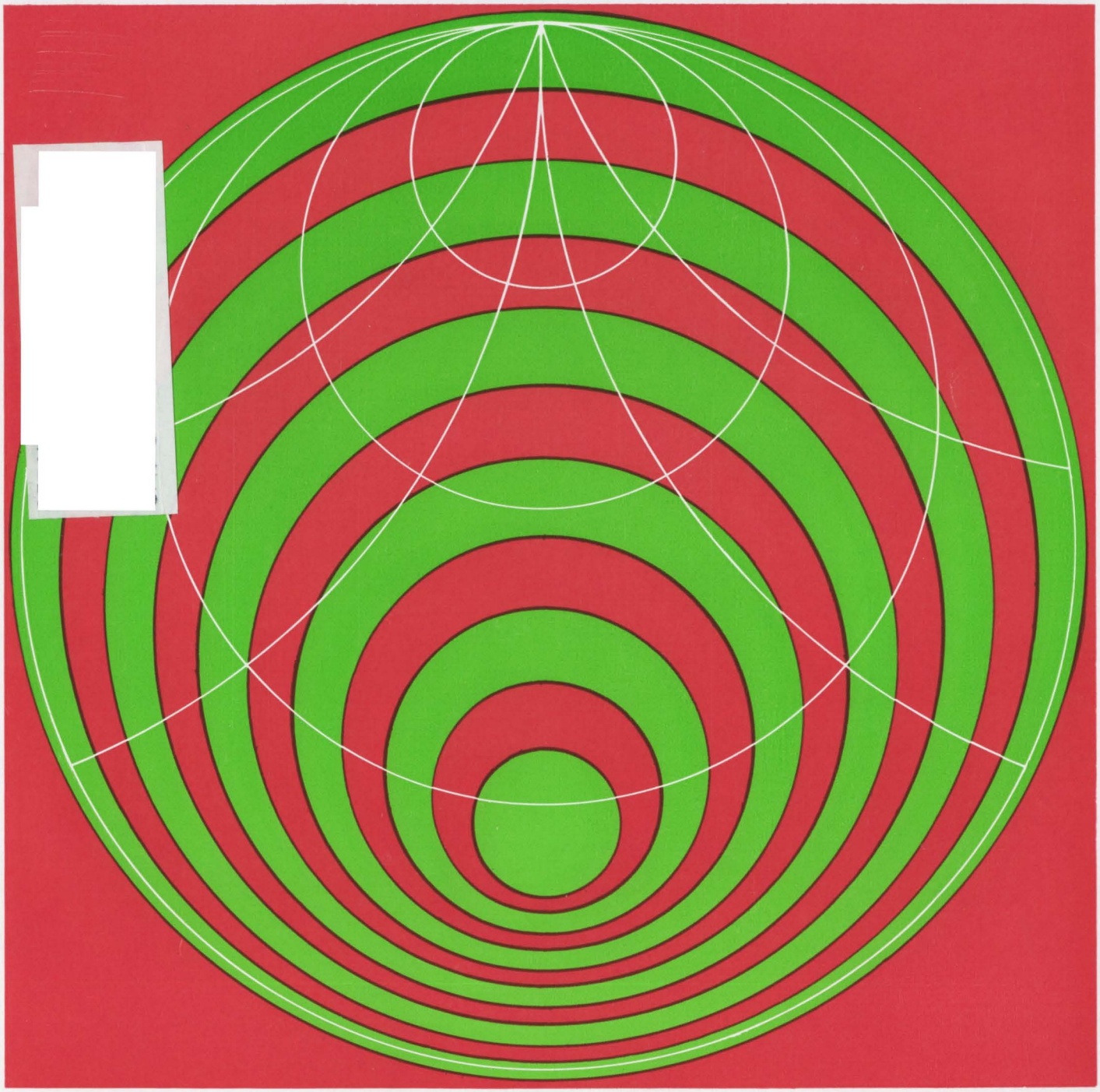
VOL. 14, NO. 25

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

NOVEMBER 8, 1966

Reduce the noise of microwave amplifiers with a design method that makes use of Linvill and quadrant charts to simplify the mathematics. The charts also help choose the best trade-offs among other major parameters, such as stability, power gain and signal-handling ability. For the complete story, turn to page 54.



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oxidation,
galling.

Now let us give you the details.

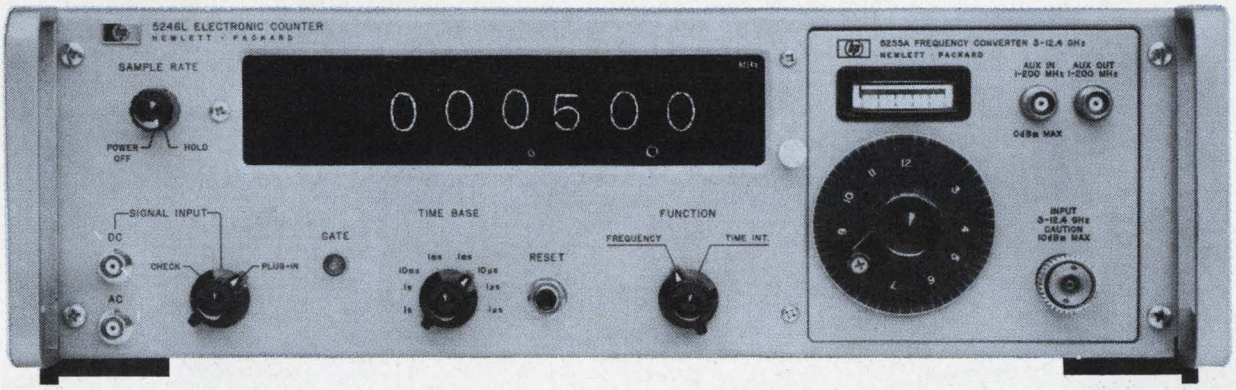
The details are in our comprehensive reference guide—a voluminous encyclopedia of precious metal electroplating processes. Here you'll find charts, graphs, technical papers, magazine articles. A compendium of today's most advanced knowledge of gold-plating—the facts that have put gold into computers, communications equipment, jet aircraft, missiles, space probes. Write for your copy of "Gold Electroplating Processes."

Sel-Rex

Sel-Rex Corporation, Dept. A-11 75 River Road, Nutley, N. J., 07110.

ON READER-SERVICE CARD CIRCLE 202

This $1800 counter won't do everything our $2950 model will.



But it takes the same plug-ins.

And one of those plug-ins can take you directly to 12.4 GHz with 1 Hz resolution. But that's not all. Look at some of the other nine plug-ins you can use with this remarkable counter:

- **Direct readout prescaler, dc to 350 MHz**
- **Time interval, 1 μsec to 10^6 sec.**
- **Video amplifier with 1 mv sensitivity**
- **Preset counting and normalizing**
- **Digital voltage measurement to 1000 v**
- **Four frequency converters—up to 12.4 GHz**

The 5246L is an economy instrument that can't be matched in performance for dollar. It can use every one of the high-performance plug-ins we developed for our 5245L Counter. Hewlett-Packard's counter experience is built into the new 5246L, along with traditional HP reliability. And you can't beat the price.

SPECIFICATIONS:

Frequency Range:	**dc to 50 MHz**
Gate Times:	**1 μsec to 1 sec**
Readout:	**6 digits (7 and 8 optional)**
Input Coupling:	**ac or dc**
Input Impedance:	**1 meg/25 pf**
Max. Sensitivity:	**100 mv rms**
Readout Storage:	**yes**
BCD Output:	**optional**
Time Base Aging Rate:	**$< \pm 2$ parts/10^7/month (< 3 parts/10^9/day optional)**
Price:	**$1800**

Want more information? Call or write your Hewlett-Packard field engineer for complete data, Hewlett-Packard, Palo Alto, Calif. 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice. Price f.o.b. factory.

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ON READER-SERVICE CARD CIRCLE 2

CMC COUNTERS

CRUSADING ENGINEERS: WRITE FOR LITERATURE AND "CHECK THE SPECS."

ALL SILICON SOLID-STATE 2.5, 5, & 225 MC

CMC's 600 series counters use all silicon semiconductors for higher reliability, superior temperature stability. Simplified design and advanced "Mother Board" circuitry reduce components. Temperature operation −20 to +65°C standard, −30 to +75° C available. All silicon memory (display storage), a standard feature, is not subject to slow response and upper temperature limitations of photoconductor memory circuits. Automatic decimal point. 0.1 volt rms sensitivity.

5 MC UNIVERSAL COUNTER-TIMER

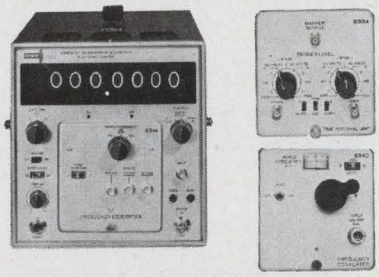
Measures frequency, period, multiple period average, frequency ratio, time interval, and totalizes. Frequency measurement range: 0 to 5 mc. Period: 0 to 1 mc. Multiple period average measurement to 10^7 from 0 to 2.5 mc. 1 mc crystal time base: stability ±2 parts in 10^7 per month. Six decade inline biquinary display. **Model 607A.**

2 CPS TO 2.5 MC FREQUENCY COUNTERS

Six models. Measure frequency, period, time interval with internal or external clock, frequency ratio, and totalize. Four to six decades with double-column neon lamps or inline long-life biquinary display. All silicon solid-state. **Models 600A, 601A, 602A, 603A, 604A, 605A.**

NEW 2.5 MC ALL SILICON PRESET COUNTER

Model 614A Preset Multi-function Counter, extends applications to normalizing and multiplication by any preselected constant. Gate time presets to any interval from 10 μsec to 100 seconds. Gate time presets by remote selection. Direct display as mph, rpm, ms per N periods, etc. **614A** also measures frequency and period and totalizes. Frequency range 2 cps to 2.5 mc. Period and frequency ratio ranges: 2 cps to 500 kc. Preset count circuitry operates dependably at frequencies through 300 kc — up to three times as fast as other variable gate time counters. 100 kc crystal time base: stability ±2 parts in 10^6 per week. Standard five decade inline biquinary display (sixth optional), with automatic decimal point and memory.



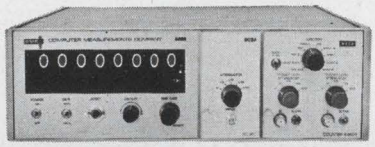
NEW 225 MC FREQUENCY METER

Model 616A provides low cost direct frequency measurement from 10 cps to 225 mc by use of a built-in prescaler. Plug-ins extend frequency to 1000 mc, 3000 mc or 12 gc. 1 mc crystal time base: stability ±2 parts in 10^7 per month. Front panel switch permits selection of (1) direct frequency measurement, 10 cps to 10 mc, (2) prescaled frequency measurement, 500 kc to 225 mc, or (3) extended frequency measurement with plug-in frequency converter. Automatic decimal and memory are standard. **Model 633A** Time Interval Meter plug-in for **Model 616A** has range of 1 μsec to 10 sec with resoultion of 1 μsec (.1 μsec optional). **Model 634D** Frequency Converter plug-in for **Model 616A** provides additional measurement capability up to 3000 mc.

SOLID-STATE DUAL PLUG-IN

25 MC, 50 MC, 110 MC

CMC's Digi-Twin® is the most versatile solid-state counter available. Frequency to 110 mc direct counting. Time measurements to 10 nanosecond resolution. Select frequency range and function plug-ins as your needs change. Buy plug-ins, not new instruments. Printer output. Automatic decimal. Power supply in basic chassis. NIXIE® readout, 1 mc crystal oscillator with decade countdown time base and related circuitry.



The **Model 800** has 8 decade readout, memory standard. Gate times: 1 μsec to 100 sec in decades. Oscillator stability: ±3 parts in 10^9 per day.

THREE FREQUENCY RANGE MODULES

Maximum frequency ranges for plug-ins: **Model 801A** is 25 mc. **Model 802A** is 50 mc. **Model 803A** is 110 mc. Same accuracy as basic counter

FUNCTIONAL PLUG-IN VERSATILITY

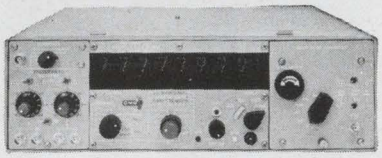
Three basic function modules available, two frequency period and one counter-timer. Period measurement: **831A** and **B** 0.5% accuracy; **832** and **833A** and **B** 0.3% accuracy. Time interval measurement range: 0.1 μsec to 10^8 sec with **801A** and **802A;** 03 μsec to 10^8 sec with **803A.** "B" Models are remotely programmable. Five special purpose modules are currently available: **Model 834B,** 600 mc heterodyne converter offers range measurement from 50 mc to 600 mc in 10 mc steps. **Model 834D,** heterodyne converter with frequency range from 100 mc to 3200 mc. **Model 835A,** Integrating Digital Voltmeter with measurement ranges of 0.1v, 1.0v, 10.0v, 100v, and 1000v full scale. **Model 838A,** digital phase meter with range from 10 cps to 100 kc, and accuracy of 0.5. **Model 846A,** is a 0.1 gc to 12 gc transfer oscillator with self-test.

NEW 10-Line/Sec. DIGITAL PRINTER

HIGH-SPEED, NEW LARGE DIGITS, SOLID-STATE DRIVE AND LOGIC

Fastest, easiest to read, not a modified adding machine or calculator. 35 millisecond data acquisition. Prints 12 columns at 10 lines per second. Electrically positioned decimal without loss of digit. Left zero elimination. New simple electromagnetic design eliminates commutators and moving contacts. Column suppression on command. Half rack size. Up-front pushbutton controls. Eight columns standard, others optional. **Model 410A.**

MILITARIZED SOLID-STATE



FULLY MILITARIZED 100 MC COUNTER

Model 880A is the first and only solid-state counter fully militarized to meet Mil Specs. It measures frequency, period, multiple period average, frequency ratio, frequency ratio average, time interval with internal and external clock, and totalizes; scales input frequency in decade steps; provides standard frequency outputs. Price close to commercial counters. Check these specs: 0 to 100 mc frequency range; oscillator stability of 1 part in 10^9; meets or exceeds MIL-E-16400, including appropriate temperature, humidity, vibration, shock, and RFI Specs. Built-in time interval measurement. Eight decade inline display.

PLUG-INS FOR MILITARIZED 880A

Model 884A, Frequency Converter plug-in extends **Model 880A** range to 500 mc. Solid-state circuitry. Acceptance-tested to MIL-E-16400, MIL-S-901, and MIL-I-16910. Step selector switch. **Model 885A,** Heterodyne Frequency Converter with range from 100 mc to 3200 mc. **Model 886A,** Transfer Oscillator plug-in with frequency range from 0.1 gc to 1.0 gc (on band 1) and 1.0 gc to 12 gc (on band 2).

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ON READER-SERVICE CARD CIRCLE 3

VOL. 14, NO. 25

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

NOVEMBER 8, 1966

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 is pending at Cleveland, Ohio, and St. Louis, Mo. 60,412 copies this issue.

Corning quietly announces

the FP Resistor: new, blue, and flameproof!

Low-power resistors that won't burn under extreme overloads will soon be available in 2, 3, 4, 5, 7 and 10 watt ratings. The same sizes and stability as in the famous CORNING® LPI Resistors. Available only from

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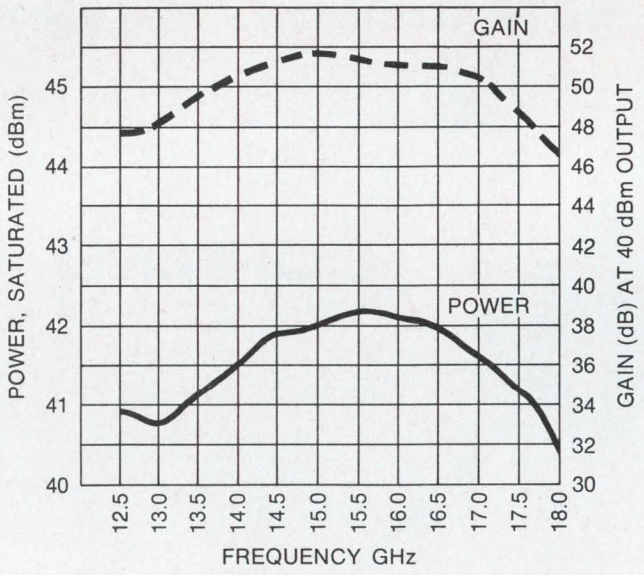
Varian ≥ 40 dBm CW TWT's offer unparalleled performance across the 1 to 18 GHz frequency range.



VA 619 G

No matter where in the 1 to 18 GHz frequency range you're working, you can find the 10 to 20 Watt TWT you need at Varian. Tubes in this series are conservatively rated at 20 Watts minimum except the VA-619, which is rated at 10 Watts minimum.

These air- or conduction-cooled tubes are built for simplicity of power supply design. They are small, lightweight tubes and are available with up to 60-dB gain. And because each tube is an all metal-ceramic, completely potted structure, they have proven exceptionally reliable even under severe environmental conditions.

Similar TWT's are available to the 200 Watt power level.

VA 614 G	VA 615 G	VA 616 G	VA 617 G	VA 618 G	VA 619 G
1-2 GHz	2-4 GHz	4-8 GHz	5.5-11 GHz	7-12.4 GHz	12-18 GHz

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 5

With 6,928 Standard Zener Diodes to Sell, How Many 'Specials' Could We Possibly Have A Story About? 10,187.

And if you'd like an introductory look at what the world's largest zener diode capability can do for your exact application requirements, write for one of our handy, quick-select, Zener Diode Selection Guides. At a glance, you can pick out a standard, ¼ to 50-watt type in all voltage ranges . . . or decide how we can best serve you with our unmatched custom fabrication capability.

Contact any of our nearly 50 well-stocked, franchised distributors located in every major city for any device listed—or our Phoenix facility for large quantities.

And the extra value you get with devices that have travelled through the world's largest zener diode QC monitoring system won't cost you a cent extra, either. In fact, when you specify Motorola units, you'll find they generally cost less.

That's a happy ending to any story.

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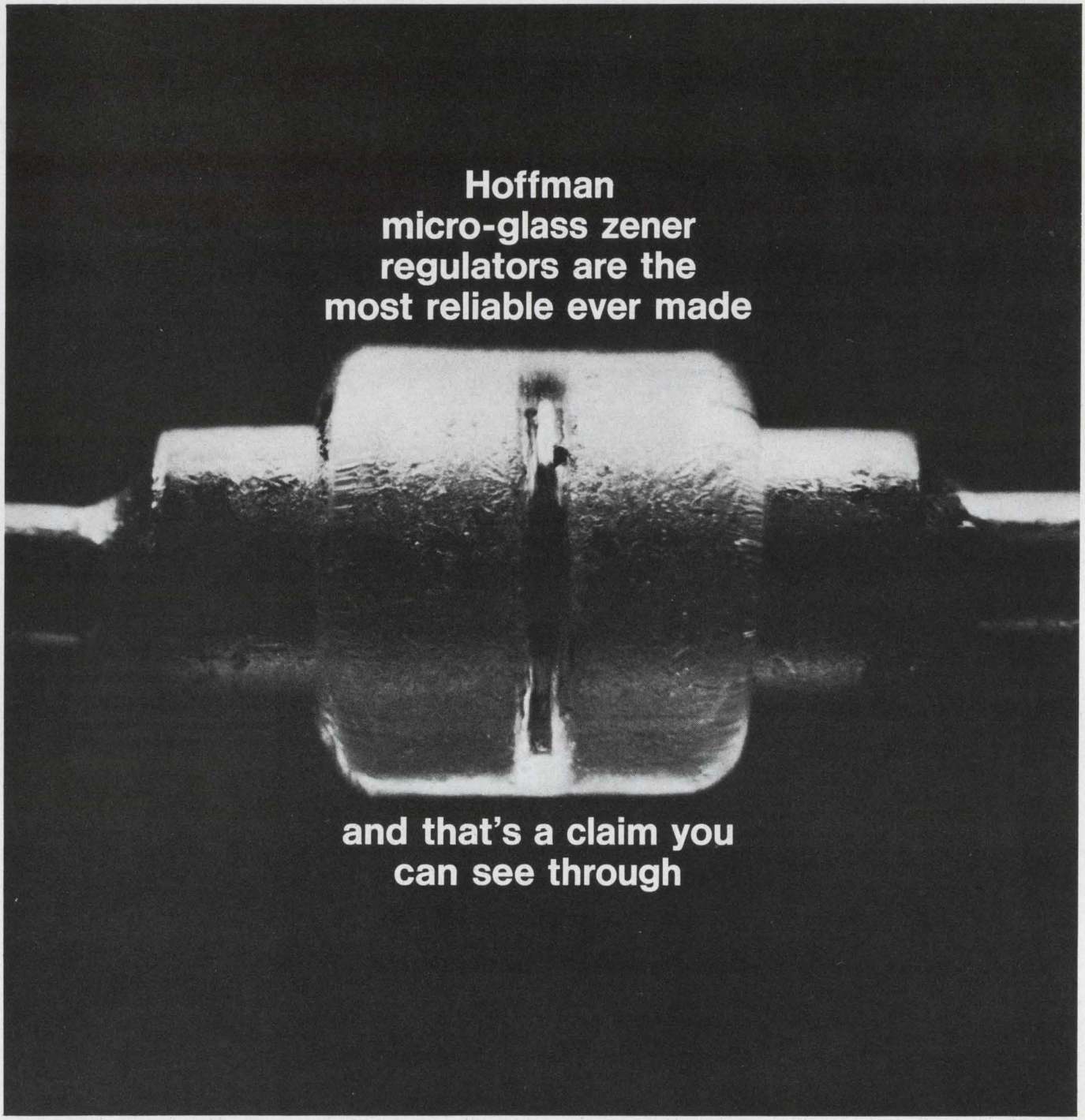

The reasons are hermetically sealed in glass. That's our exclusive way of keeping contaminants out and preventing any fusion of the metal-glass interface. The passivated silicon wafer looks like it's floating in the sleeve — the glass doesn't touch the junction anywhere.

Take a look at the slugs; you'll see they butt right up against the wafer. No intermediate contacts. And the leads are brazed not welded or soldered to the slugs. They conduct better that way, and are about 12 times stronger than if we'd welded or soldered them.

One thing you can't see is the coefficient of expansion of the glass, slugs and wafer. They're a matched seal. That, you can test, if you must.

Thirty-seven of our 1.5 watt regulators, IN4460 through IN4496 replace 749 Jedec types. They're designed for micro-circuitry, small space limitations and excess power requirements. Every one *guarantees* maximum limits on low level impedance, reverse leakage current and zener voltage regulation.

If you need regulator reliability, there's only one place you can get it — painted and marked to your specifications. Phone (213) 686-0123, or write: Hoffman/Semiconductor, Hoffman Electronic Park, El Monte, California 91734

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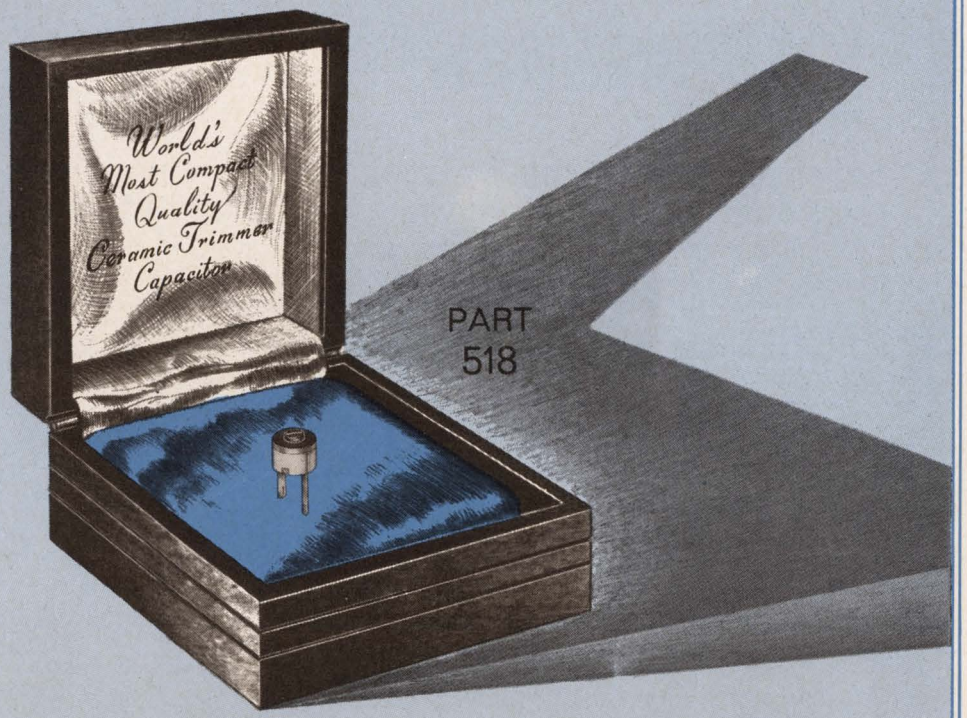
ON READER-SERVICE CARD CIRCLE 7

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

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

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PRODUCTS, INC.

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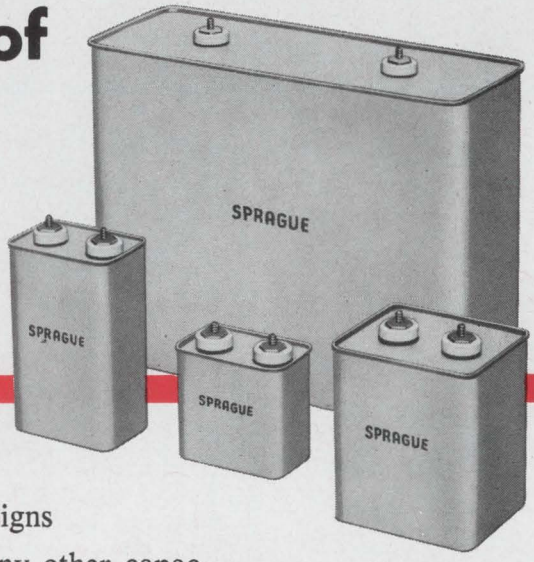
Erie, Pennsylvania

ON READER-SERVICE CARD CIRCLE 8

All from Sprague!

ENERGY-STORAGE CAPACITORS for every type of discharge application



A pioneer in high voltage capacitors, Sprague has a broader line of designs for energy-storage applications than any other capacitor manufacturer. If your project involves lasers, masers, electronic photoflash, time-control circuits, exploding wire, thermonuclear fusion research, magnetization of permanent magnets, medical equipment, or similar discharge applications, Sprague can provide a capacitor to meet your specific needs.

Light, Moderate, or Heavy Duty Capacitors

Available types range from small, light-weight units for aerospace applications such as satellites, missiles, etc., to heavy-duty capacitors for high-current/high-frequency oscillatory discharges.

Broad Range of Electrical Ratings

Voltages from 2 kilovolts to 24 kilovolts. Energy ratings up to 6700 joules. Self-inductance as low as .0025 microhenry.

Energy-Storage Electrolytic Capacitors

A selected line of cylindrical 'lytics for industrial applications requiring maximum capacitance in minimum space.

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Metallized capacitors intended for light-weight, space-saving applications . . . one-half the size, one-third the weight of conventional capacitors. Other available designs include castor oil impregnation for extremely long life (assuring a high number of discharges), and non-flammable synthetic askarel impregnation for applications where non-combustibility is a prerequisite.

For complete information or application engineering assistance on Sprague Energy-Storage Capacitors, write to Field Engineering Department, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01248.

SPRAGUE COMPONENTS

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

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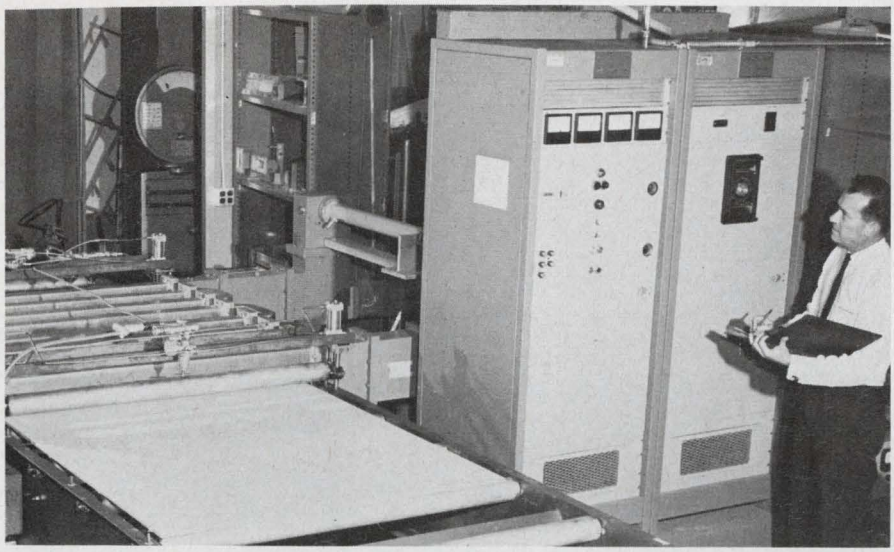
ON READER-SERVICE CARD CIRCLE 9

News



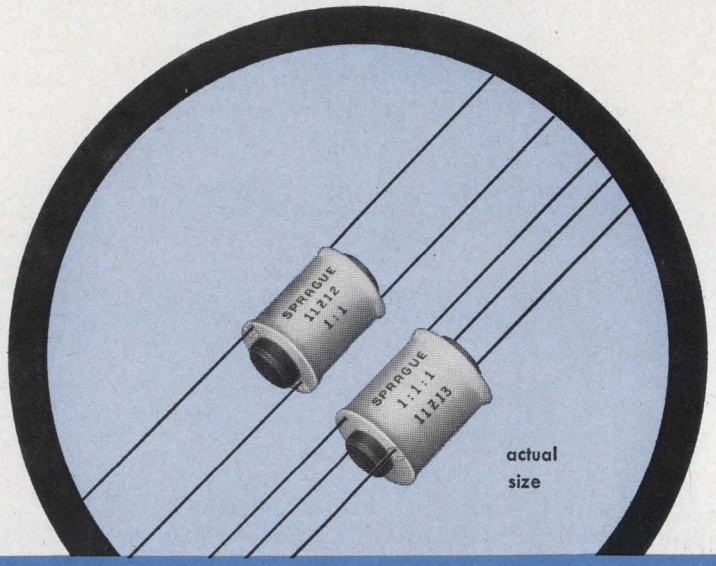
Microwave power expands into every processing industry, may eventually be sent underground to distant plants. Page 17

Traffic control is being handed over to computer systems more and more as cities strive to ease road congestion. Page 24

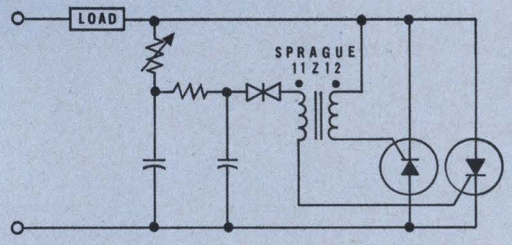
New hf radio equipment aids ionosphere studies. Page 33

Also in this section:

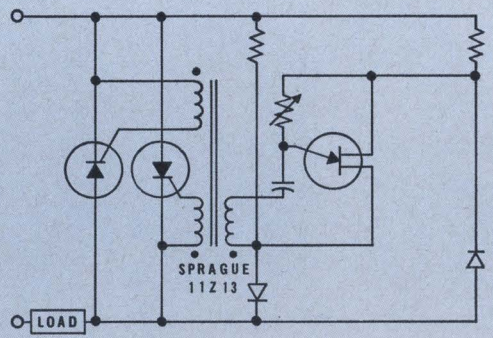
New from Sprague!



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



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



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

*trademark

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

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

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

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

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

For complete information, write for Engineering Bulletin 40,003A to the Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

SPRAGUE COMPONENTS

PULSE TRANSFORMERS	RESISTORS	CERAMIC-BASE PRINTED NETWORKS
CAPACITORS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
TRANSISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
THIN-FILM MICROCIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
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ON READER-SERVICE CARD CIRCLE 10

News Scope

Comsat down, Centaur up —a busy week in space

The disappointing failure of Comsat Corp.'s communications satellite, Lani Bird, to achieve synchronous orbit over the Pacific last week climaxed 7 busy days in space.

The satellite, officially known as Intelstat 2 but nicknamed "Lani Bird," was to have been the first of two spacecraft to be launched this fall that would eventually have extended commercial space communications to two-thirds of the world.

Preceding the Comsat launching by 13 hours was the United States' successful first double ignition of a high-energy hydrogen-fueled engine in space.

During the early launch phases Lani Bird appeared to be functioning well; however, a motor aboard the satellite misfired in an attempt to put the satellite into stationary orbit 22,300 miles above the Gilbert Islands in mid-Pacific.

Another attempt to establish a commercial communications link across the Pacific Ocean is scheduled to be made later this month with the second of Comsat's satellites due for launch this fall. Had Lani Bird been successful, this second, unnamed spacecraft was to have joined Comsat's Early Bird spacecraft launched in 1965 over the Atlantic Ocean.

The new spacecraft will be twice as big as Early Bird but will have the same 240-circuit capacity. It will, however, have twice the power and expected lifetime. The extra power will enable the satelite to relay its radio signals to a much greater area than Early Bird (see illustration below).

In the earlier launching the upper stage of an Atlas-Centaur rocket was ignited twice to hurl a dummy model of a Surveyor spacecraft toward a predetermined point in space. The launching was a rehearsal for later Surveyor soft-landing missions on the moon.

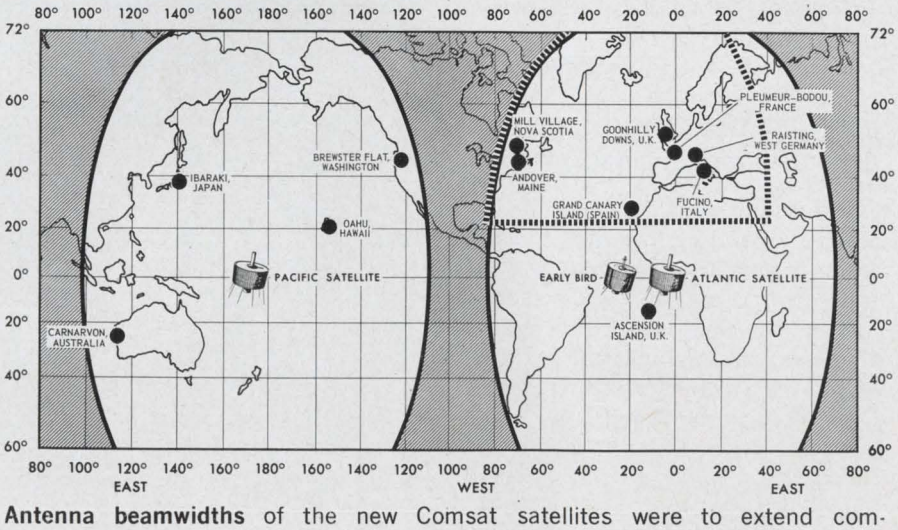
Problems in taming hydrogen as a space fuel, including failures on two previous double-ignition attempts, had set Centaur's full development program back about three years.

The recent success, according to NASA spokesmen, will enable the U. S. to send heavy payloads to the moon and other planets.

During the same week the Soviet Union's Luna 12 sent back to earth the first Russian close-ups of the lunar surface from an orbiting probe. The pictures were reported taken from an altitude of 58 miles.

Meanwhile the United States announced that it had commanded its camera-carrying spacecraft, Lunar Orbiter 1, launched last August, to crash into the far side of the moon. The purpose was to keep the spacecraft's radio signals from interfering with a new U. S. Lunar Orbiter set for next month.

