. You can transmit a few miles rather easily that way.

"To send brain-stimulation signals to the animal, you modulate a transmitter with the pulses. You use a simple, short antenna on the animal and load the antenna. The receiver can be small, and you can use batteries with that."

Ko concluded:

"All the pieces exist, or at least have been proven feasible, but no one has engineered them into a system."

## Major design objectives

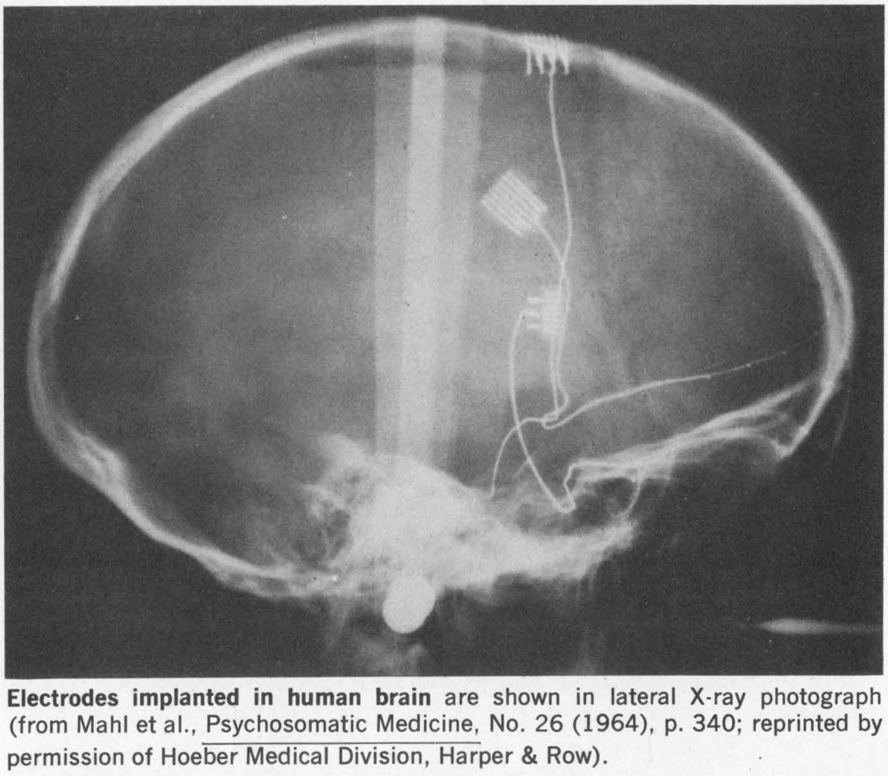
The design objectives for an implantable telestimulation system would depend on the end use: animal experiments or clinical work with humans. For example, a neurosurgeon could remove just enough bone from the skull of a sufferer from intractable pain to permit the insertion of a "button." Emanating from the button would be an RF pickup coil placed under the skin. A precise transport mechanism clamped to the skull would settle the electrodes accurately within a fraction of a millimeter.

Ironically, the brain, the master receptor of every sensation from a stubbed toe to a maiden's blush, itself feels no pain. Nor does drilling through the bone occasion much discomfort. Once implanted, the electrodes can be left in place for years without ill effect. The surgeon merely pulls the scalp flap back over the implant, so the skin can heal. Eventually there is no way of telling from the appearance of the head that a delicate brain operation was performed.

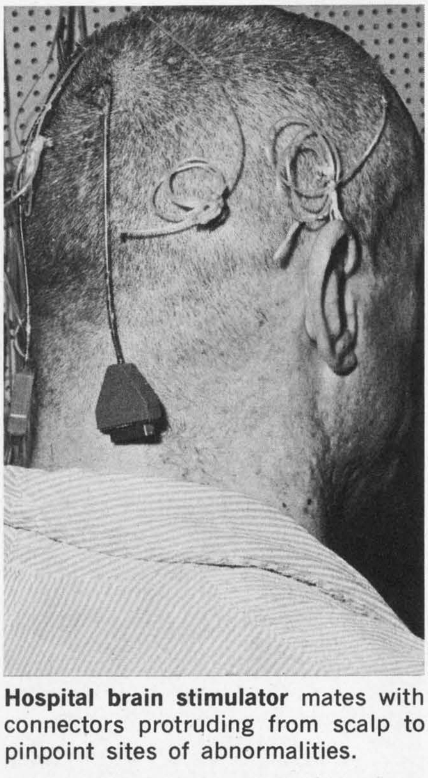
A few days after button-implant surgery, the doctors would wheel up a console containing a pulse generator and a transmitter. Activation of preselected electrodes would send driblets of current into the brain to give remission from pain, perhaps for a few hours. It is much less drastic than cutting nerve endings.

Further microminiaturization might permit a Parkinson's disease victim, for example, to control tremors of his arms and legs with pushbuttons on a portable device attached to his belt. He could thus remain out of the hospital for long periods. The only maintenance required would be replacement of the batteries in his belt pack.

With experimental monkeys in an



**Electrodes implanted in human brain** are shown in lateral X-ray photograph (from Mahl et al., Psychosomatic Medicine, No. 26 (1964), p. 340; reprinted by permission of Hoeber Medical Division, Harper & Row).



**Hospital brain stimulator** mates with connectors protruding from scalp to pinpoint sites of abnormalities.

outdoor colony, however, the engineering criteria are entirely different. Here the idea is to observe animals in a social setting and to attempt to modify their behavior.

With humans who are in the hospital for treatment, the control console is close by; with monkeys, it may be a quarter of a mile away. The monkey experiments require a telemetry link.

## Engineering problems apparent

There is much for the engineer to know before he attempts to design an electrical brain-stimulating system. Any material implanted in the body must be nontoxic and essentially nonreactive with body fluids. Thus the stimulator must be encapsulated in a biologically acceptable plastic. The electrodes are generally fashioned from stainless steel. All but the tips are insulated with Teflon or nylon, although in clinical work it is not uncommon to deliberately strip away patches of insulation, so that each electrode has several points of stimulation.

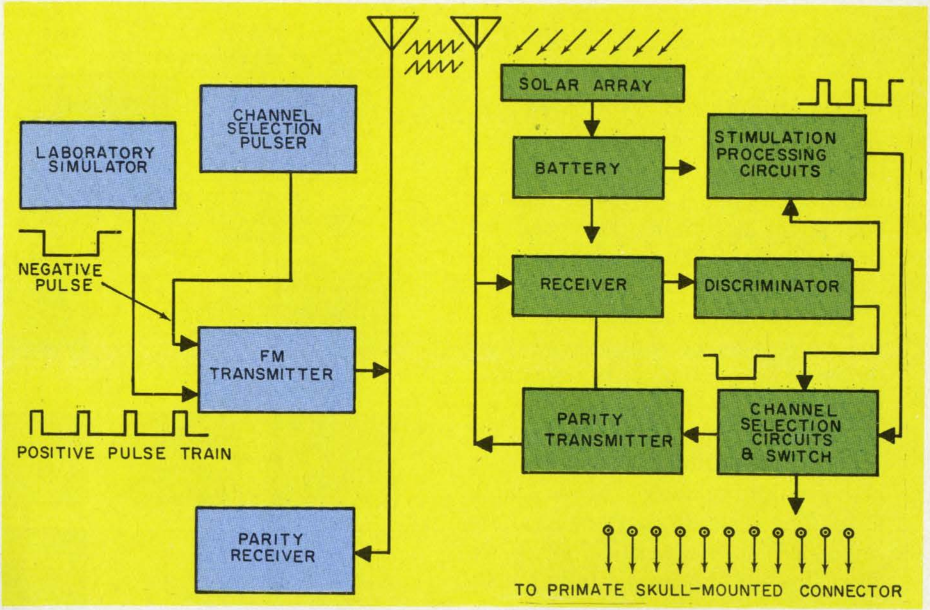
Form factor, too, is important. The implanted device must not chafe or compress parts of the body. Once in place, it must be secured. Dr. Delgado has suggested screwing or cementing his button to the skull. Teflon or nylon screws might be used, since they are nontoxic; the same would have to be true of any bonding agent.

And, naturally, the implanted device must be built to last forever. The mere notion of mean-time-between-failures is unthinkable.

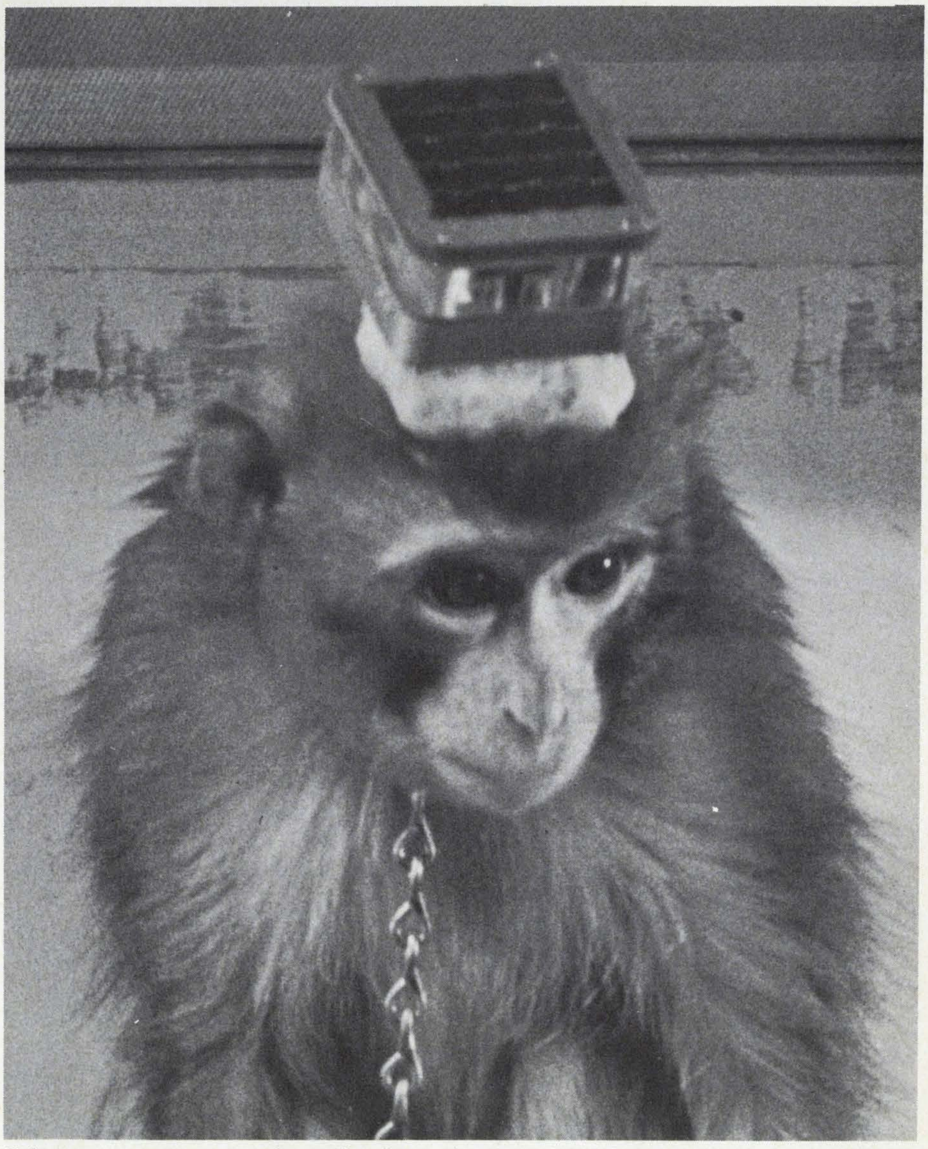
Weight is not a great problem with humans, particularly if everything possible is microminiaturized. However, for a 10-pound rhesus monkey, the implant should weigh a few grams, the entire animal-borne equipment a few ounces.

If the implanted stimulator is imbedded in the skull, there are constraints upon the size. Monkey skulls are about a quarter to a half inch thick, and the smaller figure should be used as the design goal if the device is not to put pressure on the brain.

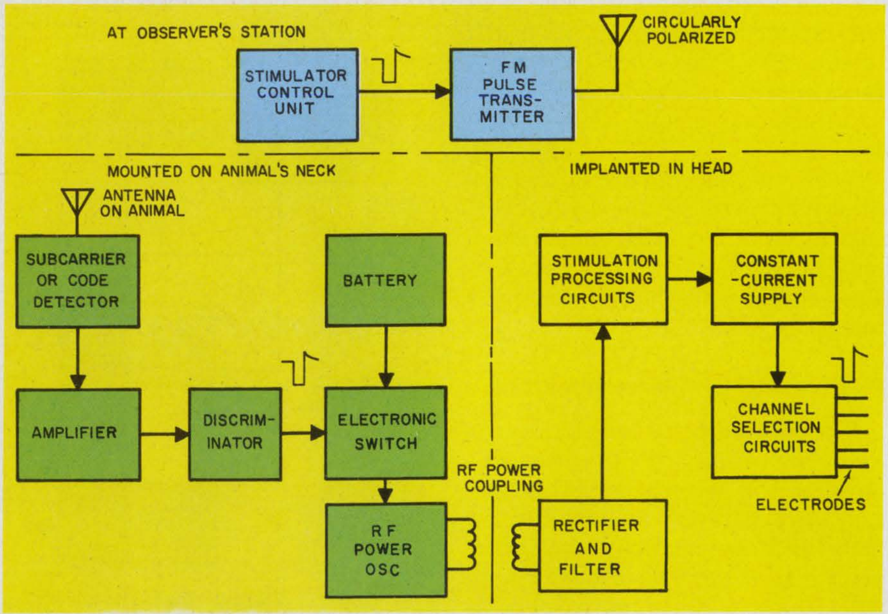
Recently the rhesus monkey has become the preferred animal for brain stimulation experiments, because it more closely resembles the human in intelligence, mannerisms and structure than either the dog or



1. **General Electric Mark II telestimulator** permits remote stimulation of more than one monkey in outdoor primate colony. Miniaturized switch steps output pulses through 11 electrodes.



**Solar array powers receiver-stimulator** developed by General Electric Co. for Dr. Bryan Robinson. Head-mounted unit weighs 200 grams and measures 7 x 6 x 3 cm.



2. **Microminiaturized implantable stimulator** would draw power from electronics pack mounted on animal without using leads that pierce the scalp. Integrated circuits and biological power source might permit implantation of receiver and antenna as well.

(**brain stimulation,** *continued*)

cat. However, monkeys are naturally curious, destructive animals and tend to tear apart any loose piece of equipment or wiring they can lay their hands on. The design must be "monkey-proof."

The nonimplantable portion of the monkey-borne equipment can be mounted on a collar or on a harness. It must be shock-resistant and designed to withstand opening by, say, a muscular 15-pounder—a heavyweight among rhesus monkeys. The receiving antenna can be imbedded in the harness or collar. The antenna is horizontally polarized.

Dr. Bryan Robinson, a neurophysiologist at Emory University, Atlanta, Ga., experiments on monkeys by means of a telestimulation system designed by Harold Warner of the General Electric Company's Missile and Space Div., Valley Forge, Pa. Dr. Robinson has dispensed with a receiving antenna entirely: he uses the body of the animal to approximate one-quarter wavelength of a vhf carrier. Furry but effective!

The control console should provide the neurophysiologist with the means for varying the parameters of stimulation: current amplitude, polarity, duration, frequency, and length of pulse train. It should also permit the selection of more than one animal for stimulation. Finally, it should permit the monitoring of EEGs; for this purpose it should provide output connections to a six- or eight-track chart recorder, and perhaps an EEG magnetic tape recorder.

A free-ranging monkey can run, jump, swing from trees, stand on its head or lie down. This would wreak havoc on wide-dynamic-range AM transmission, which requires agc. How can the investigator possibly know what signals he is applying to the simian? Because of animal ambience, the transmitting antenna should be circularly polarized and mounted on a mast.

Biotelemetry is usually conducted in the vhf band. Dr. Delgado operates at about 100 MHz at Yale, and Dr. Robinson used 130 to 140 MHz when he was working at the National Institute of Mental Health, Bethesda, Md. Of course, it is necessary to obtain the permission of the Federal Communications Commission to operate such a transmitter. Not only is there the problem of not interfering with the outside world, but in addition, it is also necessary to avoid spurious signals from outside transmitters. You don't want a satellite to stimulate your monkeys, but neither do you want a test missile to home on your laboratory.

## Multi-stimulation methods outlined

In observing social behavior in a primate colony, it is desirable to stimulate several animals simultaneously. This can be accomplished in several ways, Ko says.

"You can use subcarriers or you can change the carrier frequency," he suggests. "As you finish with one animal, you change your tuning circuit and transmit at another frequency."

Another way is to use pulse-coded transmission.

"Give each animal its own address, like the radio control of missiles of space ships," Ko says. "You can send out a coding signal to turn on a particular animal's circuit, then turn it off with a closing code."

The animal-borne receiver is not particularly difficult to design. However, it must be able to reject stray signals that might cause spurious stimulation, while offering high sensitivity to the modulated carrier. Over-all signal-to-noise ratio should be high.

The implanted stimulator delivers the current needed to stimulate nerve centers. Two technical approaches seem feasible.

One is the so-called passive stimulator, which has already been employed in cardiac pacemakers. With the pacemaker, a transmitter loaded with a coil is mounted on the patient's chest. Just inside the chest wall is a tuned receiving coil that is aligned with the transmitting coil. A preset timing circuit that is synchronized with the patient's heartbeat triggers an oscillator that modulates the output of the transmitter. Inside, a diode detector demodulates the signal and applies a pulse to the heart. For brain stimulation, a passive stimulator could be implanted in the neck.

Better yet would be a microminiaturized signal generator, encapsulated in a button seated in the skull. This, too, would be activated by inductive RF coupling from the external electronics. It would faithfully reproduce the waveforms introduced by the experimenter at the control console. Thus it is particularly suitable for medical application. Also, the absence of hard-wire connections would eliminate ground loops that might cause spurious stimulation.

The parameters of stimulation play an important role in determining the complexity of the entire brain stimulation system.

Most investigators use rectangular pulses, because they are easy to generate, measure, count and describe. Dr. Delgado uses negative-going pulses, to which he intentionally adds a positive-going overshoot on the trailing edge. A gradual return to the baseline yields zero net current, which, he says, is necessary to avoid electrolytic action in brain tissue.

Another neurophysiologist, Dr. John Roth of the Oregon Regional Primate Research Institute, has been using sine waves for seven years. He says:

"We are not in a position to argue about whether one waveform stimulates more effectively than another. However, a large part of the impedance is not of the tissue but of the tissue-electrode interface. We feel that this distorts a square wave into something that doesn't even approach a square."

He goes on to say that because the impedance of the tissue varies, a constant-current device is superior to a constant-voltage device. Besides, it would appear that sine waves also operate with zero net current.

### Frequency is critical

Sidestepping this controversy entirely is Dr. Blaine Nashold of Duke University, who is performing extensive clinical work on humans.

"Much more important than the shape of the waveform is the stimulation rate," he says. "We've tried just about every shape, and it doesn't make any difference."

He hastens to add that his work is cruder than animal research, because he is in no position to stimulate his patients over and over as neurophysiologists do in the laboratory. For example, Dr. John C. Lilly reports that sine waves are unsuitable for intensive, long-term stimulation (up to 18 hours a day for months).

Experience with both animals and humans has confirmed the importance of frequency. Stimulating the same site with different frequencies can yield completely different results.

"There are very definite responses related to frequency," Dr. Nashold says. "There are responses you don't see at 5 cps that you do at 100; there are those you don't at 60 but do at 300."

Dr. Nashold also discounts the importance of voltage, provided it does not result in excessive current.

"Going from 5 volts to 10 will give you a stronger response," he says, "but the pattern will be the same."

There is general agreement on pulse duration: experimental waveforms are normally less than 1 millisecond, because increasing the duration doesn't produce different effects, and it adds unnecessarily to the amount of current applied to the brain.

The duty cycle of brain stimulation is generally short. It is unlikely that humans would be permitted to remain out of the hospital if their conditions demanded constant stimulation. Constraints are imposed by the fatigability of various structures in the brain: The motor cortex, which controls movement, fatigues in seconds; the amygdala (in the area of the brain stem), in minutes; portions of the hypothalamus, in days.

Dr. Delgado cautions designers and experimenters alike: "If you stimulate too much, you would produce convulsions. If you increase the intensity and use very long pulses, you could burn tissue. If you apply too high a milliamperage in one direction, you cause electrolysis."

The crux of the implantation problem is how to get power to the implanted device without also implanting batteries. If a suitable power source were available right now, the implantable telestimulation system could be a reality within a year.

The ideal solution, everyone agrees, would be to use biological power sources. By this is meant a scheme for tapping the chemical, mechanical and thermal processes of the body to provide electrical energy for the implanted device.

Blood flow, for example, abounds in energy. Engineers talk of placing Lilliputian turbomotors into the aorta or other large artery. Thus far no one appears to have developed them.

Most engineers, after a few moments of thought, would suggest piezoelectric crystals. In fact, a numbers of papers have been published on them. There appear to be two main problems:

Since piezoelectric crystals are basically high-output-impedance devices, they can be short-circuited by body fluids seeping around them. The body itself is not rigid. It flows, changes its shape under stress. If pressure is applied, the body tends to deform to avoid the pressure. Eventually the output of the crystal decreases, because the motion of the stress becomes smaller.

Ko says he has found a way to avoid these problems. However, the power output attainable at present would not be sufficient to power a device with many stages.

Another idea is the so-called biological battery, which has been investigated both at the General Electric Company and at Drexel Institute. Published results indicate that it would be possible to develop about 0.6 volt by placing electrodes fabricated from such dissimilar metals as platinum-black and high-speed steel into the body. This can furnish as much as 50 $\mu$W for a few months—adequate for some cardiac pacemakers.

Ko, for one, is skeptical. He says: "They simply report on whether it will work. But I don't believe I've seen any data published on the dangers to the body.

"As everyone who has taken a high-school physics course knows, putting two different metals into a conductive fluid is enough to create a chemical cell. However, one of the electrodes will dissolve in the process. What happens to ions like the tungsten and cobalt, which are given off by the General Electric and Drexel batteries?

"Hopefully, these ions would be absorbed by the kidneys and discharged from the body in the form of urine. But in practice, many of them—I am speaking of micrograms—are trapped by the liver, the pancreas, the brain. What then? These organs are very sensitive to ions."

The Microelectronics Laboratory at Case Institute is experimenting with a biological battery containing silver chloride and zinc. Ko says it delivers a full volt, and at a much higher power density than the others—a milliwatt, instead of microwatts, per square centimeter. He and his associates are evaluating the

(**brain stimulation,** *continued*)

AgCl-Zn battery in animals to observe the rate of trapping of ions by the organs.

Perhaps the best idea of all would be the use of fuel cells, particularly one that metabolizes the glucose in the bloodstream. This is the body's own way of developing energy reserves to meet the demands placed on it by physical activity. The simple act of eating replaces all the fuel consumed.

The catch is in finding some catalyst that simulates the body's method of converting glucose into energy. The device would be completely nontoxic, since the poles and the catalyst would be inert and the byproducts would be water, hydrogen and oxygen, which the body can certainly tolerate.

Like the other biological power sources, the glucose-metabolizing fuel cell is far from a reality. To gain some "feel" for such a device, Ko conducted a laboratory experiment in which he put some yeast into a glucose solution, using a semipermeable membrance, and thereby generated electricity. Unfortunately the body cannot tolerate the presence of yeast.

Thus, with biological power sources ruled out at least for the next few years, the candidates for powering the implant are narrowed down considerably. Dr. Delgado mentions as a possibility the implantation of atomic batteries with a long half-life. Such a battery could be shielded, so that radiation would not be a problem, but there is the problem of bulk. No atomic source in sight seems to provide enough power in a package small enough for implantation.

This seems to leave only one more route to batteryless operation: the induction of power into the device. An external coil excited by electronics mounted on the animal or human would radiate energy across the air-and-tissue gap to an implanted receiving coil—in effect, an RF transmitter with primary and secondary windings separated.

Biomedical engineers have been working with RF inductive coupling for a number of years. With the type of cardiac pacemaker described previously, it is foolproof in its simplicity. The only reasons for concern are whether alignment of the two coils is critical and whether RF radiation is harmful to tissue.

Published studies show that with close coupling of the coils, power transfer at RF frequencies can attain efficiencies up to 95%. Also, there have been no apparent ill effects. Radiating about 50 watts of power through the chest doesn't seem to raise local body temperature.

When asked about the inductive coupling of RF power to energize an implanted brain stimulator, Ko replied that it was feasible.

He made an interesting observation: "If you use an implanted stimulator which merely requires power to operate, then transmitter and receiver alignment are not critical. But if you want to supply signal as well as power, then the coils must be properly aligned, since signal amplitude will be affected."

This would appear to support the design approach that calls for an implanted signal generator to recreate the waveforms.

It would be appropriate to modify the method used to power cardiac pacemakers, since the brute power radiated across the chest wall is much too high to apply to the head. It is up to the systems engineer to refine the power oscillator and to scale down the power requirements.

At this point, designers may ask: Why do neurophysiologists need such sophisticated telestimulation systems? After all, they have logged some impressive results with the hardware already on hand.

A look at their methodologies should provide the answer.

Most experimenters who stimulate animals—cats, rats, bats, dogs, dolphins, baboons—use hard-wire systems. This is all right, provided that the animal is inactive and isolated from other animals. Imagine the tangle that would result if three monkeys with long leads protruding from their heads were all in one cage.

The choice of animal is important to the experimental results. Monkeys not used to handling can be a real trial. "Rhesus monkeys" says Dr. Delgado "are usually agressive, and . . . it is dangerous to put a hand within reach of their teeth." Ten trained persons have died in about as many years from encephalitis after having been bitten in the laboratory.

Dr. Robert Doty, a neurophysiologist at the University of Rochester, says that scientists have to choose between keeping the animals in a restraining chair or staging a daily monkey roundup, with a greater risk of being bitten.

Dr. Doty, when asked whether he would use a completely microminiaturized, totally implantable stimulator, replied:

"That would be delightful. But it would consume a great deal of experimental time to work out the engineering problems, and I'm not interested in becoming the supervisor of a Manhattan Project to do this."

Thus neurophysiologists would be happy to use the latest innovations of electronic technology, if only the engineers would fabricate and market them.

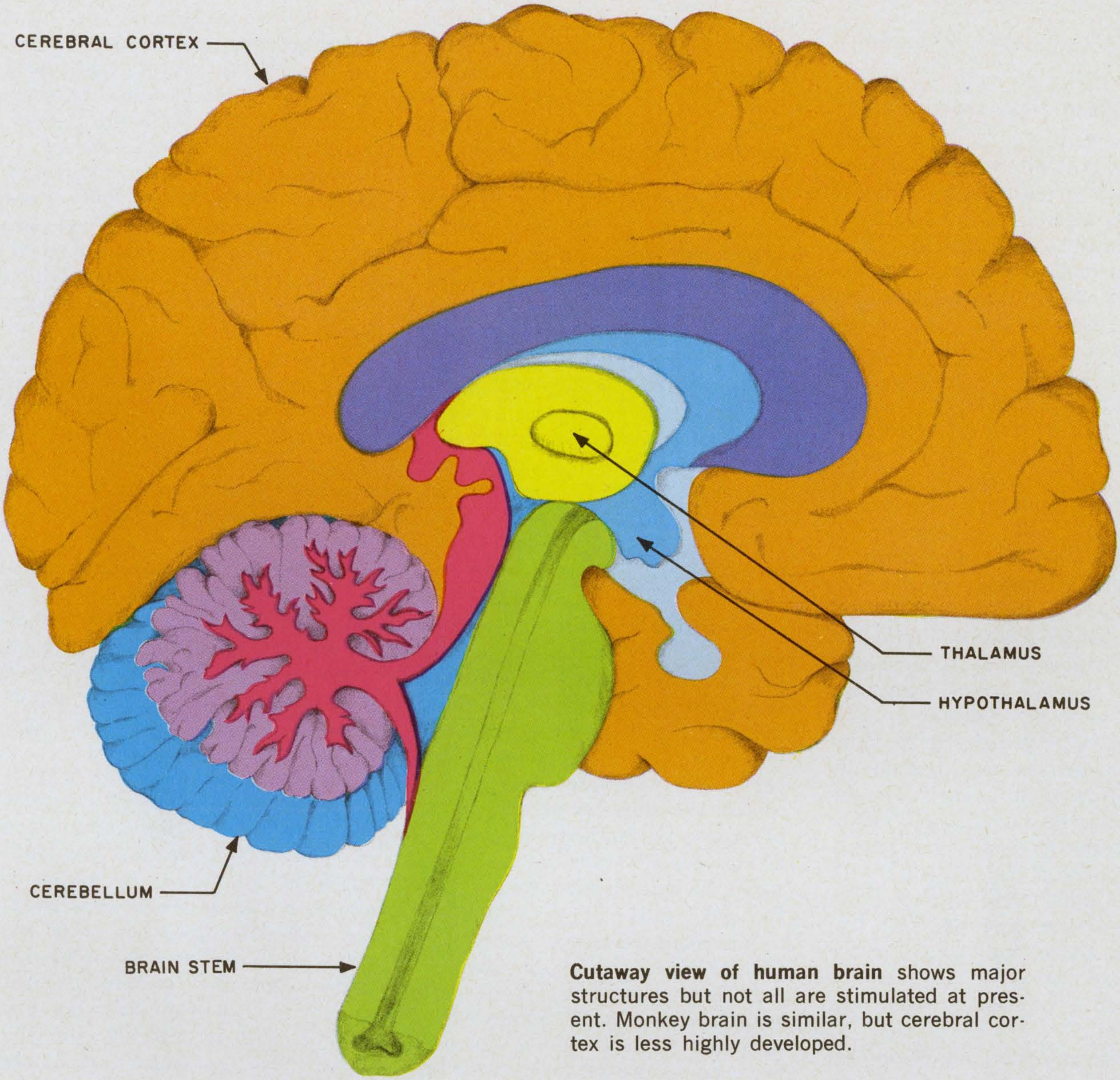
In a compromise between hardwire systems with animals under restraint and the yet-to-be-built implantable telestimulation system, stimulating signals are being transmitted via an RF link to receivers mounted on the animal. All of the electronics is external, but secure cabling is run from the signal generator to the socket to which the implanted electrodes are attached. The first system affording remote control of brain stimulation was developed in 1934, but it took the invention of the transistor to grant the radio-controlled stimulator parity with the hardwire systems.

Dr. Delgado has achieved many of his most impressive results with a unit built for him by Per Hals, an associate at the Yale University Medical School. Hals is an electronics engineer who custom-builds devices for the staff.

The best radio-controlled system now in operation is considered to be the General Electric Mark II telestimulator (Fig. 1), built for Dr. Robinson. It consists of a pulse-modulated transmitter, four receiver-stimulators for mounting on rhesus monkeys, a communications receiver with converter, and a directional antenna at the control station.

### Solar power is used

To permit sequential stimulation of several monkeys in an outdoor colony, the transmitter delivers an



**Cutaway view of human brain** shows major structures but not all are stimulated at present. Monkey brain is similar, but cerebral cortex is less highly developed.

FM carrier on any one of four frequencies in the vicinity of 140 MHz. However, the use of additional transmitters would permit the simultaneous stimulation of more than one animal.

The Mark II permits a duty cycle of 0.05 at full power and 0.15 at reduced power. Inputs to the stimulation system are furnished by a standard laboratory pulse generator. A positive pulse train modulates the transmitter, which delivers FM carriers to the antenna. The channel selection pulser selects the electrode channel, which is also displayed at the console.

A crystal-stabilized superheterodyne receiver interprets the information modulated on the carrier as brain-channel selection, pulse width, repetition rate and constant current amplitude.

The stimulation processing circuits apply the original pulse train to any one of 11 electrodes through a miniature electromagnetic stepping switch. The stepping switch also pulses a tiny parity transmitter, which produces an audible "beep" on the communications receiver. This verifies that the switch has been stepped to the proper brain-stimulation channel.

The novel feature of the Mark II, which sits astride the monkey's head like a scholar's mortarboard, is an array of 40 solar cells that recharge Ni-Cd storage batteries. Even artificial light from the laboratory is sufficient for continuously charging the storage batteries. Thus uniform power can be maintained should the level of incident light decrease.

The unit, which measures 3 x 6 x 7 cm and weighs 200 grams, is mounted on a platform that is screwed onto the monkey's head. Fastening the receiver-stimulator to the socket automatically seats pins that make contact with the electrodes.

In practice, the Mark II works quite satisfactorily. Animals tested do not seem to object to the presence of the devices on their heads. They can be allowed to prowl their compound or cages for months without any need for adjustment.

But good as they are, the radio-controlled stimulators used by Dr. Robinson and Dr. Delgado have sev-

(**brain stimulation,** *continued*)

eral disadvantages. For one, there are leads that pierce the skin, with the risk of infection at the skin-lead interface, as well as the possibility of breakage or dislocation. These hazards would be annoying for animal research but really serious for human patients. And they would disfigure a person.

Fig. 2 illustrates one concept of an implantable stimulator intended for studying animals in an outdoor enclosure. There are three subsystems: a stimulator control unit and transmitter, electronics mounted on the animal's neck or back, and a surgically implanted stimulator.

Waveforms selected at the control unit are multiplexed on subcarriers which modulate the output of an FM transmitter. A circularly polarized antenna array beams the carrier fairly directionally.

A subcarrier detector in each animal's receiver ensures that the desired animal is stimulated. The detected signal is amplified and reconverted to the original control pulses.

The control signal, together with power, is inductively coupled to the implanted stimulator at radio frequencies. An electronic switch routes power and signal to the oscillator only when a stimulating waveform is present.

The transmitting coil is coupled to a receiving coil in the neck. A rectifier and filter apply dc to the stimulation processing circuits. Pulses from this stage trigger a constant-current supply. Channel selection circuits route stimulating current to the electrodes in accordance with the control pulses.

## Research gains support

The modern era of brain-stimulation experimentation began in the 1930s, when W. R. Hess developed the technique of implanting electrodes in the brains of unanesthetized cats. He was the first to show that functions of the lower brain, which govern our more primitive emotions, as well as posture, equilibrium and sleep, could be influenced by electrical stimulation. For this work, Hess received the Nobel Prize in 1949.

Other neurophysiologists were soon attracted to the technique. Brain-stimulation experiments on animals are now conducted at hundreds of laboratories around the world. A leading center is the Yale University School of Medicine, where Dr. Delgado is famed for a research stunt he performed in Spain —facing a brave bull in a corrida, armed only with a hand-held RF transmitter. As the beast charged, he pressed a button on his transmitter, thereby actuating an electrical stimulator in the bull's brain. Immediately it stopped its charge. But when the effects of the stimulus wore off, it remembered it was a fighting bull. Once again it charged, and once again it was stopped, like a radio-controlled model auto. While El Toro had not been turned into Ferdinand, Delgado had succeeded in inhibiting its aggression.

In another experiment, Dr. Delgado stimulated the brain of a monkey. Each eye reacted differently to light of the same intensity, because different current levels were applied to two electrodes in its brain. Experimenters like Dr. Delgado can control the diameter of the eye pupils like a photographer setting the f-stops on his camera. A human wired in this fashion would react the same way.

Movements, emotions and hallucinations have also been produced artificially. Fear, hunger, rage and sexual drives can be influenced by electrical stimulation. Dr. Delgado has even temporarily overridden the maternal instinct in monkeys.

Of all his results, Dr. Delgado considers the most important to be the discovery of a functional bias. He says that when he stimulates certain structures, the electrical inputs merely bias the normal sensory inputs. For example, when he stimulates a monkey to aggression, the animal seeks as victims the ones it usually picks on anyway.

Dr. Delgado has even rigged a monkey cage with a lever that permits the Casper Milquetoasts of his primate colony to inhibit the aggressiveness of the "boss" monkey. Here we have a case of a monkey learning to stimulate the brain of one of its companions.

Despite the experimentation to date, scientists still have only a fragmentary grasp of what goes on in the brain. It is like trying to follow a motion picture when only a frame or two is projected every few minutes. Less than 20 per cent of the monkey's brain has been "mapped" with electrical probes. And even that is critically re-evaluated as new data are published.

From years of further studies of animals, neurophysiologists hope eventually to derive a methodology suitable for routine clinical work with humans. Dr. Reginald Bickford of the Mayo Clinic, Dr. Robert Heath of Tulane, Dr. Nashold of Duke and Dr. William Sweet of the Massachusetts General Hospital have studied the onset of epileptic seizures by means of electrical stimulation. However, much more research is needed before these and other diagnostic techniques are refined.

Dr. Heath has reported short-lived relief of the symptoms of schizophrenia by electrically inducing pleasure in the brains of the patients. In addition he has diagnosed the disease by detecting an abnormal spiking of spontaneous electrical activity in the brain.

One gnawing suspicion that is always going to be voiced whenever the subject of brain stimulation comes up is the Svengali-like domination of individuals by means of electrical pulses. When experimenters who have spent years in the field can be drawn into speculative conversation, they uniformly reject the notion. The brain, they say, has its own built-in controls, and the subject can recognize artificially evoked behavior.

The future course of electrical brain stimulation appears likely to follow the lines of gaining more knowledge about how the brain works. This in turn may lead to advances in the diagnosis and treatment of disorders of the brain. It may also suggest superior ways in which to educate people.

Dr. Delgado wrote in 1965:

"I am not so naive as to think that cerebral research holds all the answers to mankind's present problems, but I do believe that an understanding of the biological bases of social and antisocial behavior and of mental activities, which for the first time can now be explored in the conscious brain, may be of decisive importance in the search for intelligent solutions to some of our present anxieties, frustrations and conflicts." ■ ■

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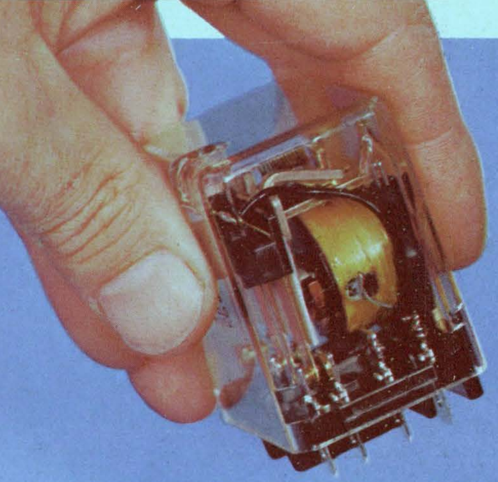

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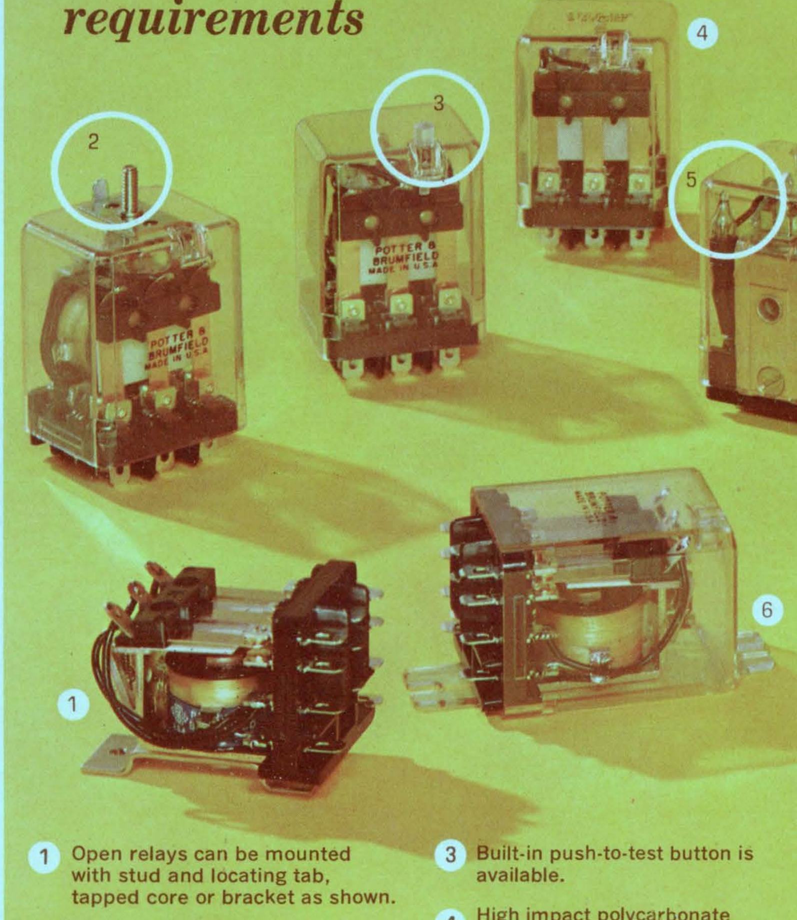

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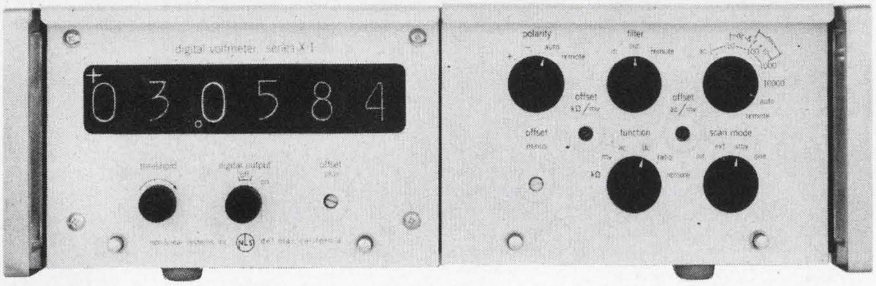

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# Photodetectors calibrated in minutes

Scientists at the National Bureau of Standards have developed an instrument that permits photodetectors to be calibrated in the visible spectrum (0.38 $\mu$ to 0.8 $\mu$) in minutes instead of hours.

The new calibrator-recorder illuminates the photodetector under test with light from a monochromator swept across the desired portion of the visible spectrum. It records the output as a function of wavelength. Its circuitry holds the illuminating energy at a fixed level to make possible measurement precisions of 2 per cent. The instrument automatically scans and records photodetector response across the visible spectrum in about four minutes, according to its developers, M. Kuder and H. Hammond III of the bureau's Metrology Div. This speed, they point out, makes the instrument especially well suited to calibrating large numbers of photodevices with moderate accuracy.

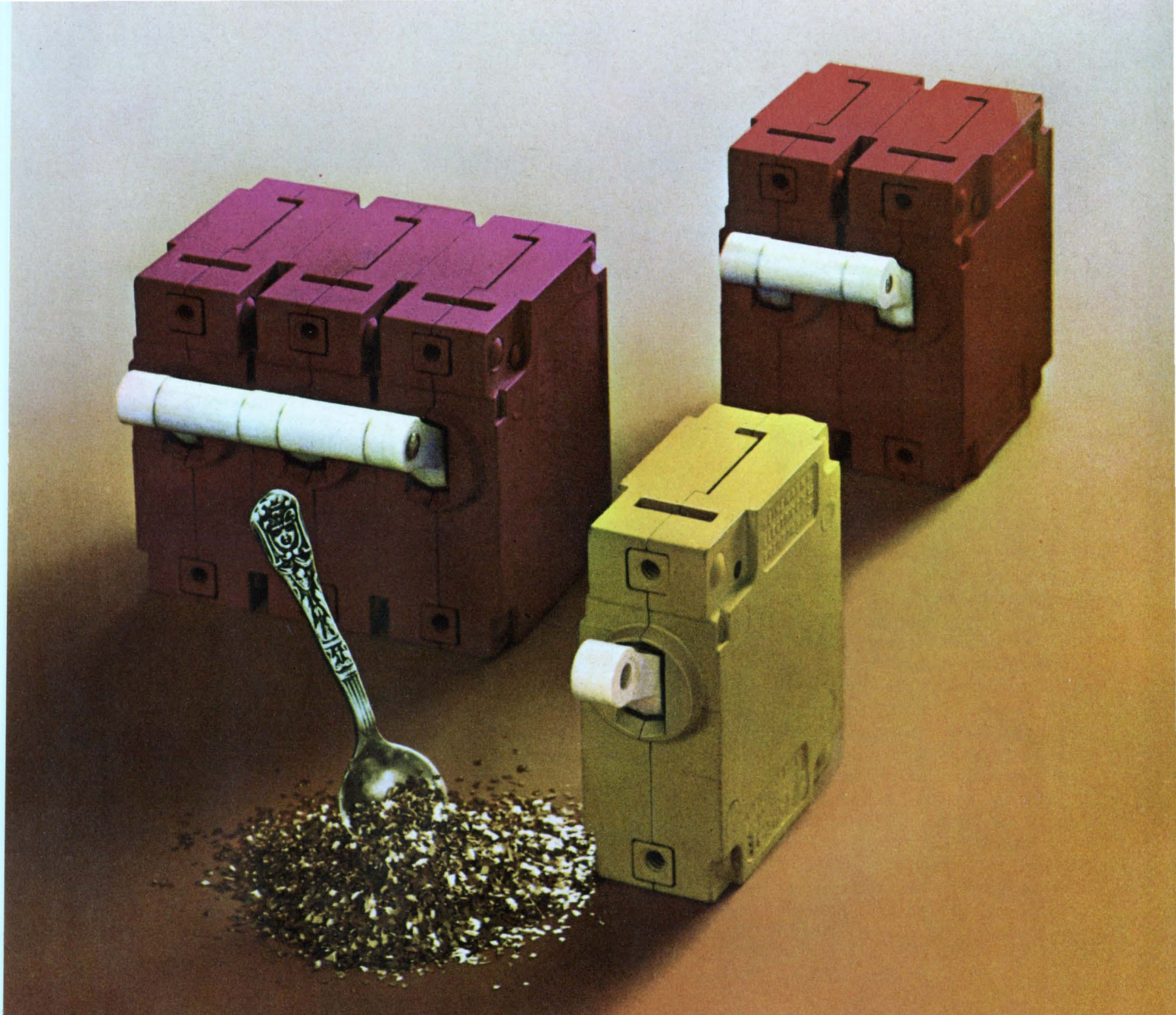
In the past, the spectral response of the photosensitive devices has been determined by measuring their output at selected wavelengths of monochromatic illumination at constant energy, using a calibrated thermopile as intensity reference. Values obtained by this method were used to plot a curve of response.

Athough the reference thermopiles used have essentially flat spectral responses, they are extremely sensitive to ambient temperature.

According to the scientists, the NBS spectral calibrator is freed of temperature instabilities and resulting inaccuracies by use of a constant-light source as a reference and the thermopile as an intensity difference-sensing device. It compares the reference and monochromator output 13 times a second by a light-chopping method, to eliminate thermal drift and to stabilize monochromator output.

The bureau describes its instrument as a specialized one, intended for running fast plots of photocell response for varying wavelength, where 4 per cent accuracy is acceptable. The bureau's photometry laboratory is now reported to be developing an equally specialized photoresponse instrument. It is expected to yield values for a succession of wavelengths from which points of the response curve can be plotted, and is expected to have an accuracy within 1 per cent but with increased running time. ■ ■

**Photoelectric cell** is plugged into new photodetector response recorder by National Bureau of Standards engineer David Goebel. A plot, representing a 4-minute scan of a photoelectric device, is shown on the x-y recorder. The monochromatic light source is in the background.



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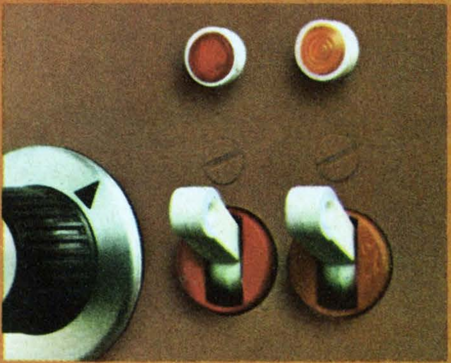

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3649

# Building-block units aid computer designers

## Washington U. 'macromodular' concept permits tryout of novel systems before manufacture

**Neil Sclater**
East Coast Editor

A building-block scheme, much like a Tinker Toy set, is permitting engineers to assemble custom computers with relative ease.

The concept for the "macromodular" computer systems was disclosed at the recent Spring Joint Computer Conference in Atlantic City, N. J. It was developed by the Computer Research Laboratory at Washington University, St. Louis.

Dr. Wesley Clark, director of the laboratory, explained that the scheme permits designers and users to devise computer systems for novel applications without the expense and time involved in ordering a system from a manufacturer.

Macromodules, according to Dr. Clark, are self-contained blocks, including registers, adders, memories and control devices, designed for assembly on special wiring frames. Program flow diagrams can be used as plans to assemble the modules.

While making clear that macromodules would be of greatest benefit in laboratories, where computational requirements are highly variable, Dr. Clark also cited advantages for computer manufacturers. He said that experimental systems could be adjusted and improved with macromodules before a system was sold for general use.

"Once a design has been realized and its value established", Dr. Clark said, "it could then be reworked into tighter engineering form, for maximum efficiency and for production by automatic wiring and fabrication techniques."

Prototypes of the macromodules are in use at Washington University, and some small, initial systems are planned for the next few months, Dr. Clark indicated. He said that design work had so far indicated that the functions selected for the module scheme were reasonable and convenient.

The macromodules are being selected from a set of 20 to 40 basic designs. Central processor modules, such as register and memory units, range in logical complexity from as few as 50 to as many as 400 gate circuits. Emitter-coupled integrated circuits have typical rise times of 6 nanoseconds. There are also modules for power, signal conditioning, input-output buffering, and control. Some input-output devices are also built as macromodules.

All parts of the system will be reusable and capable of reorganization into a wide variety of configurations. The assembly frame already built contains ducts for standard cables that connect the modules. New modules can be added without disturbing the existing system.

Data modules have been designed to process twelve-bit word segments, but greater word lengths can be obtained by interconnecting modules. The memory modules hold 4096 segments of 12 bits each. Interconnection permits the formation of larger arrays.

The control signals for computer processes have been routed along the cables of a control network the layout of which is an analog of the flow diagram of the process.

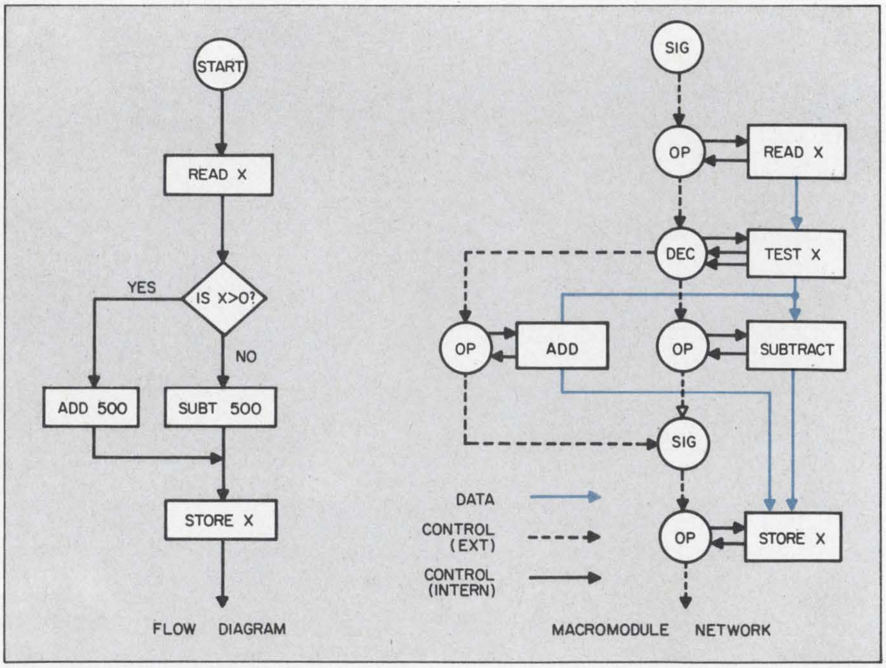
Dr. Clark said that two principal problems were encountered in the logical design of macromodules:

- Physical separation of the modules within a system created interference and signal propagation time delays.
- The process of modeling flow diagrams ruled out synchronous timing.

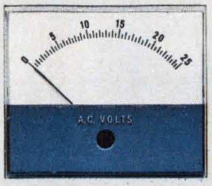
To solve these problems, all control signals were made self-timing and data validation signals were routed through wires parallel to the data paths to ensure that control does not precede data.

A set of basic logic elements capable of operating without a common time clock was designed. Macromodules depend on this logic rather than the traditional gates and flip-flops.

The logic circuits are high-speed, low-level and dc-coupled, and therefore are subject to noise problems. This problem, Dr. Clark said, is solved by transmitting data and control signals over twisted wire pairs. Shielding around all system components and cables, he said, is used to reduce signal pickup from outside sources. ■ ■



**Macromodule concept** (circles and blocks above) permits flow diagram (left) to be translated easily into a hardware data-processing network (right).



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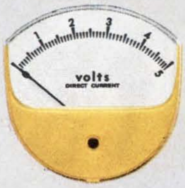

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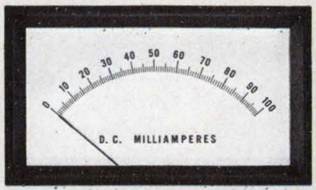

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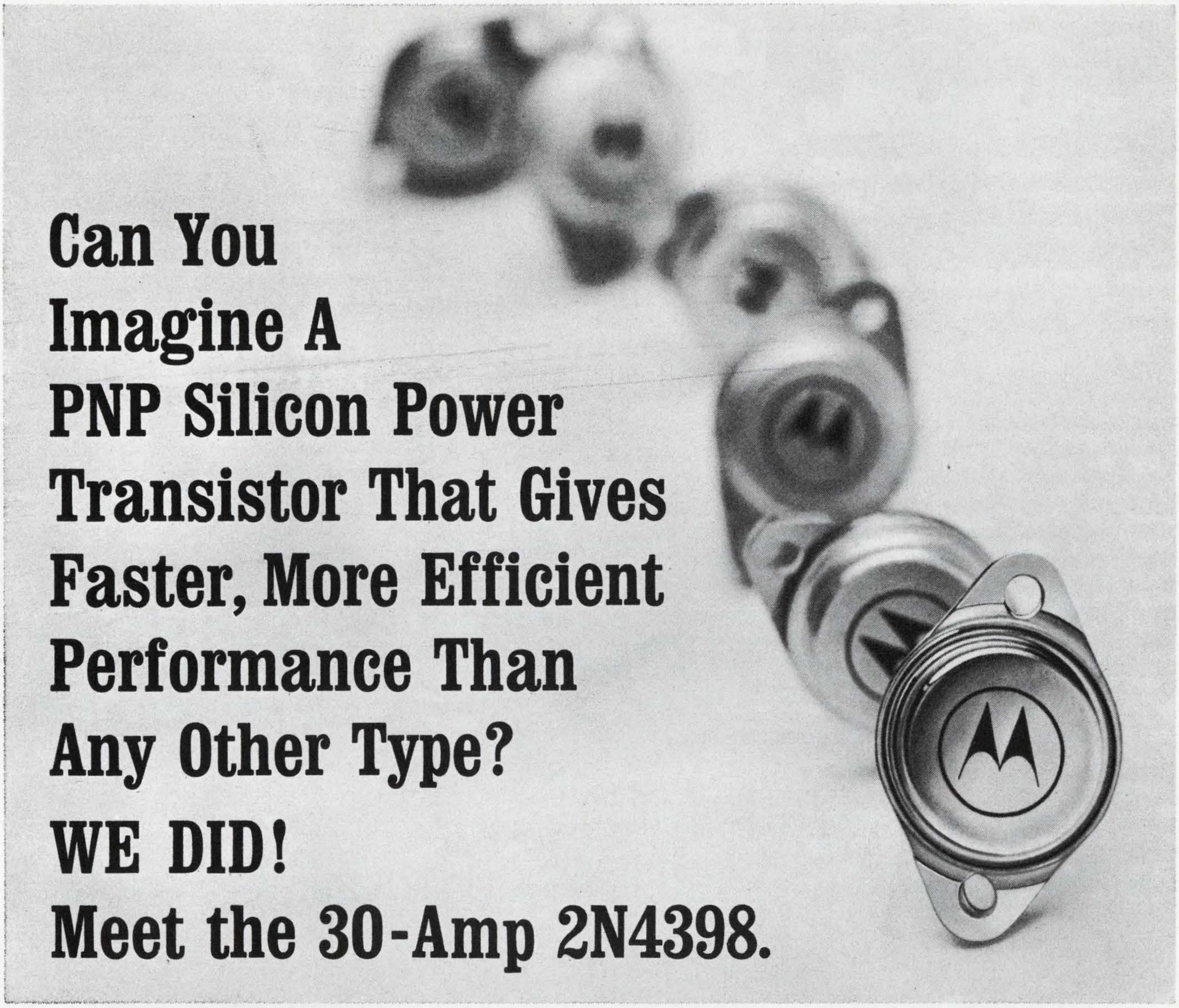

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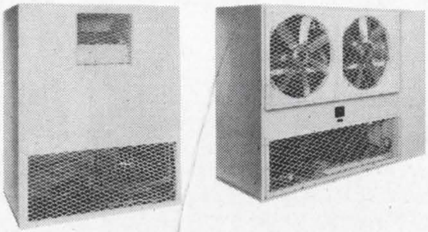

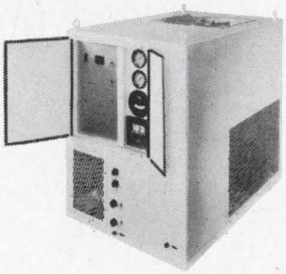

# Letters

## Positioning not critical for AUTODIN hardware

Sir:

Your article on the AUTODIN system which appeared in the Feb. 1 issue of ELECTRONIC DESIGN ["Centers to handle 32,000 messages an hour," ED 3, pp. 17-20] was excellent. We were very much impressed by the quantity and quality of the information.

I would like to clarify a possible misinterpretation of a point in the article concerning the positioning of hardware [p. 17, fourth para.]. Installation of hardware within a "one-third of an inch" tolerance is *not* a requirement and the failure to stay within one-third of an inch will *not* result in intolerable cross-talk and signal loss. It so happens that installation is being accomplished very accurately relative to installation drawings (usually within one-third of an inch), but the system performance is by no means affected by emplacements that vary from drawings by more than that amount.

M. Gelman

Manager
System Design and Analysis
Philco-Ford Corp.
Willow Grove, Pa.

## Engineers must form professional group

Sir:

I have enjoyed reading your recently published editorial ["Needed: A way to tame the gypsy in us," ED 4, Feb. 15, 1967, p. 75] concerning engineers and their professional status. I am of the opinion that engineers, especially in electronics, must begin to form associations that will benefit them as a group, since the individual is completely powerless when dealing with management. This, in my opinion, is the only way to maintain a proper professional status in the eyes of management.

I hope that ELECTRONIC DESIGN will continue to emphasize the engineer's social and professional status as well as his technical contributions to society.

N. Paul Galluzzi

Electrical Engineer
Beverly, Mass.

## Older engineers are too conservative

Sir:

Your editorial, "Life Begins at 40 . . . . Will it for you?" [ED 8, April 12, 1967, p. 51] was quite thought-provoking. In my own experience with engineers, I find they tend to become too conservative—regardless of their ability or education. For some reason, older engineers tend to become set in their ways and unable to accept management decisions which run counter to what they "know" is right. Perhaps the problem is intrinsic to the engineering mind. I hope not.

K. H. Sueker

Marketing Manager
Semiconductor Div.
Westinghouse Electric Corp.
Youngwood, Pa.

## CATV is less bad than portrayed

Sir:

A copy of your November 8 editorial ["Wasteland revisited: Must CATV be an electronic 'rubber stamp'?" ED 25, p. 51] has just come to my attention. Let me congratulate you on your concept of services that can be provided by CATV.

My first tendency is to blush a little at the fact that the present activities of many CATV operators have received so little publicity that they are in effect unknown to a publication of the stature of yours. However, since a great many of our CATV systems operate in and for people of small communities, which are served by newspapers and other publications of limited circulation, it is entirely possible that our activities in the field of origination have received a minimum of attention.

*(continued on p. 57)*

# Nearly everything that flies... flies with Cutler-Hammer power relays!

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Probably because our relays combine the utmost in small size, light weight and resistance to severe environmental conditions.

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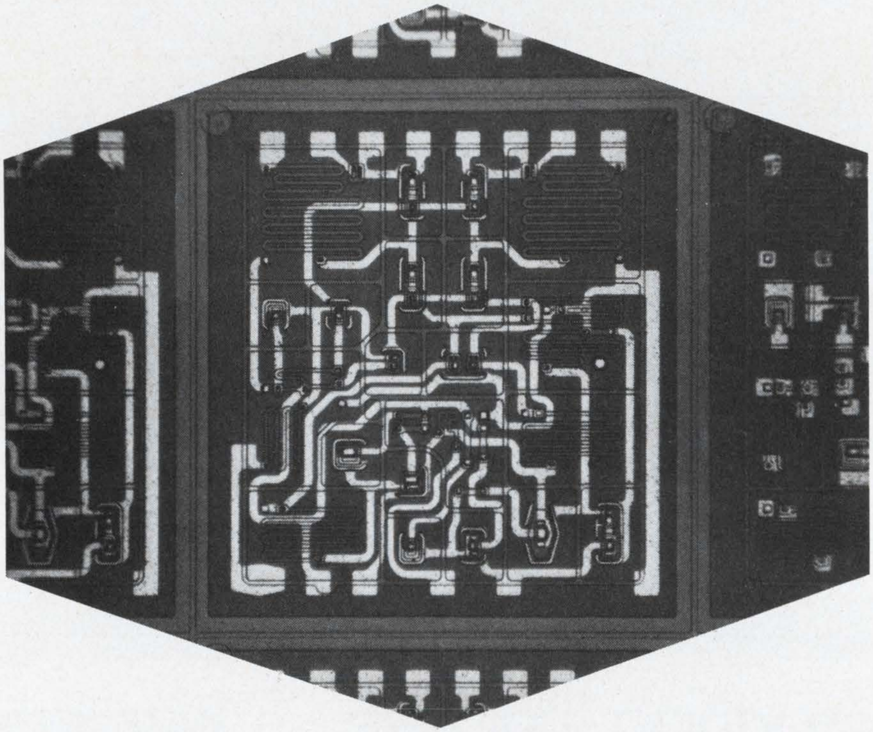
# Union Carbide's New Integrated Circuit Operational Amplifier



## The 15nA Operational Amplifier

ADVANCED DATA SHEET FOR YOUR USE

- 15nA differential input offset current (max)
- 175pA/°C differential input offset current drift (max)
- 5mV input offset voltage (max)
- 10$\mu$V/°C input offset voltage drift (max)
- 50nA input biasing current (max)
- ±10V common mode voltage (min)
- ±10V output voltage swing (min)
  2mA output current drive (min)
- 20,000 open loop voltage gain (min)
- −55°C to +125°C operating temp. in TO-101
- Offset Voltage adjustable to zero with external potentiometer
- Off the shelf delivery

*applications:* A to D converter • Bridge amplifier • DC amplifier • Differential amplifier
Integrater (DC to AC) • Sample and hold amplifier

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# MONOLITHIC OPERATIONAL AMPLIFIERS LINEAR INTEGRATED CIRCUITS

# UC4000/UC4001/UC4002

The UC4000 series of operational amplifiers are constructed on a single silicon chip. The amplifier has the following features:

- Offset voltage adjustable to zero with external potentiometer
- ±10V common mode voltage
- 15 nA differential input offset current
- 100 pA/°C differential input current drift
- 10 μV/°C input offset voltage drift

## MAXIMUM RATINGS

$T_A = 25°C$ (UNLESS OTHERWISE NOTED)

| | UC4000/UC4001/UC4002 |
|---|---|
| Supply Voltage | ±18.0 Volts |
| Internal Power Dissipation 125°C Ambient Temp. | 200 mW |
| Output Short Circuit Duration | 5 sec |
| Differential Input Voltage | ±10.0 Volts |
| Input Voltage, Common Mode | ±10.0 Volts |
| Storage Temperature Range | −65°C to +200°C |
| Operating Ambient Temperature Range | −55°C to +125°C |
| Lead Temperature Soldering for 60 seconds | +300°C |

## ELECTRICAL CHARACTERISTICS

@ 25°C and Supply Voltage ±15.0 Volts in Test Circuit Figure No. 4 (UNLESS OTHERWISE NOTED)

| SPECIFICATION | Sym. | UC4000 Min. | UC4000 Typ. | UC4000 Max. | UC4001 Min. | UC4001 Typ. | UC4001 Max. | UC4002 Min. | UC4002 Typ. | UC4002 Max. | Unit | TEST CONDITIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Large Signal, Open Loop Voltage Gain | $A_v$ | 20K | | 80K | 20K | | 80K | 20K | | 80K | | $V_{IN} = 100\ \mu V$ rms<br>$R_L = 10$ K ohms<br>$f = 100$ Hz |
| Large Signal, Open Loop Voltage Gain | $A_v$ | 15K | | | 15K | | | 15K | | | | $V_{IN} = 100\ \mu V$ rms<br>$R_L = 10$ K ohms, f=100 Hz<br>($T_A = -55°C$ to $+125°C$) |
| Differential Input Impedance | $R_{in}$<br>$C_{in}$ | 0.8 | 3.0<br>1.0 | | 0.8 | 3.0<br>1.0 | | 0.8 | 3.0<br>1.0 | | MΩ<br>pF | $V_{out} = 7$ V rms<br>$f = 1$ KHz |
| Open Loop Output Resistance | $R_{out}$ | | 100 | | | 100 | | | 100 | | ohm | $V_{out} \leq 1$ V p-p<br>$f = 100$ Hz |
| Output Voltage Swing | $V_{out}$ | ±10 | | | ±10 | | | ±10 | | | V | $R_L = 10$ K ohms<br>($T_A = -55°C$ to $+125°C$) |
| Output Current | $I_{out}$ | ±2 | | | ±2 | | | ±2 | | | mA | $R_L = 5$ K ohms |
| Equivalent Input Offset Voltage(1) | $V_{os}$ | | 3.0 | 5.0 | | 5.0 | 10.0 | | 7.0 | 10.0 | mV | $R_L = 10$ K ohms |
| Equivalent Input Offset Voltage Change with Temp. | $\Delta V_{os}$ | | | 1.8 | | | 3.6 | | | 7.2 | mV | $R_L = 10$ K ohms<br>($T_A = -55°C$ to $+125°C$) |
| Equivalent Average Offset Voltage Drift | $\Delta V_{os}$ | | | 10 | | | 20 | | | 40 | μV/°C | $R_L = 10$ K ohms<br>($T_A = -55°C$ to $+125°C$) |
| Offset Voltage Change with Power Supply Variation | $\Delta V_{os}$ | | 25 | 150 | | 25 | 150 | | 25 | 150 | μV/V | $R_L = 10$ K ohms, $V_{out} = 0$<br>$\Delta V_{PS} = 1$ V rms, $f = 100$ Hz |
| Offset Voltage Drift with Time | $\Delta V_{os}$ | | 40 | | | 100 | | | 160 | | μV/24 hr | $V_{OS} = 0$ at start,<br>$t = 24$ hrs. |
| Differential Input Offset Current | $I_{os}$ | | | 15 | | | 30 | | | 50 | nA | $V_{out} = 0$, $R_L = 10$ K ohms |
| Differential Input Offset Current Change with Temp. | $\Delta I_{os}$ | | | 31.5 | | | 63.0 | | | 126 | nA | $V_{out} = 0$, $R_L = 10$ K ohms<br>($T_A = -55°C$ to $+125°C$) |

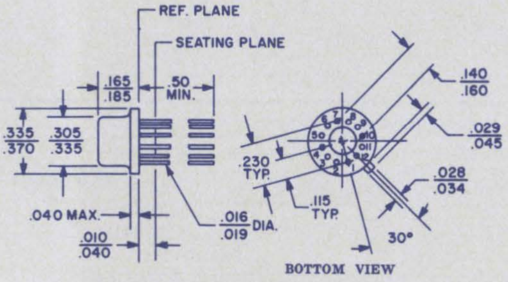
May 1967

## ELECTRICAL CHARACTERISTICS

@ 25°C and Supply Voltage ±15.0 Volts in Test Circuit Figure No. 4 (UNLESS OTHERWISE NOTED)

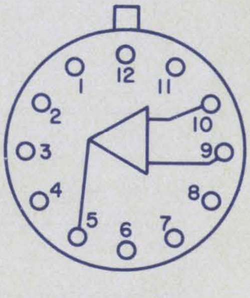
| | | UC4000 | | | UC4001 | | | UC4002 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIFICATION | Sym. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Unit | TEST CONDITIONS |
| Average Differential Input Offset Current Drift | $\Delta I_{os}$ | | | 175 | | | 350 | | | 700 | pA/°C | $V_{out} = 0$, $R_L = 10$ K ohm<br>($T_A = -55°C$ to $125°C$) |
| Differential Input Offset Current Change with Power Supply Variation | $\Delta I_{os}$ | | 500 | | | 500 | | | 500 | | pA/V | $V_{out} = 0$, $R_L = 10$ K ohms<br>$\Delta V_{PS} = 1$ V rms, f= 100 Hz |
| Differential Input Offset Current Change with Time | $\Delta I_{os}$ | | 1 | | | 3 | | | 5 | | nA/24 hr | $V_O = 0$ at start, t = 24 hrs.<br>$R_L = 10K\ \Omega$ |
| Common Mode Rejection | CMR | 90 | 100 | | 90 | 100 | | 90 | 100 | | dB | $e_{in} = 1$ V rms, f= 100 Hz |
| Common Mode Voltage Range (Note 2) | $V_{CM}$ | ±10 | | | ±10 | | | ±10 | | | V | $R_L = 10$ K, $R_f = \infty$<br>f = 100 Hz,<br>$V_{out} = 7$ Vrms |
| Common Mode Input Resistance | $R_{CM}$ | | 400 | | | 400 | | | 400 | | MΩ | $V_{out} = 7.0$ V rms<br>$V_{CM} = 7.0$ V rms |
| Input Bias Current | $I_{Bias}$ | | 40 | 50 | | 60 | 100 | | 80 | 150 | nA | $V_{out} = 0$ |
| Input Bias Current | $I_{Bias}$ | | 150 | 250 | | 300 | 400 | | 500 | 600 | nA | $V_{out} = 0$<br>($T_A = -55°C$) |
| Input Spot Noise Voltage | $e_n$ | | 200 | | | 200 | | | 200 | | $nv/\sqrt{\sim}$ | f = 100 Hz<br>$R_L = 10K\Omega$ |
| Small Signal Bandwidth—(Note 2) | BW | 1.0 | 2.0 | | 1.0 | 2.0 | | 1.0 | 2.0 | | MHz | $R_f = 0$, $R_{in} = \infty$,<br>$e_{in} \leq 100$ mV |
| P.S. Current Drain. +15 V | | | | 7.0 | | | 7.0 | | | 7.0 | mA | $V_{out} = 0$ |
| P.S. Current Drain. −15 V | | | | 8.0 | | | 8.0 | | | 8.0 | mA | $V_{out} = 0$ |
| Slewing Rate (Note 2) | $\Delta V/\Delta t$ | 1.0 | | | 1.0 | | | 1.0 | | | V/µs | $R_L = 10$ K<br>$-10 V < V_{out} < +10 V$<br>$t_r$ =10 ns, PRR= 1 KHz |
| Full Power Frequency (Note 2) | | 15 | | | 15 | | | 15 | | | KHz | $R_L = 10$ K, $V_{out} = 7$ V rms<br>$R_i = R_f = 100K\Omega$ |

Notes:
1) Adjustable to zero by external 20 KΩ potentiometer.
2) With compensation to provide 6 dB per octave roll-off (see Figure 3).
3) If balance potentiometer is not used, connect pins 7 and 12 through 10K ohm resistors to pin 6 (see Figure 5).
4) Case connected to negative supply pin 2.