As the week neared a close NASA officials announced that the first three-man Apollo space flight would be postponed at least a month, because of "unresolved engineering problems." It had been scheduled for early December. Preparations are now underway to launch the four-day Gemini 12 mission, which will conclude the Gemini manned space flight program that was begun nearly two and a half years ago.



Antenna beamwidths of the new Comsat satellites were to extend commercial space communications to ground stations throughout the world. Portion at right enclosed by broken line shows smaller area reached by Early Bird.

Chinese nuclear missile disturbs U.S. officials

Communist China's recent firing of a short-range, nuclear-tipped missile has surprised and disturbed American officials.

It demonstrated once again the unexpectedly rapid progress the Red Chinese are making in nuclear and missile technology.

According to a State Dept. spokesman, the development of an atomic warhead small enough to ride on a missile and still produce a large explosive yield represents one of the most difficult challenges of atomic technology.

One leading rocket designer noted that developing a nuclear warhead required the use of brains but relatively little engineering skill. A rocket, he added, requires a high degree of competence to solve the myriad problems of bringing tens of thousands of components together in a workable vehicle.

Defense Secretary Robert McNamara estimated earlier this year that China would be capable of launching a nuclear attack on countries within 500 miles of her borders within two or three years, and against the United States within a decade. So far this estimate has not been revised. There is some specula-

tion, however, that the Chinese missile blast might hasten the development of an operational Nike X antimissile system.

400 million ICs a year are foreseen by 1971

By 1971 the industry demand for integrated circuits will increase 15-fold to 400 million units annually, according to Ben Jacoby, marketing manager for RCA's integrated circuit division.

Addressing a recent Instrument Society of America meeting in New York City, Jacoby said that 150 million units of the 1971 total would be linear circuits, mostly for the control instrumentation market.

He listed some of the major industry-wide programs that are underway to improve linear ICs. They included:

- Extension of the frequency capability from 100 MHz today to 1 GHz in 1971.
- Reduction of low-frequency noise by a factor of 100.
- An increase in voltage capability from 50 to 100 volts.
- A rise in the component count per chip from 30 to 150.

Jacoby predicted that within five years the price of custom-made ICs, produced at the rate of 1000 units a year, would be between $10 and $25 a unit. General-purpose ICs, with production runs of 100,000 units annually, he said, will sell from $1 to $3 five years from now.

Jacoby forecast that specific integrated circuits for consumer applications and produced in quantities of two million a year would probably be sold to equipment manufacturers for as little as fifty cents each.

VSTOL planes called best hope for short hops

With rapidly increasing populations in the nation's urban areas, there is a growing need for an "air bus" to speed short-haul public transportation.

The vertical, short-takeoff-and-landing (VSTOL) airplane appears to be the leading candidate for the 1970s, according to Jack Brewer, program manager for NASA's VSTOL program. He spoke at the Second International Congress on Air Technology that was held in Hot Springs, Ark.

By 1985, Brewer said, commercial airlines will be faced with a severe logistics problem in short hauls of cargo and passengers between cities. By then, it has been predicted, more than 130 million people will be living in super metropolitan areas.

Though many different VSTOL concepts have been studied and a few have even reached the prototype stage, a number of technical problems remain to be solved. A leading problem, according to Brewer, is the need to augment the aircraft lift with power, but without excessive use of fuel, during low-speed flight in the vicinity of the terminal area.

Nuclear missile contract goes to Boeing Co.

The Air Force has awarded a $235.8 million contract to the Boeing Co. for development and production of a nuclear-tipped, air-to-ground missile for use by U.S. strategic bombers.

Known as the SRAM (short-range attack missile), the weapon will be mounted on late-model B-52 bombers and on the strategic bomber version of the F-111 to be placed in service in 1968.

The missile will have a reported range of 50 to 75 miles.

Oxygen obtained from aircraft cabin moisture

Pilots and astronauts may some day be breathing oxygen obtained from the cabin moisture of their spacecraft.

A device, developed by the General American Transportation Corp., breaks down into its components (hydrogen and oxygen) the cabin moisture which is built up through the perspiration and respiration of the occupants.

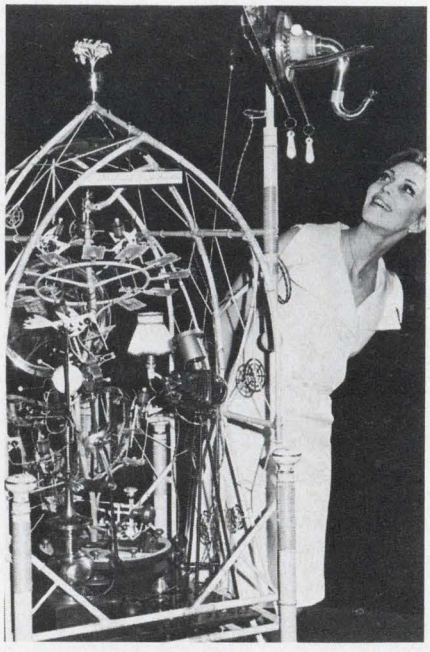
In aircraft, its use would eliminate the need to use stored oxygen —usually in the form of liquid oxygen or "lox"—and a dehumidifier.

The most likely initial application, according to a company spokesman, is in military aircraft, which often require complicated liquid-oxygen generating and storage facilities at remote airfields.

Forget-Me-Not stars in Chicago

What is it? A new medical machine? A modern sculpture? A collection of junk? In a whimsical spoof of the science of automated calculation, the Honeywell Electronic Data Processing Div. in cahoots with Britain's celebrated cartoonist, Rowland Emett, presented it at the Business Equipment Exposition in Chicago as the "ultimate" computer —the Honeywell-Emett "Forget-Me-Not."

The four-dimensional "cartoon" —a moving, blinking, noise-making creation of bamboo, birds, door knobs, lamp shades, playing cards and measuring tapes—was first shown at London's Business Efficiency Exhibition. "Our commission to Emett to invent the Forget-Me-Not stemmed from a belief that there is room for some levity in an industry that has been taken so seriously for the past 20 years," explained Walter W. Finke, group vice president of Honeywell's Computer Group.



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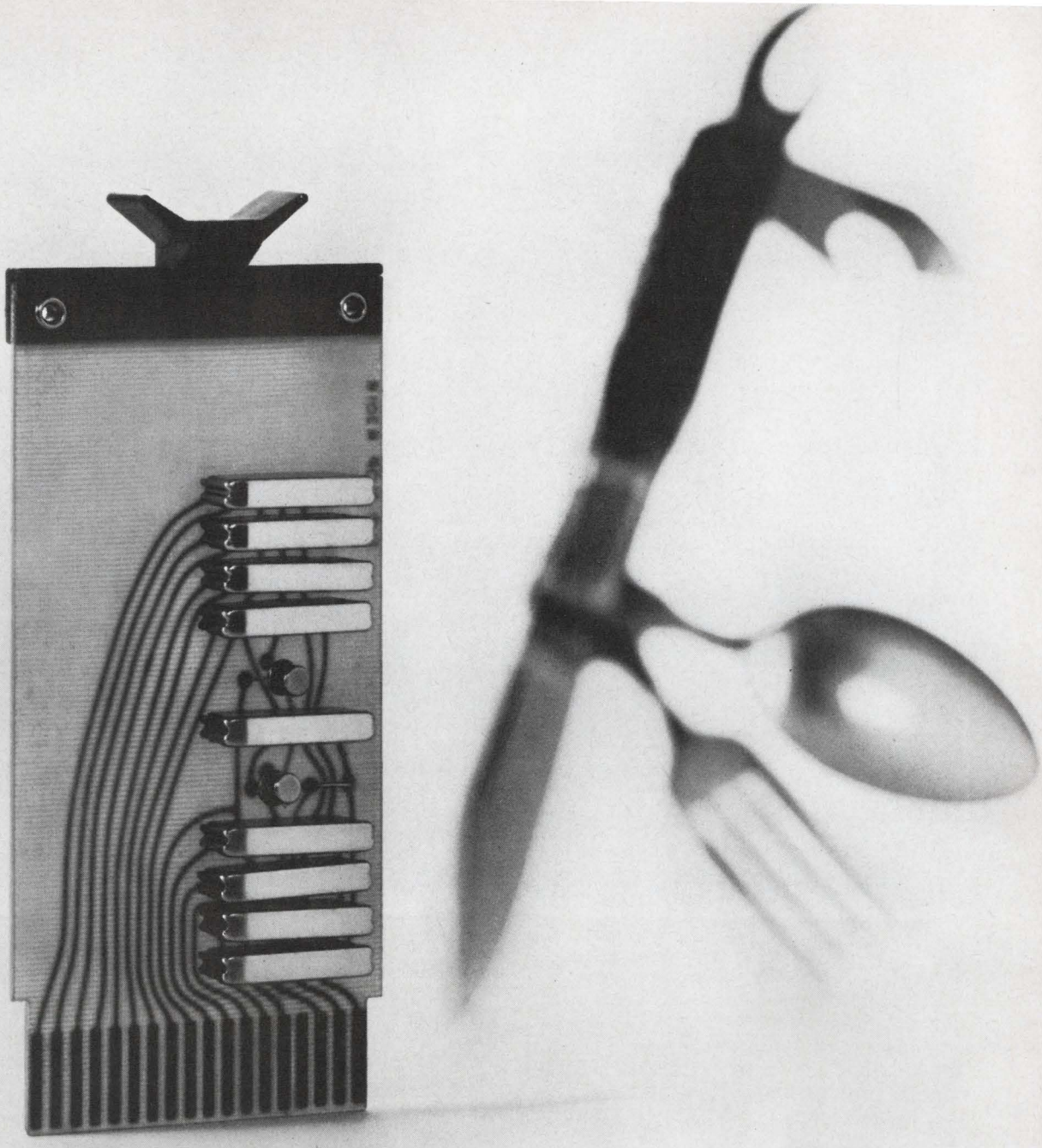
ON READER-SERVICE CARD CIRCLE 11 ➤



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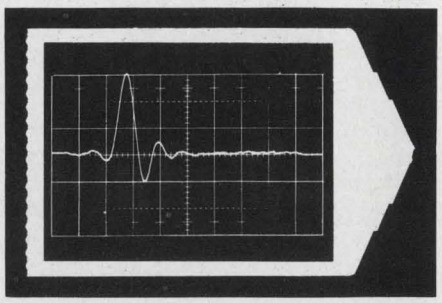
Price: Approx. $7500.00



Typical Photograph of Crosscorrelation Function of Input and Output Signals of Complex Passive Network Driven by White Noise.

For more information call (609) 924-6835 or write Princeton Applied Research Corp., Dept. E , P.O. Box 565, Princeton, N. J. 08540.

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ON READER-SERVICE CARD CIRCLE 12

New uses for microwave power explored

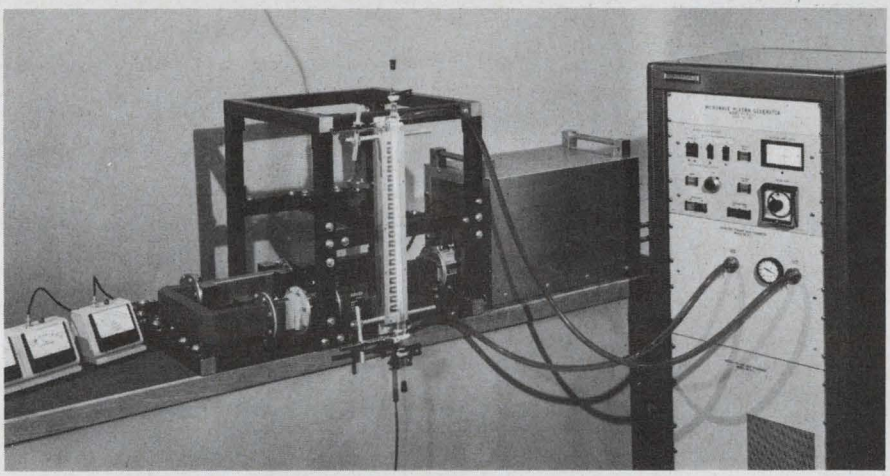
Hundred-mile underground waveguides may one day carry billions of watts to distant cities

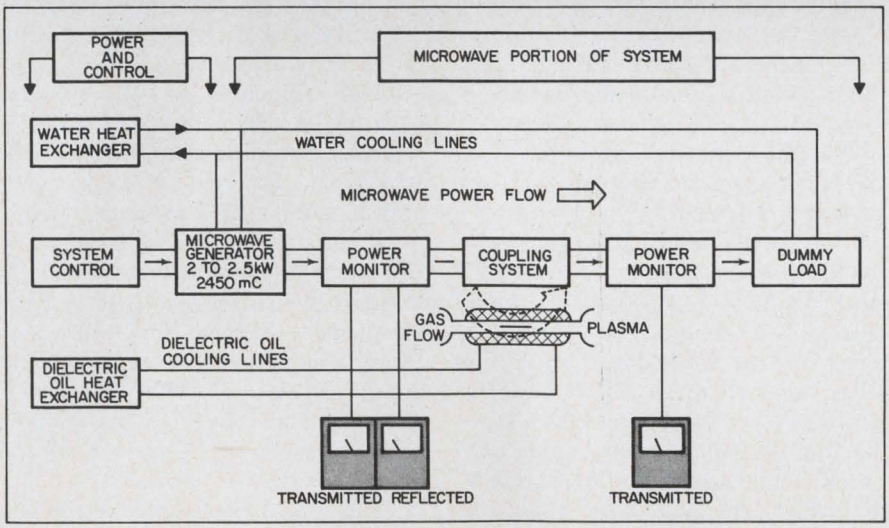
Peer Fossen
West Coast Editor

Right now, microwave power is used mostly to cook roasts in minutes or to run diathermy machines that cure sore muscles in the arm of a baseball pitcher. But billions of watts may yet travel underground in the form of microwaves to power industrial machines and to heat batches of materials.

Microwave power could travel hundreds of miles in foam-wave guides and even negotiate slight bends, according to Prof. Donald Dunn of Stanford University.

"The transmission of huge amounts of power in underground polyurethane waveguides has several advantages," he says. "No unsightly towers need mar the countryside, and the underground guide need not occupy the surface of valuable real estate. The microwaves do not interfere with radios, pose no danger of electrocution and are less vulnerable to bad weather and enemy attack."





A clear plasma can be generated with this microwave plasma generator. In addition to their use in industry, microwaves are a valuable research tool in the investigations of materials. The high-power microwave beam frees ions and electrons in a moving stream of gas without introducing either a catalyst or electrodes.

Such a microwave guide would have a diameter of about five feet. The foam layer would surround a thin copper lining, the conducting material that actually guides the beam. The waveguide's inner surface would be protected by a low-loss dielectric such as Teflon. Air would be forced through the hollow tube to cool it.

"One of the flaws in this plan is the lack of a billion-watt power tube," says Dunn. "Million-watt tubes presently operate at around 8000 MHz. But since power transmission could use much lower frequencies, we should be able to boost power with no theoretical difficulty."

Once the beam is guided into a plant, it could be used directly in heating, cooking and curing processes. But if it is to do any form of mechanical work, it must power motors. According to Dunn, this might be accomplished two ways:

The microwave beam could be rectified and used by dc motors. Or microwave motors might be developed to use the beam directly.

A study of the feasibility of microwave motors is presently under way at Stanford. A program at Marquette University, Milwaukee, is under way to develop a motor with a built-in set of rectifiers. The rectifiers would be placed in the motor's armature, and would rotate with it.

At present the difficulty in using rectifiers to convert the microwave beam to dc is similar to that in making the beam: there is no theoretical restriction, but high-power, high-efficiency rectifiers have not yet been developed.

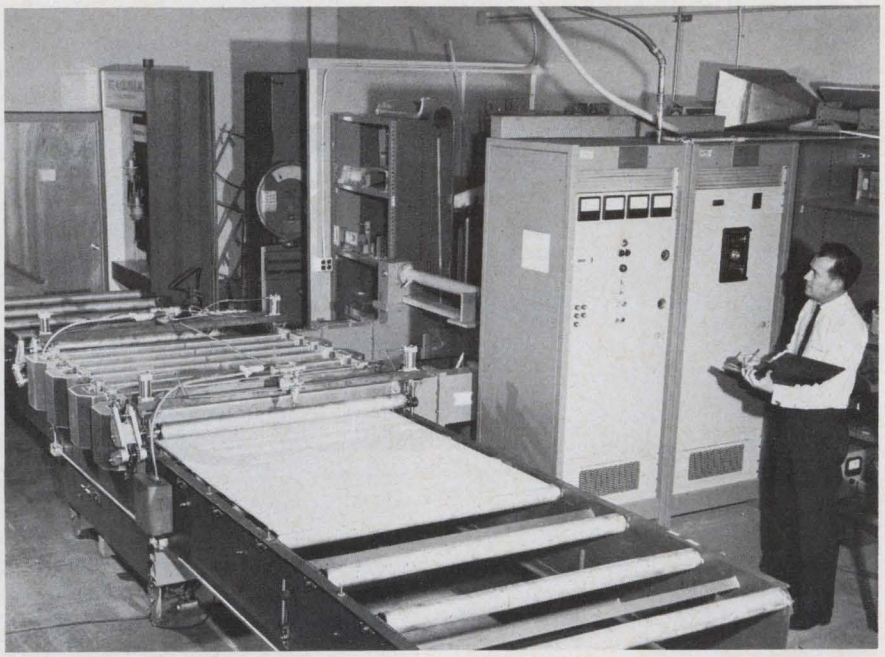
An increasing number of companies are investigating exciting microwave-energy applications, ranging from the removal of solvents in magnetic-tape production to powering helicopters. Among the leaders in this field are the Atherton Div. of Litton Industries, Palo Alto, Calif.; Cryodry Corp., San Ramon, Calif., a subsidiary of Armour & Co.; the Eimac Div. of Varian Associates,

(microwave power, *continued***)**

Palo Alto, Calif., and Raytheon Co., Waltham, Mass.

Raytheon, for example, has been working on a microwave-powered helicopter. An antenna from the ground sends microwaves to the helicopter's antenna. The received energy powers an electric motor that turns the rotors. The company has made small working models and hopes to develop a full-size whirlybird that can soar to altitudes of 10 miles. The microwave helicopter could serve as a communications relay station.

Microwaves may some day power more conventional vehicles. At Rensselaer Polytechnic Institute, Troy, N. Y., Dr. Joseph Foa is working on plans for a microwave-powered rapid transit system. As the train approaches an antenna, it would radiate microwaves to the train.



Continuous microwave processing system dries the protective coatings on plywood sheets without scorching the wood surface. The prototype 25-kW, 915-MHz system, shown above, was developed by Eimac Div. of Varian Associates. The system uses a slotted waveguide in a serpentine configuration as the microwave applicator.

Industrial uses rise

Recently there has been a spurt in industrial uses of microwaves. But these uses have capitalized more on the ability of microwaves to heat materials through and through.

Small microwave ovens operating at low power and low frequency can quickly cook any material with an appreciable relative dielectric constant. (Metals cannot absorb microwaves and thus do not lend themselves to such heating.) The first ovens were expensive, hard to maintain and their tubes didn't last long.

Most of the problems with these early ovens have been overcome in the new generation of microwave systems now going on line in processing plants throughout the world. The first manufacturers to make use of microwaves are in the food, drug, chemical and forestry-product fields. Others will be forced to look to microwave systems to remain competitive, and new fields are being explored every day.

Oddly enough, it was the successful use of microwave power in the final heating and drying process of potato chips that started moving this technology from the R&D laboratory onto the production floor.

The microwave ovens are fast and compact. And the potato chips seem to stay fresh days longer than those cooked in conventional ovens. According to Granny Goose, makers of the chips, microwave ovens, operating at 65 kW and 2450 MHz, can cook a potato at a much lower cost per chip.

While the final configuration varies from one manufacturer to another, each of the microwave systems contains certain basic building blocks:

- A power supply.
- A microwave (RF) generator.
- An applicator.
- A sensing device.
- Operating controls.

To these can be added a series of production accessories, such as waveguides, tuners, channeling devices and conveyor systems, for continuous processing.

The cost of microwave heat must be higher than the cost of heat from the combustion of natural fossil fuels. But its peculiar ability to heat volumes much more uniformly than other sources make it ideal for certain specialized jobs. For example, the protective coatings on plywood can be heated and dried quickly without the risk of scorching the outer layers of the wood.

A more novel use of microwave energy in the medical field can be credited to the University of Edinburgh. There, they simply stick the patient into a microwave oven and restore him to normal body temperature after low-temperature, open-heart surgery. Because of the short time needed to attain the desired temperature again, more time can be spent in surgery.

Still another medical application: Blood plasma is quick-thawed as it is needed for transfusions. Conventionally the plasma expected to be used during an operation is drawn out of the blood bank and thawed well in advance. Whatever is not used has to be discarded. With microwave thawing, hardly a drop need be wasted.

The principle of microwave heating is simple. It is based on the electric dipole moment of the molecules of the substance being processed. As RF energy penetrates the substance, the molecules attempt to align themselves with the electric field. Subjected to a high-frequency alternating electrical field, the dipoles oscillate about their centers. Internal friction in the material converts the mechanical energy of the vibrating dipoles to heat.

The FCC has assigned six microwave frequencies for industrial, scientific and medical use—13, 30, 915, 2450, 5800 and 22,125 MHz. There are no power limitations on the propagation of electromagnetic

(microwave power, *continued*)

waves at these frequencies.

Though the use of microwave power—particularly radiation in the two highest-frequency channels—has not yet reached its infancy, there is more than enough interest in this peculiar form of power to justify the existence of a specialized society.

Form new microwave society

Formation of a new international technical society for the exchange of information on the applications of microwave power to industrial processes was recently announced by a group of Canadian and U. S. scientists.

The group, known as the International Microwave Power Institute (IMPI), will provide economic analyses on microwave power versus ventional fossil-fuel applications, and combinations of both. Details of particular microwave heating systems will also be made available.

The new society plans to publish annual technical proceedings and direct an information program. Its next annual symposium will be held at Stanford University, Palo Alto, Calif., March 29 to 31, 1967. ■ ■

Microwave power pipeline section made of plastic foam is displayed by Prof. Donald Dunn (right) and a graduate student, Walter Loewenstern, Jr., both of Stanford University. By converting the electric power to microwave energy, they believe such a pipeline could carry billions of watts for hundreds of miles underground to cities of the future.

Pulsed plasma engine runs 2 years on an ounce of fuel

A tiny rocket engine can develop 1/10,000 of a pound of thrust by accelerating clouds of plasma down a pair of parallel conducting rails, according to its inventor Dr. Aldo LaRocca, manager of advanced propulsion, General Electric, Philadelphia. The engine, complete with voltage converter, triggering circuit and fuel, weighs only 1.5 pounds. One ounce of fuel can power the engine for up to two years, according to LaRocca.

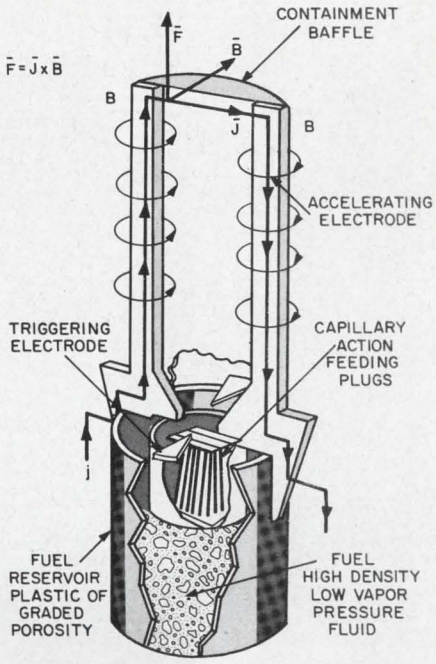
The key to the design of this extremely simple, lightweight space engine is the use of a passive fuel feed. This is nothing more than a wick that replenishes a thin film of the fuel, which must conduct electricity at least fairly well, physicist John Siviski explained.

Triggering electrodes pass 2000-volt pulses through this thin film of fuel. The fuel ionizes and then forms a cloud at the base of the two parallel accelerating electrodes. The current, j (see diagram), flowing into these two rail-like electrodes, completes a closed path by flowing through the plasma.

This ion current interacts with the component (B) of the magnetic field that is perpendicular to the plane of the rails. This magnetic field is created by the current in the rails and the cloud of ions is propelled along the rails at supersonic speed by the force resulting from this interaction. The plasma is discharged from the engine at the end of the rails, and the momentum of each ion cloud provides the thrust that pushes the engine along.

The G. E. scientists have used fine aluminum particles suspended in silicone for the fuel. The silicone is normally an insulating liquid, but the colloid of aluminum particles in silicone conducts electric current. The scientists are presently experimenting with liquid inorganic polymers that are conductive.

Thrust is controlled by regulating the frequency and intensity of the pulses to the triggering and accelerating electrodes. ■ ■



Pulsed plasma engine proposed by General Electric scientist, Dr. Aldo LaRocca, weighs only 1.5 pounds and develops 100 micropounds of thrust. The engine can theoretically operate on one ounce of fuel for up to two years.

IBM announces military/space version of the system/360

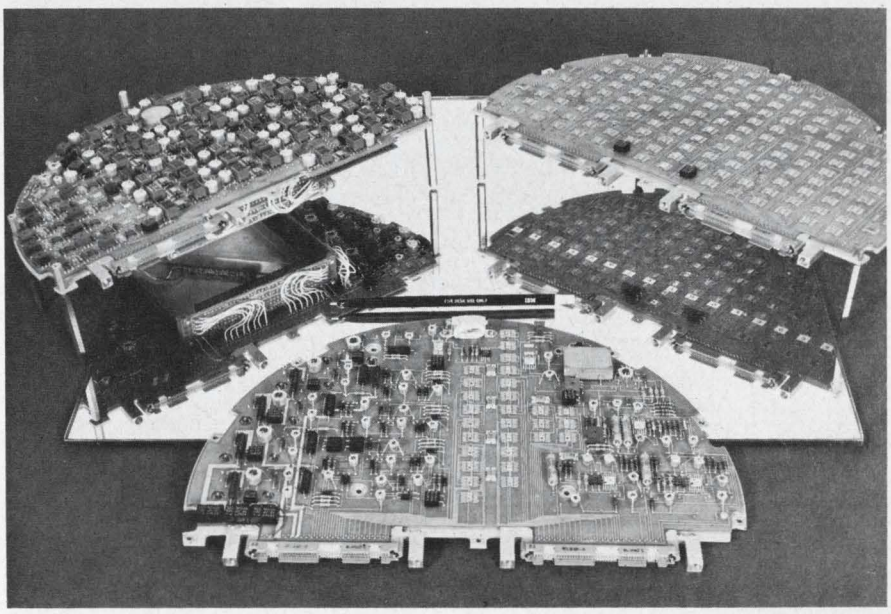
Complete capability over the data-processing spectrum is claimed by International Business Machines with the announcement of their new 4 Pi series of digital computers.

The new family of compact computers has been named 4 Pi to reflect its relationship to System/360.

The "360" in System/360 refers to the number of degrees in a circle, emphasizing the system's ability to handle total data-processing requirements. 4 Pi, the number of steradians (3-dimensional radians) in a sphere, indicates that a new dimension has been added to this capability.

Read-only storage can be used in both System/360 and System/4 Pi to control logic operation so that a general-purpose computer can be adapted easily—without rebuilding logic circuitry—to a wide range of specialized applications.

The 4 Pi series makes the first



Ready for use in a tactical missile, the TC version of the 4 Pi consists of three major subassemblies: (from left) memory, input/output and central processor. Each subassembly consists of 13.25-inch-diameter assemblies of two multilayer interconnection boards and supporting aluminum plate. Mirror shows bottom side of assemblies.

(**computer,** *continued*)

use of read-only storage to control military and space computers.

Ranging in size from 3/10 of a cubic foot to less than two cubic feet the new computers are "hardened" to withstand vibration and temperature extremes common to military and space systems.

Currently there are three 4 Pi models:

- *TC* (tactical computer) for satellites, tactical missiles, helicopters and other applications with overriding requirements for an exceptionally small and lightweight digital computer.
- *CP* (customized process) for avionics guidance and control and mobile battlefield systems.
- *EP* (extended performance) for military and space applications requiring high-speed calculations of volume data in a "hardened" environment. ■ ■

Gimbal-less gyros win NASA backing

NASA scientists favor the use of so-called "strapdown" gyroscope systems in spacecraft, as opposed to the more conventional gimbaled systems. They also advocate the use of a single, integrated, general-purpose computer—instead of several separate ones—to perform all of the computing functions aboard.

These trends in spacecraft design were reported by Dr. Winston Kock, outgoing director of NASA's Electronic Research Center at Cambridge, Mass., in a speech before the National Electronics Conference and Exhibition in Chicago. Besides reviewing the achievements of the two-year-old center, Dr. Kock announced that he had resigned, effective Oct. 1, to return to industry as director of research for the Bendix Corp. He has been replaced by James C. Elms, formerly NASA's Deputy Associate Administrator for Manned Space Flight.

The problem of gyro drift, complicated by rising costs for the fabrication of improved gimbaled gyros, was cited by Dr. Kock to explain why NASA favored strapdown gyro systems.

In the strapdown system—so called "because in it the gyroscope bearings are connected to the vehi-

cle without gimbals"—the problem of drift due to friction can be overcome, Dr. Kock said.

"With no gimbals to permit the gyros to remain oriented in their original direction as the craft rolls or yaws," he explained, "the gyros must move with the craft. This motion generates forces on the gyro bearings, and if sensors are provided to detect these forces, full information for guidance is still available."

With the advent of compact, lightweight, low-cost components, computers can now be built for use with the more complex strapdown system, Dr. Kock said.

"Strapdown guidance packages thus provide one of many examples of a trend in which substitution of electronic functions for mechanical ones can result in lower costs," he added.

Turning to other computer developments, Dr. Kock reported a new trend at NASA's Cambridge center.

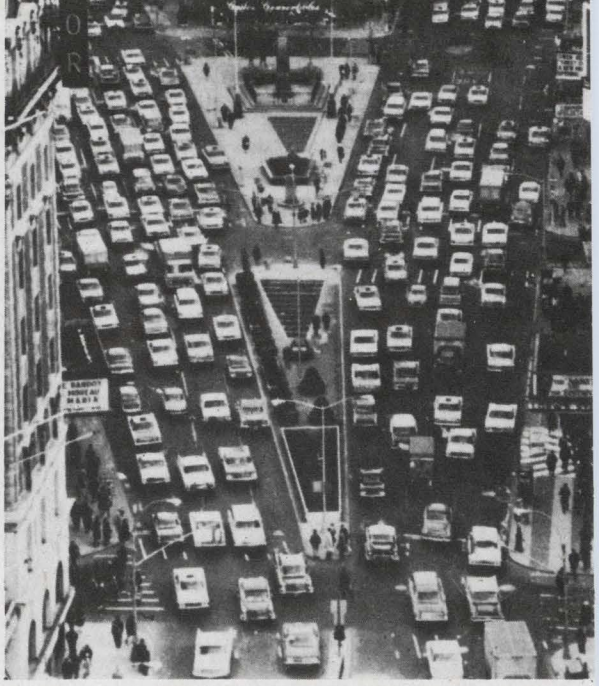
Besides the guidance and control computers, he noted, some computers on spacecraft must assemble and store data from various sensors; others are used for telemetry.

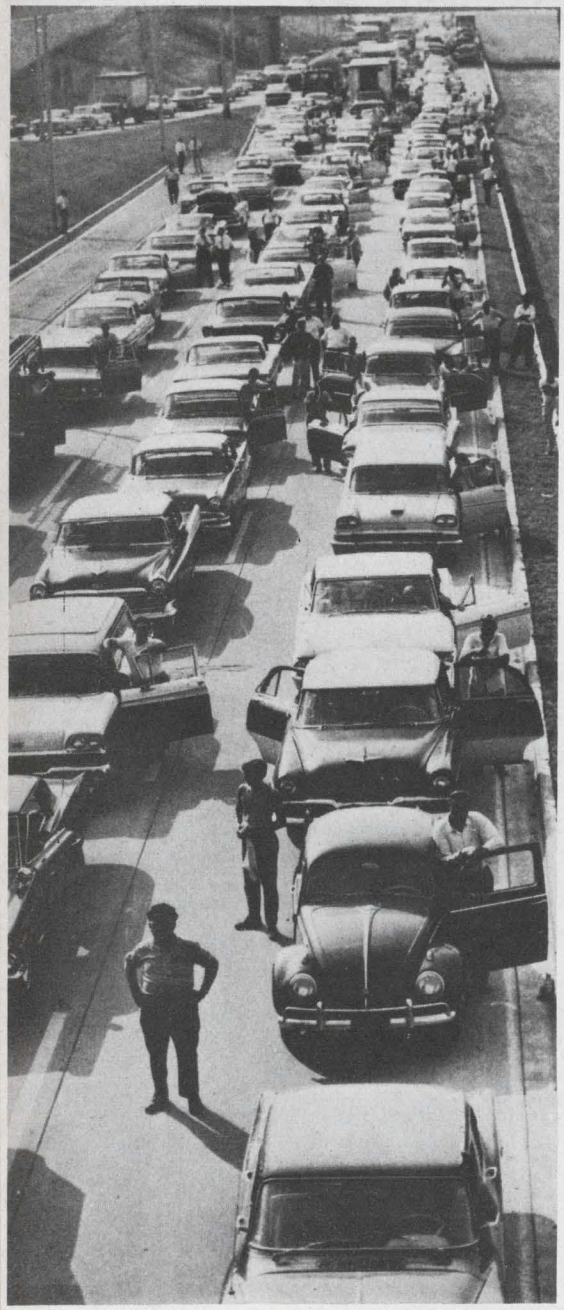
"Thus there are many computer functions," he continued, "and the question has been: Should each function have its own computer, or should there be one integrated multipurpose computer network which can accommodate all of the needs of the spacecraft?"

Scientists at the center, Dr. Kock said, feel that "under some circumstances much can be gained in flexibility and reliability by following the multipurpose computer route."

Other areas that Dr. Kock touched on included:

- Microwave technology (NASA recently used a Gunn diode in a successful voice communication circuit).
- Solid-state materials (investigations are focusing on high-band gap materials: aluminum phosphides, aluminum antimonides and sodium nitrides).
- Microwave radiometry (the center has developed a modified Dicke radiometer that makes use of signal-comparison techniques from two lobes radiated from the same antenna).
- Holography (experiments are in progress to use it in an airport landing-simulation device). ■ ■





More computer traffic cops due

New York is installing the world's largest system, and smaller cities are following the trend.

Ron Gechman
News Editor

Within eight years New York City will have the world's largest central computerized traffic-control system. It will cost $100 million and will operate the signals at 9000 intersections.

In San Jose, Calif., traffic is already flowing smoothly under the control of an IBM 1710 Model II computer. Delays have been cut 14%, the city reports, and the probability that a vehicle will have to make a complete stop has been reduced by more than 17%.

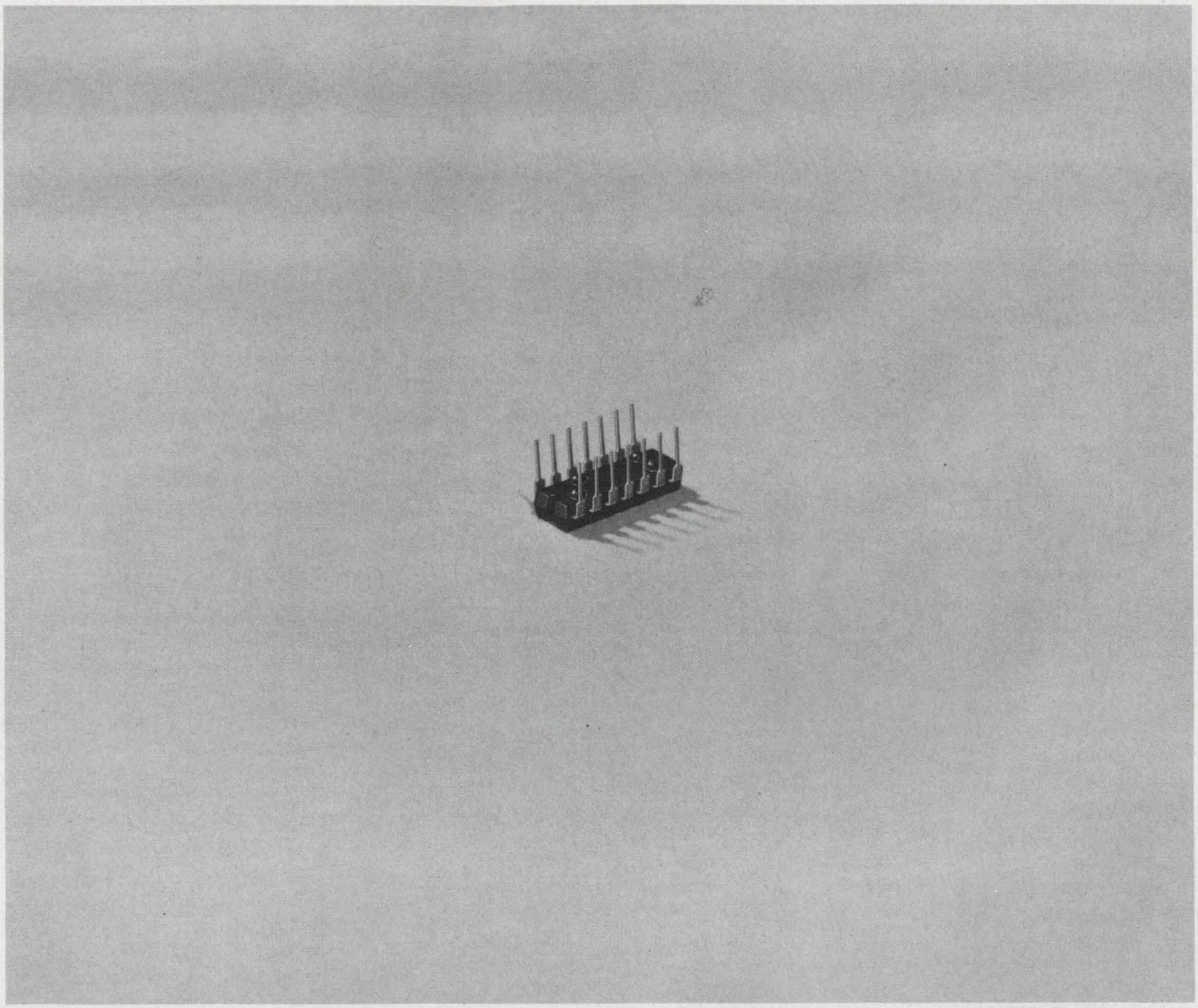
The two sides of electronic traffic control—the planning and the results—were presented to the annual convention and exhibit of the Instrument Society of America. Among the speakers at the New York event were E. Vinson Hoddinott, chief of the Bureau of Signals and Communications for the City of New York, and O. I. Bermant, program manager of vehicular traffic systems for the International Business Machines Corp.

Recalling the rapid-transit strike in New York last January, Hoddinott noted that it caused an increase of 43% in the normal daily traffic of 550,000 to 600,000 vehicles in Manhattan. Traffic became so knotted that a 20-minute ride home for some office workers stretched into two to four hours. Without electronics, the city could expect jams almost as bad as this in eight years, Hoddinott told the convention. Studies indicate, he said, that traffic in Manhattan will increase 30% by then.

New York has already taken two steps toward easing the anticipated mass snarl: it has completed an engineering study of the feasibility of electronic direction of traffic, and it has awarded a $5-million contract to the Sperry Rand Co. to furnish the computer and control equipment. Early next year, Hoddinott reported, the third phase of New York's traffic modernization program will begin with the installation of the equipment in four boroughs.

New York's approach

The computerized signal system for the city will consist of a number



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ON READER-SERVICE CARD CIRCLE 17

(computer cops, *continued*)

of area systems, interconnected and coordinated by a central computer and sub-master computers. But all of the area systems will be linked into one citywide control system.

"Unlike most of the conventional systems, which use only one master control unit, ours will operate initially with ten," Hoddinott said. These will be solid-state digital computers, functioning as both master and sub-master units. They will operate without air-conditioning or humidity controls and within ambient temperature variations from 0° to 110°F.

Control sensors at selected locations on arterial streets throughout the city will measure speed and traffic volumes, and solid-state telemetry equipment will transmit the data to the master computers.

On the basis of this information, the computers will transmit signal-timing instructions to local intersection controllers.

Two types of control sensors will be employed. One operating on the radar principle, will transmit and receive reflected radio signals from vehicles passing the device. The other will function in a similar manner, but they will operate in the ultrasonic region. The sensors can be mounted either at the side of the roadway or directly over it. Both types will be supplied by the Sperry Gyroscope Co.

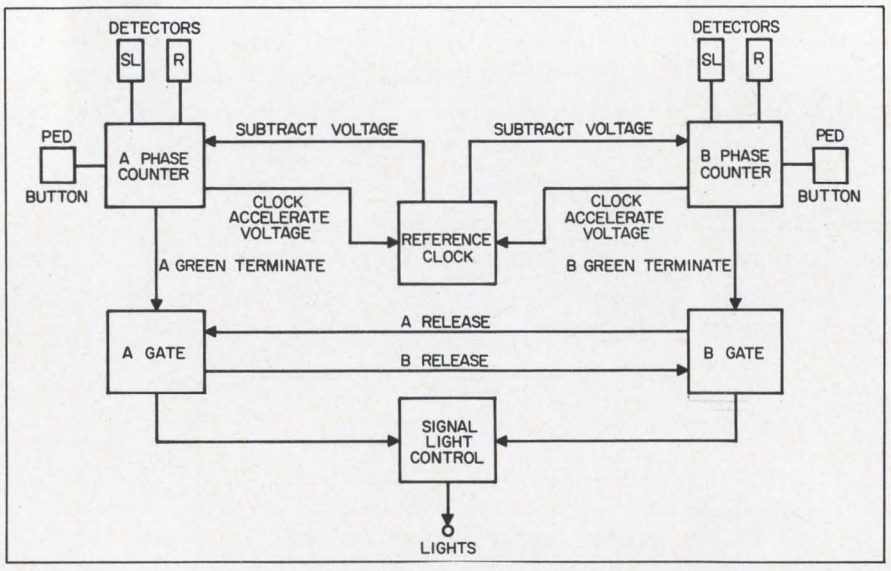
A unique feature of New York's system, Hoddinott reported, is that it will employ an entirely separate set of sensors to check on the accuracy of the control system.

Another feature is the critical intersection controller, which changes the signal lights. A non-electronic traffic controller at the intersection of two busy streets ordinarily sets the signals for a 50-50 split. In the New York system, the intersection controller may permit as little as 30% of the total green time to be allocated to either street, depending on the speed and volumes of approaching traffic.

Loop detectors in San Jose

In describing San Jose's system, IBM's Bermant said that the California city had added 320 loop detectors, used only to initiate a contact closure. The traffic detectors are connected by direct wire to the central IBM computer. The computer has a card input and output, a disk file, a printer and manual entry and display units. A display board depicts the green conditions of the intersections on a system map.

The programing system consists of a series of sub-programs, all under the control of a supervisory program, called the traffic monitor.



Two-phase variable reference-clock controller has four basic system blocks: reference clock, phase counter, AND gate and signal-light control unit. External inputs come from the vehicle detectors and pedestrian buttons. More phases can be added, simply by connecting additional detectors, counters and gates to the reference clock.

Each sub-program has a particular function to perform, such as scanning detector inputs, advancing controllers, checking the synchronization, allowing for operator intervention or logging data. The priorities under which these programs operate and the information flow between them are controlled by the traffic monitor. Each sub-program can be reloaded without affecting other sub-programs. In this way the decision-making function can be modified without changing the operational data-gathering or analysis elements.

Intersection control a problem

One decision any city must make is whether or not it should have a central computer system to control traffic intersections. Robert Doble of the Link Group of General Precision, Inc., told the convention of developments in advanced intersection control. One solution, he noted, is to control a majority of a city's traffic intersections through the central computer, which receives inputs from detectors all over the city. In the downtown areas of major cities where traffic is heavy all day long, this is desirable, since changes of offsets and cycle times must be closely coordinated.

However, in cities that have extended boundaries—like San Francisco and Los Angeles—signal lights and traffic are spread over large areas. While traffic is widely heavy at rush hours, it is relatively light the rest of the time. In these cases, Doble said, the efficiency of total computer control is doubtful, as well as costly.

He discussed two new methods of individual intersection control that do not use a central computer but do use more economical digital logic. One of the systems, called the variable clock reference method, has detectors 350 feet from an intersection and at the stop line. The controller therefore monitors the traffic arriving at an intersection and also the traffic passing over or waiting at the stop line.

Reference clock used

The reference clock runs at a predetermined speed and provides a series of subtractive pulses that are applied to a ring counter or similar

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(computer cops, *continued*)

device. Vehicles running through an intersection on a green light actuate a detector to apply additive pulses to the counter. Vehicles approaching the cross street actuate detectors to introduce subtractive pulses to the total count. The difference between the additive and subtractive pulses determines when the clock runs out. When the clock reaches zero, the counter initiates a green-light signal, which is passed through an AND gate to the signal-light control unit to change the light condition.

Four basic units

The control system is composed of only four basic units: the reference clock card, phase counter card and gate card, plus the signal-light control unit. The number of phases at any intersection can be expanded merely by plugging in the appropriate selection of these units.

The reference clock is a voltage-controlled oscillator that provides a series of subtractive pulses. The pulses are applied to a ring counter, into which additive pulses from the detectors are also fed. Therefore, vehicles running through on the green light add to the count, while the clock pulses subtract from it. Also causing the counter to reach zero at a faster rate are subtract pulses from detectors on cross streets, where vehicles are waiting for a green light. When the count reaches zero, the counter issues a green-light terminating signal to the signal-light control unit through an AND gate. One AND gate is installed for each green phase available at the intersection.

The AND gates provide a means to skip a phase, if no vehicles are waiting for that particulat phase to turn green. The gate requires two inputs: a green-light terminating signal from the counter, and a release signal generated by a vehicle passing over the detector associated with the next phase scheduled to get the green light. If no terminating signal is received, the outgoing gate passes the green terminating signal to succeeding gates, until one is found that does have a vehicle waiting.

The signal-light control unit performs the function of changing the lights on command from the signals received from the AND gates.

Loop-occupancy controller

The other new system for individual intersection control is called the loop-occupancy controller. The vehicle detector used in this system is a loop detector, consisting of a loop of wire buried in each approach lane and extending from the stop line back for 50 to 90 feet. The loop can inform the computer when a vehicle gets within it, when it leaves the stop line and whether another vehicle has followed the first one into the loop.

The loop-occupancy controller method is simpler in operation and circuitry than most other automatic-control systems. Without further complication, the system can be expanded to any number of phases, can automatically skip phases when no vehicles are present, and can be wired to provide phase overlaps—such as left turns from opposite directions—to any extent required.

In the absence of any cars in the intersection, all lights are red. A typical loop extends 65 feet from the stop line. When a car enters, the light turns instantly to green. It remains green while the vehicle travels through the loop. Immediately after the vehicle has passed the stop line, the signal cycles through amber to red.

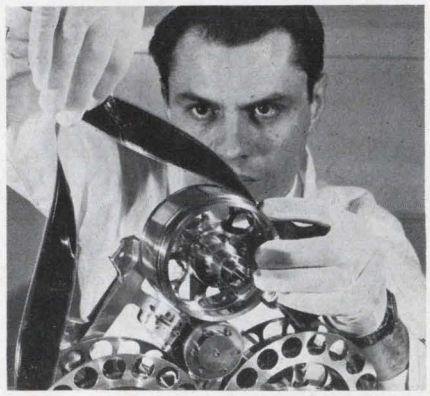
Should a number of cars enter the loop, the light remains green so long as there is continuous occupancy of the loop. Cars approaching the intersection from the cross street must wait until there is a break in traffic. Cross-street traffic, therefore, is slipped in between main street gaps.

This system can handle traffic volumes greater than other systems because it does not allow any unused green time to appear.

To eliminate the possibility that a continuous flow of traffic will keep the light permanently green in one direction, a time-delay circuit is added to terminate the green after a predetermined time.

The proceedings of the ISA Convention can be obtained from the Instrument Society of America headquarters, 530 William Penn Place, Pittsburgh, Pa. ■ ■

Camera stores image on plastic film



A new electronic reconnaissance and surveillance camera records images on a plastic film that has no magnetic surface and needs no chemical development. The film records images by storing electric charge in its dielectric surface.

The film is a flexible cronar tape that is coated with gold-copper alloy. This conducting layer is, in turn, coated with arsenic selenide (a photoconductive material). A thin layer of insulating material protects the working surface when the film is rolled on a spool.

Just prior to exposure, the tape is erased by a flood of electrons, which bring the dielectric sandwich to a constant potential over its entire area. While the image is being exposed to the film, another flood of electrons charges every point in proportion to the amount of light falling on it. During read-out an electron beam scans the film's surface and measures the charge density of the conducting layer.

The tape can be erased simply by being flooded with electrons. It can be read over and over, once the image is recorded, until it is erased. Moreover, the tape can either be carefully and slowly scanned by a very fine beam to obtain a high-resolution image, or it can be quickly scanned by a broader beam for a lower-resolution image.

It can store high-density information for long periods of time, and is extremely radiation-resistant. Combined with a color filter system, the dielectric camera can map objects in full color.

The tape and camera system were developed for NASA by the Radio Corporation of America, Princeton, N. J. ■ ■

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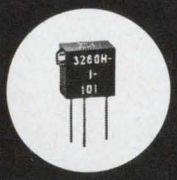

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■ TOWARD EVERYDAY USES FOR LASERS— ANOTHER MAJOR STEP

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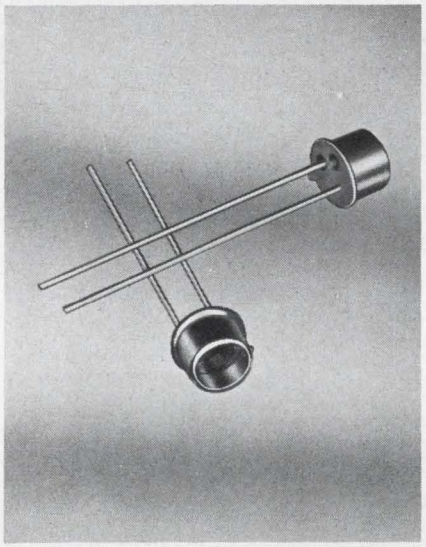
Now you can afford lasers for dozens of military, commercial and industrial applications never before considered. Wireless communication links, isolated coupling, instrumentation, and measurement present excellent possibilities.



New low-cost H1D1 pulsed room-temperature injection laser diodes—another General Electric first. Devices shown approximately twice actual size.

And plans are underway to use them for night surveillance, intrusion alarms, plant protection equipment and optical range finders.

Peak wave length of G.E.'s new H1D1 laser diode is 9,000 Angstroms at room temperature. Each is mounted in a TO-46 header and hermetically sealed in a metal can with a flat glass window at the top.

Test one yourself. H1D1's are *available now* from your G-E engineer/salesman or semiconductor products distributor. Circle *Number 812*.

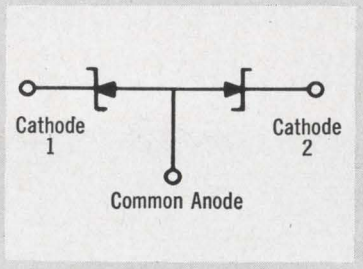
Here are those new low-cost voltage reference diodes you've been waiting for

Prices run as low as 40 cents in volume quantities. New F16H1 temperature-compensated diodes are actually two diodes connected in series within a single pellet . . . and with one common anode. Key features include:

- low temperature coefficient— $dv_z/dt < 0.025\%/°C$ max
- V_z reference voltage—6.2v (typical)
- close thermal coupling

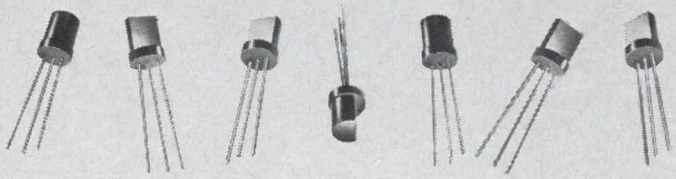
These new devices are designed for general purpose voltage reference and voltage regulator applications up to 15 milliamps. Here are just a few of their industrial and consumer possibilities in addition to uses as temperature-compensated reference diodes:

- as symmetrical voltage reference diodes.
- as dual diodes with one common anode.



- in stabistor diode applications.
- as dual or single zener diodes.
- as premium voltage reference diodes.
- as variable capacitance matched diodes.

Circle **Number 811** for more product and application information.



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This opens the door to many new uses for LED's. For example, they're a perfect spectral match for modern-day light detecting devices (such as G.E.'s new low-cost light-activated silicon controlled switch). Or you can use LED's for high speed reading of computer cards as LED's will follow a signal up to 2 megacycles. No more mechanical errors inherent with "feeler" devices.

Other distinct new advantages are possible for high-voltage isolation, optically coupled computer elements, photoelectric systems, and high-speed infra-red photography. Circle *Number 813* for more details on these and many other devices in the G-E family of opto-electronic semiconductors.

These are just a few examples of General Electric's total electronic capability. For more information on all G-E semiconductor products, call your G-E engineer/salesman or distributor. Or write to Section 220-47, General Electric Company, Schenectady, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ontario. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y., U.S.A.

GENERAL ELECTRIC

Congress to favor science

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

'67-'68 to be banner science years

The White House Office of Science and Technology is predicting that the next two years will be the biggest so far in American history for officially supported science and technology. The forecast is also being made by almost all of the technology-oriented agencies and from both sides of Capitol Hill, as Representatives from "safe" election districts and Senators not up for re-election begin thinking about the upcoming 90th Congress. The next two years, all parties point out, may not see more money spent by the Government—unless something breaks in Vietnam to ease war budget pressures—but more emphasis, more talk, more legislation and more moral support are expected for technology than in the past.

Politically science is "in." The Republicans have called for Government use of aerospace types of systems management for all major Government programs, such as the war on poverty, attacks on pollution and transportation problems, medical research and urban redevelopment. The White House says that systems engineering already is at work in most of these areas. A major G.O.P. 1968 campaign issue is expected to be whether the Administration and the Democrats in Congress have done enough to bring science to bear on non-military, non-space problems and whether Federally-supported research is being translated rapidly enough into practical, mass programs. Last summer, knowing that a Republican policy committee was about to issue study papers on the application of technology to civilian problems, President Johnson beat the opposition to the punch by ordering concentrated efforts to get research results into the mainstream of national life sooner.

Despite a NASA-sponsored report indicating that new technology cannot be forecast and that, if it could, nobody apparently really wants to attempt it, the House Committee on Science and Astronautics wants to form a national commission that would largely have as its mission the forecasting of technological change. Committee Chairman Emilio Q. Daddario (D-Conn.) says the proposed Technology Assessment Board would be an "early warning system" to alert the nation to undesirable by-products of new technologies: air and water pollution, atomic waste, collision hazards and other "evils" that temper the benefits of new technology. To predict the unwanted side effects, Rep. Daddario admits, the board would first have to forecast the development of new technology. The committee is expected to hold hearings on the proposal next year.

Subminiature connector hassle resolved

In-fighting among the military services and within the industry over standardization of subminiature cylindrical connectors has finally been resolved. A tri-services conference and the Defense Electronics Supply Center have adopted a design by the Amphenol Corp (Astro/348). Seven U.S. and one British concern presented designs in the competition. The chosen design does not meet every one of the criteria demanded by the three services, particularly with respect to air leakage. Nevertheless, a Navy spokesman for the tri-services conference said, the "over-all characteristics and performance" of the Amphenol design "were the closest to the criteria established by the three services."

No sooner was the announcement made, at a Naval Air Systems Command symposium on advanced techniques for aircraft electric systems, than a Navy spokesman revealed that the connector already was undergoing modifications to meet new requirements imposed by the military forces.

A spurt for high-speed transit R&D

Watch for R&D spending in the high-speed ground transportation program to speed up next year. The war in Vietnam is likely to make inroads into the total budget, but the Office of High-Speed Ground Transportation—now in the Commerce Department but soon to switch

to the new Transportation Department—has recently hired additional engineers and R&D administrators to monitor new programs. Programs deliberately held at a low spending level will be accelerated.

The entire program moves into a second phase later this year. Advanced technology, including electronics, will get more attention. The first phase consisted largely in organizing the office and in getting the Boston-Washington rail experiment set up. While railroad cars in the experiment are whipping along stretches of the Pennsylvania's tracks at up to 150 mph, gathering data, the Office of High-Speed Ground Transportation can reorient toward advanced technology needed for future systems. In the offing: development of data-acquisition, signaling, communications and control systems. Cryo-pumped tube vehicles and ground-effect machines that use smoothed, hardened earth paths as rights-of-way are under study. So are linear electronic motors and the vehicles that they would power.

Marines look into maintenance systems

Problems in Vietnam are showing the Marine Corps that maintenance systems that work on paper and that perform well in a well-defined, large-scale war do not necessarily work in brush fighting. The Marines are giving serious thought to redesigning their entire maintenance system. And they are looking for an R&D-oriented concern to provide the technical advice. So far there has been no official request for proposals, but companies that might be interested have been invited to outline their qualifications to do the job.

Some of the thinking at Marine Corps headquarters is that more men can be put into fighting if front-line maintenance men are replaced by modularized, pull-out, plug-in equipment. Also, with present airlift capabilities, it may be cheaper and more effective to discard, rather than repair, much equipment; new equipment could be flown in. One thing is certain, the Marines say: automatic data processing will be applied throughout any new maintenance management system.

Industry warned to sharpen management

What does the Navy want most from the electronics industry? Navy Secretary Paul H. Nitze says that all of the cries for greater reliability, faster performance, lower costs, and longer equipment life boil down to two words—"better management." He says:

"We continue to see vital and costly programs fall short of desired goals in time and performance, or even fail completely. The reasons for this are hard to isolate. We have seen the same company do an outstanding job on one program and fall short on another. We frequently see different companies unable to produce comparable results on the same or similar equipment. The causes are sometimes technical, sometimes costs, sometimes management. But even where management is not directly responsible, there are always overtones of management problems. Of all the improvements we can make, a creative approach to management offers the greatest prospect of return."

Nitze's comments were addressed to the electronics industry at a IEEE Aerospace and Electronic Systems Convention. They were part of a speech that emphasized that the Navy was moving toward more advanced electronic systems. Observers saw them as a warning that the Navy might take over some in-plant management or drop some of its contractors.

Navy studies shipboard systems costs

Any proposed changes in shipboard systems will in future probably have to measure up to a new set of standards. These standards are the result of a survey of the costs of performing a variety of jobs aboard naval vessels, which has just been completed by the Office of Naval Research (ONR). The Maritime Transportation Research Board of the National Academy of Sciences-National Research Council cooperated with the ONR to study operations—including radio and electronic—on board 20 ships. The data that they collected form the basis for a new data collection system, which they suggest should be used to evaluate proposals for modifying on-board systems or installing new ones.

The main points of the new data collection system are contained in a report on the study made of one of the 20 surveyed ships. The report is entitled: "Shipboard Systems Costs: A Functional Analysis of Work Aboard Ship, MTRB Ship Number 5—A Tanker in Domestic Service" (Order AD-637 786). Copies may be obtained for $2.00, or 50¢ in microfiche, from the Commerce Department Clearinghouse, Springfield, Va. 22151.

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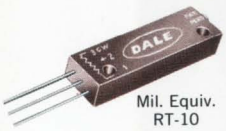

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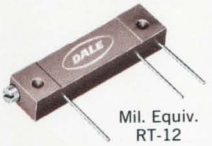

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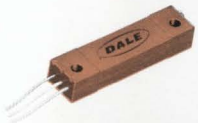

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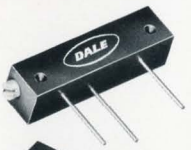

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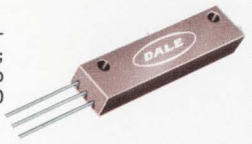

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Deeper probe of ionosphere due

Penn State to use improved equipment, better techniques to study RF signals

Ron Gechman
West Coast Editor

Improved high-frequency radio equipment and a relatively new technique for measuring the effect of disturbances on signals may soon add significantly to our understanding of the ionosphere.

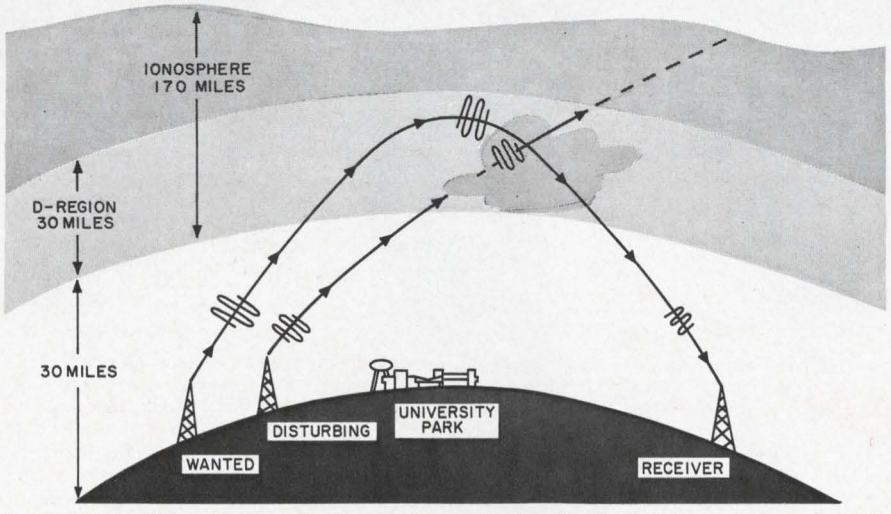
The dual approach is being pressed by Pennsylvania State University engineers, who are installing a new transmitter, antenna array and improved receiving equipment to probe deeper into the ionosphere. The equipment is scheduled to be in operation by December and will, according to one of the university's investigators, Dr. Anthony Ferraro, aid in answering such questions as these: How did the ionosphere form? What disturbs it? How can long-range radio communications be improved?

Of prime importance to researchers is the ionosphere's ability to reflect radio signals back toward earth. Because ionization depends primarily upon the sun, and the sun displays strange behavior (sun spots and flares), the reflective ability of the ionosphere varies. This causes radio fading. Also affecting the ionosphere are man-made disturbances, such as those caused by atomic explosions. The area that appears to pose the greatest problem to long-range radio transmission is the lower, or D-region, which extends from 30 to 60 miles up.

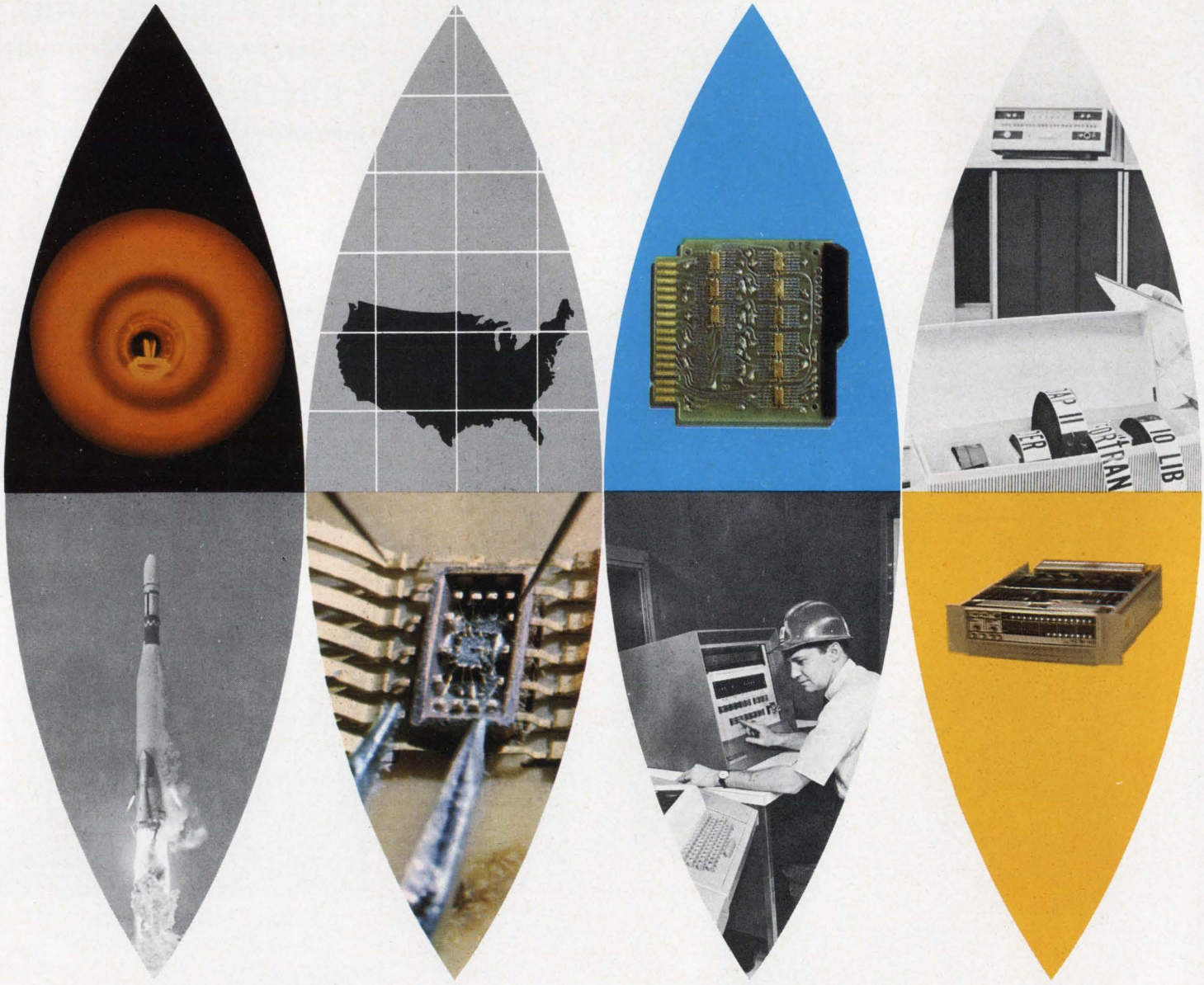
To study the effects on radio transmission, researchers needed a way to monitor quickly and continuously the electron density of the ionosphere at all altitudes and to investigate what happens to the density when it is disturbed by the transmission of radio signals. Two Penn State Engineers—Dr. Ferraro, an associate professor, and Dr. Hai-Sup Lee, assistant professor, both in the Dept. of Electrical Engineering and members of the university's Ionosphere Research Laboratory—developed a technique called phase interaction. It requires two ground-based radio transmitters, a receiver and an array of antennas.

Two high-frequency radio signals are aimed into the ionosphere, so they will intersect at a particular altitude in the D-region. On entering the ionosphere the first signal warms the electrons in its path only

(continued on p. 36)



Ionospheric-disturbance experiment is conducted by Penn State engineers with high-frequency radio signals. One signal, beamed into the ionosphere, causes a change in phase of a second signal, by heating the electrons in the ionosphere at the intersection point.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Honeywell, Computer Control Division,
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3C COMPUTER CONTROL DIVISION

ON READER-SERVICE CARD CIRCLE 21

(ionosphere, *continued***)**

slightly. The second signal, transmitted at a higher power, greatly warms the electrons, causing a change in phase of the first signal. This change is measured on the ground.

Ferraro and Lee experimented with their technique over a year ago, but when the new equipment goes into operation, many questions about the ionosphere, especially those concerning radio-wave propagation, will hopefully be answered, Ferraro says.

Situated near University Park in the center of Pennsylvania, two transmitters are synchronized with each other. The first, called the "wanted" station, broadcasts 80 pulses per second at 2.2 MHz. The output power of this station is 10 kW. The wanted signal is beamed into the ionosphere, reflected back to earth and recorded at the receiving station.

The precise altitude where the signal is reflected can be calculated from the time span between the transmission and reception of the pulses.

A second transmitter, called the "disturbing" station broadcasts at 40 pulses per second at 4.5 MHz. The power output is 500 kW, but when the new antenna array is installed, the effective power will be raised to 15 MW. Pulses from the two stations are synchronized, so the signals will intersect in the ionosphere at a point below the altitude where the wanted signal was reflected back to earth (see diagram).

The high power of the disturbing transmitter greatly warms the electrons in the path of the signal. The disturbance created at the intersection of the two signals causes a greater change in phase of the wanted signal. This change is recorded on the ground and compared with the signal received before its disturbance.

The Penn State engineers have designed and built an elaborate system to help the receiver distinguish changes in the wanted signal, even against a background of a continuously changing ionosphere. The system continually adjusts the two transmitters, so the signals will intersect at varying altitudes within the D-region.

Using an earlier system for measuring the effects of disturbances, the two engineers found they could continuously sweep the entire D-region in about an hour. If the sweeping rate could be significantly increased, all changes in the ionosphere due to either natural or artificial disturbances could be continuously monitored, the Penn State engineers reasoned. This is why the Office of Naval Research, sponsor of the program, authorized Ferraro and Lee to improve their equipment. The new equipment will allow the entire D-region to be continuously and precisely swept in less than 30 seconds, Ferraro asserts.

In another ionospheric experiment, scientists at the Cornell Aeronautical Laboratory are preparing to measure electron densities in the D-region during a total eclipse of the sun on Nov. 12.

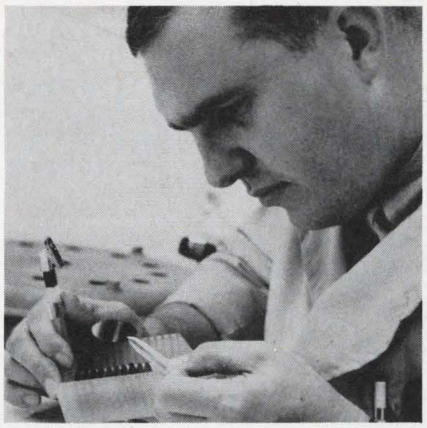
They will collect scientific data before, during and after the eclipse. Equipment is now being set up in Brazil to transmit signals into the ionosphere to obtain electron density profiles. The profiles will be analyzed to determine the effective electorn production and recombination rates. ■ ■

Fluidic navigator guides Army on March

With a five-pound fluidic navigator hooked to his belt, a soldier can pound the forest turf in darkness and be sure of his location.

A bellows attached to one foot sends a puff of air surging up to the navigation unit each time the soldier takes a step. Two permanent magnets in a liquid-filled case track magnetic north, and the unit's fluid logic calculates the soldier's new position after each step.

The unit, developed by the Martin Marietta Corp. of Baltimore, is said to be jam-proof. However, if the soldier is dragged any appreciable distance, the unit must be reset. ■ ■



Roger Smullen is a 30-year-old malcontent. He came to Fairchild six years ago in Quality Assurance. Then, he became a Production Foreman. Then, Production Engineer Supervisor. Now, he's Product Manager in the Custom Integrated Circuits department at Fairchild. He can never leave well enough alone.
We need three more like Roger. If you're not content, contact Jack Sheets at Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, California.

Roger needs a Product Engineer with a B.S. in Physics or E.E., with semiconductor or integrated circuit experience, to stretch present technology and develop new technology in the production of custom integrated circuits, from wafer fabrication and assembly to device classification.