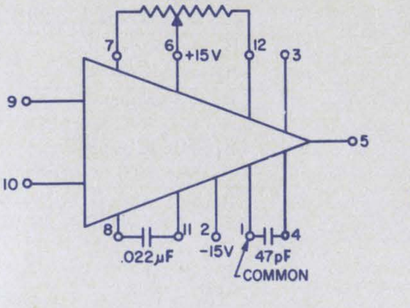
JEDEC OUTLINE TO-101.
PHYSICAL DIMENSIONS
FIGURE 1

(1) Common
(2) Negative Supply (Ref: Note 4)
(3) Output Compensation (Fig. 3 & 5)
(4) Output Compensation (Internal Resistor)
(5) Output
(6) Positive Supply
(7) Balance Potentiometer
(8) Input Compensation (Fig. 3 & 5)
(9) Input (Inverting)
(10) Input (Non-inverting)
(11) Input Compensation
(12) Balance Potentiometer (Fig. 3 & 5)

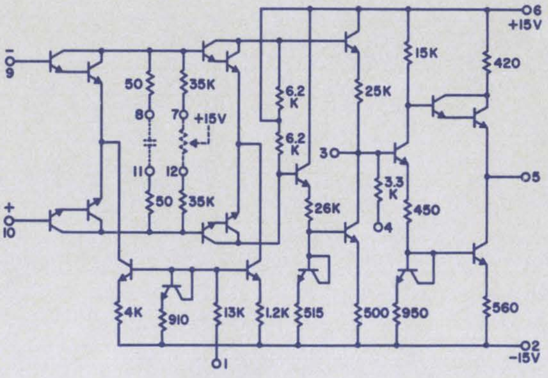


TOP VIEW

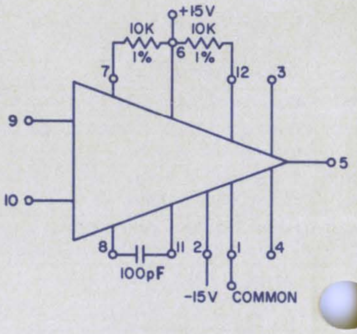
CONNECTION DIAGRAM
FIGURE 2



FREQUENCY COMPENSATION CIRCUIT FOR 6 dB/OCTAVE ROLLOFF (Ref: Note 2)
FIGURE 3

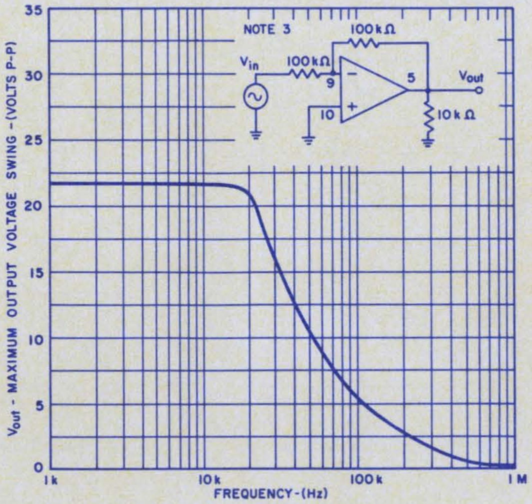


CIRCUIT DIAGRAM
FIGURE 4



STANDARD TEST CIRCUIT
(Ref: Note 3)
FIGURE 5

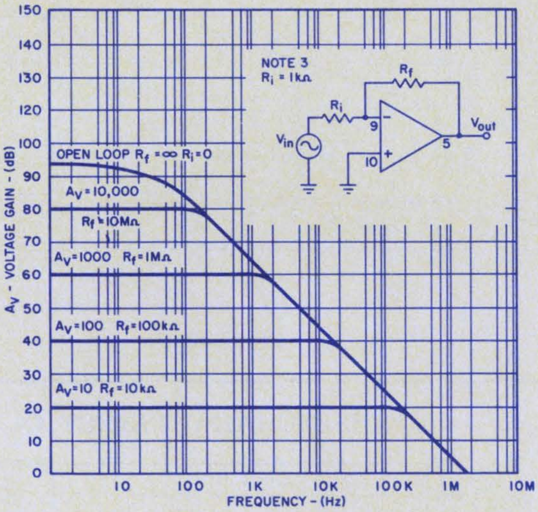
## LARGE SIGNAL CHARACTERISTIC



MAXIMUM OUTPUT VOLTAGE SWING VS FREQUENCY

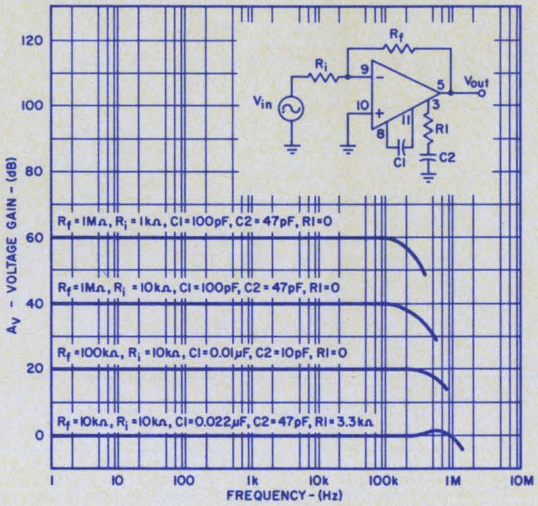
FIGURE 18

## SMALL SIGNAL CHARACTERISTIC



VOLTAGE GAIN VS FREQUENCY

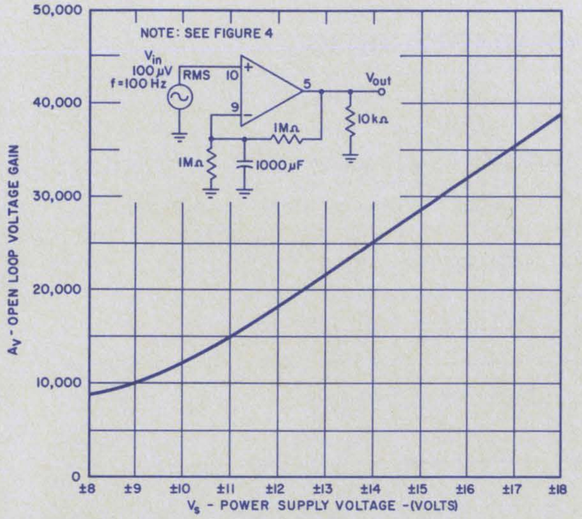
FIGURE 19



VOLTAGE GAIN VS FREQUENCY

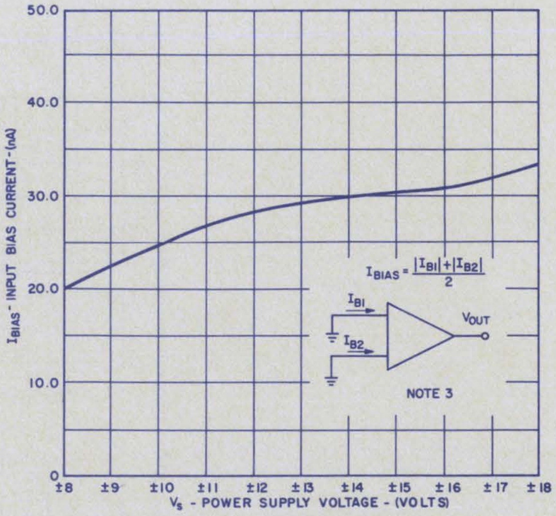
FIGURE 20

# POWER SUPPLY CHARACTERISTICS



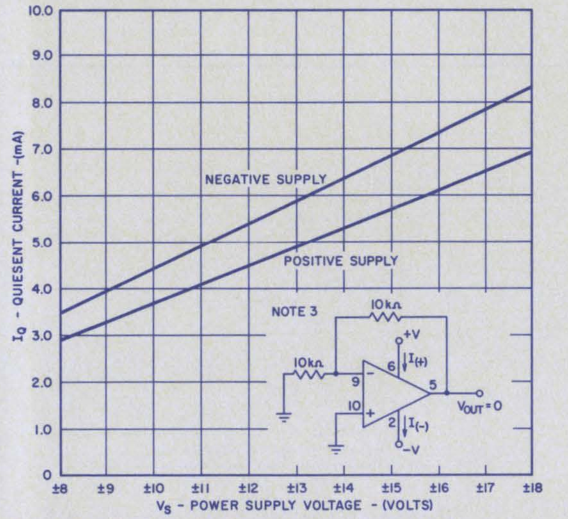
OPEN LOOP VOLTAGE GAIN VS POWER SUPPLY VOLTAGE

FIGURE 12



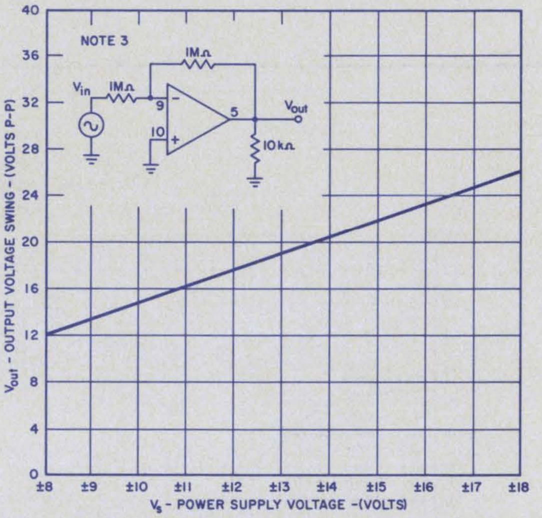
INPUT BIAS CURRENT VS POWER SUPPLY VOLTAGE

FIGURE 13



QUIESCENT CURRENT VS POWER SUPPLY VOLTAGE

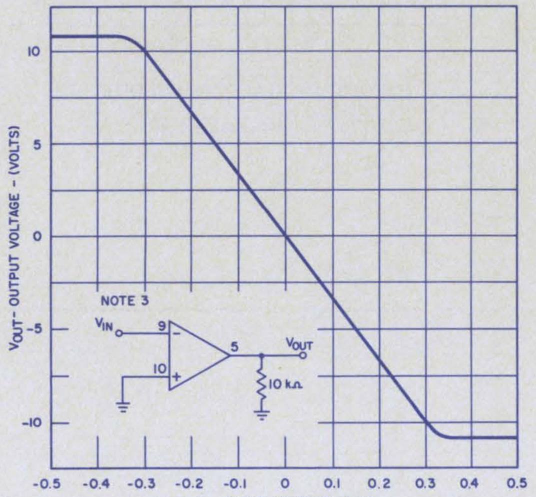
FIGURE 14



OUTPUT VOLTAGE SWING VS POWER SUPPLY VOLTAGE

FIGURE 15

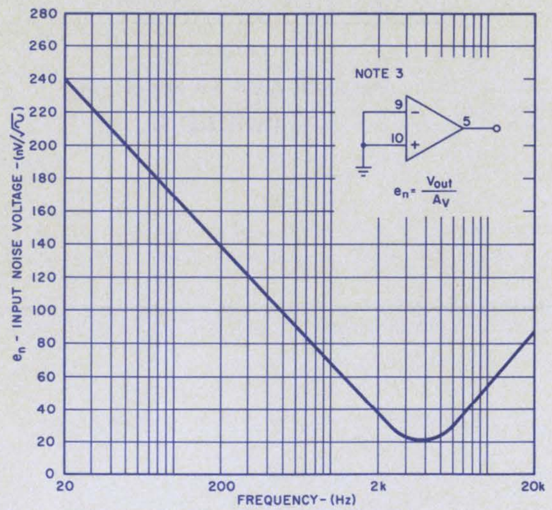
# TRANSFER CHARACTERISTIC



OUTPUT VOLTAGE VS INPUT VOLTAGE

FIGURE 16

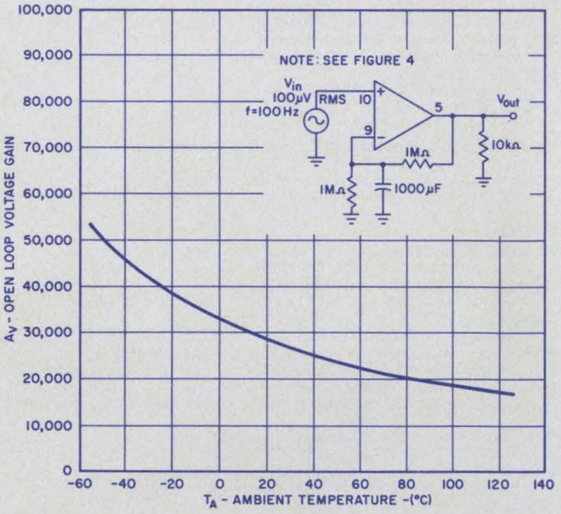
# NOISE CHARACTERISTIC



INPUT NOISE VOLTAGE VS FREQUENCY

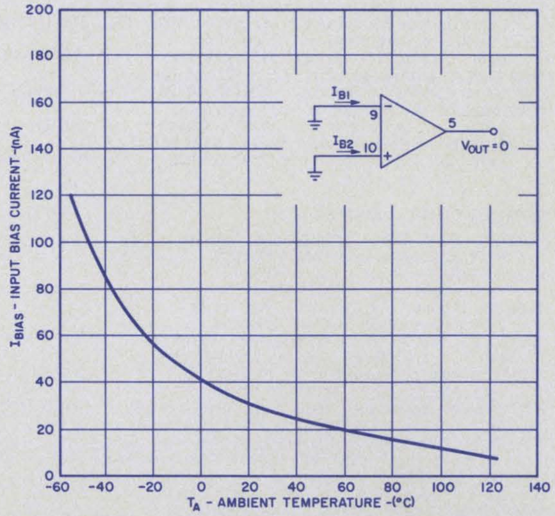
FIGURE 17

# TEMPERATURE CHARACTERISTICS



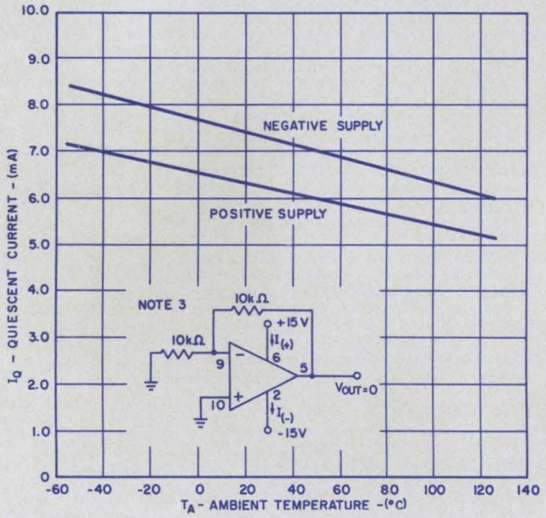
OPEN LOOP VOLTAGE GAIN VS AMBIENT TEMPERATURE

FIGURE 6



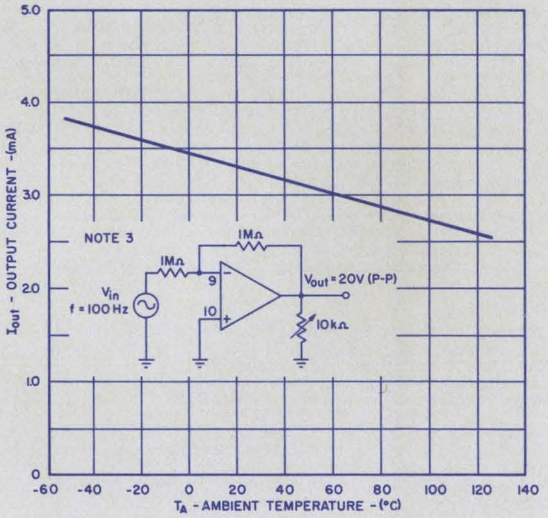
INPUT BIAS CURRENT VS AMBIENT TEMPERATURE

FIGURE 7



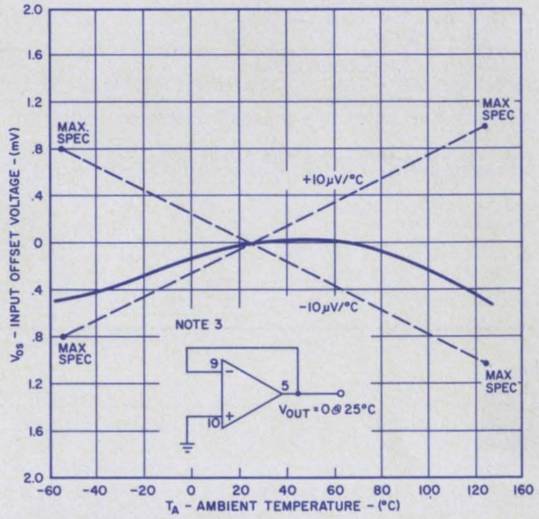
QUIESCENT CURRENT VS AMBIENT TEMPERATURE

FIGURE 8



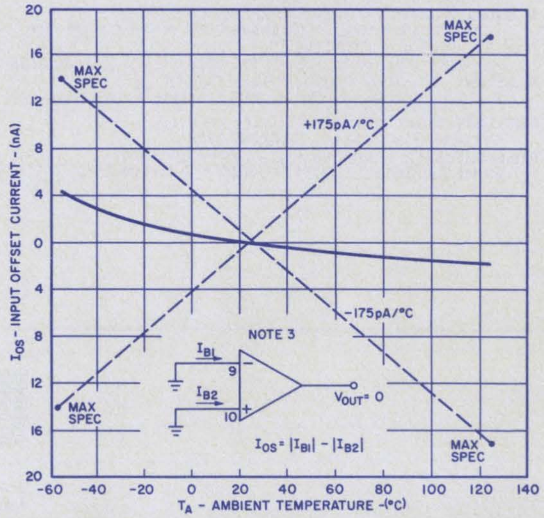
OUTPUT CURRENT VS AMBIENT TEMPERATURE

FIGURE 9



INPUT OFFSET VOLTAGE VS AMBIENT TEMPERATURE

FIGURE 10



INPUT OFFSET CURENT VS AMBIENT TEMPERATURE

FIGURE 11

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*(continued from p. 54)*

At present we estimate over 200 systems in the country are providing 24-hour time and weather service and a substantial number of these systems are providing a 24-hour news channel utilizing the news wire services of Associated Press and United Press International. Partly as a result of demands by local communities, approximately 100 CATV systems are presently engaged in some additional form of local origination (cablecasting is apparently the term that will be applied to this activity) geared to the needs of the communities they serve.

I would offer one disclaimer on the content of your editorial. You refer to "between 50 and 100 per cent" profits. We have sought, unsuccessfully, to document reports of such profits which have appeared in various articles over the past five years. We are justifiably enthusiastic about our industry and its future, but tend to regard it as a very good business rather than one in the spectacular category in which it has been depicted.

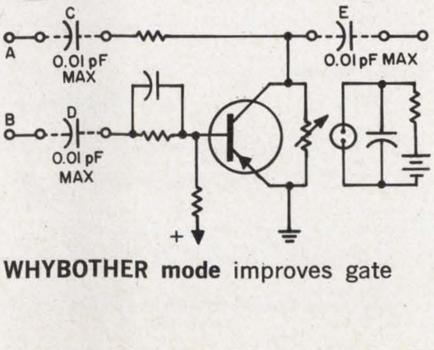
Wally Briscoe
Administrative Assistant
National Community Television Assoc.
Washington, D. C.

## MAYBE gate performs better in new mode

Sir:

A further improvement in the performance of the MAYBE gate described in ELECTRONIC DESIGN [Letters, ED 4, Feb. 15, 1967, p. 49] can be obtained by making slight modifications in the circuitry.

While operation in the FOR-SURE mode, as recently discussed [Letters, ED 7, April 1, 1967, p. 33], provides reliable results, guaranteed performance can be obtained by modifying the circuitry to allow operation in the WHYBOTHER mode (see figure).



**WHYBOTHER mode** improves gate

In this configuration, the output is affected neither by the input nor by the bias on the transistor, and there can thus never be any question of its magnitude. Additional savings allowed by the elimination of the bias supply are unfortunately decreased, however, by the necessity for careful quality control in circuit construction to minimize capacitance at points *C*, *D* and *E*.

Jud B. Flato
Senior Research Chemist
Leon Szmauz
Senior Development Engineer
Princeton Applied Research Corp.
Princeton, N. J.

## Fawkes' nomograph makes its mark

Sir:

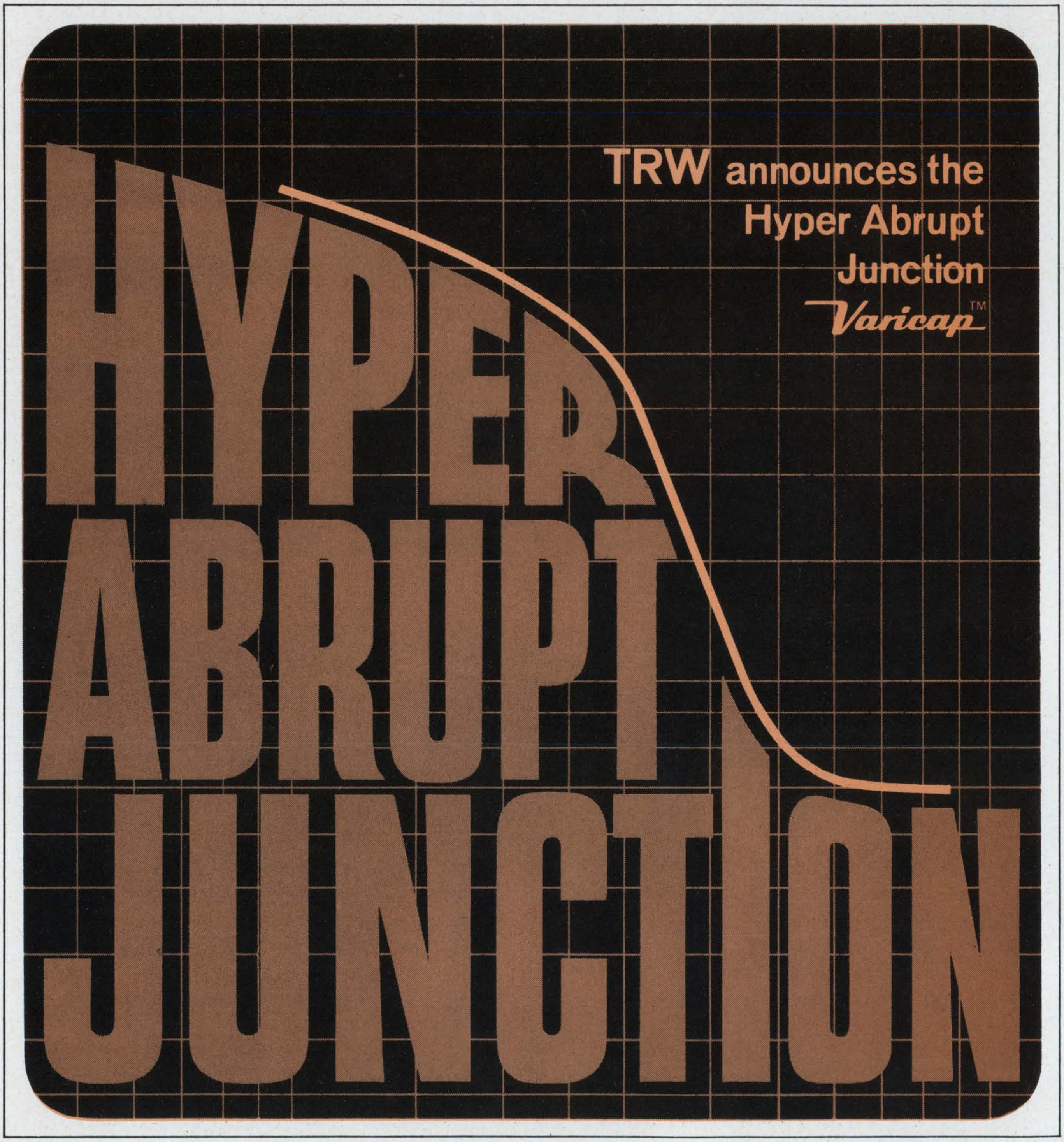
Genius fills me with awe and envy. I marvel at its process and wish that I, a journeyman engineer, could duplicate it.

The fruits of genius are the salvation of hacks like me. They also bring immortality to the discoverers, to wit, Newton and fluxions, Steinmetz and complex algebra, Heaviside and operational calculus, Shannon and Boolean algebra, and now at last, Guy Fawkes and his hertz-cps nomograph [see "Nomograph accurately converts Hz into cps" ED 7, April 1, 1967, p. 37]. A new immortal!!

William Rosenstein
Project Engineer
Development and Product Engineering Dept.
Varityper Corp.
Newark, N. J.

## Accuracy is our policy

In "Digital multimeter has pushbutton control," ED 6, March 15, 1967, p. U168, the pricing is incomplete. Cohu Electronics' basic device costs $1495, but the "full-house" version described is listed at $2750.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Hyper Abrupt
Junction
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HYPER
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EDITORIAL

# Brain research is no threat to man's individuality

Electrical stimulation of the brain has many connotations to scientists. To the clinician, it is a tool for diagnosing such abnormalities as epileptic seizures. To the physiologist, it is a method of gaining new insight into the functioning of an extremely complex organ. To the psychologist, it is a means to understand behavior of animals and men.

A layman freshly confronted with the concept lacks a sound basis for deciding whether this research is benign or malevolent. It is natural that he should be troubled at the idea of intrusion into his privacy at least, total domination at worst.

Fear of enslavement is as old as man himself. Forced-labor camps are a reality in our age. Nor is government interference with our biology novel. We submit to blood tests before marrying, to inoculation before traveling abroad. We eat iodized salt, drink fluoridated water.

Prof. José M. R. Delgado of the Yale University Medical School commented in 1965:

"These intrusions into our blood, teeth, and glands have been legally introduced, are useful for the prevention of illness, and do generally benefit society and individuals, but they have established a precedent of official manipulation."

"Fortunately," he added, turning individuals into robots is "remote, if not impossible."

Unfortunately, much nonsense has been written on this subject. An advertisement for a sensational book on the assassination of John F. Kennedy hints that Oswald, Ruby and others were controlled by means of receivers implanted in their brains.

When Dr. Delgado and other researchers say this is impossible, these are their reasons:

▪ There are anatomical and functional differences between individuals. Each person would have to be studied for a long time before the effects of implanted electrodes were known.

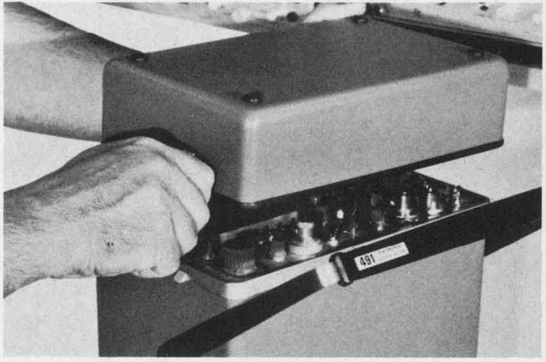
▪ Stimulation of the human brain evokes limited responses, but would not control the totality of behavior.

▪ The human brain has built-in controls of its own and resists manipulation. Stimulation can modify existing behavior; it cannot create personality.

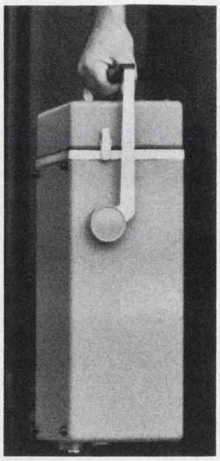
Scientific discoveries and technology cannot be shelved because of real or imaginary dangers, but their progress should be in the open. Nothing dispels unfounded fears better than knowledge.

RICHARD N. EINHORN

# Tektronix Type 491



. . . PACK IT UP



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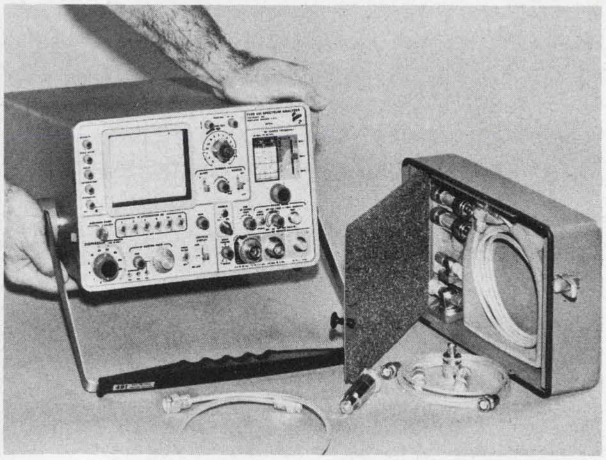
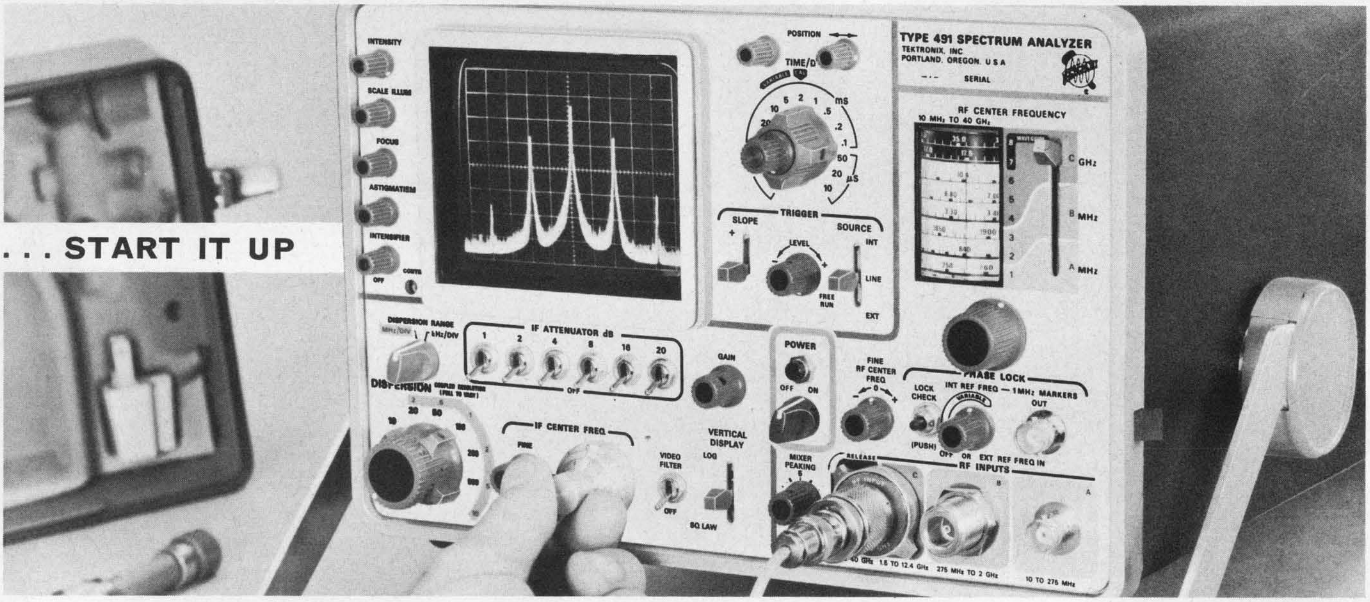


. . . SET IT UP



. . . START IT UP

# New 10 MHz-TO-40 GHz spectrum analyzer

The Type 491 is only 7" high by 12" wide and 22" deep, weighs less than 40 pounds and requires only 55 watts. Yet it has the broad frequency range and high performance you need for most applications. And setup is easy even at waveguide frequencies—just mount one of the three included external waveguide mixers to your source and couple it to the Type 491 with a flexible cable.

You can judge its performance by these features . . . internal phase lock for stable displays even at 1 kHz/div dispersion . . . resolution range of 1 kHz to 100 kHz coupled to calibrated dispersion for operational simplicity . . . dispersion range of 10 kHz (1 kHz/div) to 100 MHz (10 MHz/div) for direct readings of relative frequency from the display . . . CW sensitivity of −110 to −70 dBm depending on frequency . . . and display flatness of ±1.5 dB over 100 MHz dispersion.

With oscilloscope-type triggering and sweep circuitry, you can trigger from internal, external or line sources, and have wide choice of sweep rates from 0.5 s/div to 10 μs/div in a 1-2-5 sequence.

Other features include EMI (RFI) suppression . . . trace intensification of high speed segments of the waveform . . . camera compatibility with the Tektronix Type C-30 for easy, high quality photographs . . . bright display, small spot size, long persistence (P-7) phosphor on a new 4-inch rectangular CRT with 8x10 div (1 div equals 0.8 cm) display . . . and DC-coupled recorder output.

As shown, the carrying handle adjusts for various tilt positions and provides a sturdy support stand. The front panel cover serves as a storage case for the included accessories such as adapters, cables, waveguide mixers and coax attenuators. And the rugged construction of the Type 491 lets you carry laboratory performance to the job.

Type 491 (with accessories) . . . . . . . . . . . . $4200

U.S. Sales Price f.o.b. Beaverton, Oregon

***Tektronix, Inc.***

**For complete information, contact your nearby Tektronix field engineer or write:**

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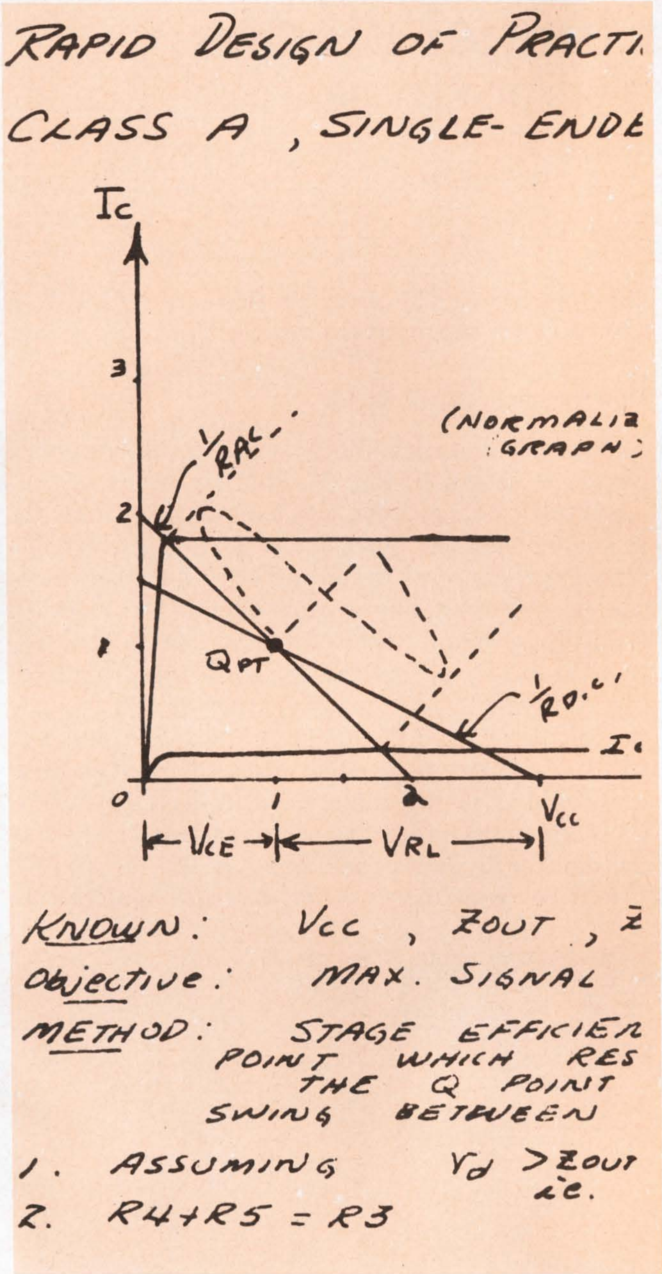
ON READER-SERVICE CARD CIRCLE 29

# Technology



RAPID DESIGN OF PRACTI

CLASS A , SINGLE-ENDE

KNOWN: Vcc , ZOUT , Z

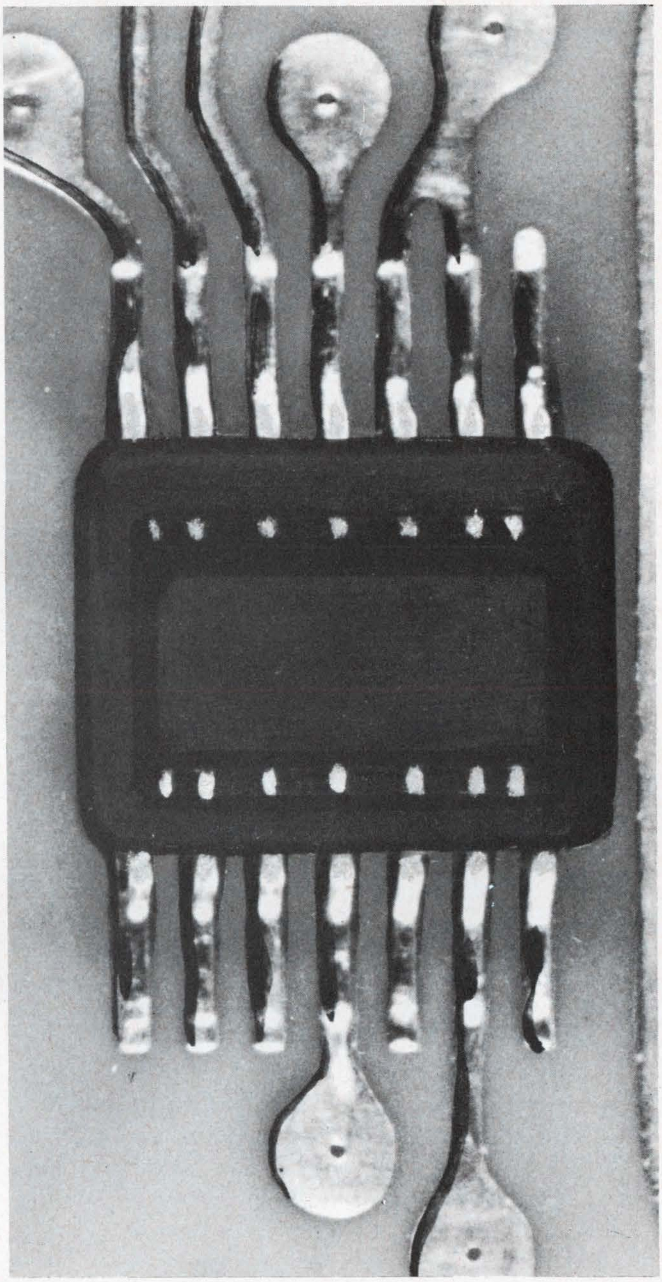
OBJECTIVE: MAX. SIGNAL

METHOD: STAGE EFFICIEN POINT WHICH RES THE Q POINT SWING BETWEEN

1. ASSUMING rd > ZOUT i.e.

2. R4+R5 = R3

**A neatly kept notebook** of basic circuit designs is an invaluable and handy reference. Page 75



**Prealloyed solder-and-flux creams** improve quality of microelectronic soldering. Page 90

## Also in this section:

# Design a log amp with tunnel diodes

## to combine high speed with temperature and phase stability. Hybrid techniques make it easy.

Logarithmic amplifiers designed with tunnel diodes can perform at frequencies above 1 GHz with bandwidths greater than 100 MHz. They dissipate one-twelfth the power of conventional logarithmic amplifiers that use ordinary diodes; they are twice as phase-stable; and they are four times more temperature-stable.

Such high-performance amplifiers can be made with thin-film passive components, tiny inductors and available tunnel diodes. They are especially useful in high-resolution radar systems or any system that requires very stable logarithmic amplification of extremely high frequencies.

The effective bandwidth of commonly used successive-detection logarithmic amplifiers is limited to about 10 MHz because they require IF decoupling at the video output of each stage. On the other hand, cascaded duo-gain logarithmic amplifiers that use conventional diodes as nonlinear feedback or load are limited—in frequency as well as bandwidth—by the capacitance and speed of their diodes.

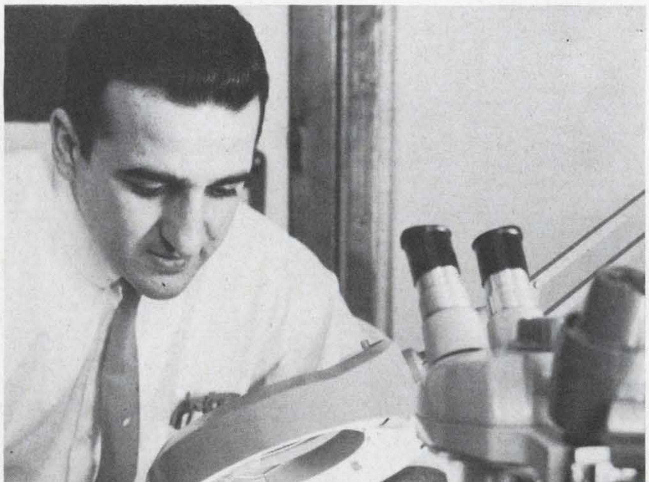
The tunnel diodes offer these benefits to the logarithmic-amplifier circuit:

- They can operate in the microwave region. The circuit is limited primarily by the speed of available transistors, which is now routinely up to 1 GHz. A stripline logarithmic amplifier, however, would probably be better at speeds of 10 GHz.
- They have low forward impedance of about 50 ohms. The amplifier thus has more small-signal gain than conventional logarithmic amplifiers. Fewer cascaded stages are required for a specific input dynamic range when tunnel diodes are used.
- They have extremely low junction capacitance—around 1 picofarad—and excellent matching characteristics. This results in less phase shift than conventional logarithmic amplifiers.
- They have excellent current-temperature characteristics. The circuit's drift is within 2% over a wide temperature range.

### How the basic circuit works

The basic tunnel-diode logarithmic-amplifier circuit is shown in Fig. 1. This circuit is a common-emitter stage with the tunnel-diode network in the emitter leg. Transistor *Q1* is a microwave transistor; hence its input and output capacitances can be neglected up to a frequency of some 10 GHz—the present state of the art of microwave transistors. $R_L$ is the load resistance and includes the equivalent collector resistance of *Q1*. $R_{in}$ is the input resistance and includes the equivalent transistor input resistance. $R_e$ is the emitter bias resistor. $C_{in}$ is the input feedthrough capacitor, $C_o$ is the output feedthrough capacitor, and $C_e$ is the emitter bypass capacitor.

Parallel resistors $R_{D1}$ and $R_{D2}$ are matched to



**Author Harry Fumea** zeroes in on one of his hybrid tunnel-diode logarithmic amplifiers.

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**Harry J. Fumea, Jr.,** Technical Director, Eastern Technical Center, Bunker-Ramo Corp., Silver Spring, Md. This work was done while the author was employed at Westinghouse Defense and Space Center, Baltimore.

the tunnel diodes, *TD1* and *TD2*, to produce the characteristic curve shown in Fig. 1. Resistor $R_x$ is used to control the gain of region 3, which is held at unity.

The equivalent circuit (Fig. 2) for the tunnel-diode–resistor network shows:

$$R_s = R_D \| R_R = R_D R_R / (R_D + R_R), \qquad (1)$$

where:

$R_s$ = series resistance,
$R_R$ = reverse resistance of the tunnel diodes.

From Fig. 2 (left):

$$Z_1 = (R_s + R_x) + Z_{D1} \| R_{D1}$$
$$= (R_s + R_x) + [Z_{D1} R_{D1} / (Z_{D1} + R_{D1})], \qquad (2)$$

where $Z_{D1}$ = impedance of tunnel diode *TD1*. From Fig. 2 (right):

$$Z_2 = (R_s + R_x) + Z_{D2} \| R_{D2}$$
$$= (R_s + R_x) + [Z_{D2} R_{D2} / (Z_{D2} + R_{D2})], \qquad (3)$$

where $Z_{D2}$ = impedance of tunnel diode *TD2*.

If the tunnel diodes are matched:

$$Z_D = Z_{D1} = Z_{D2}, \qquad (4)$$

and if $R_{D1}$ and $R_{D2}$ are chosen so that $R_D = R_{D1} = R_{D2}$, then Eqs. 2 and 3 are identical and become:

$$Z = Z_1 = Z_2 = (R_s + R_x) + Z_D \| R_D$$
$$= (R_s + R_x) + [Z_D R_D / (Z_D + R_D)], \qquad (5)$$

where $Z$ = total impedance of the tunnel-diode network.

Equation 5 shows that bipolar operation is obtained. The voltage output of Fig. 1 is given as:

$$e_o = e_{in}(Z_c / Z_e), \qquad (6)$$

where:

$Z_c$ = total collector impedance,
$Z_e$ = total emitter impedance:

$$Z_e = R_e \| Z = R_e Z / (R_e + Z). \qquad (7)$$

If bias resistor $R_e$ is made large in relation to $Z$, the total emitter resistance becomes:

$$Z_e \approx Z. \qquad (8)$$

Since $Z_c = R_L$, Eq. 6 becomes:

$$e_o = e_{in}(R_L / Z)$$
$$= e_{in}\{R_L / [(R_s + R_x) + Z_D \| R_D]\}. \qquad (9)$$

This equation describes the curves of Fig. 1 (right). $Z_D$ is nonlinear and can be broken into four approximately linear regions (Fig. 3):

In region 1, $Z_D$ is positive and small = $Z_{1D}$;
In region 2, $Z_D$ is negative and small = $Z_{2D}$;
In region 3, $Z_D$ is positive and large = $Z_{3D}$;
In region 4, $Z_D$ is positive and small = $Z_{4D}$.

Throughout region 1, the small-signal region, Eq. 9 becomes:

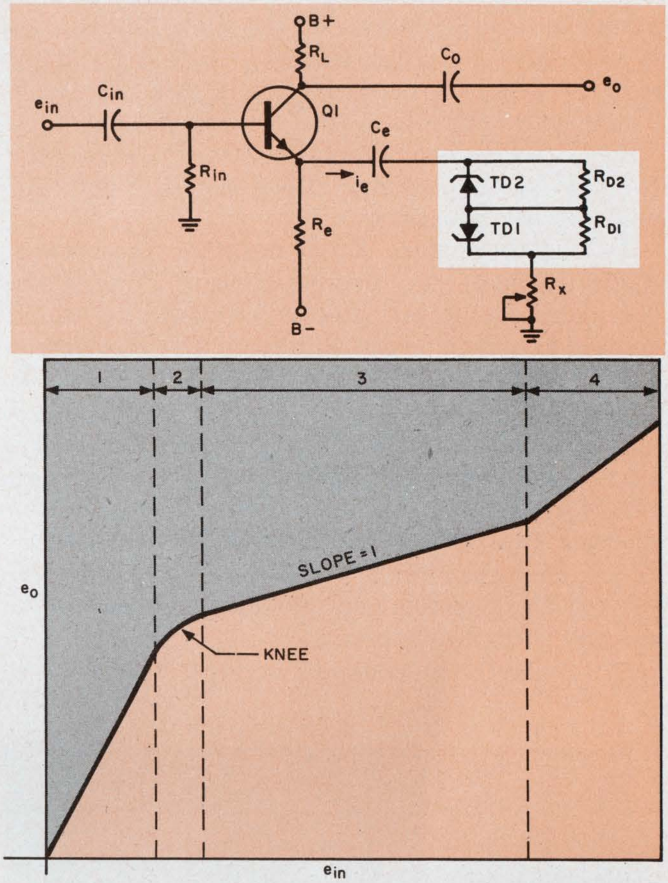
$$e_o = e_{in}\{R_L / [(R_s + R_x) + Z_{1D} \| R_D]\}. \qquad (10)$$

Since $Z_{1D}$ is small and positive, the voltage gain is maximum, as shown in Fig. 1. A typical small-signal gain is 10 dB.

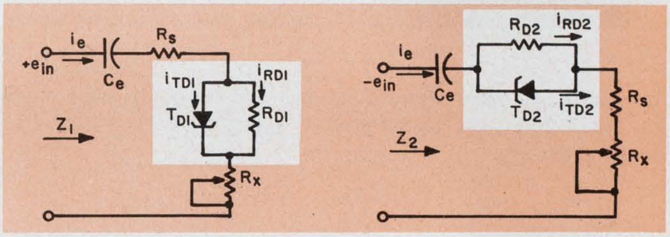
In region 3, Eq. 9 becomes:

$$e_o = e_{in}\{R_L / [(R_s + R_x) + Z_{3D} \| R_D]\}. \qquad (11)$$

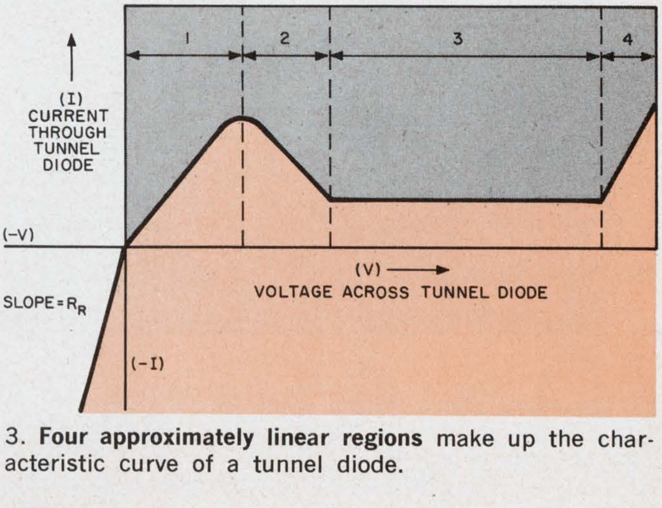
Since $Z_{3D}$ is positive and large, $Z_{3D} \| R_D$ is approximately equal to $Z_{3D}$. Since $Z_{3D}$ and $R_s$ are deter-



1. **The basic circuit** for a tunnel-diode log-amp stage (top) produces duo-gain characteristics (bottom). The circuit exploits regions 1 and 3. Region 2, the curve's knee, is minimized by selection of $R_x$. Region 4 is not used.



2. **Equivalent circuits** for the tunnel-diode–resistor network show positive excursions of the input (left) and negative excursions (right).



3. **Four approximately linear regions** make up the characteristic curve of a tunnel diode.

mined by characteristics of the tunnel diodes, $R_x$ is adjusted for a given load, $R_L$, to give a voltage gain of unity throughout this region. While it would be possible to delete resistor $R_x$ and vary either load resistor $R_L$ or emitter bias resistor $R_e$, this method would affect the dc operating point of the transistor.

In region 2, since $Z_D$ is negative, the tunnel-diode current, $i_{TD}$, decreases as $e_{in}$ increases. Normally the total emitter current, $i_e$, would remain constant or dip slightly if the $R_D$ current did not rise enough to counteract the tunnel-diode current drop. But the temperature-dependent current characteristic of $R_D$ is so chosen that the current through the resistors always increases faster than the tunnel-diode current drops. In this manner the current in $R_D$ swamps out the decrease in tunnel-diode current, so that the total current through the loop increases and causes the output voltage to increase.

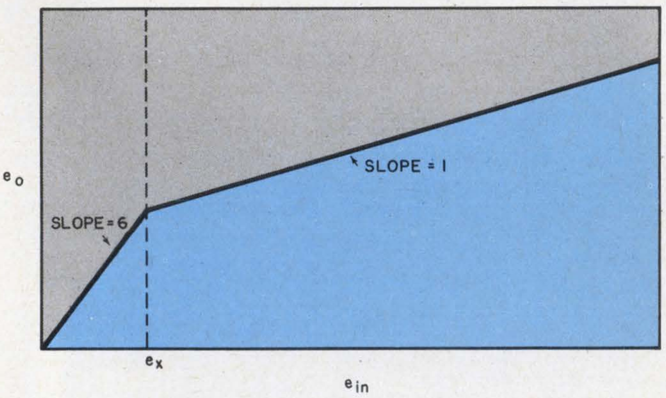
This effectively expands regions 1 and 3, as shown in Fig. 1. At the same time region 2 is reduced to a knee. If $R_D$ is made too small, however, the tunnel-diode action will be shorted out; if $R_D$ is made too large, the knee region will expand, destroying the desired response.

Region 4 is similar to region 1, but is not exploited because it would destroy the desired logarithmic characteristic. Therefore, when stages are cascaded to produce an over-all logarithmic response, the input voltage of each stage is confined below region 4.

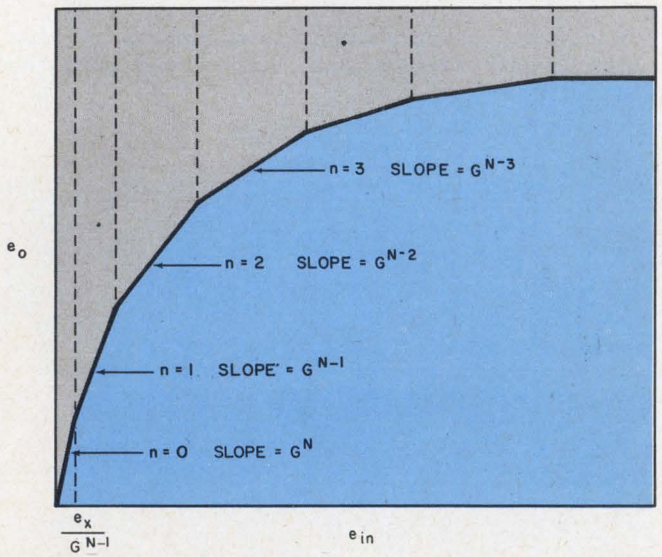
### Curve is key to logarithmic response

Having explained how the circuit of Fig. 1 produces its output-vs-input curve, it is necessary to explain why this curve is needed to produce a logarithmic response. The curve of Fig. 1 approximates the duo-gain curve—a curve made up of two linear regions with different slopes—in Fig. 4.

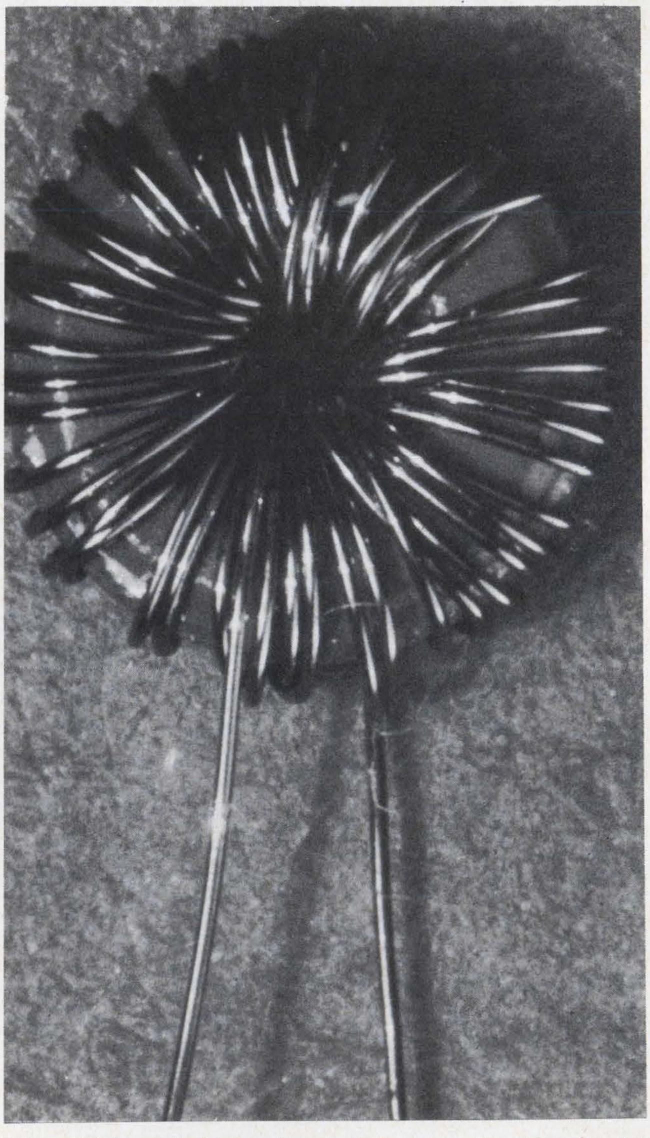
If $N$ stages of Fig. 4 are cascaded, the output of



4. **Duo-gain characteristic** shows small-signal gain = 6 ($e_{in}<e_x$) and large-signal gain = 1 ($e_{in}>e_x$). $e_x$ is the voltage across $R_x$.



5. **Cascading many stages** yields an amplifier with a linear response for small signals and a logarithmic response for large signals.



**This miniature inductor** is used to tune the circuits to the proper center frequency.

the $N$th stage is given as:

$$e_{o(N)} = n(G-1)e_x + G^{N-n}e_{in}$$
$$\text{for } e_x/G^{N-n} \leqq e_{in}e_x/G^{N-n-1}, \qquad (12)$$

where $N = n + 1 =$ the number of cascaded stages. If Eq. 12 is plotted, the resulting logarithmic response is that shown in Fig. 5.

When many stages are cascaded (i.e., when $N$ is large), the curve of Fig. 5 approximates a linear-logarithmic characteristic. A linear-logarithmic characteristic is one that has a linear small-signal region. The first segment ($n = 0$) is the small-signal, or linear, region where the over-all gain, or slope, is $G^N$. The following segment has a slope of $G^{N-1}$, the next a slope of $G^{N-2}$, and so forth. The input dynamic range is equal to the over-all small-signal gain, $G^N$. Since straight-line approximations are used, the maximum error or deviation from the true linear-logarithmic curve increases as the gain per stage increases.

In the case of the duo-gain curve, the small-signal region, the region between $e_{in} = 0$ and $e_{in} = e_x$, has a slope of $G$; the large-signal region, the region between $e_{in} = e_x$ and $e_{in\,max}$, has a slope of unity.

## Design example illustrates technique

A design example that uses typical practical values shows the use of the derived equations. Assume that the small-signal gain, $K_v$, of a stage and the value of its $R_x$ have to be found where:

$$R_R = 11\ \Omega,$$
$$R_D = R_{D1} = R_{D2} = 150\ \Omega,$$
$$Z_{3D} = 3\ \text{k}\Omega,$$
$$Z_{1D} = 50\ \Omega,$$
$$R_L = 160\ \Omega.$$

From Eq. 1 the value of $R_s$ required to produce the desired logarithmic response is:

$$R_s = R_D||R_R = R_D R_R/(R_D+R_R)$$
$$= (150)(11)/(150+11) = 10\ \Omega.$$

The voltage gain of region 3 must be unity. From Eq. 11:

$$e_o/e_{in} = R_L/[(R_s+R_x)+Z_{3D}||R_D] = 1;$$
$$\therefore R_x = R_L - Z_{3D}||R_D - R_s$$
$$= 160-143-10 = 7\ \Omega.$$

The small-signal gain is:

$$K_v = e_o/e_{in} = R_L/[(R_s+R_x)+Z_{3D}||R_D]$$
$$= 160/[(10+7)+(50||150)]$$
$$= 2.78 \text{ or } 8.9 \text{ dB}.$$

Cascading ten such stages would produce a logarithmic amplifier with 89 dB of logarithmic dynamic range.

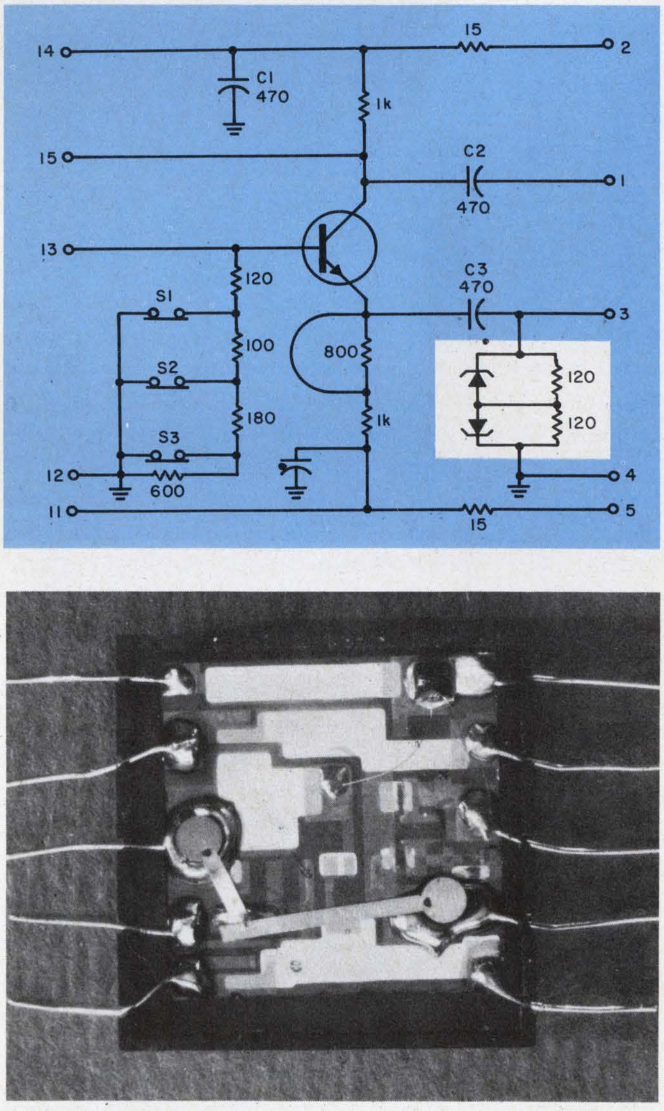
## Thin films used for passive components

A vacuum-deposited thin-film technique can be used for the passive elements (resistors and capacitors) and interconnections within the circuit (Fig. 6). Miniature powdered-iron toroid cores produce the coils in the tuned circuit wafers for frequency tuning.

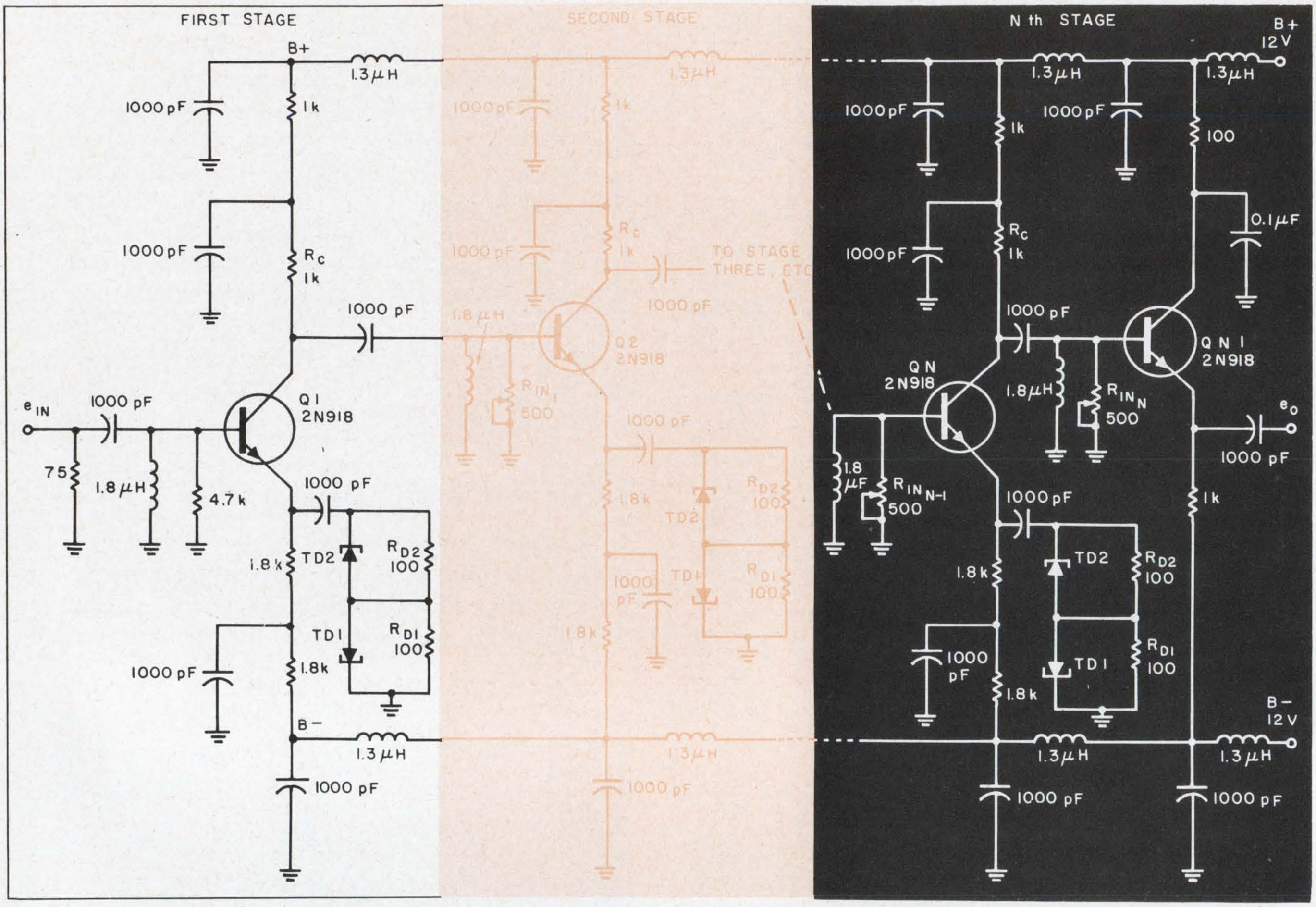
The thin-film wafer is composed of four thin films and a glass substrate. Glass is used because it has the highly polished surface needed for coherent films. The substrate is a 0.41-inch square. The thin film is placed in a hermetically sealed encapsulation. The final thin-film wafer is 0.5 in. long, 0.5 in. wide and 0.1 in. high. Resistors, conductors, lead attachment pads, and capacitor bottom plates are formed by photoetching continuous films of copper and chromium. The capacitor dielectric and top plate are formed by deposition through thin, metal masks.

## Circuit offers stable hf log amplification

Six-stage, seven-stage, eight-stage and nine-stage tunnel-diode logarithmic-amplifier units have been built according to the schematic in Fig. 7. The 1.3-$\mu$H coils are decoupling coils, the capaci-



6. **In the schematic for a single stage,** S1, S2, and S3 are shorts that can be opened to adjust input impedance (above). The stage is made on glass (below).



7. **Complete schematic** shows input stage, output stage and N$^{th}$ stage. All capacitor values are in pF. Transistors Q1, Q2 . . . QN are 2N918. Tunnel diodes are 1N3713. Five stages produce dynamic range of 60 dB.

tors on the power supply lines are decoupling capacitors, and coils *L* are tuning coils. (When tuning coils are chosen to be 1.8 μH, the circuit tunes at 30 MHz.) The output stage is an emitter-follower stage, which permits heavy loading of the multistage units. The load impedance of each stage is composed of collector resistor $R_C$, the output capacitance of each stage, coupling capacitor C, tuning coil L, input resistor $R_{IN}$, the input capacitance of the following stage, and all other stages. Since coil *L* forms a tuned circuit with all parallel capacitances and collector resistor $R_C$ is made much larger than input resistor $R_{IN}$, however, input resistor $R_{IN}$ can be considered the total effective load impedance.

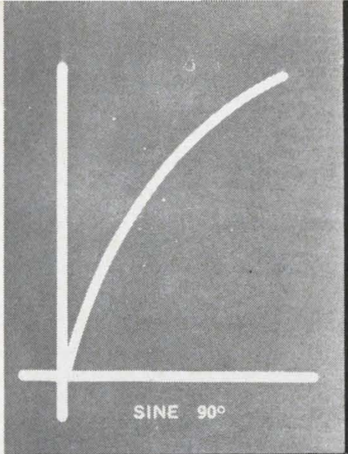
To maximize the small-signal gain, resistor $R_x$ was made zero, and the effective load resistance of each stage, $R_{IN}$ was adjusted to produce unity large signal gain. For different load $R_{IN}$ values, resistors $R_{D1}$, $R_{D2}$ in parallel with the tunnel diodes *TD1*, *TD2* must be changed to minimize output variations in the large-signal region.

With 2N918 transistors and 1N3713 tunnel diodes, the maximum dynamic range obtained was 60 dB. The minimum number of stages needed to produce 60 dB of range was five. Tunnel diodes with larger valley-to-peak voltage ratios would improve the dynamic range beyond 60 dB.

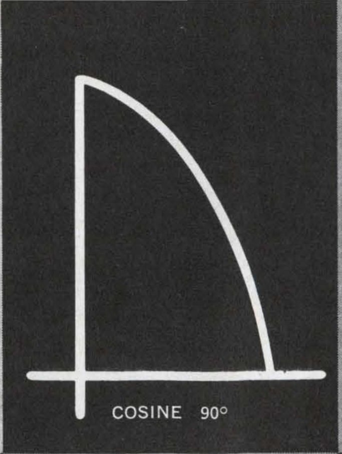
The best error obtained was ±0.5 dB maximum over 60 dB of range. This error was minimized by matching the effective load resistors to the tunnel-diode parallel resistors. The optimum effective load resistor value was 120 Ω and the optimum parallel resistor value was 75 Ω. Conventional logarithmic amplifiers can produce errors of less than ±0.25 dB over 90-dB ranges and are therefore superior in this respect.

The maximum input signal that the tunnel-diode logarithmic amplifier was capable of handling was 100 mV, which is at least 20 dB below that which conventional logarithmic amplifiers can handle. This is very good for microminiature applications where efficient operation is important, but can be a disadvantage if large input signals are anticipated.

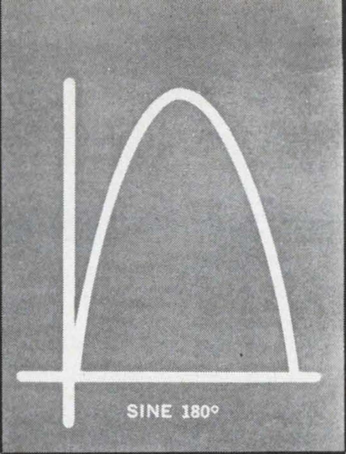
The measured bandwidth of the tunnel-diode logarithmic amplifier with 2N918 transistors was 100 MHz per stage. A five-stage unit would therefore have an over-all bandwidth of 39 MHz. Based on an $R_{IN}$ stage of 120 Ω, bandwidths of 250 MHz a stage or larger can be obtained, if microwave transistors are used. This would be equivalent to a five-stage unit with a 100-MHz or larger over-all bandwidth. ■ ■



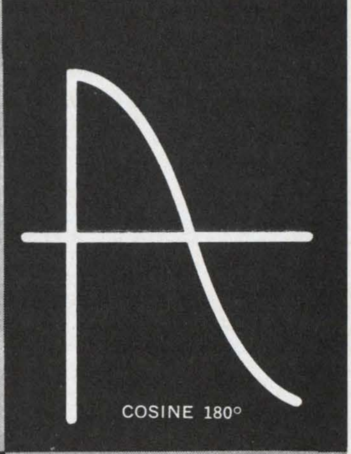
SINE 90°



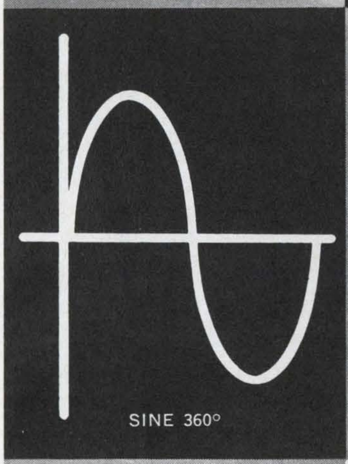
COSINE 90°



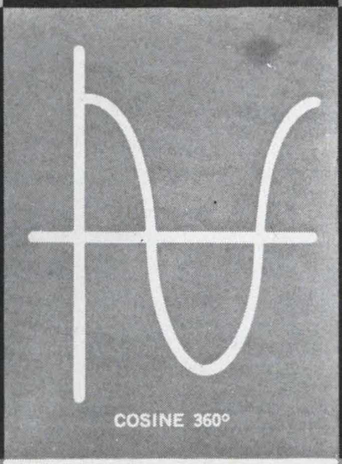
SINE 180°



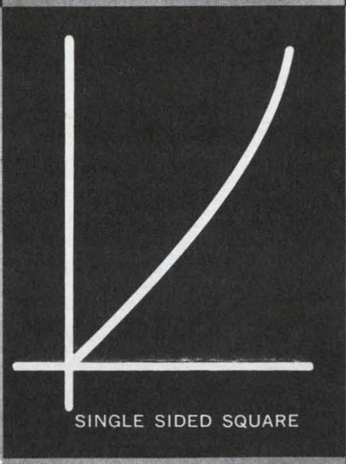
COSINE 180°



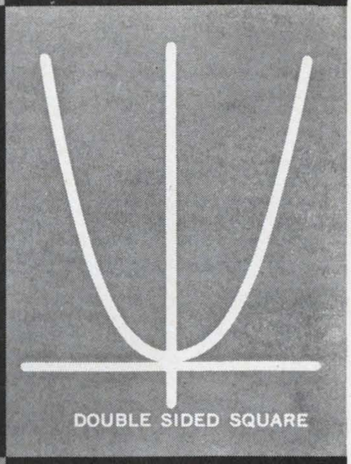
SINE 360°



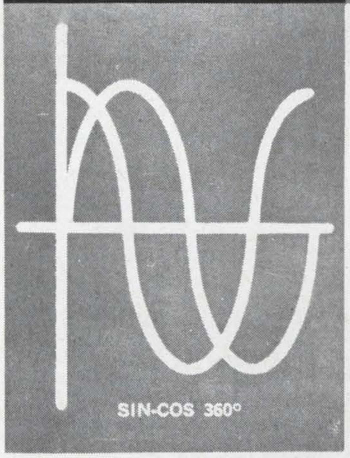
COSINE 360°



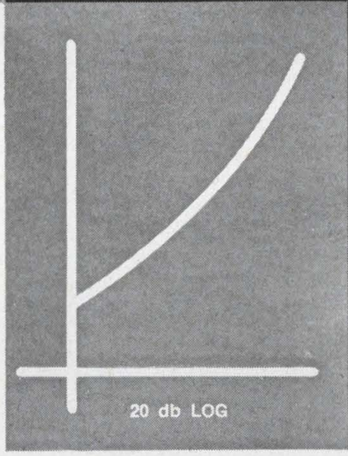
SINGLE SIDED SQUARE



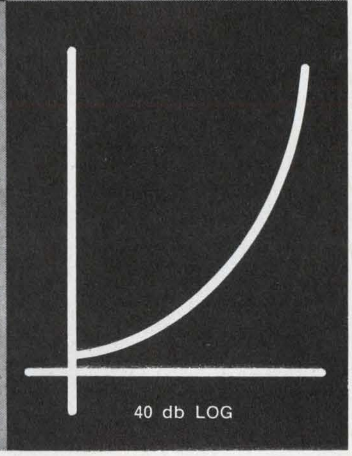
DOUBLE SIDED SQUARE



SIN-COS 360°



20 db LOG



40 db LOG

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# **Disregard load impedance** in SCR inverter design. Use a unique LC swinging turn-off circuit operating as a gate-controlled switch.