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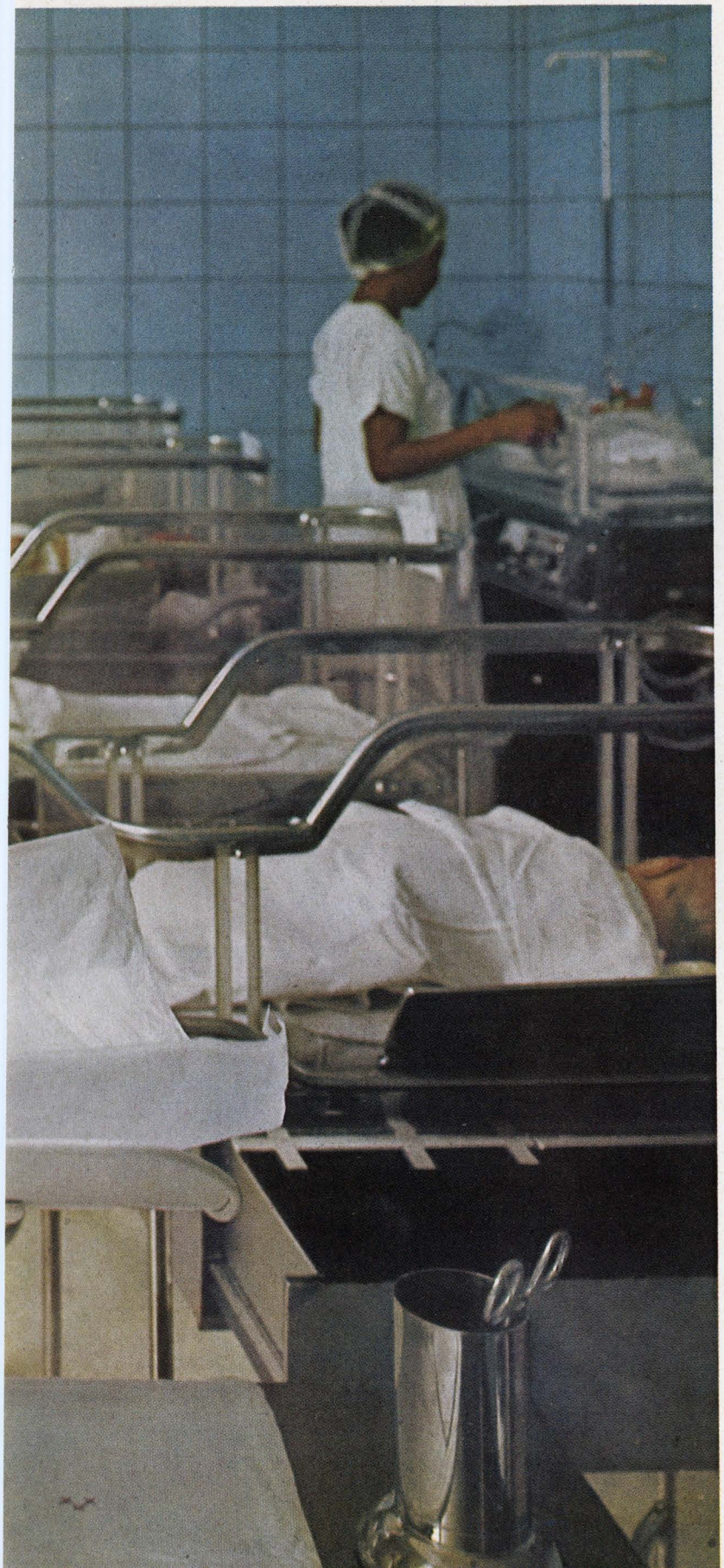

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ON READER-SERVICE CARD CIRCLE 24

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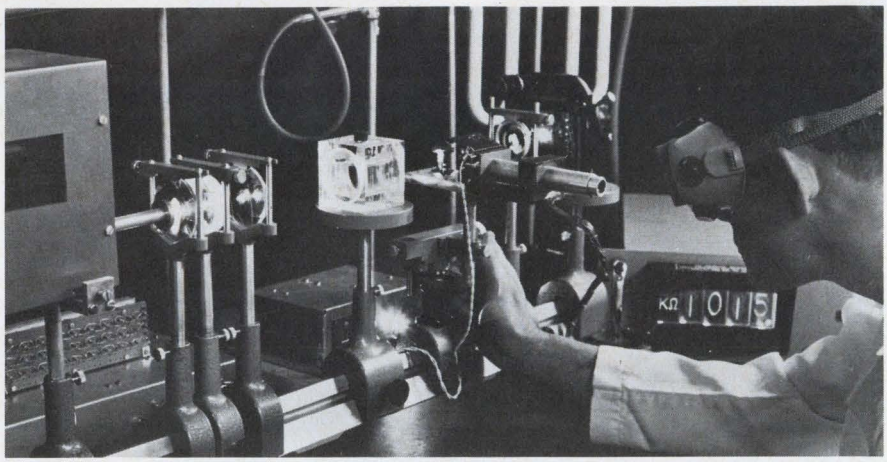
Ruby laser process controls resistivity

A new ruby laser process is being used to adjust, in a predictable and controllable way, the electrical values of the tiniest available microelectronic thin-film resistors.

Unlike other laser trimming methods, in which material is burned away, the new process alters film resistivity. This is achieved by momentarily heating the thermally alterable film above a threshold temperature.

The process is being investigated by the Univac Defense Systems Div. of the Sperry Rand Corp., St. Paul, Minn. A major advantage of their method, the researchers say, is the ability to localize the point of impact of the minute laser light on the surface of the hybrid circuit. Their hope is that ultimately it will be practical to automatically adjust resistors about one-fifth the width of a human hair. ■ ■



Adjustment of resistivity is achieved when light from a ruby laser (left) is aimed at the resistor on a one-eighth-inch-square hybrid circuit, mounted at the right of the apparatus. By precision regulation of the beam, Univac researchers can predict and control subtle changes in the electrical values of the resistor, to meet the strict electrical requirements of a given circuit.

Zinc-air battery cuts weight sharply

A practical zinc-air battery has been developed for space and military applications, and several commercial laboratory units look very promising.

The single biggest advantage of the zinc-air battery is its high energy-per-weight (watt-hours/pounds) figure. Batteries of 150 watts-hour/lbs have been developed—about twice the figure of a conventional silver-zinc battery—and the theoretical limit is 450.

Zinc-air batteries also operate well at low temperatures—as low as −40°F.

These details were disclosed at a news conference in New York City by Leesona Moos Laboratories of Great Neck, Long Island, N. Y., developer of the new battery. Dr. Stewart M. Chodosh, Product Manager-Batteries of the company, displayed several developed zinc-air batteries, described further development work, and briefly explained the working mechanism of the zinc-air battery.

In producing power, the zinc anode is converted into zinc oxide. The cathode, meanwhile, remains unchanged, acting to form hydroxyl ions from the oxygen combining with the electrolyte of potassium hydroxide.

At present zinc-air batteries can be obtained either as primary or mechanically rechargeable batteries. The mechanical recharge consists of replacing the zinc anode (the only part that "wears") with a fresh one. ■ ■

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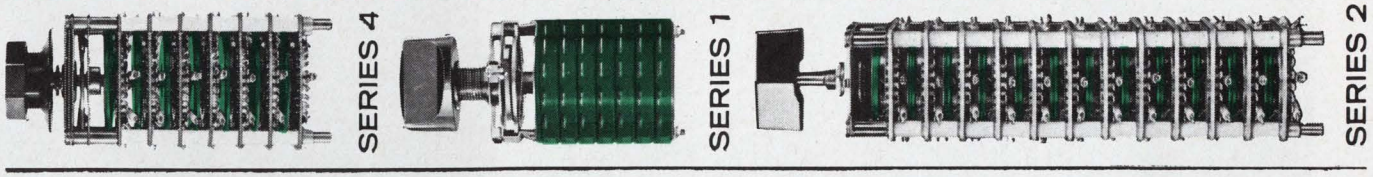

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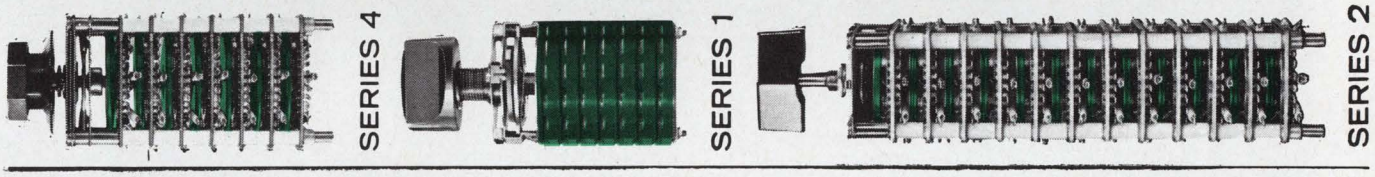

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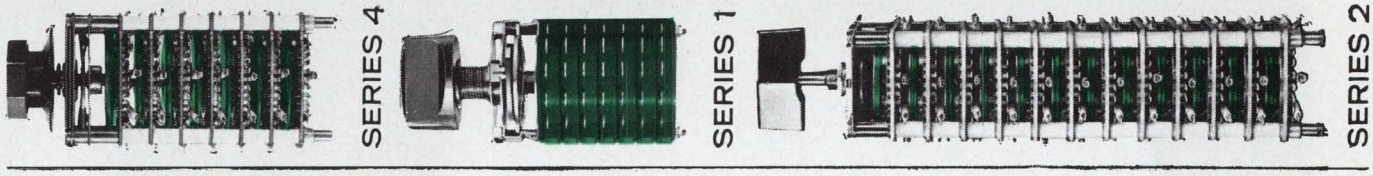

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LOWER TOTAL COST — INITIAL COSTS ARE NORMALLY LOWER (often 25 percent or more) than those for rotary switch counterparts claiming comparable quality. INSTALLATION COSTS ARE REDUCED by easily wired flared terminals (identified for location) and rugged construction features that virtually eliminate switch damage during harnessing. MAINTENANCE AND REPLACEMENT COSTS ARE REDUCED to the vanishing point by: (1) 50 in/lb stop strength ratings, (2) multiple contact wipers (for reliable circuit "making"), (3) positive action long life detents, (4) dust protection for internal switch parts, and (5) material-design combinations that reduce voltage breakdown and insulation resistance failures. Add these cost "savers" to lower specification costs (below), and you'll see why Shallcross has the most economical top quality rotary switch line in the industry — as a matter of fact, an investigation will prove that Shallcross switches are often less in total cost than the lowest priced "clip types."

OUTSTANDING DRY CIRCUIT SWITCHING — Negligible "thermals," low contact resistances (1-2 milliohms typical from input to output), and low switching noise provide ideal dry circuit switching.

EASIER SPECIFICATION — Comprehensive cataloging, reproducible specification sheets (for easier drawing creation), and easily used part number systems expedite specification.

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ON READER-SERVICE CARD CIRCLE 27

NEWS

AF memory unit 'programs' attacks

The Air Force is testing a new Integrated Armament Control System that lets the pilot "program" his pattern of attack before he reaches the target and then carry it out with a flick of a switch.

Current fighter-bombers often have entirely different controls and displays for each family of weapons, including nuclear and conventional bombs, dispensers and tanks, the Air Force says. The new system gives the pilot a consolidated armament control panel. A readout display shows the type of weapons carried, where they are located and the status of each—armed or safe.

A unique feature of the system is its memory-selection capability. With buttons on the control console, the pilot can program several different types of attack before takeoff or while he is en route to the target. He chooses the number of weapons he wants to release, the stations they will be released from, interval between releases, delivery mode and other conditions.

Several choices available

One program, for example, might call for several passes over the target, with two bombs released on each pass. Another might specify a salvo attack, with all bombs falling on one small target during a single pass. A third might call for a combination of weapons.

The pilot can select the most suitable program from the memory unit just seconds before starting his attack. He merely moves a selector switch to it, aims and touches his bomb-release button. If none of the pre-selected programs is suitable, he can quickly establish a new program to fit the target situation.

The system has a built-in test capability. To find out if all circuits are working, the pilot presses a button on the control console. If there is a major malfunction, the panel indicates the source.

The prototype for the system was developed by the Technical Measurement Corp. of North Haven, Conn. Tests are under way in an F-105 fighter plane at Kirtland Air Force Base. N. M. ■ ■

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3 watts @85°C

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Series 600
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Series 550
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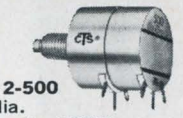
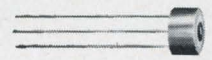


Series 2-500
3/4 " dia.
1-1/2 watts @85°C
Tandem Series 500



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11/32" dia.
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For P.C. applications

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ON READER-SERVICE CARD CIRCLE 29

LETTERS

Just plug in at any tree

Sir:

You printed a letter from Charles A. Klimko [ED 17, July 19, 1966, p. 38] which accused ED of frivolity in publishing a photograph of Michel Yardney about to plug his electric car into a tree receptacle [ED 13, May 24, 1966, p. 17]. This is not so far in the future as it may seem.

In August, 1964, we parked our travel trailer by the town park of Manti, Utah, and were delighted to find outlets on several trees, provided by the town fathers for travelers such as we. This idea should spread to any town that wants to attract travelers, for trailering has become very popular and a source of extra income for hospitable towns.

Robert W. Blanchard
Design Specialist
Lockheed Missiles/Space
Sunnyvale, Calif.

Scientific happiness draws an objection

Sir:

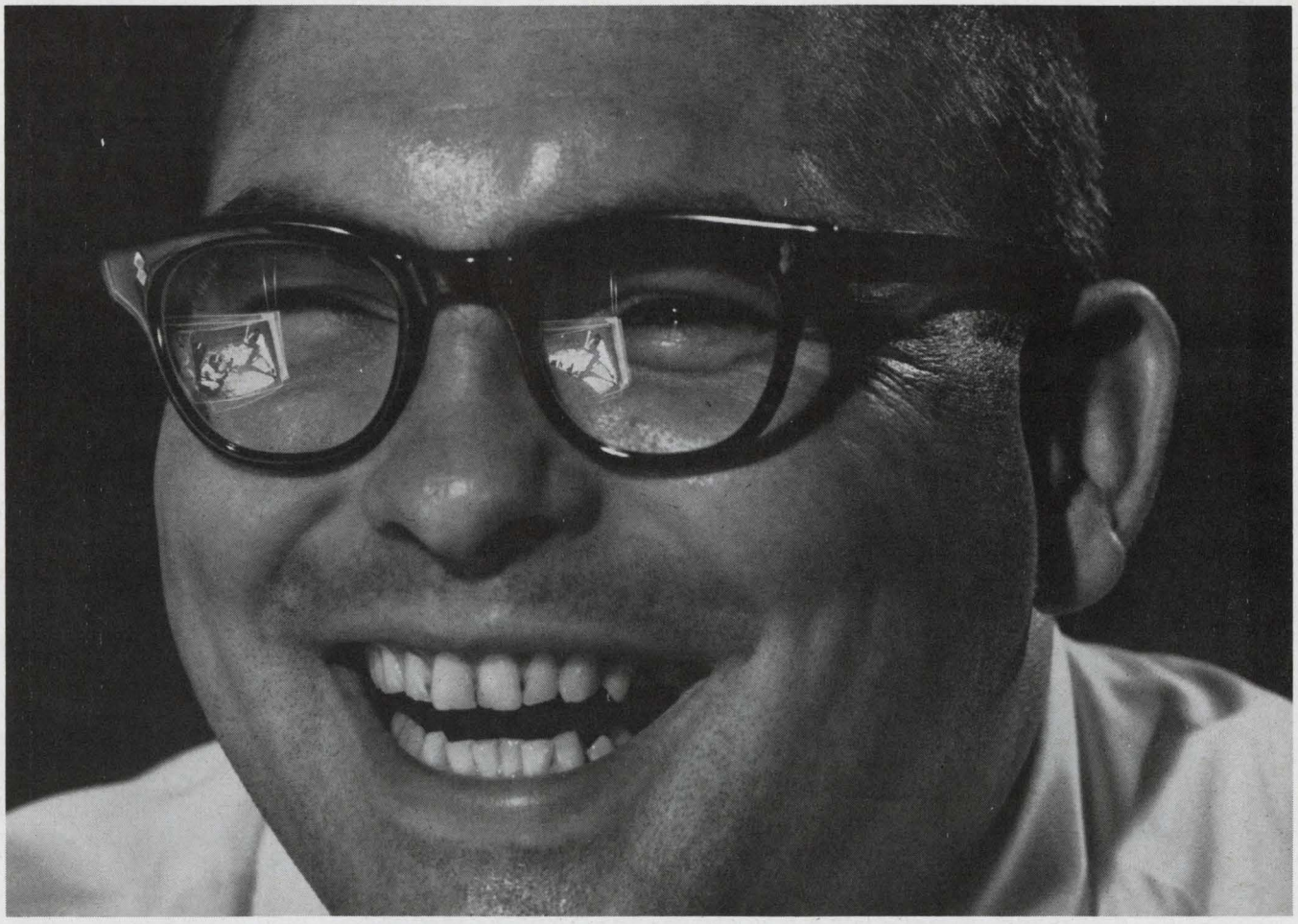
Your editorial of August 30, 1966 ["Man looks to science for his future happiness," ED 20, p. 31], does not present a complete picture.

While it is quite true—as Lester Hogan says—that "science and engineering, more than any other forces, are responsible for removing the isolation between men and nations," this removal has not always been beneficial. The same science that makes worldwide communications possible also makes possible a worldwide nuclear holocaust.

You point out that "increasingly complex controls are needed by a minority if it wishes to fool most men most of the time," but as a matter of fact these complex controls *are* available to minority groups in power. Witness managed propaganda in the U.S.S.R. or by the Johnson Administration in the U.S.

Science can provide the tools, but it is in itself a tool. It is not, nor can it ever be, the place of science to establish values—good or bad.

If we are to consider the totality of man's existence, we must look



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Forward Transfer Admittance	MPF103 MPF104 MPF105	$\|Y_{fs}\|$	1000 1500 2000	3000 4000 4500	5000 5500 6000	μmhos
Breakdown Voltage	All Types	$V_{(BR)GSS}$	−25			Vdc
Gate Reverse Current	All Types	I_{GSS}			−1	nAdc
Input Capacitance	All Types	C_{iss}		4.5	7	pF

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ON READER-SERVICE CARD CIRCLE 31

beyond science. Science may be necessary, but it certainly is *not* sufficient for man's happiness.

For man to look to science as the necessary basis for his happiness is a false hope. He is not taking a total systems approach by considering only one aspect of his existence as the basis for his future.

What factors are sufficient? This is the subject for another discussion.

Arnold Larson
Engineering Specialist
Philco WDL
Palo Alto, Calif.

Engineers can guide product development

Sir:

In reference to Dr. B. Martin Steiger's letter ["Engineers cannot govern quality," ED 21, Sept. 13, 1966, p. 44], I would like to make a few comments.

Your published interview with the men of the green beret [ED 18, Aug. 2, 1966, p. 36 ff.] was most informative and helpful to the engineers at AEL. In most organizations such as ours, it is the engineering staff which is the essential management, for it is its ingenuity and originality which dictates [to] the vice-presidents and stockholders the companies' capabilities as well as the quality of the products produced. The engineers are the individuals who write the technical proposals and who produce the final product. Knowing the problems of the men in the field aids us in producing items which most readily meet their needs. "A quick and dirty design job" reflects back upon the company and engineers and forms an image which I believe no organization would desire to own.

I believe that more articles and interviews of this nature should be published, directed to the engineers, for it is they who can most directly help their sons and brothers in the field.

Robert D. Goldblum
American Electronic Laboratories, Inc.
Systems Division
Colmar, Pa.

Since 1958, Varian has powered most of the world's satellite communication systems.

During these years Varian scientists and engineers have worked hand-in-hand with America's leading ground terminal designers to build up the most thorough knowledge, capability, and technology in the entire microwave tube industry.

For example, this close working relationship resulted in Varian's VA-884B CW amplifier, a 14 kW power output tube tunable between 5.925 and 6.425 GHz. This tube is an important part of most satellite ground terminal stations in use today.

Another example of this ability to help industry develop the most advanced klystron amplifiers is Varian's VA-925, a state-of-the-art tube which delivers over 8 kW CW power output and is tunable from 7.9 to 8.4 GHz. This tube will be used to power the latest satellite communication projects now under development.

There will be other examples soon because Varian is continuing to develop new and more sophisticated microwave tubes for new and more sophisticated satellite communication systems.

May we help you extend the state-of-the-art in your industry?

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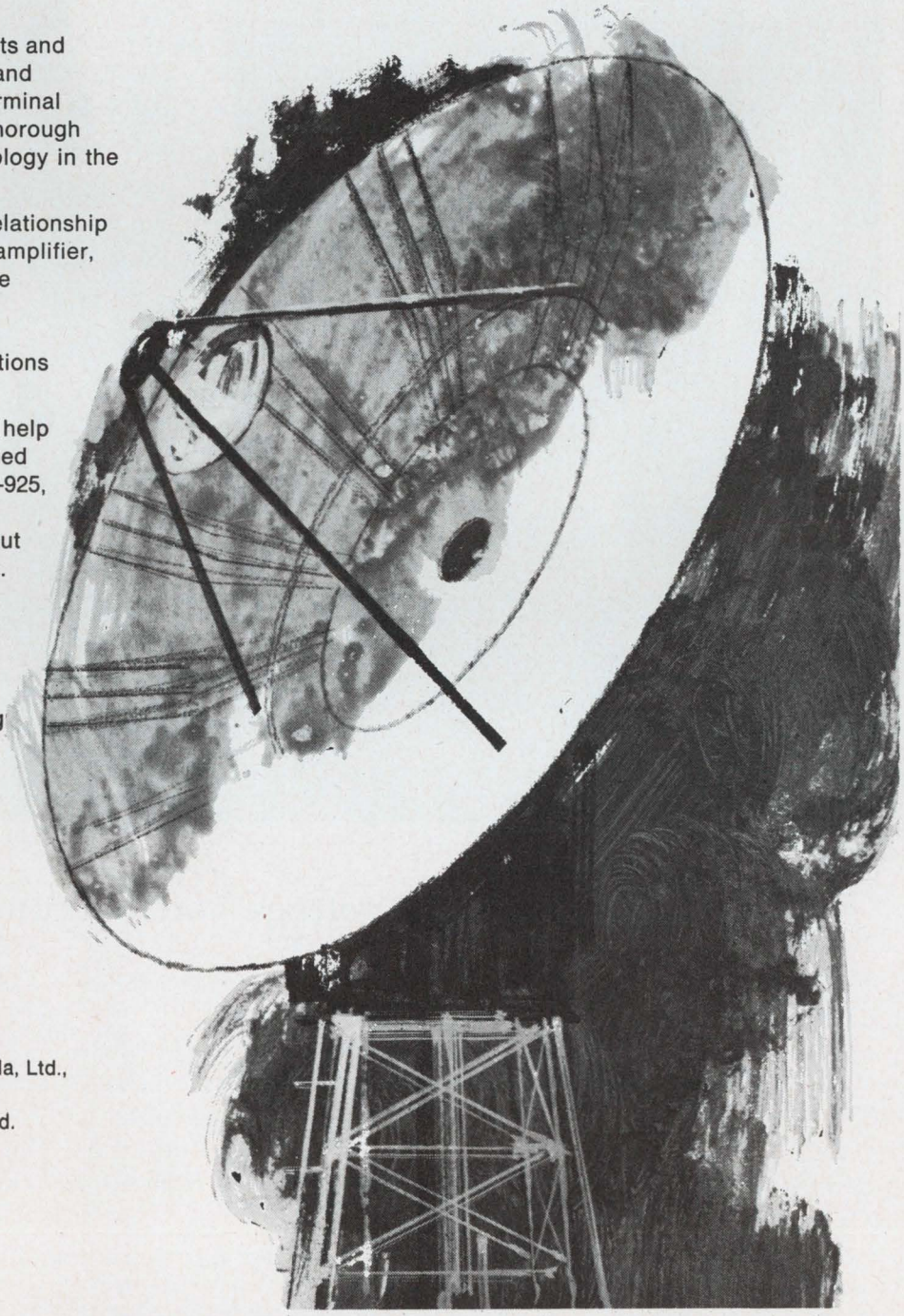

ON READER-SERVICE CARD CIRCLE 33

8-19

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ON READER-SERVICE CARD CIRCLE 34

Wasteland revisited: Must CATV be an electronic 'rubber stamp'?

When Newton Minow, then chairman of the Federal Communications Commission, called television "a vast wasteland" some years ago, one television executive whimsically retorted that it was a "conservative estimate." Today community-antenna television systems (CATV) pluck this conservatively estimated vast wasteland from the air and feed it to 6.6 million viewers in this country.

At present there are 1600 CATV systems in operation, 250 under construction, 650 franchises in preparation and 1300 pending. Two million households subscribe to a CATV service. These franchises turn a handsome profit, often between 50 and 100 per cent. But what does CATV do for the paying viewer?

A CATV franchise provides its subscribers with a clear, interference-free image of conventional broadcasts. When stock is sold and the wires are installed, the CATV directors are quite content to transmit nothing but regularly scheduled broadcasts. This, they say, is part of the terms of their franchise. They contend they are not licensed to compete with television, but rather to implement it.

This is the lazy, slothful attitude of an industry mesmerized by excessive profits. It is true that the FCC regulations strictly forbid CATV from transmitting programs that it originates itself. But those same regulations contain "white space." That is, a loosely defined clause that allows CATV operators to originate straight information in the public interest.

CATV could provide its subscribers with educational programs, in-depth news broadcasts, and transportation and weather information. Separate channels could even carry time standards, newswire services and technical programs for engineers and scientists. Its selective distribution makes it ideal for dissemination of specialized knowledge to narrow interest groups. For example, it could supply doctors with medical information, and police with law-enforcement information. In addition its closed-loop, jam-resistant wires could make it an invaluable tool for civil defense and military communications.

CATV holds the promise of fulfilling many a politician's dream: it can give each person just what he wants. But to its public it will never be worth the copper in its wires unless it abandons its present policy of taking the ambient, electronic air pollution and simply feeding it through its lines.

Here is an ideal chance for engineers to raise their voices as citizens. A letter to Congress or to the FCC can help turn the trick —if enough responsible engineers take the trouble to write.

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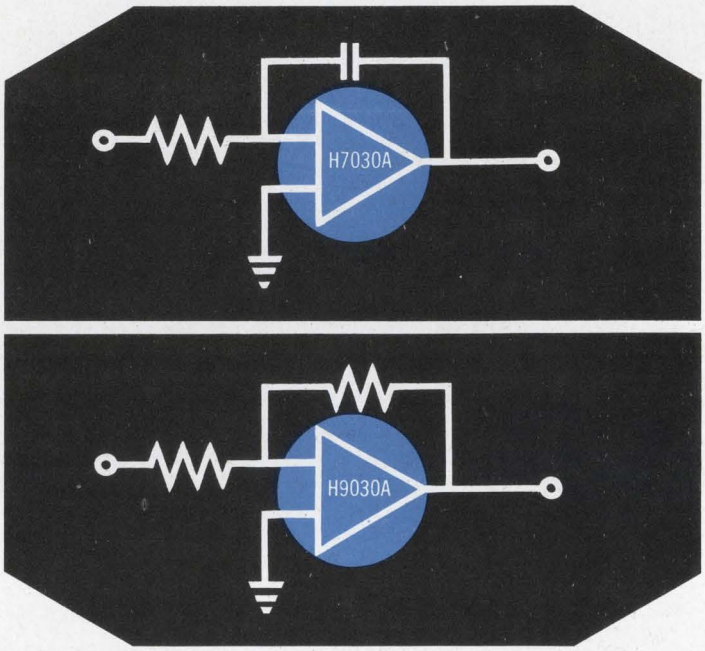

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Gain Bandwidth Product[1]	3.0	3.0	MHz
Slewing Rate	5.5	3.2	V/μsec
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Voltage Drift (max)	±25	±10	μV/°C
Current Drift (max)	[2]	± 0.5	nA/°C
Operating Temp, Range (max)	−40 to +100	−40 to +100	°C
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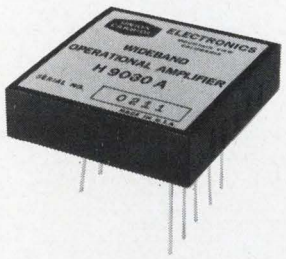
Price (1–4)	$77.50	$70.00	



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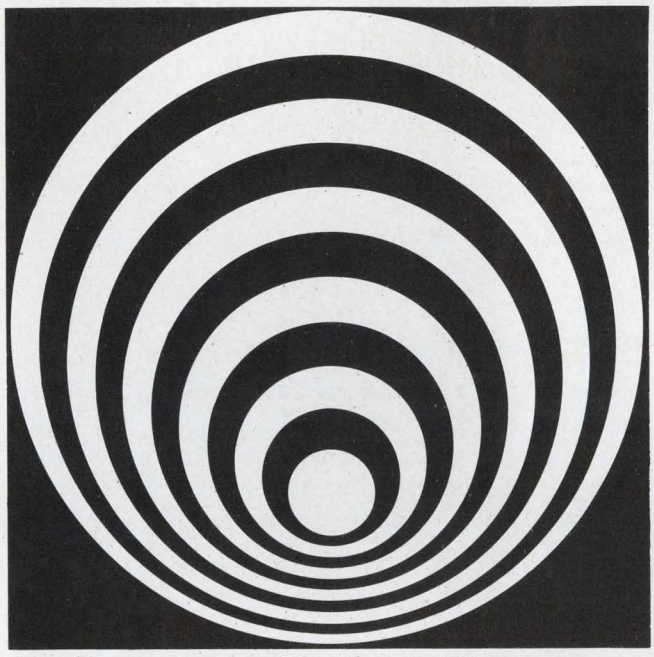
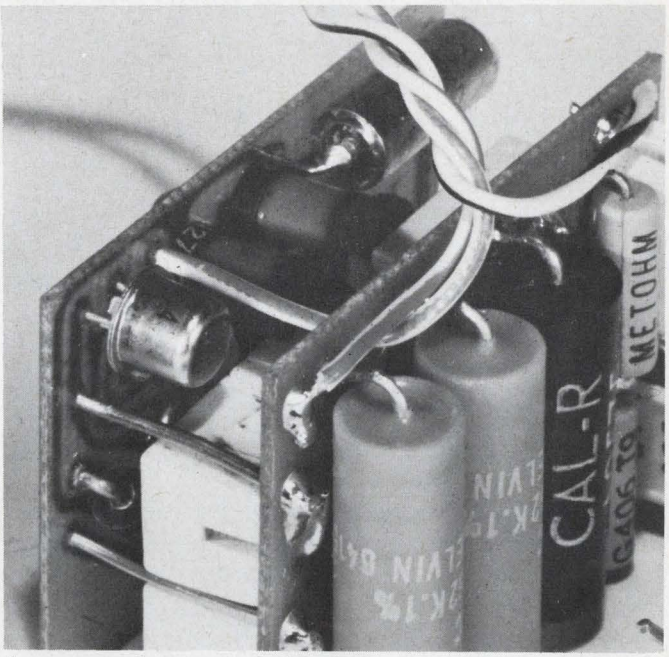
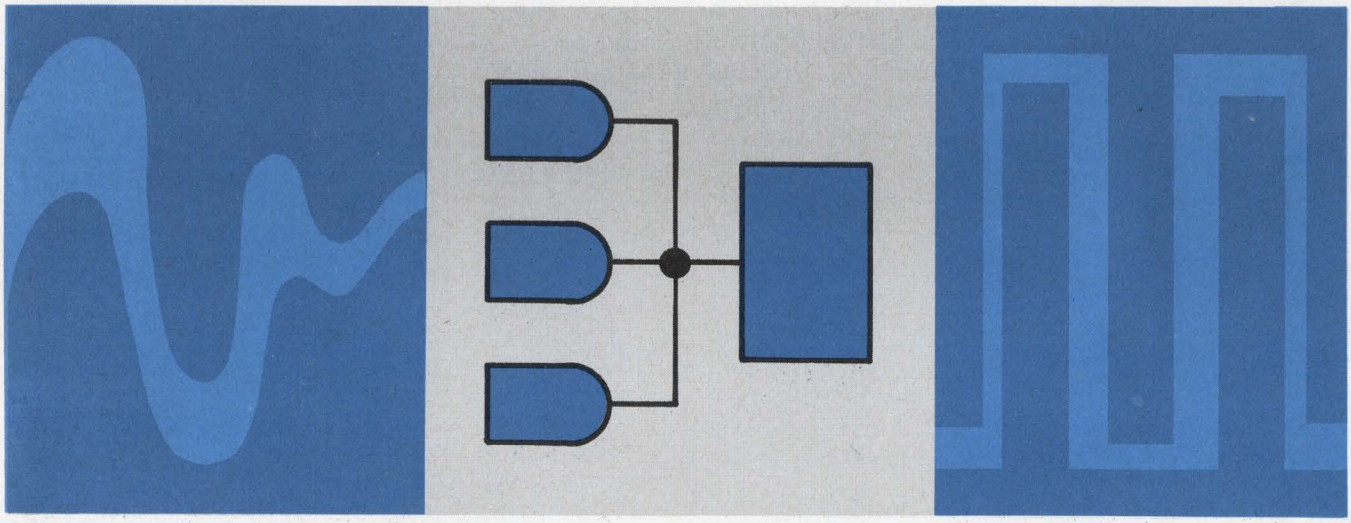
Technology



Linvill charts simplify design of low-noise microwave amplifiers. Page 54.



Inexpensive and stable RC oscillators are possible with unique design approach. Page 88.



Improve A/D converter performance with inexpensive off-the-shelf microcircuits. The unit described here combines both simplicity and low cost. Page 96.

Also in this section:

Saturating chokes and SCRs team up in inverter applications. Page 66.

FET devices provide fast, stable digital switching. Page 72.

Predict line regulation accurately in your next high-current regulator. Page 82.

Design amplifiers for low-noise by carefully considering device selection, circuit configuration and parameters essential to optimum performance

Bipolar transistors yield the lowest noise figure in microwave amplifiers—provided they are used in the right circuit configuration and the proper trade-offs are taken care of. The design procedure must be carefully mapped out, to achieve the best balance among the other important parameters, like gain, power, stability and signal-handling ability.

To show that indeed the bipolar transistor is the best device for low-noise microwave amplification, let's consider the other possibilities; that is, FETs and MOSFETs. The examination of the relative merits of the devices requires the development of certain fundamental considerations.

For a precise description of noise performance, the source immittances and bias conditions must be specified.

The configuration becomes important, because at microwave frequencies (above 500 MHz), the common-emitter and common-base noise figures are not the same. External package parasitics contribute a great deal to the noise figure at these frequencies.

The selection of the best device should start with an examination of Fig. 1 which shows the optimum noise figure, as a function of frequency, for FETs, MOS-FETs, bipolar pnp germanium and npn silicon transistors. These devices are the ones that are most frequently considered for low-noise microwave amplifiers. Schottky barrier diodes are usually employed as microwave mixers at the high end of the spectrum. The curves show the optimum performance in each group.

Even though junction FETs and MOS devices are shown together, the MOS is, in general, slower. Since present MOS devices are about two orders of magnitude below their theoretical speed limit, however, their development may be spectacular. Bipolars are almost at their theoretical limits. The really major difference between silicon and germanium bipolar noise figures is in the region above 1 GHz. In the case of the junction FET, noise figures lag somewhat behind silicon.

George D. Johnson, Section Head, Microwave Circuit Dept., Texas Instruments, Inc., Dallas, Tex.

Bias conditions affect noise figure

In a comparison of noise performance it is necessary to mention bias conditions and their effect. The internal noise mechanisms in a bipolar junction transistor can be represented in terms of an external noise-voltage generator, Eq. 1, and an internal noise-current generator, Eq. 2:

$$(\overline{e_n^2})^{1/2}=[2kTBr'_e+4kTBr'_b+2kTB (r_e'+r_b')^2/\beta_o r_e']^{1/2} \quad (1)$$

$$(\overline{i_n^2})^{1/2}=2kTB[1+(f/f_\alpha\sqrt{1-\alpha_o})^2]/\beta_o r_e'. \quad (2)$$

The first term in Eq. 1 is due to the emitter-base shot noise, the second term to the thermal noise in the base and the third term to the collector-base diode noise. Low-noise amplification with bipolar transistors requires:

- As low a value of r_b' as possible.
- A high value of β_o since the noise sources are inversely proportional to β_o.

The FET is subject to the same types of noise that are found in bipolar transistors; however, its gate-to-source capacitance tends to couple the output noise back to the input and thus to modify the noise figure.

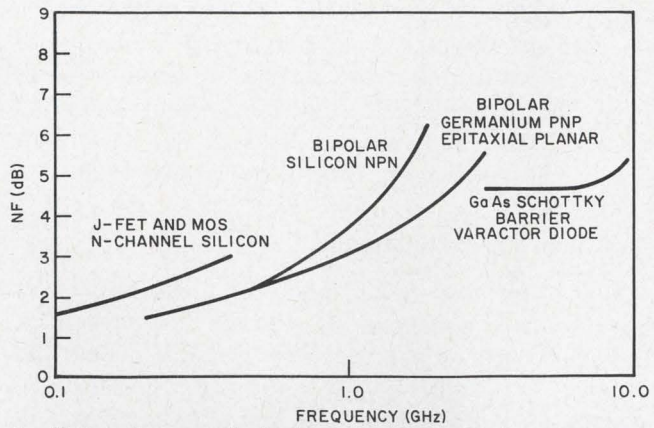
The noise figure of bipolar transistors is given by Eq. 3 while the one used for FETs is given in Eq. 4:

$$F_{HF}=1+(r_b'/R_g)+(r_e/2R_g)+[(r_e+r_b'+R_g)^2/2\alpha_o R_g r_e][(f/f_\alpha)^2+(I_{co}/I_E)+(1/h_{FE})], \quad (3)$$

$$F=1+2\lambda\omega(C_{gs}+C_{gd})/g_m+\lambda/g_m [G_s-\omega(C_{gs}+C_{gd})/G_s]^2, \quad (4)$$

The noise figure of bipolar transistors tends to increase as the emitter current is decreased below the optimum level. As the emitter current is increased, on the other hand, thermal noise and collector-base noise become increasingly prominent.

The comparison of noise figures among the various device types is permissible, even though the bias currents are not identical. Each type optimizes at different current levels, determined by constants that change according to the intend-



1. **Noise figures of devices capable of microwave amplification** indicate optimum performance for each type. The data were taken with bias currents and source immitances that yield the best results for each device.

ed application of the active device. For example, many germanium bipolar low-noise transistors have optimum noise performance in the current region about 1.5 mA, while some silicon bipolars may optimize at about half this value. Junction FETs, by contrast, may optimize at currents as high as 4 mA.

Noise figure depends on source immittance

Source immittance must always be given to specify the noise figure adequately. Equation 5 can be used for both bipolars and FETs:

$$F=F_0+R_n(Y_s-Y_{s(opt)})^2/\mathrm{Re}(Y_s). \qquad (5)$$

The plots of optimum source conductance and susceptance for a bipolar germanium planar

Definition of symbols used in the article

$(\overline{e_n^2})^{1/2}$ = root mean square external noise-voltage generator

$(\overline{i_n^2})^{1/2}$ = root mean square internal noise-current generator

k = Boltzmann's constant = 1.380 x N^{-23}

T = absolute temperature in degrees Kelvin = 300° at room temperature

B = noise bandwidth (Δf)

r_e' = emitter resistance

r_b' = base resistance

β_o = low-frequency transistor current gain

f_α = alpha cutoff frequency, the frequency at which $\alpha = 0.707\ \alpha_0$

α = common-base current gain

α_o = α at zero frequency

F_{HF} = high-frequency bipolar noise figure (Eq. 3)

F = noise figure

$\omega = 2\pi f$ or operating frequency

g_m = low-frequency transconductance

λ = fractional length of conducting channel

R_g = real part (Re) of generator impedance

G_s = real part of source or generator admittance

B_s = imaginary part of source or generator admittance

C_{gs} = gate-to-source capacitance

C_{gd} = gate-to-drain capacitance

h_{FE} = static forward current transfer ratio (common-emitter)

F_0 = optimum noise figure

R_n = noise resistance

Y_s = source admittance

$Y_{s(opt)}$ = optimum source admittance

I_{co} = collector cutoff current

$R_{g(opt)}$ = optimum generator resistance for noise figure

M_E = noise measure

G = available power gain

f_A = upper noise corner frequency

$\overline{i_{ne}^2}$ = mean square value of emitter-base diode thermal and shot noise current

$\overline{i_{nc}^2}$ = mean square value of noise current in the collector-base junction

$\overline{i_{nb}^2}$ = mean square value of noise current in the base

$\overline{i_{ne}^* \cdot i_{nc}}$ = mean square correlation term noise source between emitter and collector currents

e = electronic charge

$\overline{i_{ns}^2}$ = mean square source noise current

$y_{ie} = y_{11e}$ = small-signal input admittance for ac short-circuited output

$y_{re} = y_{12e}$ = small-signal reverse transfer admittance for a short-circuited input

$y_{fe} = y_{21e}$ = small-signal forward transfer admittance for a short-circuited output

$y_{oe} = y_{22e}$ = small signal output admittance

C = inherent stability factor

g_{11} = Re (y_{11}), the real part of the short-circuit input admittance

G_{oo} = power delivered to Re (Y_L) divided by the power delivered to the input of the two-port, where Y_L is conjugately matched to y_{22}.

K = circuit stability margin

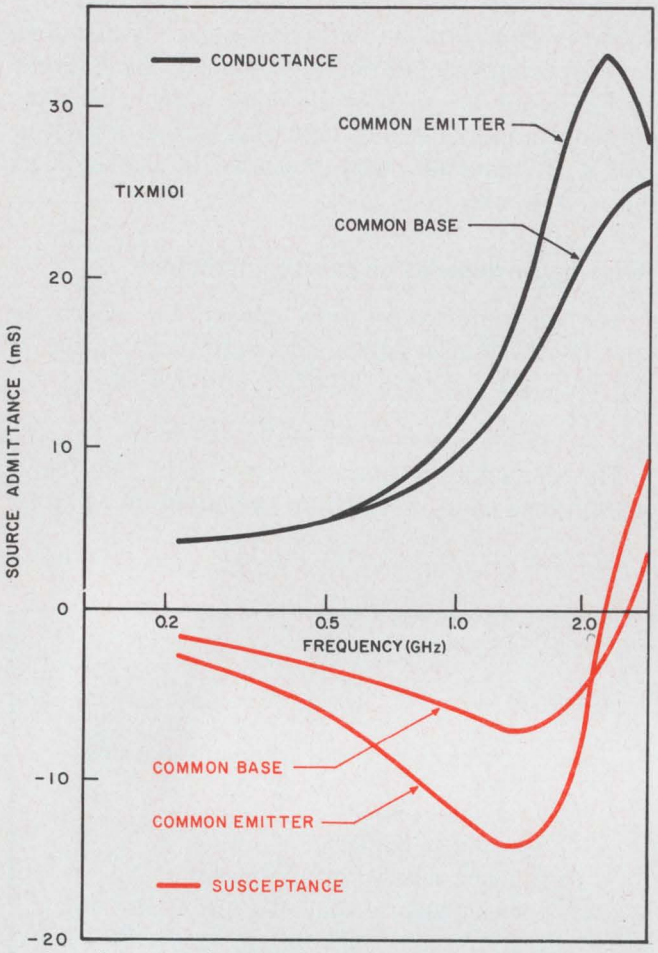
P_1 = Re (Γ_s)

Γ_s = external input immittance

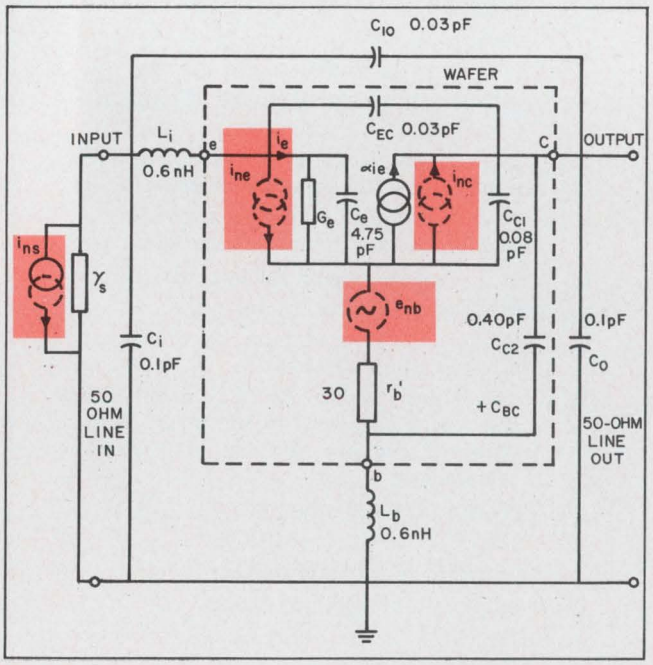
Γ_L = external output immittance

ρ_{11} = Re (γ_{11}) the real part of the input immittance

γ_{11} = the input immittance



2. **At microwave frequencies** the optimum source immittances for low noise differ for common-emitter and common-base connections. The transistor is a bipolar germanium planar device.



3. **Accurate calculation of the noise figure** requires an equivalent circuit that includes package parasitics. For a germanium planar transistor in a stripline package, the noise generators are i_{ns}, i_{ne}, i_{nc} and e_{nb}.

transistor are shown in Fig. 2. At frequencies in the low vhf region (about 500 MHz), the value of source immittance that gives optimum noise performance for bipolars is the same for common emitter (CE) and common base (CB). At higher frequencies, however, this is no longer true.

Parasitics make a difference

The difference in CE and CB noise figures at microwave frequencies is caused by parasitics. Degenerative feedback lowers the gain of the CE connection but also lowers its noise figure. Regenerative feedback in the CB connection decreases stability, which can cause arbitrarily high gain, but also increases the noise figure over the CE value. The parasitics which have the most effect on the noise figure are:

- Common lead inductance.
- Feedback capacitance.

Since both of these parameters have an effect on gain and stability it is important that they be included in the calculations.

It is evident from the above discussion that there is an interdependance between gain and noise figure at microwave frequencies. To specify noise performance for a single stage in terms of both noise figure and gain, use Eq. 6:

$$M_E=(F-1)/[1-(1/G)], \qquad (6)$$

The noise figure of a cascade of identical stages, where G is very large, in terms of M_E is given by:

$$F=M_E+1. \qquad (7)$$

Here F is the noise figure of the cascade.

M_E therefore determines the best over-all system noise figure that is attainable with a particular active device. It can be optimized by suitable circuit transformation to produce the same cascaded noise figure for all three configurations, since $M_{E(opt)}$ is invariant under reciprocal lossless transformation and interchange of terminals. M_E is thus a more comprehensive comparison of noise performance than F alone.

Two factors limit bipolars

The fundamental noise performance of bipolar transistors is limited by two phenomena: thermal noise in r_b' and uncorrelated portion of the collector shot noise ($f\alpha$ *limit*).

The noise caused by base resistance may be reduced by:

- Heavy doping under the base contacts (applicable to both Si and Ge).
- More complex geometry to produce parallel paths.
- Very shallow diffusions.

The uncorrelated portion of the collector shot noise is directly related to $f\alpha$. Since $f\alpha$ is itself directly related to the transit time for minority

carriers through the base, it is not possible to consider $f\alpha$ without also considering r_b'. It is obvious that shallow diffusions produce thinner bases and higher $f\alpha$ but they also increase r_b'. Thus, a compromise must be found between these two quantities. At present, germanium $f\alpha$ is limited to about 8 GHz while silicon $f\alpha$ is limited to about 5 GHz.

An accurate prediction of the noise figure of microwave transistors can be made by use of a suitable equivalent circuit that includes package parasitics. An equivalent circuit for germanium planar microwave transistors in L-band is shown in Fig. 3. The values of the parameters are for a germanium transistor, TIXM101, in a stripline package, with a V_{CB} of -5 V and an I_E of 1.5 mA.

The total collector depletion capacitance, $C_{c1} + C_{c2}$, is determined from 1-MHz capacitance measurements. The value of r_b' is obtained by comparison of calculated y-parameters from the equivalent circuit with measured values obtained from the transfer function bridge. The value of f_T is determined from h_{fe} at approximately 400 MHz. It is good to check this, too, with a transfer function bridge. The value of $r_b' C_c$ is determined by measurement of h_{rb} at 319 MHz. Some care must be taken here, because correction must be made for header capacitance—the prime cause of parasitics. This correction may be made by subtracting the package feedback capacity. From h_{rb} and r_b', the value of C_{c1} may be obtained. The most difficult but most important parameter to determine is $f\alpha$. Perhaps the most accurate method is to compare the calculated noise figure with the measured one at a number of frequencies above $f_{h_{fe}}$ (the frequency at which $h_{fe}=0.707\ h_{feo}$).

The values of the different noise sources are:

$$\overline{i_{ne}^2}=4\,kT\,\Delta f\,\mathrm{RE}\,(Y_e)-2\,eI_E\,\Delta f \tag{8}$$

$$\overline{i_{nc}^2}=2\,eI_c\,\Delta f \tag{9}$$

$$\overline{i_{nb}^2}=4\,kT\,r_b'\,\Delta f \tag{10}$$

$$\overline{i_{ne}^{*}\cdot i_{nc}}=2\,kT\alpha Y_e\,\Delta f \tag{11}$$

$$\overline{i_{ns}^2}=4\,kT\,\mathrm{Re}\,(Y_s)\,\Delta f \tag{12}$$

The output noise of the FET at high frequencies and for a short-circuited input is the sum of the low-frequency noise and the thermal noise of $|g_{12}|$. The limiting noise of the FET at low frequencies is attributed to the thermal noise of the channel resistances r_s and r_d. The increase in thermal noise at higher frequencies has been attributed to $|g_{12}|$, the high-frequency conductance between gate and drain. The high-frequency input conductance, g_{11}, also exhibits full thermal noise. It may be shown that g_{11} and $|g_{12}|$ both vary as the square of the frequency. Therefore, g_{11} and $|g_{12}|$, along with r_s and r_d, represent parameters which limit the high-frequency noise performance of the FET.

In summary, we may conclude that germanium bipolar transistors still lead in noise performance at microwave frequencies. The common-emitter connection, rather than common-base, presents a better compromise between the quantities:

- Noise figure.
- Stability factor.
- Power gain.

In the case of FETs, the common-gate configuration represents the best compromise between gain, noise figure, cross modulation and stability. On the other hand, if noise figure is the sole consideration, common-source connection is recommended.

Regardless of the device, designers should be careful in selecting the type of parameters (ie—y, h, etc.). The h-parameters represent a better description of the active device at low frequencies. The y-parameters are better at high frequencies. Scattering parameters present the best description of the active device at microwave frequencies. It is not advisable to convert one set to another through matrix manipulation at microwave frequencies. Inaccuracies will be introduced because of the different effect that the package has on each configuration. In other words, a measured set of common base data at microwave frequencies will not, in general, agree with a set of common base data obtained by performing a simple matrix transformation on measured common emitter data.

The design of the amplifier itself involves many trade-offs, but fortunately there is a graphical method that considerably simplifies the procedure.

Linvill chart highlights trade-offs

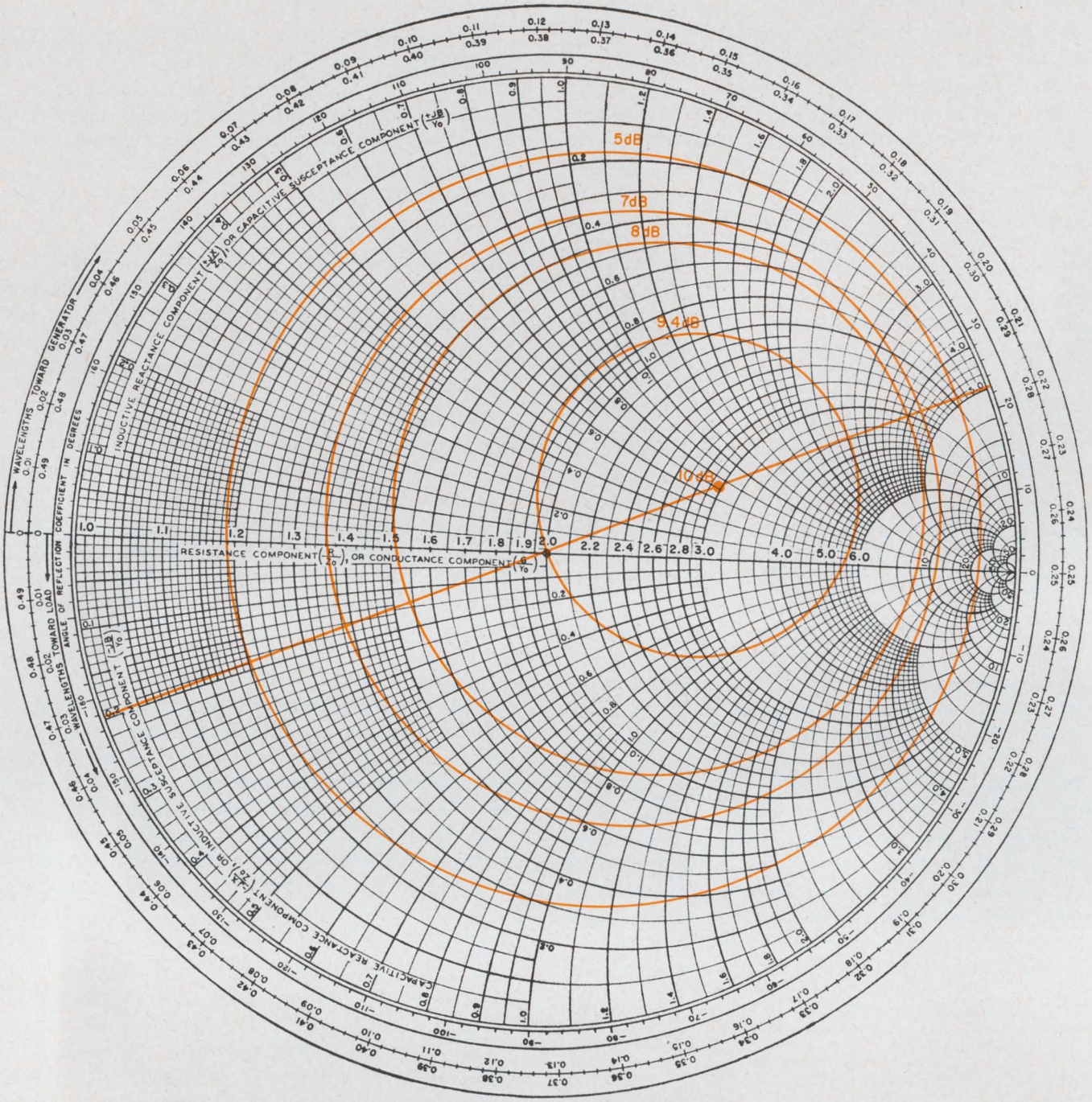
With the Linvill chart,[1] the circuit designer can quickly determine the input and output immitance that will establish a specified margin of stability and alignability while maintaining a specified amount of gain. Any trade-off in these quantities is displayed graphically.

The actual design procedure may be divided into four steps:

1. Measure the terminal parameters of the active device.
2. Construct the Linvill chart.
3. Design the input network for minimum noise figure.
4. Determine the actual circuit stability margin.

The design of a 450-MHz amplifier will serve as an example. It is assumed that the bandwidth is narrow and that the y-parameters at 450 MHz are unchanged through the band. The y-parameters of the 2N2415 450-MHz amplifier are:

$$y_{ie} = 29.7+j14.3$$



4. **Linvill chart** is a set of constant-gain circles superimposed on a Smith chart. The centers of the circles lie on the straight line. The maximum available gain (10 dB) is only a point, since it can occur only for one particular load: The circles represent the 450-MHz amplifier used as an example in the text.

$$y_{re} = -0.38 - j2.0$$

$$y_{fe} = 10.3 - j50.2$$

$$y_{oe} = 0.93 + j5.31$$

The measurement of the terminal parameters is the most important step of all, since inaccuracy at this point invalidates all the remaining work.

The stability factor is defined as:

$$C = |y_{21}\, y_{12}|/[2\, g_{11}\, g_{22} - \mathrm{Re}(y_{12}\, y_{21})] \qquad (13)$$
$$= 105/[2(29.5)(0.93) - (-97)] = 0.69.$$

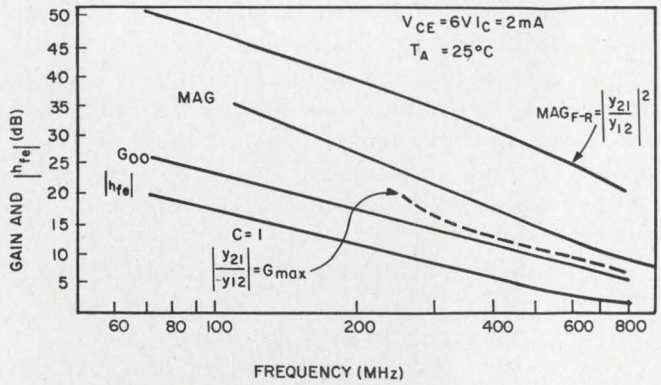
It must be less than 1 for unconditionally stable operation. If it is larger than 1, it means the stage is potentially unstable and that a set of terminations can be found that will cause the circuit to oscillate.

$$G_{oo} = \frac{\textit{Power delivered to } \mathrm{Re}(Y_L)}{\textit{Power delivered to input of two-port}}, \qquad (14)$$

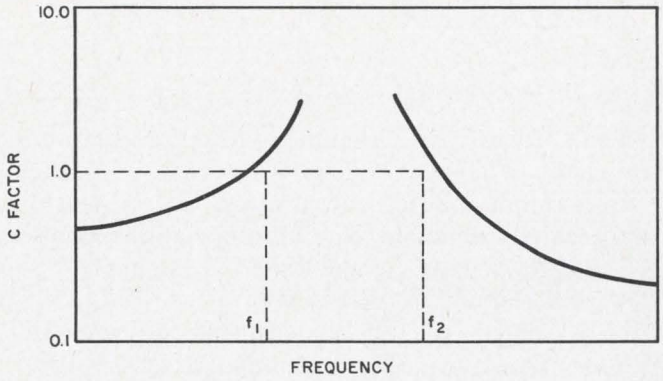
where Y_L is conjugately matched to y_{22}.

The value of G_{oo} may be calculated for the linear active network by means of the expression:

$$G_{oo} = |y_{21}|^2/4\, g_{11}\, g_{22} - 2\,\mathrm{Re}(y_{12}\, y_{21})$$
$$= (C/2)|y_{21}/y_{12}|$$
$$= (0.69/2)|51.3/2.0| \qquad (15)$$



5. **Gain and stability vs frequency** curves for a common-emitter transistor configuration point up the fact that the maximum stable gain can be practically obtained only with a negative real termination.



6. **The inherent safety factor, C,** crosses unity at two frequencies, f_1 and f_2, for common-emitter connection of bipolar transistors. The frequency region between these two is potentially unstable.

$$= 9.4 \text{ dB}.$$

A Linvill chart for the 450-MHz amplifier is shown in Fig. 4. The circles indicate lines of constant gain and any point on a circle represents a load that will produce that gain. The centers of the constant-gain circles lie on the straight line that passes through the center of the Smith chart. The maximum gain occurs at a single point on this line if the device is unconditionally stable as it is in Fig. 4.

For the input network, $Y_{s(opt)}$ is calculated with the aid of Eq. 5. The mismatch loss with $Y_{s(opt)}$ for the CE configuration usually results in about a 1.5 dB reduction in gain. This is another trade-off, where power gain is sacrificed in favor of lower noise figure.

It is advisable to use as few components in the input circuit as possible in order to minimize component losses which add directly to noise figure.

The last stage is to evaluate the actual circuit stability margin, K. The mathematical expression is:

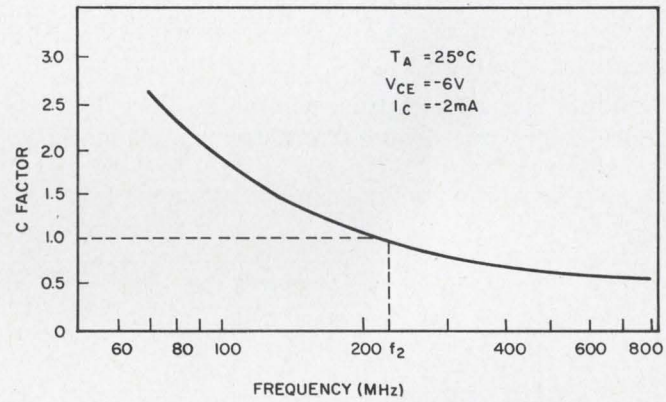
$$K=[2(P_1+\rho_{11})(P_2+\rho_{22})-\text{Re}(\gamma_{12}\gamma_{21})]/|\gamma_{12}\gamma_{21}|, \quad (16)$$
$$K \geq 1 \text{ (for circuit stability)},$$

where

γ = complex general parameters, either y, h, g, z, *or* $ABCD$,
$\rho_{11} = \text{Re}\ \gamma_{11}$,
$P_1 = \text{Re}\ \Gamma_s$,
$P_2 = \text{Re}\ \Gamma_L$.

Examination of Eq. 16 points to the fact that an increase in K leads to a drop in the gain. K increases through P_1 and/or P_2, which means larger loads at the terminals. A K value of 2 has proved to be a good compromise between stability and gain in cases where the circuit is not subjected to environmental stresses or replacement of transistors.

If large temperature variations are expected, K may have to be as large as 4. Values above 5 are rarely needed.



7. **Common-emitter germanium transistors** reach f_2 somewhat above 200 MHz and are unconditionally stable above this frequency.

Another way of looking at Eq. 16 is to let P_1 be equal to the real part of $Y_{s(opt)}$ and find K for the input termination that yields the lowest noise figure. In this case the designer obtains optimum noise performance and knows the level of circuit stability at once.

Therefore, the Linvill chart technique is a valuable tool in the design of low-noise microwave amplifiers. It allows the analysis of tradeoffs between power gain, stability, bandwidth and, with the aid of Eqs. 3 and 5, noise figure.

To illustrate some practical results, consider the curves of gain and stability vs frequency for a germanium transistor in Fig. 5. Note that the maximum stable gain:

$$G_{ms} = |y_{21}/y_{21}|, \quad (17)$$

is only obtainable with negative real termination.

G_{ms} may, however, be lower than can be safely obtained in circuits that are designed in the region of potential instability. The region of potential instability for bipolar transistors in the common-emitter connection is shown in Fig. 6. The two critical frequencies are approximately given by:

$$f_1 = 1/r_c C_c,$$

and

$$f_2 = f_t r_e/2r_b'.$$

The C-factor for a common-emitter germanium transistor is shown in Fig. 7.

In a common-base configuration, the transistor is potentially unstable to a frequency approximately equal to f_t. It is evident that CE is superior to CB from a stability standpoint.

Had C been greater than unity, the value of G_{max} would have been unbounded. If $C = 0.69$, G_{max} is finite and may be calculated by evaluating K_G and multiplying by G_{oo}:

$$K_G = 2[1-(1-C^2)^{1/2}/C^2 = 1.15;$$

$$G_{max} = (K_G)(G_{oo}) = (1.15)(8.7) = 10 \text{ dB}.$$

While the gain in this example is very low by more recent microwave transistor performance, it should be remembered that in many cases it is not necessary to have much more than 10- to 15-dB power gain in the RF amplifier. Usually this is sufficient to negate the noise figure contribution of the mixer. In some cases, large gain is actually undesirable, since it is usually more economical to develop the overall gain in the IF portion of the system.

The load for a maximum gain of 10 dB is given as:

$$G_2 + jB_2 = G_L + jB_L + y_{22}.$$

Solve for G_L:

$$G_L = G_2 - \text{Re } y_{22}$$

From the Linvill chart, G_2 is equal to 3 Re y_{22} for maximum gain.

$$G_L = 3 \text{ Re } y_{22} - \text{Re } y_{22} = 1.86\times10^{-3} \text{ mhos}.$$

Now evaluate the reactive part:

$$B_L = B_2 - \text{Im } y_{22}$$

From the Linvill chart, $B_2 = 0.7$ Re y_{22} for maximum gain.

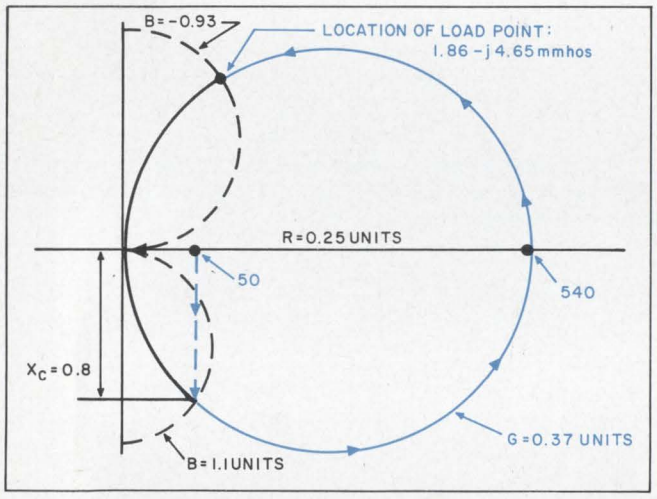
$$B_L = 0.7 \text{ Re } y_{22} - \text{Im } y_{22} = -4.65\times10^{-3} \text{ mhos}$$

The load should be $1.86 - j4.65$ mmhos to yield a 10-dB gain. The transformation from 50 ohms may be done with the aid of an admittance-impedance chart. One possible form of the network is shown in Fig. 8, where the capacitor offers dc isolation and impedance matching. The values of the components are obtained through conventional impedance transformation techniques.

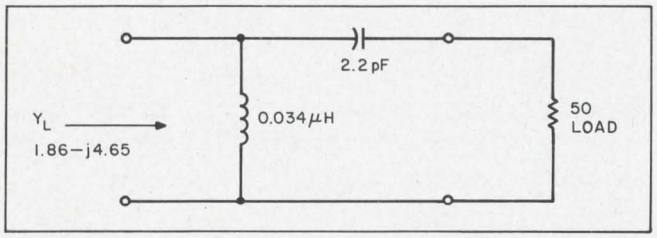
Locate the 50-ohm load on the impedance coordinate system, Fig. 9, using a scale factor of one unit as 200 ohms or 0.5 x 10^{-2} mhos. This point is on the horizontal axis where $R = 0.25$. The value of the series capacitive reactance is added as a vertical line down from 0.25. The reactance necessary to transform 50 to 540 ohms is obtained by moving down from 50 ohms to the constant conductance circle marked $G = -0.37$, since:

$$G = 200/0.37\ \Omega = 540\ \Omega$$

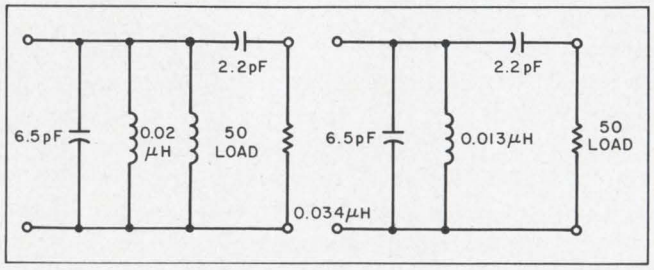
At this point the transformation from 50 to 540 ohms is completed, but the terminal value is rather capacitive. To neutralize this, it is neces-



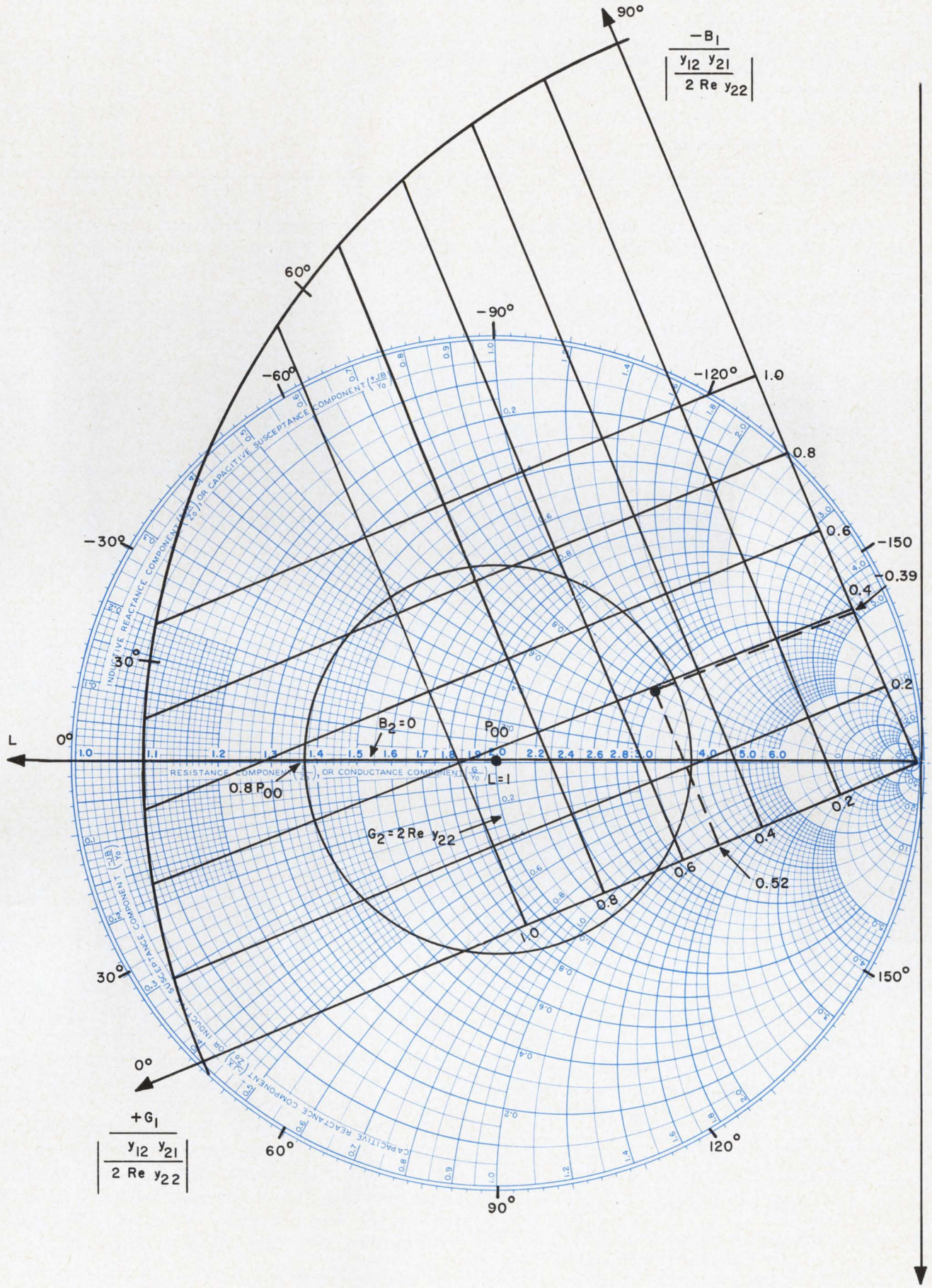
8. **Load resistance transforming network** transforms 50 ohms to 1.86−j4.65 mmhos. The capacitor also takes care of the dc isolation.