In the design of an SCR-controlled inverter the most difficult problem is to turn the SCRs on and off. The ideal control system is one where this action is not influenced by the load. Such a system, using an LC swinging circuit switched by an auxiliary SCR, has been designed to achieve forced commutation of the load-carrying SCR in a configuration that bypasses the load impedance.

With these features, the turn-off circuit functions as a gate-controlled switch capable of handling the power levels of SCRs. This renders the circuit particularly applicable to bridge-type single-phase and three-phase inverters that rely on SCRs.

### Turn-off circuit swings into operation

The basic operation of the turn-off circuit can be explained with the low-voltage chopper shown in Fig. 1.

The turn-off circuit is enclosed in the dashed lines. When the auxiliary rectifier *SCR2* is turned on, the voltage across capacitor $C$ is applied across diode *D1* and load-carrying rectifier *SCR1*. If the voltage across $C$ is initially negative, *SCR1* will be turned off.

At this point, the swinging circuit consisting of capacitance $C$ and inductance $L_T$ (the transformer primary) will come into play, to provide a positive voltage across $C$ to turn *SCR2* off. When *SCR2* is off, the swinging circuit consisting of *L1* and $C$ will return the voltage across $C$ to its initial negative state, and this will then be used again to turn *SCR1* off.

In turning *SCR2* off, the transformer, consisting of coils $n_1$ and $n_2$, is made to operate first with its secondary open and then with it closed. When $n_2$ is open, a voltage swing to turn off *SCR2* is started. To prevent this swing from becoming excessive, the voltage is clamped when secondary winding $n_2$ is closed by the conduction of *D3*.

This transformer action takes place as follows: when *SCR1* is first turned off, secondary $n_2$ is open with *D3* back-biased. Therefore at this time $L_T$ consists of primary leakage inductance, $L_p$, plus mutual inductance, $L_m$. When the $L_TC$ swinging circuit reaches the point where $V_C$ attains a positive magnitude such that the voltage across *D3* becomes somewhat positive, forward conduction occurs in *D3*. Since the output impedance of voltage source $V_{dc}$ can be considered as a dynamic short across secondary $n_2$, the mutual-inductance portion of $L_T$ is shorted out, leaving only the smaller leakage-inductance portion, $L_p$. This action clamps the voltage swing. At this point, the swinging circuit will consist of the leakage inductance $L_p$ and capacitor $C$, and oscillation will continue until the current tries to reverse through *SCR2*. This will turn *SCR2* off and clamp the voltage across capacitor $C$. *SCR2* will now be back-biased by a voltage equal to $V_C - V_{dc}$. Then, *L1* comes into action and returns $V_C$ to its initial negative value—ready to turn off *SCR1* again.

The important feature of this circuit is the fact that the load impedance is not part of the turn-off circuit.

### Turn-off circuit analyzed

Detailed discussion of the commutation performed by the turn-off circuit shown in Fig. 1 involves the following definitions:

$V_C$ = voltage across commutating capacitor $C$,
$V_{SCR2}$ = voltage across *SCR2*,
$i$ = current in primary $n_1$ (this equals the load current until the beginning of commutation),
$i_{SCR2}$ = current through *SCR2*,
$i_2$ = current in secondary $n_2$, and
$I_L$ = magnitude of load current at the beginning of commutation.

If *SCR1* is turned on and $V_o$ is equal to $V_{dc}$ initially, diode *D1* is back-biased. On the assumption that $V_C \approx -[(1 + r)V_{dc} + \Delta V]$, where $r$ is the ratio of transformation, $n_2/n_1$, and $\Delta V$ is the voltage increase across capacitor $C$ produced by swinging circuit $L_p$, $L_s$ and $C$ when turning *SCR2* off, then it will be possible to turn *SCR1* off through forward-biased diode *D1* when *SCR2* is turned on. Product $L_TC$ is designed large enough to hold the voltage across capacitor $C$ negative until *SCR1* recovers. Note particularly that the transient through $L_T$, $C$, *SCR1* bypasses load $Z_L$, and is therefore unaffected by the character of

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$Z_L$, that is, by the load power factor. The magnitude of $Z_L$, however, will have an effect on the turn-off of *SCR1* through the current it produces in $L_T$.

In Fig. 1, inductor *L1* is much larger than $L_T$ so that its influence can be neglected at this point. After *SCR1* recovers, i.e., turns off fully, capacitor $C$ would charge up in the positive direction to approximately $3V_{dc}$, if it were not clamped at a voltage of approximately $(1 + r)V_{dc} + \Delta V$. This clamping action is accomplished by $L_T$, which, as stated, consists of primary leakage inductance $L_p$ plus mutual inductance $L_m$ as long as voltage $V_L$ across it is less than approximately $(n_1/n_2)V_{dc}$. As soon as $V_L = (n_1/n_2)V_{dc}$, diode *D3* in series with secondary winding $n_2$ is forward-biased, the $L_m$ portion is shorted out, and $L_T$ consists of primary and secondary inductance, $L_p + L_s$, thus clamping the voltage swing. The swinging circuit of $L_p + L_s$ and $C$ will then turn *SCR2* off. At this time,

$$V_C \approx V_{dc} + (n_1/n_2)V_{dc} + \Delta V \approx (1+r)V_{dc} + \Delta V,$$

where $\Delta V$ is the voltage increase across capacitor $C$ produced by swinging circuit $L_p + L_s$ and $C$ while *SCR2* is being turned off.

Voltage $V_C$ reverses through the swinging circuit consisting of inductor *L1* and capacitor $C$, and is clamped by diode *D2* at approximately $V_C = -(1+r)V_{dc} + \Delta V$. This swinging circuit is much slower than the one that consists of $L_T$ and $C$. The ratio $L1/L_T$ is chosen so that $\omega_1 = 1/(L1C)^{1/2} << \omega_2 = 1/(L_TC)^{1/2}$. Meanwhile, inductor $L_T$ discharges into the supply, and the circuit is back to its initial state and ready to turn *SCR1* off again.

The transformer nature of $L_T$ is an important characteristic of the circuit. Without this, the voltage across capacitor $C$ would increase indefinitely. Every time *SCR1* is turned off, energy is put into the circuit, and without a return path into the supply, energy—apart from losses—would accumulate in the capacitor.

To clamp the voltage across the capacitor at a level not much above $V_{dc}$, the ratio of transformation, $r$, has to be high. Since the voltage across diode *D3* when *SCR2* is turned on is approximately $2(1 + r)V_{dc}$, a large $r$ will lead to extremely high voltages; therefore, the circuit in Fig. 1 is practical for low input voltages only.

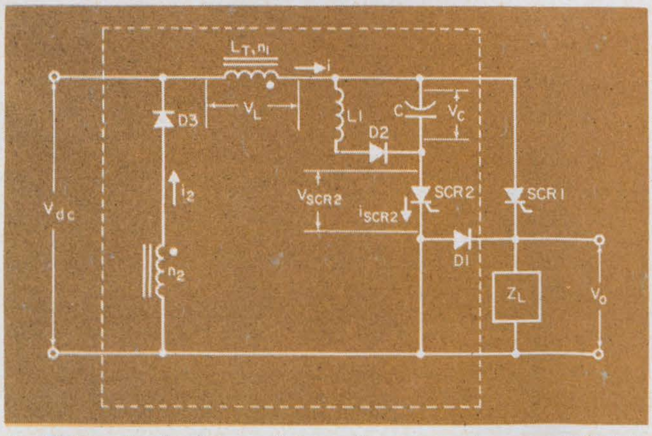
A way to avoid high voltages across diode *D3*, when higher input voltages are involved, is shown in Fig. 2. Here *L2* is a pure inductor and the transformer action is taken over by a separate transformer, $T$. So long as capacitor voltage $V_C < [1 + (n_1/n_2)]V_{dc}$, the transformer is disconnected from the circuit by diode *D4*. But when the voltage reaches this value, it is clamped by the transformer, which feeds magnetic energy stored in *L2* back to the supply. Since diode *D4* prevents reverse voltages from being impressed on the transformer, the voltage across diode *D3* is never higher than $V_{dc}$. In a practical circuit, however, transients will occur and produce high voltages across *D3*. Simple RC circuits placed across the diode can quench these.

It is of interest to note how the circuits in Figs. 1 and 2 operate with reactive loads. The voltage across an inductive load will reverse when *SCR1* is turned off and be clamped by diode *D1*. The load current will circulate in the *D1*-$Z_L$ loop until *SCR1* is turned on again.

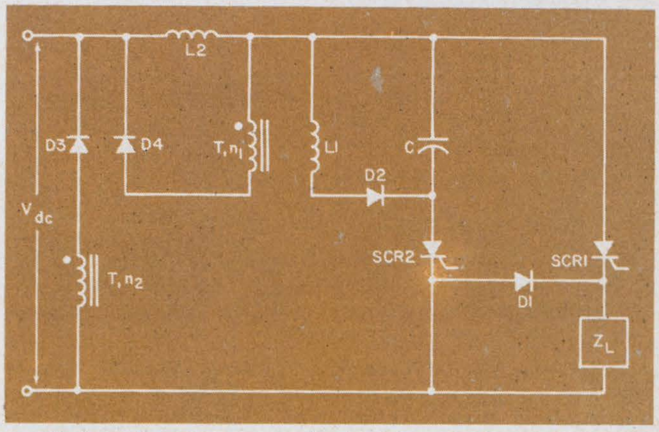
A capacitive load will cause *SCR1* to be turned off before *SCR2* is turned on, when the half period of the swinging circuit formed by *L2* and the capacitive $Z_L$ is less than the time between turning *SCR1* on and *SCR2* on. If the capacitive load is larger than its critical value determined in this manner, *SCR1* will be switched off by the turn-off circuit as in the case of a resistive load.

### Design equations for circuit parameters

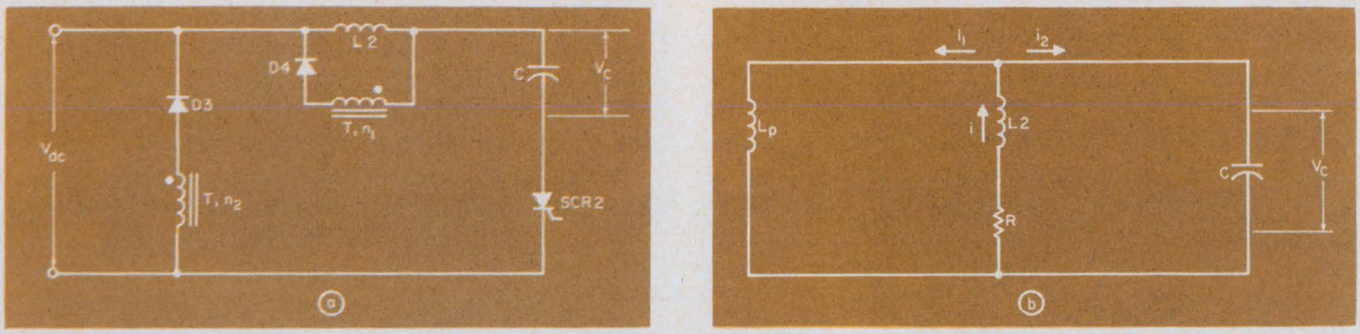
An expression for the commutating capacitor $C$ in Fig. 2 may be obtained in the following manner. If $t = 0$ is taken to be the beginning of the turn-off process, i.e., when *SCR2* is turned on, and $V_C$



1. **SCR swinging turn-off circuit** to control power SCR1 is built with the components enclosed by the dashed lines. Load impedance has no effect on its operation.



2. **High voltages across diode D3** can be avoided by modifying the basic turn-off circuit of Fig. 1; diode D4 was added and the components were slightly rearranged.



3. **The active portion** of the circuit of Fig. 2 is shown in (a). Its equivalent circuit appears in (b).

is negative, the voltage $V_C$ across capacitor $C$ may be expressed as:

$$V_C = -[(1+r)V_{dc}+\Delta V]\cos\omega t + V_{dc}(1-\cos\omega t) + V_{L2}\sin\omega t, \qquad (1)$$

where:

$r$ = transformer turns ratio,
$\Delta V$ = voltage increase across capacitor $C$ produced by swinging circuit $L_p+L_s$ and $C$ while turning *SCR2* off,
$V_{L2}$ = voltage drop across *L2* due to the load current.

Since it is known that:

$$\omega = 1/(L2C)^{1/2},$$

and that:

$$V_{L2} = (L2/C)^{1/2}I_{load}$$

(from the relationship $(L2\,I_{load}/2)^2=(C\,V_{L2}/2)^2$), an expression for $C$ at full load may be obtained. If $V_C$ is set equal to zero and $t$ = the maximum turn-off time of *SCR1* as specified by the manufacturer, and on the assumption that $(L2/C)^{1/2} \approx V_{dc}/I_{FL}$ yields a small value for $C$ with a reasonably short cycling time, then:

$$C \geqq \{I_{FL}/[V_{dc}(1+r)]\}t_{off}, \qquad (2)$$

where $I_{FL}$ = the magnitude of full load current at the beginning of commutation.

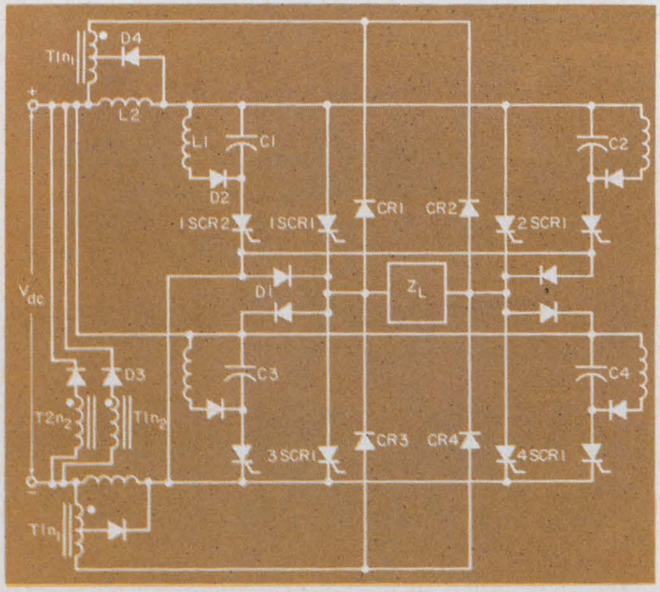
Once the value of $C$ has been determined from Eq. 2, *L2* can be calculated from the relationship:

$$(L2/C)^{1/2} \approx V_{dc}/I_{FL}:$$
$$L2 = (V_{dc}/I_{FL})^2C.$$

Swinging circuit *L1C* is chosen so that it has negligible influence on the operation of swinging circuit *L2C*. Therefore:

$$(L1C)^{1/2} = 5(L2C)^{1/2},$$
$$\therefore L1 = 25\,L2.$$

Now that the circuit parameters are established, it is possible to check whether the circuit provides a suitable turn-off time for *SCR2*.



4. **Simplified schematic of a 1.5-kVA inverter** using the swinging turn-off circuit is shown without high-voltage suppressing and balancing networks. SCR1s form a bridge to provide a square-wave voltage across the load $Z_L$. Turn-off circuit for 1SCR1 consists of L1, D2, C1, 1SCR2, D1, D3, T1, L2, D4. CR1, CR2, CR3, CR4 provide current paths to discharge inductive loads into supply. See box for the component values.

### Single-phase bridge-type inverter

**Operating characteristics**

| | |
|---|---|
| Output power | 1.5 kVA |
| Input voltage | 150 V dc |
| Output voltage | 148 V square wave zero-to-peak |
| Frequency | 50-1000 Hz, adjustable |
| Efficiency | 92% at 400 Hz and full power (only slightly affected by power factor) |

**Circuit parameters**

| | |
|---|---|
| *SCR1* | Type C40C |
| *SCR2* | Type C20D |
| *D4, CR1, CR2, CR3, CR4* | 1N3495R |
| *D1, D2* | 1N2070 |
| *D3* | 1N2071 |
| *L1* | 3 mH |
| *L2* | 190 μH |
| *C1, C2* | 2.2 μF |
| *C3, C4* | 2 μF |
| *T1, T2* | Transformers with 2-mH primary magnetizing inductance, 12:1 secondary-to-primary ratio, *r*, and 1.2:1 primary tap ratio. |

### Calculating the turn-off time of SCR2

That portion of the circuit of Fig. 2 that plays an active part in turning *SCR2* off is redrawn in Fig. 3a and the corresponding equivalent circuit is shown in Fig. 3b. Both are valid after *SCR1* is turned off and may be represented by an open circuit. In Fig. 3b, $L_p$ represents the leakage inductance reduced to the primary of transformer $T$, and $R$ is the equivalent loss resistance of *L2*.

The equivalent circuit assumes that:

- The forward voltage drops across *SCR2*, *D3* and *D4* are zero.
- The winding resistance of transformer $T$ is negligible.
- *L1* is so large that the current it draws while *SCR2* is being turned off is negligible.

Solving the proper differential equation based on the equivalent circuit of Fig. 3b gives:

$$i_2 = I_o(L_p/L2)\epsilon^{-t/\tau}(\cos\omega t + RC\,\omega\sin\omega t), \quad (3)$$

where:

$t = 0$ when the combination of *D3* and $n_2$ just begins to clamp the capacitor voltage,

$\tau = L_m/R$,

$$\omega = \frac{1}{C[L_p\,L2/(L_p + L2)]^{1/2}},$$

$I_o =$ the current flowing in *L2* when transformer $T$ just begins to clamp the capacitor voltage.

$I_o$ approximately equals the load current flowing in *L2* just before *SCR1* is turned off and therefore:

$$I_o \approx 2\,I_L.$$

*SCR2* will turn off when $i_2 = 0$. With this condition, the time $t_1$ necessary to accomplish this can be computed from Eq. 3. Then the voltage rise across capacitor $C$, $\Delta V_C$, by current $i_2$ is:

$$\Delta V_C = (1/C)\int_0^{t_1} i_2\,dt.$$

Solving this integral gives:

$$\Delta V_C \approx 2(L_p/L2)V_{dc}. \quad (4)$$

At time $t_1$, when the increase in capacitor voltage reaches $\Delta V_C$, *SCR2* turns off and is reverse-biased by $\Delta V_C$. This is because the rest of the capacitor voltage is balanced by voltage drops across the primary of transformer $T$ and diode *D3*.

The capacitor voltage will reverse through swinging circuit *L1* and $C$, diminishing $\Delta V_C$. The length of time $t_2$ during which *SCR2* is reverse-biased may be calculated from the equation for $V_{dc}$:

$$V_{dc} = [(1+r)V_{dc} + \Delta V_C]\cos\omega_2\,t_2, \quad (5)$$

where:

$$\omega_2 = 1/(L1C)^{1/2}.$$

Assuming $L_p/L_m = 0.02$, $L_m/L2 = 10$ and $0.1 < r < 0.2$, substituting $V_C$ from Eq. 4 into Eq. 5, and solving for $t_2$ yield:

$$t_2 \approx 0.8(L1C1)^{1/2};$$

since $L1 \approx 25\,L2$, then:

$$t_2 \approx 4(L2C)^{1/2}. \quad (6)$$

A large $L_m$:*L2* ratio is necessary in order for magnetic energy stored in *L2* to be fed into the supply instead of into $L_m$. Even with infinite $L_m/L2$, however, there will still be some buildup of magnetic energy in $L_m$, which will produce overvoltages unless dissipated in surge suppressors.

Now, substituting the relationship $L2/C \approx V_{dc}/I_{FL}$ into Eq. 2 and solving for $(L2C)^{1/2}$ yield the following relationship:

$$t_{off} = (L2C)^{1/2}/(1+r),$$

or:

$$(L2C)^{1/2} = (1+r)t_{off}. \quad (7)$$

Substitution of Eq. 7 into Eq. 6 gives an expression for the circuit turn-off time, $t_2$, of *SCR2* in terms of the maximum turn-off time of *SCR1*:

$$t_2 \approx 4(1+r)t_{off} \approx 4.5\,t_{off_1}, \quad (8)$$

assuming $r \approx 0.1 \rightarrow 0.2$.

Because the circuit turn-off time for *SCR2* is greater than that for *SCR1* by a factor of 4.5, it can be seen that no stringent requirements govern the selection of a silicon-controlled rectifier for *SCR2*.

### The turn-off circuit used in an inverter

A schematic of a single-phase bridge-type inverter that uses the turn-off circuit of Fig. 2 appears in Fig. 4. This novel turn-off circuit lends itself particularly well to this type of inverter.

Some of this inverter's interesting features are:

- Commutation—that is, turn-off of the load-carrying SCRs—is independent of load power factors.
- Starting is easy.
- It has inherent overload protection.
- The inverter output voltage can be controlled and regulated by pulse width modulation.

The design philosophy for this single-phase inverter is especially applicable to multiphase inverters. This, too, is because of the unique turn-off characteristics of the turn-off circuit.

Controlled rectifiers *1SCR1*, *2SCR1*, *3SCR1* and *4SCR1* form a bridge circuit to produce a square-wave voltage across the load $Z_L$. Components *L1*, *D2*, *C1*, *SCR2*, *D1*, *D3*, *T1*, *L2* and *D4* constitute the turn-off circuit for *1SCR1*, as in Fig. 2. The other three main SCRs in the bridge have similar turn-off circuits. *T1*, *D4*, *L2* and *D3* serve the turn-off circuits of both *1SCR1* and *2SCR1*. The same applies to *T2* in relation to the bottom half of the circuit. Rectifiers *CR1*, *CR2*, *CR3* and *CR4* provide current paths to discharge inductive loads into the supply as in the McMurray-Bedford inverter.[1]

Control and regulation of the inverter output voltage is made possible by varying the time interval between turn-on pulses to the load-carrying SCRs and their associated auxiliary SCRs. To secure proper voltage across the capacitors when starting up the inverter, pulses to the gates of the auxiliary SCRs are applied first.

The only difference between individual SCR turn-off circuits in Fig. 4 and the turn-off circuit in Fig. 2 is that in Fig. 4 transformers $T1$ and $T2$ have tapped primary windings (the primaries are autotransformers) with feedback rectifiers $CR1$, $CR2$, $CR3$ and $CR4$ connected to them. This design feature is necessary in case of inductive loads. Magnetic energy trapped in the load when the main SCRs are turned off (e.g., $2SCR1$, $3SCR1$) will drive current into the dc supply through the feedback rectifiers (e.g., $CR1$, $CR2$). When the next two main SCRs ($1SCR1$ and $4SCR1$, in this instance) are turned on, however, any magnetic energy trapped in inductor $L2$ will cause a circulating current to flow in the loop $L2$, $1SCR1$, $CR1$, $T1$. This can become a cumulative process and cause failure of either $1SCR1$ or $CR1$.

Tapping the primary of the transformer produces a back emf which prevents these circulation currents from flowing. The value of this back emf should be larger than the sum of the forward voltage drops through an SCR and a rectifier, that is, the sum of the voltage drops across $1SCR1$ and $CR1$, when forward-biased. For example, the tapped portion of $T1$ opposite feedback rectifiers $CR1$, $CR2$ will prevent current from flowing in the loop consisting of $L2$, $1SCR1$, $CR1$ and $T1$ by putting out about 3 volts.

Internal short circuits due to overloads can be prevented by gating the turn-on pulses to the load-carrying SCRs. If, for some reason, the two SCRs conducting during a half cycle are overloaded and, as a result, do not open when the next half cycle begins, a short circuit will result. The gating will involve sensing the voltage across the lower main SCRs, i.e., $3SCR1$ and $4SCR1$. To prevent the upper two main SCRs from not turning off on account of a short circuit, their commutating capacitors are selected to have a somewhat larger capacitance than the other two commutating capacitors.

The system will automatically keep trying to resume normal operation until the overload disappears. When this happens, the main SCR that failed to turn off will recover, and the inverter output voltage will reappear.

For clarity's sake, a number of high-voltage suppressing and balancing networks, necessary for proper inverter operation, are not shown. Practical circuit parameters and operating characteristics for a single-phase bridge-type inverter are listed in the box. ■ ■

**Reference:**

1. W. McMurray and D. P. Shattuck, "A Silicon-Controlled Rectifier Inverter with Improved Commutation," *AIEE Trans.*, LXXX, Pt. 1, Nov., 1961, 531-542.

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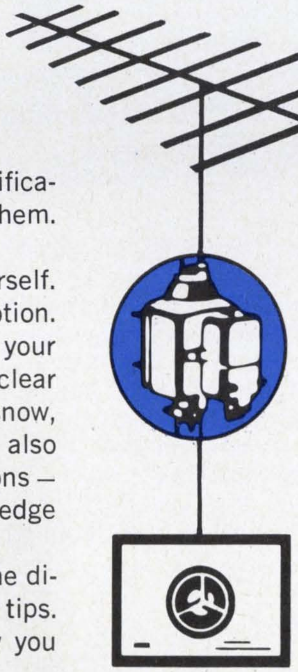

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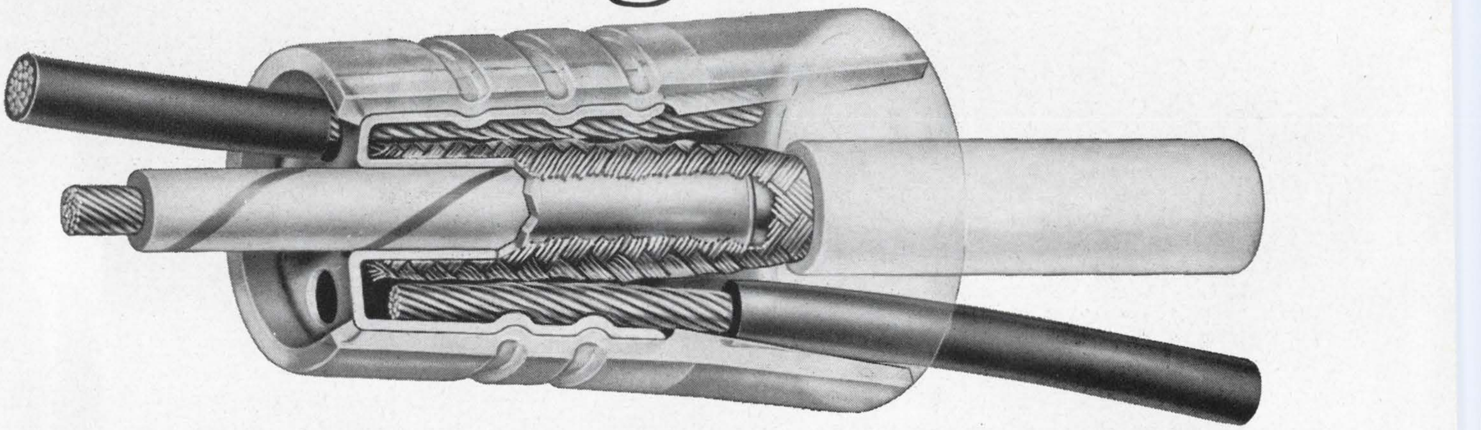

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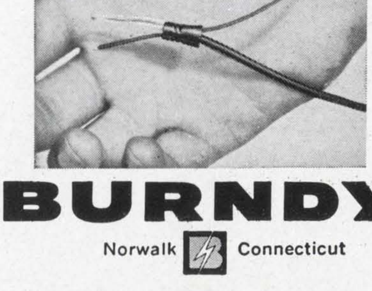

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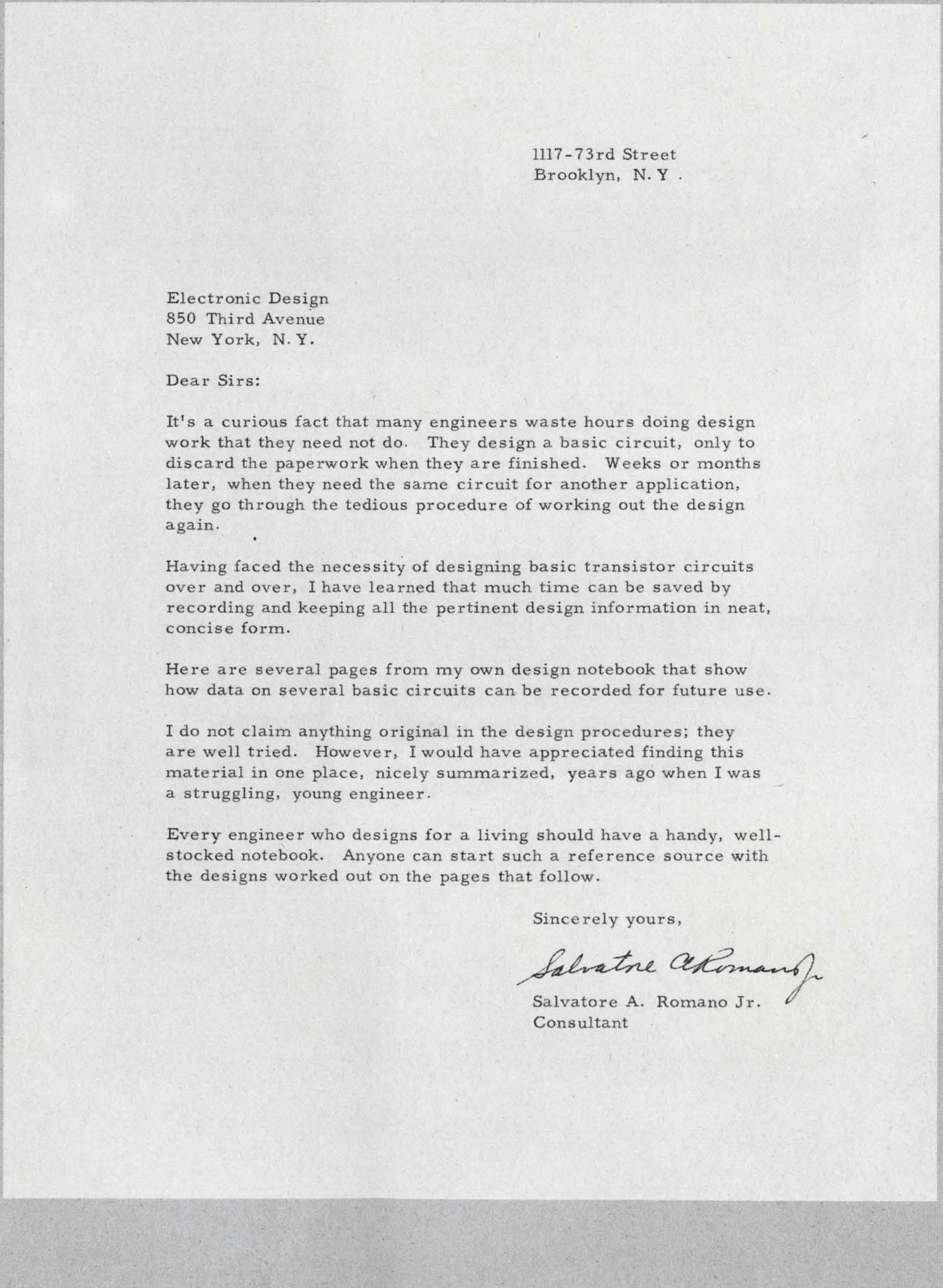
ON READER-SERVICE CARD CIRCLE 33

**Stop wasting design time.** Keep a good notebook of basic circuits, and the next time you need one, it will be ready for instant reuse.



1117-73rd Street
Brooklyn, N. Y .

Electronic Design
850 Third Avenue
New York, N. Y.

Dear Sirs:

It's a curious fact that many engineers waste hours doing design work that they need not do. They design a basic circuit, only to discard the paperwork when they are finished. Weeks or months later, when they need the same circuit for another application, they go through the tedious procedure of working out the design again.

Having faced the necessity of designing basic transistor circuits over and over, I have learned that much time can be saved by recording and keeping all the pertinent design information in neat, concise form.

Here are several pages from my own design notebook that show how data on several basic circuits can be recorded for future use.

I do not claim anything original in the design procedures; they are well tried. However, I would have appreciated finding this material in one place, nicely summarized, years ago when I was a struggling, young engineer.

Every engineer who designs for a living should have a handy, well-stocked notebook. Anyone can start such a reference source with the designs worked out on the pages that follow.

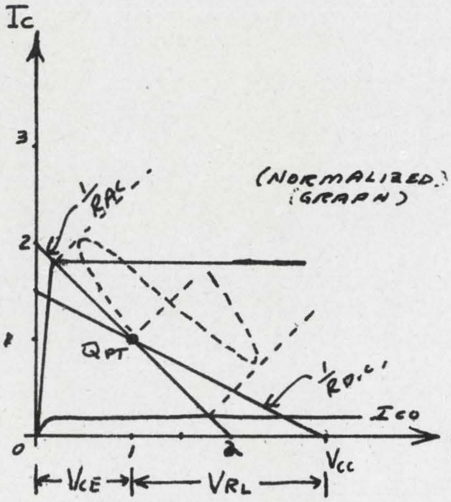
Sincerely yours,

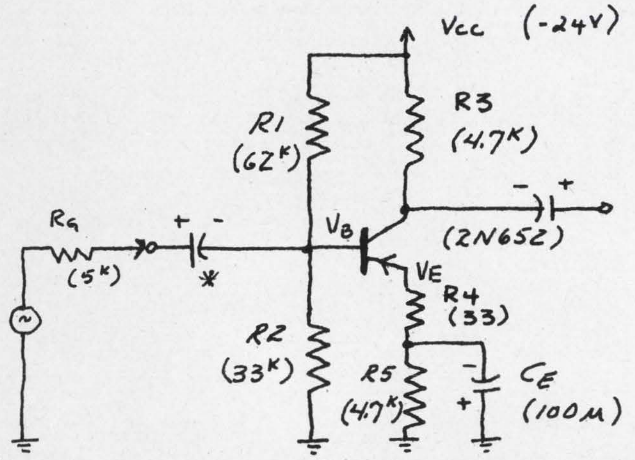
Salvatore A Romano Jr

Salvatore A. Romano Jr.
Consultant

# RAPID DESIGN OF PRACTICAL AMPLIFIERS

## CLASS A, SINGLE-ENDED, R C COUPLED, LOW DISTORTION





* CHOICE OF Coupling Capac. left To DESIGNER USING CONVENTIONAL METHODS

KNOWN: $V_{cc}$, $Z_{OUT}$, $Z_{IN}$, APPROX. VOLTAGE GAIN (V.G.)

Objective: MAX. SIGNAL WITH MIN. DISTORTION, TEMPERATURE STABILITY — 60°C AMB.

METHOD: STAGE EFFICIENCY WILL BE SACRIFICED TO ACHIEVE AN OPERATING POINT WHICH RESULTS IN MINIMUM DISTORTION.
THE Q POINT WILL BE PLACED FOR EQUAL HALF CYCLES OF SIGNAL SWING BETWEEN $I_{CO}$ & $I_{SAT}$.

1. ASSUMING $r_d > Z_{OUT}$ i.e. $r_d \simeq 100^K$ SET $R3 = Z_{OUT}$
2. $R4 + R5 = R3$
3. D.C. LOAD LINE $I_m = \dfrac{V_{cc}}{R_3 + R_4 + R_5}$
4. CHOOSE $I_Q = \dfrac{2}{3} I_m$ ; $\therefore V_E = \dfrac{V_{cc}}{3} = V_{CE} = V_{R3}$
   OR $V_{RL} = \dfrac{2}{3} V_{cc}$ ; $R_L = R_3 + R_4 + R_5$
5. CHOOSE $R4 > r_e$ ; where $r_e \simeq \dfrac{30\Omega}{|I_e|}$
   $I_E \doteq \dfrac{V_E}{R_4 + R_5}$ $r_e$ @ 1ma = $30\Omega$
   WITH $r_e$ KNOWN & VOLT. GAIN DESIRED $R_4$ MAY BE GOTTEN FROM
   $V.G \simeq \dfrac{R_3}{R_4 + r_e}$
6. $R_5 = (R_4 + R_5) - R_4$ SINCE $R_4 + R_5 = R_3$
7. R1 & R2 CHOSEN SO current Stability factor, S, < 5 for Germanium and < 10 for Silicon
   CHOOSE: $R_1 \parallel R2 = 4(R_4 + R5)$ for Germanium
   neglect $V_{be}$ THEN $V_E \simeq \dfrac{R_2}{R_1 + R_2}$
   $\therefore R_1 = 2R2$
   CHOOSE: $R_1 \parallel R_2 = 8(R_4 + R_5)$ for Silicon
8. CHOOSE $X_{CE} \leq \dfrac{R_4 + R_{IN_E}}{10}$;
   where $R_{IN_E} = \dfrac{R_B + r_b}{\beta} + r_e$ : $R_B$ = Total source impedance
   $r_b$ may be determined from h parameters at Q pt current OR approximated from base characteristics curves as $\Delta V_{BE}/\Delta I_B$ about the operating pt.
9. $P_{DISSAP\ No\ signal} = V_{CE} I_Q$ ; $P_{OUT} = \dfrac{V_{CE} I_Q}{4}$
   $P_{IN\ BATTERY} = V_{cc} I_Q$ $V_m = V_{cc}$
   $P_{DISSAP\ MAX\ signal} = \dfrac{3}{4} V_{CE} I_Q$
10. STAGE EFFICIENCY $\eta = \dfrac{P_O}{P_{IN}} = \dfrac{\frac{V_m I_m}{18}}{\frac{2}{3} V_m I_m} = 8.3\%$

### SAMPLE DESIGN

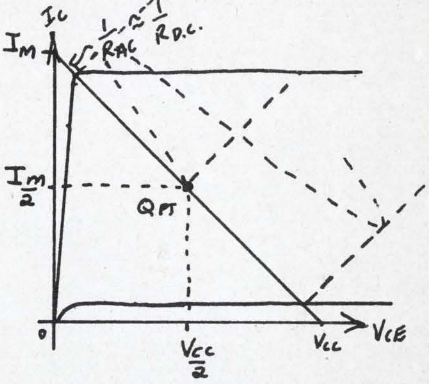
$Z_{OUT} \doteq 5^K$ ; $V_{cc} = -24^V$ ; 2N652 ; V.G. = 100

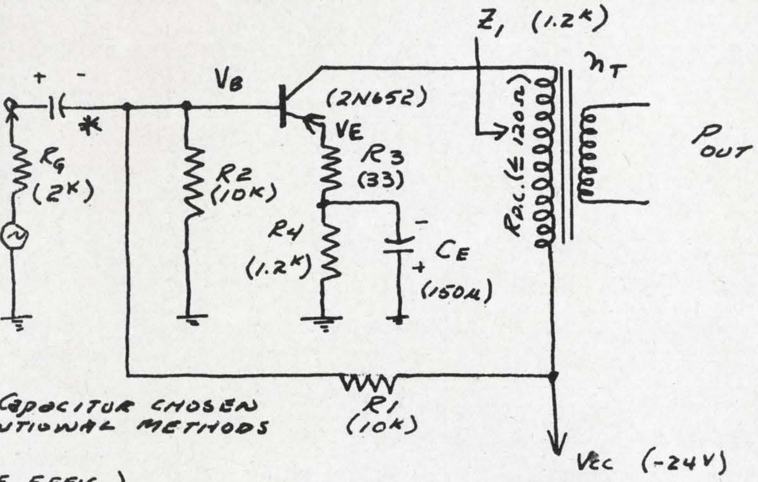
1. $R3 = 5^K$ USE $4.7^K$
2. $R_4 + R_5 = R_3 = 4.7^K$
3. $I_m = \dfrac{24}{9.4^K} = 2.56$ ma ; 4. $I_Q = 1.7$ ma $\doteq I_E$
   $V_E = \dfrac{V_{cc}}{3} = 8$ VOLTS $= V_{CE} = V_{p\text{-}p}$ MAX. possible
5. $r_e \doteq \dfrac{30}{1.7\text{ma}} = 17.7$ OHMS
   $V.G. \approx \dfrac{R3}{R_4 + r_e}$ $\therefore R_4 \doteq 30\Omega$ USE $33\Omega$
6. $R5 = R_3 - R_4 = 4.7^K - 33$ IN THIS CASE NEGLECT $R_4$
   $\therefore R5 = 4.7^K\Omega$
7. $\dfrac{R_1 R_2}{R_1 + R_2} = 4(4.7^K) \approx 20^K$ & since $R_1 = 2R_2$
   $R_2 = 30^K$ USE $33^K$
   $R_1 = 60^K$ USE $62^K$
8. $X_{CE}$ : $R_B = R_1 \parallel R_2 \parallel R_G$ ; $R_G = 5^K$
   $\therefore R_B \approx 4^K$ $r_b \approx 1^K$ $\beta = 100$
   $\therefore X_{CE} = 10$ Taking $f_{LOW}$ = 200cps - 1DB
   $C_E = \dfrac{1}{2\pi f X_{CE}} \approx 80$ mfd USE 100 mfd

BECAUSE Standard values of resistance have been used & $V_{be}$ neglected $V_E$ will be slightly less than $\dfrac{V_{cc}}{3}$ & $I_Q$ slightly different. Where necessary these inaccuracies can be done away with by not neglecting $V_{be}$, $I_c = \alpha I_e$ etc. where accurate $Z_{OUT}$ necessary DO NOT NEGLECT $r_d$

9. $P_{DISSAP\ NO\ SIG} = 13.6$ milliwatts ; $P_{OUT} = 3.4$ m.w.
   $P_{IN} = 24(1.70\text{m}) = 40.7$ m.w.
   $P_{DISSAP\ @\ MAX\ SIG} = \dfrac{3}{4}(13.6\text{ m.w}) = 10.2$ mw
   $\eta = \dfrac{3.4\text{mw}}{40.7\text{mw}} = 8.3\%$

## CLASS A SINGLE-ENDED TRANSFORMER COUPLED





* COUPLING CAPACITOR CHOSEN BY CONVENTIONAL METHODS

KNOWN: $R_G$, $P_{OUT}$, $V_{CC}$, $\eta_T$ (TRANSF EFFIC.)

Objective: MAX. SIG. SWING. with min. distortion
$Z_{IN}$ as high as practical
Temp. Stability

METHOD: A PRACTICAL COMPROMISE ACHIEVED BY MAKING THE AC LOAD LINE ≈ D.C. LOAD LINE

1. $P_{STAGE} = \frac{1}{\eta} P_0 = \frac{V_{CE} I_Q}{2}$ ; CHOOSE $V_{CE} = \frac{V_{CC}}{2}$

2. $I_Q = \frac{2 P_S}{V_{CE}}$ ; $R_{L_{A.C.}} = \frac{V_{CE}}{I_Q} = Z_1$

3. $R_{D.C.}$ TRANSF $\leq \frac{R_{LA.C.}}{10}$ FOR MILLIWATT TRANSF.

4. CHOOSE: $R3 + R4 = R_{LA.C.}$

& SINCE $R3 << R_4$ & $R_{LAC}$ $R_{A.C.} \approx R_{D.C.}$ LOAD LINE

5. $V_{CE} = \frac{V_{CC}}{2}$ neglecting $R_{D.C.}$ TRANSF.

$V_E \approx \frac{V_{CC}}{2}$

ASSUME $I_E \approx I_Q$

6. CHOOSE: $R_3 > r_e$ ; $r_e \cong \frac{30}{|I_E|}$

TRY $R_3 \gtreqqless 10\, r_e$ in accordance with $R_G$ & the $R_{IN}$ THAT MUST be created NOT TO LOAD IT excessively

$R_{IN} = R_1 \| R_2 \,//\, r_b + \beta(r_e + R_3)$

7. $\therefore R_4 = \frac{V_E}{I_E} - R_3$ ; OR $\underbrace{(R_4 + R_3)}_{R_{LAC.}} - R_3$

8. $R_1$ & $R_2$ chosen so current Stability factor, S, is $< 5$ for Germanium & $< 10$ for Silicon

$\therefore R_1 \| R_2 = 4(R3 + R4)$ for Germanium

$R_1 \| R_2 = 8(R_3 + R_4)$ for Silicon

9. CHOOSE $X_{CE} \leq \frac{R3 + R_{INE}}{10}$ ; where $R_{INE} = \frac{R_B + r_b}{\beta} + r_e$

$R_B = R_1 \| R2 \,//\, R_G$

$r_b$ determined from transistor characteristics

10. $P_{DISSAP\ NO\ SIG} = V_{CE} I_Q$ : $P_{OUT\ STAGE} = \frac{V_{CE} I_Q}{2}$

$P_{IN}$ BATTERY $= V_{CC} I_Q$

$P_{DISSAP\ MAX\ SIG} = P_{DISSAP\ NO\ SIG} - P_{OUT\ STAGE} = \frac{V_{CE} I_Q}{2}$

11. STAGE EFFICIENCY

$\eta_s = \frac{P_0}{P_{IN_{BATT}}} = 25\%$ BEFORE TRANSFORMER

$\eta_0 = 18.8\%$ including transformer

### SAMPLE DESIGN

$P_{OUT}$ req'd = 45 milli-watts
$V_{CC} = -24$ VOLTS ; $\eta_{TRANSF} = 75\%$
2N652 $R_G = 1.2^k$ $T_A = 55\,°C$

1. $P_S = \frac{P_0}{.75} = 60$ m.W. $V_{CE} = \frac{24}{2} = 12$ VOLTS

2. $I_Q = \frac{2(60\text{mw})}{12\text{ mu}} = 10$ milli-Amps

$R_{LAC} = \frac{12}{10m} = 1.2^K$ OHMS $= Z_1$

3. $R_{D.C.}$ TRANSF $\leq \frac{1.2^K}{10} \leqq 120$ OHMS

4. $R_3 + R_4 = 1.2^K$

5. $V_E = 12^{V.}$ ASSUME $I_E = I_Q = 10$ma

6. $r_e = \frac{30}{10} = 3\,\Omega$

$R_3 = 10(3) = 30\,\Omega$ USE 33 OHMS

7. $\therefore R_4 = 1.2^K - 33\,\Omega$ USE $1.2^K$ OHMS IN THIS CASE

8. $R_G = 1.2^K$

$\frac{R_1 R_2}{R_1 + R_2} = 4(1.2^k) = 4.8^K$ USE $5^K$

SINCE $V_E \approx 12^V$ & NEGLECTING $V_{BE}$
$V_B = 12^V.$
$R_1 = R_2$ $\therefore R_1 = R_2 = 10^K$

9. $X_{CE}$

$R_B = \frac{5^K(2^K)}{7^K} \simeq 1.4^K$ ; $R_G = 2^K$

USE $r_b = 1^K$ from CHARAC.

$R_{IN_E} = \frac{1.4^K + 1^K}{80} + 3 + 33 = 66\,\Omega$

$\beta = 80$ from CHARACTERISTICS

$\therefore X_{CE} = \frac{66}{10} = 6.6\,\Omega$ ; $C_E = \frac{1}{6.28(200)\,6.6}$
USING $f_{LOW} = 200$ CPS $= 120$ μfd
USE 150 mfd.

10. $P_{DISSAP\ NO\ SIG.} = 12(10\text{ma}) = 120$ mw.

$P_{IN}$ BATTERY $= 24(10\text{ma}) = 240$ mw

$P_{OUT} = 60$mw

$P_{DISSAP\ MAX\ SIG.} = 120\text{ mw} - 60\text{mw} = 60$ mw

11. STAGE EFFICIENCY

$\eta_s = \frac{60\text{mw}}{240\text{ mw}} = 25\%$ excluding TRANSF.

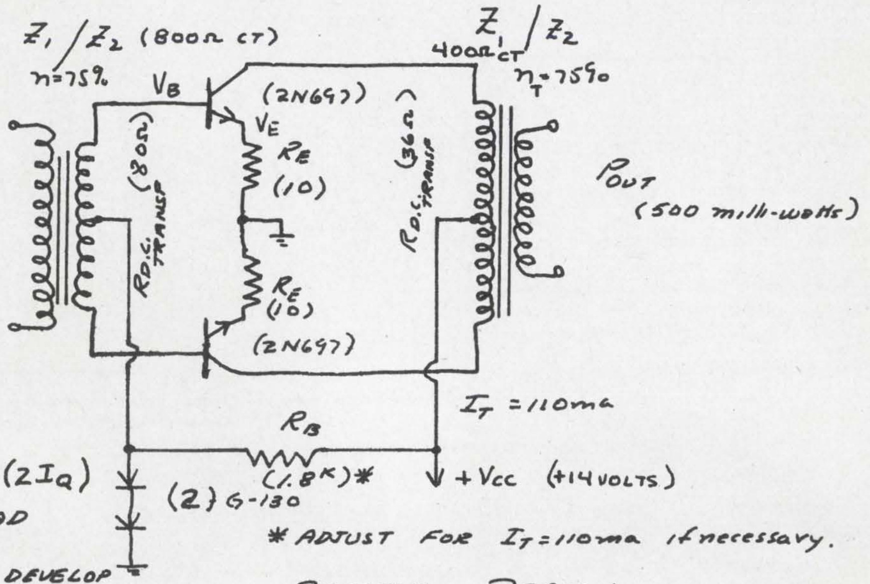
$\eta_0 = \frac{3}{4} \times 25\% = 18.8\%$ OVERALL

## CLASS A PUSH-PULL

USED WHEN LOW INTERMODULATION DISTORTION REQ'D.

KNOWN: $P_{OUT}$, $V_{CC}$

Objective: $P_{OUT}$ with low distortion
Temp. stability – 60°C



* ADJUST FOR $I_T$ = 110ma if necessary.

1) $P_1 = \frac{P_O}{\eta_T}$ ; $\eta_T$ = transf. eff.

2) $P_1/_{TRANS} = \frac{V_{CE} I_Q}{2}$

3) CHOOSE $V_{CE} \approx V_{CC} - 2$ VOLTS

Allowing 2 VOLTS for drops IN TRANSF & RE

4) $I_Q = \frac{2 P_1}{V_{CE}}$

$I_{TOTAL\ D.C.} = 2 I_Q$

5) $P_{IN\ TOTAL\ BATT} = V_{CC} I_T = V_{CC} (2 I_Q)$

6) $R_L/_{TRANS\ A.C.} = \frac{V_{CE}}{I_Q}$ : REQ'D LOAD LINE FOR EACH TRANSISTOR TO DEVELOP DESIRED POWER

7) ∴ $R_{L\ TOTAL} = 2 R_L/_{TRANS}$ : SINCE CLASS A

8) $R_{D.C.}$ TRANSFORMER

WITH Power level Known & $R_{L AC.}$ determined a transformer can be chosen.

FOR TRANSFORMERS UP TO APPROX. 1 watt $R_{D.C.} \leq \frac{R_{L AC.}}{10}$ SHOULD BE ADEQUATE

For transformers of higher wattage & therefore more current-requirements dictate an $R_{D.C.}$ of considerably less. DROPS OF LESS THAN 1 VOLT ARE DESIRABLE

9) RE should be as large as possible to provide beneficial degenerative current feedback which raises the $Z_{IN}$ too.

CHOOSE $V_E \leq$ 1 VOLT depending on how much of anticipated loss of foregoing 2 VOLT, ALLOWANCE, ACTUALLY IS being lost across "the" transformer.

A min. RE of approx. 0.5Ω is recommended in high power stages.

10) $P_{DISSAP}/_{TRANS} = (P_{IN} - P_{OUT} - P_{LOSSES})/_{TRANS}$

11) $\theta_{JA}$ REQUIRED $= \frac{T_J - T_A}{P_D}$ °C/WATT

THE THERMAL RESISTANCE THAT MUST NOT BE EXCEEDED FOR PROPER OPERATION OF THE TRANSISTOR

12) ∴ $\theta_{JA} = \theta_{JC} + \underset{\text{CASE TO SINK}}{\theta_{CS}} + \underset{\text{SINK TO AMBIENT}}{\theta_{SA}}$

∴ $\theta_{SA} = \theta_{JA} - \theta_{JC} - \theta_{CS}$

$\theta_{SA}$ IS THE REQ'D THERMAL RESISTANCE (MAX. ALLOW) OF THE HEAT SINK CHOSEN

13) BASE INPUT $I_B/_{TRANS} \cong I_Q/\beta$

14) $V_B = V_{BE} + V_E$ $V_{BE}$ from Trans. base charac.
CHOOSE BIAS NETWORK TO ACHIEVE $V_B$

15) $P_{IN\ REQ'D}/_{TRANS} = \frac{V_B I_B}{2}$ ; $P_{IN\ TOTAL} = 2 P_{IN}/_{TRANS}$

16) $R_{IN}/_{TRANS} = R_B + \beta(R_E + r_e)$ $r_e \approx \frac{30}{|I_E|}$

$I_E \approx I_Q$ $R_B$ from base charac. AT OPER. POINT $\frac{\Delta V_{BE}}{\Delta I_B}$

17) $R_{IN\ TOTAL} = 2 R_{IN}/_{TRANS}$ ; SINCE CLASS A

$R_{D.C.\ TRANSF} \leq \frac{R_{IN}}{10}$

18) $\eta_{overall} = \frac{P_O}{P_{IN\ BATT}} \eta_T = \frac{V_{CE} I_Q}{(V_{CC} I_Q) 2} \lambda_T \approx 43\% \eta_T$

## SAMPLE DESIGN

$P_{OUT}$ = 500mw η = 75% $V_{CC}$ = +14 VOLTS
TA = 60°C

1) $P_1 = \frac{500m}{.75}$ = 665mw

2) $P_1/_{TRANS} = \frac{665mw}{2}$ = 332.5mw

3) $V_{CE}$ = 14 − 2 = 12 VOLTS

4) $I_Q = \frac{665 mw}{12}$ = 55ma ; $I_T$ = 110ma

5) $P_{IN\ BATT}$ = 14(110ma) = 1.54 watts

6) $R_L/_{TRANS\ A.C.} = \frac{12}{55ma}$ = 218Ω ; use 200Ω

7) ∴ $R_{L\ TOTAL}$ = 2 (200) = 400 OHMS

8) $R_{D.C.}/_{TRANSF.} = \frac{1^V}{55ma}$ = 18 OHMS

9) $RE \leq \frac{1^V}{55ma}$ = 18Ω : USE 10 OHMS

THIS will yield a safety factor on the voltage swing possible with low distortion

10) $P_{DISSAP}/_{TRANS}$ ≒

$P_{LOSSES}/_{TRANS} = (55ma)^2 10 + (55ma)^2 18$ = 74mw

∴ $P_{DISSAP}/_{TRANS} = \frac{1,540}{2}$ mw − 332.5mw − 74mw
= 363.5 milli-watts

11) A 2N697 chosen since it can dissipate 460 mwatts at 60°C

THIS BEING THE CASE NO HEAT SINKS ARE REQ'D, BUT AS A SAFETY FACTOR TWO SNAP-ON, RADIAL-FIN HEAT SINKS USED

12) BASE INPUT $I_B/_{TRANS} = \frac{55ma}{40}$ = 1.4ma

$V_{BE} \cong 0.86^V$ from charac.

∴ $V_B = V_{BE} + V_E = 0.86 + 0.55 = 1.41^V$
CHOOSE BIAS NETWORK TO ACHIEVE THIS. (SEE ABOVE)

13) $P_{IN\ REQ'D}/_{TRANS} = \frac{V_B I_B}{2}$ = 0.98 mwatts

$P_{IN\ TOTAL}$ = 2(.98) = 1.96 mwatts

14) $R_{IN}/_{TRANS} = R_B + \beta(R_E + r_e)$

$R_B = \frac{\Delta V_{BE}}{\Delta I_B}$ ABOUT QPT ≈ 40Ω

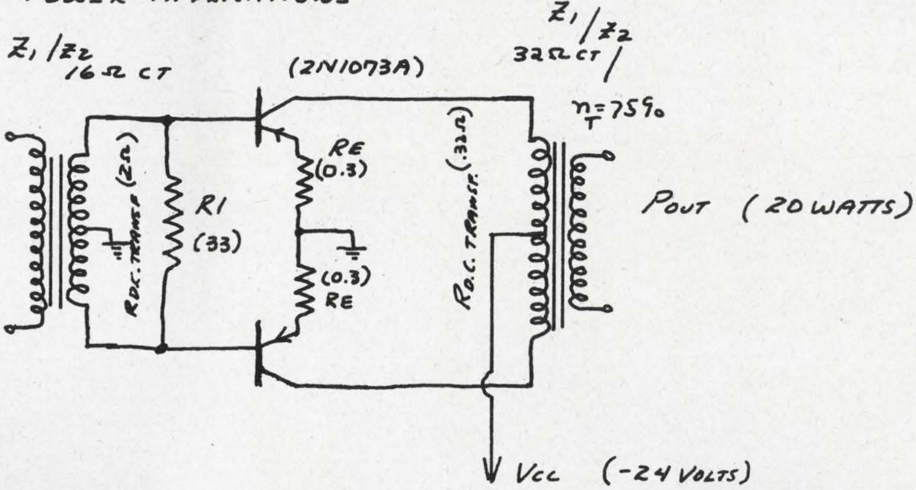
$r_e$ small so neglect

∴ $R_{IN}/_{TRANS}$ = 40 + 40(10) = 440 OHMS
USE 400 OHMS

15) $R_{IN\ TOTAL}$ = 2 (400) = 800 OHMS
SINCE CLASS A.

16) $\eta_{overall} = \frac{500mw}{1.54 watts}$ = 32.5%

## CLASS B PUSH-PULL
HIGH POWER APPLICATIONS



1. $P_1 = \frac{P_O}{\eta_T}$   $P/_{TRANS} = \frac{P_1}{2}$

2. $P/_{TRANS} = \frac{V_m I_m}{4}$

$V_m = V_{CC} - 2$ VOLTS

allowing 2 volts for anticipated drops through $R_E$ + 1/2 TRANSF.

3. $I_m = \frac{4\,P/_{TRANS}}{V_m}$

4. $I_{D.C.} = 2\frac{I_m}{\pi}$

5. $R_L/_{TRANS} = \frac{V_m}{I_m}$ ; $\therefore R_{L\,TOTAL} = 4\,R_L/_{TRANS}$

$R_{D.C.} \leq R_L/_{100}$   SINCE CLASS B

6. $P_{IN}/_{TRANS}$ FROM BATT $= V_{CC}\frac{I_m}{\pi}$

7. $P_{DISSAP}/_{TRANS} = P_{IN}/_{TRANS\,BATT} - P_O/_{TRANS} - \frac{1}{2}P_{LOSSES}$

$P_{LOSSES} = I_m R_E + I_m R_{D.C.\,TRANSF}$

$R_E \approx \frac{1^V}{I_m}$

8. BASE DRIVE $I_{B_m} = \frac{I_{Cm}}{\beta}$

$V_{BE_m}$ from charac. for $I_{Bm}$

9. $V_{B_m} = V_{BE_m} + V_{E_m}$

10. $P_{IN\,REQ'D}/_{TRANS} = \frac{V_{Bm} I_{BM}}{4}$

$P_{IN\,TOTAL} = 2\,P_{IN}/_{TRANS}$

11. $R_{IN}/_{TRANS} = R_B + \beta(R_E + r_e)$

$R_B$ from $\frac{\Delta V_{BE}}{\Delta I_B}$ at oper. pt. on base charac.

$r_e$ small neglect.

AS ABOVE $R_E \approx \frac{1^V}{I_m}$

12. $\therefore R_{IN\,TOTAL} = 4\,R_{IN}/_{TRANS}$ ; CLASS B

13. $R_1$ chosen equal to $R_{IN}$ of transistors to create a more constant input imped for the base driver stage.

14. $\therefore Z_2 = R_{IN} \parallel R_1$   $R_1 = R_{IN}$

$\therefore Z_2 = \frac{R_{IN}}{2}$

15. $\theta_{JA\,REQ'D} = \frac{T_J - T_A}{P_D}$ °C/W   MAX. ALLOWED

$\theta_{SA} = \theta_{JA} - \theta_{JC} - \theta_{CS}$   MAX. REQ'D THERMAL RESIST. OF HEAT SINK

16. $\eta_{overall} = \frac{P_O}{P_{IN\,BATT}}\eta_T = \frac{\frac{V_m I_m}{2}}{\frac{2 V_m I_m}{\pi}}\eta_T \cong 75\%\,\eta_T$

### SAMPLE DESIGN   TA = +55 °C

$P_O = 20$ watts   $\eta_T = 75\%$   $V_{CC} = -24$V.

1. $P_1 = \frac{20}{.75} = 26.6$ watts   use 30 watts

2. $P/_{TRANS} = \frac{30}{2} = 15$ watts

$V_M = 24 - 2 = 22$ VOLTS

3. $I_m = \frac{4(15)}{22} = 2.72$ AMPS

4. $I_{D.C.} = 2\frac{(2.72)}{\pi} = 1.73$ AMPS

5. $R_L/_{TRANS} = \frac{22}{2.72} = 8.1$ OHMS   use 8 OHMS

$\therefore R_{L\,TOTAL} = 4(8) = 32$ OHMS

$R_{D.C.} \leq \frac{32}{100} = 0.32$ OHMS

6. $P_{IN}/_{TRANS\,BATT} = \frac{24(2.72)}{\pi} = 20.75$ watts

7. $P_{LOSSES}/_{TRANS} = 2.72(R_E + R_{D.C.})$

$R_E \cong \frac{1^V}{2.72} = 0.3\,\Omega$   $\therefore P_{LOSS}/_{TRAN} = 1.23$ watts

8. $P_{DISSAP}/_{TRANS} = P_{IN}/_{TRANS\,BATT} - P_O/_{TRANS} - P_{LOSS}/_{TRANS}$

$= 20.75 - 15 - 1.23 = 4.52$ watts

use 5 watts

9 BASE DRIVE $I_{B_m} = \frac{I_m}{\beta}$

AT THIS TIME TRANSISTOR CHOSEN 2N1073A

$\beta = 20$ MIN at $I_{MAX}$

$\therefore I_{BM} = \frac{2.72}{20} = 136$ ma.

$V_{BE} = 0.56$V at $I_{BM}$ from base charac.

10. $V_{BM} = V_{BE} + V_E = 0.56 + .816 = 1.376$ VOLTS

11. $P_{IN\,REQ'D}/_{TRANS} = \frac{1.376(136\,ma)}{4} = 47$ mw   $P_{IN\,TOT} = 100.0$ mw

(SINCE $R_E \approx \frac{1^V}{2.22} = 0.3\,\Omega$ ; $R_B = \frac{\Delta V_{BE}}{\Delta I_B} = 2\,\Omega$

12. $R_{IN}/_{TRANS} = 2 + 20(.3) = 8$ OHMS

13. $\therefore R_{IN\,TOTAL} = 4(8) = 32\,\Omega$   : CLASS B

14. LET $R_1 = 33\,\Omega$

15. $Z_2 = 16\,\Omega$

16. $\theta_{JA} = \frac{100-55}{5} = 9$ °C/W

17. $\theta_{SA} = \theta_{JA} - \theta_{JC} - \theta_{CS} = 9.0 - .8 - .4 = 7.8$ °C/W

USE AN AUGAT HEAT SINK WITH #9006-165   $\theta_{SA} = 6$ °C/W

18. $\eta_O = \frac{20}{21.5} \cong 46\%$

APPENDIX 1.

## FORMULA DERIVATIONS

### CLASS A

QPT AT $\frac{V_{cc}}{2}$, $\frac{I_m}{2}$ $\qquad V_{cc} = V_m$

$$P_{OUT} = \frac{1}{2\pi}\left[\int_0^{\pi} \frac{V_m}{2}\frac{I_m}{2}\sin^2\omega t\, d\omega t + \int_{\pi}^{2\pi} \frac{V_m}{2}\frac{I_m}{2}\sin^2\omega t\, d\omega t\right]$$

$$= \frac{V_m I_m}{8\pi}\left\{\frac{\pi}{2} - 0 + \frac{2\pi}{2} - \frac{\pi}{2}\right\} = \frac{V_m I_m}{8} \quad : \quad V_{CE} = \frac{V_m}{2}, \quad I_Q = \frac{I_m}{2}$$

$$= \frac{V_{CE} I_Q}{2}$$

$$P_{IN\,BATT} = V_m \frac{I_m}{2} = 2 V_{CE} I_Q.$$

$$\therefore \eta = \frac{P_O}{P_{IN}} = 25\% \quad \text{MAX}$$

### CLASS A

Q PT AT $\frac{V_{cc}}{3}$, $\frac{2 I_m}{3}$ $\qquad V_{cc} = V_m$

$$P_{OUT} = \frac{1}{2\pi}\left[\int_0^{\pi} \frac{V_m}{6}\left(\frac{2 I_m}{3}\right)\sin^2\omega t\, d(\omega t) + \int_{\pi}^{2\pi} \frac{V_m}{6}\left(\frac{2 I_m}{3}\right)\sin^2\omega t\, d(\omega t)\right]$$

$$= \frac{V_m I_m}{2\pi\, 9}\left(\frac{\pi}{2} - 0 + \frac{2\pi}{2} - \frac{\pi}{2}\right) = \frac{V_m I_m}{18} \quad : \quad V_{CE} = \frac{V_m}{3}, \quad I_Q = 2\frac{I_m}{3}$$

$$= \frac{V_{CE} I_Q}{4}$$

$$P_{IN\,BATT} = V_m \frac{2 I_m}{3} = V_{cc} I_Q$$

$$\eta = \frac{P_O}{P_{IN}} = 8.3\%$$

### CLASS A PUSH-PULL

$$P_{OUT\,TRANS} = \frac{1}{2\pi}\left[\int_0^{\pi} V_m \frac{I_m}{2}\sin^2\omega t\, d(\omega t) + \int_{\pi}^{2\pi} V_m \frac{I_m}{2}\sin^2\omega t\, d(\omega t)\right]$$

$$= \frac{V_m I_m}{4\pi}\left\{\frac{\pi}{2} - 0 + \frac{2\pi}{2} - \frac{\pi}{2}\right\} = \frac{V_m I_m}{4} \qquad V_{CE} \approx V_m, \quad I_Q = \frac{I_m}{2}$$

$$= \frac{V_m I_Q}{2} = \frac{V_{CE} I_Q}{2}$$

$$P_{OUT\,TOTAL} = V_{CE} I_Q$$

$$P_{IN\,BATT} = V_{cc} I_m = 2 V_{cc} I_Q \qquad \& \; V_{cc} \approx V_{CE}$$

$$\therefore \eta = \frac{P_O}{P_{IN}} \approx \frac{1}{2} = 50\% \quad \text{MAX.}$$

## CLASS B PUSH-PULL

$$P_{OUT}/_{TRANS} = \frac{1}{2\pi}\left[\int_0^{\pi} V_m I_m \sin^2 \omega t \sin^2 \omega t \, d(\omega t) + \int_{\pi}^{2\pi} 0 \right]$$

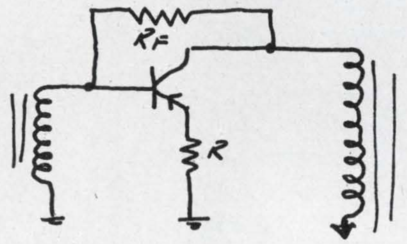
$$= \frac{V_m I_m}{2\pi}\left[\frac{\pi}{2} - 0\right] = \frac{V_m I_m}{4}$$

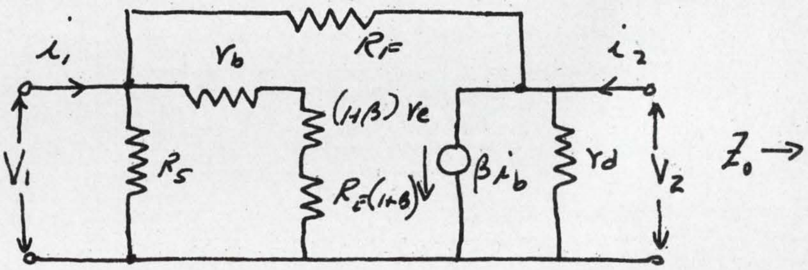
$$P_{OUT} = \frac{V_m I_m}{2}$$

$$P_{IN\ BATT} = V_m \, 2 \frac{I_m}{\pi} = 2 \frac{V_m I_m}{\pi}$$

$$\eta = \frac{P_O}{P_{IN}} = 78.5\%$$

VOLTAGE FEEDBACK TO CREATE A DESIRED $Z_{OUT}$





$$Z_o = \frac{\Delta + Z_{22} Z_g}{Z_{11} + Z_g} \qquad \Delta = Z_{11} Z_{22} - Z_{12} Z_{21}.$$

BY MATRIX DERIVATION

$$Z_o = \frac{r_d(\beta R_E + R_F)}{R_F - r_d}$$

OR TO DETERMINE $R_F$ FOR DESIRED $Z_0$

$$\therefore R_F = \frac{r_d(Z_0 + \beta R_E)}{Z_0 - r_d}$$

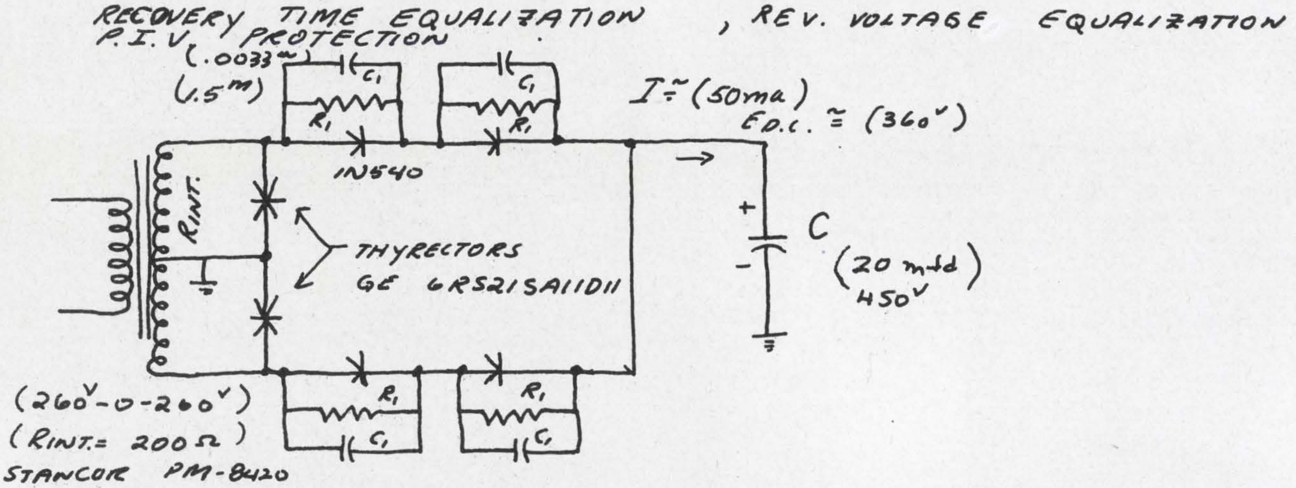
for push-pull CLASS B + SINGLE-ENDED CLASS A

FOR CLASS A PUSH-PULL DOUBLE RF CALCULATED

The actual value of $R_F$ will have to be found experimentally As much as 30% error has been noted however this may have been due to inaccurate data available to determine $r_d$ from.

ROMANO

# DESIGN PROCEDURE FOR MULTIPLE DIODE, HIGH-VOLTAGE SILICON DIODE POWER SUPPLY.



1) $R_1$ EQUALIZES VOLTAGE DIVISION — REVERSE — WHICH MAY OCCUR DUE TO DIFFERENCES IN THE BACK RESISTANCE OF DIODES

$R_1 = \frac{1}{2}\,\frac{E_{MAX}}{I_{MAX}}$ D.C. – REV. RATING / REV. CURRENT AT MAX. OPER. TEMPERATURE JUNCTION

2) USING JUNCTION TEMP RISE $= \theta \times P_D = \Delta T_{J\,MAX}$

$\therefore\ T_J = TA_{MAX} + T_{J\,MAX}.$

3) $C_1 = \frac{nt}{R_L}$  $R_L$ = EQUIV. LOAD RESISTANCE
$n$ = no. of rectifiers

$t$ = REV. RECOVERY TIME OF RECTIFIER USED.

4) MIN SERIES RESISTANCE REQUIRED IN SERIES WITH RECTIFIERS TO REDUCE FWD SURGE.

CALC: $\frac{C_S E_m}{\sqrt{3I^2t}}$ ; $C_S = C + 200\%C$

USE $E_m = 1.1\,E_{PK}$ OF SUPPLY VOLTAGE

REFERENCE: G.E. RECT. COMP. MANUAL

$I^2t$ FROM RECTIFIER SPEC. FOR DIODE USED.

FOR VALUE OF $\frac{C_S E_m}{3I^2t}$ ; DET. RC *

*FROM CHART IN REFERENCE P. 36.

5) $R_{\substack{INT\\+EXT.}} = \frac{RC}{C_S}$  NOW IF TRANSFORMER HAS THIS MIN. NO ADDITIONAL NEED BE ADDED.

6) CHOOSE THYRECTORS TO LIMIT REV. VOLTAGES FROM EXCEEDING RECTIFIERS TOTAL RATING

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## EXAMPLE

1) 360V D.C. OUTPUT AT 50ma DESIRED

$\therefore$ P.I.V. ACROSS EACH LEG AT LEAST 720V

CHOOSING 1N540 WITH 600V PIV + USING TWO IN SERIES

2) TO DET $I_{MAX\ REV}$

$T_J = T_A + T_{J\,MAX}$  $\theta = 100°/\text{WATT}$

$\Delta T_J = 100°C/\text{watt} \times 400\,mw$
$= 40°C$

$\therefore T_J = 55°C + 40°C = 95°C$ USE 100°C

AT 100°C $I_{MAX\,REV.} \cong 100\mu a.$

$\therefore\ R_1 = \frac{1}{2}\,\frac{400}{100\mu} \cong 2\,M\Omega$ USE 1.5MΩ

3) $C_1 = \frac{nt}{R_L}$  $R_L = \frac{360^V}{50ma} = 7.2^K$

$n = 2$ ; $t$ = REV. RECOV. time = 10μsec.

$\therefore C_1 = \frac{2(10\mu)}{7.2^K} = 2.775\,m\mu$ use 3 or .0033 μfd

4) $\frac{C_S E_m}{\sqrt{3I^2t}} = \frac{60\mu(400)}{\sqrt{2.7}} = .0146$

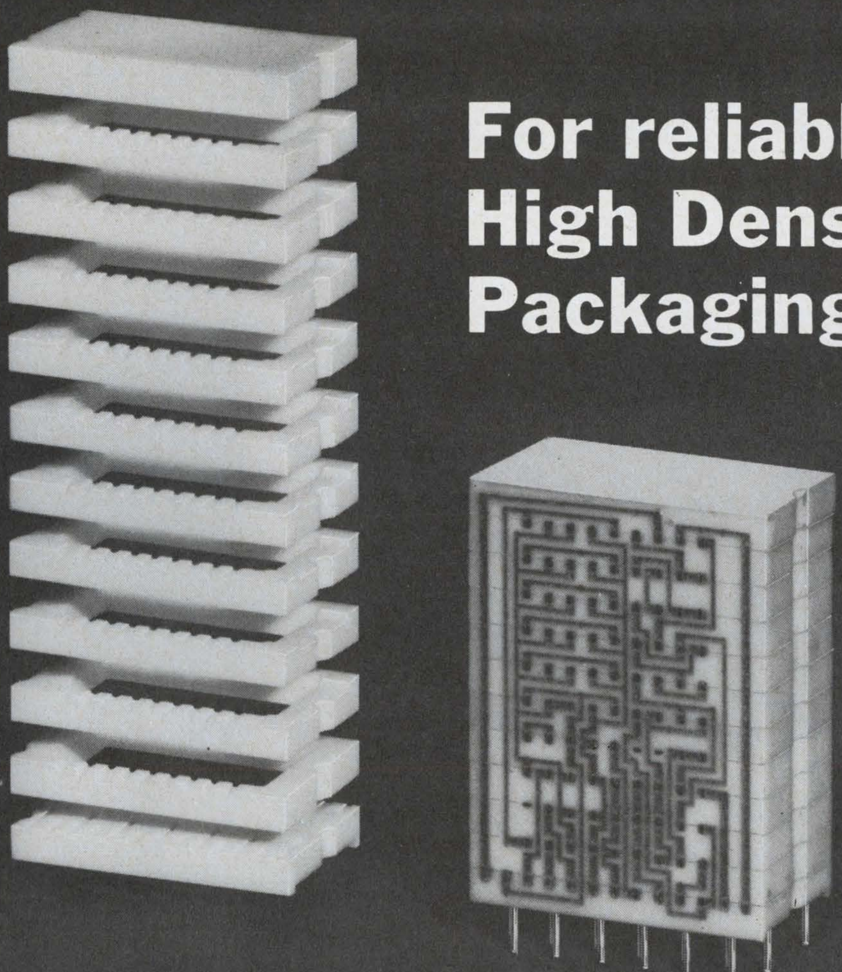
$\angle\ I^2t$ for 1N540 = .93 amp² - sec
$t \leq .008$ sec.

5) FOR .0146 from chart = RC = $5\times10^{-3}$

$R = \frac{5\times10^{-3}}{60\mu} = 83.3\,\Omega.$

TRANSFORMER CHOSEN HAS 100Ω/LEG
$\therefore$ NO ADDITIONAL REQUIRED.

6) THYRECTORS CHOSEN
SINCE AC 260V - 0 - 260V
USE 275V RMS, 385V PK UNITS



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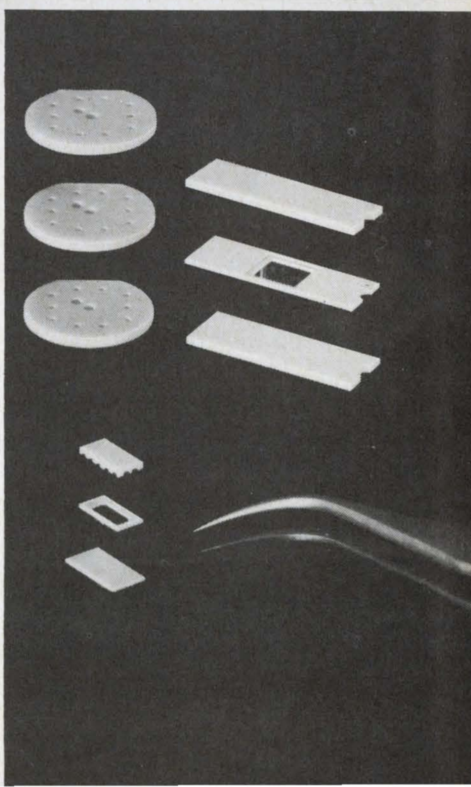
ON READER-SERVICE CARD CIRCLE 34



# Cut the size of your vhf attenuators

## with a simple circuit. Other virtues are fast response time and continuously variable attenuation.

A design approach that uses a bridge-type circuit with pin diodes makes it possible to fit uhf and vhf attenuators into small packages. The technique makes allowance for the requirements of both variable and fixed attenuations at power levels up to 100 watts cw over bandwidths up to 25%. Its upper frequency limit is some 2 to 3 GHz.

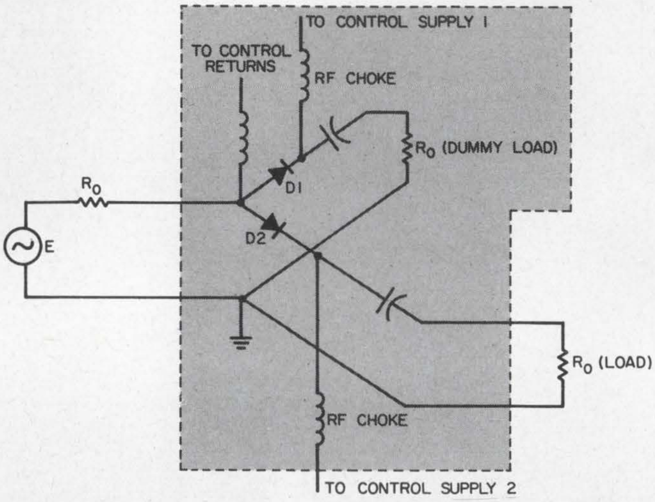
In many systems a practical attenuator at uhf and vhf frequencies must both be compact and provide for fixed and variable attenuation. It must, furthermore, remain matched to the system over its whole range. Above 500 MHz these requirements pose no problems; a matched multidiode attenuator or a ferrite isolator in conjunction with a reflective diode attenuator are among the devices available to the systems engineer. At lower frequencies, however, their size makes them incompatible with most system requirements.

The bridge-type diode circuit in Fig. 1 not only overcomes the size problem (it is about half the size of the devices mentioned above) but also meets the other requirements. Its major areas of application include modulation of RF signals over broad power and frequency ranges, remote gain control of RF amplifiers, protection of receivers by RF power-leveling, and the control of radiated power.

The major factor in the design is selection of the diodes. Attenuation range, insertion loss and input power have all to be considered at once when the choice is made.

### Diodes are merely resistances

The basic circuit of Fig. 1 may be used to establish the design criteria. It is assumed that the RF impedance of diode 1 can be represented as $Z_1$ and that of diode 2 as $Z_2$. To ensure a matched condition, the RF input impedance of the attenuator must be $R_0$, where $R_0$ is the system's characteristic impedance. The load is simply the rest of the system, so it, too, has a value of $R_0$. Neglecting transmission-line effects, this requires that:



1. **Basic attenuator circuit** is built around two RF diodes. Both the generator and load impedances are assumed to be equal to $R_0$. The diodes are pin type and have resistive impedances through their bias range. The attenuation is continuously variable through the bias of the diodes, which varies their impedances from about 0.5 to 5000 ohms.

$$R_0 = [(Z_1+R_0)(Z_2+R_0)]/[Z_1+Z_2+2R_0]. \quad (1)$$

If $Z_1$, the impedance of diode 1, equals $R_1 + jX_1$, and $Z_2$, the impedance of diode 2, equals $R_2+jX_2$, then Eq. 1 becomes:

$$R_1R_2-X_1X_2+j(R_1X_2+R_2X_1)=R_0^2. \quad (2)$$

Since $R_0^2$ is a real number, the imaginary part of Eq. 2 must be zero: $R_1X_2 = -R_2X_1$. This is easily realizable on condition that:

$$R_1+jX_1=(R_2-jX_2)C^2, \quad (3)$$

for then $Z_1 = C^2Z_2^*$, that is, $Z_1$ is proportional to the complex conjugate of $Z_2$. ($C$ is a constant and * denotes the complex conjugate.) Using Eq. 3 in the real part of Eq. 2 gives:

$$R_2^2+X_2^2=(R_0/C)^2. \quad (4)$$

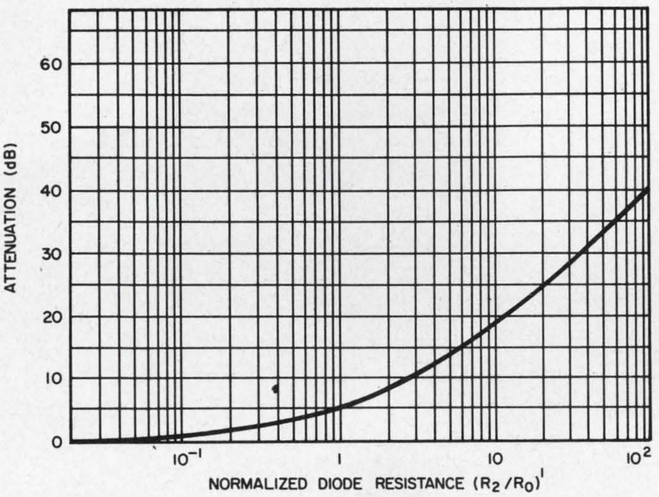
In other words, the impedance of diode 2 must be controlled so that it has a magnitude equal to:

$$(Z_2Z_2^*)^{1/2}=(R_2^2+X_2^2)^{1/2}=R_0/C,$$

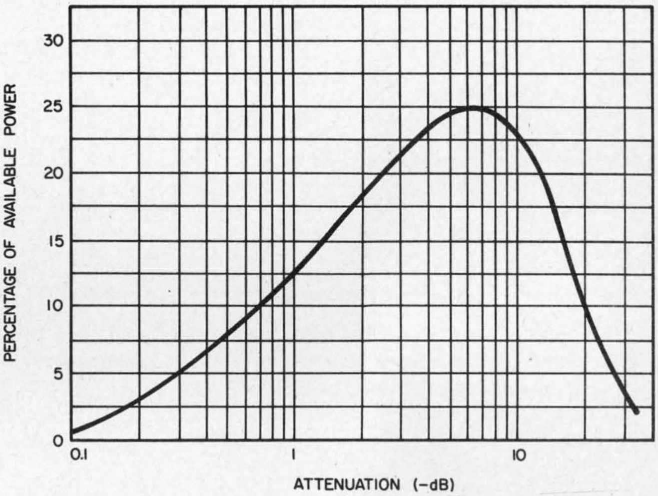
and simultaneously the impedance of diode 1 must be equal to $C^2Z_2^*$. However, if $Z_1$ equals $R_1$ and $Z_2$ equals $R_2$ (that is, $X_1 = X_2 = 0$), Eq. 2 is sat-

---

**Hugh R. Malone,** Electrical Engineer, and **Donald E. Allen,** Sr. Engineer, Motorola Government Electronics Div., Scottsdale, Ariz.



2. **Continuously variable attenuation** is achieved by changing the diode's resistance. Here the resistance is normalized with respect to the system's impedance, $R_o$. It is assumed that both diodes in Fig. 1 have the same resistances; which vary from 0.5 to 5000 ohms. The range of the attenuator is greater than 40 dB, and its insertion loss is less than 0.1 dB.



3. **Dissipation in the diodes reaches its peak** at the 6-dB attenuation level. The absorbed power is expressed as a percentage of the total input power. Each diode must therefore be rated to dissipate one-fourth of the controllable power. However, if $R_1R_2 = R_o^2$, then even a larger percentage of the input can be dissipated in a diode. Diodes can dissipate 1 to 5 watts with good heat sinks.

isfied by:

$$Z_1Z_2 = R_1R_2 = R_0^2. \quad (5)$$

A matched attenuator (or variable power divider) can then be achieved by controlling the diodes' impedances.

### Loss in passband is down to 0.1 dB

The two remaining parameters are the insertion loss and the maximum permissible power dissipation. The insertion loss determines the attenuation range of the circuit and dissipated power affects the amount of attenuation.

The insertion loss is defined as the ratio of power delivered to a matched load to the power available to a matched load. For real diode impedances, it is given by:

$$\textit{Insertion Loss} = [(R_1+R_0)/(R_1+R_2+2R_0)]^2, \quad (6)$$

where $R_2$ is related to $R_1$ by Eq. 5.

The diode's impedances may be normalized for simplicity: $R_n' = R_n/R_0$, where $n = 1, 2$. When the loss is expressed in decibels, Eq. 6 becomes:

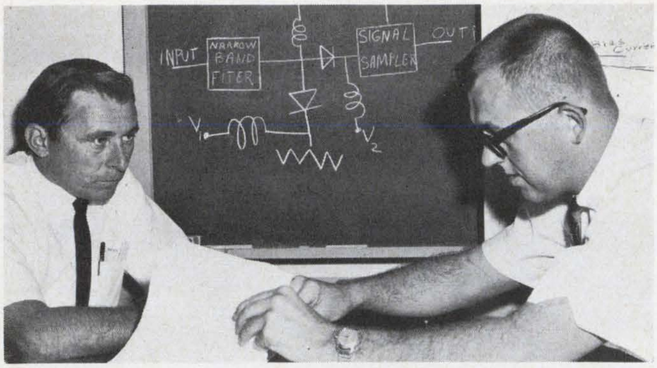
$$\textit{Insertion Loss}_{dB} = 20 \log_{10}[1+R_2']. \quad (7)$$

The achievable attenuation is plotted in Fig. 2 as a function of $R_2/R_0$, with the implicit condition that $R_1R_2 = R_0^2$. Note that in a 50-ohm system impedance level, an attenuator with less than 0.1-dB insertion loss and a range of attenuation greater than 40 dB can be implemented with diodes with resistances that can be varied from 0.5 to 5000 ohms. The measured swr at the input of the attenuator is 1.0 when $R_1R_2 = R_0^2$.

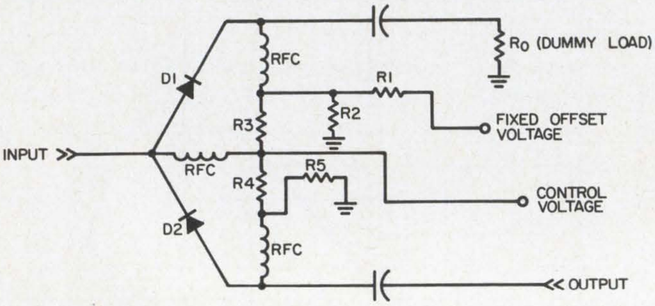
### Diodes should share power equally

The power dissipated in each diode depends on the impedances of the generator and the load and, of course, on the diodes' impedance. If Eq. 5 is valid (i.e., $R_1R_2 = R_0^2$) and both the load and the generator impedances are equal to $R_0$, then the two diodes absorb equal amounts of power. The percentage of dissipated power in each diode, $P_d$, is therefore:

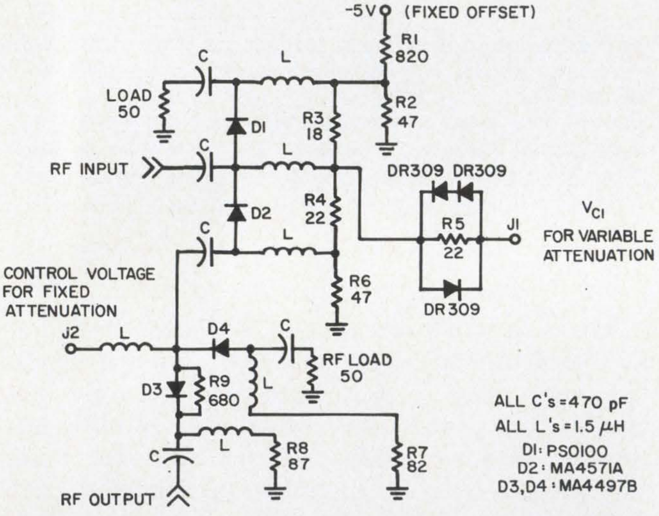
$$P_d = [R_2'/(1+R_2')^2] \times 100\%, \quad (8)$$



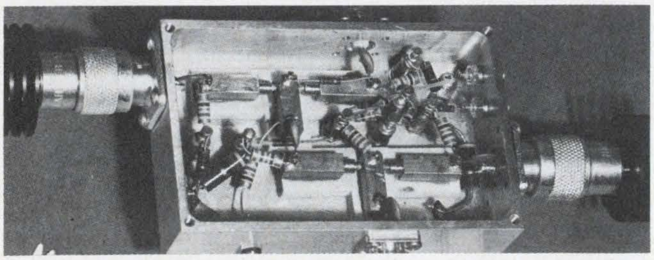
**A simple block diagram and a Smith chart** help authors Allen (left) and Malone to come up with the right devices.



4. **A single control source** may bias both diodes if one of the diodes is reversed. Here diode D2 is reversed with respect to its original direction in Fig. 1.



(a)



(b)

5. **Power attenuator** is designed for 200 MHz. A spdt diode switch (D3 and D4) has been added to provide a fixed attenuation of 23 dB. The variable attenuation of 28 dB is controlled by $V_{C1}$, as shown in (a). The size of the prototype package is about 4 x 2.5 x 1 inches (b).

where the primed symbols again represent diode impedances normalized to $R_0$. The relative power dissipated by each diode, as a function of the attenuation level, is plotted in Fig. 3. The maximum power is absorbed by each diode at the 6-dB attenuation point. At this attenuation value, one quarter of the available power is dissipated in each diode, the power load and the external load, respectively. To prove that maximum power absorption occurs at the 6-dB point, the derivative of Eq. 8 is taken and set equal to zero:

$$\frac{\partial P_d}{\partial R_2'} = \frac{(1+R_2')^2 - R_2' \, 2(1+R_2')}{(1+R_2')^4} = 0.$$

Hence $R_2' = 1$ when maximum power is absorbed in either diode. Substituting $R_2' = 1$ into Eq. 7 yields the attenuation value of 6 dB.

If the condition that $R_1 R_2 = R_0^2$ does not hold, then an even higher percentage of the available power can be dissipated in a diode than is predicted by Eq. 8.

In view of all that has been discussed, it is clear that the diodes are completely specified by these three conditions:

- The attenuation range determines their maximum and minimum impedances (Eqs. 5 and 7 and Fig. 2).
- One quarter of the input power determines their power-dissipating capability.
- The RF impedances of the diodes should be real over the entire bias range.

Typical pin diodes appear to be the best choice for wide attenuation ranges and medium power levels. They have RF impedances that can be varied with the bias and are nearly real in the vhf and uhf bands.[1,2] Their typical minimum value during forward bias is less than 1 ohm. These diodes are normally rated as capable of dissipating 2 to 5 watts, when provided with a sufficient heat sink.

### Passive components have low impedances

Once the diodes are selected, the circuit design becomes mostly empirical; common sense will help the designer more than mathematical formulas.

In the circuit in Fig. 1, the RF chokes provide a means of injecting the diode bias. The chokes must provide sufficient reactance at the RF frequency to ensure a low-loss attenuator. The dc blocking capacitors, which isolate the bias paths, the dummy load, and the external attenuator load, must have low RF impedances.

Several variations are possible in the bias circuitry. As an example, one of the diodes can be reversed and both diodes can be biased by a single control source. A typical circuit of this type is shown in Fig. 4. The selection of bias circuit is mostly determined by available voltages.

Since, when the attenuation is 6 dB, a quarter of the available RF power to a matched load is dissipated in each diode, the major thermal problem is that of providing a sufficient heat sink for each diode.

If a coaxial transmission line is used within the attenuator, the problem is to provide a high-thermal-conductivity – low-electrical-conductivity path between the inner and outer coaxial conductors. Simultaneously, a high thermal-conductivity path is required between the diode package and the coaxial inner conductor.

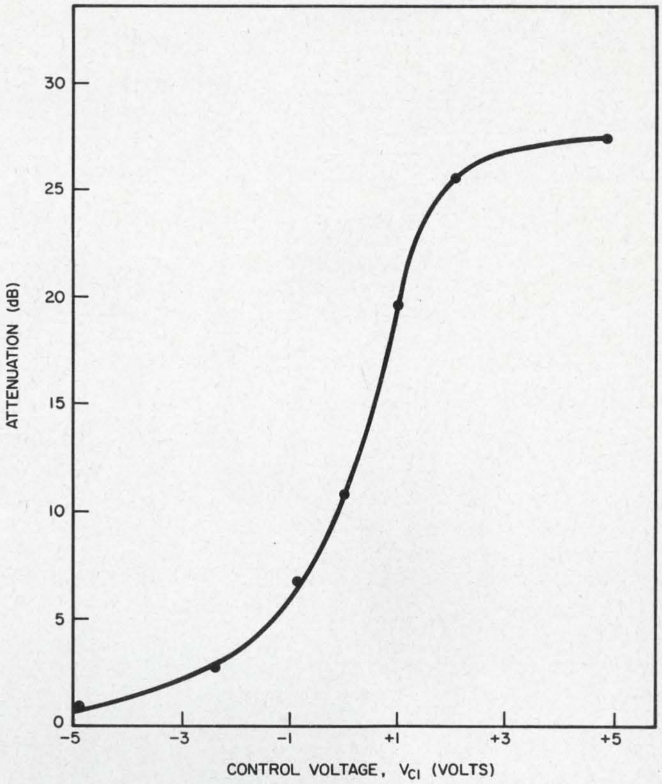
Experiments show that a beryllium oxide loaded transmission line satisfies both criteria. An assembly of this type has been designed to control 10 watts of average RF power with MA 4571 diodes over ambient temperature ranges of −50°C to +50°C. This attenuator, shown in Fig. 5, operates at 200 MHz. Its continuously variable attenuation ranges are from 1.0 to 28 dB, with a maximum swr of 1.6 when used in a 50-ohm system. The maximum control power is 0.6 watt. A response time (not considered a minimum) of less than 0.3 μs was measured.

## Add switch for fixed attenuation

An additional spdt diode switch has been added, so that both fixed and variable attenuation can be obtained. Some additional bias circuitry is also included to linearize partially the continuously variable portion of the attenuation with control voltage.

Resistors *R1* through *R6* and the DR309 diodes were selected empirically so that the attenuation-vs-control curves were sufficiently linear. Resistors *R7* and *R8* are current-limiting resistors. Their values are determined by the maximum desirable bias currents of RF diodes *D3* and *D4*. *R9* limits the attenuation achievable by RF diode *D3*. It would not even be used in most instances.

All capacitances are chosen for minimum RF impedance and compatibility with switching requirements. As the values of capacitances are increased, RF losses drop. The switching time of the attenuator, however, will be increased with increasing values of *C*. The values shown in Fig. 5 reflect a compromise between these two criteria. The inductances are selected in a similar manner. All chokes are 1.5 μH and all capacitors are 470 pF. An offset voltage of −5 V and a control voltage of ±5 V at *J2* provide a step (fixed) attenuation of 23 dB. A second control voltage, $V_{C1}$, provides the continuously variable 28-dB range of attenuation. Applied at *J1*, it is continuously variable from −5 to +5 volts. Hence, a total attenuation of 51 dB is available.



6. **Measured variation of continuously variable attenuation** with control voltage $V_{C1}$ shows rapid control. The switching time of the device over the entire attenuation range is less than 300 ns.

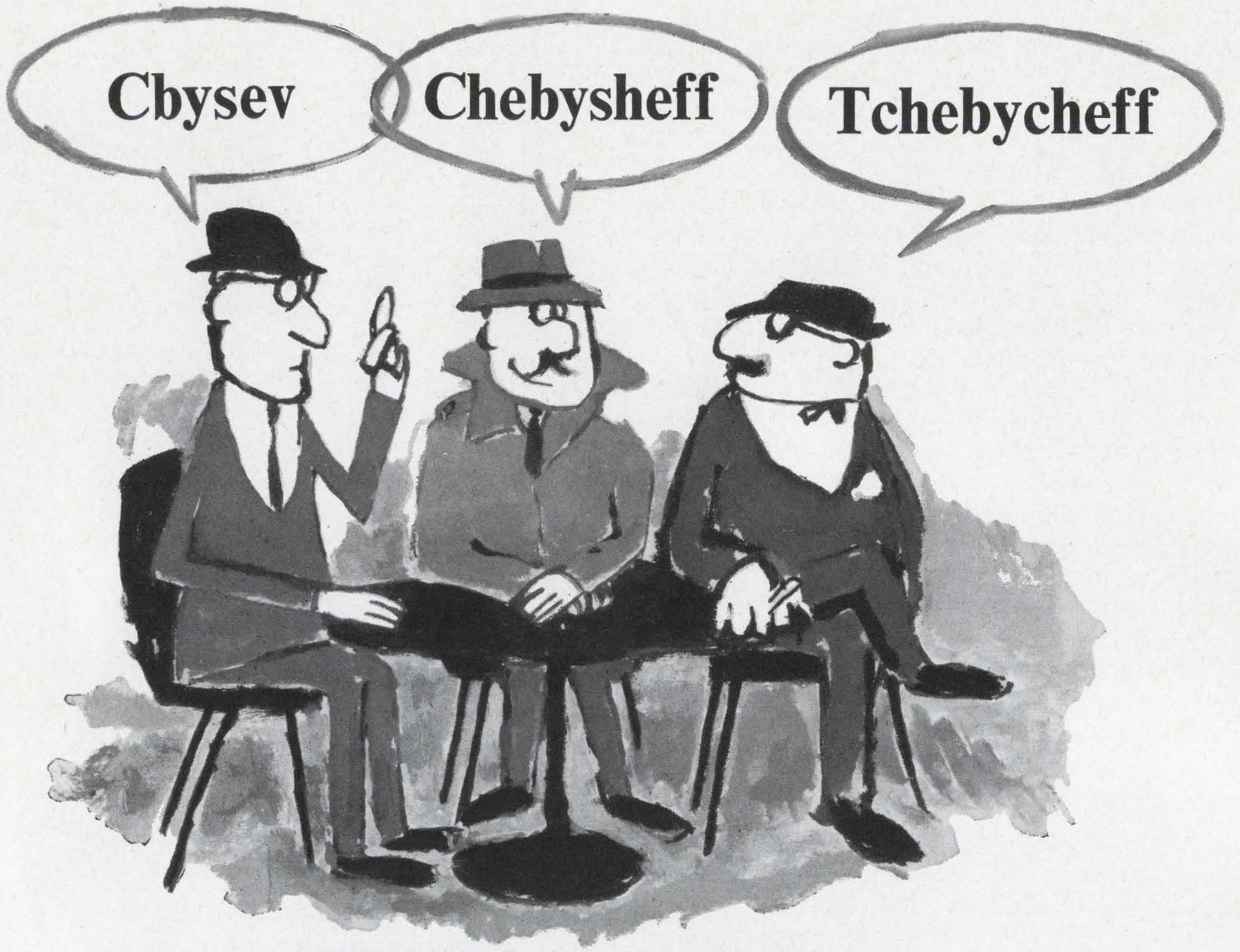
The continuously variable portion of the attenuation depends on control voltage $V_{C1}$, as shown in Fig. 6. The maximum swr measured over the entire attenuation range is 1.6:1, with typical values of less than 1.3:1. The device, evaluated over an RF bandwidth of 25% and an ambient temperature range of −50°C to +50°C, shows only negligible variations from the data of Fig. 7. The switching time of the device over the entire range of attenuation is less than 300 ns.

The operational frequency and maximum power-handling capability of the attenuator design are very difficult to calculate. Exact diode impedances, exact thermal properties, exact diode impedances, and exact thermal properties of the diode mounts must be known. The estimated upper limit of operating frequency is about 2 to 3 GHz, for the circuit in Fig. 5. Careful design can push up the maximum power-handling capability to about 100 watts. Diodes would have to be carefully selected and a good thermal design would be imperative. In the vhf and uhf ranges, bandwidths of 25% are estimated as feasible for the mean frequency. ■ ■

**References:**

1. A. Uhlir, "The Potential of Semiconductor Diodes in High-Frequency Communications," *Proc. IRE*, XLVI (June, 1958), 1099-1115.

2. Donald E. Allen, "An Investigation of the Microwave Equivalent Circuit of the pin Diode" (Master's thesis. Arizona State University, June, 1965).



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ON READER-SERVICE CARD CIRCLE 35

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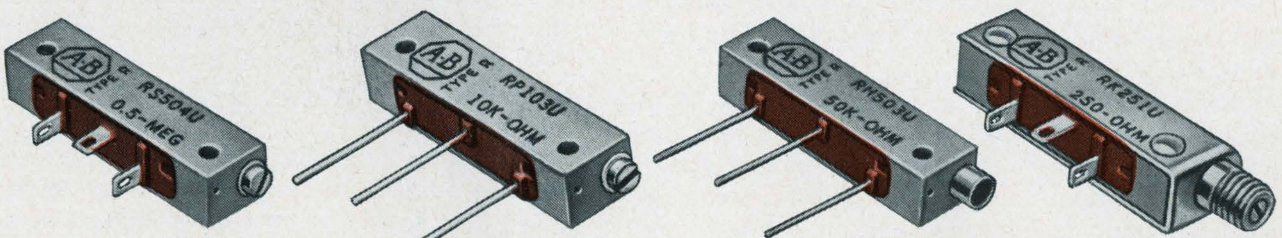

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ON READER-SERVICE CARD CIRCLE 36

# Speed microelectronic soldering

## by using prealloyed-solder/flux creams. This also increases uniformity and reliability.

Soldering minute parts in high-density electronic packages presents problems uncommon to other joining methods. The amount of solder and flux required for adequate joining is extremely small. Excessive solder and flux will result in a bridge that will cause the assembly to short. Space is at a premium and the location where the solder and flux should be placed must be closely controlled. In addition, the heat from the soldering operation and the residues from the soldering materials cannot be permitted to affect the rest of the assembly adversely. When soldering many joints on one assembly, remelt must not occur. Solder creams or pastes offer a solution to many of these problems.

### Choice depends on application

Solder creams are flux and solder combinations made from prealloyed solder powder and fully activated, mildly activated or nonactivated flux, according to the application. The composition of the prealloyed solder powder itself depends on the specific use to which it is to be put.

Two factors govern choice of the proper solder alloy:

- Soldering temperature—An alloy that solders at a low temperature will help minimize thermal damage to the assembly. This is an important consideration when dealing with temperature-sensitive components. Table 1 lists the melting points and plastic temperatures of common alloys.
- Solder joint strength—Physical and mechanical stresses that an assembly must withstand have to be borne in mind.

Storage requirements dictate selection of a curable or of a noncurable solder. Curable creams are used if the assembly is to be handled or stored after application. Noncurable creams are used when handling and storage are unnecessary and soldering can be accomplished immediately.

Unlike roll solders, exact amounts of solder pastes may be precisely located. A specific volume can be selectively screened or masked onto the assembly surface. It can also be extruded onto the assembly surface with an air syringe to provide close control over the volume of cream deposited.

Controlling the amount of solder and flux used to make the joint by preplacing the solder cream eliminates bridging problems resulting from excessive solder (see Fig. 1). It also cuts out the possibility of using too little solder. Dependence on an operator's technique for making solder joints in an exact location, using the proper amount of solder, and handling a soldering iron is overcome. Reliability is increased by the fact that each joint is made with a premetered amount of solder and flux. Rejects and the need to repair inadequate joints are reduced.

When soldering many joints on one assembly, remelt can occur. If the joints are made one at a time, the heat required to bring one joint to soldering temperature may be sufficient to remelt those joints already made. With the automatic application of a solder cream to all joints at once and a single application of heat, the joints are soldered simultaneously and there is no possibility of remelt.

### Solder applicable by several methods

Once the volume of solder has been calculated[1] and this calculation has been corroborated by prototype soldering, preplacement of solder cream onto the assembly can be automated, even when dealing with microminiature assemblies. Although the methods of applying solder cream can be varied, the underlying techniques fall into the broad categories of screening, masking, or using automated equipment.

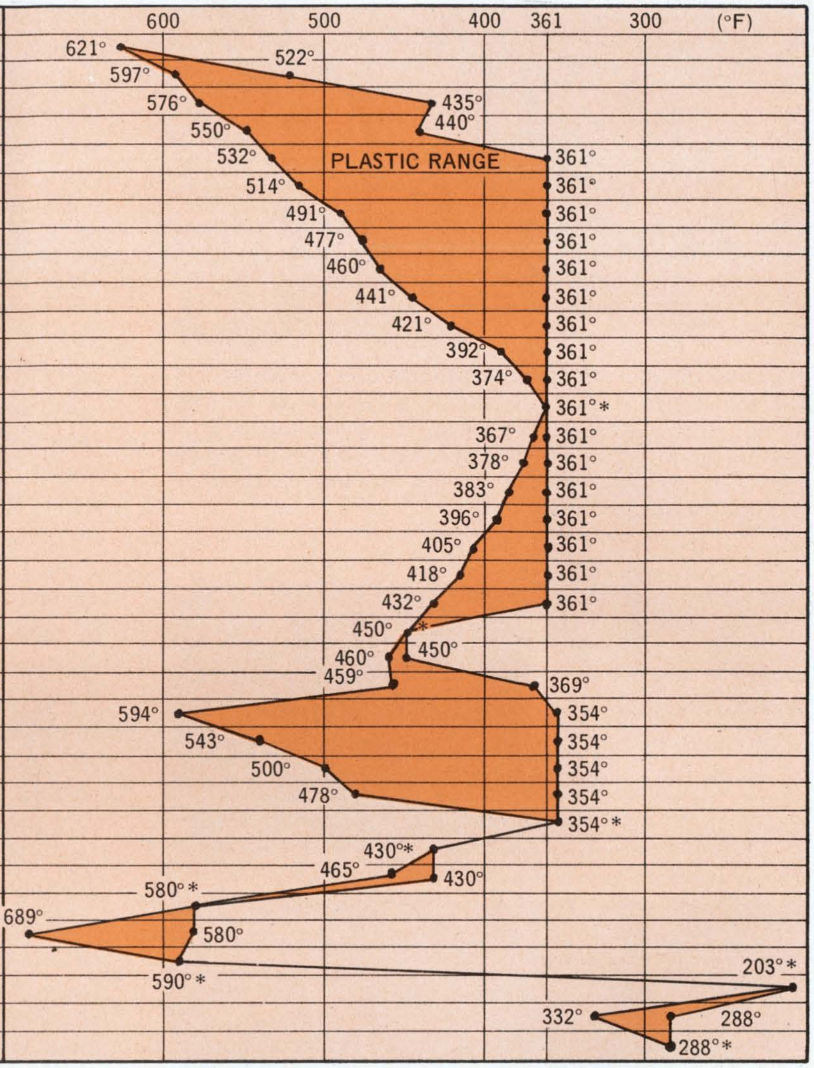
*Screening* is usually appropriate for very thin deposits—generally no greater than 0.001 inch thick. The screening process permits the deposition of solder cream in custom amounts and configurations to meet specific needs. Since heavier deposits may present registration problems, another application method should be employed when the required thickness exceeds 0.001 inch.

---

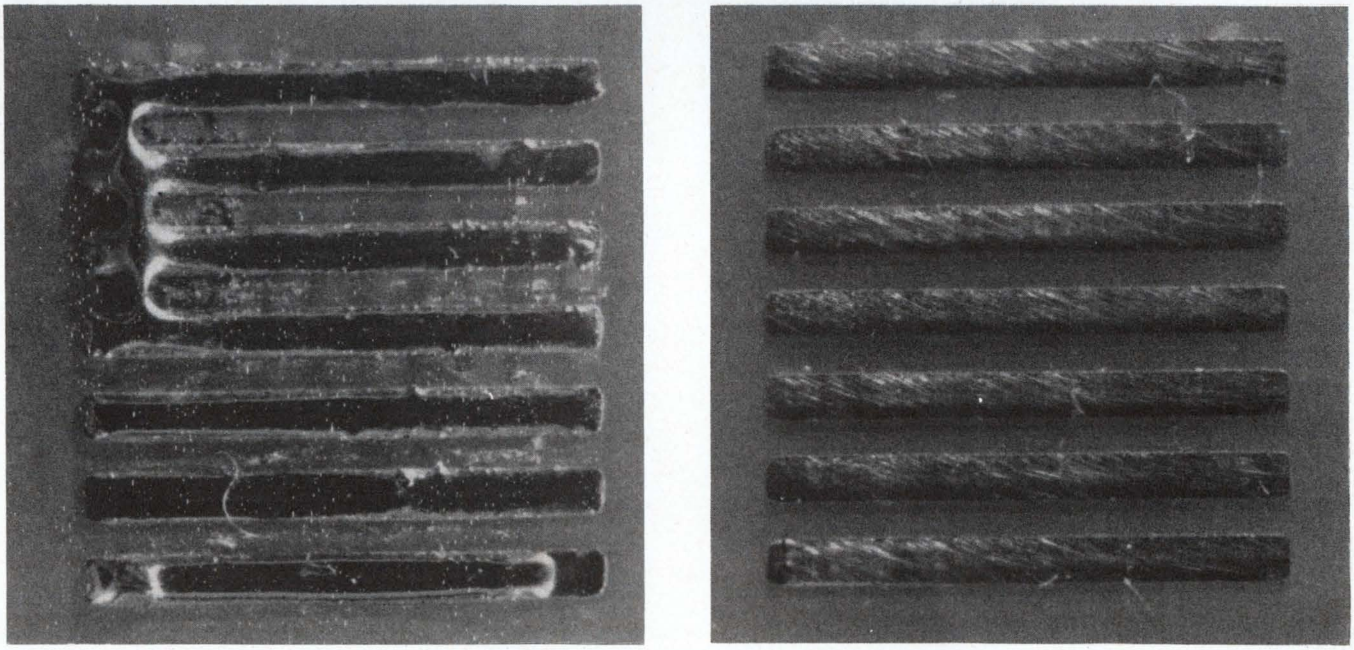
**H. H. Manko,** Director, Solder Research & Development, Alpha Metals, Inc., Jersey City, N. J.

# Table 1. Plastic and liquid temperatures of common alloys

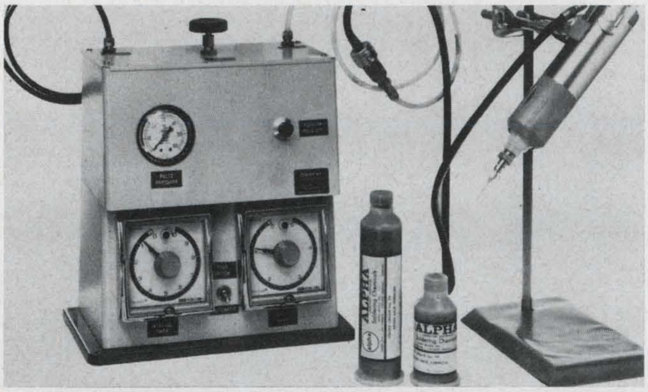
| TIN | LEAD | SILVER | ANTIMONY | OTHERS |
|---|---|---|---|---|
| 0 | 100 | | | |
| 5 | 95 | | | |
| 10 | 90 | | | |
| 15 | 85 | | | |
| 20 | 80 | | | |
| 25 | 75 | | | |
| 30 | 70 | | | |
| 35 | 65 | | | |
| 40 | 60 | | | |
| 45 | 55 | | | |
| 50 | 50 | | | |
| 55 | 45 | | | |
| 60 | 40 | | | |
| 63 | 37 | | | |
| 65 | 35 | | | |
| 70 | 30 | | | |
| 75 | 25 | | | |
| 80 | 20 | | | |
| 85 | 15 | | | |
| 90 | 10 | | | |
| 95 | 5 | | | |
| 100 | 0 | | | |
| 95 | | | 5 | |
| 35 | 63 | | 2 | |
| 27 | 70 | 3 | | |
| 40 | 57 | 3 | | |
| 50 | 47 | 3 | | |
| 61.5 | 35.5 | 3 | | |
| 62.5 | 36.1 | 1.4 | | |
| 96 | | 4 | | |
| 95 | | 5 | | |
| | 97.5 | 2.5 | | |
| | 95 | 5 | | |
| 0.75 | 97.5 | 1.75 | | |
| 16 | 32 | | | 52Bi |
| 50 | 40 | | | 10Bi |
| 51.2 | 30.6 | | | 18.2Cd |



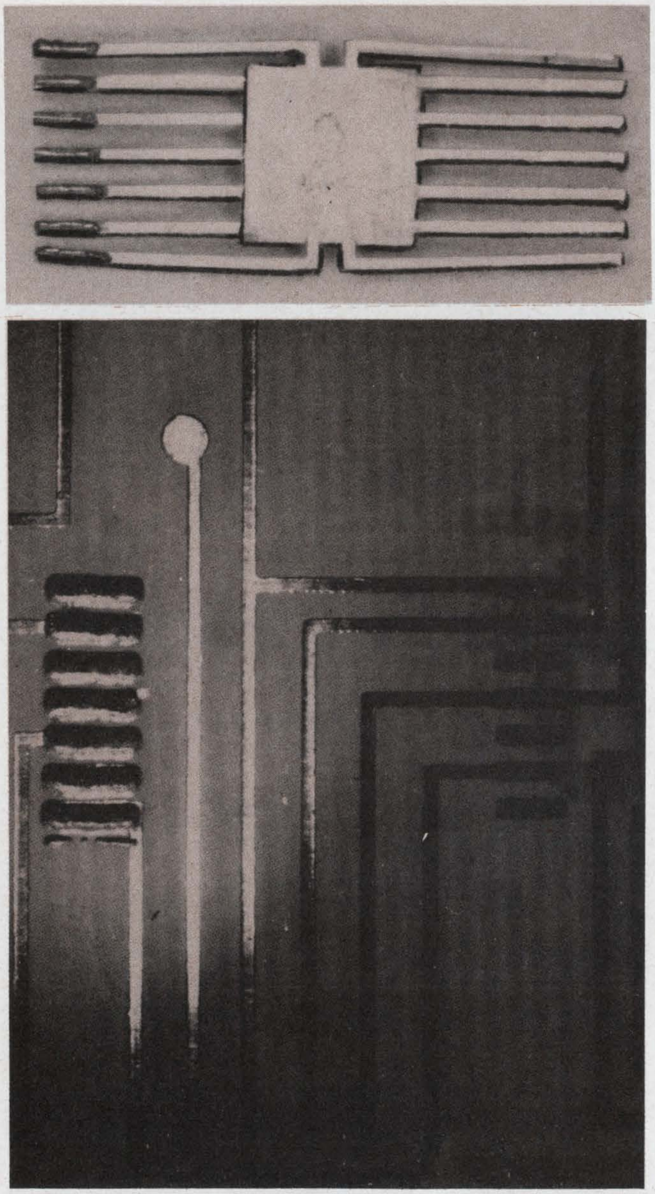
*Eutectic (Plastic and liquid temperatures coincide)
Courtesy Gardiner Solder Co.



1. **"Bridged" solder encountered in dip soldering** operation is shown at left. Assembly at right shows uniform layers obtained with solder cream. There is no danger of shorting across contacts.



2. **Extrusion-type automatic dispensing unit** applies solder. The shot timer, Kenics model 500 SIFM, pulses air into the dispensing hopper. The dispenser, Pyles model 950-60X, is outfitted with a needle nozzle which dispenses solder in response to the pulses. Tubing is standard Polyflow plastic.



3. **Two methods for joining flat packs to PC boards.** On the flat pack above, solder cream is directly applied to the leads. On the board below, solder cream is deposited straight onto the bonding pads.

Masking or extrusion is appropriate.

*Masking* is used for heavier deposits of solder cream. The cream is applied in any configuration through a stainless-steel mask or pre-etched stainless-steel template. The thickness of the stainless-steel mask determines the thickness of the deposited layer of solder cream.

*Continuous conveyors and automatic extrusion devices* can be effectively adapted to automate the application of solder cream (see Fig. 2). A technique similar to that used to paint silver on ceramics or a combination extrusion and stamping procedure may also be used.

If handling or storage is required, the solder cream should be cured in an oven or with hot-air blasts. Table 2 shows some typical curing times and temperatures for patches up to 2 square inches in area. A typical curing criterion would be 10 to 15 minutes' exposure in an oven at a temperature of 200°F, assuming that the solder cream is of medium thickness. The assembly may then be stored, if necessary. Assemblies containing cured solder cream have been subjected to atmospheric conditions and humidity-chamber conditions for 18 months without showing deterioration of solderability. This means that the base material containing a cured coating of solder cream can be stored for prolonged periods prior to soldering without detriment. After curing, the solder takes on a dry, gray, paint-like appearance and is hard to the touch. It adheres well to the assembly surface. A strip of copper containing a 0.008-inch-thick deposit of solder cream can be bent to a 30° angle without any flaking of the solder. Even when the copper strip is bent farther, flaking does not occur, although the solder cream deposit does crack. This cracking does not impair the assembly's solderability; it simply means that the coating is no longer uniform. The cured solder coating not only permits handling and storage, but also protects the surface that is to be soldered against oxidation.

When the solder cream is used with ceramic substrates, perfect registration of the cured solder cream is not essential. It will climb back onto the metallic area of the substrate once it has been reheated for soldering. The soldering operation may be accomplished by any conventional means. Soldering irons, conduction heaters, resistance tools, light banks, torch flames, infrared radiation, hot air and many other methods are all applicable. Although soldering time and temperature depend on the alloy used, in general the soldering temperature should be approximately 100°F above the liquidus or total melting point of the alloy.

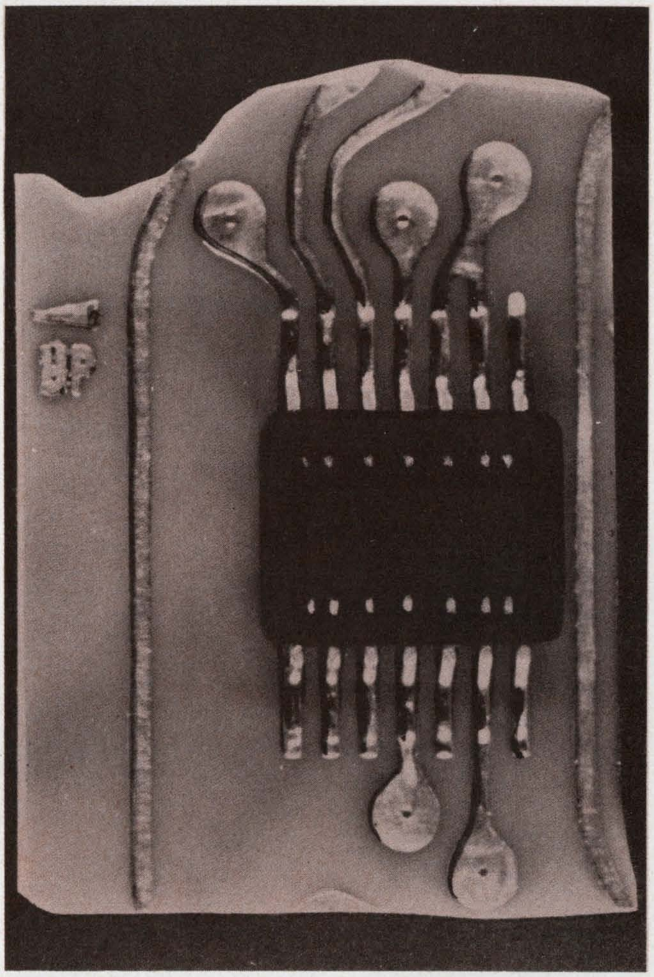
The flux residues left after soldering with the cream are nonconductive and nonhygroscopic and therefore considered noncorrosive for most applications. If desired, the flux residues can be removed with most commercial cleaners and rosin flux removers.

### Two techniques for microelectronic soldering

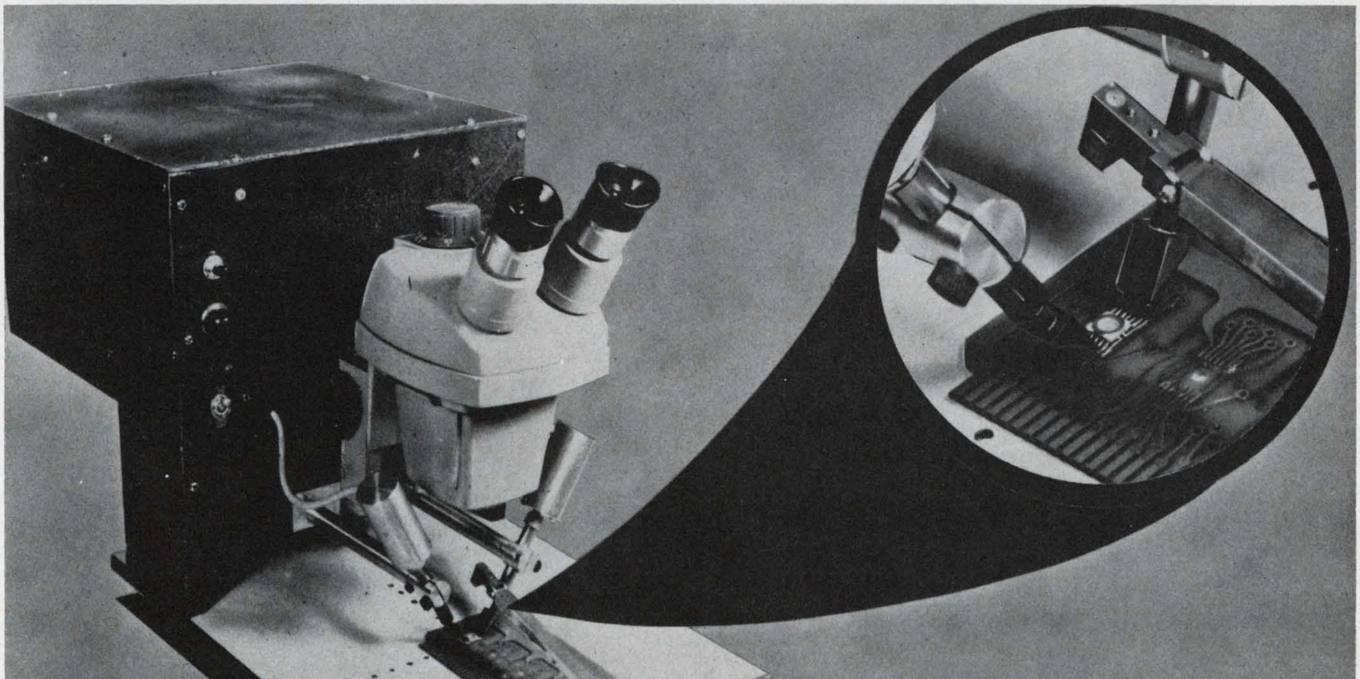
With solder cream, flat packs can be uniformly soldered to printed-circuit boards and still be very easy to inspect. Two methods are available. By one, the solder cream is applied to the printed-circuit-board pads immediately after board manufacture when the pads are still simple to solder. The flat packs with solderable leads are simply placed where desired and, when heat is applied to the solder cream, a fillet is formed. The other approach involves placing the solder cream on the flat-pack leads. The leads are then placed on the PC-board pads. In this instance, the process is in effect reversed. Moreover, whereas in the first approach little solder is present on top of the lead, in the second, the solder completely encompasses it. Thus from an inspection standpoint, the first approach is more desirable. Figure 3 shows both

## Table 2. Curing time and temperature

| Temperature | Time | Thickness |
|---|---|---|
| 210°F (99°C) | 20 minutes | 0.010 inch |
| 230°F (110°C) | 20 minutes | 0.018 inch |
| 250°F (121°C) | 25 minutes | 0.030 inch |



4. **Completed assembly using solder cream** on the bonding pads. Note the absence of bridging.



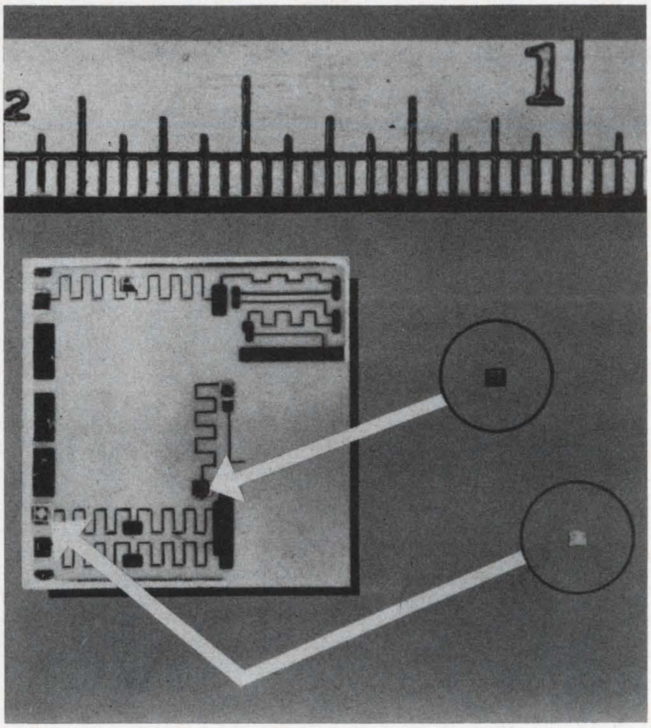
5. **Typical resistance soldering setup.** A Weller Electric Corp. unit is used. Soldering temperature is about 100°F above total melting point of the alloy. Blow-up area of photo shows actual soldering operation.

approaches graphically. Figure 4 shows an actual flat pack that was soldered to a printed-circuit board with solder cream on the pad, not on the lead. Focused infrared light was used as the heat source and all solder joints were made in a period of four seconds.

Another system used successfully is the resistance equipment shown in Fig. 5. Here, two blocks containing the heating element and a large heat sink are used to generate a high current to provide enough heat for the soldering operation. The heat sinks on top of the heating elements help cool the solder immediately after it becomes molten, thus shortening the cycle. The microscope enables the operator to position the flat packs precisely.

Applications are not limited to soldering leads and joining microcircuitry. The material can also be used to join active devices to microcircuit systems. Figure 6 shows an application of this type. The solder cream (containing a 10 Sn/90 Pb alloy and water-white rosin) was used to solder the tiny chips to a hybrid microcircuit.

Solder cream can be used to attach leads to metallized ceramic surfaces when manufacturing inexpensive integrated circuits. In this application, metallized chips are first screened with solder cream. A continuous length of ribbon, to be used as leads, is brought into contact with the solder cream. When heat is applied, the ribbon is soldered in place and then cut to the appropriate lead length. This process is then repeated for the next device. The solder cream itself is not a metallizing material and may not be used as such. It can only adhere to solderable metallic surfaces.

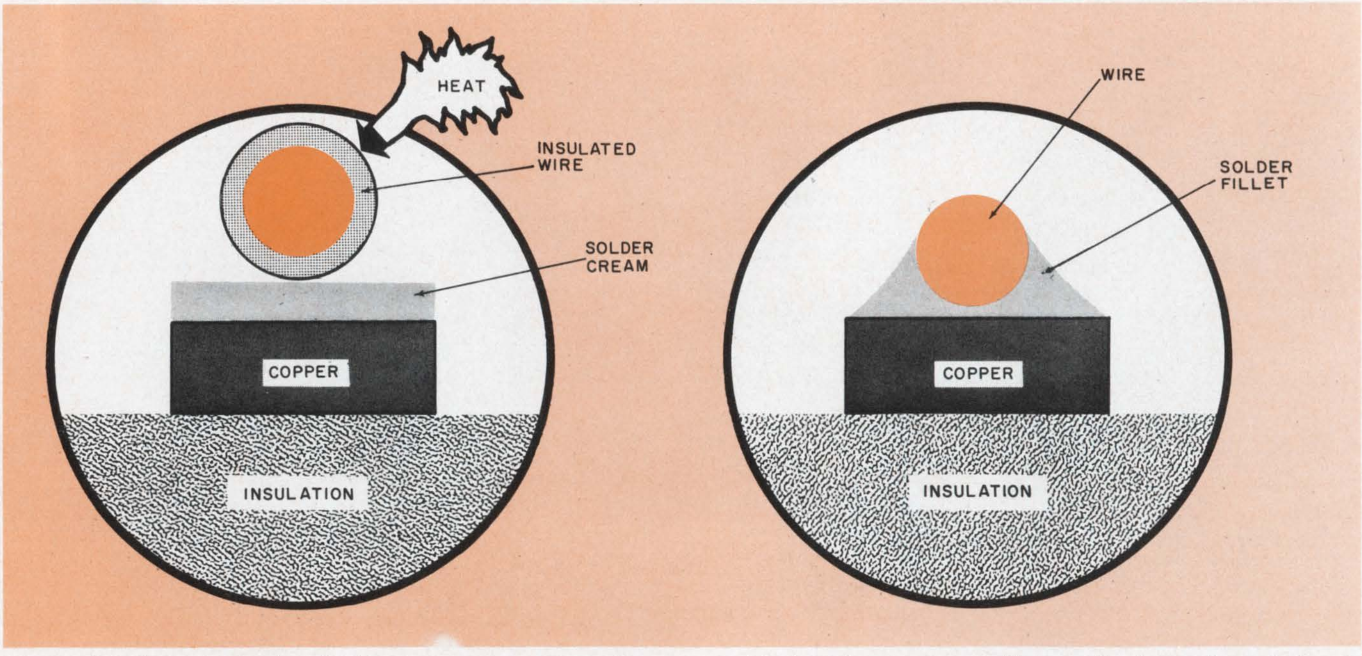


6. **Active devices joined to a hybrid microcircuit.** The same soldering techniques as for flat packs may be used.

Another area of interest is in the manufacture of computer memory core arrays. Figure 7 shows how to locate insulated magnet wire over a frame containing cured solder cream, after the matrix has been woven. In a single operation, the application of heat from above forms the solder fillet while simultaneously stripping the insulation from the copper wire without weakening the wire. ■ ■

**Reference:**

1. Howard H. Manko, *Solder and Soldering* (New York: McGraw-Hill Book Co., Inc., 1964), chap. 5.



7. **Insulated magnet wire** is located over a computer memory array frame containing cured cream after the matrix has been woven. The application of heat forms the solder fillet and strips the wire simultaneously.

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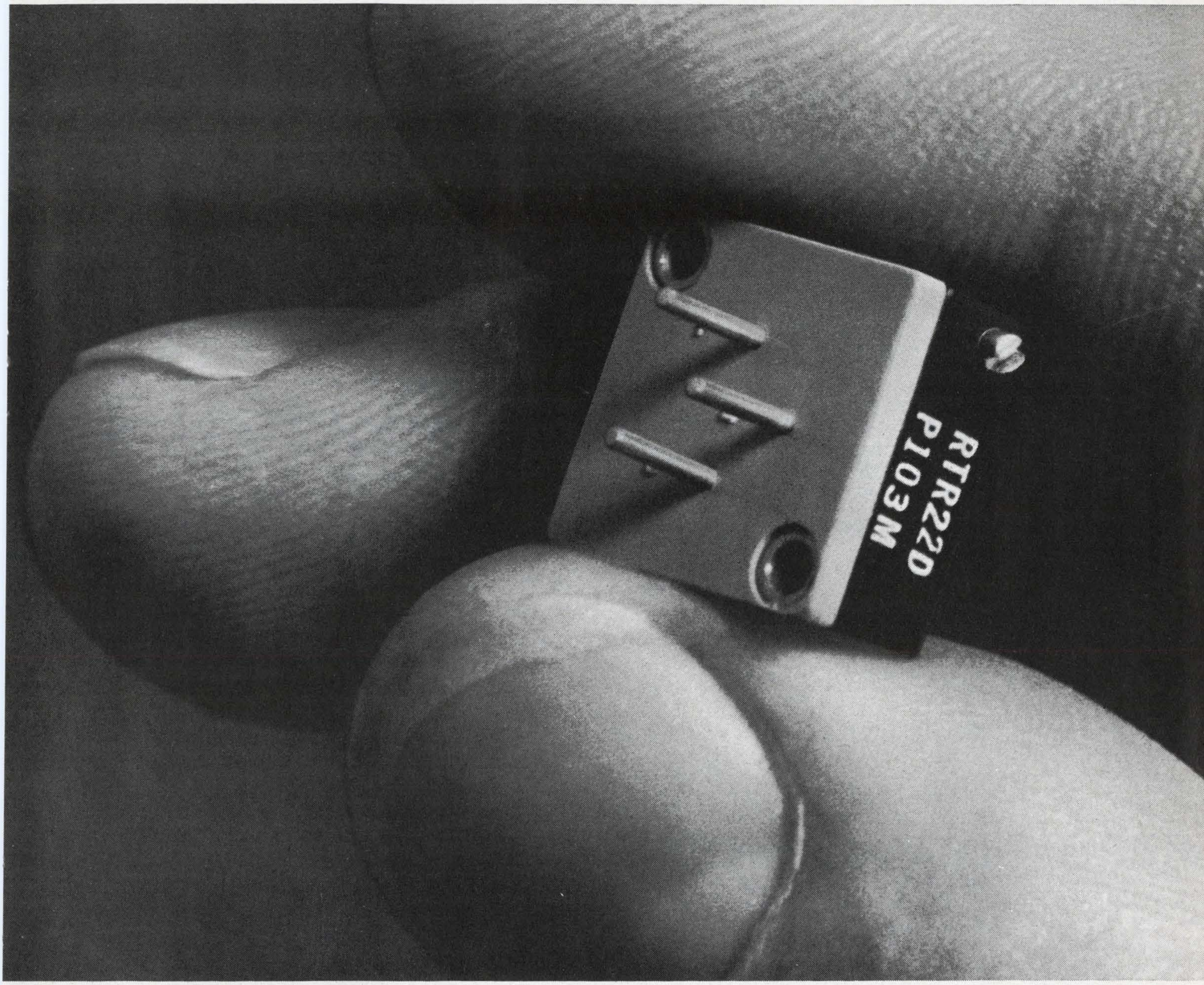

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# Make your next proposal sell

the services and products you offer. Many an award has been lost by garbled language.

"We have the lowest price, the fastest delivery, a good technical proposal and look what happened—that fly-by-night outfit ran away with the award!"

Sound familiar? Relax. Don't start howling about payola and customer ignorance until you see the other company's proposal.

Your own proposal may not have been as good as you thought. Clearly, if your price was rock-bottom, your delivery the speediest, you were well on your way to landing the job. Now ask yourself what went wrong. Did you explain your proposal satisfactorily?

Provided that the proposal's technical approach was sound, it's likely that your trouble lay in the explanation—you failed to get your point across. It didn't sell. The customer may even have had trouble understanding it.

Let's face it at the outset of this discussion: the object of any technical proposal is to sell. As in any selling campaign, you must display your product in its most favorable light.

Before you begin, be sure you can answer yes to the following questions:

- Do you know your customer?
- Are you certain you understand the customer's needs?
- Have you made sure that all people associated with the contract award can appreciate the details in it, even details that do not directly concern them?
- Is the proposal responsive to the customer's request?

## Know your customer

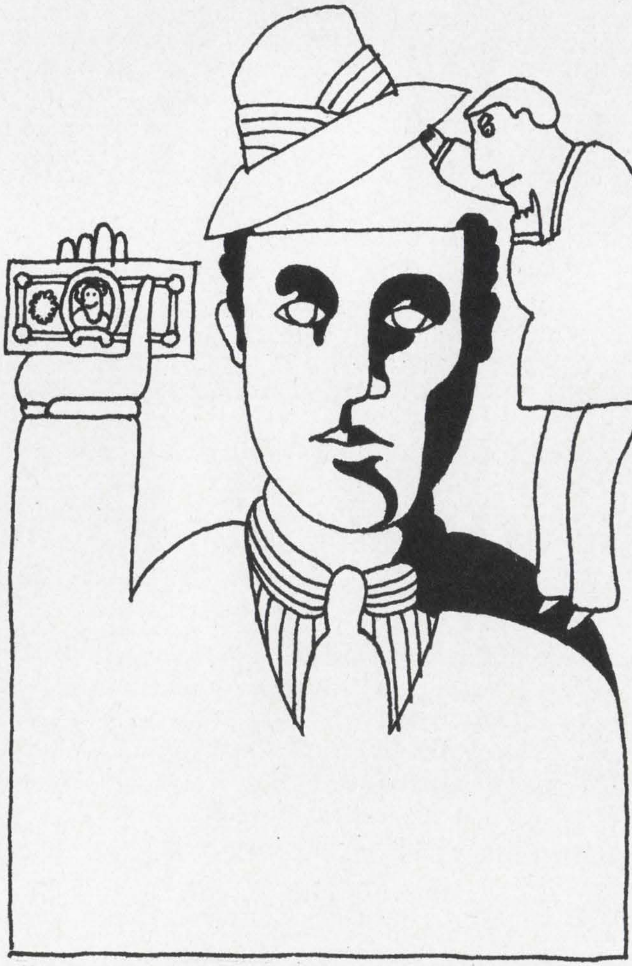
Your customer may be a government agency, another company or, sometimes, a division of your own corporation. Always try to gather as much information about the customer as possible. Such information may include the following:

- The customer's past experience with bidders on the program, with particular stress on pitfalls to avoid. What past technical approaches have left him high and dry, for example?
- The points that are most important to the customer—on-time delivery, cost, technical ingenuity, or whatever.

Remember, after the job is lost, it is too late to blame your marketing people for not supplying you with the information. If you write the technical proposal, it is up to you to obtain information from the marketing staff, salesmen and others who have dealt with the customer.

## Understand the customer's needs

More often than not, a request for a proposal



Know your customer

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**Peter N. Budzilovich,** Technical Editor, Electronic Design.

contains a mixture of specifications, some of which are important, some superfluous, some even contradictory. Whenever time permits, draw up a set of working specifications by meeting with the customer and resolving all gray areas. In most cases, agreement can be reached by pointing out that a better product at a lower cost may result from a thorough understanding of the specifications. Depending on the nature of the contract—CPFF (cost plus fixed fee), CPIF (cost plus incentive fee), FP (fixed price) or any other[1,2]—get together with your contract administrators and ask for advice before talking to the customer. Whenever possible, ask the administrator to come along when you meet with the customer. Under all circumstances, make sure that you understand every request of the customer.

### Write for the proposal evaluators

A contract award usually depends on several evaluations. In the case of government agencies, a proposal is read by contract personnel, program managers, efficiency experts and technical specialists. If you have fulfilled the first basic requirement (know your customer), you should know who will evaluate your proposal. The next basic step is to summarize all your data in tidy sections, so that every reader will find exactly what he needs to know in one place.

There are eight main sections to the average technical proposal, ranging from "Introduction" and "Statement of the Problem" to "Experience" and "Facilities." The contract administrator, for example, who may well not be an engineer, is interested in your program organization and how you propose to meet schedules and costs. Don't bore him in these sections of your proposal with flowery descriptions of the company's technical prowess. Technical qualifications and methods are stated in the engineering section.

In preparing your proposal, make sure that all points raised by the customer are answered. Ask yourself how you would react if someone ignored your questions. Simple or complex, pertinent or irrelevant, all customer's questions must be conclusively answered. To facilitate reading by the customer, the answers to such questions may even appear as headings or subheadings in the outline of your technical section. In any case, don't substitute your own jargon for the customer's definitions. For example, if the customer asks for a "flat frequency response to 100 kHz," make sure that there is a title exactly like this. Don't hide it someplace in reams of pages entitled "Improved Amplifier Performance."