9. **Impedance-admittance chart** for the output network is useful for finding the values of components in Fig. 8. The needed load is found from the Linville chart (0.37−j 0.93 in the scaled units). The capacitance is determined from the point of intersection of the G = 1.86 x 10^{-3} mhos (0.37-unit circle and of a vertical line from the required 50-ohm (0.25-unit) impedance. The reactive curve passing through this point is B=0.55 x 10^{-2} mhos (1.1 units). The shunt inductance is selected so that the given load point is reached on the G=0.37 circle.



10. **Complete output network** includes a tuning capacitor of 6.5 pF and an inductance that resonates at 450 MHz (0.02 μH).



11. **Quadrant chart,** superimposed over the Linvill chart, allows a rapid analysis of the input immittance. The Linvill chart shows a gain of 10 dB at $G_2=3$ Re y_{22} and $B_2=0.7$ Re y_{22}.

sary to add $-jB$ to the $+jB$ due to the transformed value of the series capacitor. However, the Linvill chart indicates that a complex load is necessary to achieve G_{max}, so the desired load point has the components:

$$\text{Real part: } (1.86\times10^{-3})/(0.5\times10^{-2}) = 0.37 \text{ units;}$$

$$\text{Imaginary part: } (-4.65\times10^{-3})/(0.5\times10^{-2}) = -0.93 \text{ units.}$$

Now, instead of stopping at the horizontal axis, the process is continued until the point $0.37 - j0.93$ is reached.

Solve for X_c:

$$X_c = (0.8)(200) = 160\ \Omega;$$

$$C = 2.2 \text{ pF at 450 MHz.}$$

When solving for the amount of shunt inductance, it is necessary to move to the desired load point on the constant-conductance circle, $G=0.37$:

$$X_L = 200/2.03 = 98\ \Omega \text{ (where } 2.03 = 1.1 + 0.93);$$

$$L = 0.034\ \mu\text{H at 450 MHz.}$$

To allow tuning of the network, a shunt capacitance is added. It is calculated by selecting a fractional bandwidth of 0.1:

$$FBW = 0.1\ (45 \text{ MHz}).$$

By definition:

$$Q_L = 10 = \omega CR, = (540)(6.28)(450\times10^{6})C;$$

$$C = 10/[(540)(6.28)(450\times10^{6})] = 6.5 \text{ pF.}$$

The inductance required to resonate with 6.5 pF is 0.02 μH at 450 MHz. The complete output network appears as in Fig. 10.

Input network is found with quadrant chart

Before the input networks are designed, the value of the input immittance must be obtained for the specified load.

A quick way has been devised which not only reduces the amount of complex algebra but allows a rapid analysis of input immittance. The input admittance is:

$$Y_{in} - y_{11} = G_1 + jB_1. \qquad (18)$$

If a quadrant chart is placed over the Linvill chart (Fig. 14) and rotated so that its real axis lies parallel to the gradient line, the input impedance may be evaluated. Reading the values of:

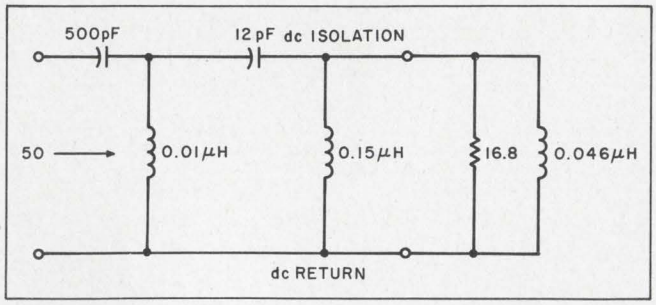
$$G_1/|y_{12}\, y_{21}/2 \text{ Re } y_{22}| = 0.52;$$

and

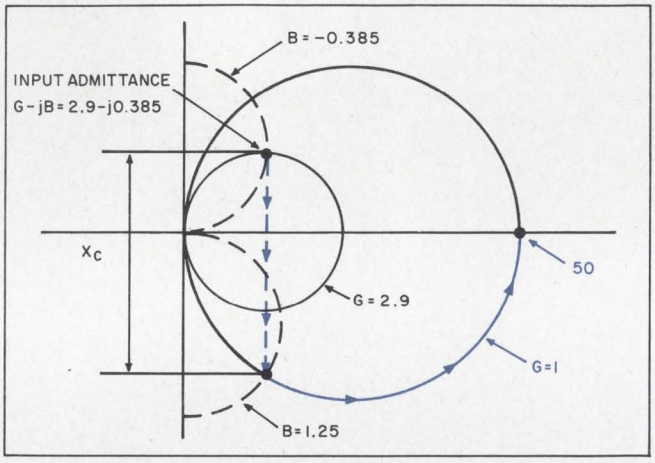
$$B_1/|y_{12}\, y_{21}/2 \text{ Re } y_{22}| = -0.39;$$

$$\text{and } |y_{12}\, y_{21}/2 \text{ Re } y_{22}| = (105\times10^{-6})/[(2)(0.93\times10^{-3})] = 56.5\times10^{-3},$$

which are indicated by the point of maximum gain, we may calculate the value of Y_{in}. The substitution in Eq. 18 yields:



12. **Input admittance of terminated stage** at 450 MHz (left) requires a matching network toward the generator (right), dc return to the base and dc isolation.



13. **In the design of the input circuit** the admittance chart is again used. Here one unit is equal to 50 ohms, or 0.02 mmhos. The starting point is the input admittance and the procedure is similar to that used in Fig. 9.

$$Y_{in} = (0.52)(56.5\times10^{-3}) - j(0.39)(56.5\times10^{-3}) + 29.7\times10^{-3} + j14.3\times10^{-3}$$

$$= 59.1\times10^{-3} - j7.7\times10^{-3}.$$

Therefore the input admittance of the terminated stage at 450 MHz and the input network to match the generator to this admittance are as shown in Fig. 11. The circuit includes dc return for the base and dc block for the input.

In designing the input network, use 1 unit-50 ohms or 0.02 mmhos. The input admittance is 59.1 $- j7.7$ mmhos, which becomes $2.9 - j0.385$ units. Locating this on the admittance chart (Fig. 12) establishes the starting point. Notice that the input admittance is automatically converted to a series combination simply by reading the rectangular co-ordinates at this point.

The first component in the desired network is a series C which requires a move straight down the chart from $2.9 - j0.385$ until the constant-conductance circle of 1 is intersected (shown in color in Fig. 12). This is the value to which 16.8 ohms is transformed. The value of X_c required is:

$$X_c = (0.58)(50) = 29\ \Omega;$$

$$\therefore C = 12 \text{ pF at 450 MHz.}$$

Moving around the constant-conductance circle

from $B=1.25$ to $B=0$ requires the addition of a shunt inductance to the network. Its value is:

$$X_L = 50/1.25 = 40\ \Omega;$$

$$\therefore L = 0.014\ \mu\text{H at 450 MHz.}$$

The input network of Fig. 11 is set for a conjugate power match. For CE, however, it is adjustable for minimum noise figure; that is, for an input admittance of $Y_{s(opt)}$. ■ ■

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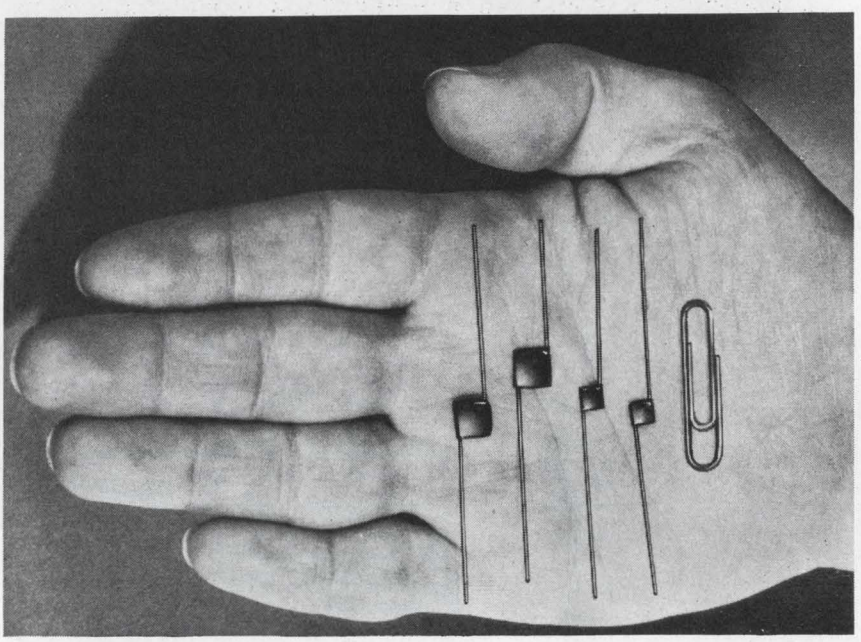
DESIGNER'S

P. R. MALLORY & CO. INC., INDIANAPOLIS, INDIANA 46206

New miniature tantalum capacitor for microcircuits



The Mallory TUR is a miniature solid electrolyte tantalum capacitor designed for use with integrated circuits, thin film and other microelectronic circuits. It is supplied unencapsulated to provide extremely small size per rating. It is intended for use with microcircuits where it will be encapsulated after assembly.

The TUR has a new configuration which provides maximum capacity per unit volume. It's a square chip, only .225″ to .325″ square, and .04″ to .170″ thick depending on rating. It is supplied with an electrically insulating coating on the positive side of the case, so it can be stacked or placed directly on the circuit chip or board prior to encapsulation. When properly predried and encapsulated, it withstands MIL environments.

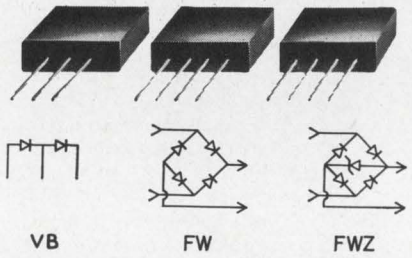
CV (capacity x voltage) product is extremely high. Ratings range from 47 mfd., 6 VDC to 15 mfd., 50 VDC. Temperature rating is −55°C to +85°C, de-rated linearly to ⅔ voltage at 125°C. DC leakage is low. Three configurations keyed to lead position are available. Standard units are polarized; non-polarized units on special order. Leads are gold-plated ribbons, can be welded or soldered.

DIMENSIONS

Case Size	A Max.	B Max.	C Max.
A	.225	.225	.040
B	.225	.225	.050
C	.225	.225	.060
D	.225	.225	.075
E	.225	.225	.110
F	.325	.325	.060
G	.325	.325	.075
H	.325	.325	.110
J	.325	.325	.125
K	.325	.325	.170

ON READER-SERVICE CARD CIRCLE 105

Reducing costs with Mallory packaged rectifier circuits



You can save both on component costs and on assembly costs, with Mallory rectifier packages. Each of these factory-connected circuits costs less than what you would pay for an equivalent number of separate rectifiers. The four-rectifier bridge package costs less than four separate rectifiers, and the full-wave and doubler packages cost less than a pair of rectifiers.

Savings in assembly come from reduction in number of soldered connections which you need to make . . . one less on a doubler or full-wave circuit, two less on a bridge. You can figure it out for your own conditions, but here's a typical analysis. At a labor rate of $1.60 per hour, the saving is about $300 per 25,000 doubler packages, or $600 per 25,000 bridge packages. Extra reliability due to fewer solder joints is a plus value.

Cold-case encapsulated circuits include Type FW full wave bridge, Type VB voltage doubler, Type CT full-wave center tap with either positive or negative polarity . . . all rated for 100°C, in PRV values from 50 to 600 volts. Bridge circuits, Type FWZ, are also supplied with an integral, factory-connected zener diode across DC output terminals; all standard zener voltage ratings are available in this configuration.

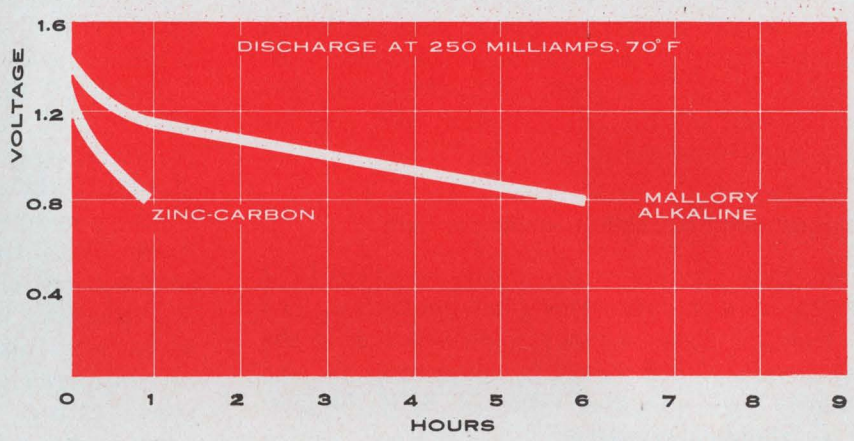
ON READER-SERVICE CARD CIRCLE 106

FILE MALLORY 50th ANNIVERSARY

Improved heavy-duty performance now provided by Mallory Alkaline Batteries

Recent refinements in Mallory Alkaline Batteries increase their ability to deliver long life at higher values of current drain, and further improve their advantage over conventional zinc-carbon batteries both in service dependability and cost per hour.

This added capability is the result of new internal construction which increases the effective anode area in relation to cell volume. Internal impedance of the cell is reduced, particularly at low temperatures. At 70°F ambient, the Mallory alkaline system delivers up to 7 times more hours of service on continuous heavy drain than ordinary batteries (see chart). At 32°F, the improvement in performance is even better.



Added refinements in case and seal construction have also been made to insure reliability of the seal under even the most severe vibration.

Mallory Alkaline Batteries with the new construction are available in a broad range of standard cell configurations.

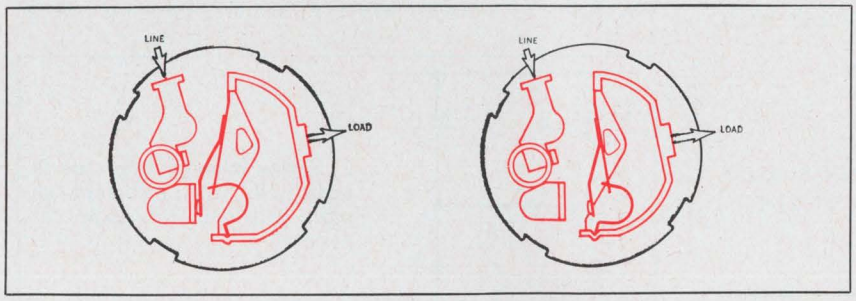
CIRCLE 107 ON READER SERVICE CARD

Circuit breaker-switch now available on Mallory controls

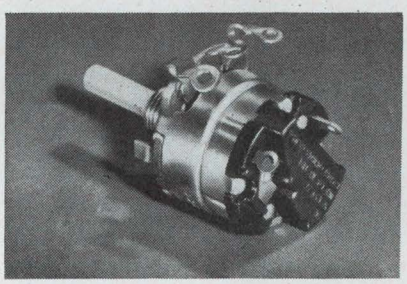
The OCB breaker-switch eliminates the need for a separate circuit breaker by combining overload protection and line switch into a single, compact unit. It's an extra convenience idea for television and stereo equipment, for instruments and any products which require overload breakers under 5 amperes.

To reset the breaker after it trips, you simply turn the switch back to OFF, then to ON. You cannot hold the breaker closed against an overload.

Holding current is factory-set to your specifications; standard range is 1.25 to 1.9 amperes, with special models available up to 5 amperes.



Diagrams show operation of breaker mechanism: at left, in MAKE position; at right, in BREAK position.



OCB breaker switch attached to volume control.

Break current is 50% higher than holding current. The OCB switch will withstand a 10% overload for 4 hours at 65°C ambient. It will take a 50 ampere surge, peaking in 1.6 millisec and decaying to normal in 3 millisec, without opening or being damaged.

The OCB is supplied attached to standard Mallory volume controls as a rotary on-off switch, or can be supplied as a separate breaker switch. As a combination control-switch-breaker, it offers savings in total component and assembly cost.

CIRCLE 108 ON READER-SERVICE CARD

ON READER-SERVICE CARD CIRCLE 105 thru 108

Team saturating chokes with SCRs

to improve inverter performance and at the same time reduce circuit complexity.

The saturating choke and the SCR appear a rather unlikely pair when it comes to electronic matchmaking. Yet, with a little application ingenuity, the two can form a potent combination in SCR circuits—such as inverters—that use self-quenching for SCR turnoff. Both improved performance and circuit simplification are possible with a variety of configurations.

Technique simplifies self-quenching circuits

Many SCR circuits employ series resonant LCR elements in a self-quenching configuration. The most familiar form of this circuit is probably the series inverter, but resonant quenching is also frequently used in other types of SCR circuits, such as chopper regulators.

The basic action of the series inverter circuit is illustrated by the simple circuit of Fig. 1. Capacitor C is initially discharged. When the SCR is triggered, ringing occurs in the circuit, causing C to be charged to something greater than the supply voltage. The current drawn by C is approximately sinusoidal, and when this attempts to reverse (C to discharge), the SCR extinguishes. The circuit of Fig. 1 is essentially single shot, in that there is no means of removing the accumulated charge on the capacitor. In all practical arrangements some other circuit is provided to do this; for example, the push-pull configuration of the simple series inverter shown in Fig. 2.

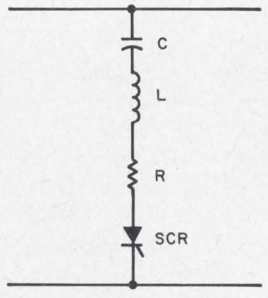
The use of saturating inductances in series with the SCRs in circuits like that of Fig. 2 offers two benefits. These are:

- The high initial inductance delays the rise of current.
- The desaturation of the inductor may be used to provide a pulse when the SCR is about to extinguish. Each of these benefits will be dealt with separately.

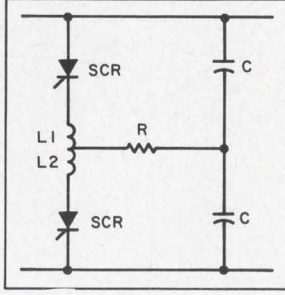
Current limiting provides protection

The use of small inductors, saturating or nonsaturating, has been described[1] as a means of reducing the rate of rise of current in the SCR during the turn-on time. These applications normally involve switching into capacitive loads, where the rate of rise of current could be very high, possibly causing device failure due to local breakdown burnout of the SCR. Similar precautions are not required for conventional high-power series inverters, since they are limited in frequency to about 10 kHz and have sinusoidal current waveforms. Consequently they have relatively long rise times. With time-sharing inverters,[2] which are combinations of basic series inverters, the operating frequency is increased by at least an order of magnitude. Initial current buildup must therefore be considered with respect to device failure and power rating. As the turn-on time of an SCR tends to be independent of operating frequency, the transient dissipation experienced during turn-on becomes increasingly important as frequency rises. This is illustrated in Fig. 3, where it is assumed that the voltage across the SCR falls linearly during the turn-on period and remains at 1 volt for the rest of the conducting time. The current is taken to be a sinusoid starting as soon as the voltage starts to fall.

It can be appreciated from Fig. 3 that there is a



1. **Triggering of the SCR** causes capacitor C to charge to a value greater than the input supply voltage. When C then attempts to discharge, it extinguishes the SCR.



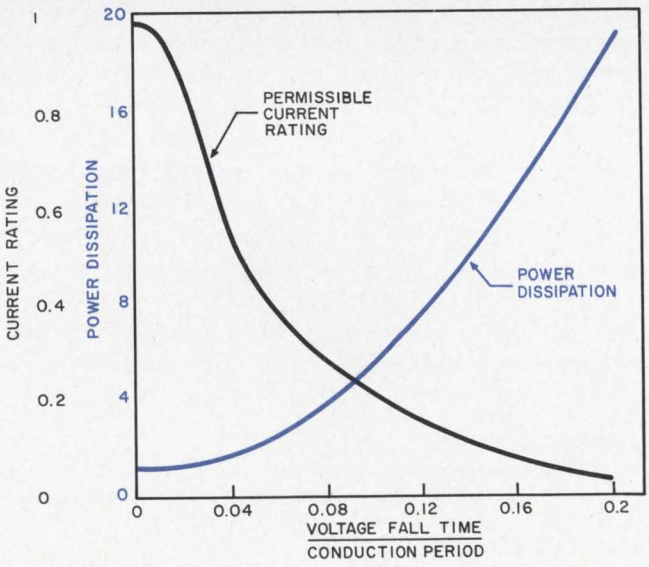
2. **Series inverter operates in push-pull,** with a discharge path provided for each capacitor.

R. Thompson, Design Engineer, The Plessey Co., Ltd., Havant, England.

very real incentive to reduce this transient dissipation in high-frequency inverters. And delaying the start of current with saturable chokes is a simple method of doing this. Unfortunately the savings gained are not as great as might be expected. This is mainly due to the fact that, while the voltage across the SCR initially falls before any appreciable current flows, there is a tendency for it to rise again when the current starts to increase. This is shown in the oscilloscope tracings of Fig. 4. These show the voltage across the SCR and the current through it. The current pulse is one half-cycle of 125 kHz and has a peak value of 20 A. The SCR is a 16-A device and is switching 40 V.

In Fig. 4a no choke is used, while Fig. 4b shows the effect of a saturable choke in delaying the rise in current and allowing the voltage to fall. As the delay in Fig. 4b is under a microsecond, however, the voltage rises sharply again when the current builds up. A method of increasing the delay in current rise without having to increase the number of high-current turns on the choke is to apply bias amp-turns by means of another winding. This technique has been used to vary the delay, and its effect is shown in Figs. 4c and 4d.

As the delay in current rise is increased, the voltage rise across the SCR is reduced. Comparison of Figs. 4a and 4b shows that the effective turn-on time increases if the SCR current is kept low. Ideally the delay must be much greater than the turn-on time with no choke, although useful savings in device dissipation may be obtained with delays less than this. While these savings could be appreciable, in many cases the incentive to use saturating chokes will not be current limiting, but rather the generation of trigger pulses.

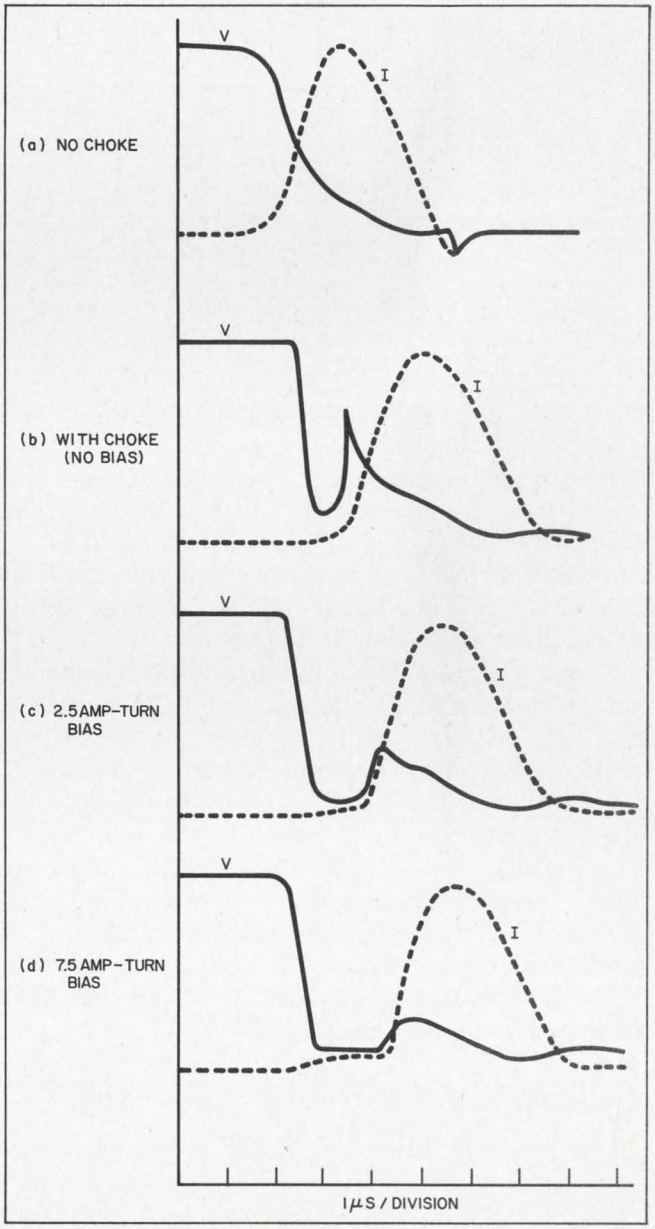


3. **Variation of SCR dissipation** and permissible current rating as a function of voltage fall time shows that transient dissipation can be a particularly severe problem at high frequencies.

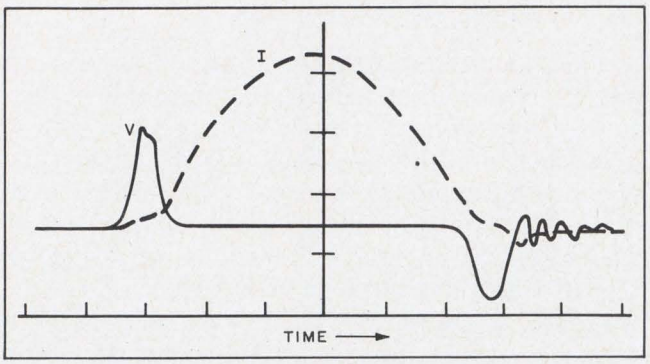
Technique generates trigger pulses

When an SCR switches on, most of the circuit voltage is developed across the saturable inductance, if one is used. This inductance proceeds to store energy until it saturates, and then, when the current falls again, the energy is fed back into the circuit. This pulse of energy can be coupled out of the core of the saturable inductance by a secondary winding and used as an SCR trigger source.

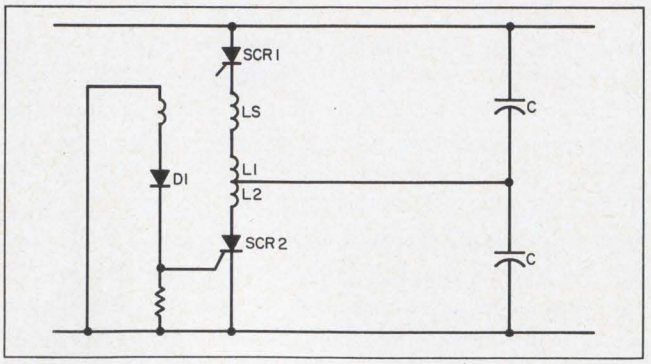
Figure 5 shows a typical waveform from a saturable inductance in a series inverter. The waveform can be coupled from the inductance by means of a floating winding, and hence is ideal for triggering SCRs, particularly those that do not have grounded cathodes. The low dc resistance of



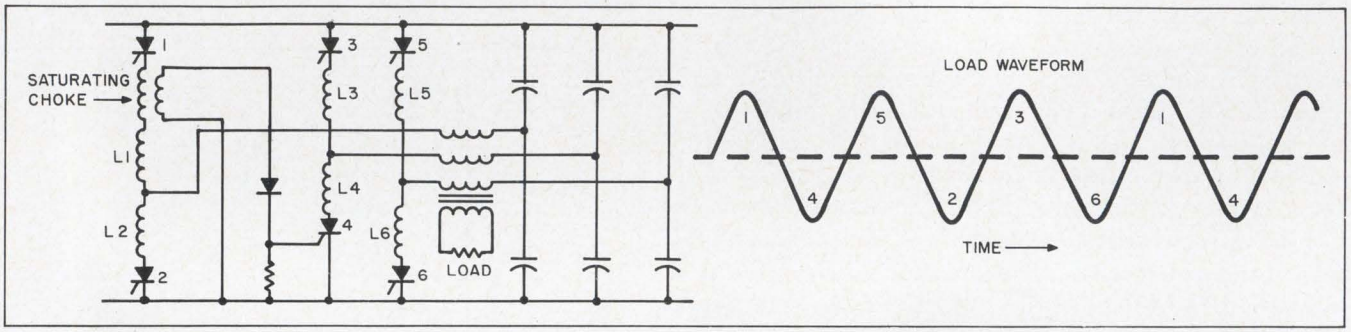
4. **Curves show SCR voltage and current waveforms** during turn-on. In (a) no choke is used to delay the current. In (b) a saturable choke is used, but the voltage tends to rise again when the current builds up. In (c) and (d) bias turns are used on the choke for the purpose of increasing the current delay.



5. **Waveforms from a saturable inductance** in a series inverter are highly suitable for triggering other SCRs.



6. **Saturable choke LS provides a trigger pulse** for triggering SCR2 each time SCR1 is quenched.



7. **Complex high-frequency inverter** consists of three series inverters sequentially feeding a common load. Sequential firing of the six SCRs can be established by a suitable configuration of saturable chokes, one of which is shown.

the winding results in good temperature and dv/dt performance.

The other important feature of the pulse is that it occurs at a time suitable for use in many circuits, such as that of Fig. 2. If *L1* and *L2* in Fig. 2 are mutually coupled, a saturable choke may be used to provide a trigger pulse for one of the SCRs. This is shown in Fig. 6.

When *SCR1* of Fig. 6 is triggered, inductor *LS* saturates after the initial delay. Diode *D1* protects the gate of *SCR2* from excess reverse voltage while high voltage is being developed across *LS*. When *SCR1*, *L1*, *R* and *C* have completed the half-cycle of operation, *LS* desaturates, feeding a trigger pulse to *SCR2*. This fires *SCR2*, and completes the extinguishing of *SCR1* by the transormer action of the coupled inductors *L1* and *L2*. A second saturating choke may be associated with *SCR2* to fire *SCR1*, with the circuit free-running once one SCR has been fired.

Trigger pulses desirable for high-frequency use

The technique of Fig. 6 is a valuable simplification of inverter triggering. In more complex circuits, such as time-sharing, high-frequency inverters, the use of this type of triggering is even more desirable. These circuits require not only suitable pulse generators, but also circuitry such as ring counters to obtain a suitable sequence of pulses.

A six-SCR inverter is shown in Fig. 7. This is basically three series inverters of the type shown in Fig. 2 feeding, in turn, to a common load. The firing order is indicated on the load waveform. For simplicity, only one triggering choke has been shown. In practice five of the SCRs would have interconnected triggering. The sixth would be triggered from a separate timing circuit. This allows the circuit to be run at a constant frequency, with variations in tuning of the resonant circuits merely causing a timing error in the waveform once every six half-cycles. If this error is not acceptable, which may be the case when the load has a variable reactance, more external triggering may be introduced. For instance, it would be convenient to take pulses from either side of a multivibrator and trigger SCRs *1* and *2*.

While the utility of this form of triggering is best illustrated by more complicated circuits, it should be remembered that many other inverters and chopper circuits use resonant quenching and could employ saturable choke triggering. ■ ■

Acknowledgment:

The author wishes to make acknowledgment to the directors of The Plessey Co., Ltd., for permission to publish this article.

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2. R. Thompson, "Designing Series SCR Inverters," Electronic Design, XI, No. 14 (July 5, 1963), 48-59.