Remember, the customer had certain reasons for asking specific questions. They must all be answered.

In preparing the proposal, start with an outline, such as the one below:

1. Introduction to the Company.
2. Statement of the Problem.
3. Program Summary.
4. Program Organization.
5. Technical Approach.
6. Key Personnel.
7. Company Experience.
8. Company Facilities.

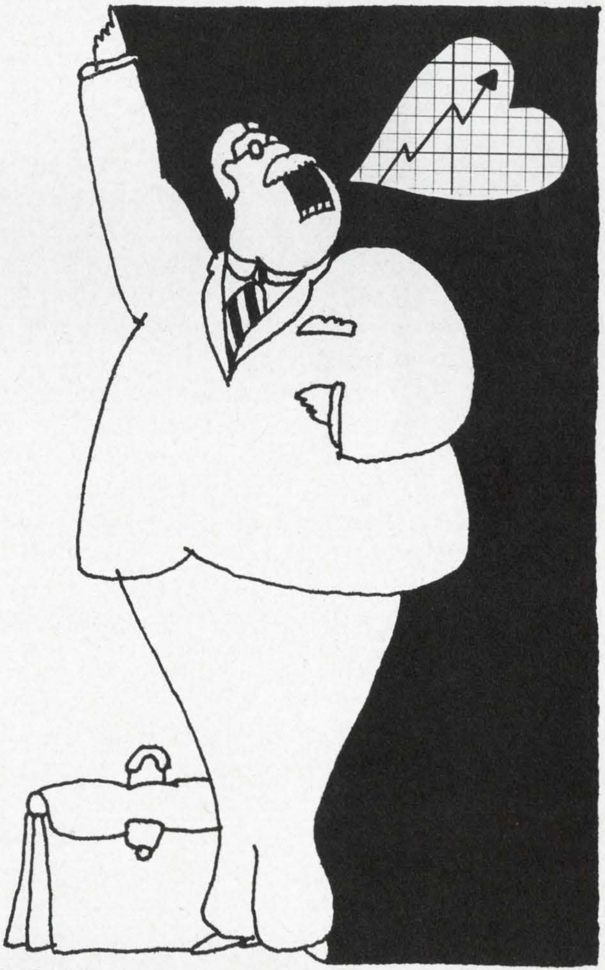
This general form will cover a wide variety of proposals.

Bear in mind that the written proposal will represent you, your colleagues and your company to the customer; it will be the only way a customer can judge whether or not to give you the award. The place to begin, then, is by introducing yourself to the customer.

### Introduce your company

In preparing this first section, think how you introduce yourself at a business visit: "My name is so-and-so, I represent Awfully Big Laboratories (call me ABL, for short). We are making such-and-such, and the reason for my call is as follows."

These, in a nutshell, are the essentials of an



**Don't sing praises to your company**

introduction section. Try this approach:

"Awfully Big Laboratories, hereinafter referred to as ABL, is pleased to submit this proposal in response to the request for proposal XYZ. ABL proposes to furnish personnel, equipment, facilities (with the exception of ______) required to carry out the development of new molecular mousetraps.

"In the last several years ABL has gained considerable experience in this field. Our personnel have been involved in all phases of design and production of a variety of mousetraps.

"The deliverable items are listed in Section 3, 'Program Summary,' and organization of the program is outlined in Section 4, 'Program Organization.' Section 5 details our technical approach to the problem.

"To demonstrate that ABL possesses suitable talent for successful performance of the contract, we list the key personnel in Section 6.

"Our pertinent experience is summarized in Section 7, 'Company Experience.'

"Section 8, 'Company Facilities,' lists our specialized facilities. which will be available for the project."

That is all there is to it; there is no more to the introduction. Don't start singing praises to yourself and your company. Just tell the customer who you are, why you should get the job, and where to look for various details.

### State the problem

Next, you want to be sure that you and the customer see eye to eye on the object of the program. This is done in the section called "Statement of the Problem."

In defining the problem, state it as clearly and concisely as you can, without any technical detail. For our mousetrap problem, for example, the statement should read:

"The problem is to design, develop and produce *X* prototypes of a molecular mousetrap."

This is the problem. How you are going to lure the mice, or how you are going to catch them, is not a problem. These are design details that will be treated in the section called "Technical Approach." State the problem in one sentence!

Let's review briefly at this point. After reading only two sections of your proposal, your customer should know:

- Who you are.
- Why you feel you should get the job.
- Where to look for detailed information.
- The object of the program.

### Summarize your proposal

"Program Summary," the next section, tells the customer in easily understood language exactly what he gets for what he pays. Tell him that the program will culminate in delivery of *X* prototypes, drawings, reports and manuals. Tell him, for example, that the mousetraps will be small (if this is important), light, reliable and inexpensive. Once again, don't bore him with details. If your device is really outstanding, one page of tentative specifications (alongside the customer's specifications) may be included.

### Organization of the program

The section on "Program Organization" is one of the most important. Be sure to state all details that affect the success of the program. Your proposed organization, with all its key personnel, must be shown. Include details on program management (a staff with suitable technical backgrounds), documentation, cost control, reporting, production control, purchasing. Enclose easy-to-follow milestone schedules.

PERT charts can also be included, but for easy understanding by nonengineers, simpler charts should be prepared. List the assignments for personnel responsible for various phases of the program. In short, convey to the customer that if you get the job, you are ready to "jump in and grind with both feet." He is dealing with a responsible, business-like organization that knows very well how to produce.

### Present the technical meat

You have now summarized fairly well most of the key points except your company's technical excellence. The reader, at this point, knows all about the job, except the details of various systems that are needed to produce what is promised. In fact, the presentation, being largely nontechnical, may even stir the interest of nonengineers. An elated customer contract man may wonder: "So far I understand everything about this highly complex technical program. Maybe these fellows will keep it this way in their technical section."

Try not to disappoint him. Do your best in the "Technical Approach" section to state your method in a simple, understandable way. If the Special Theory of Relativity can be explained to high-school students, you can explain your system to a contract man. No one will be taken in if you lard your proposal with incomprehensible jargon. If you want to say, "The building is very high," don't say, "The vertical extension of the edifice is considerable." Naturally there will be highly technical aspects that will leave a nontechnical reader gasping. But he is prepared for this, to a certain extent. Just keep in mind that if he succeeds in understanding the broad concept clearly, you have won another vote on the proposal evaluation board.

Roughly, the style of the technical section should be that practiced by the news reporter. Begin with a general description of the system. (A set of preliminary specs should appear at this point, and the most important parameters should be emphasized.) Follow with a detailed, block-by-block system description, down to the circuit schematics.

Use simple examples: "Previously this was done with 100 components. Our approach will use only 10 with equal or better results." The illustrations will show your ingenuity, creativeness and knowledge of the field.

### Write the 'boiler plate'

Now that you have told how you will do the job, both in general and in detail, provide more backup information. Thus, in the section on "Program Organization," you listed the persons who will be responsible for the program. The customer, however, does not know these people. So provide a section entitled "Key Personnel." This states broadly the skills, education, and experience of those assigned to the program and demonstrates that they are technically competent.

Next, to demonstrate your readiness to start, list various facilities that will be needed to carry out the job. These facilities must be pertinent. Don't submit pages and pages of descriptions of electron microscopes, mass spectrographs and complex instrumentation just to impress the customer; he isn't apt to be misled. Give him a clear listing of facilities that relate directly to the job. If you want to show the general prominence of your company in other fields, make two facilities sections—one called "Specialized Facilities" and the other "General Facilities."

The experience section should be treated in identical fashion. Don't list your participation in a Mars landing program if you are bidding on a mousetrap development.

### Make one final check

And now that you have finished drafting your proposal, check it. Remember these cardinal rules:

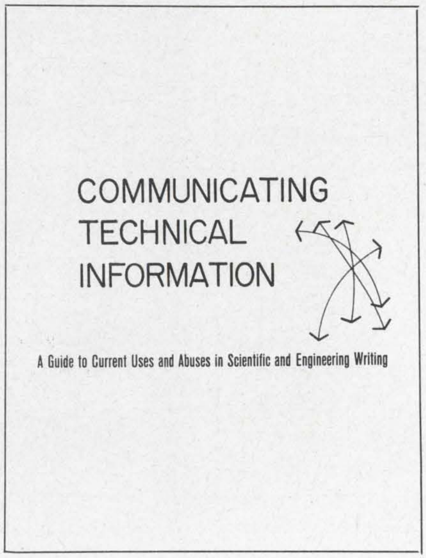
- Make sure that each section is complete and deals with one topic at a time.
- Be certain that every proposal evaluator finds the facts he needs in one place and that they are not obscured by irrelevant statements and references.
- Answer all questions raised by the customer.
- Use simple, everyday language in place of specialized jargon.

Good luck. At least you have a fighting chance now. ■ ■

**References:**

1. John A. Bianchini, "Learn the basics of contracts," ELECTRONIC DESIGN, XIV, No. 22 (Sept. 27, 1966), 100-105.
2. George O. Thogerson, "Pinpoint your profits," ELECTRONIC DESIGN, XV, No. 4 (Feb. 15, 1967), 104-106.

# Book Reviews



COMMUNICATING
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A Guide to Current Uses and Abuses in Scientific and Engineering Writing

## Technical writing guide is both handy and helpful

*Communicating Technical Information*, Robert R. Rathbone (Addison-Wesley Pub. Co., Reading, Mass.), 104 pp. $1.95.

Many nonprofessional authors write in a manner that is stupefyingly dull. This little book—a couple of hours' reading—is therefore welcome. It is intended as a self-help reference for engineers and scientists on the job and in the classroom. Sections cover the writing of abstracts, titles, technical descriptions, and conclusions and recommendations. Other chapters deal with organization of material, editing, and "noise"—obstacles to clear presentation and easy understanding of written matter.

The book contains a wealth of suggestions and hints that all technical writers would do well to heed. Rathbone's style is itself a little patchy: some passages are bright and cogent; others induce boredom. But then, few things are harder to write about consistently interestingly than how to write. Nevertheless, the book can safely be recommended to all those faced with the need to write technical matters. In the final analysis, though, as Rathbone says, "You will have to do more than just read about writing—you will have to write, write, write."

*—Peter J. Beales*

## Transform and state variables

*Transform and State Variable Methods in Linear Systems*, Someshwar C. Gupta (John Wiley & Sons, New York), 426 pp. $12.75.

This book is an in-depth survey of eigenvalues and eigenvectors in control and circuit problems. Transform methods are used and developed systematically, and time-varying systems are treated by both transform and matrix methods. The book's features include a full outline of simple, multiple and complex eigenvalues, and an exhaustive treatment of networks by state variable methods; a reasonably elementary development of higher-order delta functions, including Fourier series and networks by the delta-function approach; and a comprehensive description of the time convolution and the determination of limits of integrals for the time convolution.

## Marketing guide to R&D

*Marketing Guide to U.S. Government Research and Development*, Robert Rickles (Noyes Development Corp., Park Ridge, N. J.), 229 pp. $20.00.

This book offers an introduction to the research and development activities of the U.S. Federal Government, the largest performer and financier of research and development in the world. It is intended as a guide to the two important markets that exist in the Federal R&D structure: contract research and development, and the market for knowledge. For each Government department or agency that performs or finances research and/or development in the physical sciences, the following information is given: mission of the agency with regard to research and development, its R&D funds, location of its facilities, the officials to contact, its personnel, the nature of its extramural contracts and restrictions on them, the nature of its intramural research, and organizational charts.

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**Employment History** – present and previous employers

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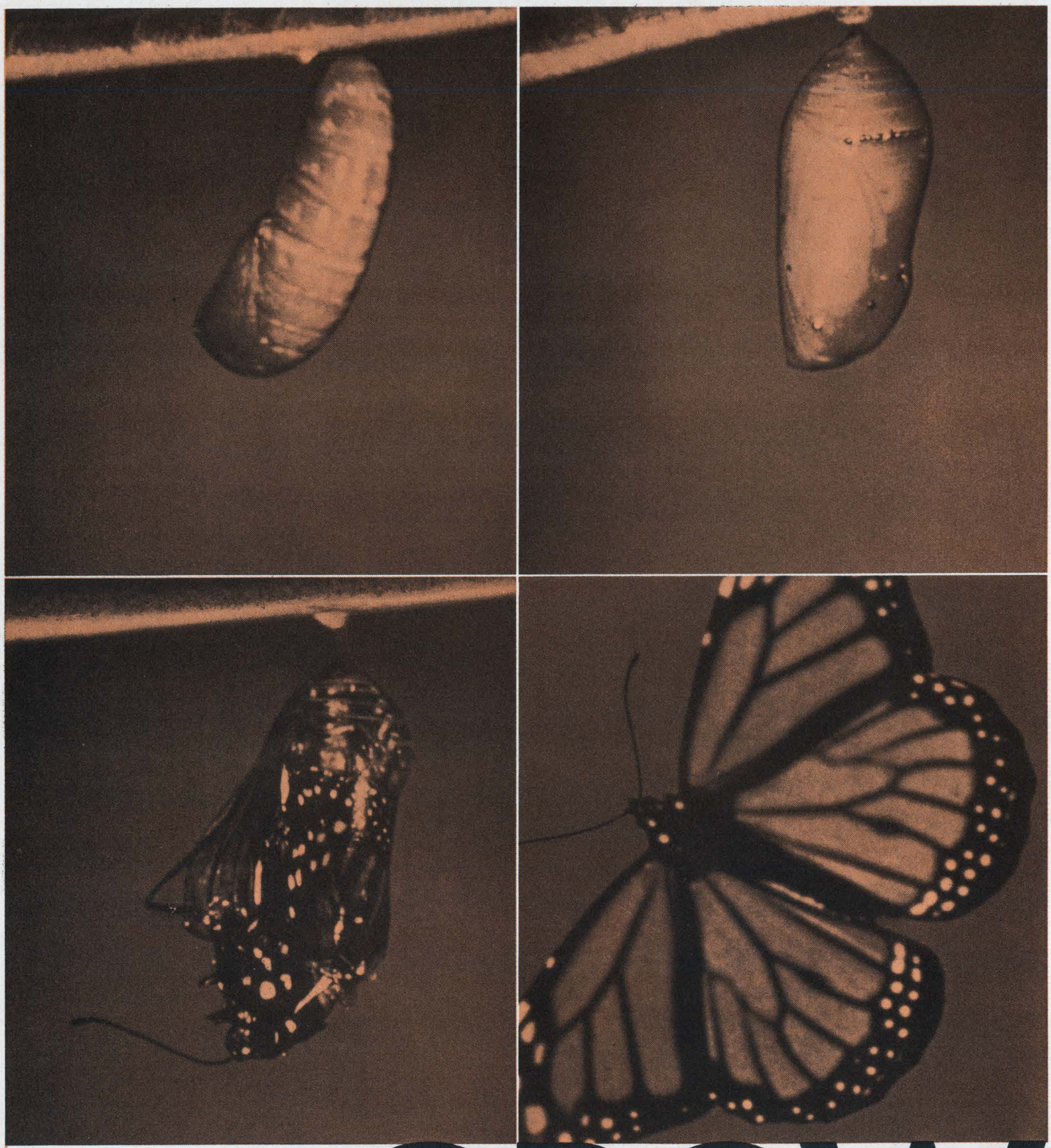
**ELECTRONIC DESIGN**
850 Third Avenue
New York, New York 10022



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## Circuit analysis

*Transistor Circuit Analysis and Design*, John J. Corning (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 466 pp. $14.65.

Here is a thorough yet easy-to-read presentation of the principles of circuit analysis and the application of these principles to the design of circuits with specific performance attributes. The material is divided into four general areas: an introduction to semiconductor physics and its relation to junction behavior in diodes and transistors; a concentrated coverage of transistors from the device viewpoint; the analysis and design of transistor circuits (the major portion of the book); and a series of laboratory experiments. The circuit design engineer will find this a useful reference work.

## Pulse generators

*High-Power Semiconductor-Magnetic Pulse Generators*, Godfrey T. Coate and Laurence R. Swain, Jr. (M.I.T. Press, Cambridge, Mass.), 136 pp. $7.50.

This monograph fills a longstanding need to augment and update vacuum- and gas-tube pulse-generator techniques evolved during and shortly after World War II. Describing a solid-state circuit technique for generating repetitive high-power pulses, the authors present a flexible design procedure for adapting the technique to a broad range of specific pulse-generator applications. Radar pulse-modulator designers and those concerned with the design of particle accelerators and similar repetitive high-power pulse circuits will be especially interested in this book.

## Random-process techniques

*Random-Process Simulation and Measurements*, Granino A. Korn (McGraw-Hill, New York), 234 pp. $12.50.

This presentation of random-process simulation and measurement with emphasis on computer techniques will be useful to many engineers and scientists involved in control, guidance, communication, detection and instrument design. The book describes new hybrid analog/digital techniques for Monte Carlo simulation of linear and nonlinear, stationary and nonstationary random phenomena, and treats new techniques that permit savings in instrumentation, circuitry, and operating time. At the same time, the author outlines all relevant theory.

## Computer-aided analysis

*System Analysis by Digital Computer*, Franklin F. Kuo and James F. Kaiser (John Wiley & Sons, New York), 438 pp. $8.95.

A comprehensive and carefully-detailed exposition of the computer's role in engineering problems, this book is concerned mainly with computers' application to the analysis and synthesis of electric networks and systems. The first chapter is an introductory survey of network analysis techniques and programs; the remainder of the book deals with the application of computer techniques to actual problems of engineering analysis and design.

## Electromagnetic theory

*The Plane Wave Spectrum Representation of Electromagnetic Fields*, P. C. Clemmow (Pergamon Press, New York), 185 pp. $7.50.

The purpose of this book is to explain how general electromagnetic fields can be represented by the superposition of plane waves traveling in diverse directions. It illustrates the use of this plane-wave-spectrum representation in characteristic problems relating to the classical theories of radiation, diffraction and propagation. The reader is assumed to be familiar with integration in the complex plane, but otherwise the discussion is virtually self-contained. Although this book can furnish the student of electromagnetic theory with a useful technical tool, its pedagogic style does not make for easy reading.

## Electromagnetic theory

*Electronic and Magnetic Behavior of Materials,* Allen Nussbaum (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 156 pp. $5.95.

Contained in this relatively short electronics book is a brief but very ample review of the nature of fields inside materials and a basic treatment of quantum theory. An understanding of modern physics and a familiariy with the vector differential operators is assumed.

A thorough introduction to the qualitative and quantitative aspects of the theory of semiconductor materials and devices, magnetic materials, dielectrics and quantum electronics is developed almost from "scratch." Concise reviews of the necessary background in electromagnetic and quantum theory contribute to making this book a complete source for the engineer. All theories dealt with are developed on the basis of atomic physics.

The primary thesis of Nussbaum's book is that the behavior of materials is determined by their atomic, molecular, crystallographic and microscopic structure. As such, it provides a broad selection of reference material in the major areas of interest to physical metallurgists, ceramists and other materials-oriented electronic engineers. Principal disciplines dealt with and emphasized are those of structure, thermodynamics, kinetics of reactions, mechanical properties and physical properties.

## Using transformers

*Transformers for Electronic Circuits,* Nathan R. Grossner (McGraw-Hill, New York), 321 pp. $14.00.

Here is a comprehensive guide for all engineers using transformers in electronic circuits. In a simple, logical style, the book concentrates on basic principles and fundamental relationships, avoiding complicated equations and masses of design data on the realistic assumption that most users today select their transformers rather than design them. The discussion of design considerations is planned to give the user an understanding of the logic and methods of the transformer specialist. This book will aid the practicing engineer to obtain optimum, limit-of-the-art performance from his transformers, to write specifications with greater confidence of obtaining a desired performance, and to consult and understand certain practical charts and tables directly useful in his work.

## Tunnel diode circuits

*Analysis and Synthesis of Tunnel Diode Circuits,* J. O. Scanlan (John Wiley & Sons, New York), 274 pp. $9.75.

Beginning with an introductory approach to the early material and proceeding to advanced treatment in the later pages, this book aims to treat completely all sinusoidal aspects of tunnel diodes in an integrated and practical manner. The book sets out clearly the principles of operation of the tunnel diode, and from this basis develops both small- and large-signal representations. The design principles of narrow- and broad-band amplifiers are discussed, and the applications of the diode in general network synthesis techniques as well as its nonlinear applications are covered.

## Electron motion

*Electron Dynamics of Diode Regions,* Charles K. Birdsall and William B. Bridges (Academic Press, New York), 270 pp. $10.00.

The motion of charged particles in time-varying fields between two electrodes is the subject of this monograph. The models analyzed are simplified versions of parts of practical devices, primarily active microwave devices, tubes and semiconductor amplifiers. Detailed development of widely applicable linear analyses and nonlinear computer experiments with charged sheets is given. Model construction is also presented in detail in order to help the reader to develop his physical insight and to progress to more complex models.

## Transistor amplifiers

*Transistor Bandpass Amplifiers* and *Designing Transistor I. F. Amplifiers,* W. Th. Hetterscheid (Phillips Technical Library, Springer-Verlag, New York), 314 pp. and 330 pp. $11.40 and $11.25.

*Transistor Bandpass Amplifiers* deals theoretically with the analysis and design of selective amplifiers as used in the IF parts of radio, television and radar receivers, with special reference to the application of transistors. Use is made of a four-terminal network representation of the transistors or vacuum tubes. This facilitates mathematical description of the performance of the complete amplifier by means of a single determinant. Single-stage amplifiers as well as multistage amplifiers, with arbitrary types of interstage or terminating networks, are treated in detail.

The design and construction of IF amplifiers with transistors for radio, television and radar receivers is the subject of *Designing Transistor I.F. Amplifiers.* A survey of the theory is presented, from which a practical design procedure is developed, making use of a large number of normalized design charts. The design procedures described are elucidated by means of six fully worked-out examples.

## Circuit design

*Semiconductor Circuit Design,* J. Watson (D. Van Nostrand, Co., Inc., Princeton, N. J.), 318 pp. $19.75.

This text on circuit design with discrete semiconductor components concentrates on the amplification and switching of audio-frequency and direct currents. The treatment is thus in somewhat greater depth than would be possible in a more widely based volume. Discussion also covers semiconductor devices other than bipolar transistors, such as field-effect transistors. Particular emphasis is placed on the photoelectric family and its usefulness in general circuit design. Throughout the text, the author stresses the importance of design rather than analysis.

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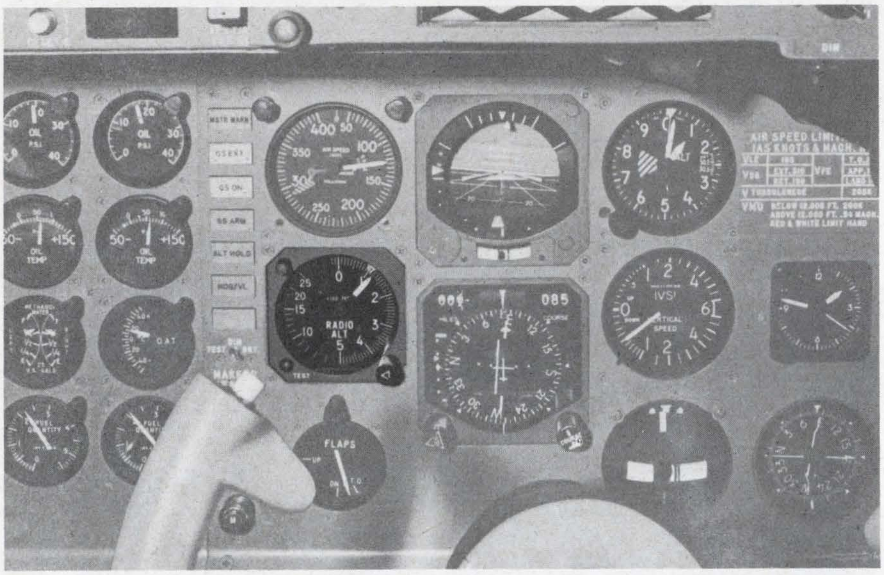
# PROBLEM SOLVERS?



### Pilots Rely On This Solution For All-Weather Landings

PROBLEM: To provide highly accurate altitude information for use in all-weather landing systems. An instrument providing this information is used only during approach and landing phases of the flight. The pilot, however, must be assured in advance that the instrument will function properly when it's called upon for its vital information. Accuracy alone is not enough. The instrument must be capable of "knowing" throughout the flight whether it will function properly at the critical moment.

APPROACH: Two separate but interdependent investigations were conducted to determine: 1) The best possible technique to measure altitude displacements ranging from zero to 2,500 feet, with accuracy suitable for use in an aircraft low approach system, and 2) what must be done to give the necessary assurance of both performance and "anticipated" performance.

Selection of a measurement technique was made at the conclusion of a systematic study of areas such as radar characteristics of terrain, adaptability of various forms of modulation, dynamic errors that could be produced as a result of information processing or by geometric situations of flight, and operational characteristics resulting from the embodiment of the possible techniques.

Along with the study necessary to select the measurement technique, other studies were directed toward means of providing constant evaluation of equipment status before and during the phase of flight where operation is required. Special consideration was given to areas such as aircraft flight procedures, component failure modes, display techniques and human factors. With a clear and complete understanding of the objectives and techniques, the designers exercised their judgement to provide optimum performance and integrity monitoring with minimum complexity.

SOLUTION: Altitude is measured through use of a solid-state 4-GHz FM-CW transmitter modulated by a linear triangular waveform in conjunction with a wide bandwidth receiver which detects the frequency shift proportional to altitude. The altitude information is presented to the pilot via a visual display and supplied to the autopilot or landing system. Repeatable altitude accuracy exceeds the standards required for Category II and Category III landing systems.

Performance integrity is monitored by a comprehensive system of checks and cross checks of each essential parameter. This complete monitoring provides assurance of performance during the critical approach period as well as a check of anticipated performance throughout other phases of the flight profile. A unique system of antenna monitoring was devised to verify antenna integrity continuously, even at high altitudes where a normal ground return signal was not available for this purpose. A self-test feature further augments the monitoring to give added confidence in accuracy and system integrity by exercising all circuits and requiring a proper indication on command of the pilot.

This equipment is now in use in many types of aircraft which have been certified for Category II landings and is currently being used in Catetgory III test programs.

### Custom Crystal Filters Designed As Standard Items

THE PROBLEM: Meet widespread need for custom crystal filter designs in less than the three-month period normally required.

THE APPROACH: Develop computer-assisted design techniques which permit Collins to offer "special design" filters as standard product line items.

THE SOLUTION: Data on a wide range of filter applications may be programmed into Collins' computer, which analyzes customer's parameters, furnishes bill of materials, and produces a performance curve. A tested prototype is delivered to the customer in one-third the time formerly required.

### Controlling The Antenna For Launch Control

THE PROBLEM: Design a receive antenna for Minuteman Missile Weapon System. It will be stored underground and automatically erected after nuclear attack for use by Launch Control communications. It must be erected from 28 feet below ground level to full height instantaneously.

The mast is driven by instantaneous release of high pressure air, which acts as an inefficient piston. Maximum erection velocity is 66'/sec. It must be stopped at a given height ± 3¼ inches.

THE APPROACH: Many energy absorbing methods were considered. Trade-off studies were performed taking into account the advantages and disadvantages of each technique. Finally tests were performed to verify the selected solution to the problem.

THE SOLUTION: A crushable aluminum honeycomb absorber was selected. This material has a predictable crushing strength, an area of 62.4 sq. ins. and a maximum crushing distance of 6.75 inches.

COMMUNICATION/COMPUTATION/CONTROL

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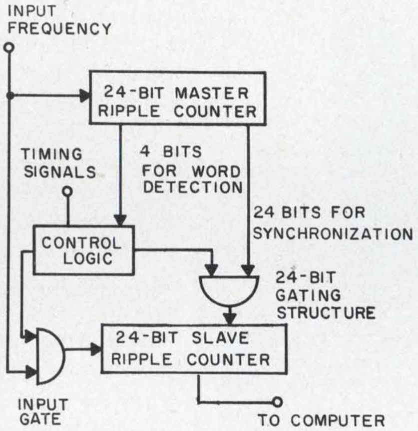
ON READER-SERVICE CARD CIRCLE 42

## Simple logic reads out during counting

**Problem:** Devise a digital frequency counter that can be read out accurately at one-second intervals without interrupting or disturbing the counting process. This counter is to be used to monitor the frequency of a programed exciter that serves as a local oscillator capable of providing frequencies from 0 to 50 MHz/s in steps of 0.01 Hz. Previous counters required an inordinate amount of gating logic and high circuit speed.

**Solution:** Incorporate a master counter and a slave counter with novel logic interconnections.



Two 24-bit ripple counters are used, one a master, the other a slave. Both counters count the input frequency, but in addition, the slave counter may either be synchronized with the master counter, or disconnected from the input frequency by the control logic.

Sometime before the count value is desired, both the input signal from the input gate and the synchronizing signals from the master counter are connected to the slave counter. The synchronizing signals are fed directly into the dc inputs of the slave counter flip-flops, which are represented by the 24-bit gating structure.

When a carry ripple is propagating down the master counter, the slave counter is in an indeterminate state because of possible interference between the synchronizing signals and the slave internal ripple signals.

When no ripple is present in the master counter, the state of the slave counter is exactly that of the master counter. At this time the control logic disconnects the synchronizing signals from the slave counter, for the ripple in the slave counter occurs at the same time as the ripple in the master counter.

The condition of no-ripple exists when the first four least-significant-bit positions of the master counter are equal to 1. This indicates that 15 counts of the input frequency have occurred since the previous major carry bit was propagated. Sufficient time has thus been allowed for all carries to have been completely propagated. At this time both counters are counting the same signal and contain the same count, but otherwise are completely independent of each other.

When the instantaneous count value is desired, the input signal is disconnected from the slave counter. After any carry ripples have finished propagating in the slave counter, the individual slave counter flip-flops may be read by the computer.

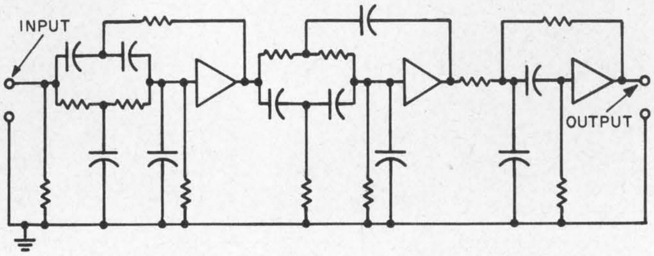
The counter can be readily adapted to provide frequency readouts at 0.1-second intervals.

*For more details, contact: Technology Utilization Officer, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103 (B66-10658).*

## RC bandpass filter is adapted to miniaturized construction

**Problem:** Design a sixth-order unsymmetrical bandpass filter suitable for use in integrated circuits.

**Solution:** Replace LC networks with RC ones in filters.



Three stagger-tuned stages are used in the circuit shown as the basic structure with modifications to allow for the asymmetric infinite attenuation poins. Each stage uses passive RC components and an amplifier that acts as an ideal voltage-conrolled voltage source of low gain. Parallel ladder networks in two of the stages provide the finite zeros and the feedback to realize the desired complex conjugate poles. These networks permit completely independent selection of the pole and zero positions. A somewhat simpler RC network in the third stage yields the zeros at the origin and at infinity, and the third set of complex conjugate poles.

The amplifiers are suitable for cascade connection, without coupling or bypass capacitors. In addition, they have very high gain stability, an input impedance exceeding 20 megohms, and an output impedance less than 20 ohms. Each amplifier uses three transistors and five resistors. In its present form, the amplifier has a frequency response of dc to 5 MHz. The networks require gains of between 1 and 4, and the amplifier provides an open-loop voltage gain of greater than 1,000, thereby allowing excellent stability, as a result of the feedback.

The RC circuit has exceeded a comparable LC circuit in notch rejection at 5 and 15 kHz, and produced a gain of 500 in the pass band, which is 2 kHz wide, centered at 10 kHz. Temperature tests have shown less than 1% overall system gain change from room temperature to 100°C.

The primary advantages of the active RC filter network are in the reduction in size and weight and in the elimination of magnetic materials. The latter advantage is particularly important in instruments used for measuring very weak magnetic fields.

Even without using integrated circuitry techniques, this complete filter-amplifier could be packaged in a 1-inch cube using off-the-shelf, discrete components.

*For further information, contact: Technology Utilization Officer, Ames Research Center, Moffett Field, California 94035. Refer to: B66-10309.*

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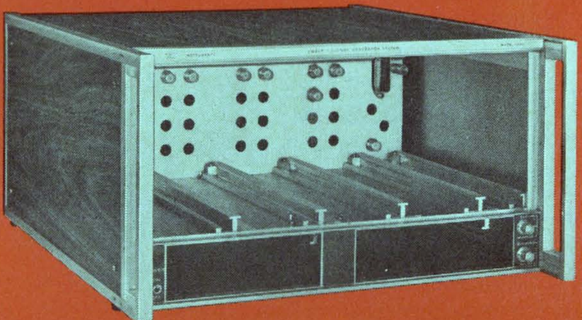

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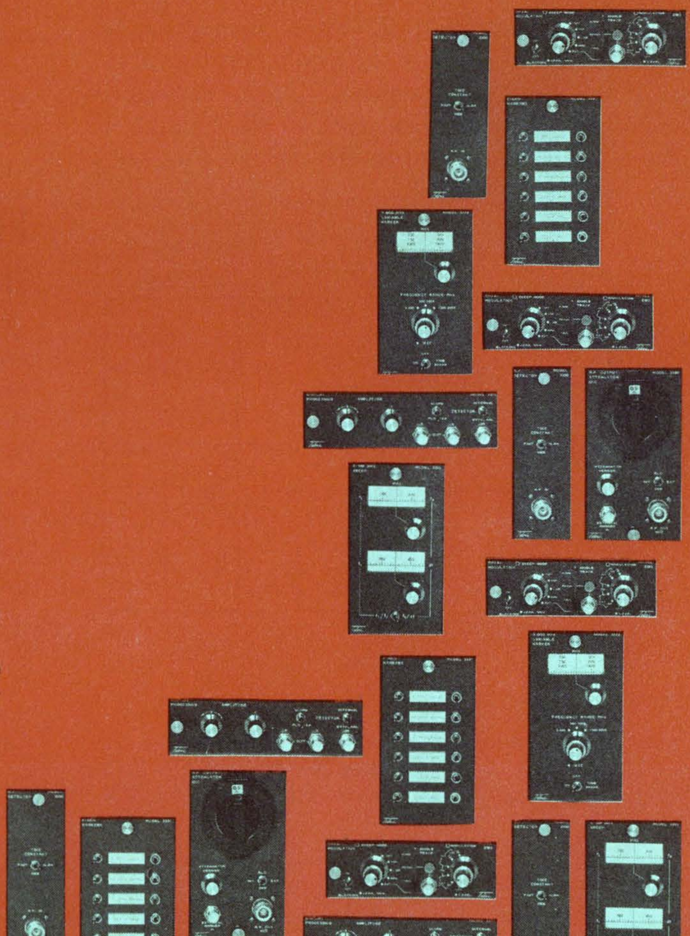
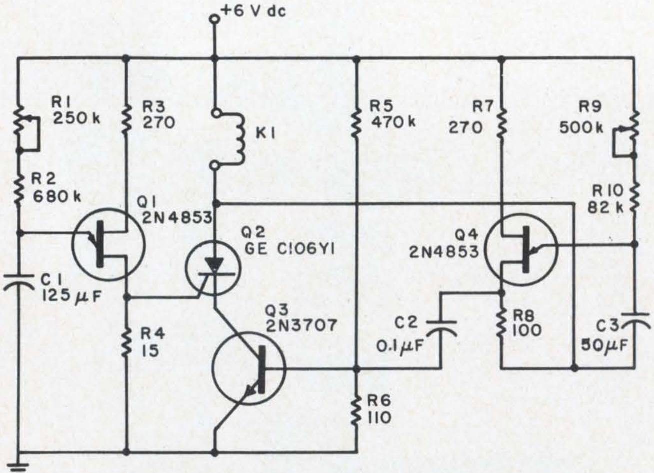


# Astable multivibrator has timing interval as long as one cycle per 6.7 minutes

The astable multivibrator shown in the figure was designed for a laboratory instrument which required relatively long timing intervals of variable frequency and duty cycle. With the values shown, the frequency is variable from 0.0025 hertz (one cycle per 6.7 minutes) to 0.006 hertz (one cycle per 3 minutes). The duty cycle may be varied continuously from 66% to 3% at the 0.006-hertz setting and from 33% to 1.5% at 0.0025 hertz.

*Q1* operates as a conventional UJT oscillator and sets the frequency of operation, while *Q4*, also operating as a UJT oscillator, determines the duty cycle. *Q2* is a relay driver and *Q3* is a switch biased in the on condition by the voltage divider, *R5* and *R6*. *R1* is the frequency control and *R9* is the duty cycle control.

When power is applied to the circuit, *C1* charges through *R1* and *R2* until the voltage at the emitter of *Q1* reaches the peak point and *Q1* fires. The resulting positive pulse developed across *R4* is applied to the gate of *Q2* turning it on; this, in turn, operates the relay, *K1*. *Q2*'s simultaneous firing results in application of voltage across *Q4* and its associated circuitry. Thus *C3* begins to charge through *R9* and *R10*. When the emitter of *Q4* reaches the peak point, *Q4* fires. A positive pulse developed across *R8* is applied to the base of *Q3*, momentarily turning it off. This also turns off *Q2* and subsequently *Q4*. In the meantime *C1* has been charging and will fire *Q1* when its voltage reaches the peak point of *Q1*. The cycle is then repeated.



**Very slow astable multivibrator** uses separate timing circuits, Q1 and Q4, to turn the relay K1 on and off. Both the frequency and duty cycle can be varied independently.

The long timing intervals are due to the low peak-point triggering current of the 2N4853: 0.4 μA. The *B1* resistor of *Q1*, *R4*, is kept low in order to prevent erratic triggering of SCR *Q2* which has an extremely sensitive gate. The *B1* resistor of *Q4*, *R8*, has a relatively large value to ensure a sufficient pulse to turn *Q3* off. The relay used was a New Product Engineering No. 822-0111-506 but a Sigma 65P1 or 11F series worked equally well.

*George W. Barrowcliff, Zeta Engineering Co., Euless, Tex.*

VOTE FOR 110

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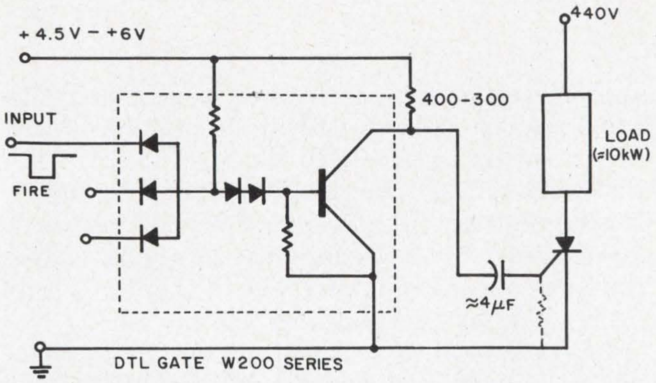
# Fire SCRs directly from integrated circuits

It is possible to fire fairly large SCRs directly from some integrated circuit gates. The figure shows a 16-amp, 400-volt SCR fired by a standard Westinghouse Series 200 DTL gate. The Series 200 gates are particularly useful in this application, for they are available without collector resistors. This enables the designer to use external collector resistors that are lower than normal. The gate can thus deliver sufficient current to turn a large SCR on. These gates' 6-volt operating level, moreover, helps them to deliver more gating current to the gate lead of large SCRs.

A capacitor has to be placed between the logic gate and the SCR gate because the SCR gate jumps to about 1.5 volts when the device is turned on. Should the gate then for some reason lose the *0*-state input signal that turned the SCR on in the first place, the NAND nature of the gate would try to turn the SCR on and would burn it out.

This logic-gate-to-SCR arrangement makes it possible to go from the milliwatt levels of integrated circuits to kilowatt powers in a single step.



**SCR firing circuit** uses single IC and two discrete components.

This is made even easier by the high voltage ratings of today's SCRs. When a 1000-volt SCR is controlling 10 amps, for instance, the going is from the 100 milliwatts of the DTL gate to the 10 kilowatts of the load.

This approach could be applied to industrial control systems where IC logic has to govern power loads like heating ovens, motors or lighting. It could also be used in SCR systems where advantage can be taken of the IC's counting, timing and delay (if a delay monostable is developed from integrated modules with external capacitors).

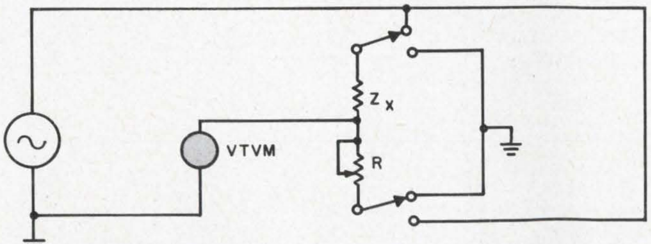
*Robert Cushman, Chief Engineer, Cybiotronics, Port Washington, N. Y.*

VOTE FOR 111

## Simple circuit measures impedances at af

The illustrated circuit offers a simple and reasonably foolproof means for the quick measurement of impedances at audio frequencies. It is particularly useful where a large reactive component is combined with resistive and ac-resistance components like magnetic transducers. Only an oscillator, VTVM, decade box and dpdt switch are required.

In operation the switch is used to compare voltage drops across $Z_x$ and $R$; the latter is adjusted until the voltage readings are equal. The value of $|Z|$ can then be read off the decade box used as $R$. $R$ should be noninductive.



**Real part of Z** is determined by adjusting R until voltages across $Z_x$ and R are equal. The value is then read off the dial of the decade box, R.

The switch can be built into a small box with suitable terminals for connection to other circuit elements. If high impedances—greater than 10 kΩ—are to be measured, internal wiring should be shielded.

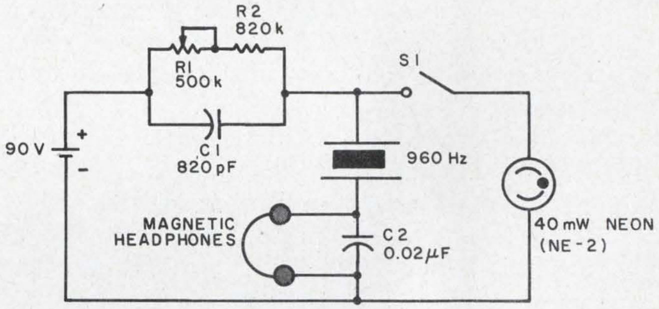
*Harry Teder, Chief Engineer, Advanced Development, Acoustic Products Div., Telex Corp., Minneapolis.*

VOTE FOR 112

## Af oscillator uses crystal and neon bulb

A simple oscillator (see figure) can be made with a crystal and a neon bulb.

When switch *S1* is closed and the pulse repetition rate of the neon bulb oscillator is near the resonant frequency of the crystal, two things happen. First, the crystal is shock-excited into mechanical vibration at its resonant frequency. Secondly, the emf generated by the crystal pulls the relaxation oscillations into step. When this synchronism occurs, the crystal vibrates even more energetically and assumes control of both frequency and waveshape; sine-wave oscillation then results.



**Versatile relaxation oscillator** results when a neon bulb is combined with an audio crystal.

The oscillator configuration makes use of the capacitor in parallel with the resistance rather than the more common connection in which the capacitor is connected across the neon bulb. Although better operation is secured in this way, this is not the salient feature of the oscillator. Relaxation oscillation of about the same frequency obtains for either connection, when the crystal is absent. For use with the crystal, the capacitor-resistance parallel connection is advantageous because a much lower impedance path is provided for the crystal current during the time the neon bulb is extinguished. This yields a considerably greater oscillation amplitude.

Some manipulation is necessary first to achieve crystal-controlled operation. Once attained, however, the operation is surefire thereafter. How is it known when the circuit functions as a crystal-controlled oscillator? There are several indications. If the oscillator is disabled by opening switch *S1*, the tone will cease abruptly if the crystal is not controlling the oscillation; a bell-like gradual diminution of the tone will be heard, however, if the crystal has properly asserted itself. If the circuit is properly adjusted for crystal-controlled operation, it will also take some time for synchronism to occur after switch *S1* has been first turned on. In this case, several tones are heard: that of the unsynchronized neon bulb oscillator, that of the crystal, and the beat frequency modulation products. As the crystal gains in activity, the relaxation frequency can plainly be heard being pulled closer to the crystal frequency. As this occurs, the most prominent beat frequency becomes lower and lower until it finally vanishes. All that remains then is a single pure tone of constant pitch. This final lock-in is also accompanied by a dip in average dc current, as indicated by a microammeter connected in one leg of the battery.

It is very important to adjust *R1* very slowly, for it takes time for the crystal to respond. A fixed resistance can be substituted once adjustment has been attained. It is well to experiment with several neon bulbs, because some show intense variation of ionization and deionization voltage. Also, occasional bulbs exhibit considerable polarity preference.

The simplicity of this oscillator and its economy make it useful for electronic organs, for techniques employed in radio control of models, and as a workhorse tone-generator wherever crystal stability is required. It is not suitable for use beyond the audio frequency range owing to the relatively long deionization time of the neon bulb. It is also more compatible with tube than transistor circuitry as a consequence of its 90-volt operating requirement. (Bulb selection can reduce this to the vicinity of 70 volts.) The circuit is quite flexible; a transformer is readily substituted for the headphones. Conversely, the headphone connections can be replaced by a small resistance, and output can be sampled through a small capacitor with respect to either battery terminal.

*Irving M. Gottlieb, Menlo Park, Calif.*

VOTE FOR 113

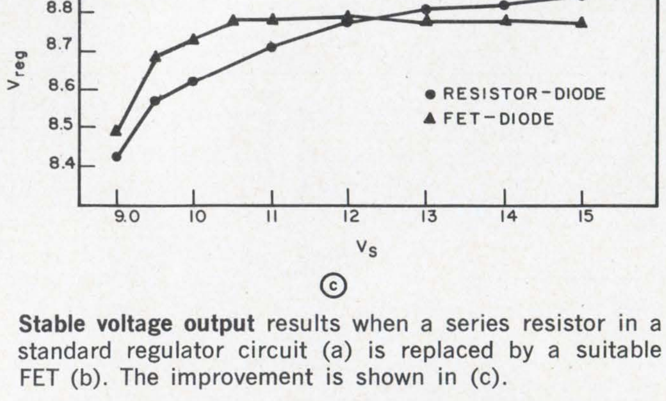
# FET stabilizes Zener current in a simple voltage regulator

The need sometimes arises for constant-voltage sources more stable over variations in supply voltage than a simple resistor-Zener combination (Fig. 1a). A field-effect transistor (FET) with gate shorted to source will supply a Zener diode with current that is stable over large changes in supply voltage (Fig. 1b). Quite simply, the desired Zener current is calculated and then a FET with that value of $I_{DSS}$ is chosen. To maximize stability, it is best to choose a FET with low knee voltage or low gate cutoff voltage, for once the voltage across the FET drops below this value, the FET ceases to supply constant current.

In a representative circuit for use in a device powered from a 12.6-volt NiCd battery, an MPF103 FET with an $I_{DSS}$ of 1.8 mA was combined with a 1N935A 9.0-volt Zener. The regulated voltage-vs-supply-voltage curve is compared with that for a resistor-diode regulator in Fig. 1c.

The main drawback of this circuit is the variations of $I_{DSS}$ with temperature—typically 0.8% per degree Centigrade. This adds a negative temperature coefficient to the regulated voltage, since $I_{DSS}$ decreases with increasing temperature. In the representative circuit, output changed +0.02 volts when temperature dropped from 20°C to −15°C. Greater temperature stability can be achieved through standard techniques, such as use of a positive-temperature-coefficient Zener diode.

There are three advantages in such a circuit. The first is the simplicity of the arrangement. The second comes from the reduction in Zener current necessary to attain a given voltage stability. There is no need to operate far out on the Zener diode's characteristic breakdown curve in an attempt to obtain reduced dynamic impedance. This is a decided advantage in portable equipment where battery drain must be minimized. The third advantage of the circuit is its low cost, especially if



**Stable voltage output** results when a series resistor in a standard regulator circuit (a) is replaced by a suitable FET (b). The improvement is shown in (c).

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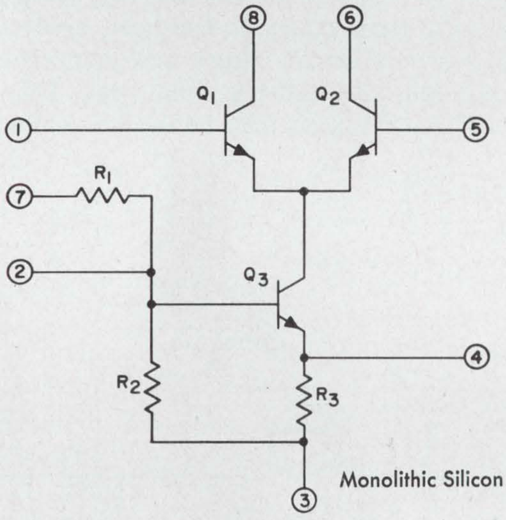

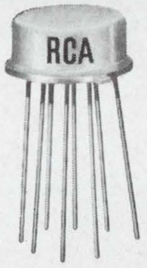

Monolithic Silicon Integrated Circuit, CA3028

## TYPICAL SPECIFICATIONS

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|---|---|---|---|
| Power Gain | @ 10.7 MHz | Cascode 39dB | Differential Ampl 32dB |
| | @ 100 MHz | Cascode 20dB | Differential Ampl 17dB |
| Voltage Gain ($R_L = 1K\ \Omega$) | @ 10.7 MHz | Cascode 98 | Differential Ampl 32 |

AGC Range (Max. power output to full cut-off) @ 10.7 MHz 62dB

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| | |
|---|---|
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*Peter F. Moulton, Design Engineer, Research Section, Science Committee on Psychological Experimentation, Cambridge, Mass.*

VOTE FOR 114

## Pocket radio detects corona or insulation breakdown

An inexpensive transistor pocket radio makes a simple tool for checking for corona or insulation breakdown. All that is necessary is to tune the radio to a clear spot on the dial and bring the radio near the apparatus to be checked. If the apparatus has a corona source or voltage breakdown arc, static will be heard from the radio loudspeaker. This same technique may be applied to checking transformers for adequate insulation: imminent intrawinding and interwinding failures can be quickly spotted. Where the apparatus is enclosed in a metal case, it may be necessary first to insert an "antenna" into the case or attach a one- or two-foot piece of wire to one of the terminals entering the case to obtain sufficient RFI. The equipment must have normal operating voltage applied while the checks are being performed.

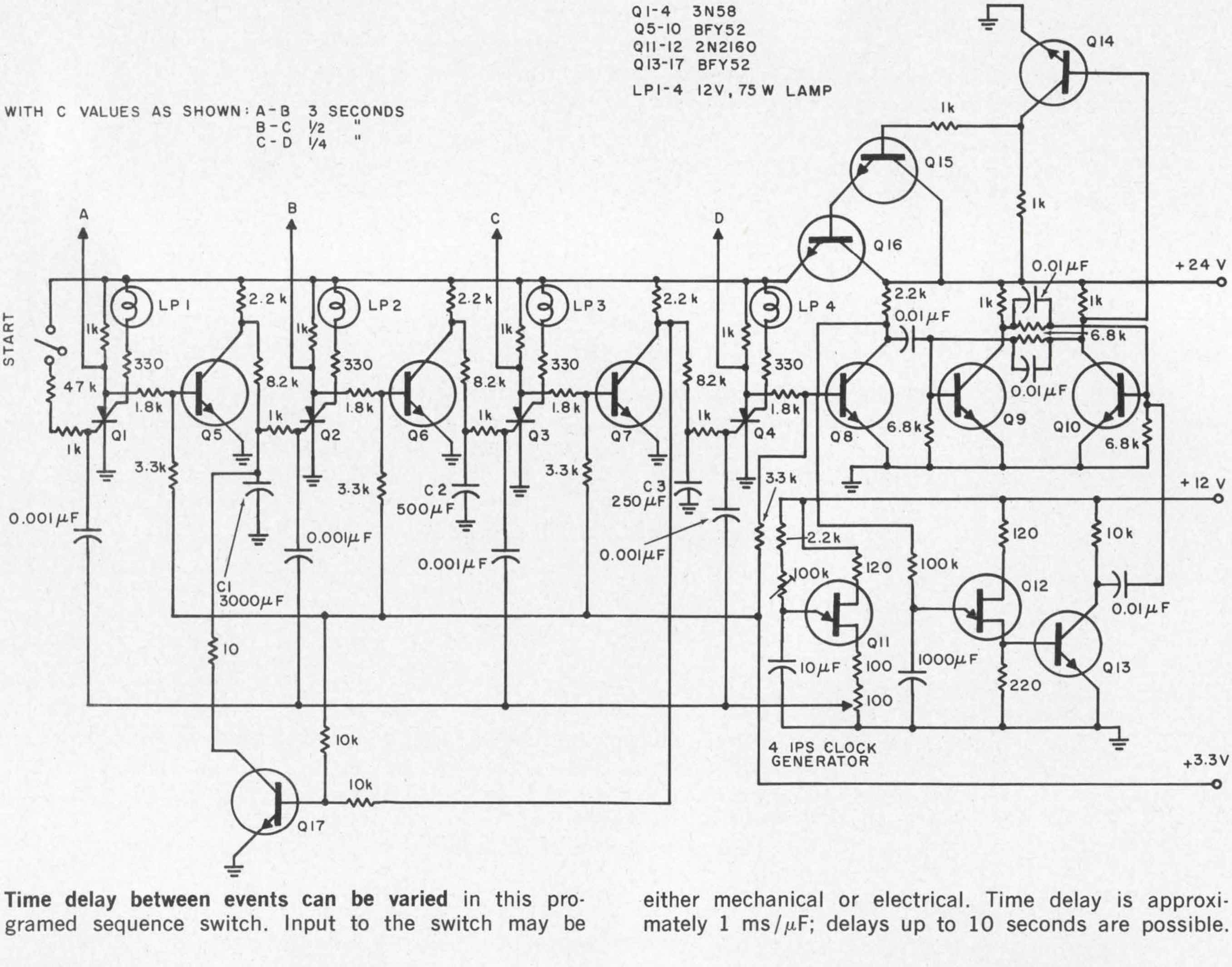
*K. G. Holmes, Chief Engineer, Magnetic Circuit Elements, Inc., Montrose, Calif.*

VOTE FOR 115

## Sequencing is easy with this expandable, wide-range circuit

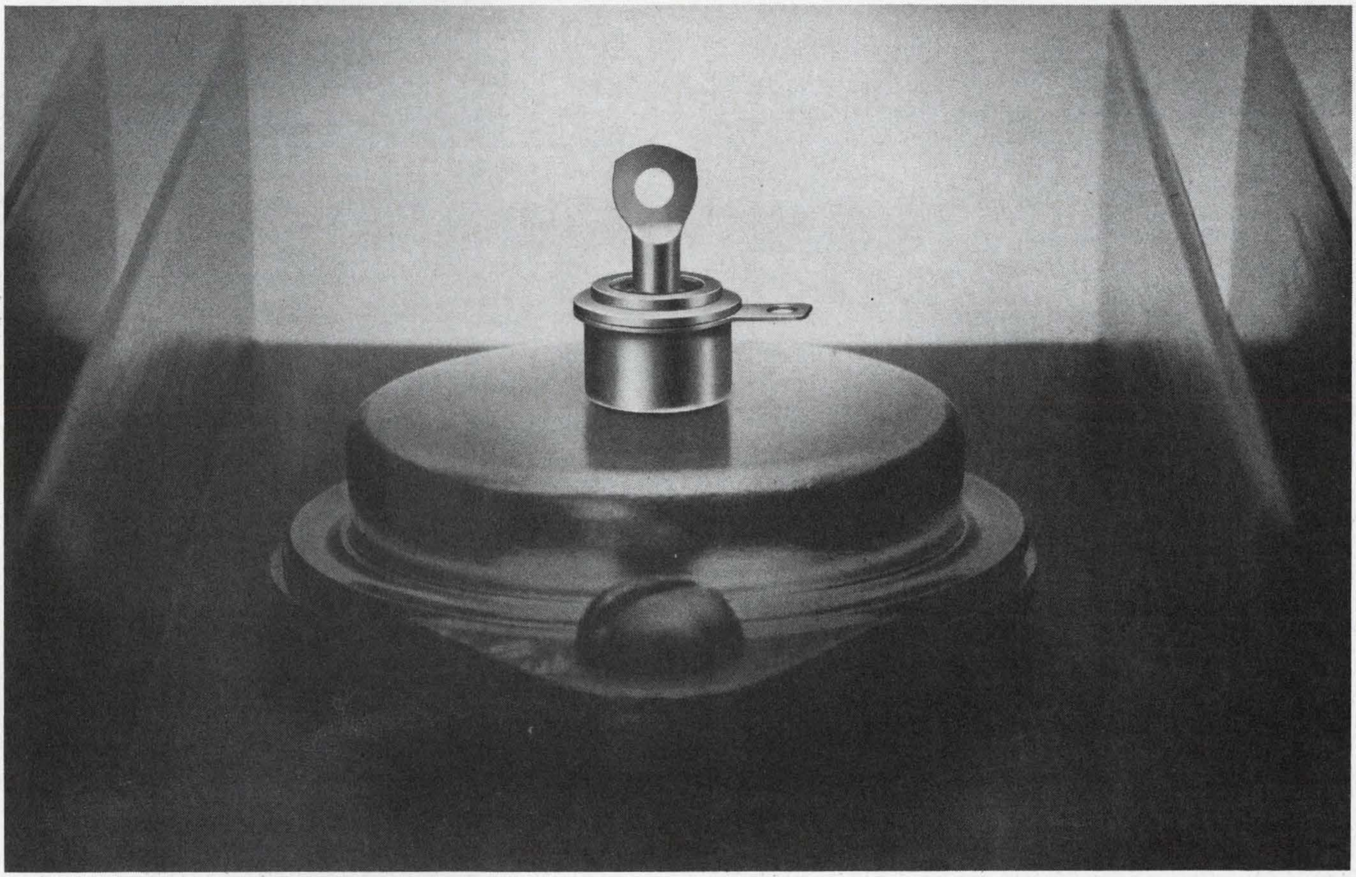
Whenever you have a need for a sequence of events with varying time delays between them, try the circuit shown in the figure. It is a programed sequence switch that can be operated over a large time range. It has been used successfully in test equipment where a sequence of events is required with varying time delays between them.

The start input may be mechanical or electrical



**Time delay between events can be varied** in this programed sequence switch. Input to the switch may be either mechanical or electrical. Time delay is approximately 1 ms/μF; delays up to 10 seconds are possible.

# Fastest Thermal Switch.



You're looking at the smallest snap-action thermal switch on the market today. That's why it has a faster thermal response than any other. It's a KLIXON® "Tiny-Stat", now widely used to control temperatures in missile radar, aircraft and commercial electronic applications.

KLIXON 3BT and 4BT Series Tiny-Stat thermal switches respond to temperature change 5 times faster than their nearest equivalents. They're rated at 1 amp, 115-ac/30v-dc for 10,000 cycles. Temperature range is 0° to 350°F, open or close on temperature rise. Vibration resistance is 5 to 2000 cps at 30 G. Their small size makes them ideal replacements for thermistors and their electronic switching circuitry.

We offer a complete line of precision thermal switches, solid state switches, electromechanical switches, thermal and magnetic circuit breakers, cooling effect detectors, component ovens, proportional temperature controllers and power storage systems.

For complete information on your specific requirements for any one of our products in these lines write to TI Control Products Group, Attleboro, Mass. 02703 or phone (617) 222-2800.

**TEXAS INSTRUMENTS**
INCORPORATED

and causes *Q1* to fire when the first pulse is received from the clock pulse generator *Q11*. The delay is provided by the 8.2-kΩ resistor and the large-value capacitor (*C1-3*) in each switch stage. The time delay is approximately 1 ms/μF, and time delays of up to 10 seonds have been achieved.

Any number of stages up to ten may be used with the trasistor types shown for *Q15* and *Q16*. For a greater number of stages a higher-current transistor is needed. The outputs *A*, *B*, *C*, and *D*, switch from +15 V in the OFF condition to +1 V in the ON condition. These may be used to operate bistable gating elements. An auxiliary output is provided and a lamp is used to indicate the state of the sequence.

Reset of the controlled switches is performed at the end of the count by a bistable trigger, *Q9-10*, which feeds an inverter, *Q14*, and then the compound emitter follower, *Q15-16*, which removes the +24 V from the switches for a predetermined time, controlled by the pulse generator *Q12-13*.

The additional circuit of *Q17* allows the high-value capacitor to be discharged quickly to increase the speed of operation.

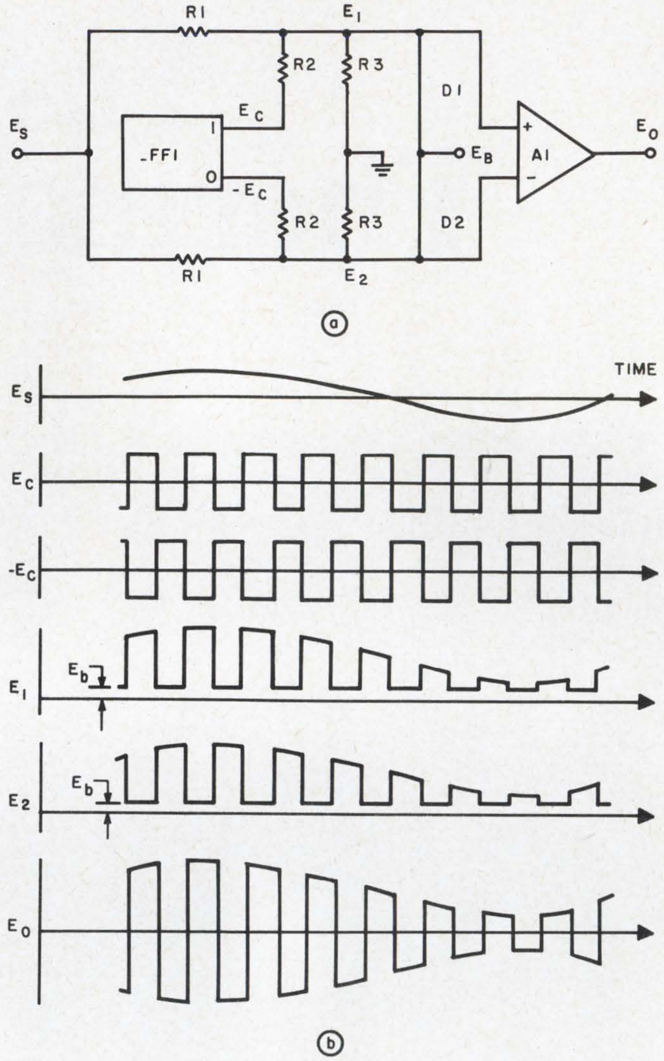
*A. Thomas, Potters Bar, Hertfordshire, England.*

VOTE FOR 116

## Amplitude modulator uses differential amplifier

The novel circuit arrangement shown in Fig. 1a simulates the function of a full-wave chopper modulator by using the inverting and noninverting characteristics of a differential amplifier. The amplifier performs a dual function: it provides the amplitude modulated output and its gain is used to increase the signal level. The maximum modulating frequency of operation is set by the gain-bandwidth characteristic of the differential amplifier and the diode impedances.

The flip-flop *FF1* provides the carrier frequency voltage, $E_c$. Both outputs from *FF1* are utilized —$E_c$ and $-E_c$. The signal voltage, $E_s$, is resistively summed with the carrier voltage and its inverted complement. Linear superposition of the signal onto the carrier by the summing network causes little distortion of the signal waveform. Diode clippers *D1* and *D2* allow only positive polarity voltage to pass to the inputs of the differential amplifier, *A1*. Positive or negative clipping of the signal produces the same result. Forward biasing of the diodes by voltage $E_b$ provides an effective means for adjusting the relative amplitudes of signal and carrier voltages.



**Amplitude modulated output, $E_o$,** is obtained with the simple circuit (a). All waveforms on common time base are shown in (b).

This means full advantage can be taken of the amplifier's dynamic range to increase the signal level. Minor adjustments are all that is necessary to prevent $E_b$ from appearing at the amplifier output.

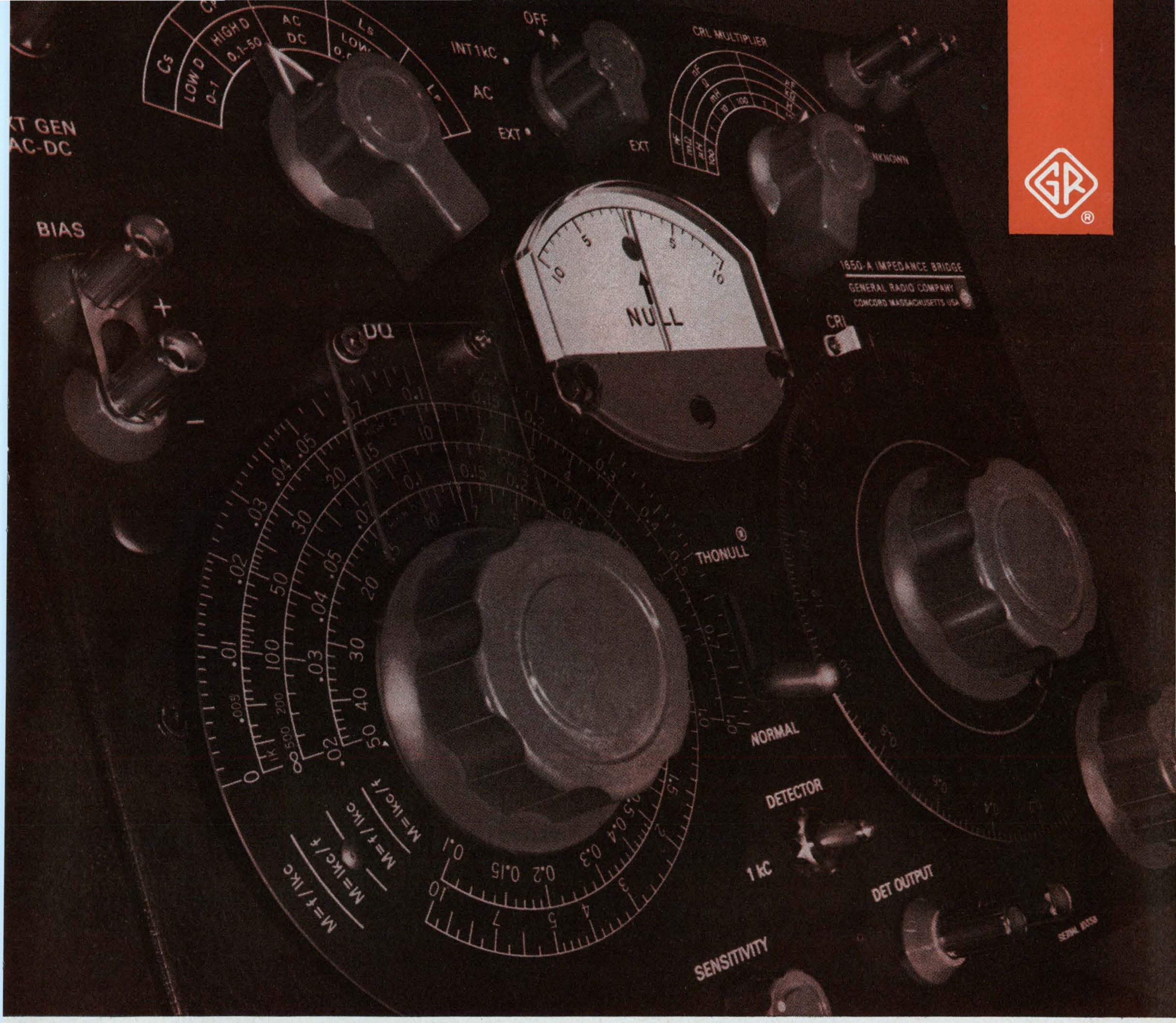
Because of the inversion of one of the input voltages through the differential amplifier, the resulting output, $E_o$, will have the waveform of a full-wave chopper modulator, as shown in the waveform diagram (Fig. 1b).

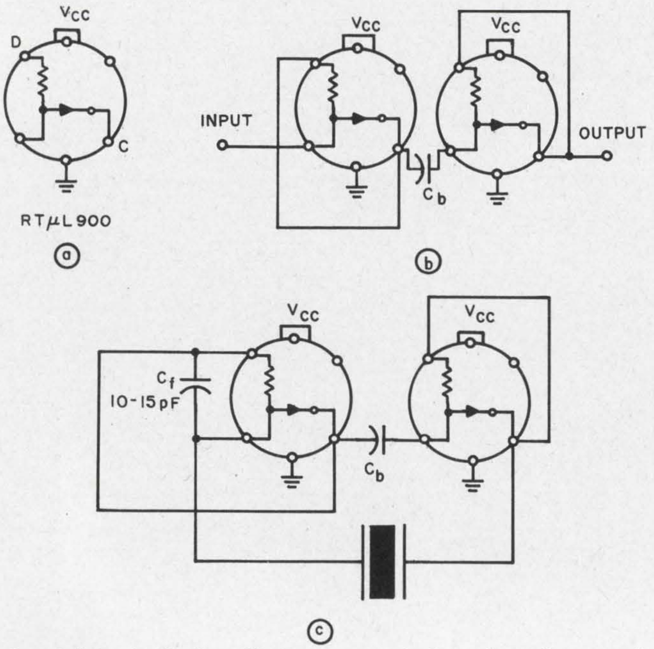
*George Hunka, Advanced Technology Department, RCA Defense Electronic Products, Camden, N. J.*

VOTE FOR 117

## Crystal-controlled oscillator employs microcircuits

Two standard Fairchild RTμL 900 buffers can be used to build a crystal-controlled oscillator.


NULL
THONULL
NORMAL
DETECTOR
1 kC
DET OUTPUT
SENSITIVITY
BIAS
CRL MULTIPLIER
INT 1kC
AC
EXT
OFF
1650-A IMPEDANCE BRIDGE
GENERAL RADIO COMPANY
CONCORD MASSACHUSETTS USA



**Crystal-controlled oscillator** uses only two discrete capacitors in addition to the crystal.

Some of its features include:

- Few external components.
- High fan-out.
- High stability.

Figure 1a shows the buffer schematic. Connecting pins *C* and *D* yields an amplifier with low input and output impedances (Fig. 1b.) Two such amplifiers can be arranged to obtain a crystal-controlled oscillator (Fig. 1c).

The highest frequency of this oscillator is about 8 MHz. Capacitor $C_f$ suppresses spurious oscillations due to the parallel stray capacitance of the crystal. $C_b$ is a coupling capacitor.

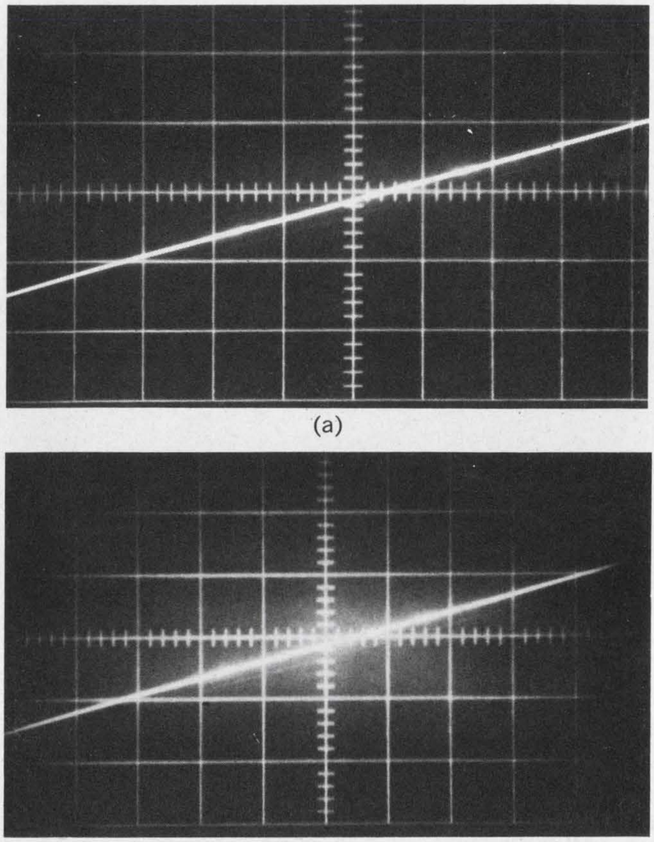
*B. Altieri, Engineer, Digital Group, S.G.S. Fairchild, Agrate, Milan, Italy.*

VOTE FOR 118

## Oscilloscope used to copy Polaroid photographs

Quite often a breadboard is taken apart and it is found that more photos are needed than originally planned. If a photocopier is not available, it is still possible to make quick copies of Polaroid photographs.

The horizontal sweep of an oscilloscope is allowed to free-run and the horizontal line adjusted so that it is fairly bright and in focus. The graticule is removed from the CRT and the photograph mounted flush to the face with black, photographic masking tape. The remainder of the CRT and the graticule lamps are masked with the tape to minimize stray light.



**The copy (b) made with the aid of a CRT** is essentially the same as the original Polaroid photograph (a).

The camera is then mounted on the oscilloscope. The camera shutter is opened and the vertical positioning knob of the oscilloscope turned steadily until the horizontal line moves vertically across the CRT face behind the photograph. Then the shutter is closed and the film developed.

If the brightness is excessive, the CRT beam intensity should be reduced. As Fig. 1b shows, except for a small change in the over-all size, the duplicate photograph is essentially the same as the original in Fig. 1a. The photographic paper is translucent enough to permit light through the white waveform but opaque enough to attenuate almost all unnecessary light.

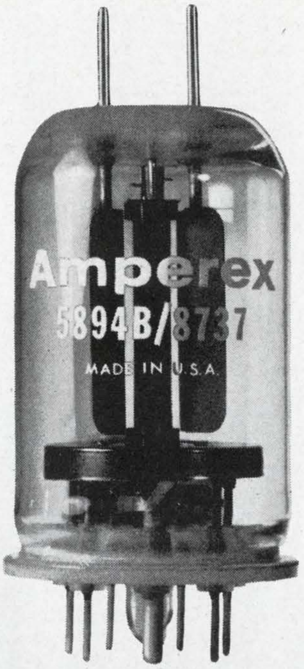
*Alfred W. Zinn, Kearfott Products Div., General Precision, Inc., Aerospace Group, Little Falls, N. J.*

VOTE FOR 119

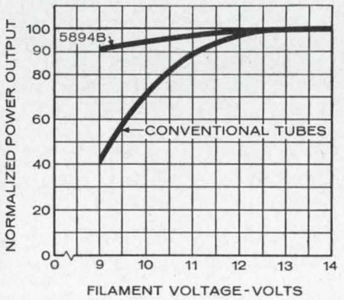
---

**IFD Winner for Feb. 15, 1967**

**R. R. van den Berg,** Development Engineer, NV. Peekel, The Hague, Netherlands.
His Idea, "High input impedance obtained in a differential amplifier," has been voted the $50 Most Valuable of Issue Award.
**Cast Your Vote for the Best Idea in this Issue.**



# insensitive to heater-voltage variations



**POWER PERFORMANCE vs. CATHODE VOLTAGE**

It's the new version of the Amperex 5894, that famous old workhorse, now with the WIDE-RANGE CATHODE that we developed specifically for vehicular communciations equipment.

Today's 5894's are being designed into transmitters for mobile vehicles that have modern alternator electrical systems. Alternators are just fine but they do create heater-voltage-regulation problems. So . . . the 5894B/8737, with the wide-range cathode was created.

5894B/8737 cathode emission is essentially independent of heater voltage over a wide range. While a conventional twin tetrode produces 60% less than its rated output at 9 volts, the new tube, with its wide range cathode, puts out more than 90%. Above 13 volts, conventional cathode materials sublimate, damaging the tube; the 5894B/8737 is immune to sublimation with as much as 16 volts on the heater.

Whether the alternator is idling or turning at full rpm, the Amperex 5894B/8737 gives the kind of performance that has made the 5894 the standard of the mobile vehicular communications industry.

As a 174 MHz push-pull amplifier, the 5894B/8737 delivers 96 watts ICAS; operating PTTS*, it delivers 111 watts with 5.5 watts drive, with a tube efficiency of 69%. And all this at any heater voltage from 10 to 16.

**PTTS: Push-To-Talk Service; for vehicular communications systems. Maximum duty cycle: 1 minute ON/4 minutes OFF.*

For complete data on the new 5894B/8737 and other Amperex twin tetrodes for mobile applications, write: Amperex Electronic Corporation, Tube Division, Hicksville, L. I., New York 11802.

**Amperex®**

TOMORROW'S THINKING IN TODAY'S PRODUCTS

ON READER-SERVICE CARD CIRCLE 44

# VERSATILE

You name it

# CAPABLE

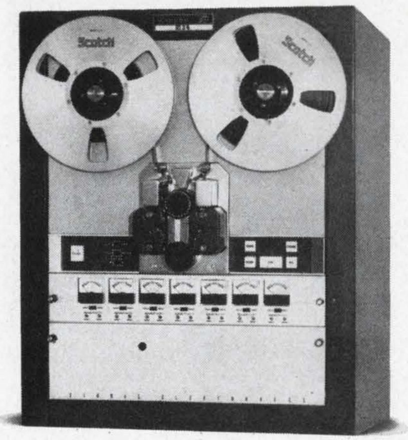
The Paul Bunyan of 3M Recorders

# AFFORDABLE

We're almost
ashamed of the
low price

# MODEL 34

**VERSATILE**—With direct frequency response to 600 kHz, and IRIG FM to 80 kHz, the Mincom Model 34 does many things in many ways. Rack-mounted or in easily portable carrying cases. ¼, ½ or 1-inch tape. 10½-inch or 7-inch reels. Speed options: $1\frac{5}{16}$, 1⅞, 3¾, 7½, 15, 30, 60 or 120 ips.



**CAPABLE**—Practically the only thing that's *not* an option is 3M quality—that's standard on all configurations of the Model 34. Starting with the Isoloop Drive® on the tape transport (the same as on recorders costing several times as much), Model 34 can record 7 or 14 channels of the cleanest data for over twelve hours. All types of record/reproduce modules are interchangeable, allowing any channel combination desired. Push-button controls. Dynamic braking in all modes. Fail-safe braking for AC failure. End-of-tape sensing. Solid state electronics. Input/output meters.

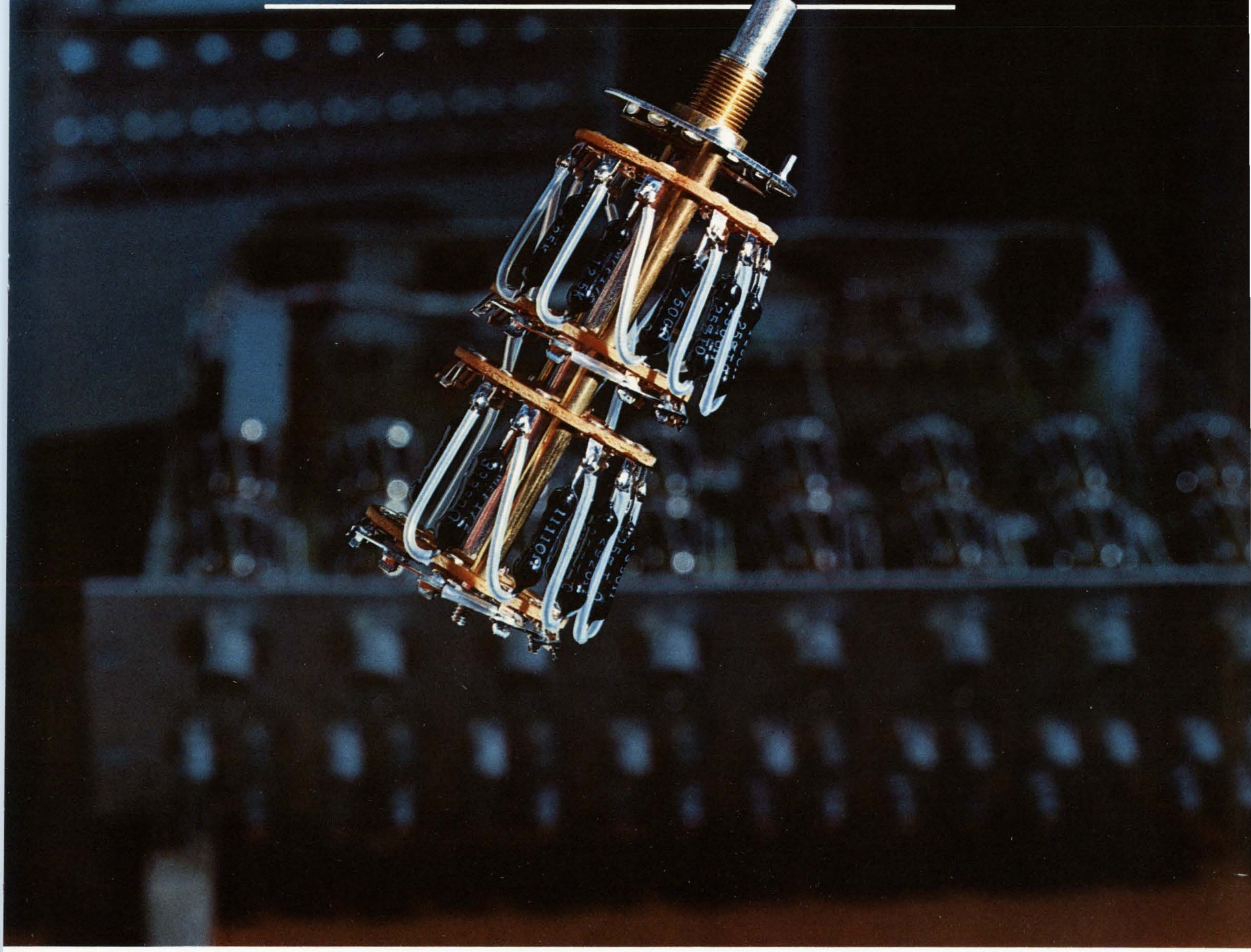
**AFFORDABLE**—As you can see, there are a lot of different ways to configure a Model 34—and there are just as many prices.

But this we can be definite about: Model 34 is *the* recorder for people who've always wanted 3M quality—but couldn't afford it *before*. Give us a call.

**Revere-Mincom Division 3M COMPANY**
300 SOUTH LEWIS ROAD • CAMARILLO, CALIFORNIA 93010

ON READER-SERVICE CARD CIRCLE 45

# "NO NOISE WORRIES with Dale Metal Film Resistors"



Dale Metal Film Resistors provide precise voltage attenuation in the Brush Mark 200 Recorder. This highly accurate direct writing system is now in use in the Apollo Deep Space Program.

## "Piece by piece selection to insure low noise was eliminated when we began using Dale Metal Film Resistors"...

*C. M. Jeffries, Works Manager, Clevite Corporation*
*Brush Instruments Division, Cleveland, Ohio*

Getting optimum value from a resistor may hinge on a single performance characteristic. For Brush Instruments, this characteristic was the outstanding low noise construction of Dale Metal Film Resistors. For you, optimum value may come from Dale's ability to supply metal film parts with tightly controlled T.C.; or from the excellent stability of Dale MF resistors in critical high frequency applications. Optimum value can also result from the assured fast delivery made possible by Dale's expanded metal film facilities. ■ Check metal film suppliers from every angle—including price and the ability to provide special parts tailored to your special needs. Then call Dale.

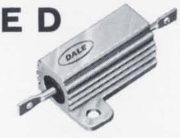
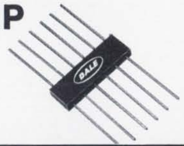
**DALE®** ***for optimum value in precision resistors***

**Dale Electronics, Inc. 1300 28th Avenue, Columbus, Nebraska**

# We're really rolling on metal film delivery!

Erase delivery from your procurement problems! Expanded metal film production facilities in Norfolk, Nebraska, have enabled us to slash delivery schedules to the bone. Production increases daily on all types listed below. Call Dale for the best *all-around value* in metal film resistors. The number is 402 – 564-3131.

## QUICK DELIVERY REFERENCE DALE METAL FILM RESISTORS

| | | |
|---|---|---|
| **TYPE MF**<br> | Epoxy-molded metal film resistor. Meets MIL-R-10509F (Char. C, D and E). Combines high stability with low noise and offers exceptional moisture protection. | **Power:** 1/20, 1/10, 1/8, 1/4, 1/2, 1 and 2 watt sizes<br>**Resistance Range:** 10 Ω to 10 Megohms, depending on size and T.C.<br>**Resistance Tolerance:** .1%, .25%, .5%, 1%<br>**T.C.:** ±25, ±50, ±100, ±150 PPM standard |
| **TYPE MFF**<br> | Epoxy roll-coated metal film resistor. Designed primarily for commercial applications. Meets electrical and environmental specifications of MIL-R-10509F. Small size. Low cost. | **Power:** 1/8, 1/4, 1/2, 1 and 2 watt sizes<br>**Resistance Range:** 10 Ω to 10 Megohms, depending on size and T.C.<br>**Resistance Tolerance:** .1%, .25%, .5%, 1%<br>**T.C.:** ±25, ±50, ±100, ±150 PPM standard |
| **TYPE D**<br> | Precision power film resistor molded into an aluminum housing for complete environmental protection and high stability. Wide resistance range, low reactance at high frequencies. | **Power:** 4, 8, 12 watt sizes<br>**Resistance Range:** 50 Ω to 2.6 Megohms, depending on size<br>**Resistance Tolerance:** .1%, .25%, .5%, 1% and 2% standard |
| **TYPE MP**<br> | Epoxy-molded metal film package with from 2 to 6 elements. Meets MIL-R-10509F. Available with matched T.C., matched resistance ratio. Excellent H.F. characteristics. Very low noise levels. | **Power:** 50 milliwatts per element at 125° C<br>**Resistance Range:** 30.1 Ω to 80.6K Ω each element<br>**Resistance Tolerance:** .1%, .25%, .5%, 1%, 2%, 5% |

Printed in U.S.A.

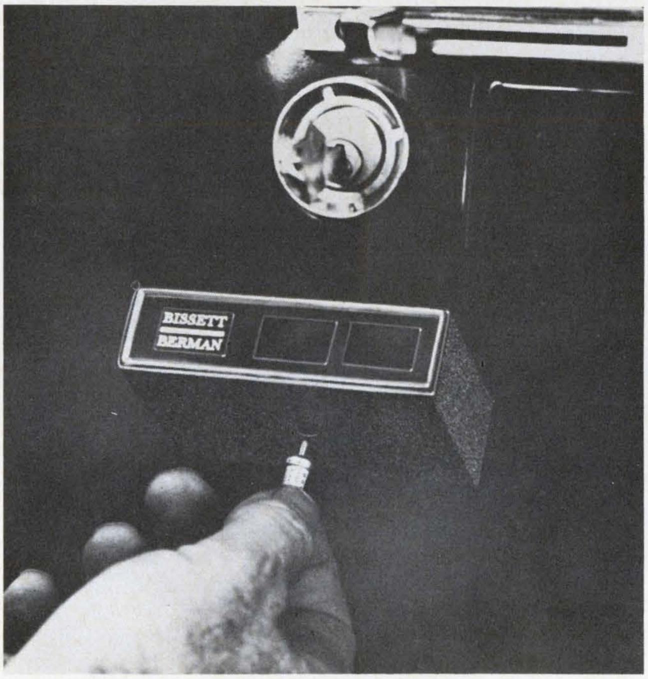
**For complete information circle No. 181**

***Write for Catalog A*** *– complete information on precision metal film, precision wirewound and industrial wirewound resistors.*

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

# Products

**Submicron tungsten carbide powder** averages one-fifth the size of conventional powder. The size and high-energy shape suggest use in cermet or thermoelectric devices. Page 150



**Tiny electrochemical timing cells** are the heart of this auto maintenance computer. Page 122

**Thin spot heaters** obtain temperatures to 450°F, up to 10 watts/square inch. Page 126

## Also in this section:

**Strobing voltmeter** makes single-shot voltage measurements on fast waveforms. Page 146

**IC package uses aluminum bumps** to eliminate fragile lead frames. Page 148

**NiCad batteries charged to 90%** capacity in less than 15 minutes. Page 154

**Design Aids,** Page 160 . . . . **Application Notes,** Page 162 . . . . **New Literature,** Page 164

# Electrochemical timing cell adds three new functions

*Bissett-Berman Corp.; Components Div., 3860 Centinela Ave., Los Angeles. Phone: (213) 394-3270. P&A: reusable and plug-in cell: $25 (1 to 9), $20 (10 to 49), $15 (50 to 99), $10 (100 to 999), multi-electrode cell: $50 (1 to 9), $40 (10 to 49), $30 (50 to 99), $20 (100 to 999); stock for small quantity.*

Bissett-Berman's unique electrochemical circuit element, the E-cell, has been modified to add three additional capabilities. They are:

- A reusable cell.
- A multiple-electrode cell which can perform two separate timing or integration functions with separate read-out.
- A cell designed for plug-in sockets.

Basically, the E-cell employs Faraday's electroplating laws to provide precisely measured timing and integrating functions at solid-state-compatible current and voltage levels (see ED, Aug. 31, 1964, p. 68). Typical short-duration current values range from 2 μA to 5 mA. The capacity of the cell is expressed in microampere-hours and is a direct coulometric function of the quantity of platable material put on the charged electrode (anode). As long as current flows through the electrolyte and plating action is taking place, the cell has a low equivalent impedance value as it looks to the rest of the circuit. The basic timing circuit is shown in Fig. 1 and a fixed time-delay starting circuit designed around the cell in Fig. 2. Time delays may range from seconds to days.

When plating is complete, the cell changes state (from a low to a high equivalent impedance). This is accompanied by a voltage rise which can be as high as 0.8 volt. Bissett-Berman claims virtual immunity from shock, vibration and temperature effects from −55° to +75°C.

The reusable cells (types 400-001 and 002) differ from the standard cell in that the anode is not charged by the factory. It is supplied with no platable material at the center electrode. It can be used as an integrator by passing a current (within the operating range) proportional to the function to be integrated from the cup (+) to the center electrode (−). At the end of the desired integrating period, the value of the total integral can be read out. Read-out is accomplished by using the cell, which now has platable material on its center electrode, in a manner similar to that of a timer. With a constant current, the time to reach the voltage transition point is proportional to the integral. In this manner, the cell can be reused many times. This mode is also useful for laboratory testing and evaluation of E-cell timer circuitry. The cell can be preset with a current-time integral and then used as a timer. This process can be repeated many times if the stop voltage is kept below 0.6 volt for no longer than several minutes.

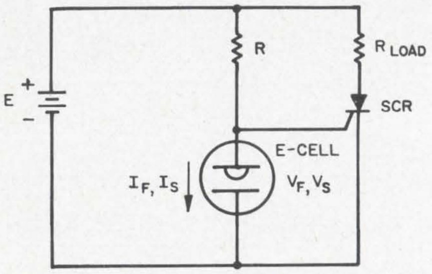
The multiple-electrode cells (type 410) have two anodes and therefore can perform two separate timing or integration functions, separately read out. The units are essentially two cells in the same can with the cup serving as common cathode. It has two anodes, one plated with a large charge and one with a smaller one. The smaller-charge anode is sealed coaxially in the center of the larger one. Functionally, the cells may be thought of as the equivalent of two separate cells, with leads for separate inputs and readouts. Maximum current acceptable in either direction ranges from 120 μA at −55°C to 3.5 mA at 70°C. Minimum stop voltage is 700 mV at 3 μA.

Figure 3 shows the double-integration function. Here, the cell is an indicator of distance from the voltage output of an accelerometer.

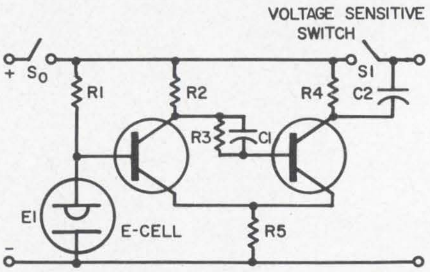
The plug-in units (type 450) were originally developed for automobile service computers (photo, p. 121). With three inputs (engine operating hours, accumulated start time and elapsed calendar time) and the plug-in cell serving as memory and arithmetic sections of the dashboard analog computer, drivers will be reminded with a "service" light that their auto needs maintenance.

Electrical parameters for the 450 are the same as for the 400. The three new cells require a very small amount of power, require minimal interfacing with solid-state components and have temperature characteristics compatible with solid-state components.

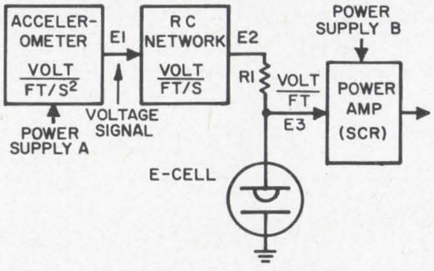
**CIRCLE NO. 371**



1. **Basic timing circuit** requires resistor and SCR. $V_F$ is voltage in timing condition, $V_S$ afterward. The max forward current $I_F$ must exceed sum of stop current, $I_S$, and threshold current to fire SCR gate.

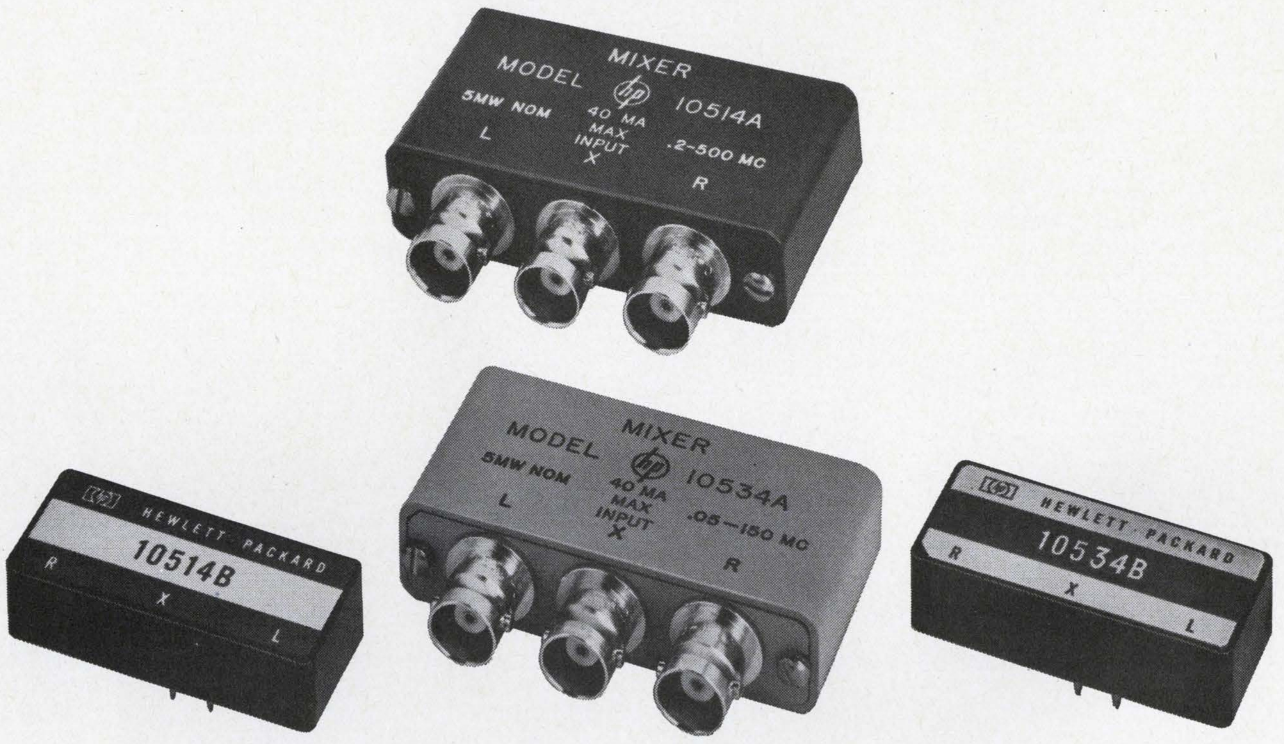


2. **Fixed time-delay circuit** uses an E-cell to fire Schmitt trigger. When $S_0$ closes, the charged cell starts timing. When it is timed out, its voltage rises, firing the Schmitt circuit at 0.5 V. This fires $S_1$ through C2.



3. **Double-integration function** is performed as E-cell provides a signal source which indicates the distance from the voltage output of an accelerometer. Uses are in airborne cargo drops or ordnance.

# The family has grown



# and lowered the budget

**HP mixers are low in price, low in noise, high in performance.** These wideband double-balanced mixers now bring performance extras to your applications—all the way to 500 MHz. New members of the family offer double-balanced performance at single-balanced mixer prices. Each member of the family offers:

- Lowest (and fully specified) l/f noise.
- Complete testing, with all parameters specified in detail.
- Guaranteed performance over a wide environmental range.

These three new models follow the popular 10514A, a 200 kHz to 500 MHz double-balanced mixer with BNC connectors. The new 10514B is similar to its predecessor, but it's packaged for printed circuit mounting; the 10534A/B are optimized from 50 kHz to 150 MHz . . . and priced close to single-balanced mixers.

Low l/f noise characteristics mean high performance in any phase detector application such as phase-locked loops or short-term stability measurements by phase noise methods. Note that single-sided noise is specified all the way down to 50 kHz on the DC-coupled port.

Consistent specs between models in the family mean that an equivalent printed circuit model can replace a BNC model in breadboard . . . with no trouble at all. And our testing and environmental demands save you extra time and concern. This family meets specs and works wherever you need it.

Use these HP mixers for extracting frequency sums or differences, as modulators, spectrum or comb generators, phase detectors, current-controlled attenuators, frequency doublers . . . or to extend spectrum analyzer range.

For complete application information contact your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

**Brief Specifications**

| Model | Freq. range MHz (2) | Conversion efficiency | | Single unit (1) Price |
|---|---|---|---|---|
| | | 0.5-50 MHz | 0.2-500 MHz | |
| 10514A | 0.2-500 | 7 dB | 9 dB | $180 |
| 10514B | 0.2-500 | 7 dB | 9 dB | $150 |
| | | 0.2 to 35 MHz | 0.05-150 MHz | |
| 10534A | 0.05-150 | 6.5 dB | 8 dB | $ 75 |
| 10534B | 0.05-150 | 6.5 dB | 8 dB | $ 60 |

**(1) Prices are lower in quantity.**

(2) "L and R" ports; "X" ports extend to DC for phase detector applications.

The l/f noise is specified on all models as <100 nV per $\sqrt{Hz}$ at 10 Hz, and is typically much better. Single-sided noise figure specification is the same as the conversion efficiency specification shown above, but with the frequency of the X port extending from 50 kHz to the upper limit frequency. The balance specifications are extremely good, 12 to 45 dB (typical performance much better), depending upon frequency and test connections.

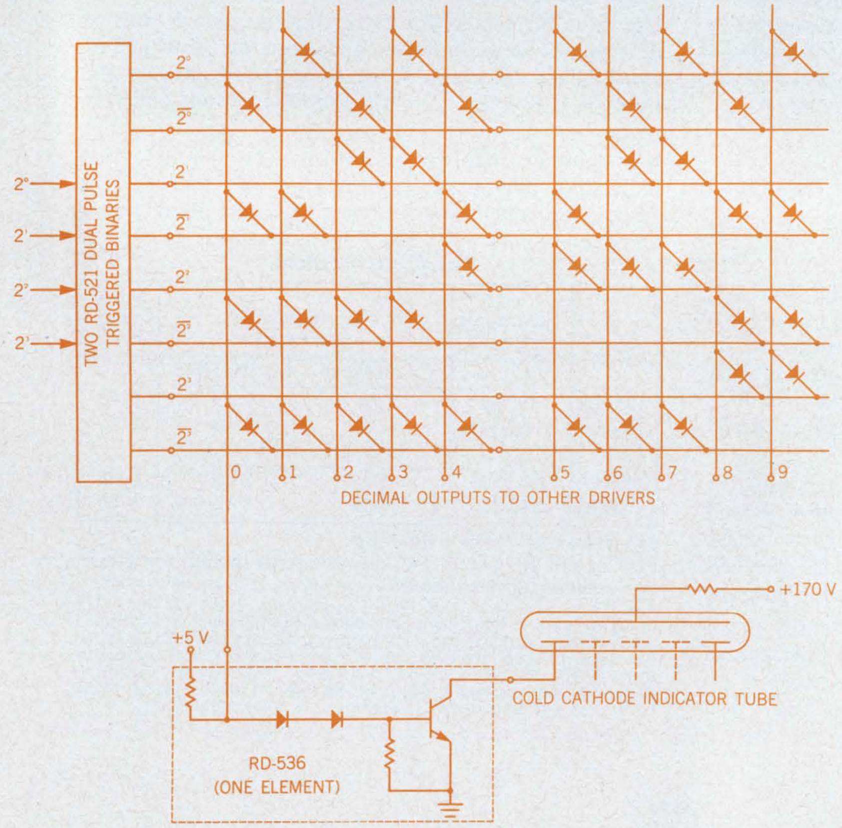
HEWLETT hp PACKARD

02701

ON READER-SERVICE CARD CIRCLE 47

# State of the monolithic art

## Radiation's Diode Matrices and High Voltage interface circuits provide all monolithic circuits for a cold cathode numeric display



A simplified approach to the design of BCD decode networks is now possible using Radiation 8 x 5 Monolithic Diode Matrices. Other integrated BCD decoders are limited to only one weighted binary code. However, Radiation Matrices can be "customized" to any weighted binary code to decimal conversion. This design flexibility is achieved through Radiation's fusing technique for selecting desired coding patterns.

The 8·4·2·1 BCD decoder display, shown at left, is only one example of the many possible monolithic circuit displays which can be formed. The circuit requires only two Radiation 8 x 5 RM-17 Monolithic Diode Matrices. Data storage is provided by two Radiation RD-521 Dual Pulse Triggered Binary elements, while two high-voltage RD-536 Hex Indicator Drivers directly drive the cathodes of the cold cathode numeric indicator tube.

Extremely high counting rates can be achieved, since frequency is limited only by the counters.

**TRUTH TABLE**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $2^0$ | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| $2^1$ | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| $2^2$ | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| $2^3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Decimal output | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

**Note: True logic positive. Only one output will be true at any one time.**

Radiation Monolithic Diode Matrices and interface circuits are supplied in TO-84s as well as in ceramic dual in-line packages.

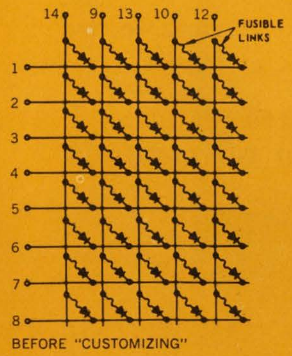
Radiation's popular dielectrically isolated matrices provide an unusual degree of flexibility. (1) RM-17 Matrices contain 40 active devices per chip. (2) A fusible link in series with each diode permits unlimited matrix patterns to be formed. And (3), circuits can be combined to produce an almost infinite variety of size configurations.

In addition to flexibility, Radiation 8 x 5 Matrices offer the increased reliability of monolithic construction. Size and weight requirements are slashed through reduced package count. Further, cost of matching, testing and assembly of discrete diodes is eliminated.

Production has been expanded to guarantee fast shipment of matrices "customized" to your exact requirements. In fact, most orders are shipped on a 24-hour basis.

*A new low-cost RM-114 design in a ceramic dual in-line package is available in volume at a unit price of $4.00—and can be supplied to any code configuration requested.*

Write for data sheets on the entire line of Radiation Monolithic Diode Matrices. *Worst-case limits* are included, as well as all information required by design engineers. We'll also be glad to supply our new manual, Monolithic Diode Matrix Technical Information and Applications. For your copy, request publication number RDM-T01/A01 from our Melbourne, Florida office.



BEFORE "CUSTOMIZING"

**Radiation 8 x 5 Monolithic Diode Matrices* (typical limits)**

| Characteristic | Symbol | RM-17 | RM-19 | RM-14<br>RM-114† | Unit | Test conditions ($T_A = +25°C$) |
|---|---|---|---|---|---|---|
| Forward drop | $V_F$ | 1.0<br>0.7 | 1.3<br>0.75 | 1.0<br>0.7 | V | $I_F = 20$ mA<br>$I_F = 1$ mA |
| Reverse breakdown | $BV_R$ | 60 | 60 | 50 | V | $I_R = 100\ \mu A$ |
| Reverse current | $I_R$ | 7 | 25 | 70 | nA | $V_R = 25$ V |
| Reverse recovery | $t_{rr}$ | 7 | 11 | 30 | ns | $I_F = 10$ mA to<br>$I_R = 10$ mA |
| Crosspoint capacitance | $C_{cp}$ | 1.9 | 1.9 | 2.0 | pF | $V_R = 5$ V; f = 1 MHz |
| Coupling coefficient | $I_{CL}$ | 20 | 20 | 20 | $\mu A$ | See data sheet |

*Supplied in T0-84 packages. †Supplied in ceramic dual in-line package.

**All Radiation integrated circuits are dielectrically isolated.**

**RADIATION INCORPORATED**

*MICROELECTRONICS DIVISION*

Sales offices: Suite 622, 650 North Sepulveda Blvd., El Segundo, Calif. (213) 772-6371—Suite 232, 600 Old Country Road, Garden City, N. Y. (516) 747-3730—Suite 201, 1725 Eye Street, N. W., Washington, D.C. (202) 337-4914—P.O. Box 37, Dept. ED-05, Melbourne, Florida (305) 723-1511, ext. 554

**ON READER-SERVICE CARD CIRCLE 148**

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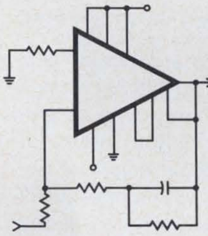
# State of the design art

Radiation's Operational Amplifiers are ideal for use in DC servo preamplifiers. They simplify design, offer unconditional stability without external compensation, and allow accurate determination of lag and lead frequencies.



For example, Radiation's RA-239 Broadband Amplifier is used in the lag-lead DC servo preamplifier illustrated. Feedback components are selected to optimize overall preamplifier parameters...without regard to the active element in this configuration.

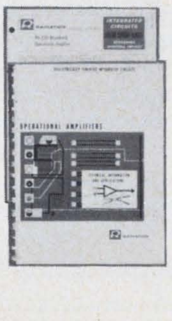
For a gain of 100, the preamplifier will provide full output up to 140 kHz. Undistorted output voltage is 21.6 $V_{P\text{-}P}$. Total swing is + 10.8 V to —12.2 V.

The stability and versatility of Radiation's Operational Amplifiers is made possible through advanced dielectric isolation and thin film over oxide technology.

For further information, refer to our ELECTRONICS advertisements of June 26.

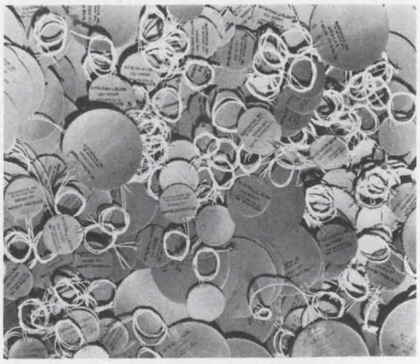
Write for data sheets on our entire line of operational amplifiers. *Worst-case limits* are included, as well as all necessary design information.

We'll also be glad to send a copy of our new manual, Operational Amplifier Technical Information and Applications, ROA-T01/A01. Contact our Melbourne, Florida office for your copy.



**ON READER-SERVICE CARD CIRCLE 149**

## Thin spot heaters produce up to 450°F

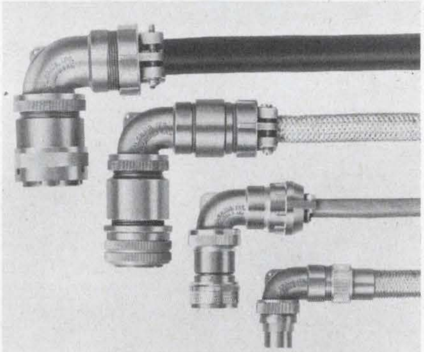


*Electrofilm, Inc., 7116 Laurel Canyon Blvd., N. Hollywood, Calif. Phone: (213) 875-1000.*

Spot heaters can produce 2, 5 or 10 watts/in$^2$. The heaters contain a high-reliability heating element and conductors laminated in silicone rubber. They can obtain surface temperatures up to 450°F. They are 0.045 inch thick, flexible, and have a dielectric capability of 1000 Vac. Heaters are available in 2, 4, 6, 8 and 12-inch diameters for each watt/in$^2$.

**CIRCLE NO. 372**

## Solid 90° elbows for EMI/RFI shield

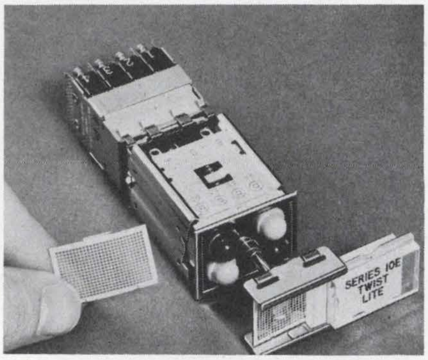


*Glenair, Inc., 1211 Air Way, Glendale, Calif. Phone: (213) 245-8587.*

Available in 12 cable entry sizes, these 90° solid elbows provide EMI/RFI shield termination, cable jacket sealing, cable-to-connector mating or any combination thereof. All elbows feature a positive 30° clocking action for cable orientation. Designed to fit circular connectors such as MIL-C-5015, MIL-C-26482, MIL-C-22992, MIL-C-26500, MIL-C-38300, MIL-C-3899 and NAS 1599, the elbows are available with a choice of strain reliefs.

**CIRCLE NO. 373**

## Fine-mesh shield cuts pushbutton RFI

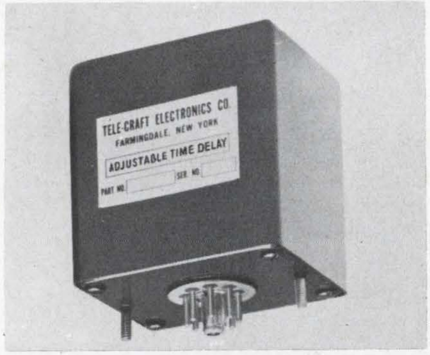


*Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. Phone: (714) 642-2427.*

Four-lamp lighted pushbutton switches use a built-in, fine-mesh shield to protect circuitry from radiated or conducted RFI through control panel cutouts. The shield is constructed of silver-plated beryllium copper. Attached to the switch lens retainer behind the display screen, the shield makes contact with the housing of the switchlight in four separate areas to ground any RFI.

**CIRCLE NO. 374**

## Time delay relays range 0.1 to 60 seconds

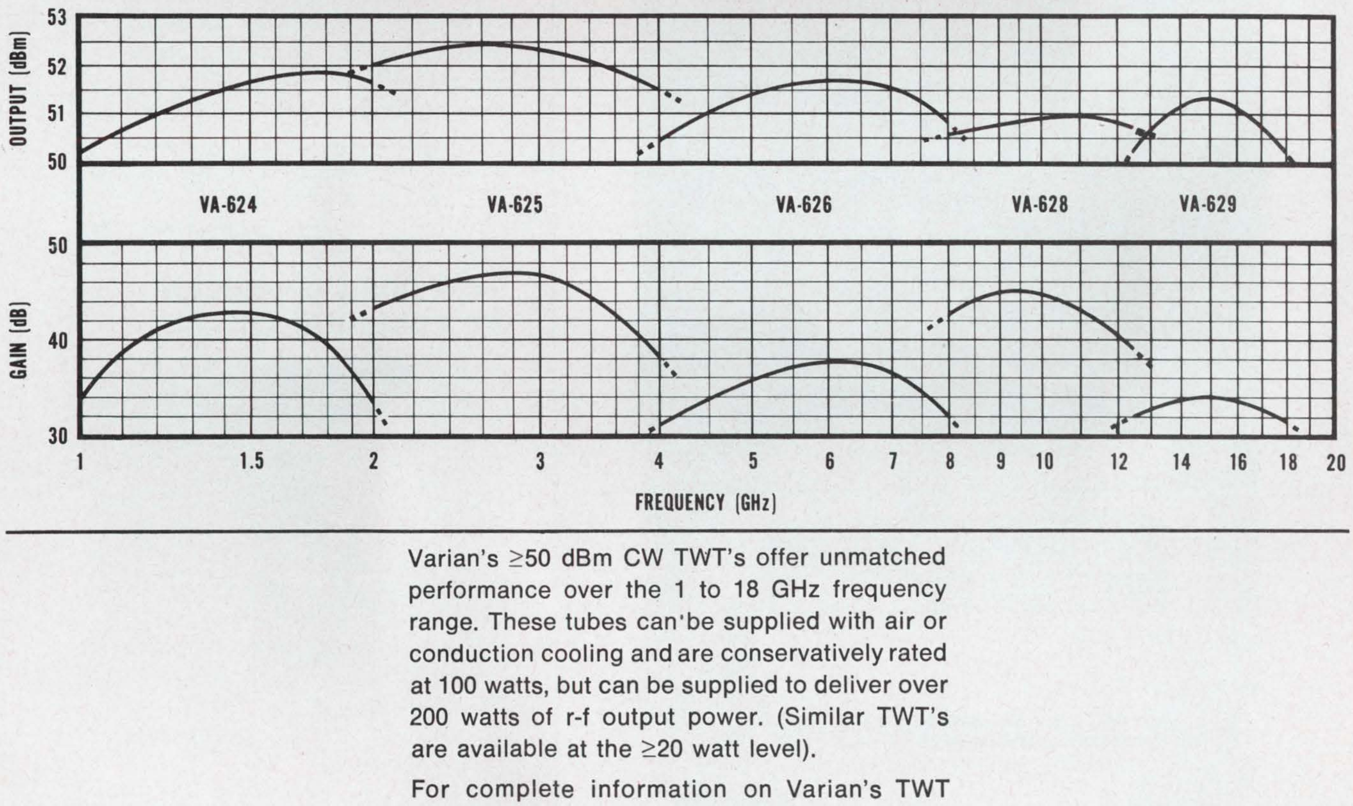


*Tele-Craft Electronics Co., 125 Schmitt Blvd., Farmingdale, N. Y. Phone: (516) 694-4300.*

Time delay relays are available with fixed or adjustable delays in ranges from 0.1 to 60 seconds. Sealed timers can be provided with automatic reset if the cycle is interrupted before timing out. SCR output to operate external relay or other trip device is rated nominally 2 A and 200 V. Input to the timers is 115 Vac or 24 Vdc.

**CIRCLE NO. 375**

# 100 Watt CW TWT's from Varian

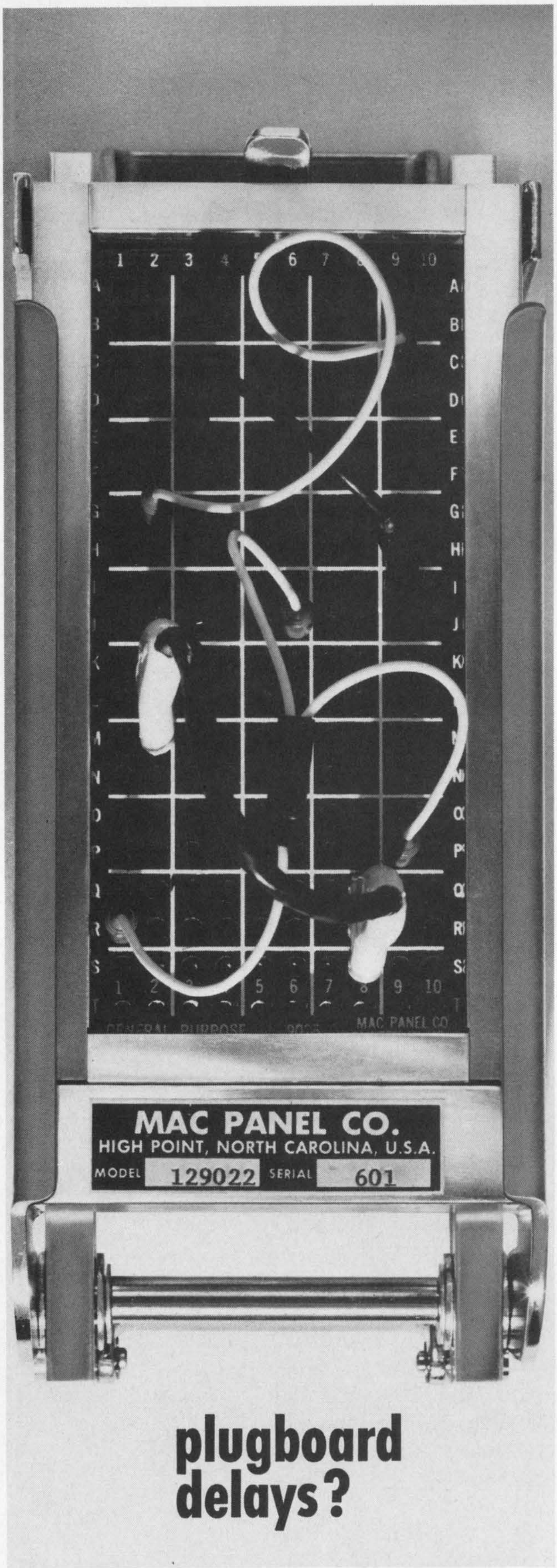


Varian's ≥50 dBm CW TWT's offer unmatched performance over the 1 to 18 GHz frequency range. These tubes can be supplied with air or conduction cooling and are conservatively rated at 100 watts, but can be supplied to deliver over 200 watts of r-f output power. (Similar TWT's are available at the ≥20 watt level).

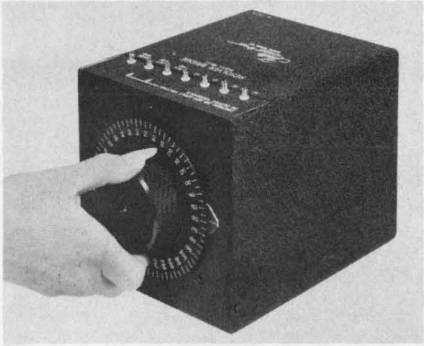
For complete information on Varian's TWT capabilities, write the Palo Alto Tube Division, 611 Hansen Way, Palo Alto, California. In Europe: Varian A.G., Zug, Switzerland. In Canada: Varian Associates of Canada, Ltd., Georgetown, Ontario, Canada.

varian

ON READER-SERVICE CARD CIRCLE 51



## Synchro/resolvers measure error to 2 s

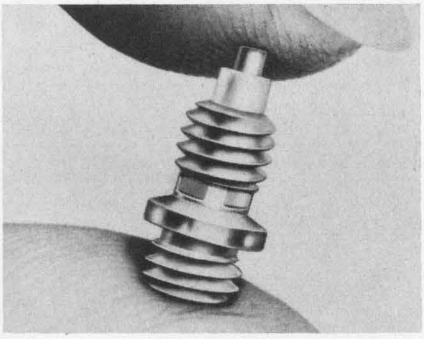


*Theta Instrument Corp., Saddle Brook, N. J. Phone: (201) 843-6060. P&A: from $300; stock.*

Panel-mounted synchro and resolver bridges measure electrical error and conform to MIL-S-20708B. The bridges do not in any way affect the characteristics of the synchro itself through impedance loading or switching transients. Models are available with built-in meters or digital indicators to directly display electrical error. Range is 0 through 360° with an accuracy to 2 seconds of arc. Impedance is 10 kΩ or 100 MΩ and interval is 5°.

**CIRCLE NO. 376**

## Test point connector for computer circuits

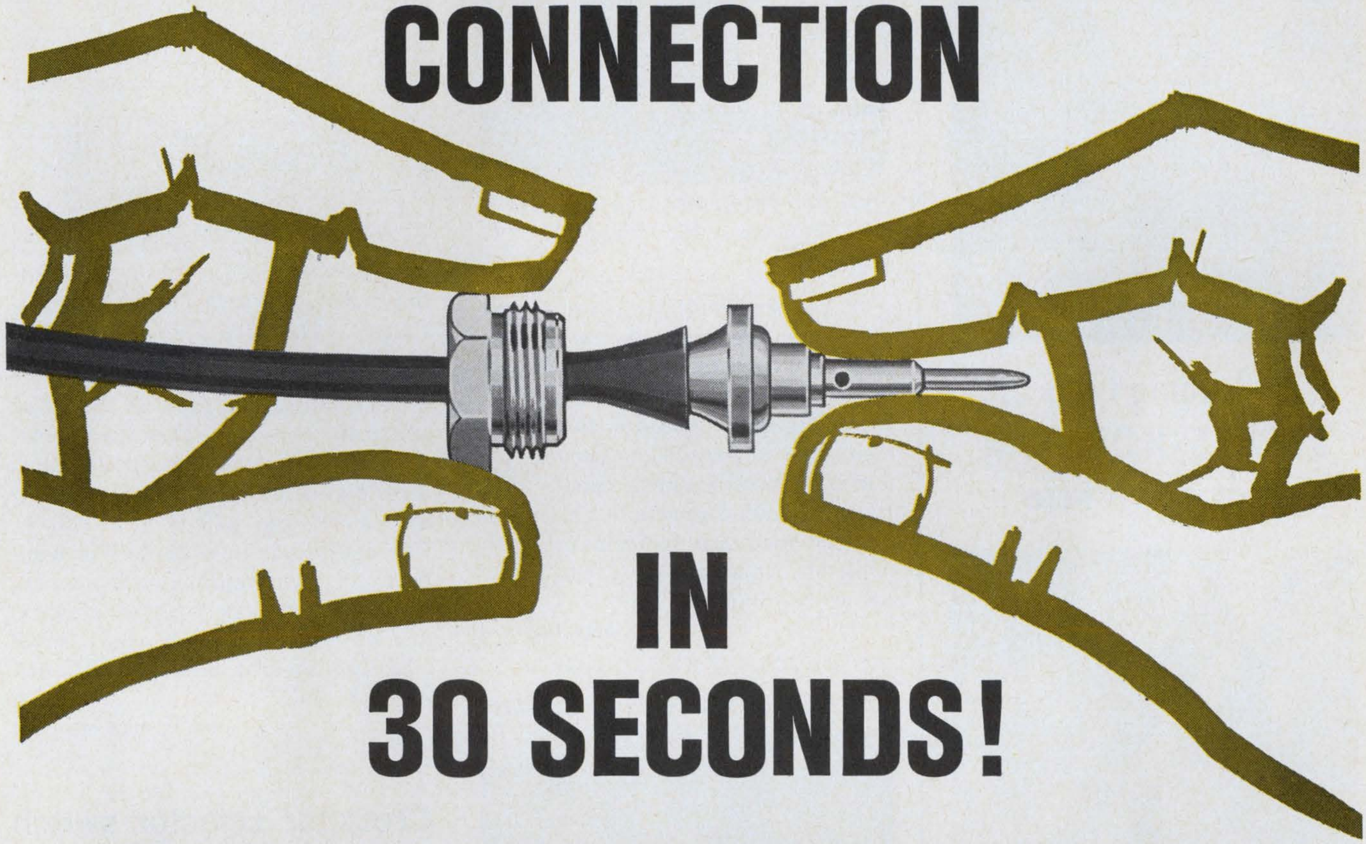


*Hugh H. Eby Co., 4701 Germantown Ave., Philadelphia. Phone: (215) 324-7000.*

A test point connector claims a high degree of stability and uniformity of insertion and retention values. The device is for use with an 0.031-inch diameter pin and has applications in the testing of computer circuits. The body of the test point is silver-plated brass, and the insulator is Teflon. A stamped, wraparound type contact of gold-plated beryllium copper is used.

**CIRCLE NO. 377**

# ASSEMBLE THIS WEATHERPROOF CONNECTION

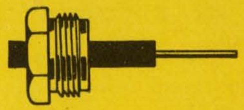


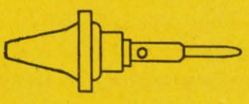
# IN 30 SECONDS!

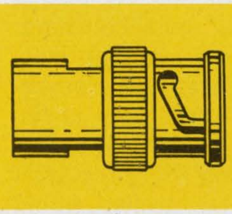
Again, BENDIX/DAGE engineering has solved a major problem for equipment builders! New DAGE Square-Cut RF Connectors reduce assembly time 50%-75% . . . produce weathertight seals with a pull test of 50 lbs. Only 3 parts—no special tools required!

Time-and-money-saving benefits of Square-Cut Connectors are typical of BENDIX/DAGE contributions to the state of the art . . . *practical* ideas that help you design for greater capability in *your* circuitry and equipment.

Write for Square-Cut literature. If you have a special problem, call Dage Engineering Department. Call today!







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a subsidiary of the **Bendix** Corporation

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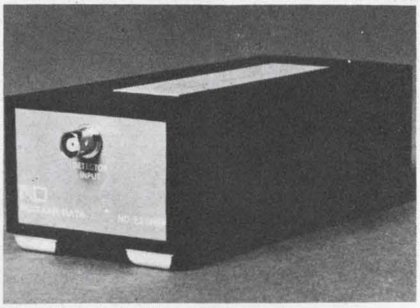
ON READER-SERVICE CARD CIRCLE 53

## High-resolution preamp uses FET input

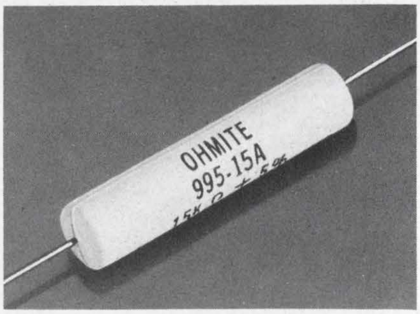


*Nuclear Data, Inc., 100 W. Gold Rd., Palatine, Ill. Phone: (312) 529-4600.*

A charge-sensitive preamp provides the low-noise linear preamplification necessary for application of solid-state radiation detectors. Input circuitry contains two FETs connected in parallel, to provide the low-noise performance. Inputs with four parallel-connected FETs for greater low-noise performance with detector capacitance exceeding 250 pF are available.

**CIRCLE NO. 378**

## Vitreous enamel resistor rated at 15 watts

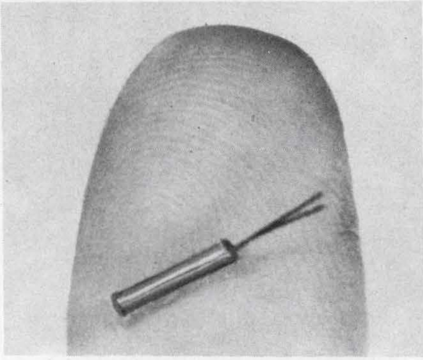


*Ohmite Manufacturing Co., 3680 Howard St., Skokie, Ill. Phone: (312) 675-2600.*

Wirewound molded vitreous enamel resistors are rated at 15 watts. They are offered in a resistance range of 0.1 Ω to 243 kΩ. The resistor is available in three styles: a commercial type with a standard tolerance of 5%, a high-stability type with a standard tolerance of 3% (tolerances to 0.25% available) and a resistor which complies with style RW56 (14 watts) of MIL-R-26 but has a slightly higher wattage rating. Uniform thickness of the enamel jacket guarantees 1000-Vac insulation breakdown.

**CIRCLE NO. 379**

## Resistance thermometer barely a thumbful

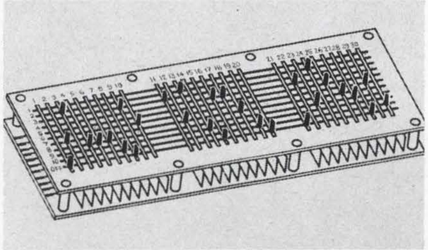


*Minco Products, Inc., 740 Washington Ave. North, Minneapolis. Phone: (612) 338-6753. Price: $12 to $52.50.*

Measuring 0.08 inch in diameter and 0.46 inch long, this thermometer has a CP nickel element that has a resistance of approximately 284 Ω at −40°F and 673 Ω at +250°F. The device has applications in compact or lightweight instrumentation packages, medical, laboratory, and other applications where small size, light weight, and high gain are desired.

**CIRCLE NO. 380**

## Crossbar selector switch replaces 30 wafers



*Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Park, Ill. Phone: (312) 432-8182. P&A: $43; stock.*

Time, effort and expense involved in using rotary switches for programing are reportedly reduced by the C10-43A crossbar type selector switch. This high-density switch replaces 30 single wafer switches (10 position), occupies 41 in$^2$ of panel space and requires no soldering. The switch can be installed in less than five minutes. The C10-43A selector switch has 300 crosspoints.

**CIRCLE NO. 381**

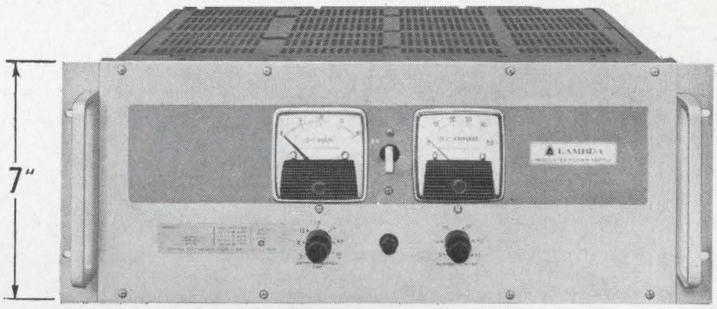
# Now—the broadest line of convection-cooled, all silicon, .015% regulated power supplies

## For test equipment and lab use—rack or bench

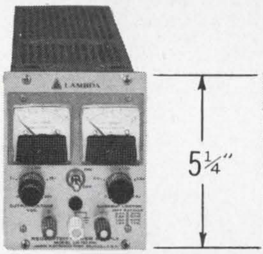
## 0-10, 0-20, 0-40, 0-60, 0-120 VDC, from 0-.5 amp to 0-66 amps—

### Features and Data

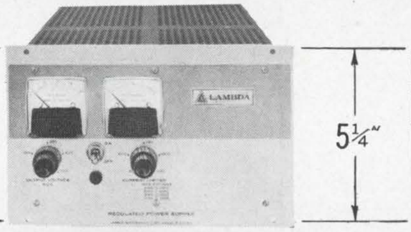
- **Full five year guarantee on materials and labor**
- **Convection Cooled**
- **Remote Programing**
- **Regulation**—.015% or 1 MV (Line or Load)
- **Temp. Coef.** .015%/°C
- **Completely Protected—** Short circuit proof—Continuously adjustable Automatic current limiting
- **Remote Sensing**
- **Constant I./Constant V.** by automatic crossover
- **Series/Parallel Operation**
- **No Voltage Spikes or Overshoot** on "turn on", "turn off" or power failure
- **Ripple—** LK models—500 µV RMS LH models—250 µV RMS, 1 MV P-P
- **Meet MIL Environment Specs**



**Full Rack 7" LK Series**



**¼ Rack LH Series**



**½ Rack LK Series-LH Series**

**Full Rack 5¼" LK Series**

3 Full-rack Models — Size 7" x 19" x 18½"

| Model[2] | Voltage Range | CURRENT RANGE AT AMBIENT OF:[1] | | | | Price[2] |
|---|---|---|---|---|---|---|
| | | 40°C | 50°C | 60°C | 71°C | |
| LK 360 FM | 0–20VDC | 0–66A | 0–59A | 0–50A | 0–40A | $995 |
| LK 361 FM | 0–36VDC | 0-48A | 0–43A | 0–36A | 0–30A | 950 |
| LK 362 FM | 0–60VDC | 0–25A | 0–24A | 0–22A | 0–19A | 995 |

3 Full-rack Models — Size 5¼" x 19" x 16½"

| Model[2] | Voltage Range | CURRENT RANGE AT AMBIENT OF:[1] | | | | Price[2] |
|---|---|---|---|---|---|---|
| | | 40°C | 50°C | 60°C | 71°C | |
| LK 350 | 0–20VDC | 0–35A | 0–31A | 0–26A | 0–20A | $675 |
| LK 351 | 0–36VDC | 0–25A | 0–23A | 0–20A | 0–15A | 640 |
| LK 352 | 0–60VDC | 0–15A | 0–14A | 0–12.5A | 0–10A | 650 |

5 Quarter-rack Models — Size 5³⁄₁₆" x 4³⁄₁₆" x 15½"

| Model[2] | Voltage Range | CURRENT RANGE AT AMBIENT OF:[1] | | | | Price[2] |
|---|---|---|---|---|---|---|
| | | 30°C | 50°C | 60°C | 71°C | |
| LH 118 | 0–10VDC | 0–4.0A | 0–3.5A | 0–2.9A | 0–2.3A | $175 |
| LH 121 | 0–20VDC | 0–2.4A | 0–2.2A | 0–1.8A | 0–1.5A | 159 |
| LH 124 | 0–40VDC | 0–1.3A | 0–1.1A | 0–0.9A | 0–0.7A | 154 |
| LH 127 | 0–60VDC | 0–0.9A | 0–0.7A | 0–0.6A | 0–0.5A | 184 |
| LH 130 | 0–120VDC | 0–0.50A | 0–0.40A | 0–0.35A | 0–0.25A | 225 |

11 Half-rack Models — Size 5³⁄₁₆" x 8⅜" x 15⅝"

| Model[2] | Voltage Range | CURRENT RANGE AT AMBIENT OF:[1] | | | | Price[2] |
|---|---|---|---|---|---|---|
| | | 40°C | 50°C | 60°C | 71°C | |
| LK 340 | 0–20VDC | 0– 8.0A | 0– 7.0A | 0– 6.1A | 0–4.9A | $330 |
| LK 341 | 0–20VDC | 0–13.5A | 0–11.0A | 0–10.0A | 0–7.7A | 385 |
| LK 342 | 0–36VDC | 0– 5.2A | 0– 5.0A | 0– 4.5A | 0–3.7A | 335 |
| LK 343 | 0–36VDC | 0– 9.0A | 0– 8.5A | 0– 7.6A | 0–6.1A | 395 |
| LK 344 | 0–60VDC | 0– 4.0A | 0– 3.5A | 0– 3.0A | 0–2.5A | 340 |
| LK 345 | 0–60VDC | 0– 6.0A | 0– 5.2A | 0– 4.5A | 0–4.0A | 395 |

| Model[2] | Voltage Range | CURRENT RANGE AT AMBIENT OF:[1] | | | | Price[2] |
|---|---|---|---|---|---|---|
| | | 30°C | 50°C | 60°C | 71°C | |
| LH 119 | 0–10VDC | 0– 9.0A | 0– 8.0A | 0– 6.9A | 0–5.8A | $289 |
| LH 122 | 0–20VDC | 0– 5.7A | 0– 4.7A | 0– 4.0A | 0–3.3A | 260 |
| LH 125 | 0–40VDC | 0– 3.0A | 0– 2.7A | 0– 2.3A | 0–1.9A | 269 |
| LH 128 | 0–60VDC | 0– 2.4A | 0– 2.1A | 0– 1.8A | 0–1.5A | 315 |
| LH 131 | 0–120VDC | 0– 1.2A | 0– 0.9A | 0- 0.8A | 0–0.6A | 320 |

[1] Current rating applies over entire voltage range.

[2] Prices are for non-metered models (except for models LK360FM thru LK362FM which are not available without meters). For metered models, add suffix (FM) and add $25 to price of LH models; add $30 to price of LK models.

[3] Overvoltage Protection: add suffix (OV) to model number and add $60 to the price of LH models; add $70 to price of half-rack LK models; add $90 to price of 5¼" full-rack LK models; add $120 to price of 7" full-rack LK models.

[4] Chassis Slides for full rack models: Add suffix (CS) to model number and add $60 to the price.

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LA-180

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With Features and Performance
Never Before Available At Less Than $200

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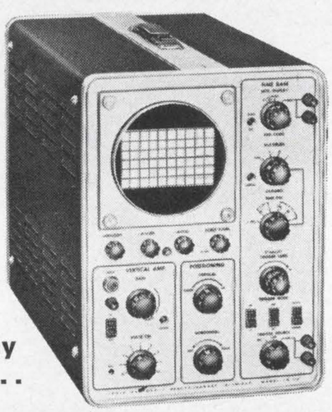
**Kit IM-25,** 10 lbs. (Available May) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **$80.00**
**Assembled IMW-25,** 10 lbs. (Available June) . . . . . . . . . . . . . . . . . . . . . **$115.00**

New Lower Kit Price on Professional
IO-14 DC Oscilloscope . . . Now Save $40



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Than Ever . . .

Kit Now Only $259, Factory Assembled $399

• High stability 5" DC oscilloscope with triggered sweep • DC to 8 MHz bandwidth, 40 nanosecond rise time • Vertical signal delay through high linearity delay lines — capable of faithful reproduction of signal waveforms far beyond the bandwidth of the scope • Calibrated vertical attenuation • Calibrated time base • Forced air cooling • Input for Z axis modulation • Input for direct access to vertical deflection plates • Easy circuit board construction & wiring harness assembly • Components are packaged separately for each phase of construction • Easy to align • Fulfills many production and laboratory requirements at far less cost • Wiring options enable 115/230 volt, 50-60 Hz operation

**Kit IO-14,** 53 lbs. . . . . . . . . . . . . . . . . . . . . . . . Was $299.00, **Now Only $259.00**
**Assembled IOW-14,** 47 lbs. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **$399.00**

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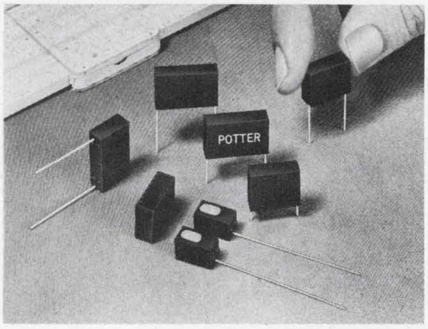
ON READER-SERVICE CARD CIRCLE 56

## Polycarbonate caps mount PC boards

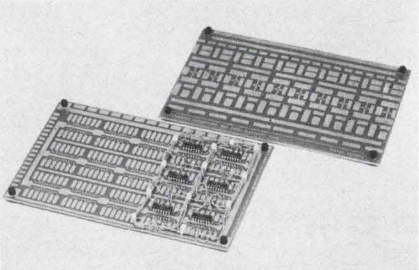


*Potter Co., Wesson, Miss. Phone: (601) 643-2216. P&A: 32¢ to $1.50; 4 to 6 wks.*

Metallized polycarbonate capacitors with radial leads for PC board mounting range from 0.001 to 2 μF. The 3908 series operate at full rated voltage from −55° to +125°C without derating and are available in three voltage ratings: 200, 400 and 600 Vdc. They will withstand the application of 140% rated voltage at 125°C for 250 hours and have a dissipation factor of less than 0.5% at 25°C and 1 kHz. Standard tolerance is ±20%, but ±10, ±5, ±2 and ±1% are available.

**CIRCLE NO. 382**

## Component breadboard for discretes, ICs



*Andresen Enterprises, Inc., 3691 Lee Rd., Cleveland. Phone: (216) 561-4100. Price: $4.85 (1 to 9).*

Components are tacked on top of conveniently arranged pads on these printed circuit breadboards to form expedient connections. IC dual-in-line modules are similarly tacked on and interconnected with hook-up wire. Since no cutting of component leads is necessary, all components can be salvaged after use. The breadboards are made on a phenolic base with 2-oz copper-clad 60/40 solder-plated.

**CIRCLE NO. 383**

**Pay a Little.** The price is as small as the product. It's a miniature rear projection readout, and it costs as little as $14.00. The new IEE Series 345 Readout requires very little space, but it offers the readability and versatility available only with rear projection readouts. And the price is comparable to other types of readouts with limited messages and cluttered displays.

The Series 345 operates on the rear projection principle. A lamp in the rear of the unit illuminates one of the 11 film messages, and projects it to the front viewing screen. A single plane display on the non-glare screen, so you get no distortion or confusion. It is very versatile, since anything that can be put on film can be displayed on the screen. You can display a variety of messages or colors.

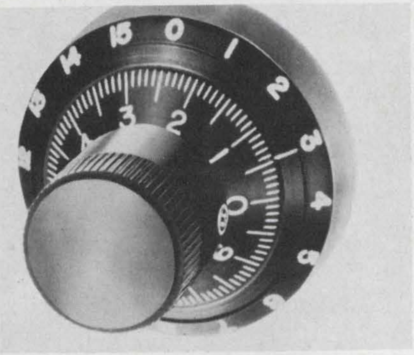
The Series 345 has a front plug-in feature. It can be quickly inserted into the housing. It can be just as easily removed to insert a new readout with a different display, or to replace a lamp.

*Series 345 Readout:* ½" wide x ¾" high. Six digits will fit in a 3" wide panel space. Depth, 2½". Character height, ⅜". Weight, ¾ oz. Six available colors, including white, amber, yellow, blue, red or green. Straight decimal input. Vertical and horizontal viewing angle 175° with V-1 viewing screen, or 160° with standard screen.

**IEE** **"I double-E," the world's largest manufacturer of rear projection readouts.**
**Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, California**

**ON READER-SERVICE CARD CIRCLE 57**

## 15-turn dial mounts on pot shafts

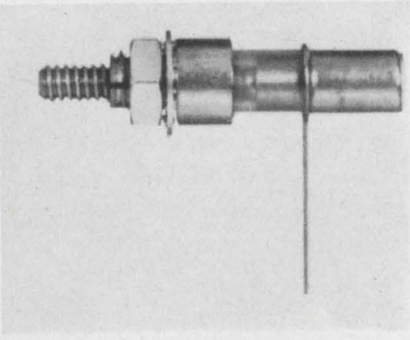


*IRC, Inc., 401 N. Broad St., Philadelphia. Phone: (215) 922-8900. P&A: $6.50 (100 lots); 30 days.*

Two 15-turn dials are designed for use with multiturn precision potentiometers. The 1-inch diameter dials have an angular surface for easy readout. Primary and secondary scale presentation is 000 to 1499. Set-screwed directly to a potentiometer shaft, there is no backlash and no necessity for extra panel holes. Designated RDK-411 (black with white figures) and RDK-461 (clear with black figures), they accept a 1/4-inch shaft and mount on a 3/8-32 NEF 2A threaded bushing.

**CIRCLE NO. 384**

## Piston trimmer operates over full MIL range

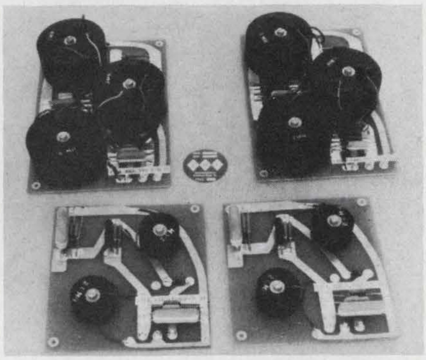


*Erie Technological Products, Inc., Erie, Pa. Phone: (814) 456-8592.*

A direct-drive piston trimmer operates over the full military temperature range of −55 to +85°C. The unit incorporates a dielectric of polyphenylene oxide with a typical Q of 1000 at 3 GHz. Rated at 250 wVdc, the part has tuning resolution of 0.37 pF/360° turn and offers a capacitance range of 0.8 to 4.5 pF.

**CIRCLE NO. 385**

## Bandpass filters stable to 0.5%



*TRF, Inc., 6641 Backlick Rd., Springfield, Va. Phone: (703) 451-5131. P&A: $40 to $240; 15 to 30 days.*

Low-frequency passive bandpass filters are based on computer-derived tables and feature zero insertion loss. They are available in single or multiple-pole configurations and offer symmetrical and other customer-specified passband characteristics with 0.5% frequency stability over a 0° to 50°C temperature environment. Center frequency is 1 kHz to 1 MHz with a 3-dB bandwidth of 3 to 20%.