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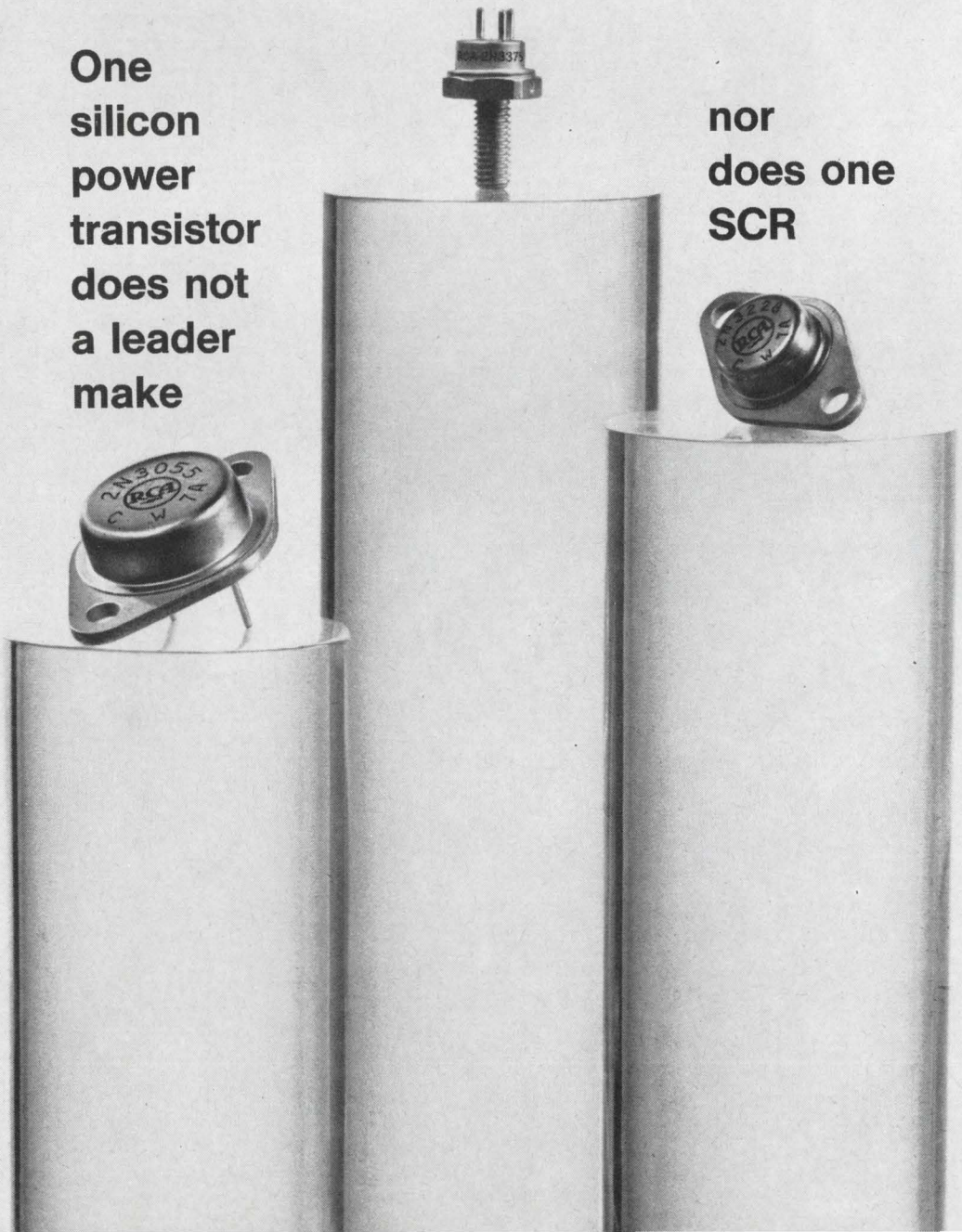

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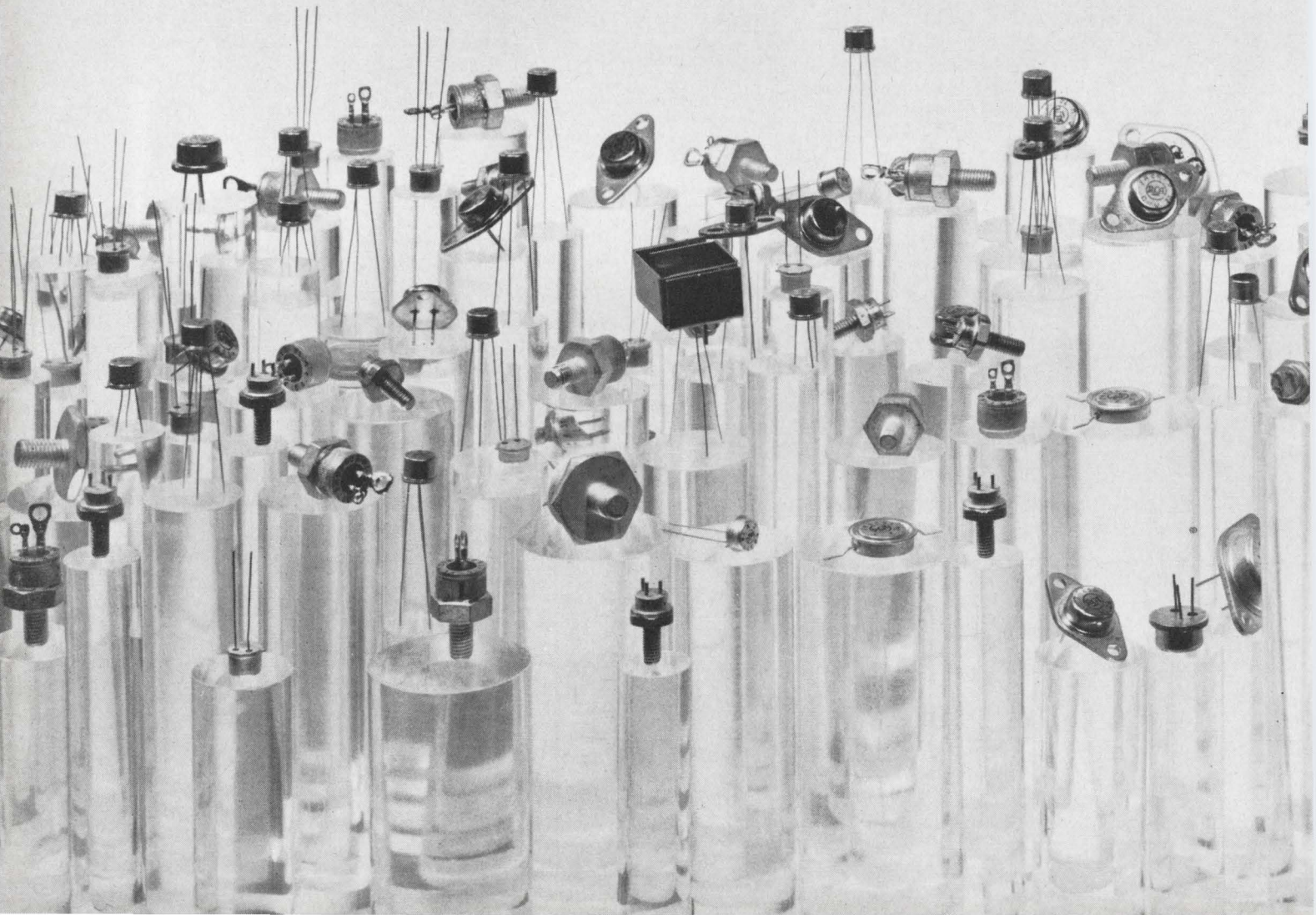

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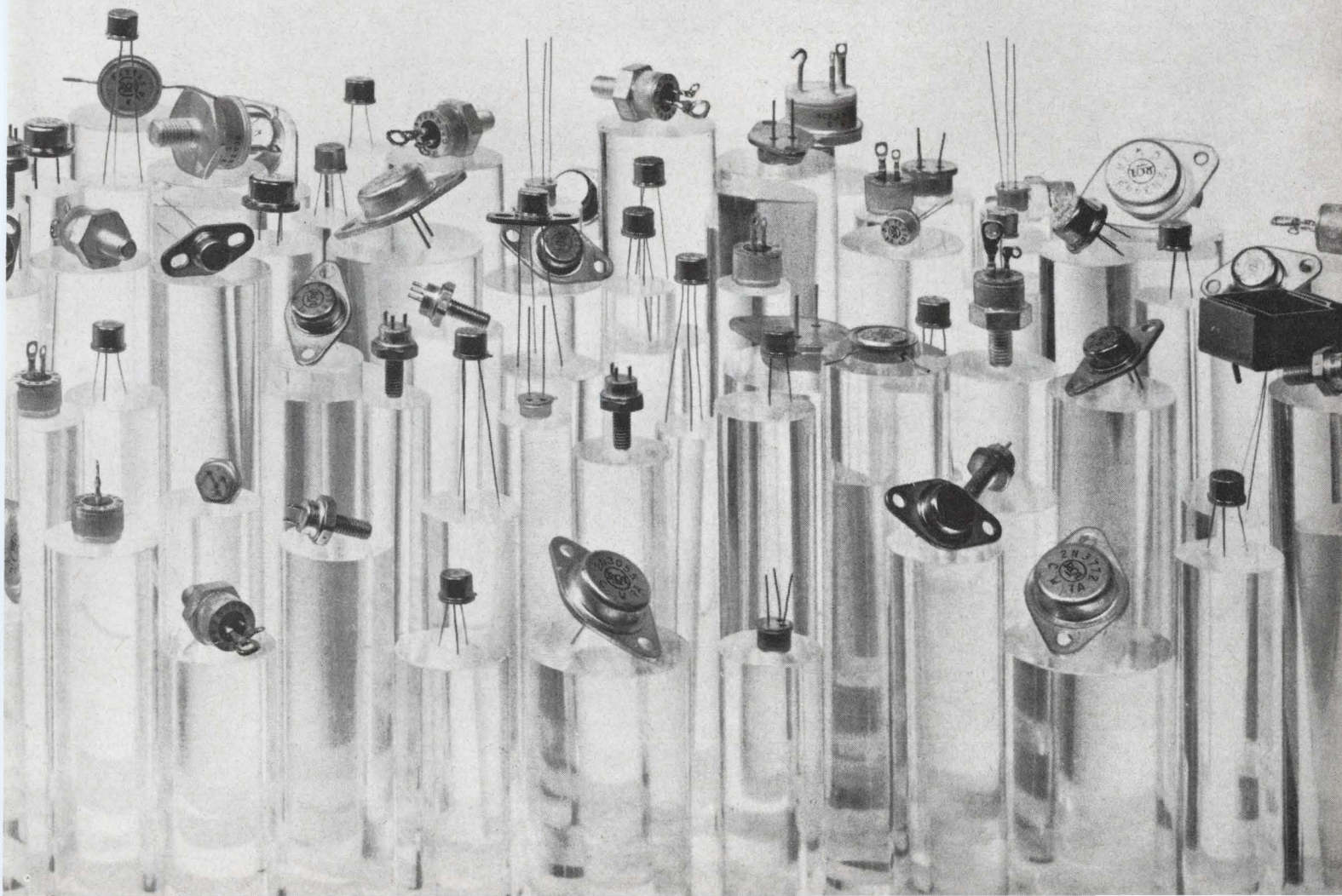


FETs make digital switching a snap.

Logic circuits employing J-FETs and MOS-FETs are fast, stable, need few components and are easily designed

Part 2 of a two-part article

Field-effect devices are well suited to digital circuits that require high fan-out, low power and good temperature stability. Both the junction type (J-FET) and metal-oxide semiconductor version (MOS-FET) provide these characteristics in logic designs.

NAND and NOR gates, half-adders, flip-flops and other digital switching networks are quickly and easily built with FETs. FETs feature moderate switching speeds (tens of nanoseconds), can be combined for complementary design purposes, and exhibit low component counts. What's more, the MOS-FETs are compatible with microelectronic technology; some of these logic designs are already available in integrated-circuit form.

The second part of this article deals with the actual design of FET digital switching subsystems and shows how the advantages of FETs can be exploited.

Inverter—fundamental FET switching block

The basic digital circuit is the inverter circuit already discussed.* Two J-FET inverters connected in series form a NAND gate (Fig. 1a). Reversing the definitions for logical *1* and logical *0* makes this circuit a NOR circuit. The disadvantage of this series arrangement can be seen from the equivalent circuit for the ON condition (when $A = B = 1 = +V$) in Fig. 1b. For the 2-input NAND gate, the logical *0* voltage will be the combined voltage drops across r_{ds1} and r_{ds2}. For NAND gates of higher order, the logical *0* voltage can become large.

The series combination of r_{ds} also reduces the noise margin of this circuit. For example, with an n-input NAND gate:

$$e_{n(0)} = V_{1(HT)} - [V_{DD}\, n r_{ds}/(R_D + n r_{ds})], \quad (1)$$

where $e_{n(0)}$ is the noise margin, $V_{1(TH)}$ the threshold voltage, n the number of inputs, V_{DD} the bias supply, R_D the drain resistance, and r_{ds} the drain-to-source resistance of the J-FET. Note how the margin is reduced by the series-connected r_{ds} values.

The other basic logic gate is the NOR circuit. A parallel NOR gate is illustrated in Fig. 2a. Again, if the definitions for logical *1* and *0* are reversed, the NOR gate becomes a NAND gate. In the parallel arrangement, the logical *0* level is derived from n paralleled channel resistors. This gives a low logical *0* level, and a high *0* noise-immunity level. The disadvantage of the parallel arrangement comes from the parallel leakage currents when the gates are OFF.

Figure 2b shows an equivalent circuit for the logical *1* condition. For the parallel case the logical *1* noise margin is reduced by the combined $I_{D(off)}$ currents appearing in the load. This is given by:

$$e_{n(1)} = V_{DD} - n\, I_{D(off)}\, R_L - V_{0(TH)}. \quad (2)$$

Note that $V_{0(TH)}$ here refers to the threshold of the *1* state.

Another disadvantage of the parallel NOR gate becomes apparent when only one of the parallel devices is ON while the rest are OFF. By means of the common drain resistor R_D, the single ON device must conduct the current normally handled by the rest of the FETs. For example, a 5-input gate designed for a current of 1 mA in each gate must handle 5 mA when only a single gate is conducting. As the width of the gate is increased, the current handled by a single device becomes larger and the maximum $V_{DS(on)}$ increases. Another disadvantage is that the output voltage varies with the number of parallel devices that are conducting.

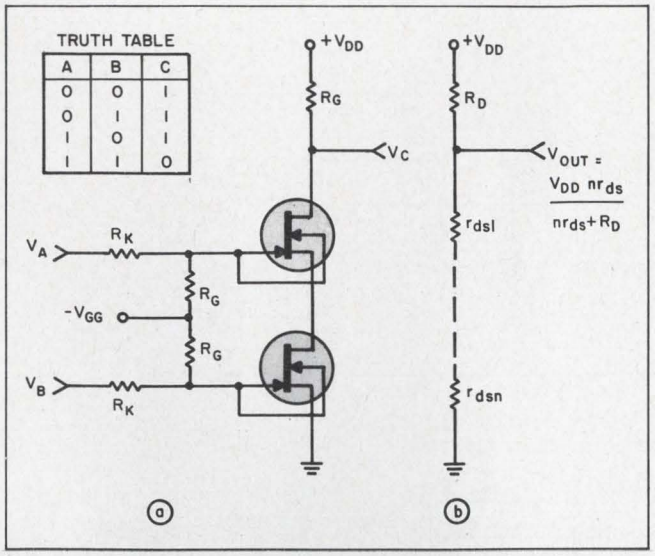
Normally these problems are not serious when constructing more complex circuits. With shift registers and adders where only two or three input gates are required, the J-FET NAND and NOR gates are suitable.

Summing NOR gates yields half-adder

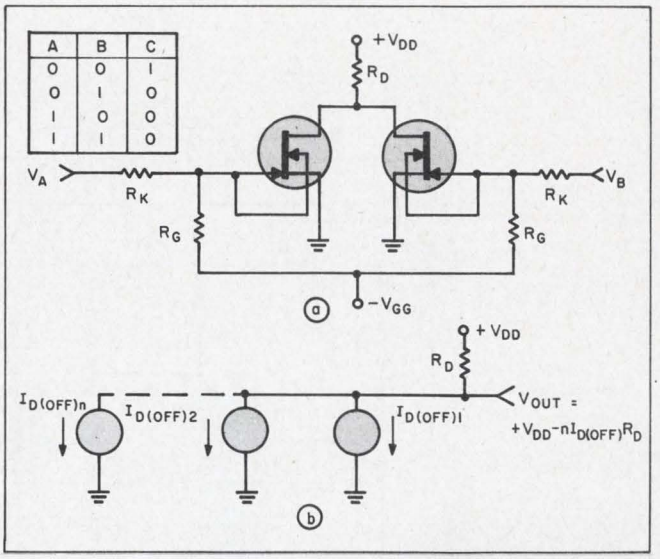
When a number of NOR gates are paralleled, the result is a half-adder circuit (Fig. 3a). This type of subsystem requires complementary inputs,

*See Part 1, "Switch over to FETs," in ED 24, Oct. 25, 1966, pp. XX-XX.

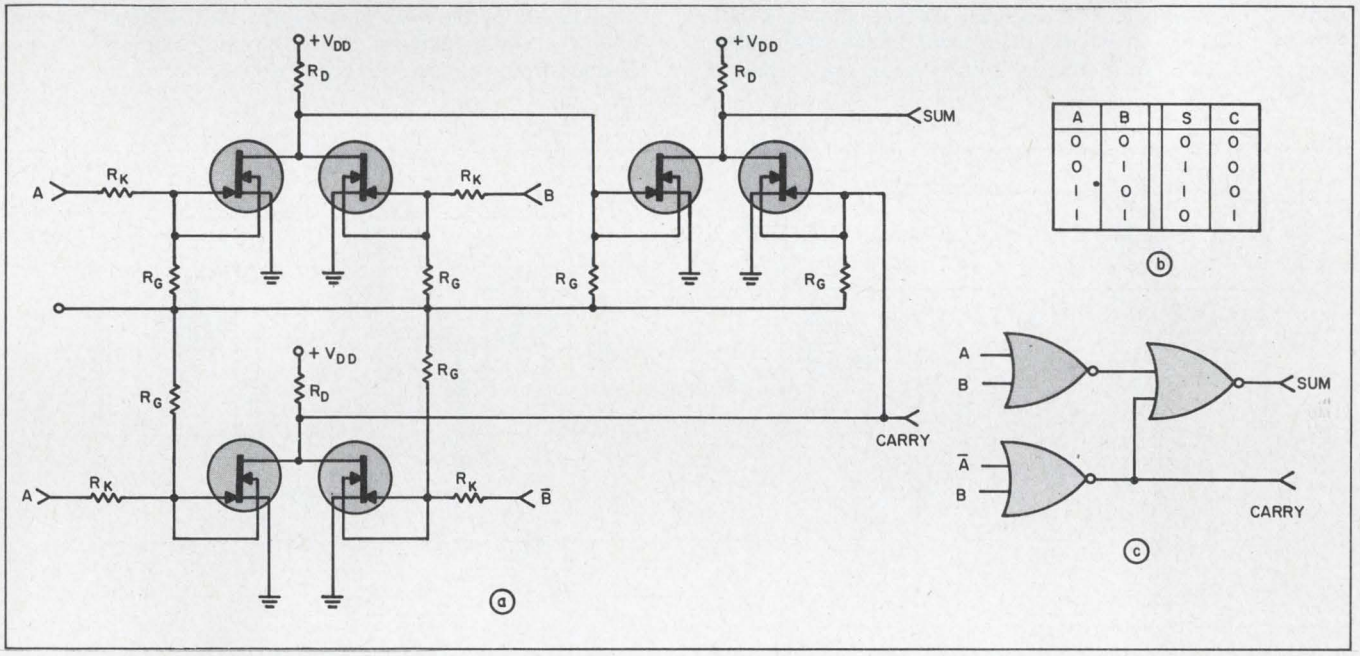
Jim Kane, Applications Engineer, Motorola Semiconductor Products, Inc., Phoenix, Ariz.



1. **NAND gate** is formed by connecting two J-FET inverters in series (a). If the truth table definitions of logical 1 and 0 were reversed, a NOR gate would result. Equivalent circuit for ON state of NAND gate appears in (b).



2. **NOR gate** uses two J-FETs in parallel (a); equivalent circuit for logical 1 state is exhibited in (b). Noise margin for one state is reduced by the parallel combination of OFF leakage currents.



3. **Half-adder** is constructed with parallel NOR gates (a). Truth table (b) and logic diagram (c) show that complementary inputs are required. Note that the J-FETs are all n-channel types.

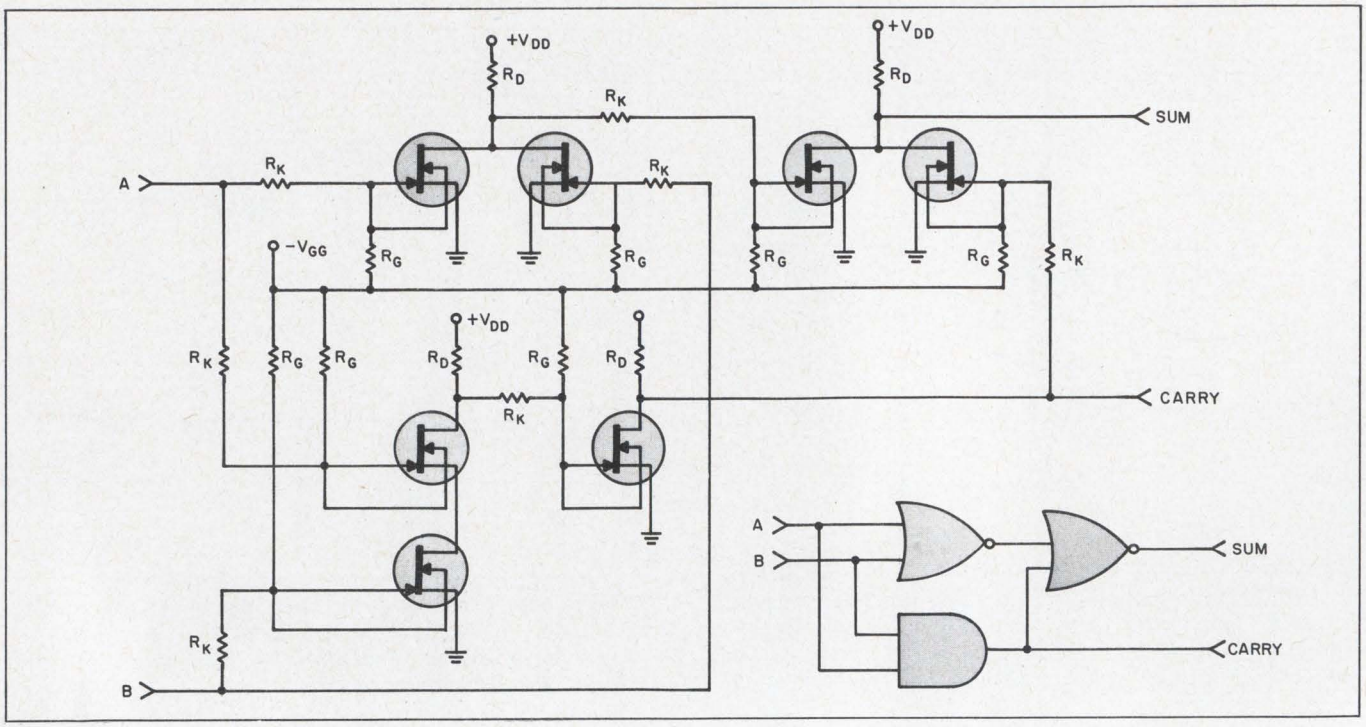
as is made clear by the truth table (Fig. 3b) and the logic diagram (Fig 3c). If the complementary signals are not normally available, a slightly more complex half-adder must be constructed (Fig. 4). In this circuit a two-input NAND gate followed by an inverter replaces one of the NOR's of Fig. 3a. This subsystem does not require complementary inputs.

Flip-flops using J-FETs can also be made by the Eccles-Jordon approach. A set-reset (R-S) flip-flop built on this principle is shown in Fig. 5. The design equations for the R-S flip-flop are the same as the classic Eccles-Jordan equations for vacuum tube flip-flops.†

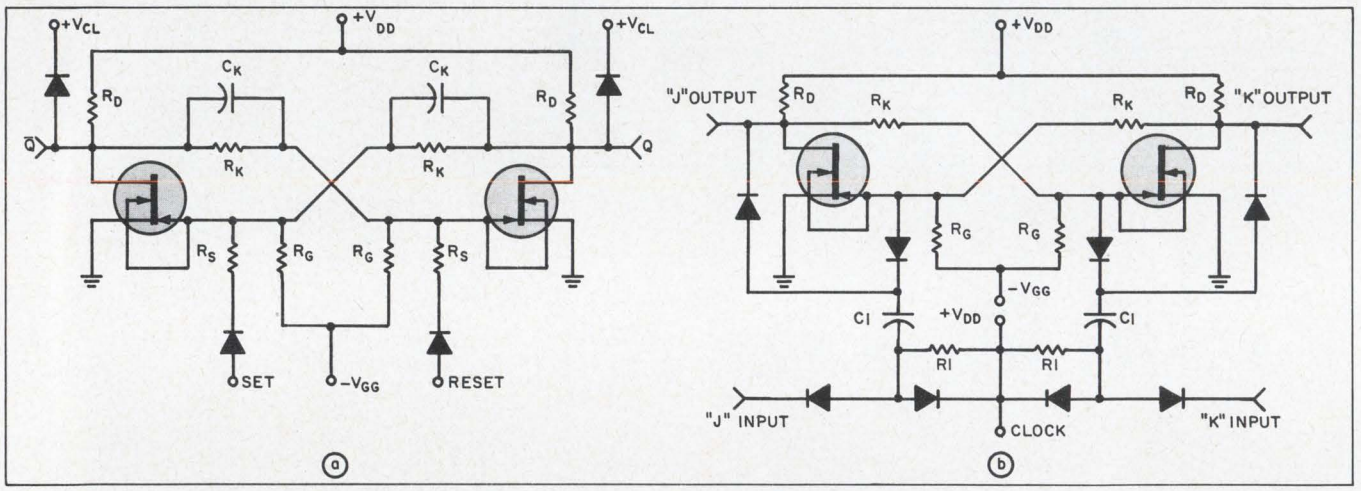
With conventional triggering schemes, the R-S flip-flop of Fig. 5a can be transformed into a J-K flip-flop (Fig. 5b). The J-K version offers conventional trailing-edge triggering.

Consider the condition $J = K = 1$ with the J output at ground. With the J, K or clock inputs grounded, the trigger capacitors cannot charge, since all the diodes clamp the intersection of *C1* and *R1* at ground. When the J and K inputs go positive, their diodes disconnect. However, the

†See Millman and Taub, *Pulse and Digital Circuits* (New York: McGraw-Hill Book Co., Inc., 1956), pp. 174-187.



4. **Complementary inputs are not required by this half-adder.** Comparing it with Fig. 3a, we see that a NAND gate and an inverter have replaced one of the NOR gates. Note that this is an n-channel J-FET circuit exclusively. It may be observed that the NAND gate and the inverter are represented by the AND gate symbol in the logic diagram. Thus the slight increase in the circuit complexity is not obvious from the logic diagram alone.



5. **Flip-flops are easily built with J-FETs** by vacuum tube design techniques. The reset-set (a) and J-K (b) multivibrator versions demonstrate this. One benefit of these circuits over their bipolar-transistor counterparts is their lower power dissipation. This is because J-FETs don't draw base (gate) current; bipolars do. Moreover, noise immunity is higher and temperature stability is slightly better with J-FET devices.

clock diodes continue to clamp to ground. When the clock becomes positive, all diodes are disconnected and the capacitor on the J-out side charges to $+V_{DD}$ through the ON J-FET. The output diode on the K side is blocked by the high voltage at the K output terminal. When the clock goes to ground again, a large negative-voltage spike appears at the gate of the J output and the flip-flop toggles.

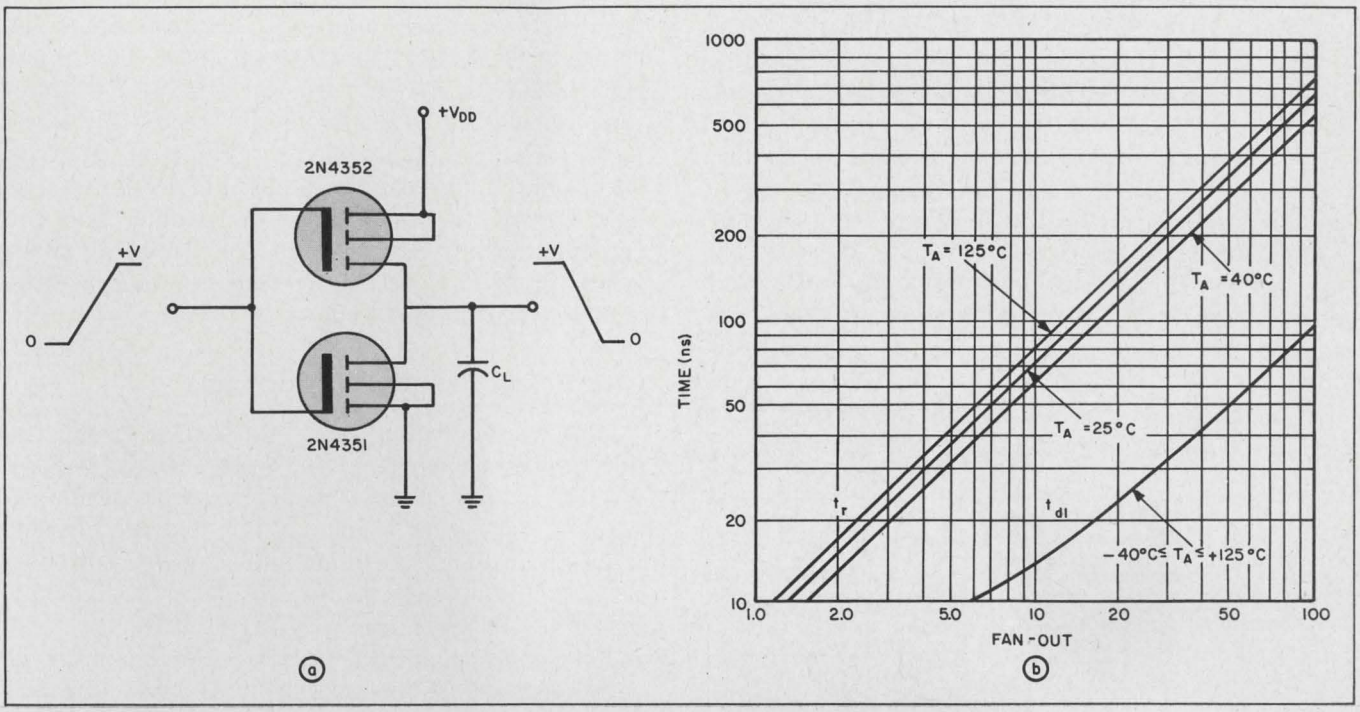
With these basic building blocks, a family of J-FET logic circuits can be built.

The major advantages of J-FET switching circuits are:

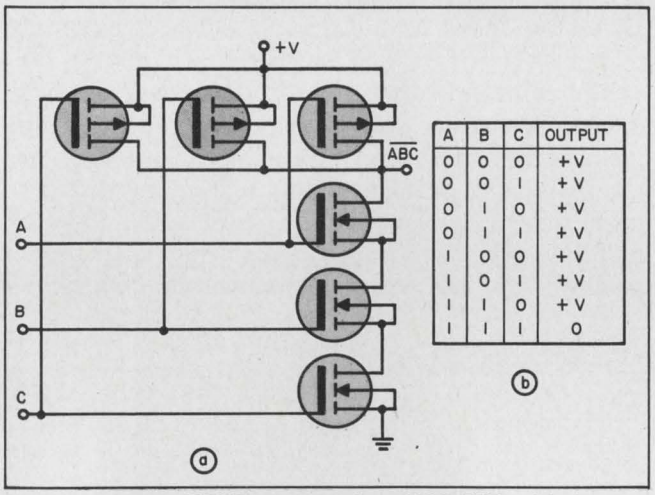
- Good noise immunity.
- Temperature performance considerably more stable than that of conventional junction-transistor circuitry.
- Less radiation sensitivity.
- Lower power dissipation than conventional junction-transistor circuits because no base (gate) current is required.

MOS-FET digital superior to J-FET

Attractive as the J-FET may appear in



6. **MOS-FET inverter** circuit (a) is a superior digital design to both its J-FET and bipolar counterparts. Stability, minimal power needs and circuit simplicity are characteristics of this complementary network. Switching performance (b) demonstrates little variation in time parameters with temperature change. Here $V_{DD}=10$ V, $V_{GS}=10$ V, $C_{IN}=10$ pF and the fan-out refers to the ratio of load capacitance to input capacitance. Also, t_r is the rise time and t_{d1} the turn-on delay time. Note that t_{d1} variation over the ambient range −40 to +125°C is imperceptible.



7. **Three-input NAND gate** using MOS-FETs (a) has p-channel units in parallel and n-channel devices in series. Truth table (b) shows that output is always high (at +V) except for the conditon of A=B=C=1.

contrast to a bipolar, for digital applications it runs second to the other basic field-effect device, the MOS-FET. Comparatively, the main benefits of MOS-FET switching circuits are:

- Circuit simplification.
- Higher thermal stability.
- Far less stringent power requirements.

The capacitive input to the MOS-FET lends itself to direct-coupled circuitry—a saving in component count and circuit wiring. In addition, the MOS-FET is innately more stable with temperature than the J-FET. And when complementary MOS-FET designs are used, power is dissipated only during the switching interval.

Several families of MOS-FET logic have been proposed. For this discussion, attention will center on complementary logic. The basic complementary inverter circuit is shown in Fig. 6a. This circuit has the unique attribute of dissipating almost no power in either stable state.

With the input at zero, the upper p-channel MOS-FET is fully ON. The load capacitance C_L is charged to $+V$ through the p-channel MOS-FET. Once C_L is at $+V$, the only current flow in the circuit is the I_{DSS} of the p-channel unit. This I_{DSS} is in the picoampere range, since the 2N4351 with a zero gate voltage is completely OFF. The voltage drop across the 2N4352 is simply the I_{DSS} of the 2N4351 times the channel resistance of the 2N4352 (about 300 Ω). The voltage drop across the 2N4352 is therefore approximately 3 nV.

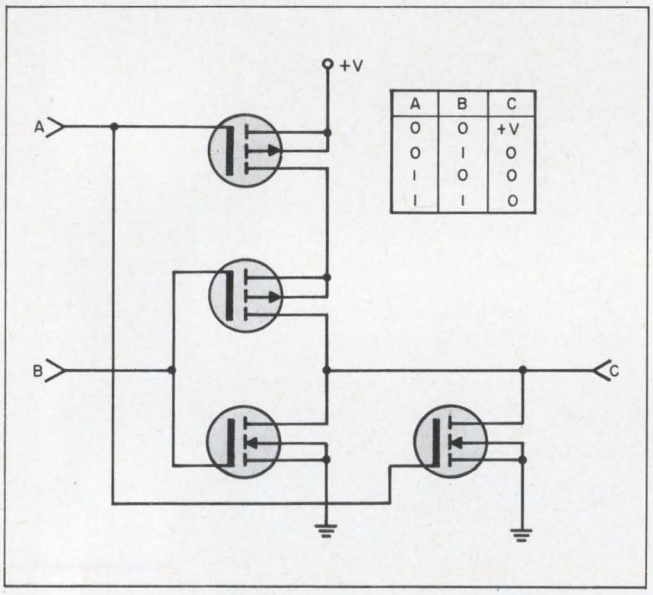
With the input at $+V$, the n-channel 2N4351 is fully ON and the p-channel is cutoff; C_L discharges to ground and the 2N4352 then limits current flow to picoamperes. The voltage drop across the n-channel MOS-FET is again in the nanovolt region.

Figure 6b shows the switching performance of the MOS-FET complementary inverter as a function of the fan-out. Fan-out is defined as C_L/C_{IN} where C_{IN} for the 2N4351-2N4352 pair is about 10 pF. Thus, for example, the rise time with a fan-

out of 10 when $T_A = 25°C$ is 70 ns and the delay time is 13 ns. At a fan-out of 100, representing a load capacitance of 1000 pF, the rise time is about 650 ns with a 100 ns delay time.

The temperature variation of this circuit is also displayed in Fig. 6b. At a fan-out of 10, the variation in rise time over the temperature range of $-40°C$ to $+125°C$ is only 20 ns. There is no appreciable change in the delay time over this temperature range. Turn-off is much the same as turn-on, since one device of the pair is always turning ON.

The complementary NAND gate is formed as in Fig. 7. The p-channel devices are connected in parallel and their n-channel complements are connected in series. The truth table for the 3-input NAND gate is also shown. For the NAND function, the output is always high, unless all three inputs are high. If any one or any pair of inputs is high, one or more of the p-channel FETs will be held ON by the remaining low inputs, and the common output bus will be at $+V$. When all three inputs are high, all three series n-channels will be ON, and the output is low.



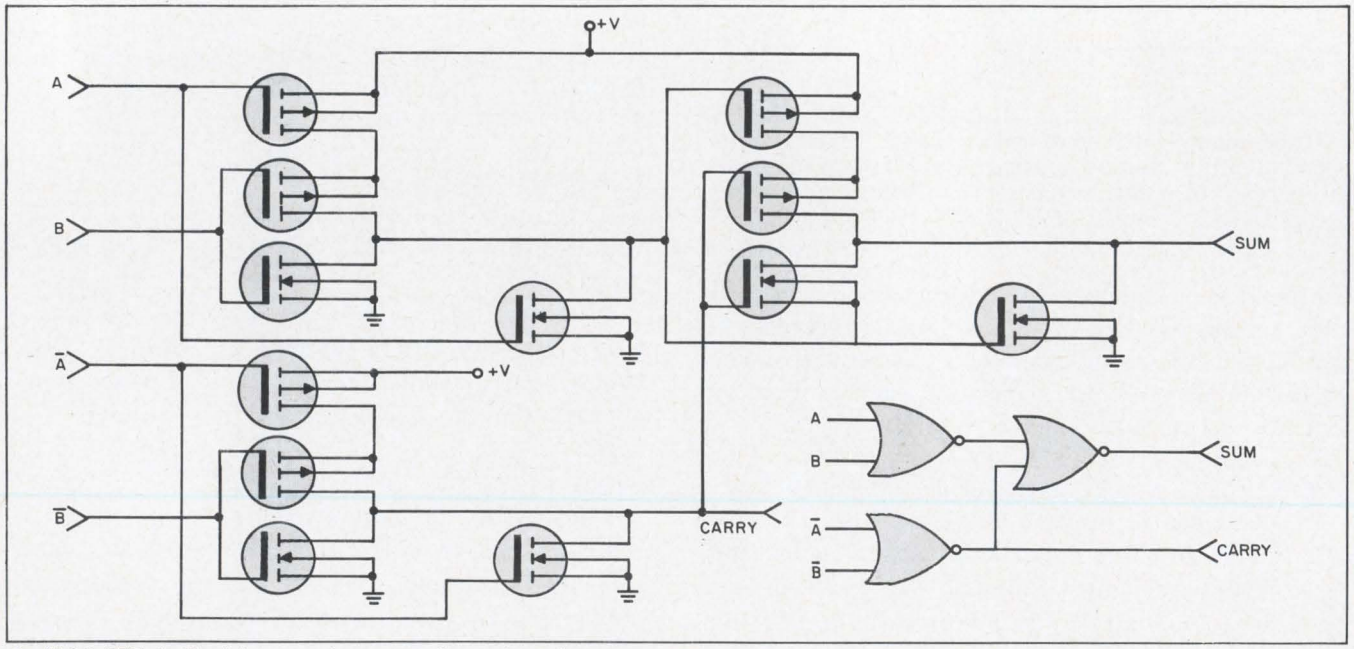
8. **Complementary NOR gate** has p-channel MOS-FETs in series and n-channel units in parallel (cf. NAND network in Fig. 7). Output (c) is "high" only when both inputs A and B are "low."

Little leakage in MOS-FET NAND gate

This configuration does not suffer from the noise-margin problems of the series J-FET NAND gate. The zero output level is developed across three series elements. The leakage current from all three of the p-channel devices, however, is in the picoampere range, resulting in nanovolt output levels even for very large gates.