**CIRCLE NO. 386**

## Programable switch cuts output reset time

*Marconi Instruments, 111 Cedar Lane, Englewood, N. J. Phone: (201) 567-0607. Price: $120 (2-way), $170 (4-way), $245 (8-way).*

Users of signal generators on production line testing of receivers can use this programable switch. Previously, to make receiver sensitivity and overload measurements using a signal generator, the piston attenuator had to be moved through its complete travel. By using this switch in conjunction with fixed pads, two levels of output (100 mV and 0.1 $\mu$V) can be selected. Operation of the coax switch can be automated or manually controlled from an external switch. Since the output level is set by the fixed pad, exact reduplication of settings is achieved with high absolute accuracy. Insertion loss of the switch is 0.9 dB at 1 GHz with vswr of 1.25. Four- and eight-position models are available.

**CIRCLE NO. 387**

# don't confuse it with a tube...

Actual Size

## RCA's new 40468 (MOS)FET performs like a tube with its exceptionally low cross modulation, high unneutralized gain and wide dynamic range, but it's a solid state device.

**Now for the first time you can design solid-state front-ends for hi-fi FM radios, receivers, and tuners without compromising performance or sacrificing gain... at economy prices!**

Because of its excellent square law characteristics and wide dynamic range, the new RCA 40468 (MOS)FET can greatly reduce spurious responses and interference from undesired signals. Very low cross modulation distortion makes it an exceptionally fine RF amplifier *or* mixer, offering noticeably better performance than is possible with bipolar transistors.

Extremely low feedback capacitance (0.2 pF max.) provides as much gain *without* neutralization as junction FET types do with neutralization, so you can reduce production costs. If neutralization is added, even more stable gain can be achieved.

In addition, the RCA 40468 (MOS)FET's insulated gate permits large signal swings to be handled at the maximum gain point without input circuit detuning or loading.

Investigate the advantages of designing RCA's 40468 (MOS)FET into FM receivers, tuners, and auto radios. Your RCA Field Representative will be glad to give you complete information, including price and delivery. For a technical data sheet, write RCA Commercial Engineering, Section EG5-2, Harrison, New Jersey 07029.

**ALSO AVAILABLE THROUGH YOUR RCA DISTRIBUTOR.**

RCA Electronic Components and Devices

**The Most Trusted Name in Electronics**

ON READER-SERVICE CARD CIRCLE 59

# *From the recognized leader in*

# CLARE offers

**Two** SIZES

**Three** PACKAGE CONFIGURATIONS

**Four** DIFFERENT SWITCHES

**Five** COMPLETE LINES

**A. Clareed Open-coil Relays for pcb (CRT, CRTN)**

**B. Clareed Metal-enclosed Modules for pcb (CRM)**

**C. Clareed Relays (plug-in or solder type) for wired assemblies (CRA, CRB)**

**D. MicroClareed Epoxy-molded Modules for pcb (MRME)**

**E. MicroClareed Open-coil Relays for pcb (MRMC)**

**CLAREED RELAY CHARACTERISTICS**

| | GENERAL PURPOSE | HIGH VOLTAGE | MERCURY-WETTED | MICROCLAREED |
|---|---|---|---|---|
| Contact Arrangements | Forms | Forms | Forms | |
| Enclosed Modules (up to 3 spaces) | A, B, C | A, B, C | A, B | Up to 5 form A |
| Open Coil Modules (up to 12 spaces) | A, B, C | A, B, C | A, B | Up to 5 form A |
| Round Cans (up to 12 spaces) | A, B, C | A, B, C | A, B | |
| Contact Rating | | | | |
| Switched Load | 15 va max., non-inductive<br>1 amp max., 250 v max. | 15 va max., non-inductive<br>1 amp max., 250 v max. | 50 va max., non-inductive<br>3 amps max., 500 v max. | 10 va max., non-inductive<br>.750 amp max., 200 v max. |
| Carry Load | 5 amps max., not switched | 5 amps max., not switched | 5 amps max., not switched | 2 amps max., not switched |
| Life Expectancy | | | | |
| High Level Load | 20 x $10^6$ operations<br>.500 amp, 28 v | 20 x $10^6$ operations<br>.500 amp, 28 v | 100 x $10^6$ operations<br>3 amps, 16.5 v | 10 x $10^6$ operations<br>.125 amp, 28 v |
| Low Level | 100 x $10^6$ operations | 100 x $10^6$ operations | 1 x $10^9$ operations | 100 x $10^6$ operations |
| Stand-Off Voltage | 500 v rms | 1500 v rms, Standard<br>5000 v peak, Special* | 1000 v rms, Standard<br>3000 v peak, Special* | 250 v rms |
| Operate Time** (nominal coil power, including bounce) | As low as .6 ms | | | As low as .5 ms |
| Must Operate Sensitivity | As low as 80 mw | | | As low as 60 mw |

*AVAILABLE WITH SPECIAL ASSEMBLIES **DEPENDING ON NUMBER OF CONTACTS *sealed-contact reed relays–*

# Maximum Choice in

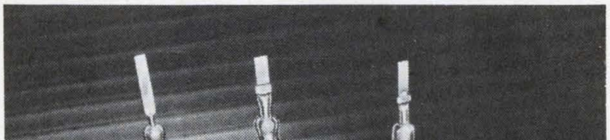
# REED RELAYS

Your application determines the Clareed® Relay you use...with the versatile Clareed and MicroClareed lines!

These high-reliability, long-life reed relays offer you the inherent maintenance-free reliability of contacts sealed in glass... switching speeds in the low millisecond range...a variety of operate power and contact loads...plus your choice of enclosed pcb modules, open-coil pcb relays, or round cans for wired assemblies.

Clareed and MicroClareed® Relays are Clare-built from start to finish...with automated, superclean production assuring you Clare quality and Clare reliability. All are 100% tested for dielectric strength, operating characteristics, contact resistance, and seal integrity.

Choose the relay characteristics you need. Clare will help you specify for long life and utmost economy in operation.



*Left to right: General Purpose, Mercury-Wetted, High Voltage, MicroClareed*

**For complete information, ask your Clare sales engineer, circle the Reader service number below, or write**

**Group 5A4**
**C. P. CLARE & CO.**
**3101 Pratt Blvd.**
**Chicago, Illinois 60645**

CLARE®

*relays and related control components*

**ON READER-SERVICE CARD CIRCLE 60**

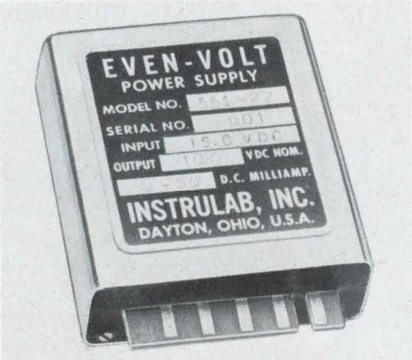
## Micromin connector 19/32 inch across

*Frazar & Hansen, Ltd., 150 California St., San Francisco. Phone: (415) 981-5262. P&A: $2 to $15; 3 to 5 wks.*

Microminiature connectors measuring 19/32 inch in diameter are designed for coaxial and multipin (up to 14) applications. With an overall plug length of 1 inch, series C is available in four configurations: straight plug panel-mounted receptacle, panel-mounted with back shell, and clamp and cable receptacle. The multipin models have a 2-A rating, a contact-to-contact test voltage of 1.2 kV and a contact-to-ground test voltage of 1.4 kV. Wire size is AWG #24 or 26. Coaxial models have 50 and 75-Ω impedance and Teflon inserts.

**CIRCLE NO. 388**

## Reference power source fully regulated

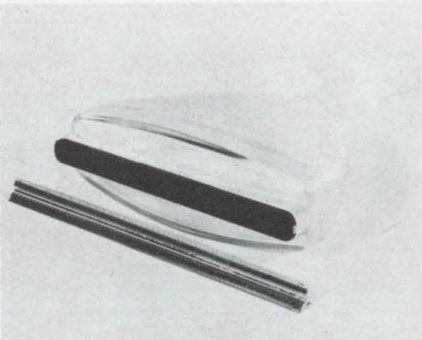


*Instrulab, Inc., 1205 Lamar St., Dayton, Ohio. Phone: (513) 223-2241.*

Tiny reference power sources achieve a constant dc voltage output, regardless of temperature or line voltage variations. Stable reference diodes and a high-gain operational amplifier are used. Regulation is 0.01% or ±1 mV, load and line. Output is 10 Vdc ±1 mV.

**CIRCLE NO. 389**

## Fiber optic faceplates for line-scan CRTs

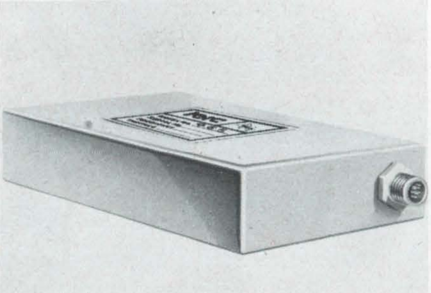


*Chicago Aerial Industries, Inc., 550 W. Northwest Hwy., Barrington, Ill. Phone: (312) 381-2400.*

A fiber optic faceplate for line-scan CRTs brings the intensity-modulated line display of the CRT to the front surface, eliminating parallax. By moving photosensitive paper past the line scan, contact prints can be generated of photos or charts. The faceplate is available up to 10-1/2 inches long by 2 inches wide. Any thickness can be supplied to meet voltage standoff or three atmosphere pressure test requirements. It is directly solder-glass sealable to KG-12, 0120, or glasses with equivalent coefficients of expansion.

**CIRCLE NO. 390**

## Vhf transmitter withstands 1000 G



*International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. Phone: (213) 849-2481.*

A 0.5-watt, solid-state, FM transmitter is capable of operating in severe acceleration environments to 1000 G. The model 465 is a full IRIG, crystal-controlled unit operating in the 215-to-260-MHz band. The unit's small size (2-1/4 x 2-1/4 x 1 inch) and weight (6 oz) suit it for missile applications.

**CIRCLE NO. 391**

# This integrating DVM *still* offers better performance than any other of its kind.

Measure low-level signals even in the presence of extreme noise with Hewlett-Packard's 2401C Integrating Digital Voltmeter. It has a floating and guarded input for minimizing the effects of common mode noise; and integration averages out all noise superimposed on the signal.

But the 2401 DVM could do that when it was first introduced. Since then there have been two new models and many additional features to keep the 2401 the industry's most useful bench and system DVM.

Here's why:

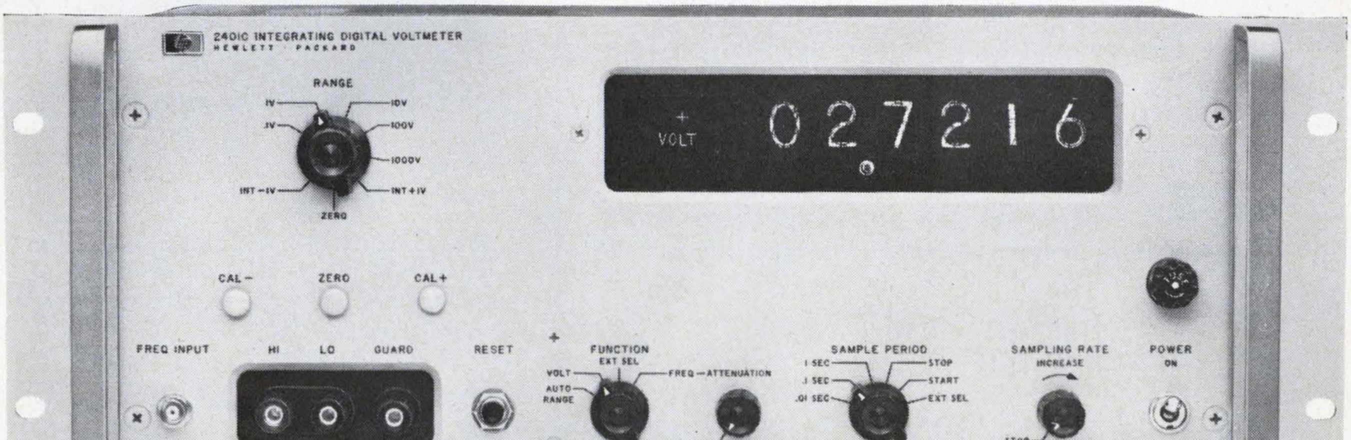
5 ranges, 100 mV, 1 V and the 3 usuals; 300% overranging on the 4 most sensitive ranges, 6th digit for overrange display; integration through zero; full programmability; BCD output for systems use; independent internal calibrate source stable to 0.006% /6 mo.; 300 kHz frequency counting ability; optional autoranger with 34 msec maximum change time.

If this isn't enough, a full repertoire of options and compatible systems instruments is available to satisfy your measurement needs.

Price: still $3950.

Call your local Hewlett-Packard field engineer or write direct to Dymec Division of Hewlett-Packard, 395 Page Mill Rd., Palo Alto, California 94306, Tel. (415) 326-1755; Europe: 54 Route des Acacias, Geneva.

HEWLETT
PACKARD
DYMEC
DIVISION



ON READER-SERVICE CARD CIRCLE 62

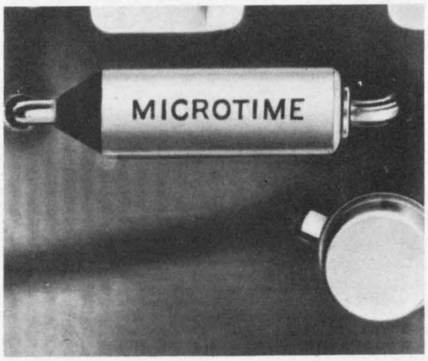
## Magnetic circuit boosts reed relay sensitivity

*Babcock Relays, 3501 Harbor Blvd., Costa Mesa, Calif. Phone: (714) 540-1234.*

A magnetic circuit, said to increase relay sensitivity, is featured in this miniature 7-pin plug-in mercury-wetted relay. The unit uses two independent permanent-pole magnets with separate induction bars for improved magnetic field return. The relay is available in single-side-stable and bistable types. Specifications include a max power dissipation of 1 watt, contact rating of 2 A and max contact resistance of 40 mΩ.

**CIRCLE NO. 392**

## Tiny circuit protector replaces fuses



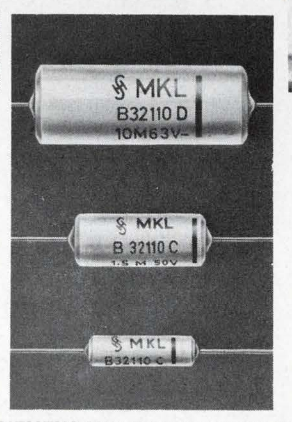
*Micro Devices Corp., P. O. Box 501, Far Hills Station, Dayton, Ohio. Phone: (513) 298-5246.*

The resistance of this tiny circuit protector is only a fraction of that offered by fuses. This permits use in lower voltage and lower power circuits but does not prevent use in high power circuits. The Microtime protectors, which open when current increases critically, may be specified to respond to such an increase within microseconds.

**CIRCLE NO. 393**

# self-healing

**. . . and the smallest film capacitors available anywhere!**
The secret? A metal deposit between two dielectric films each .00005 inch thick, forms a truly two-layer construction with improved insulation resistance and voltage reliability. Siemens MKL capacitors are specially designed for circuits requiring the absolute minimum of space, such as space and satellite equipment. Typical applications include bypassing, coupling, time circuits, etc. Let a Siemens engineer show you how Siemens components can improve your product. It's child's play.



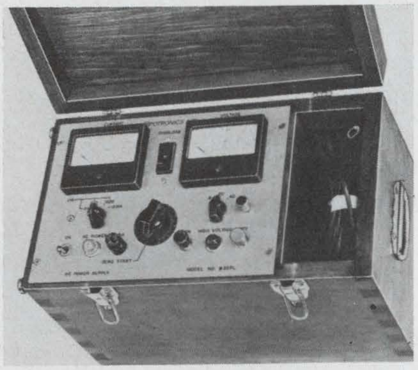
**SIEMENS MKL FILM CAPACITORS**
Double, self-healing characteristic at both high and low voltages (even milli-volts). Small size: a 10 mF capacitor for conservative 25 volt D.C. is only .43" diameter by .99" length. Available out of stock, in axial leaded case from .1 mF through 10 mF for 25, 63, 100, 160 and 250 volt. Special 630 volt version available from .033 mF through 4.7 mF. Higher values available up to 100 mF on request.

**SIEMENS AMERICA INCORPORATED**

Components Division • 230 Ferris Avenue, White Plains, N.Y. 10603

ON READER-SERVICE CARD CIRCLE 64

## Dc insulation testers for wire and cable

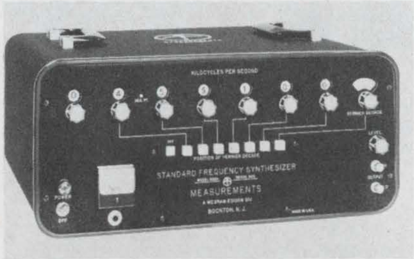


*Hipotronics, Inc., Box 1, Brewster, N. Y. Phone: (914) 279-8091. P&A: $700 to $1800; stock.*

Portable dc insulation testers are designed for wire, cable and insulation testing. Surge devices, an instantaneous overload relay, an internal and an output shorting relay with discharge resistor aid in equipment protection. Other features include triple-range output-connected kV meter with recalibration facilities, triple-range current meter in grounded return, continuously adjustable output control and square Weston meters with 2% accuracies.

**CIRCLE NO. 394**

## Frequency synthesizers range dc to 100 kHz

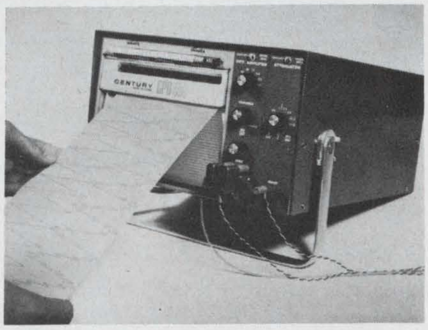


*Measurements, P. O. Box 180, Boonton, N. J. Phone: (201) 334-2131. P&A: $2850; stock.*

Model 500A frequency synthesizer spans the frequency range from dc to 100 kHz with digital selection of 0.01 cycle. A variable oscillator provides continuous frequency selection over the range of any digit except the 10-kHz digit. It operates on the direct synthesis principal avoiding the problems common to methods involving phase-locked oscillators.

**CIRCLE NO. 395**

## Light beam oscillograph at pen-and-ink price

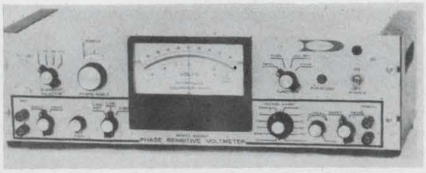


*Century Electronics & Instruments, Inc., 6540 E. Apache St., Tulsa, Okla. Phone: (918) 835-9951. Price: under $1000.*

A two-to-six-channel light-beam recording oscillograph is priced to compete with pen-and-ink recorders. The instrument, with two signal conditioners and two galvanometers, reportedly can handle higher frequency events than mechanical recorders. The galvanometers offer a flat frequency response to 2 kHz. Plug-in signal conditioners such as attenuators, amplifiers, and differential amplifiers are available. Each is calibrated. Operators may select any of 12 different paper speeds from 0.1 to 80 ips.

**CIRCLE NO. 396**

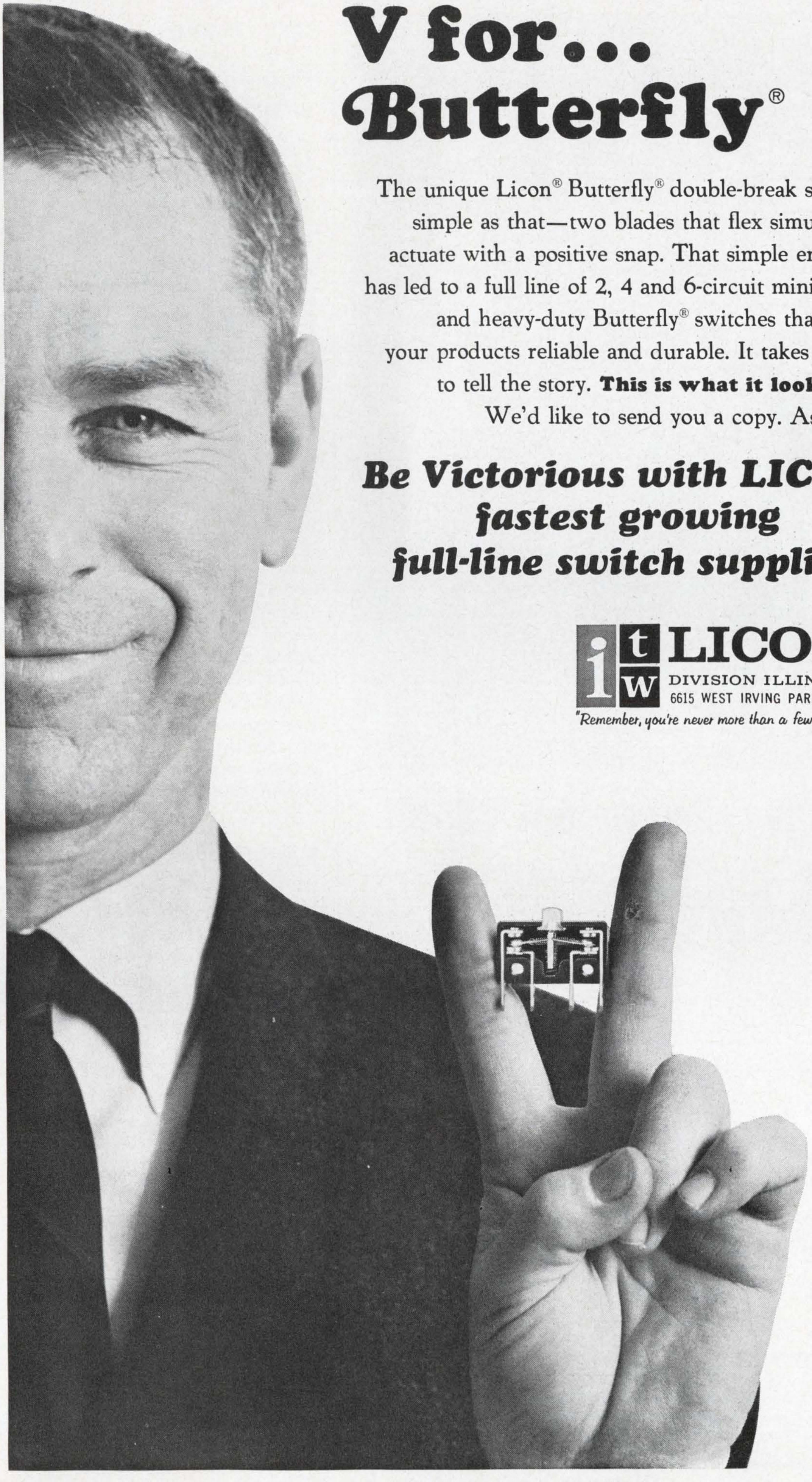
## Phase-sensitive voltmeter has high $Z_{in}$

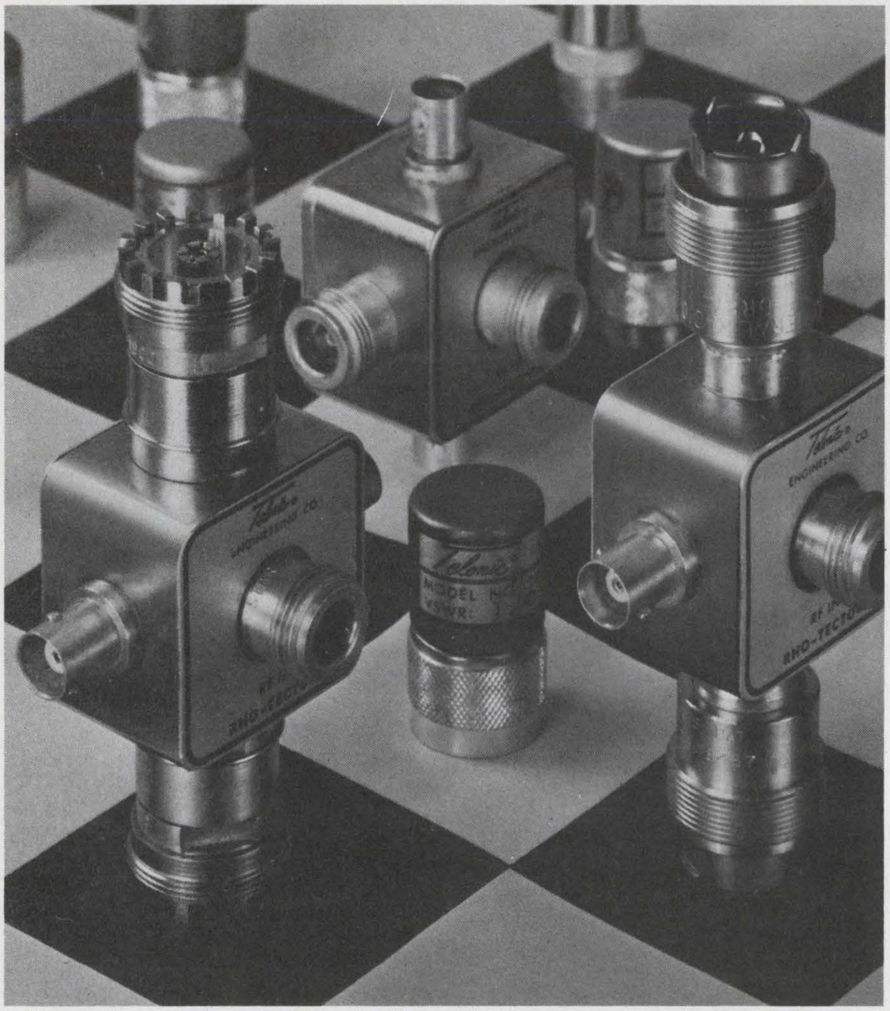


*Dytronics Co., Inc., 4800 Evanswood Dr., Columbus, Ohio. Phone: (614) 885-3303. P&A: $880; 1 wk.*

This phase-sensitive voltmeter reportedly overcomes the problem of circuit loading when using isolation transformers. It incorporates isolation transformers with an input impedance of 1.5 MΩ. This high input impedance permits floating circuit measurements without appreciable loading. It will measure in-phase voltages, quadrature voltages, total and fundamental voltages, as well as phase angle.

**CIRCLE NO. 397**





The game is called Swept VSWR

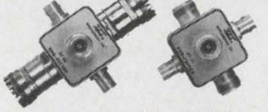
And the winner receives a fast, precise answer to a difficult test problem. Until Telonic developed the Rho-Tector impedance comparator, swept VSWR measurement was usually a fairly complex, and always an expensive, procedure. Now it's simply a matter of hooking up and reading directly from a Telonic Rho-Meter or scope display, or XY recorder at any frequency from .5 to 4000 MHz.

And what kind of accuracies can you expect from something so easy? How about 50 dB?

| Model | TRB-1 | TRB-2 | TRB-3 | TRB-4* | TRB-5 | TRB-8 | TRB-9* | TRB-10 |
|---|---|---|---|---|---|---|---|---|
| Range in MHz | .5-1000 | .5-2500 | .5-1000 | .5-1000 | 200-4000 | .5-2500 | .5-1000 | 200-4000 |
| Min. Unbalance (Return Loss) in dB | 30 | 30 | 50 | 50 | 30 | 30 | 50 | 30 |

*with ALC Detector

Complete Guaranteed Specifications in Catalog C-101. Available on request.



For a complete VSWR measuring system, Telonic provides eight Rho-Tector Models,

Microwave Terminations in 21 VSWR values, (also available in VSWR kits with Rho-Tectors) and

the Rho-Meter for direct read-out of VSWR values.

Telonic® ENGINEERING CO.
A DIVISION OF TELONIC INDUSTRIES, INC.
P.O. Box 277, Laguna Beach, California 92651 • Tel. 714-494-9401 • TWX 910-596-1320
REPRESENTATIVES THROUGHOUT THE U.S. AND OVERSEAS. FACTORY OFFICES IN MAIDENHEAD, ENGLAND AND FRANKFURT, GERMANY.

ON READER-SERVICE CARD CIRCLE 67

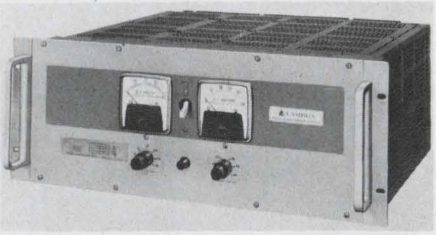
## High-impedance preamp virtually noiseless

*Servo Corp. of America, 111 New South Rd., Hicksville, N. Y. Phone: (516) 938-9700.*

A high-impedance, low-noise preamplifier measures 1.12 x 1.56 x 0.9 inches. The noise figure of the preamp at 100-Hz bandwidth is less than 1 dB with a source impedance of 1 MΩ and less than 3 dB with a source impedance of 100 kΩ. The device provides an adjustable voltage gain up to 60 dB and has a 0.1-Hz-to-50-kHz bandwidth range at 3 dB below peak. Input impedance is more than 20 MΩ and output impedance is less than 30 Ω. Maximum voltage output is 3 V rms and the voltage supply is ±15 Vdc at 8 mA.

**CIRCLE NO. 398**

## Regulated 66 A, 60 Vdc in 7-inch package

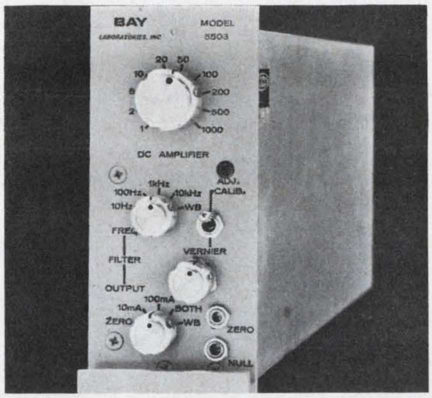


*Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N. Y. Phone: (516) 694-4200. Price: $950 and $995.*

Convection-cooled all-silicon regulated supplies rated to 60 Vdc and 66 A measure 7 inches high. The 0-to-60-Vdc model has a current rating of 0 to 25 A at 40°C, 0 to 24 at 50°C, 0 to 22 at 60°C and 0 to 19 at 71°C. Current ratings apply over the entire voltage range. Temperature coefficient is 0.15%/°C. Current limiting is settable to 105% of load. Regulation is 0.015% or 1 mV, whichever is greater, line or load.

**CIRCLE NO. 399**

## Diff-amp operates with 500-V common-mode



*Bay Laboratories, Inc., 20160 Center Ridge Rd., Cleveland. Phone: (216) 333-3898. P&A: $600 (1 to 10); 30 days.*

The series 5000 differential dc data amplifier allows operation in a direct-coupled configuration with up to ±500 volts common-mode voltage. Since choppers or modulators are not used, a bandwidth of 100 kHz is possible and output noise is reportedly free from intermodulation, hash or spikes. Other features are 120-dB common-mode ratio (1-kΩ unbalance), 50-MΩ input impedance and linearity of ±0.01%.

**CIRCLE NO. 400**

## Lock-in amplifiers find signals in noise

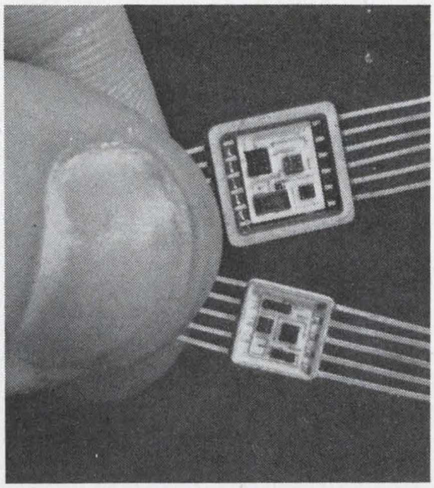
*Teltronics, Inc., P. O. Box 466, Nashua, N. H. Phone: (603) 882-6264. Price: $1795.*

Measurement of ultra-low-level signals in a high-noise environment is provided by synchronous detection techniques used in this coherent amplifier. It compares, amplifies, filters, synchronously detects and integrates a low-level signal despite high noise. The amplifier is continuously tunable over 1.5 Hz to 200 kHz with a full-scale sensitivity of 100 nV. It operates from broadband to a Q of 25 without gain change. Output is determined from a built-in meter and from output connections suited to a DVM, high-impedance recorder or recording galvanometer. Reference voltage can be obtained from an external source within a range of 0.5 to 300 V rms as well as from the internal tunable oscillator.

**CIRCLE NO. 401**

# Columbia Components Thick-film hybrids.

## Send us your specs for fast action.



The answers to your micro-packaging problems are as close as this coupon.

The hybrid circuit is a versatile tool in the hands of the design engineer faced with problems in high power ratings, thermal tracking, precision component tolerances, intermixing monolithic IC's and other interfacing circuitry and components. In applications where the design may undergo changes up to the first production article, the hybrid offers the designer freedom to institute necessary changes with minimal cost and time.

Columbia Components Corporation's Thick-Film Hybrid Circuits are capable of reproducing any given circuit without degradation in circuit functions. These hybrids also present the most economical approach to most problems.

Please sketch schematic (or print, if available) and attach.

Application

Customer Print #

Rev: Lead Forming

Is qualification acceptance required?

Is lot acceptance required?

Package style & size:

Body Material

Lead materials

MAXIMUM RATINGS

Storage Temp. Range Operating Temp.

Ambient Temp. Power Dissipation of 25°C

☐ Have your engineer call.

☐ Send descriptive literature.

| R | Value | Tol. | T.C. | Wattage | Q | Generic Type | Tol. |
|---|---|---|---|---|---|---|---|
| R1 | | | | | Q1 | | |
| R2 | | | | | Q2 | | |
| R3 | | | | | Q3 | | |
| R4 | | | | | Q4 | | |
| R5 | | | | | Q5 | | |
| R6 | | | | | Q6 | | |
| R7 | | | | | | | |
| R8 | | | | | | | |
| R9 | | | | | | | |
| R10 | | | | | | | |

| C | Value | Tol. | Rated Voltage | CR | Generic Type | Tol. |
|---|---|---|---|---|---|---|
| C1 | | | | CR1 | | |
| C2 | | | | CR2 | | |
| C3 | | | | CR3 | | |
| C4 | | | | CR4 | | |
| C5 | | | | CR5 | | |
| C6 | | | | CR6 | | |
| C7 | | | | | | |
| C8 | | | | | | |
| C9 | | | | | | |
| C10 | | | | | | |

Environmental Specifications

Military Specs., if any Frequency

Other applicable specs

Voltages

Name Title

Company

Address Telephone

City State Zip

**COLUMBIA COMPONENTS CORP.**

**A Subsidiary of Computer Instruments Corp.,**
Woodside, N. Y. 11377. Tel: (212) 726-2600

**ON READER-SERVICE CARD CIRCLE 68**

## Single-shot tests with strobing voltmeter

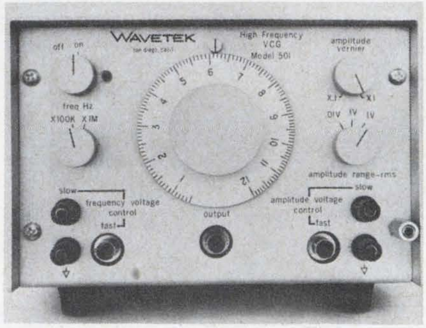
*E-H Research Labs., Inc., 163 Adeline St., Oakland, Calif. Phone: (415) 834-3030. Price: $2940.*

Model 153 strobing voltmeter is one approach to the problem of making voltage measurements on fast waveforms at precisely located points on the time axis. It uses a balanced diode-bridge gate to isolate its measuring circuitry from its 50-Ω feedthrough signal line. This gate is held closed except for the strobe period of several ns. The time location of the strobe, which opens the gate and allows signal information to reach the memory-amplifier chain, is variable by panel controls or by remote program inputs. The voltage present on the signal line at the end of the strobe pulse is passed through a memory-amplifier chain which has a voltage gain of 10 and stretches the measurement pulse to an output step with a decay constant of 250 ms. An additional amplifier block with a gain of ten, and a X10 attenuator pad allow scale factors of X1, X10 and X100.

Measurement cycle time is controlled by a fixed ramp-trigger time-block generator which effectively locks out the input trigger recognition circuit for a period of approximately 1 ms after a trigger is accepted. The standard instrument is thus essentially a single-shot device which is capable of making up to 1000 measurements a second. The design achieves excellent noise characteristics and dot-transient response by using high sampling efficiency. The amplifier-memory chain is dc coupled throughout.

**CIRCLE NO. 370**

## Volt-controlled generator ranges to 12 MHz



*Wavetek, 8159 Engineer Rd., San Diego, Calif. Phone: (714) 279-2200. P&A: $595; 60 days.*

A high-frequency voltage-controlled generator allows external voltage control of frequency and amplitude. The unit generates sine waves from 100 kHz to 12 MHz. The instrument offers control of frequency and amplitude by external voltage, either dc programing or wide-band ac frequency modulation. Output is variable from 0.001 to 1 V rms in three attenuator ranges, calibrated into a 50-Ω load.

**CIRCLE NO. 405**

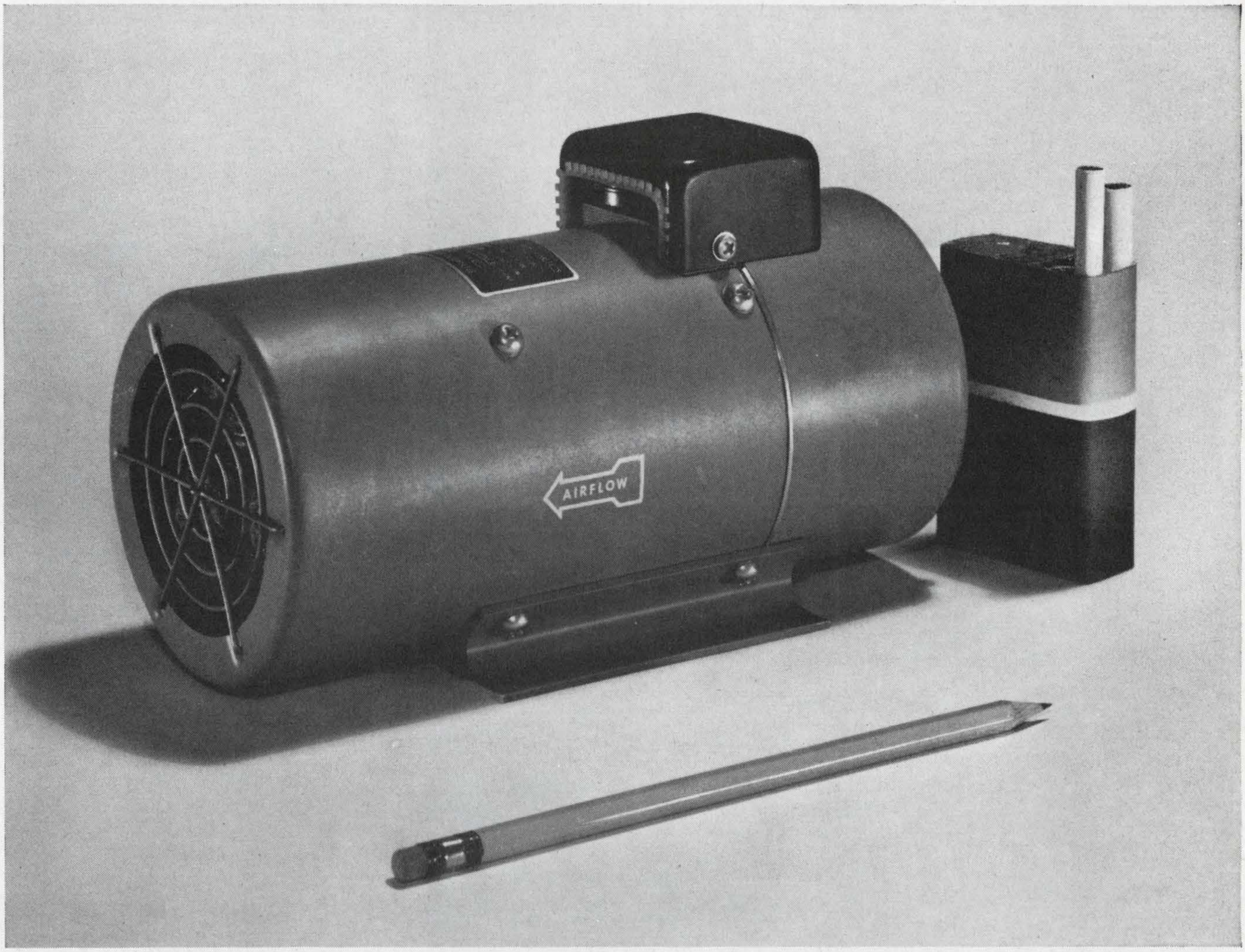
## Ac/dc voltmeter compact, portable

*Precision Standards Corp., 911 Westminster Ave., Alhambra, Calif. Phone: (213) 289-2453.*

A solid-state ac/dc voltmeter features dc accuracy of 0.02% of reading, ac accuracy of 0.2% of reading, 100-μV null sensitivity and a 6-digit in-line readout. The portable unit is available with a self-contained, rechargeable battery that provides up to 60 hours of operation. Ranges are 1100, 110 and 11 V and 1100 mVac and dc and 110 mVdc.

**CIRCLE NO. 406**

# TUNG-SOL 28 GP SERIES POWER SUPPLIES



## up to 400 AMPS. D.C. in new weight-saving package

A tremendous break-through was achieved in space and weight reduction of air-borne power supplies when the Tung-Sol Y-series configuration was first developed. Now, this unique design has been adapted to the requirements of ground-based equipment, to provide the same advantages for applications in the 100 amp. to 400 amp. range.

The Tung-Sol 28 GP series consists of four standard units that supply 100, 200, 300 or 400 amps. at 28 volts D.C. They are production items available on an off-the-shelf basis. All units embody high-performance characteristics. They have high environmental adaptability and are especially suited to seaborne installations. Important, also, is the fact that they can be mounted in any attitude. For equipment that is to be transported by air, the weight factor is an exceptional advantage.

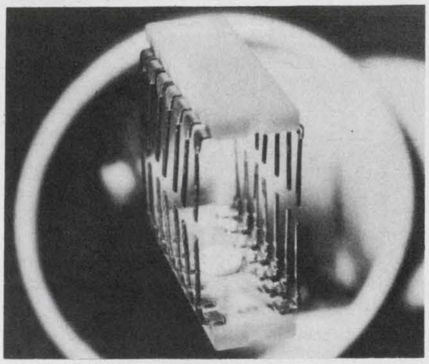
| | |
|---|---|
| **28 GP 100**<br>Output: 100 Amps.<br>Size: 8½" L x 4" W x 5⅛" H<br>Weight: 7.5 lbs. | **28 GP 300**<br>Output: 300 Amps.<br>Size: 10½" L x 6" W x 7½" H<br>Weight: 19 lbs. |
| **28 GP 200**<br>Output: 200 Amps.<br>Size: 10½" L x 5" W x 6⅜" H<br>Weight: 13 lbs. | **28 GP 400**<br>Output: 400 Amps.<br>Size: 13" L x 6" W x 7½" H<br>Weight: 26 lbs. |

**For full technical information write for Bulletin.**

**TUNG-SOL DIVISION**
**Wagner Electric Corporation**
630 West Mt. Pleasant Ave. • Livingston, N.J. 07039

ON READER-SERVICE CARD CIRCLE 70

## Aluminum bumps bond DTL ICs



*Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530.*

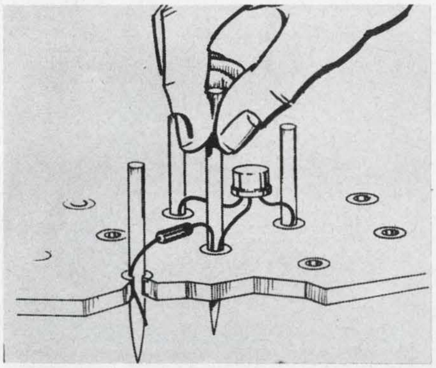
Dual-in-line packages, which incorporate a face-down bonded die, are available for Fairchild DTL elements 9930, 9932, 9945 and 9946. The Fairpak design (ED 4, Feb. 15, 1967, p. 17) employs special bonding fixtures to assemble a 14-lead microcircuit die in a single operation. Bonds are now machine-made and demonstrate uniformity.

The need for any lead frame or metal structures to be encapsulated within the hermetic seal area is eliminated. Instead, a conductive ceramic pattern (a printed ceramic circuit) is deposited on an aluminum substrate and serves as the conductor between the die and the dual-in-line type leads. This printed circuit is enclosed in the seal area instead of the leads. By this process, hermeticity on the order of $10^{-8}$ is achieved. The process permits use of existing masks. The conventional wafer diffusion and metallization goes through two additional processing steps including deposition of a glass layer over the die circuit to provide physical isolation between the circuitry on the die and the bonding pads. The second operation is the deposition of the aluminum pads. Through a vacuum deposition process, the pads are formed to sufficient thickness and diameter to permit an ultimate bond strength to the substrate of roughly five times that of the conventional wire bonded package.

Other features are equivalent thermal dissipation to eutectic die attachments, a lower package profile and a 50% weight savings.

**CIRCLE NO. 402**

## Breadboard components with pegs and pegboard

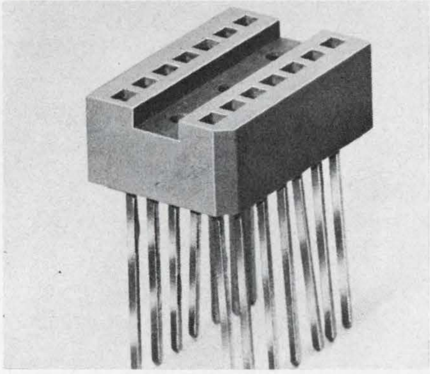


*Berkeley Applied Research Corp., P. O. Box 181, Alamo, Calif. Phone: (415) 934-0806. Price: $11.90.*

Here's a fast way of breadboarding your electronics. This 9 x 12-inch pegboard with brass eyelets spaced to accomodate electronic components comes with a supply of tapered pegs for securing component leads in the eyelets. Components can be used without preparation and are not damaged by installation.

**CIRCLE NO. 403**

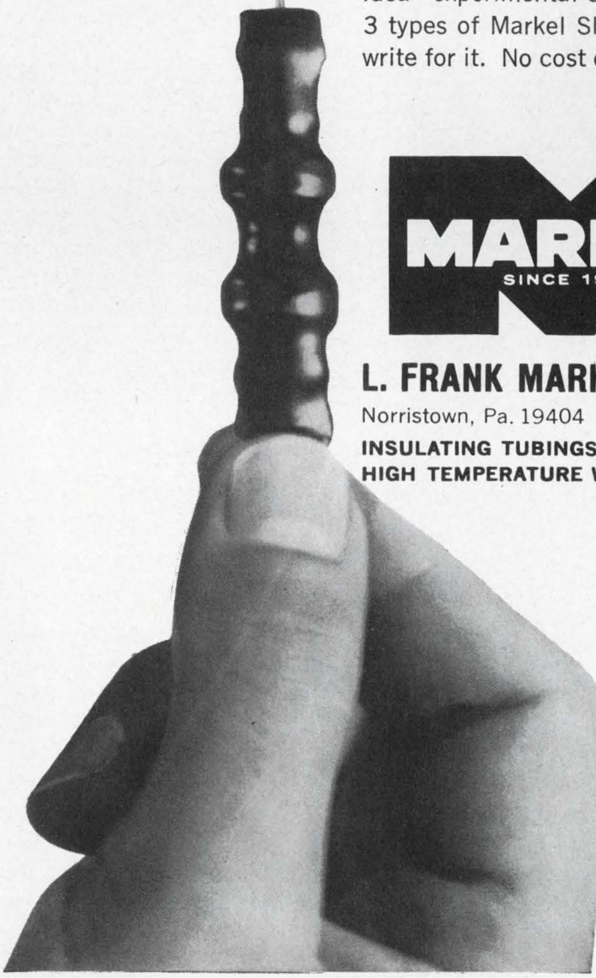
## Mounting receptacle accepts dual-in-lines



*Elco Corp., Willow Grove, Pa. Phone: (215) 659-7000.*

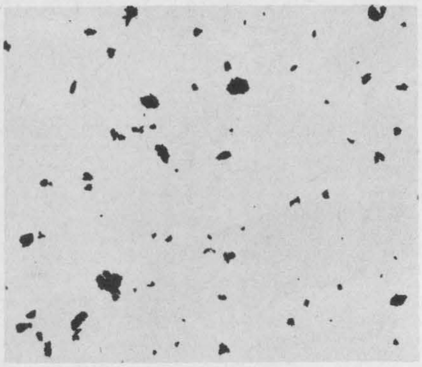
A mounting device accepts all dual-in-line packages with 14 round or blade leads. The low-profile design permits side-by-side mounting on 0.5-inch centers or in-line mounting on 0.8-inch centers. Wire-wrap contacts are double-leaf type and are made of spring-temper phosphor bronze with a gold flash over a nickel underplate. Mounting is by interference fit between contacts and PC holes.

**CIRCLE NO. 404**



**ON READER-SERVICE CARD CIRCLE 72**

## Tungsten carbide powder in submicron size



*Shwayder Chemical Metallurgy Corp., 700 E. Woodbridge, Detroit. Phone: (313) 965-4850. P&A: $9/lb.; stock.*

Submicron tungsten carbide powder can be used in composite materials and in devices requiring high emissivity. An electron microscope, using a magnification of 15,000 times, shows the high-surface-energy Mikrocarbide 77 (above) averaging one-fifth the size of conventionally produced powders. The small size of the particles, down to 0.5 micron Fisher, and its high-energy shape, showing multiple sharp edges, make this form of tungsten carbide useful to manufacturers of cermets, thermoelectric devices and high-temperature fiber composites. Tungsten carbide's high melting point, over 5000°F, and metal-carbon bond make it compatible as a heat-resistant filler in plastic bearings and heat shields.

**CIRCLE NO. 407**

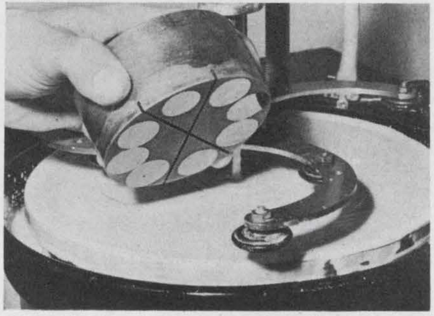
## Be-Cu alloy in thin-wall tubes

*Uniform Tubes, Inc., 1200 W. 7th, Collegeville, Pa. Phone: (215) 489-7293.*

Free-machining beryllium-copper alloy 33-25 is available as thin-wall, seamless tubing with OD from 0.01 to 0.625 inch. Wall thicknesses range from 0.05 inch to 0.0005 inch. Machining time for RF connectors and other electronic tubular parts is reportedly reduced by as much as 60% with the new alloy tubing. Electrical and spring properties of the alloys are similar to Be-Cu 25.

**CIRCLE NO. 408**

## Polishing material for wafer makers



*Geoscience Instruments Corp., 435 E. Third St., Mt. Vernon, N. Y. Phone: (914) 664-5100.*

Politex Microfin is designed for high-speed polishing of silicon wafers, laser rods, ferrites and memory substrates. The material is highly porous, practically inert and withstands the corrosive environments encountered in chemomechanical polishing systems for finishing solid-state materials. This cloth is made from a reinforced substrate of polyurethane bonded polyester, with a uniform poromeric structure similar to fine leather. The polishing cloth may be sueded, perforated, densified and textured. It is available in various thicknesses with a pressure-sensitive adhesive back.

**CIRCLE NO. 409**

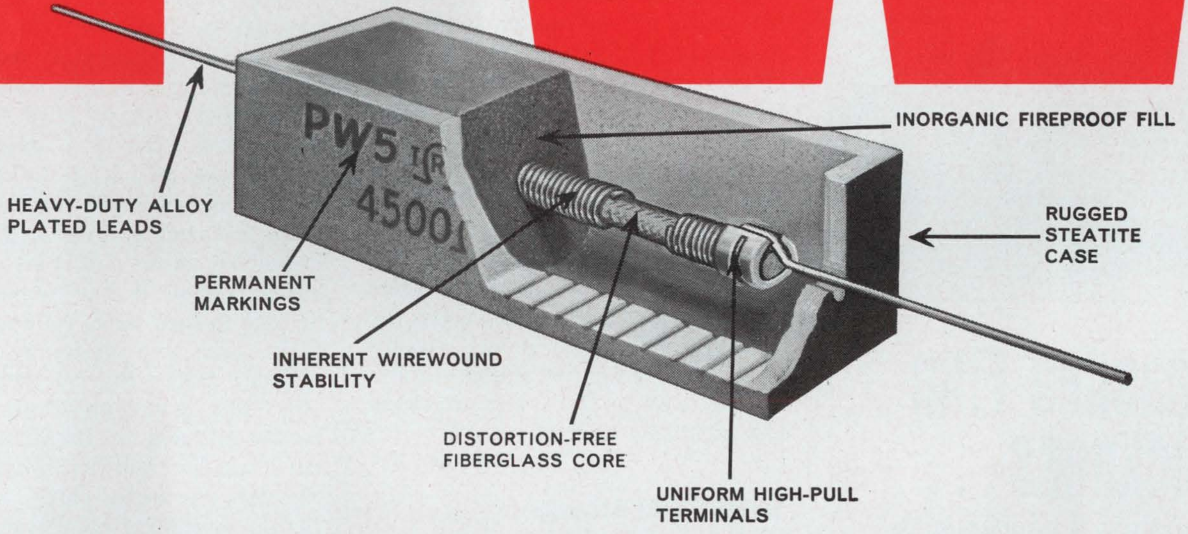
## Thin-wall wire insulated with polyethylene

*General Electric, Wire and Cable Dept., Bridgeport, Conn. Phone: (203) 334-1012.*

Thin-wall, general-purpose electronic wire is insulated with cross-linked polyethylene. The Vulkene wire can be used as replacement for PVC, silicone rubber, irradiated polyethylene and fluoroethylene types. The wire exhibits good resistance to solder damage, radiation and fungus. It lends itself to encapsulation in epoxy, polyurethane or silicone-rubber types of potting compounds. No treatment of the wire surface is required. It is rated at 600 volts, and can be used for missile and aerospace use at a conductor temperature of 125°C or for electronic use at 90°C.

**CIRCLE NO. 410**

# PW



# Protect low power circuits

## Fireproof construction...plus lowest cost per watt

Exclusive from IRC . . . a fireproof resistor that can't be matched for the price. Inorganic fireproof construction withstands high temperatures and high overloads. Ideal low-cost protection for transistor and low-power circuits in radios, TV's and industrial equipment.

High quality wire and automated assembly allow resistance values nearly 50% higher than comparably rated power wirewound units. Easily solderable axial leads for point-to-point wiring or PC board insertion.

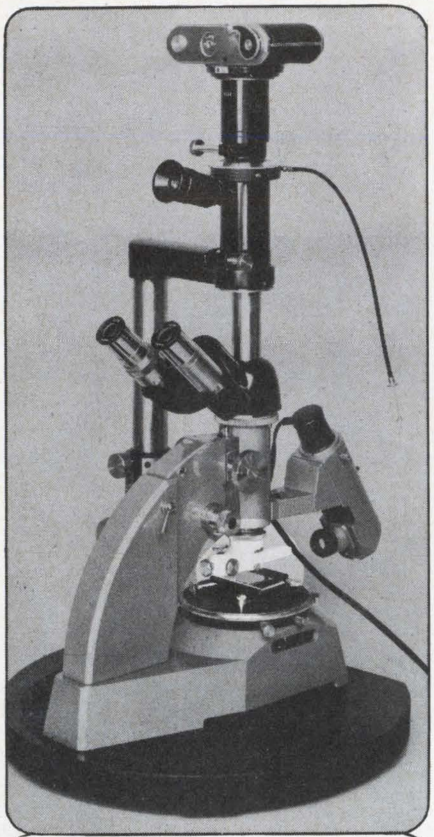
PW types are also available as fusible resistors, and with special positive temperature coefficient wire for temperature compensating applications. Write for data, prices and sample. IRC, Inc., 401 N. Broad Street, Philadelphia, Pa. 19108.

### CAPSULE SPECIFICATIONS

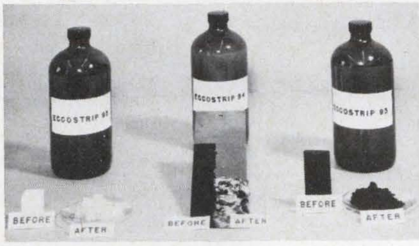
| | |
|---|---|
| RATINGS: | 2, 3, 5, 7, 10 and 15 watts |
| RESISTANCE: | 0.1 ohm to 30K |
| TOLERANCES: | |
| Standard | ±10% |
| Special | ±5% |
| TEMPERATURE COEFFICIENT: | |
| Standard | +300 to 600ppm/°C max. |
| Special | +1300 to +5500ppm/°C |

IRC

ON READER-SERVICE CARD CIRCLE 74



## Epoxy and urethane stripped chemically

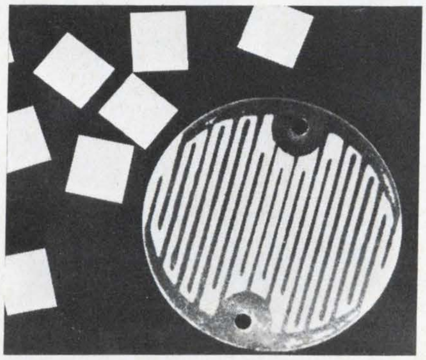


*Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. P&A: $1.50 to $2/lb; stock.*

A line of stripping agents for epoxy and urethane resins is offered. Eccostrip 57 is a general-purpose stripping agent which disintegrates many polymer systems. It is recommended for flexible epoxy systems and rigid systems that use aliphatic amine hardeners. Eccostrip 93 is useful on many hard rugged systems. Eccostrip 94 is designed for coatings up to about 1/8 inch thick and Eccostrip 95 is used at elevated temperatures for epoxy systems cured with aromatic amine hardeners, as well as for rigid urethane castings and foams.

**CIRCLE NO. 411**

## Glass-ceramics outdo alumina

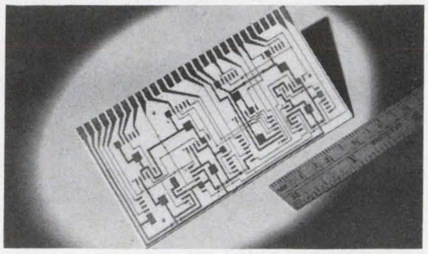


*Fusite Corp., 6000 Fernview, Cincinnati. Phone: (513) 731-2020.*

A family of glass-ceramics can be substituted for more expensive alumina in many applications without performance loss. Two types are available. One is a high-strength sealing glass with a crystalline phase. The other is a structural material unaffected by sealing temperatures. Both offer twice the thermal conductivity and mechanical strength of glass. They can be metallized and some compositions are self-glazing.

**CIRCLE NO. 412**

## Composite substrates for 3-D circuitry



*American Lava Corp., Manufacturers Rd., Chattanooga, Tenn. Phone: (615) 265-3411.*

Composite ceramic substrates permit the designer to bury metal patterns in planes in a monolithic, high-alumina ceramic and provide ready access to any level from any other level. Circuit planes can be stacked one on top of the other and connected wherever desired. Each plane is hermetically sealed from its neighbors above and below. Greater concentration in the same surface area is gained since conductors can cross over and under each other without destroying electrical integrity. The interconnections, permanently encased in alumina, are secure against unintentional shorts. Shorter electrical paths result in faster switching and lower electrical resistance. Narrow line widths, sometimes necessary to place the required number of connectors in a small device area, can be avoided by taking some of the lines through to another plane. Normal line widths are 7 mils on 14-mil centers. Line widths of 4 mils spaced on 8-mil centers converging about a chip area are feasible. Line resistance down to 10 mΩ per square or better is possible.

**CIRCLE NO. 413**

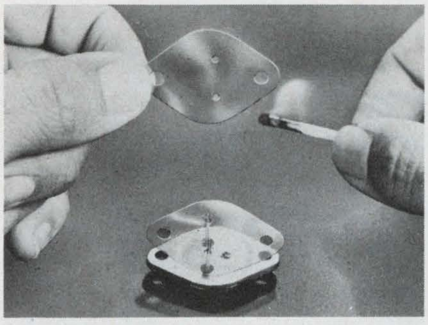
## Teflon tubing shrinks to 50% in seconds

*Penntube Plastics Co., Inc., Holley St. & Madison Ave., Clifton Heights, Pa. Phone: (215) 622-2300.*

A 2:1 heat-shrinkable Teflon FEP tubing heat shrinks up to 50% in diameter in seconds upon application of heat up to 400°F. The see-through tubing encapsulates and insulates components and won't split when shrunk on parts over full shrinkage range. It is available up to 1-inch ID.

**CIRCLE NO. 414**

## Insulating washers conduct like mica

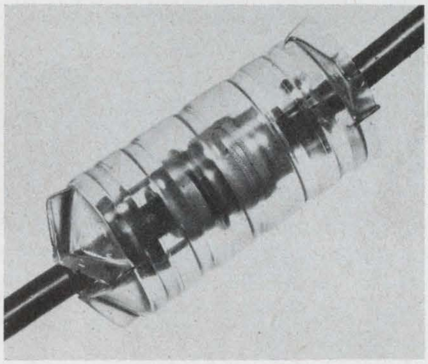


*Thermalloy Co., 8717 Diplomacy Row, Dallas. Phone: (214) 637-3333. P&A: $12/M; stock.*

Insulating washers for power semiconductors utilize a special plastic film material which has the thermal conductivity, low cost, and dielectric strength of mica washers, yet will not puncture, fracture or peel. Breakdown voltage is 7000 V/mil, temperature range is −269° to +400°C and types available are 14 JEDEC styles including TO-3, TO-36, TO-66, power epoxy, and round washers. The material is 2 mils thick.

**CIRCLE NO. 415**

## Vinyl slip-on cover protects connectors

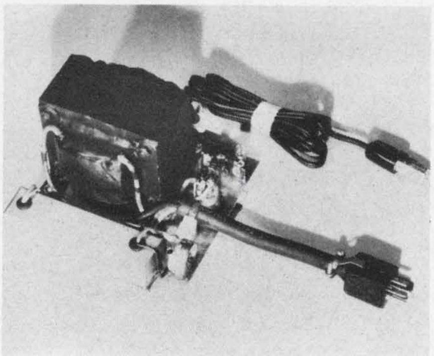


*Molded Devices, 2170 Colorado Ave., Santa Monica, Calif. Phone: (213) 393-0558.*

A protective vinyl cover for cable connectors, tube fittings, and conduit fitting protects against impact damage, scratches and nicks and prevents dust damage and contamination. It simply slips on and off the component. The guard sleeves resist ozone, salt water, and nearly all chemicals and gases. They are available in more than 30 sizes for connectors up to 3-1/2 inches OD.

**CIRCLE NO. 416**

## NiCad batteries charged to 90% in 15 minutes



*General Electric, Battery Business Section, Gainesville, Fla. Phone: (904) 462-3911.*

High-rate charging of nickel cadmium batteries to 90% of their capacity in 15 minutes, rather than the typical 16 hours, is now possible with this charging system. The fast-charge circuit charges at a high constant-current rate to a temperature-dependent cutoff voltage and then reverts to a 12-hour rate which can be sustained indefinitely. Batteries are charged at the high rate to approximately 90% of their capacity before switching to the lower rate.

The charge current is supplied by a high-reactance transformer. An SCR passes high-rate charge current until a reed switch is closed by the sensing circuit at a cutoff voltage which is governed by battery temperature. The rectifier protects the SCR gate from reverse voltage and rectified low-rate charge current. The resistor which limits SCR gate current is in parallel with another resistor, establishing the low-rate charging current.

The sensor circuit is a temperature-compensated voltage-sensitive relay made up of a reed switch and coil. Due to the low drop-out voltage of the reed switch relay, the battery will remain in low-rate charge until sensor circuit continuity is broken. Whenever continuity is re-established, the charger will again operate at the high rate until the proper cutoff voltage is reached. If the charge control should fail for any reason, the battery temperature will rise and the thermal protective device will terminate the charge.

**CIRCLE NO. 417**

Momentary or Push On, Push Off

**MINIATURE**

**Push Button Switches**

Exceptionally high current. Positive snap-action with fast make and break contacts. SPDT, DPDT & 4PDT, useable as either a Normally Open or Normally Closed switch. Silver contacts and terminals.

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WRITE!

**ALCOSWITCH**

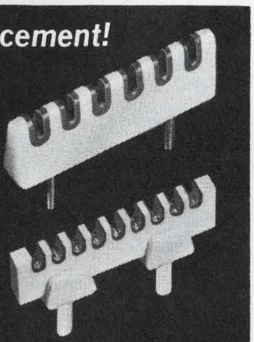
DIV. OF ALCO ELECTRONIC PRODUCTS INC., LAWRENCE, MASS.

ON READER-SERVICE CARD CIRCLE 79

Simplify Component Replacement!

**CERAMIC**

**Terminal Strips**



The uniform manufacturing of the miniature terminal strips gives the assembly a neater appearance; adds a quality look overall. Tinned copperplate on silvered ceramic facilitates soldering of components and leads. Withstands excess heat. Available with 3-5-7-9-13-16-20 terminals.

FREE
12-PAGE
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WRITE!

**ALCOSTRIP**

By ALCO ELECTRONIC PRODUCTS, INC., LAWRENCE, MASS.

ON READER-SERVICE CARD CIRCLE 80

This coupon could
help you
breathe easier.

A CHRISTMAS SEAL SERVICE

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GPO, Box 2400
New York, N. Y. 10001

Send me the free booklet, "Your Breathing Troubles: Understand Them, Face Them, Treat Them"

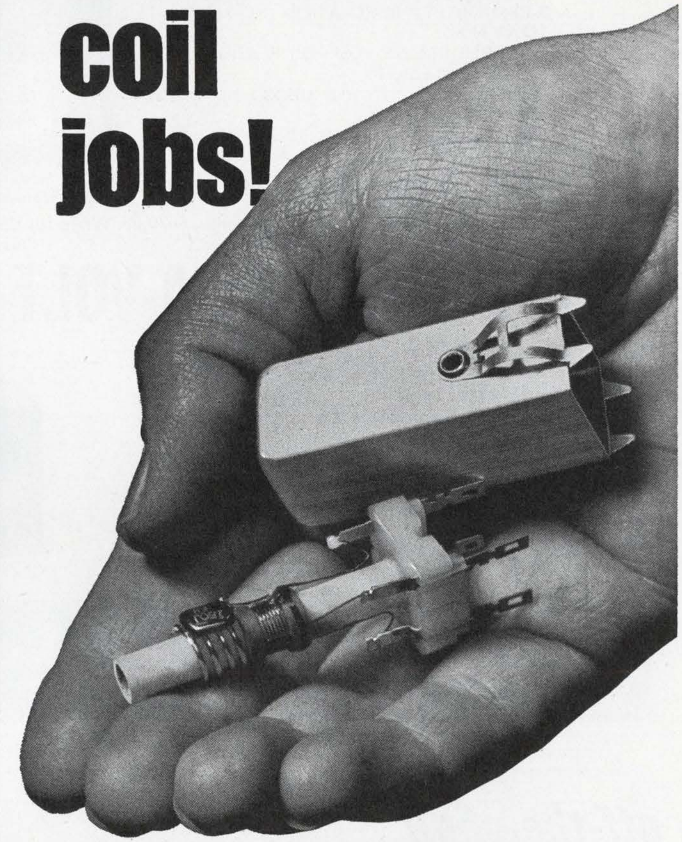
Name

Address

City State Zip Code

Free booklet published by Emphysema-Bronchitis, National Tuberculosis Association

**We'll take your tough coil jobs!**



*Sioux-produced video detector transformer. Frequency—44.75 mc. Bandwidth—11%. Trap circuit provides attenuation of at least 40 db at a point only 7% removed from the center frequency.*

AT Dale's Sioux Division we're specialists in inductive technology—sought out for our ability to make wirewound components do precision jobs in difficult sizes and configurations. Of course, we're geared for commercial production, too—but we relish the tough jobs. When your next project calls for precision inductors—or custom assemblies using inductors—get in touch with the Sioux Division. We can help every step of the way from design through production.

DALE®

**DALE ELECTRONICS, INC.**
*SIOUX DIVISION* Dept. E.D
Yankton, South Dakota

*Write for New Facilities Report*

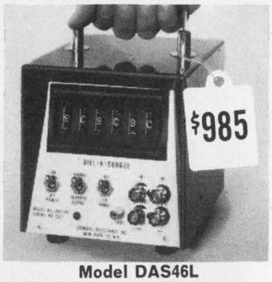
*Producers of:* Toroids, Series Resonant Traps, Variable Pitch Inductors, Miniature High Frequency Inductors, Degaussing Coils, Industrial and Military Coils, Sub-Miniature Coils, Surge & Lightning Arresters, Custom Assemblies.

ON READER-SERVICE CARD CIRCLE 81

Gen Res DIAL-A-SOURCE

(DIALABLE "ZERO IMPEDANCE" VOLTAGE SUPPLY)

- 1 PPM RESOLUTION
- SECONDARY STANDARD
- 25 M.A. (ZERO IMPEDANCE)
- 1 MICROVOLT TO 10 VOLT RANGE
- 5 PPM OUTPUT REGULATION (NO LOAD TO 25 M.A.)
- DIALABLE IN-LINE VOLTAGE READOUT
- ±10 PPM STABILITY
- FLOATING OUTPUT; 1000 MEGS ISOLATION
- REMOTE SENSING SUPPLIES .0025% CALIBRATED VOLTAGE AT THE LOAD
- NOISE AND RIPPLE LESS THAN 3 PPM OF OUTPUT OR 20 MICROVOLTS PEAK



Model DAS46L
.0025% Transportable Accuracy

Also available Model DAS46 ±.005%, $875.00. Write for Bulletin #512

Gen Res DIAL-A-VOLT

(DIALABLE VOLTAGE REFERENCE)

- D.C. VOLTAGE ACCURACY, 5 MODELS – .0015% TO .005%
- RANGE 1 MICROVOLT TO 10 VOLTS
- 6 DIAL, 1 PPM RESOLUTION
- 10 PPM STABILITY
- TEMPERATURE COEFFICIENT TO ±1 PPM/°C
- DESIGNED FOR D.C. CALIBRATION AND REFERENCE
- FINGERTIP DIALABLE CONTROL

Priced from $399.00. Write for Bulletin #407

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ON READER-SERVICE CARD CIRCLE 82

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EQUIPMENT PROTECTION

Standard Fiberglass and ABS Thermoplastic Transportation and Operating Cases

Skydyne maintains industry's most complete line of standard, off-the-shelf fiberglass and ABS thermoplastic transportation and operating cases . . . over 33 standard fiberglass cases and 29 ABS cases . . . all with published price lists. Equipment protection against every environmental hazard, including shock, vibration, and moisture, is assured with the fastest possible delivery cycle at realistic prices. Slightly modified versions of these standard cases completely conform to Military Specs.

Skydyne also can supply, with extremely fast delivery, custom designed Sandwich Panel cases from stock components to meet all Military Requirements.

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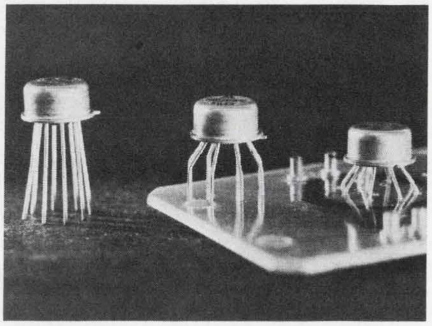
ON READER-SERVICE CARD CIRCLE 83

PRODUCTION EQUIPMENT

## Lead trimmer/former handles 500 per hour

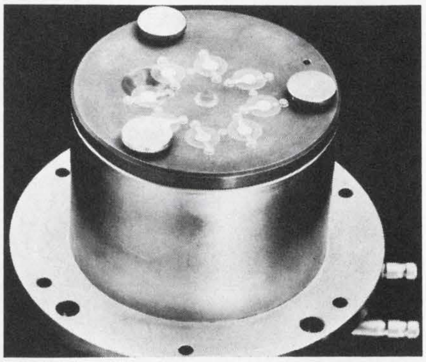


*Versitron, Inc., 6310 Chillum Pl. N. W., Washington, D. C. Phone: (202) 882-8464. Price: $275.*

A tool for forming and trimming IC leads handles TO-5 and equivalent IC modules with a 90° turn of the operating lever. The leads are angled outward to the diameter of the TO-5 housing, then directed downward, and finally sheared to a predetermined length. The resulting module stands clear of a PC board by 1/8 inch.

**CIRCLE NO. 418**

## Quartz crystal monitors thin-film deposition

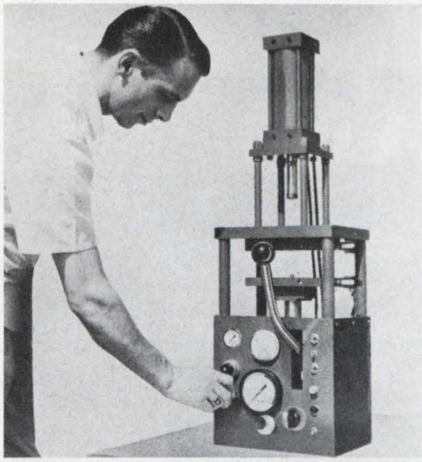


*Bendix Corp., Vacuum Div., 1645 St. Paul St, Rochester, N. Y. Phone: (716) 342-0400.*

Quartz crystal monitors for thickness measurement during vacuum deposition combine fast response and high stability. The monitor provides twin instrumentation for the measurement and control of both film thickness and deposition rate. It operates on the principle of the frequency change of a crystal as the thickness of the evaporated film increases. Easily changed crystal holders cooling (shown above) permit an increase in frequency stability by a factor of 30.

**CIRCLE NO. 419**

## Transfer molding press for soft-flow epoxy



*Morris Enterprises, Inc., 16799 Schoenborn St., Sepulveda, Calif. P&A: $1450; 6 wks.*

A compact molding machine is designed for use with inexpensive aluminum (hand) molds and soft-flow epoxy molding compounds. The press is designed for the encapsulation of components such as transformers, coils, and semiconductors, or for molding cups, cases, lead forms and terminal blocks. The JD-11 molding press features a 5-ton hydraulic clamp, fully adjustable air transfer system and front panel gauges that indicate hydraulic ram force in tons and psi, air transfer pressure and top and bottom platen temperatures.

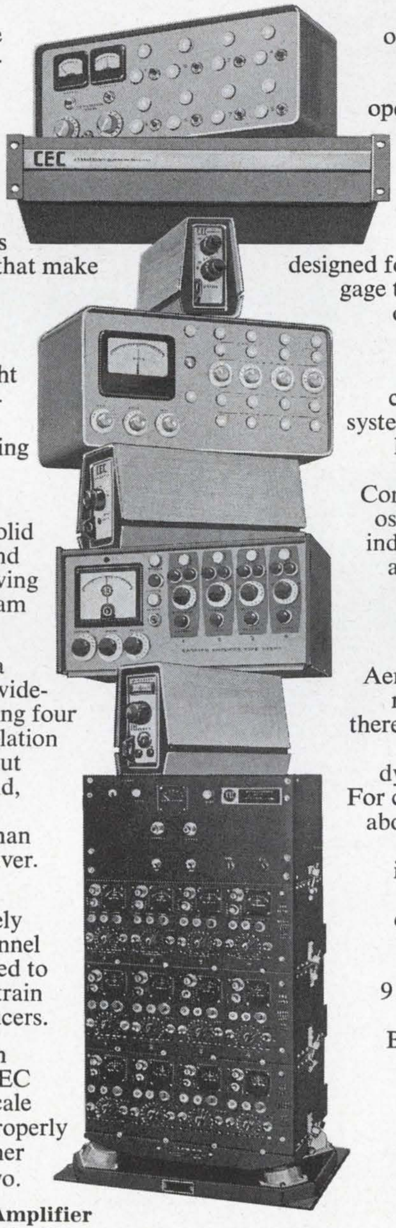
CIRCLE NO. 420

## Soldering tools have coated tip

*E. V. Roberts & Associates, Inc., 9601 West Jefferson Blvd., Culver City, Calif. Phone: (213) 870-9561.*

A miniature soldering tool has coated tips that allow extended soldering operations without loss of heat content of the tip caused by dressing of the soldering face. The tool has a 1/8-inch tip shaft diameter, a 610°F tip face temperature and a 12-W rating. It offers two types of coated tips. One is sealed against effects of flux fumes, preventing waste of shank and freezing of the tip in the barrel due to oxidation of exposed copper. The second has an additional heavy coating on the soldering face.

CIRCLE NO. 421



# If your signal conditioners don't stack up...

# CEC has the ones that do.

In other words, a *complete line* of dc and ac signal conditioning equipment specifically created to do the job at a realistic price. Furthermore, this wide range of instruments assures a compatible match with virtually any transducer device being used today.

Now add the advantage of single-source responsibility from event to readout, and you know why so many users prefer to come to CEC.

Taking it from the top, here are some highlights about the conditioners that make up our "signal tower":

**8-108 Bridge Balance** provides coupling between as many as eight strain gages or resistive-bridge-type pickups and any suitable recording or indicating device.

**1-162A Galvanometer Driver Amplifier** is a solid state, low-gain, wideband power amplifier for driving high frequency light beam galvanometers.

**1-165 DC Amplifier** is a differential, high-gain, wideband instrument featuring four terminals to provide isolation between input and output and circuitry and ground, thus offering greater application versatility than a single-ended galvo driver.

**1-118 3 KHz Carrier Amplifier** is a completely self-contained four-channel carrier amplifier designed to amplify the output of strain gages and other transducers.

**1-163 DC Amplifier** can match and deflect all CEC galvanometers to full scale rated deflection, plus properly damp and drive any other available recording galvo.

**1-127 20 KHz Carrier Amplifier** raises the level of small signals produced by resistance-bridge or variable-reluctance-type transducers to a level suitable for operation of companion CEC galvanometers.

**3-140 Voltage Supply**—a solid-state, precision power source specifically designed for excitation of strain gage transducers and other devices requiring a dc excitation voltage.

**System D** is a multi-channel, dual-purpose system incorporating both linear-integrating and carrier amplifiers. Consequently, any single oscillograph record can indicate strain, pressure, acceleration, vibration and other physical phenomena.

**APPLICATIONS**
Aerospace, industry and medicine... wherever there is a need to acquire, measure and display dynamic or static data. For complete information about any or all of these signal conditioning instruments, call your nearest CEC Office, or write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Bulletin Kit #307-X5.

**CEC**

DATAGRAPH PRODUCTS

**BELL & HOWELL**

ON READER-SERVICE CARD CIRCLE 84

**FOR MARKING PRODUCTS OF ANY SIZE, SHAPE, OR FINISH.**

**When you mark more than a few — but less than a lot, with changing words and/or numbers.**

1/16 ABC123
3/32 ABC123
1/8 ABC123
5/32 ABC12

**NO SCREWS TO LOSE, NO TOOLS TO USE.**

Note the man-size winding adjustment button that controls the clamps quickly, easily and holds type in perfect alignment. No need to fiddle with screws, tools, or troublesome attachments.

| BAKELITE TYPE HOLDER "A" (Type Styles to Fit) | BAKELITE TYPE HOLDER "B" (Type Styles to Fit) |
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Set type easily, change it speedily, lock it in. It aligns automatically. Type is engraved, deep-kut vinylite, acid-resistant, clog-free — lasts indefinitely. Markings are razor-sharp and permanent. Inks available in all colors.

*These low priced sets are available by mail only, from:*

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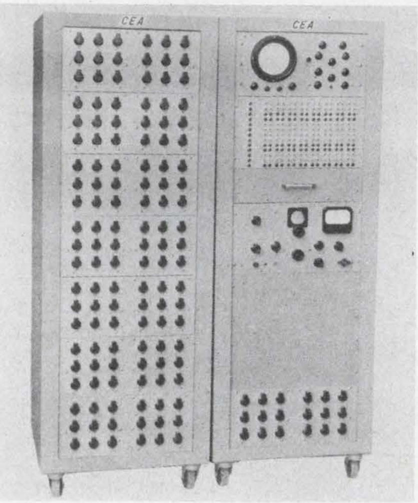
**ON READER-SERVICE CARD CIRCLE 85**

Cool your "overheat" problem! Get the Littelfuse miniature heat fuse for thermal overload protection. 7/8" long x 7/64" dia. Fully insulated. Crimp style connections.

**LITTELFUSE**
DES PLAINES, ILLINOIS

**ON READER-SERVICE CARD CIRCLE 86**

## Computer designs passive filters



*CEA Div. of Berkleonics, Inc., 1221 S. Shamrock Ave., Monrovia, Calif. Phone: (213) 359-9261. Price: $10,000 to $100,000.*

A filter design computer can simulate simple and complex filters with up to 125 discrete passive elements. It includes built-in voltage sources and readout devices. The computer can be programed and response data obtained in minutes. The average-size model is housed in two 6 x 9-ft. portable racks and requires minimal power with no air-conditioning and no peripheral equipment. This system simulates complex filters with up to 48 discrete passive elements.

**CIRCLE NO. 422**

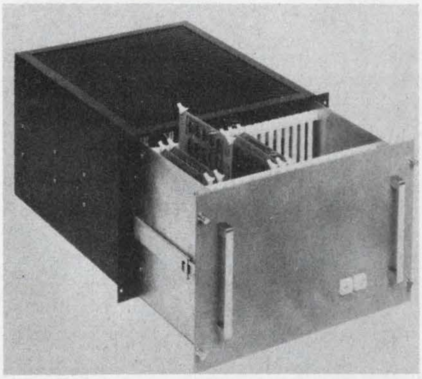
## Military core memory easy to maintain

*Information Control Corp., 1320 E. Franklin Ave., El Segundo, Calif. Phone: (213) 322-6930.*

Military random-access core memory systems are organized to be expandable from 512 words to 8192 words, and from 4 bits to 24 bits. The memory is a 4-wire coincident-current system using 22-mil lithium ferrite cores. It can be operated in clear/write, read/restore, read/modify write and read only modes. Full cycle times are 1.5 μs. Interface characteristics are compatible with DTL and TTL IC output voltages. The 8192-word x 10-bit memory utilizes less than 100-W prime power.

**CIRCLE NO. 423**

## Digital data adapters control 8 serial circuits

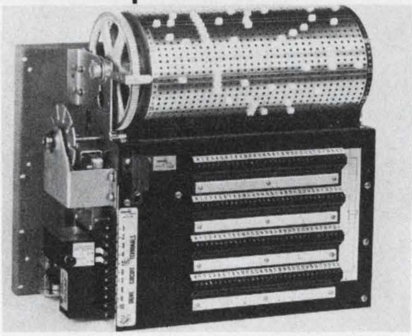


*Western Telematic, Inc., 5507 Peck Rd., El Monte, Calif. Phone: (213) 442-1862.*

These multichannel digital data communications adapters control up to 8 complete and independent serial data circuits including serial-deserializer, vertical and longitudinal parity checking, dataset control and externally selected operating modes. The TM series is specifically designed for 5- to 8-level codes. Each channel serializer flags and synchronizes its internal register to transfer a parallel character from the processor.

**CIRCLE NO. 424**

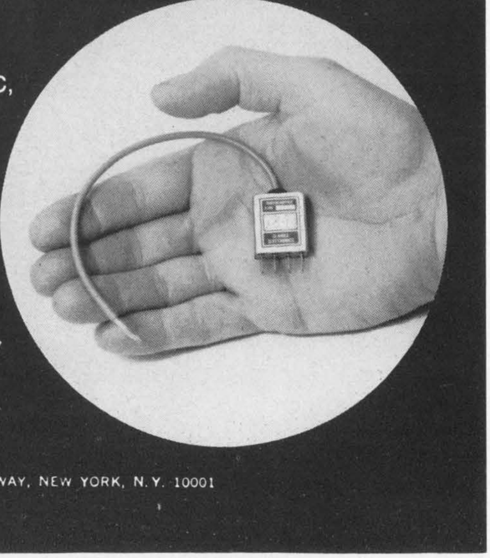
## Stepping drum programs 400 steps/minute



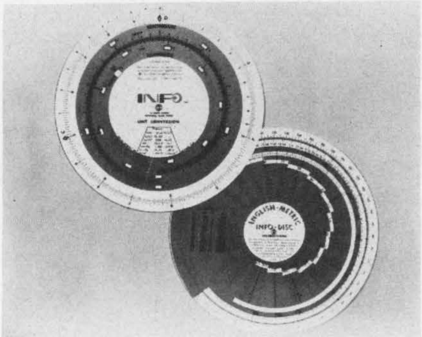
*Tenor Co., P. O. Box 2766, Milwaukee. Phone: (414) 781-4800.*

High-speed drum programers can sequence at up to 400 steps per minute. This programer is available in models with 16 to 93 output switches operating through 30, 60 or 100 steps. It is a pulse-actuated, motor-driven switching device which automatically sequences operations according to a preset program. The program pattern is established by inserting switch-actuating plugs in the drum.

**CIRCLE NO. 425**



# Design Aids



## English-to-metric rule

Fast, accurate conversion between inches and millimeters in graduations of thousandths or 64ths from 0 to 12 inches are made in a single setting of this calculator. A table gives values for converting up to 1000 inches and 100 feet. The back features a Fahrenheit-to-Centigrade temperature scale that converts to the nearest degree from absolute zero to 6332°F. A conversion factor table gives 70 common conversions for length, area, volume, pressure, power and weight.

*Available for $4.50 from Info Inc., 13 Boyd St., Newton, Mass.*

## Cryogenic copper data

Ten graphs summarize the cryogenic performance of OFHC and AMZIRC copper. The data show that tensile and yield strengths, elasticity, elongation, notched tensile strength and fatigue properties all increase substantially when temperatures are lowered to 4°K. The data is drawn from research programs conducted at the NBS and other institutions to determine what extreme cold does to properties of materials and how induced changes can be used in devices intended for operation in the cryogenic range. Metals Refining Div., American Metal Climax, Inc.

**CIRCLE NO. 426**

## Electrolyte evaluation chart

Thirty-five different metals and alloys with recommended electrolytes to produce light or dark marks are tabulated on this chart. The chart also includes the type of current necessary and general comments. Wall-hung, it is a handy reference. Electromark Corp.

**CIRCLE NO. 427**

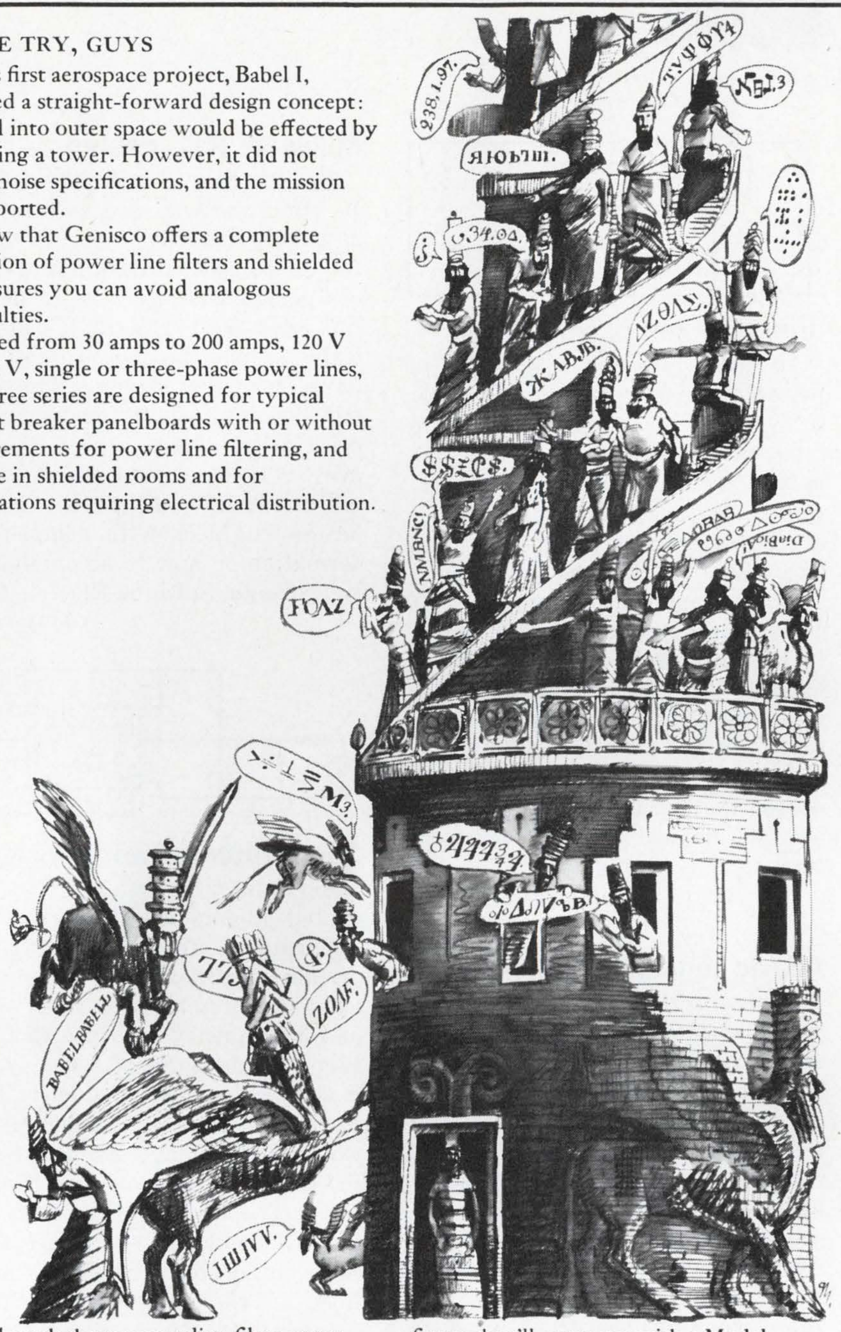
# Chapter VI. *The Word from GENISCO.*

## NICE TRY, GUYS

Man's first aerospace project, Babel I, utilized a straight-forward design concept: Travel into outer space would be effected by climbing a tower. However, it did not meet noise specifications, and the mission was aborted.

Now that Genisco offers a complete selection of power line filters and shielded enclosures you can avoid analogous difficulties.

Rated from 30 amps to 200 amps, 120 V to 250 V, single or three-phase power lines, the three series are designed for typical circuit breaker panelboards with or without requirements for power line filtering, and for use in shielded rooms and for installations requiring electrical distribution.



Although these power line filter assemblies meet MIL-F-15733, we do not recommend their use in towers extending beyond terrestrial limits. This application is not approved by The Chief Design Engineer.

**ON READER-SERVICE CARD CIRCLE 121**

## DIDJA HEAR THE ONE ABOUT THE BI-PLANAR NAB 14″ REELS?

Seems like there's this Model 10-276 magnetic tape recorder for aircraft, shipboard, or field portable use. Now, it has this low inertia capstan drive motor, and 6 speed selectable servo to eliminate belts, pulleys, and like that. And get this: no pinch rollers and solenoids to create flutter and skew! Well, these Genisco guys are making a mint on the thing, but they figure they'll come out with a Model 10-286 with 14″ instead of 8.5″ reels for customers who need longer record time! Then they go and stack the reels in a bi-planar configuration to save space. The funny thing is it works great. Not much of a story maybe, but they sure are nice tape recorders.

**ON READER-SERVICE CARD CIRCLE 122**

## EARN BIG $$$$ AS A TELEMETRY PERSON !!!

Now you can learn telemetry in the privacy of your own home! Take this free aptitude test NOW!

1. (T) (F) A telemeter is what they put on the back of the TV to find out what you watch.

2. (T) (F) A telemetering checkout station is where you sign out for a telemetering.

Congratulations! You've just won our free correspondence course! Naturally you'll now want a Model A-180 or A-186 completely portable ground station. The A-180 completely de-multiplexes any standard FM/FM Signal. Ideal for checkout of airborne or sledborne applications. The A-186 has fourteen stunning channels. Its receiver is continuously tunable over the 215MC to 260MC band. So get on the road to success! Buy some of our telemetry stuff.

**ON READER-SERVICE CARD CIRCLE 123**

## WHEEP! WHEEP! WHEEP!

As your missile speeds downrange you are secure in the knowledge that its electro-explosive device can be armed only by the precise signal you alone can send.

Or, horror of horrors, by an unfiltered random burst of identical frequency and duration.

As perspiration beads your brow you feel a sudden fondness for Genisco, renowned experts in RF hazard testing. How nice of them, you think, to have in stock or to design just the filters for the RFI and EMI protection my firing circuits need.

By golly, you conclude, next one of their ads I see I think I'll just

**ON READER-SERVICE CARD CIRCLE 124**

## IT JUST KEEPS ROLLIN', KEEPS ON ROLLIN' AROUND.

Going round and round is our new Model 1147 rate-of-turn table's main trick. It keeps at it no matter how much you abuse it.

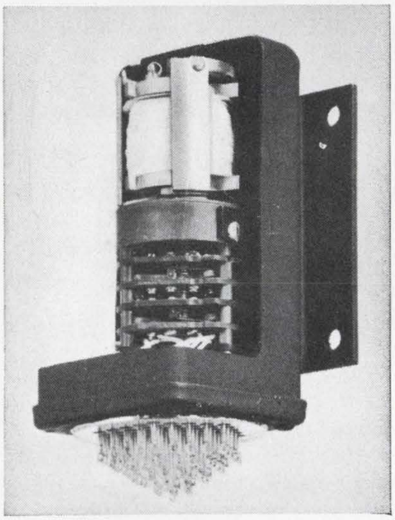
Hydrostatic bearings give precise dimensional stability, excellent alignment, low runout and eccentricity, low mechanical noise, and long happy life. It rotates smoothly at less than sidereal rates (0.004°/sec.). And it's just as smooth up to 1500°/sec. Which is why particularly brilliant (and handsome) engineers picked it as the AGE gyro test table for the F-111 Aircraft System.

Great for the lab or just to tote around de field.

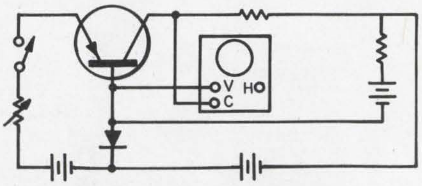
**ON READER-SERVICE CARD CIRCLE 125**

GENISCO TECHNOLOGY CORPORATION
18435 SUSANA ROAD
COMPTON, CALIFORNIA 90221

**ON READER-SERVICE CARD CIRCLE 121 THRU 125**



# Application Notes



## Junction temp calculation

In order to ensure reliability in power transistor circuits, it is necessary that the maximum junction temperature remain below the maximum rated value. The calculation of the junction temperature under steady-state conditions is relatively simple. However, in many switching applications, short pulses of very high power are encountered. In this discussion, a simple method (above) for calculating instantaneous maximum junction temperatures under pulsed conditions is presented. This calculation makes use of the concept of "thermal capacity," defined as the energy in watt-seconds stored per °C. Delco.

**CIRCLE NO. 428**

## Ac/dc converter design

Design considerations for high-speed, wideband, ac-to-dc converters are detailed in an 8-page note. The paper is oriented to the requirements of ac-to-dc converters at the input of high-accuracy digital voltmeters. Particular attention is paid to questions of frequency response, settling time, stability, accuracy and convenience. The discussion deals primarily with the average-responding converters used to extend the measuring power of DVMs from dc volts to ac volts. Dana Laboratories, Inc.

**CIRCLE NO. 429**

## Peak, rms and average power

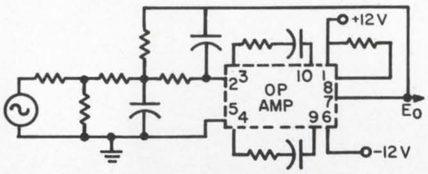
A discussion of modulation envelope shapes and their effect on RF power measurement is the subject of a 4-page application note. The essay treats cw, AM, SSB, and pulsed RF transmissions, comparing the peak envelope power and average heating power with eight examples. Bird Electronic Corp.

**CIRCLE NO. 430**

## Milliwatt RTL design

Design rules for milliwatt RTL IC logic elements are covered in a 20-page application note. It defines the terms used in design and develops design rules for use in designing logic with mW RTL elements. Explanations are also presented for noise margins, propagation delay and power consumption along with descriptions and applications of mW RTL elements. Data sheets for each mW RTL device furnish the design engineer with complete information on how to accomplish the logic design. Sprague Electric Co.

**CIRCLE NO. 431**



## Servo-filter network design

Servo-filter design using an integrated op-amp is described in this application note. The WC 161 operational amplifier used as an active low-pass filter has a gain of 54 dB and a frequency response to 15 Hz. Since the designer of servo systems must consider the frequency bandpass of the error signals, this network is particularly suitable for use in guidance and control applications. The design of a servo filter network is one such application. The complete design procedure is outlined in the 4-page note. Curves, schematics and tables aid the discussion. Westinghouse, Molecular Electronics Div.

**CIRCLE NO. 432**

## Vhf diode tuner design

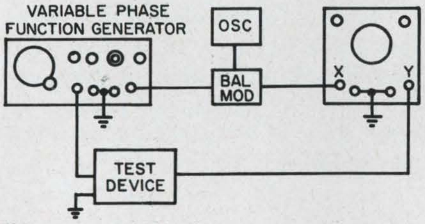
This bulletin describes a vhf tuner which is designed with two silicon transistors and two variable capacitance diodes. The necessary supply voltage is 9 V. For tuning through the receiving range (87 to 104 MHz) the tuning voltage is varied from 4 to 20 V. The eight-page discussion includes schematics, charts and necessary design equations. Telefunken Sales Corp.

**CIRCLE NO. 433**

## Common-coupling problems

The circuit engineer is confronted with the common-coupling problem in any amplifier design which involves high gain and wide bandwidth. Common coupling, a conducting feedback mechanism due to parasitic circuit elements, can introduce amplifier performance faults of poor stability, low gain, reduced bandwidth and distortion of the band-pass and phase responses. The microcircuit can provide the gain and bandwidth performance of a complete discrete circuit amplifier to make terminal connections to ground, supply, source and load significantly more sensitive to parasitic inductances of the leads. To illustrate a practical approach to this problem, calculated limitations of lead inductance are established for a broadband monolithic microelectronic amplifier. Equations, charts and schematics aid the development of the design. Philco/Ford Microelectronics.

**CIRCLE NO. 434**

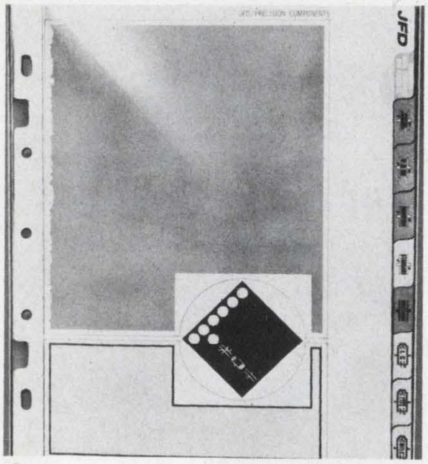


## Phase-shift measurements

An 11-page application note describes techniques for making phase-shift measurements at frequencies ranging from 60 kHz to lower than 0.01 Hz. The note discusses how the phase delay encountered by a signal in passing through the device under test, such as a servo system, is measured by oscilloscope comparison with the variable phase output of a variable-phase function generator. The bow-tie method shown above is one example. A method of overcoming flicker in the scope display at very low frequencies is also described and illustrated. Hewlett-Packard, Loveland Div.

**CIRCLE NO. 435**

# New Literature



## Components compendium

This "non-catalog" components catalog is a modular information storage and retrieval system. Presented at one time is the full spectrum of the manufacturer's component capabilities and details on product lines. Covered in the brochure is product information including piston trimmers, air-variable capacitors, ceramic variables, standard capacitors, fixed capacitors and miniature tuners. Each product contains formatted data sheets with photos, drawings, and specifications. As a general design aid, the book is a reference file of tables, charts, formulas and nomographs used by the design engineer. JFD Electronics Co.

**CIRCLE NO. 436**

## Recorder selection

A 20-page bulletin makes it easy to select the most suitable recorder for your application. Applications including measurements of volts, amperes, power factor, watts, frequency, motor horsepower output or speed are covered. The manual includes a guide for specifying and applying recorders. Graphs are shown for plotting load trend data and converting kW input to horsepower output of a motor. They show how to tabulate the following data in less than one minute: systems kW, kVAR, power factor, kVA and the rating of capacitors required to change the system power factor. General Electric.

**CIRCLE NO. 437**

## Printed-circuit design

This 16-page technical booklet describes techniques for the design and production of printed circuits and assemblies for high-reliability applications. It covers such design/production considerations as manufacturing methods, how to select electroplates, hints for specifying dielectric base materials and eyelet vs plated-through holes in two-sided circuit patterns. Charts illustrating current-carrying capacities, performance characteristics of base materials, and a table giving applications and properties of plated coatings are included. Industrial Circuits Co.

**CIRCLE NO. 438**

## Infrared radiometry manual

Information describing the theory and practical application of radiometric measurements using infrared techniques is contained in this bulletin. The theory of emitted radiation, its measurement, and spectral filtration techniques for wideband or monochromatic measurements is described, along with radiometric techniques for the conversion of surface radiance into temperature information without contact with the surface. Huggins Laboratories, Inc.

**CIRCLE NO. 439**

## Electronic counters

A 24-page catalog contains information on frequency counters, timers, preset controllers, frequency difference meters, D-to-A converters and algebraic data comparators. Performance and mechanical specifications along with prices are included. Atec, Inc.

**CIRCLE NO. 440**

## Magnetic shielding alloys

This brochure gives the engineer and designer a choice of shielding alloys over a range of coercive forces. It includes magnetization as well as attenuation curves to optimize the choice of foils and sheet materials. Primec Corp.

**CIRCLE NO. 441**

## RF shielded chambers

This folder describes the construction and performance of various types of RF shielded chambers. It lists the typical insertion loss vs frequency achievable with each type of construction. The shielding effectiveness against magnetic fields, electric fields and plane waves is shown. Emerson & Cuming, Inc.

**CIRCLE NO. 442**

## Electronics cements

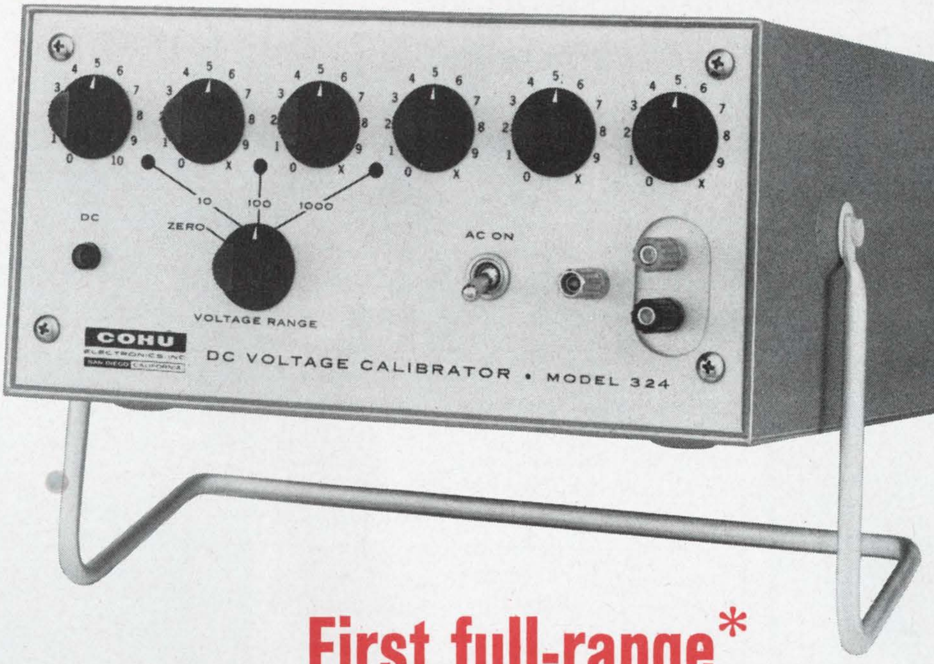
Cements for the electronics industry are described in a four-page technical data bulletin. It lists and describes the applications and characteristics of 40 cements, lacquers and enamels. Maas & Waldstein.

**CIRCLE NO. 443**

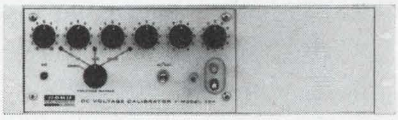
## Tantalum capacitor data

"Parameters of Tantalum Capacitors—Physical, Electrical and Chemical" is a 40-page book of 5 articles. They are: "Introduction to Tantalum Capacitors," "Types of Tantalum Capacitors," "The Parameters of Tantalum Capacitors," "Tantalum Capacitor Fundamentals" and "Applications." Each article provides an easy-to-use reference. Also included are a number of helpful graphs, photographs and illustrative diagrams, which help define the operating characteristics of tantalum capacitors.

*Available on company letterhead from Tansitor Electronics, Inc., West Rd., Bennington, Vt.*



# First full-range* DC Voltage Calibrator with .01% accuracy for under $1000 –



# Cohu's new Model 324!

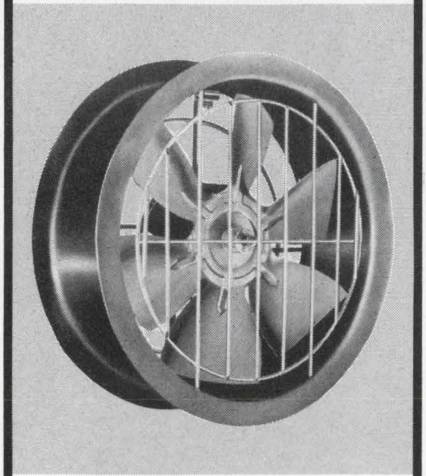
| | |
|---|---|
| *Output voltage ranges: | 10-V Range: 0 to 11.11110 volts (10 $\mu$V steps)<br>100-V Range: 0 to 111.1110 volts (100 $\mu$V steps)<br>1000-V Range: 0 to 1111.110 volts (1 mV steps) |
| Output current capability: | 0 to 25 milliamperes nominal at any voltage setting. |
| Accuracy: | 0.01% of setting. |
| Stability: | Within 30 PPM for 24 hours, 50 PPM for 30 days. |
| Dimensions: | Cabinet: 10½″ W x 5¼″ H x 15½ D.<br>Rackmount: 19″ W x 5¼″ H x 15½ D. |
| Price: | Cabinet (324): $995. Rackmount (324R): $1050.<br>F.O.B. San Diego. Additional export charge. |
| Delivery: | Immediate, from stock. |

For full details, contact your Cohu engineering representative.

COHU
ELECTRONICS, INC
SAN DIEGO DIVISION

Box 623
San Diego, California 92112
Phone: 714-277-6700

ON READER-SERVICE CARD CIRCLE 92



## Operational manifolds

A brochure describing operational manifolds—analog instruments for breadboarding, computing, modeling, measuring and on-line controlling—has been released. The units are designed for applications in instrumentation, on-line analog data processing, circuit development experimentation and for teaching feedback technology. Circuit diagrams of typical applications are also included along with descriptions of accessory kits for connection hardware, computing components and 15-contact uncommitted plug-in boards. Philbrick Researches, Inc.

**CIRCLE NO. 444**

## NiCad battery data

A reference catalog on rechargeable nickel-cadmium batteries and cells is offered. The brochure lists information in tabular form, and gives specifications on dimensions, weights, capacities and charging rates. The data cover commercial sealed cells, commercial aircraft batteries, military aircraft batteries, special-purpose batteries and high-reliability space batteries. Sonotone Corp.

**CIRCLE NO. 445**

## Coil winding machinery

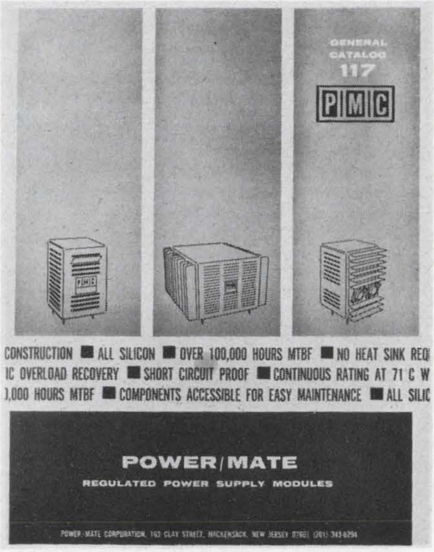
This 68-page catalog has data on machines for coil winding needs in high production, prototype or laboratory applications. A page of winding formulas and a page describing a high-speed wire scraping machine is included. The catalog also contains data on 22 tensions and 6 counters and 9 pages devoted to tailstocks, accessories and optional equipment. Stevens Mfg. Co., Inc.

**CIRCLE NO. 446**

## Microwave equipment

A 16-page catalog describes microwave receivers, transmitters, mixer-preamps, linear, log IF, RF and microwave amplifiers. The catalog contains information on 270 individual models and series. Photos, curves, specifications and block diagrams illustrate the equipment. RHG Electronics Lab.

**CIRCLE NO. 447**



## Power supply catalog

A 16-page volume lists thousands of power supply modules. It covers mechanical data pertaining to the power supplies along with connections, impedances, weights and accessories. Power/Mate Corp.

**CIRCLE NO. 448**

## Kit and instruments catalog

A 36-page catalog featuring a line of 200 electronic kits and factory-assembled instruments is available. The fields of CB, ham, and shortwave communications, mono/stereo hi fi, test instruments for education, lab, hobby, electronic technicians, and industry are covered. An easy-to-build professional-component project is also included. EICO Electronic Instrument Co., Inc.

**CIRCLE NO. 449**

## 36-page diode brochure

A thirty-six page catalog on controlled avalanche rectifiers and Zener diodes includes information on lead materials, applications, mounting, derating and reliability. A new reliability specification, HR-201, is contained in the volume. Unitrode Corp.

**CIRCLE NO. 450**

## 88-page module catalog

An 88-page catalog contains information on solid-state modules and related equipment. The volume lists specifications, schematics, applications and prices for the logic modules. BRS Electronics.

**CIRCLE NO. 451**

## ZIP code guide

Are you doing your marketing by mail? This "Guide to ZIP Coding" can help. The 24-page illustrated booklet contains information for bulk mailers. It describes the fundamentals of ZIP coding, procedures for bundling and stacking, post office sorting and post office mailing-list services and contains a third-class postage cost comparison along with other important facts. Major multi-ZIP-coded post offices are listed. Addressograph Multigraph Corp.

**CIRCLE NO. 452**

## Catalog of coil forms

A 36-page catalog describing ceramic, resinite and Velvetork coil forms is available. PC board and bushing-mounted coil forms covered in the catalog permit operation over a frequency range extending to 300 MHz. The brochure gives dimensional drawings, specifications and prices for coil forms with diameters from 0.162 to 0.5 inch. Contained are specifications and prices for 13 series of commonly used adjustable RF coils. J. W. Miller Co.

**CIRCLE NO. 453**

## Radiation detectors

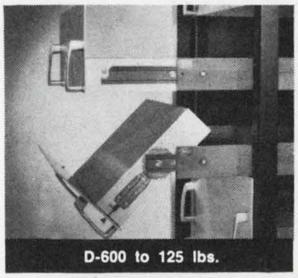
This 12-page reference guide describes neutron and gamma radiation detectors. It contains specifications and schematics for each detector type, with a brief technical discussion of theory and application. Also included are charts showing the operating ranges for each detector type, and a diagram telling where and how each type should be used. Westinghouse Corp.

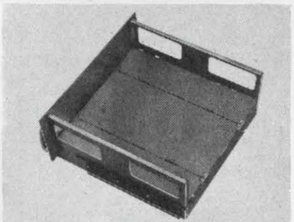
**CIRCLE NO. 454**

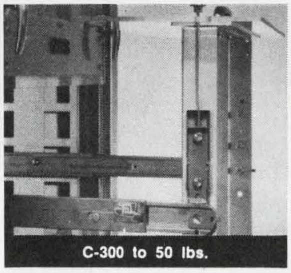
## Galvanometer strips

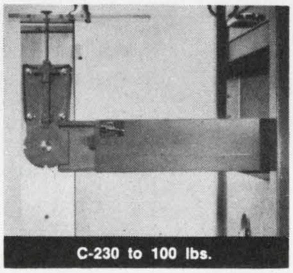
An alloy of 10% nickel/90% platinum with high tensile strength and resistance to corrosion is described in a bulletin which outlines its basic advantages. It contains information on suspension vs pivots, apparatus for measuring torque, pendulum mass, etc. It also includes two comparative tables on platinum/10% nickel band strip and 14K gold suspension strip. Sigmund Cohn Corp.

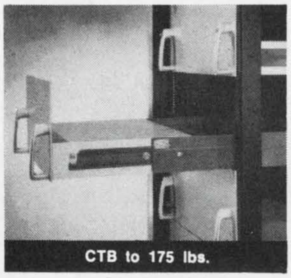
**CIRCLE NO. 455**

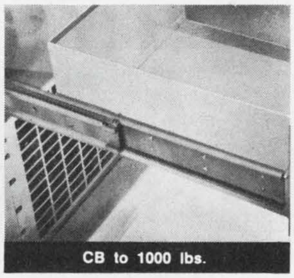

D-600 to 125 lbs.

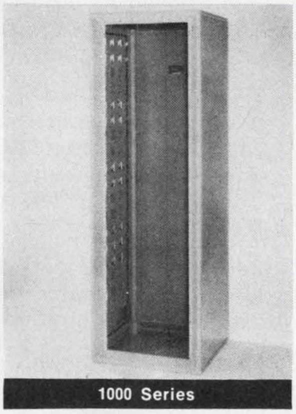

VENT-RAK Modular Chassis

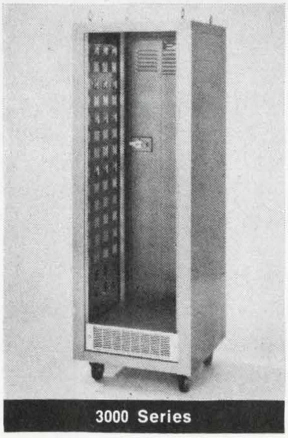

C-300 to 50 lbs.

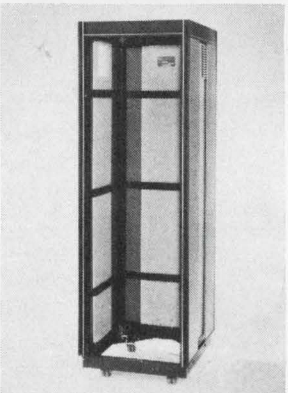

C-230 to 100 lbs.


CTB to 175 lbs.

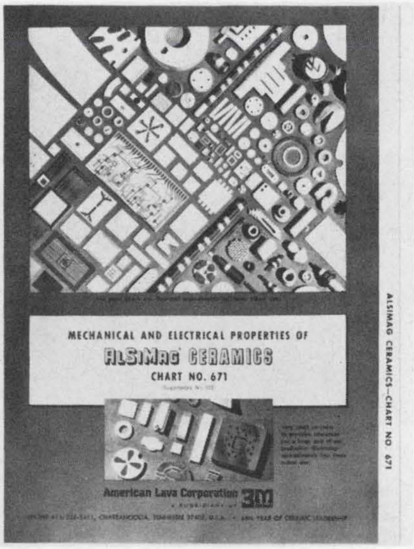

CB to 1000 lbs.


1000 Series


3000 Series


5000 Series


5050 Series



MECHANICAL AND ELECTRICAL PROPERTIES OF ALSIMAG CERAMICS CHART NO. 671

American Lava Corporation 3M

ALSIMAG CERAMICS—CHART NO. 671

## Ceramics for electronics

Properties of 27 ceramics are tabulated in this fold-out chart. Mechanical, electrical, thermal, chemical and other characteristics are included. American Lava.

**CIRCLE NO. 456**

## Solenoid data

Complete and up-to-date facts on solenoids are contained in this 36-page catalog. A valuable feature is an article which outlines the four factors involved in getting best performance from a solenoid. These are work requirements vs solenoid capabilities, operating temperature and duty cycles, methods of increasing life expectancy, and electrical requirements and power limitations. Guardian Electric Manufacturing Co.

**CIRCLE NO. 457**

## 128-page antenna catalog

A 128-page catalog gives product information and engineering data on microwave, uhf, vhf and telemetry antennas, flexible coaxial cables and elliptical waveguides, and switching and pressurization equipment. Also included are system accessories such as radomes, positioners and telescoping masts. Andrew Corp.

**CIRCLE NO. 458**

## MIL-spec ac fans

A bulletin describing compact MIL-spec ac fans is available. It gives dimensional and performance data for 115-Vac, 60-Hz 1-phase units. Globe Industries, Inc.

**CIRCLE NO. 459**

## Fluidic technology

A booklet describing Corning's fluidic devices is available. The publication begins with an introduction to fluidics followed by text and photos describing the material used to make the devices. The devices, discrete and integrated, are made of a glass-ceramic material that withstands nuclear radiation, corrosive liquids and gases, and physical shock and vibration. Corning Glass Works.

**CIRCLE NO. 460**

## Solar energy converters

A brochure describing solar energy converters includes descriptions of the cell structure, functions of the converter, applications and uses, cell characteristics and design data and specifications. Illustrated diagrams on voltage-current, spectral response and output variation with temperature complete the presentation. Sensor Technology, Inc.

**CIRCLE NO. 461**

## High-voltage test equipment

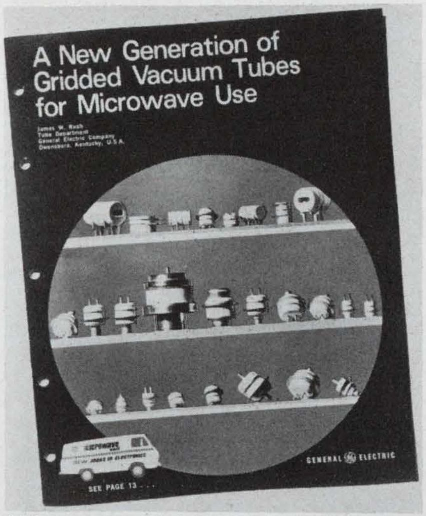
A catalog illustrating high-voltage equipment contains technical data, photos, prices and delivery information. Included in the volume are 1-to-300-kV ac and dc power packs, power supplies and test sets for dielectric strength, breakdown, leakage, corona and continuity tests. Peschel Instruments, Inc.

**CIRCLE NO. 462**

## Reliability evaluation

A 67-page booklet describing methods for evaluating contractor reliability programs describes the key factors which make a reliability assurance program effective. It gives specific criteria for evaluating each of fourteen reliability program areas. The description of criteria for evaluating each reliability task is directed toward fundamentals and should be of use to contractors and subcontractors in aerospace and other industries which employ reliability assurance programs.

*Available for $3 (NASA SP-6501) from Clearinghouse, Springfield, Va. 22151.*



### Microwave vacuum tubes

"A New Generation of Gridded Vacuum Tubes for Microwave Use" describes the GE family of gridded ceramic planar tubes. The illustrated publication provides a summary of the required electrical and mechanical features of gridded tubes designed to work into the higher microwave frequencies. Introductory pages cover the electrical and mechanical requirements of advanced radar equipment. The brochure goes on to describe the ceramic planar tubes. The brochure also includes detailed application notes, with full coverage of oscillator and amplifier tube/cavity combinations. General Electric Co.

**CIRCLE NO. 463**

### Thermistors and varistors

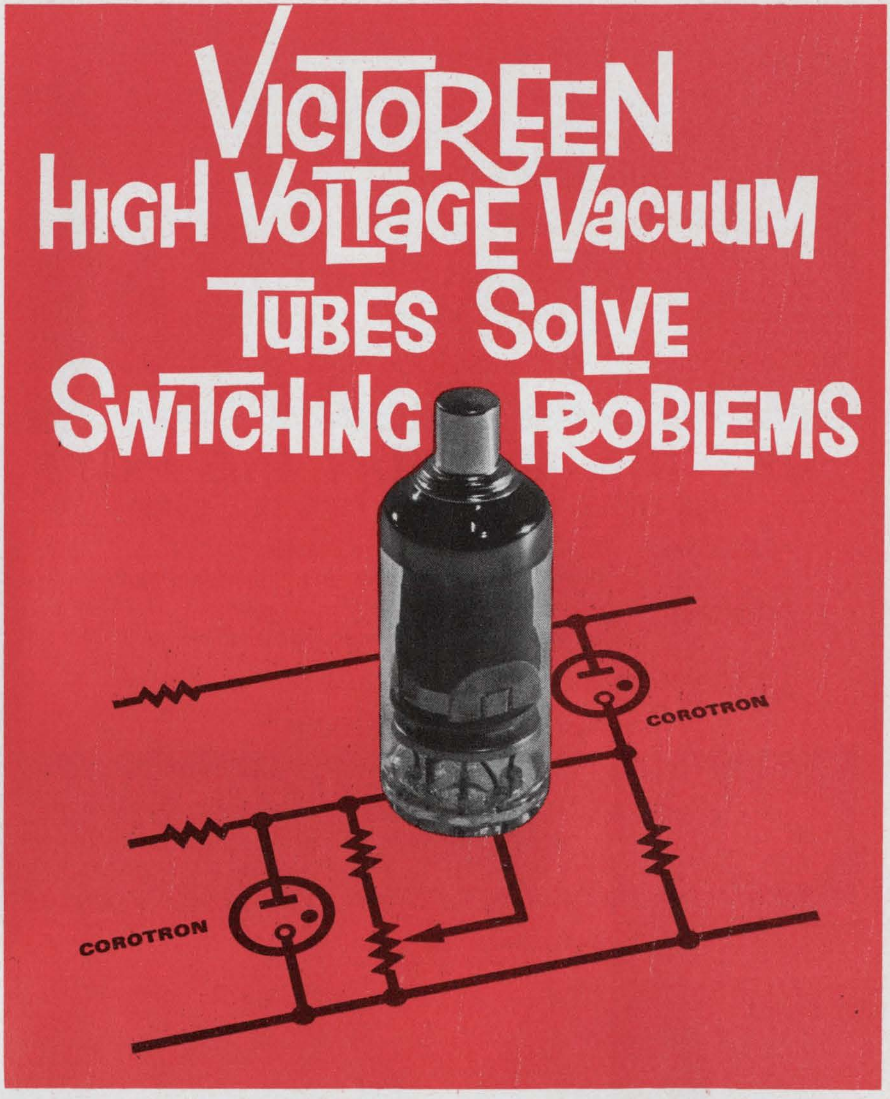
A selection of frequently used thermistors, varistors and assemblies are covered in this catalog. Included are technical data covering resistance-temperature characteristics, dissipation and time constants, electrical properties, dimensions and other operating and performance characteristics. Victory Engineering Corp.

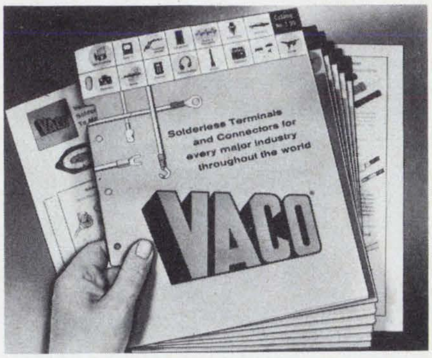
**CIRCLE NO. 464**

### Rotary stepping switches

A 36-page catalog describes a line of rotary stepping switches. The brochure gives specs and application information as well as mounting data on each type of switch. It concludes with sections on hermetic and protective enclosures, and reference data. Automatic Electric Co.

**CIRCLE NO. 465**





## Terminal selection

Consisting of 28 pages, this catalog gives instructions for the selection and use of the correct terminals and the correct crimps to assure good terminations or splices for every wiring need. Vaco Products Co.

**CIRCLE NO. 466**

## Pushbutton switch catalog

A 22-page catalog describes a line of pushbutton switches. The brochure contains information and illustrations on the modular design of these switches. It also describes the basic module elements, module functions and assemblies as well as accessories. Mechanical, electrical and environmental specifications are included in the catalog as are dimensional drawings for three basic series of switches. Centralab.

**CIRCLE NO. 467**

## Metal-clad laminates

Design information and materials data for PC boards are contained in an 8-page brochure which describes metal-clad laminated plastics. Included in the discussion are thin-film laminates and prepregs for multilayer circuitry along with a brief note on laminates clad with electro-deposited nickel foil. Synthane Corp.

**CIRCLE NO. 468**

## PC connector catalog

This 64-page guide describes and illustrates a line of printed circuit connectors, enclosures and installation equipment. Described are suggested applications, mounting data, PC card layouts and specifications. The catalog covers plug-and-receptacle and card-edge connector types. Elco Corp.

**CIRCLE NO. 469**

**Electronic Design**

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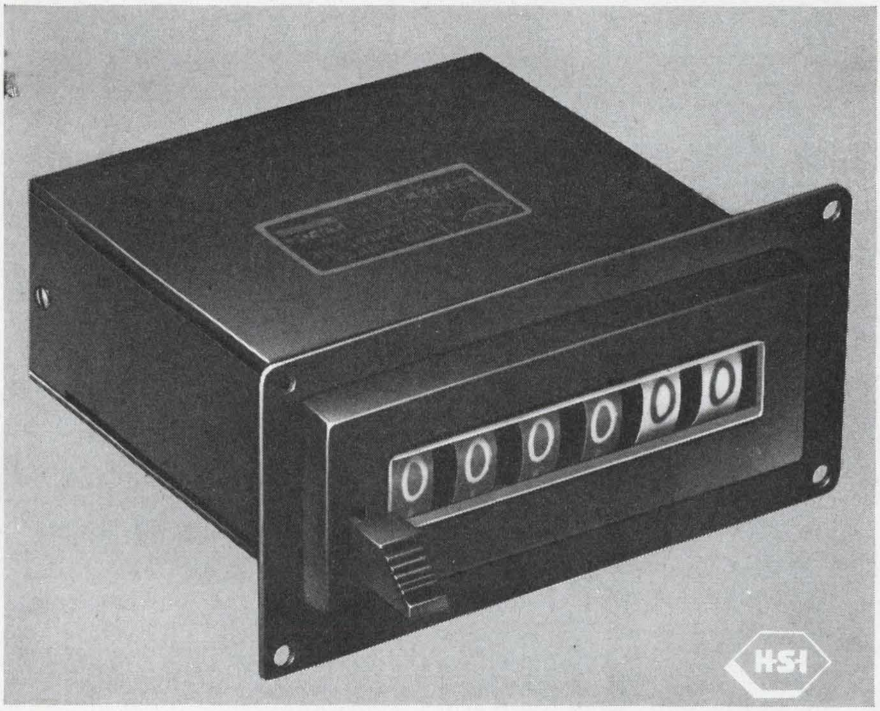
AMERICAN BUSINESS PRESS, INC.



# Advertisers' Index

Electronic Design 6

## Electronic Design

ELECTRONIC DESIGN's aim is fourfold. It aids progress in the electronics manufacturing industry by promoting good design. It gives the electronic design engineer concepts and ideas that will make his job easier and more productive. The magazine serves as a central source of timely, up-to-the-minute electronics information. And finally it seeks to encourage two-way communication between manufacturer and engineer.

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**We strive for accuracy.** We take the utmost pains to ensure the highest standard of accuracy throughout the magazine. A single mistake in practical design information can have serious consequences. But to err is human, and for all the care we take, an occasional error slips through. Whenever this occurs, we publish a correction at the earliest opportunity. You will find these corrections printed at the end of the Letters column. If you should spot an error, be sure to let us know. You may save your colleagues heartaches.

**Microfilm copies are available** of complete issues of ELECTRONIC DESIGN that have been published since the beginning of 1961, and of single articles. Complete issues cost 4¢ a page, individual pages cost 50¢ each; shipping and handling charges are extra. The minimum charge is $3; delivery time runs from 10 days for single pages to five weeks for complete issues. For further details and to place orders, get in touch directly with University Microfilms, Inc., 300 N. Zeeb Road, Ann Arbor, Mich. 48106; telephone (313) 761-4700.

**Want to contact us?** If you have any inquiries about these or other matters, or if you have a manuscript outline or article idea, address your correspondence to:

Howard Bierman, Editor,
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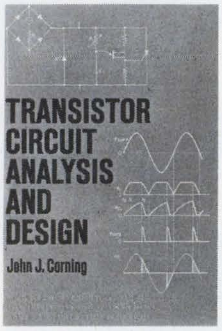
# Design Data from

## Transistor Circuit Analysis And Design



Quickly see how to apply circuit analysis principles to *design circuits* with the specific performance attributes you want. You get discussions of a broad scope of circuits in detail—d-c bias techniques, a-c equivalent circuits, small and large signal amplifiers, frequency effects, high frequency amplifiers, oscillators, pulse circuits and power supplies. Written by John J. Corning, Manager of Monolithic Circuit Packaging Engineering at IBM, 448 pp., pub. Sept. 1965. Send for your 15 day examination copy by circling the number to the right.

**Prentice-Hall, Inc.**
**Englewood Cliffs, N. J. 07632**

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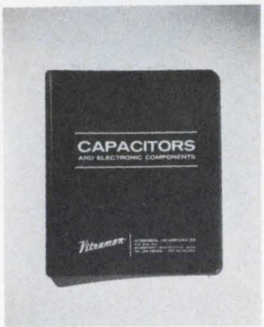
## Capacitor and Component Catalog



This catalog features the 20 standard "VY" Porcelain and "VK" Ceramic Capacitor series and components offered by Vitramon, Inc. Each series is featured on individually removable data sheets containing photos, diagrams, specifications, ordering instructions, and typical curves. A handy selector locates the exact component you need. Included are 5 new products; special *Thin Line,* high current and voltage, chip, wafer, high reliability capacitors; and other high quality, monolithic series. 60 pages.

**Vitramon, Incorporated**
**P. O. Box 544**
**Bridgeport, Connecticut 06601**

**175**

## Equipment Under Test Sign

Bright red and white signs to attach to equipment while it is under test to forestall accidental interference are available from POWER/MATE CORP., Hackensack, N. J. The company is offering these heavy cardboard signs along with their new Power Supply Module Catalog No. 117. The Catalog lists all of the many supplies available from PMC. The package will also include information about their new Uni-88—a 0-34 volt, 1.5 amp. supply that sells for only $88.00. Racks and other accessories are also available. Write today.

**Power/Mate Corp.**
**163 Clay St.**
**Hackensack, N. J. 07601**

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# Manufacturers

*Advertisements of booklets, brocnures, catalogs and data sheets. To order use Reader-ServiceCard.*

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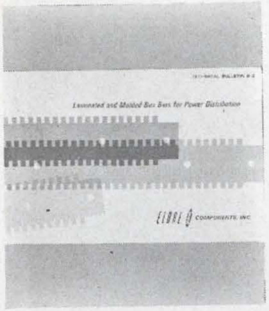
## Laminated and Molded Bus Bars For Power Distribution



A 16 page Technical Bulletin is now available, describing a new concept in power distribution. Basic mechanical and electrical design principles, along with descriptive pictures and diagrams, are included in this bulletin. These compact buses can replace bulky cable harnesses and repetitive wiring for computer or modular application. This method of construction satisfies the demanding requirements of low inductance and resistance of high speed, solid state systems, while controlling electrical noises.

**Eldre Components, Inc.**
1239 University Avenue
Rochester, New York 14607

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## New "Tape Lift" Printed Circuit Drafting Aids

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DRAFTING AIDS
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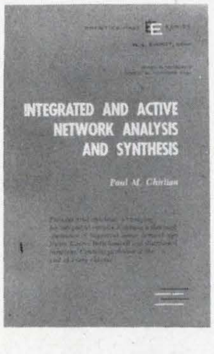
## Intgd. & Active Ntwk. Anlys. & Syn.



INTEGRATED AND ACTIVE NETWORK ANALYSIS AND SYNTHESIS
Paul M. Chirlian

Integrated and active network analysis and synthesis, shows you the latest techniques for handling difficult circuit design problems.

Covers lumped and distributed networks and gives you fully worked out examples for every synthesis procedure. Written by Paul M. Chirlian, approx. 416 pp., pub. May 1967. Send for your 15 day examination copy by circling the number to the right.

**Prentice-Hall, Inc.**
Englewood Cliffs, N. J. 07632

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# Designer's Datebook

JUNE

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| 23/30 | 24/31 | 25 | 26 | 27 | 28 | 29 |

For further information on meetings, use Reader Service card.

**June 6-8**
**Microwave Exposition/67** (New York City) Sponsors: Microwave Expositions, Inc., and Hayden Publishing Co.; M. Meisels, Hayden Publishing Co., 850 Third Ave., New York, N. Y. 10022.

CIRCLE NO. 470

**June 6-8**
**Conference on Laser Engineering and Applications** (Washington, D. C.) Sponsors: IEEE; L. Winner, 152 W. 42 St., New York, N. Y. 10036.

CIRCLE NO. 414

**June 13-15**
**National Electronic and Packaging Conference (NEP/CON)** Sponsor: Electronic Packaging and Production Magazine; M. Kiver, Industrial and Scientific Mgt. Conf., 222 W. Adams St., Chicago, Ill. 60606.

CIRCLE NO. 471

**June 19-20**
**Microelectronics Symposium** (St. Louis) Sponsor: IEEE; T. F. Murtha, Conductron-Missouri, P. O. Box 426, 2600 N. Third St., St. Charles, Mo. 63301.

CIRCLE NO. 472

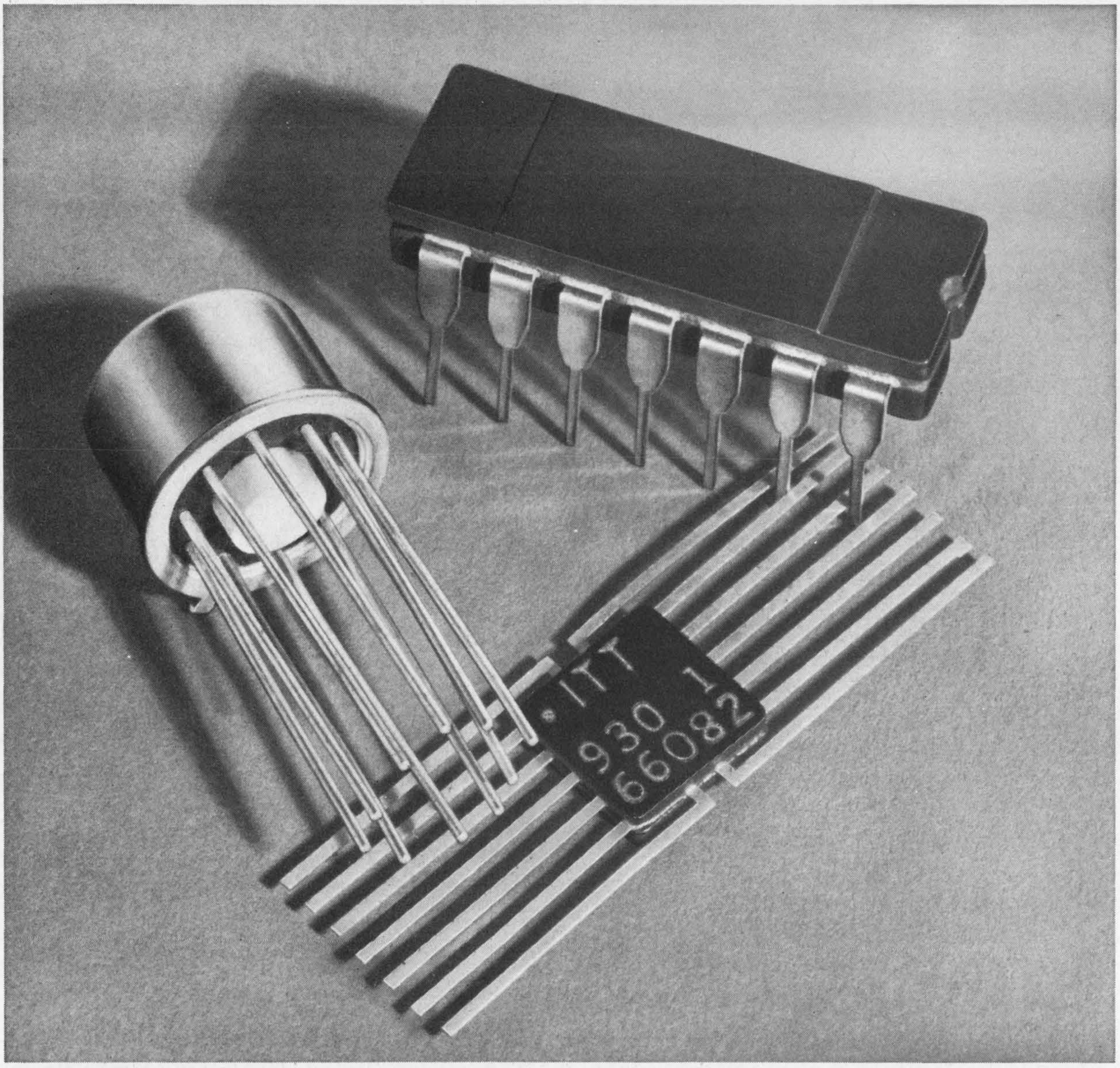
**June 25-28**
**National Consumer Electronics Show** (New York City) Sponsor: Electronic Industries Assoc.; EIA, 200 Eye St., N.W., Washington, D.C. 20006.

CIRCLE NO. 473

**June 28-30**
**Joint Automatic Control Conference** (Philadelphia) Sponsor: IEEE; L. Winner, 152 W. 42 St., New York, N. Y. 10036.

CIRCLE NO. 474

# The Predictables.



## 100% DC and dynamic testing verifies the performance of every circuit in ITT's full line of Series 930 DTL

When your order of ITT Series 930 DTL arrives, you can have absolute confidence in its performance. First of all, every circuit gets full DC and dynamic testing at 25°C, plus temperature cycling, centrifuge, and fine leak tests. Then there's 1% AQL testing at −55°C, +25°C and +125°C for 15 DC parameters and at +25°C for 2 dynamic parameters. If circuits flunk, we just don't ship them.

ITT's Series 930 "predictables" come in 15 circuit functions and three package styles. If you're tired of rejecting and returning DTL, try ordering it from ITT. It's available off-the-shelf from your distributor or direct from the factory through your ITT representative. ITT Semiconductors is a Division of International Telephone & Telegraph Corporation.

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Select the model with 0 to 1600 volts DC output at 0 to 5ma. Regulation, less than 0.01%, and less than 5mv p-p ripple and noise. Stability better than 0.05%.

**Model 6515A** — 3½" High, Half-Rack Width. Price .............................. $235.

### Higher Voltage + 4-Digit Voltage Programmer

Add 1400 volts and get 0 to 3000 volts at 0 to 6ma, plus a 4-digit front panel programmer for selecting the output voltage. Ripple and noise less than 5mv p-p, stability better than 0.05%.

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### 5-Digit Voltage Programmer + Better Regulation, Stability

Add an all solid-state temperature-controlled oven and sophisticated circuit refinements, plus another digit of resolution to the output programmer, and achieve stability and resettability of 0.01%, regulation of 0.001%, and less than 1mv p-p ripple. Output is 0 to 3000v DC at 0 to 6ma.

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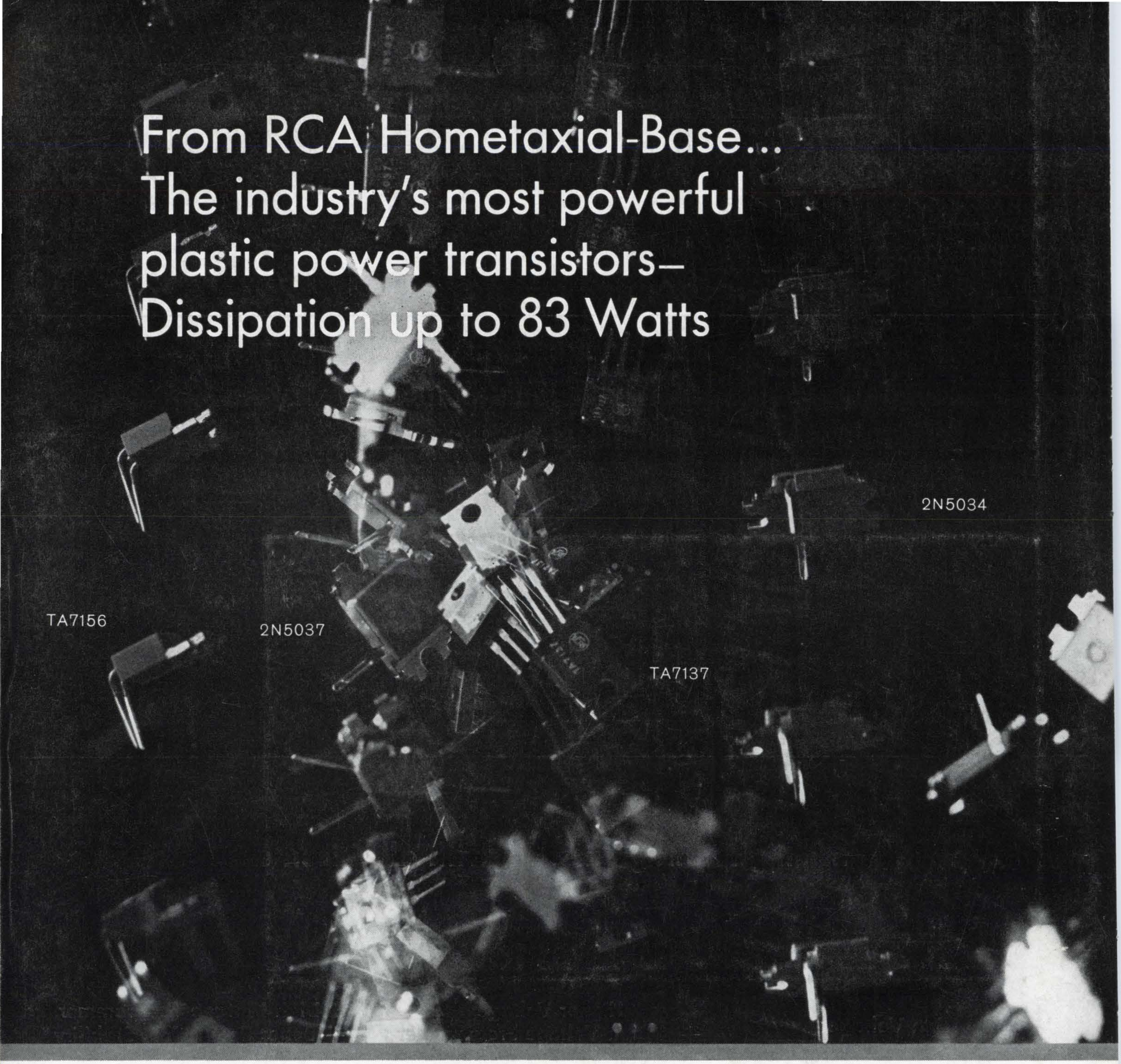

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| TYPE | PACKAGE | $V_{CER}$ (sus) | $I_C$ | $h_{FE}$ | $O_{J\text{-}C}$ | $P_T$ @ 25°C |
|---|---|---|---|---|---|---|
| 2N5036<br>2N5037 | TO-3 equivalent<br>P.C. type | 60 V @ $R_{BE}$ = 100 ohms | 8A | 20-70 @ 3A | 1.5 °C/W | 83 W |
| 2N5034<br>2N5035 | 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 @ 1A | 3.5 °C/W | 36 W |

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