For example, at $+125°C$, the leakage current of the p-channel 2N4352 is about 100 nA and the channel resistance of the n-channel 2N4351 at a 10-volt bias and $+125°C$ is about 130 Ω. For a 50-input gate the total leakage current is 5 μA. The series output resistance is 6.5 kΩ, resulting in an output voltage of 0.325 V, an extremely low value. A limitation of the width of the NAND gate exists: switching speed decreases and power dissipation increases as the width increases.

The complementary NOR gate appears in Fig. 8. Here the order has simply been reversed. The p-channel devices are connected in series and the n-channel are in parallel. If any one of the inputs is high, one of the parallel n-channels will be ON, and the output will be low. Only when both inputs are low will both series p-channels be ON, allow-



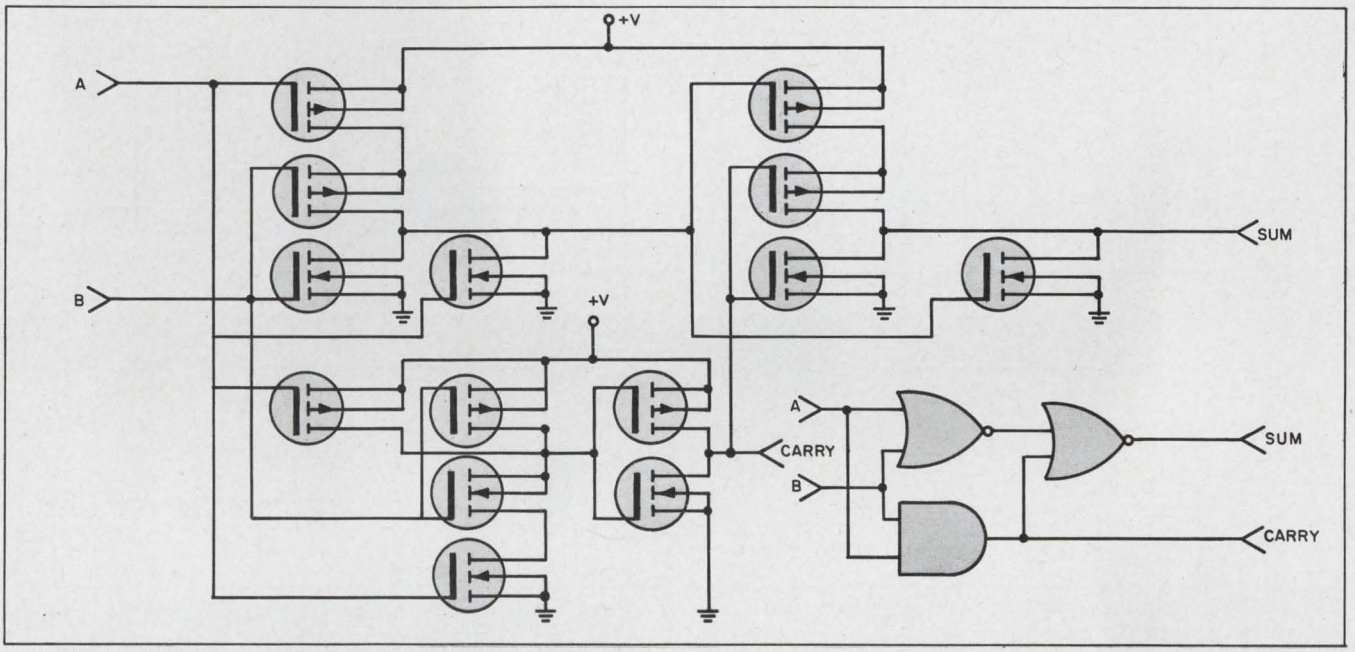
9. **MOS-FET half-adder** requires complementary inputs.

ing the output to go "high." Thus the conditions stated in the truth table are satisfied. The same comments about size apply to the NOR gate as to the NAND gate.

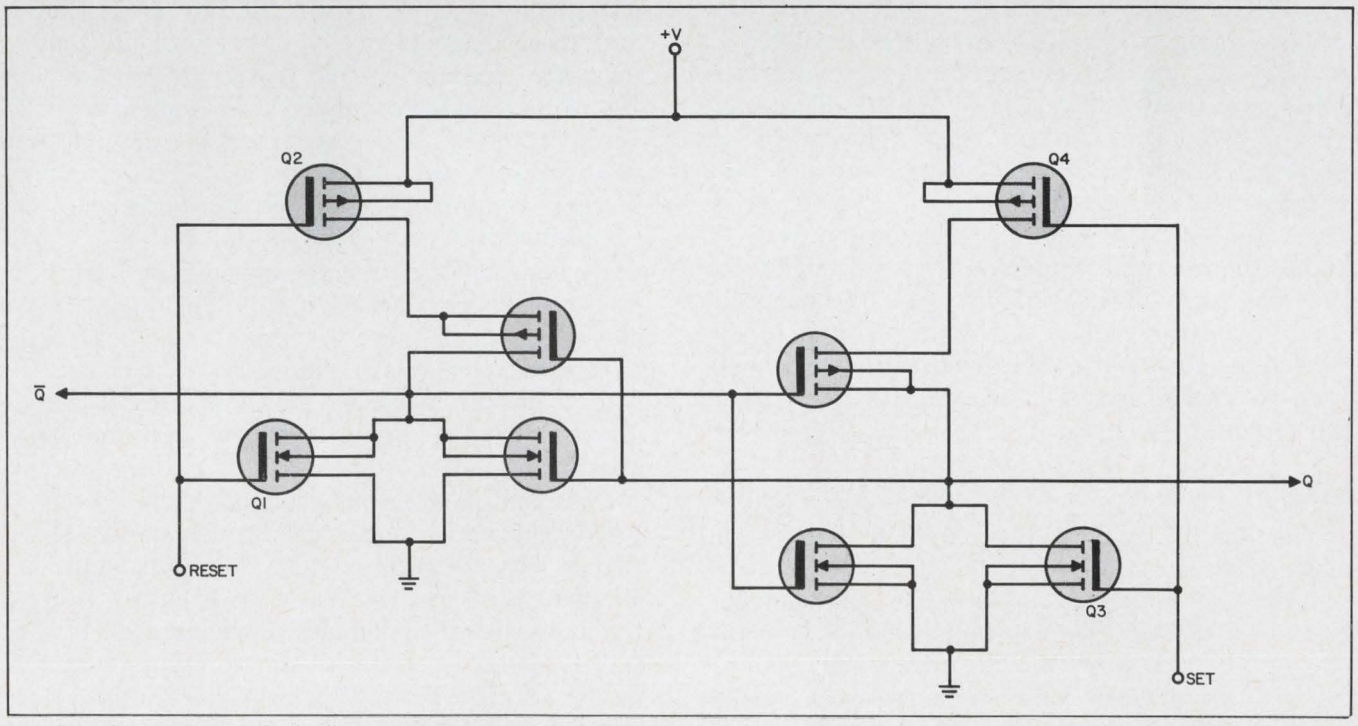
As a practical example of the use of the NOR gate, a half-adder configuration using three NOR gates is shown in Fig. 9. The carry digit is taken from the NOR gate handling the complement inputs, while the sum digit is picked up from the NOR gate that sums outputs from the first two NOR gates.

Referring back to Fig. 6b, which shows the switching times of the complementary pair, consider the carry digit in the half-adder to the next stage as a fan-out of one, and the input to the sum-digit NOR gate as a fan-out of one. The carry NOR gate now faces a fan-out of two. For a fan-out of two, according to Fig. 6b, the rise time at room temperature should be 15 ns. Therefore, the propagation delay from the input to the carry digit is 15 ns.

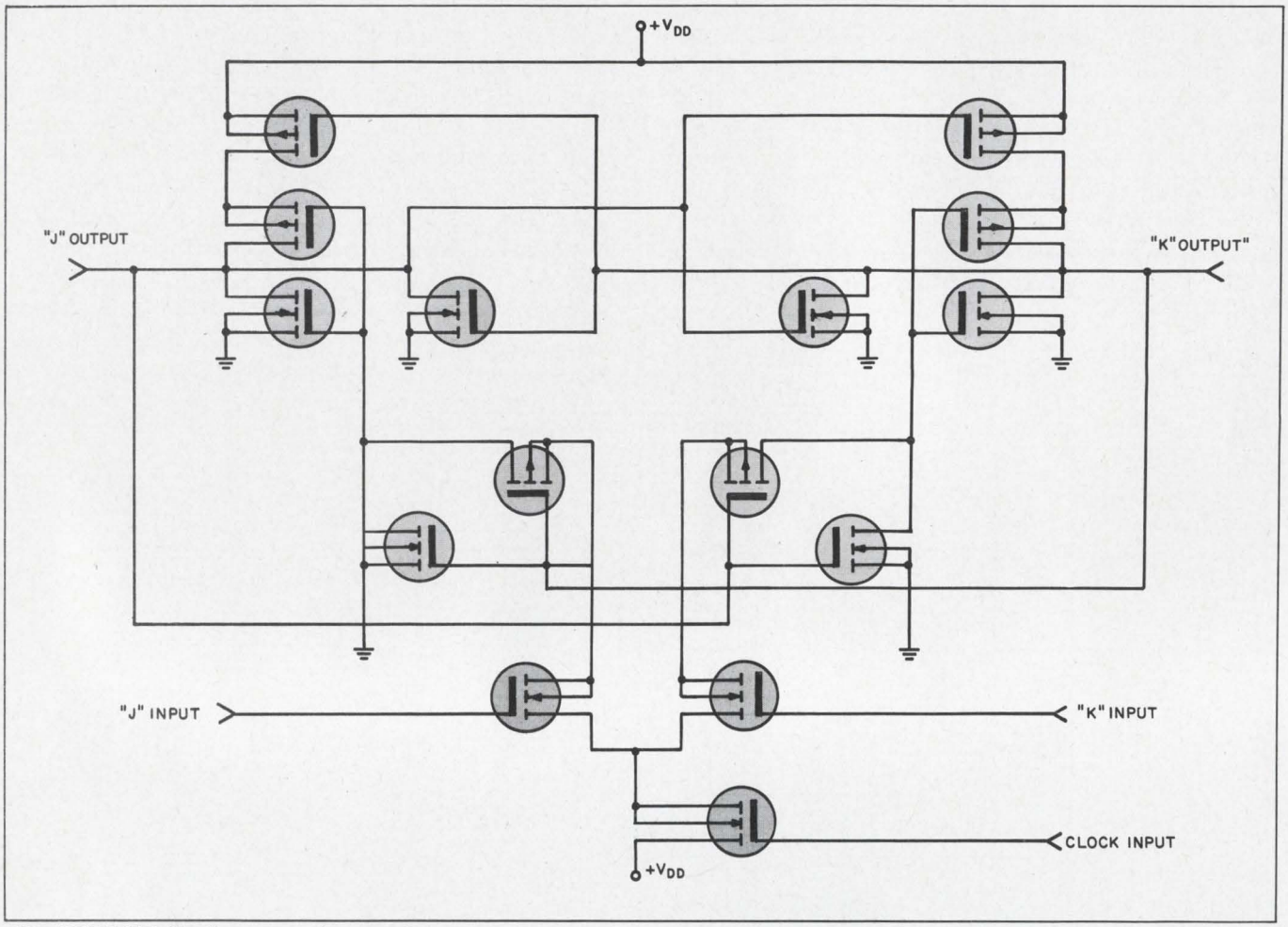
Assume a fan-out of two for the sum-output



10. **This half-adder requires no complementary inputs** because a NOR gate in the half-adder of Fig. 9 has been replaced by an AND gate. In addition to its greater complexity, this circuit has longer propagation delays. It should therefore be used only when complementary inputs are not available.



11. **Complementary R-S flp-flop** employs eight MOS-FETs. Note the direct-coupling between stages.



12. **MOS-FET flip-flop** uses six complementary pairs and three single devices for gating the J, K and clock inputs.

NOR gate, and a total propagation delay from the input to the sum digit of 30 ns, consisting of 15 ns to the carry input plus another 15 ns through the final NOR gate.

Once again, the half-adder can be modified to handle only one set of inputs by changing one NOR gate to an AND gate (Fig. 10). The AND gate is formed by a NAND gate followed by an inverter. This additional stage increases the propagation delay somewhat. The fan-out from the NAND gate is one for a propagation delay of 10 ns; the fan-out of the inverter is assumed to be two, for an additional 15 ns. Total propagation time to the carry digit is now 25 ns, and to the sum digit, 40 ns. The additional stage then, adds 10 ns to the propagation delay times expected in the circuit of Fig. 9.

MOS-FET flip-flops are direct-coupled

The complementary R-S flip-flop requires a more complex design approach than simply cross-coupling gates (Fig. 11). One of the major advantages of MOS-FET logic is that it makes it possible to design highly reliable, direct-coupled circuits. Care, however, must be exercised to avoid "sneak-paths" that are a hazard of direct-coupled circuits.

The R-S flip-flop is a case in point. If the set and reset lines are applied directly to the basic flip-flop gates, the output is driven directly from the set and reset lines. Logically, therefore, all that is needed to accomplish this feat is the circuit wiring. An additional complementary pair is required for both the set and reset lines, *Q1*, *Q2*, *Q3* and *Q4*, to isolate them from the load. The circuit of Fig. 11 then becomes the basic flip-flop circuit for complementary MOS-FET logic.

By a suitable triggering scheme, the basic flip-flop can be made into a J-K flip-flop (Fig. 12). To steer the trigger pulse for the $J = K = 1$ condition, a complementary pair is used to sense the output of the opposite side. Additional single device gates are used to gate the J, K and clock inputs.

Consider the J output grounded. The $J = K = 1$ condition is to toggle the flip-flop. With the J output low, the p-channel of the right-hand sensing pair is biased ON. While the K output is high, the n-channel of the left-hand sensing pair is kept ON. High inputs at the J and K inputs turn ON their respective gates. When the clock input comes "true" (or high), the $+V_{DD}$ is propagated

through the clock gate, through the K input gate, through the right-hand sensing gate, and to the K output gate, toggling the flip-flop.

The trigger signal does not propagate through the left-hand sensing gate since it is blocked. Naturally, this scheme requires a narrow clock pulse. The clock pulse must not be present when the K output has switched, since the left-hand sensing pair would then become inadvertently biased ON.

Without excessive precautions with the circuit layout and device selection, the J-K flip-flop of Fig. 12 can be operated at frequencies from dc to about 5 MHz. Tighter control of layout and device matching should make it possible to construct circuits operable above 10 MHz.

Integration of MOS-FETs easily realized

Obviously, the MOS-FET design approach is much more amenable to integrated-circuit techniques than the J-FET method. Integrated MOS-FET circuitry arrays are being increasingly used. Already logic families built with single-polarity devices have been marketed. The complementary MOS-FET pair has particularly noteworthy low power dissipation, fast switching times, and very stable temperature characteristics.

The MOS-FET fabrication process is simpler and inherently more reliable than conventional triple-diffused junction-transistor integrated circuitry. The MOS-FET has a size advantage over conventional integrated circuits. The use of active load resistors in place of conventional diffused resistors also further reduces the size of MOS-FET integrated circuits. Because of this smaller size, and of the higher yields of the MOS-FET process, the complexity of integrated circuits can be increased by an order of magnitude or more. Whole shift-registers, 16- and 32-word memory units, and eight-bit full-adders can now be projected for integrated circuits.

This present presentation of J-FET logic circuits has been limited to rather straightforward RTL-type circuitry and is intended merely as an example of J-FET switching circuits. The RTL circuits described do, however, achieve lower power dissipation levels than conventional junction-transistor RTL circuitry and are not so susceptible to current-hogging problems. There is some doubt about the integration of J-FET circuits. To date, none has been marketed, largely because of processing difficulties.

Although the switching behavior of FETs is difficult to characterize, and many interesting logic schemes have yet to be explored, the FET, by virtue of its unique characteristics of inherent stability, low power consumption, and potentially very high reliability, will be a permanent member of the digital device family. ■ ■

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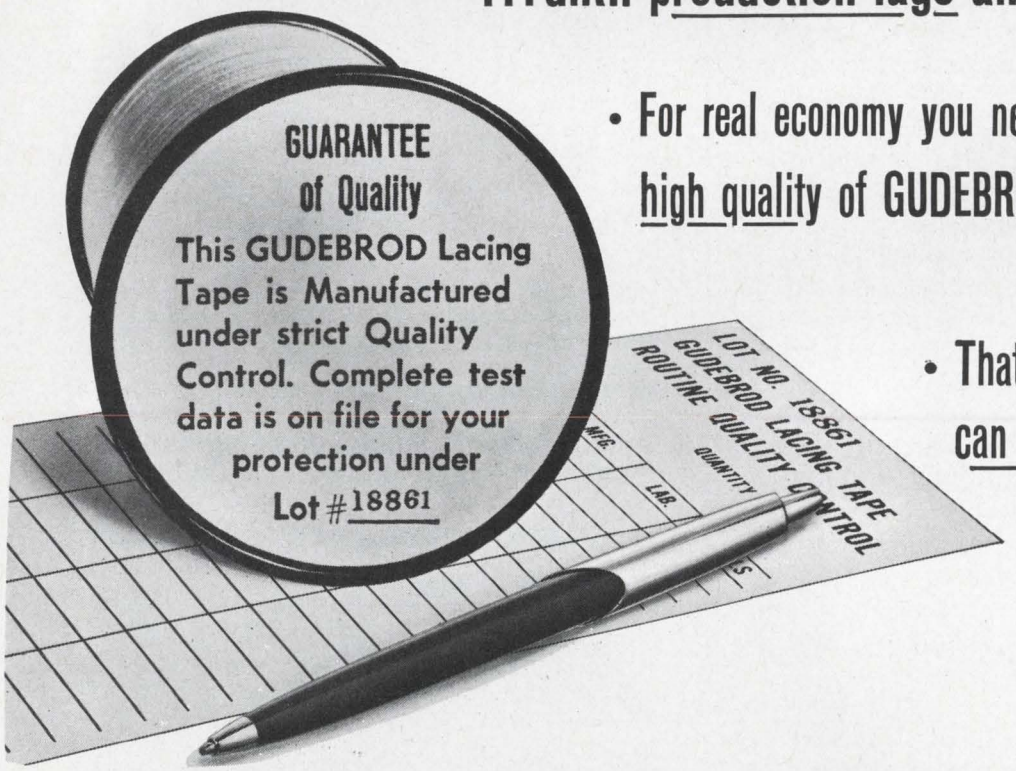

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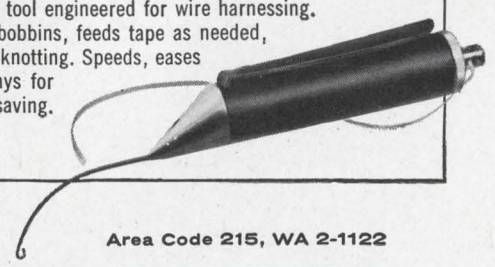

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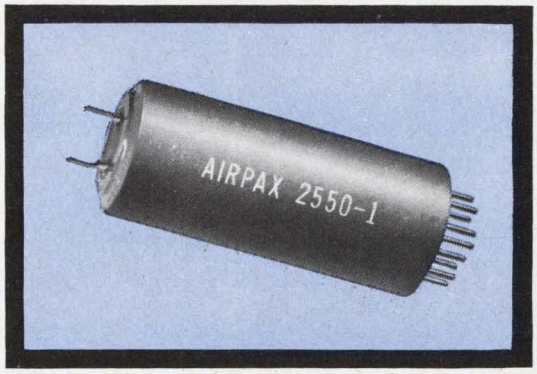
ON READER-SERVICE CARD CIRCLE 41

AIRPAX

DPDT CHOPPERS
Series 2550 and 2750



Airpax double-pole double-throw electromechanical choppers, Types 2550-1 and 2555-1 (for 60 CPS operation) and Types 2750-1 and 2755-1 (for 400 CPS operation) are designed for synchronous modulator-demodulator functions, stabilized DC instrument amplifiers, shared channel applications and null seeking servos. In some instrumentation applications it is desirable to have different dwell times on the individual sections of a DPDT chopper. Typically, a longer dwell is used on the modulator section than on the demodulator portion. Types 2555-1 and 2755-1 are designed to have a 165° dwell on one set of contacts and 120° on the second set. This prevents even slight contact bounce from affecting the demodulated output.

TYPICAL CHARACTERISTICS

	2550-1	2555-1	2750-1	2755-1
Drive Voltage and Frequency	6.3 volts 60 cps	6.3 volts 60 cps	6.3 volts 400 cps	6.3 volts 400 cps
Switching	DPDT BBM	DPDT BBM	DPDT BBM	DPDT BBM
Noise	5 uv RMS - 1 meg 3 uv RMS - 100 ohms	5 uv RMS - 1 meg 3 uv RMS - 100 ohms	10 uv RMS - 1 meg 5 uv RMS - 100 ohms	10 uv RMS - 1 meg 5 uv RMS - 100 ohms
Shock	50 G non-operative	50 G non-operative	50 G non-operative	50 G non-operative
Vibration	10 G 55 to 500 cps non-operative	10 G 55 to 500 cps non-operative	10 G 55 to 500 cps non-operative	10 G 55 to 500 cps non-operative
Temperature Range	Oper. −65°C to +100°C	Oper. −65°C to +100°C	Oper. −65°C to +100°C	Oper. −65°C to +100°C
Life	2000 hours minimum	2000 hours minimum	2000 hours minimum	2000 hours minimum
Contact Rating	10 V 1 MA	10 V 1 MA	10 V 1 MA	10 V 1 MA
Bounce	4° maximum	4° maximum	4° maximum	4° maximum
Dwell Time	165°	165° pins 1, 2 and 3 120° pins 4, 5 and 6	165°	165° pins 1, 2 and 3 120° pins 4, 5 and 6
Balance of Dwells	15°	15°	15°	15°
Transfer Time	5° minimum	5° minimum	5° minimum	5° minimum
Phase Angle	20° ±10°	20° ±10°	54° ±18°	54° ±18°
Coil Resistance (DC) at 25°C	90 ohms	90 ohms	90 ohms	90 ohms
Coil Impedance at 25°C	100 ohms ±20%	100 ohms ±20%	127 ohms ±20%	127 ohms ±20%
Weight	1 ounce maximum	1 ounce maximum	1 ounce maximum	1 ounce maximum
Case Volume	0.70 cubic inches	0.70 cubic inches	0.70 cubic inches	0.70 cubic inches

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ON READER-SERVICE CARD CIRCLE 42

Predict line regulation accurately in high-current regulators by including output conductance in your calculations.

Output conductance is so low that it is generally ignored in calculating line regulation for most transistor series regulators. But this parameter cannot be overlooked when high-current silicon power transistors are used as pass elements. Here then are two methods—one exact, one approximate—of making the calculations.

The reason why output conductance (h_{oe}) is so important to the operation of a pass transistor is clear when we analyze how a silicon transistor performs as a pass device. The high saturation voltage drop of a silicon transistor makes it necessary to locate the operating point of a silicon regulator close to the "knee" of the characteristic curve in order to keep internal power dissipation at a minimum. Since this "knee" is the point at which the characteristic curve becomes nonlinear, h_{oe} increases considerably so that it cannot be omitted from calculations.

The line regulation may be calculated from one of two equations, one an approximation, one exact. The approximate solution employs a voltage divider model and, though simpler to work with, will often make the regulator look as though it has poor line regulation. Down to a line regulation of 5% the more precise analysis will improve calculated line regulation by a factor of two.

Exact approach improves line regulation

In the typical series regulator shown in Fig. 1, pass transistor Q is defined by the following relationships:

h_{FE} = dc current gain,
h_{fe} = small-signal current gain,
h_{oe} = output conductance, and
R_x = dynamic base resistance = V_{be}/I_{OUT}.

The error amplifier is assumed to be a linear amplifier that has infinite input resistance and these characteristics:

A = unloaded open-loop voltage gain,
g_m = transconductance, and
R_o = output resistance = A/g_m.

W. S. Cohen and J. Saia, Design Engineers, Systems Development Div., IBM, Kingston, N. Y.

The regulation of this series regulator is affected by three major factors:

- Load resistance change—specified as source resistance ($R_S=\Delta E_{OUT}/\Delta I_{OUT}$) at a constant input voltage (e_{in}) and temperature.
- Temperature change—specified as temperature sensitivity ($\Delta E_{OUT}/\Delta T$) at a constant input voltage and load resistance.
- Input voltage change—specified as line regulation ($\lambda=\Delta E_{OUT}/\Delta e_{in}$) at a constant load resistance and temperature.

Line regulation is obtained by calculating the effects of input voltage changes (Δe_{in}) on the circuit in Fig. 1. This change must be absorbed by the change in the voltage across Q (ΔV_{ce}) and R_{LOAD} (ΔE_{OUT}). The voltage change (ΔV_{ce}) is found by evaluating the transistor characteristics shown in Fig. 2.

In Fig. 2, the total collector current change is separated into two parts where ΔI_{C2} is simply $h_{oe}\cdot\Delta V_{ce}$ and ΔI_{C1} is $h_{fe}\cdot\Delta I_B$. Since $\Delta I_C=\Delta I_B+\Delta I_E$, the change in output current becomes:

$$\Delta I_{OUT}=\Delta I_E=h_{oe}\cdot\Delta V_{ce}-(h_{fe}+1)\Delta I_B. \quad (1)$$

Rearranging this expression and using $\Delta E_{OUT}=\Delta I_{OUT}\cdot R_{LOAD}$ gives:

$$\Delta V_{ce}=[\Delta E_{OUT}/R_{LOAD}+\Delta I_B(h_{fe}+1)]/h_{oe}. \quad (2)$$

To find ΔI_B, consider the voltage change across R_o caused by an output voltage change (ΔE_{OUT}), where:

$$\Delta I_B=[(1+A)/R_o]\Delta E_{OUT}+[R_x/R_o]\Delta I_{OUT}. \quad (3)$$

Since $\Delta e_{in}=\Delta E_{OUT}+\Delta V_{CE}$, the line regulation ($\lambda = \Delta E_{OUT}/\Delta e_{in}$) becomes:

$$\lambda=\Delta E_{OUT}/(\Delta E_{OUT}+\Delta V_{CE})=1/(1+\Delta V_{CE}/\Delta E_{OUT}), \quad (4)$$

and, using Eqs. 2 and 3:

$$\lambda=1/\{1+(1/h_{oe}R_{LOAD})+[1+A+(R_x/R_{LOAD})]\,[(h_{fe}+1)/h_{oe}R_o]\}. \quad (5)$$

Rewritting λ in terms of the source resistance, R_S, makes the equation easier to handle. From the definition of source resistance and by use of Fig. 2, it can be shown that:

$$R_S = \frac{R_o + (h_{fe} + 1)\, R_x}{h_{oe}R_o + (h_{fe} + 1)\,(A + 1)} \qquad (6)$$

A more conventional form of R_S is achieved if h_{oe} is allowed to go to zero. If Eq. 6 is divided by h_{oe}, the term:

$$\frac{(A + 1)\,(h_{fe} + 1)}{h_{oe}R_o} = \frac{1}{h_{oe}R_S} + \frac{R_x(h_{fe} + 1)}{h_{eo}R_oR_S} - 1$$

can be isolated and substituted in Eq. 5 by further manipulation. Equation 5 can be expressed as:

$$\lambda = H_T\, h_{oe}\, R_{SPL}, \qquad (7)$$

where

$$H_T = 1/[1 + (h_{fe} + 1)R_x/R_o] \qquad (8)$$

and

$$R_{SPL} = R_{LOAD}\, R_S/(R_{LOAD} + R_S). \qquad (9)$$

H_T may vary from 0.4 to 1.0. Equation 7 indicates the trade-offs that are possible between h_{oe} and the product $H_T\, R_{SPL}$. In most cases, R_S is approximately equal to R_{SPL}.

Approximation assumes conductance is constant

The approximate solution for line regulation (λ') is obtained by considering a simpler model of the series regulator where only first order effects are considered. In this model, R_{LOAD} is replaced by R_S in parallel with R_{LOAD}, and Q is represented by a transistor having a linear characteristic in shunt with a conductance, h_{oe}. Since the transistor, because of its "flat" characteristic, appears as a constant generator in parallel with h_{oe}, it can be omitted. This yields the model in Fig. 3.

The calculation of line regulation now becomes merely a voltage divider analysis:

$$\lambda' = 1/[1 + 1/h_{oe}\, R_{SPL}]. \qquad (10)$$

The percentage error of this approximation is:

$$[(1 - \lambda')/H_T - 1]100\%, \qquad (11)$$

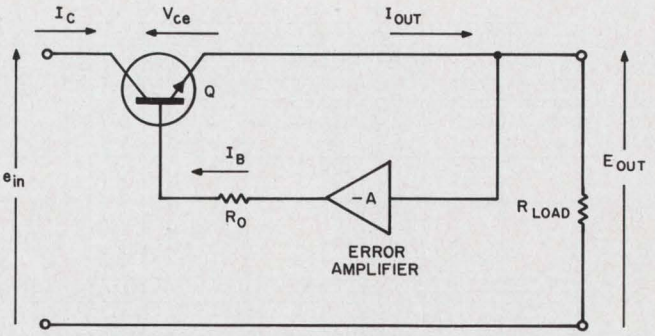
and the relationship between the exact value of λ and λ' is:

$$\lambda = H_T\, \lambda'/(1 - \lambda'). \qquad (12)$$

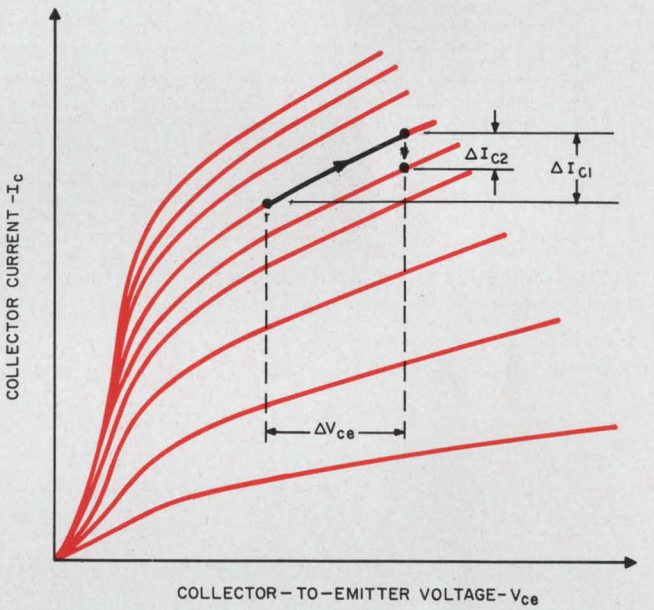
From Eq. 10, it is apparent that λ can be more or less than λ', depending on the specific value of H_T and λ'.

Figure 4 shows line regulation for a range of values for the product $h_{oe} \cdot R_{SPL}$. The dashed curve represents the approximate solution where $H_T = 1$. Other plots for exact values of H_T ranging from 0.1 to 1.0 are also shown in this figure. When the regulation is greater than 5%, the exact solution should be used.

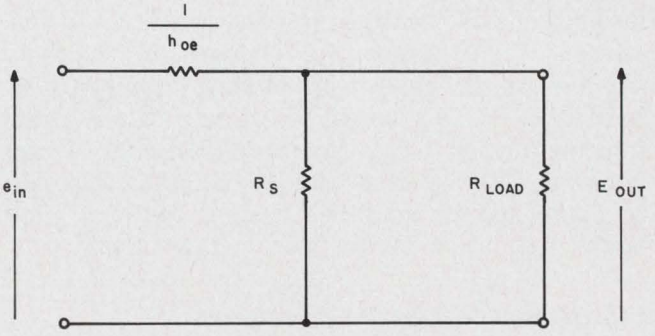
To determine the effect of line resistance, the resistance between the source and the collector of the pass transistor, as shown in Fig. 5, is included in the following relationship, where Λ is the



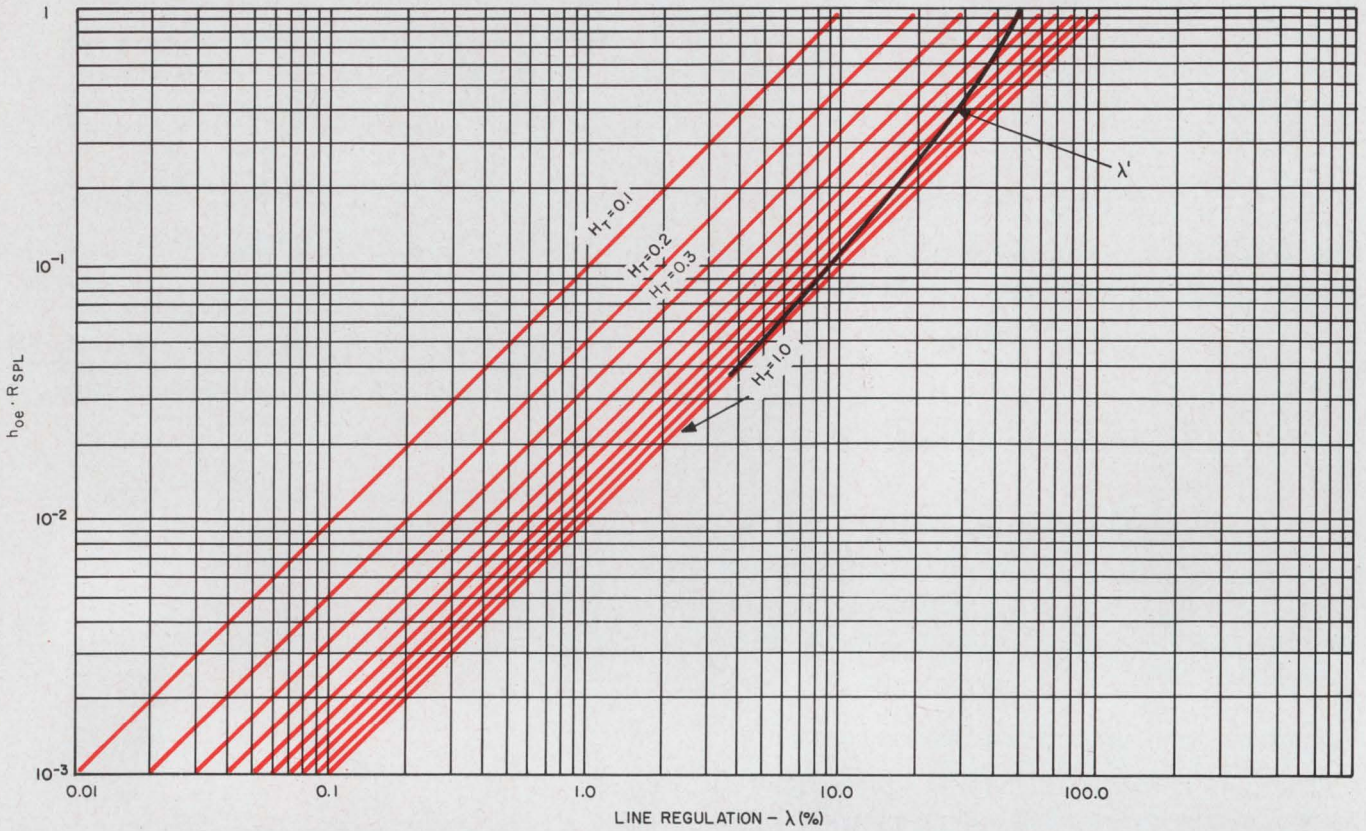
1. **Regulator uses an error amplifier** which compares the output voltage to an internal reference. The transistor's base drive is adjusted to regulate the output volatge.



2. **Common-emitter family of curves** shows the change in voltage that transistor Q sustains due to a change in input voltage.



3. **Simpler model of regulator circuit** assumes operation over the more linear portion of the characteristic curve. As a result, the regulator often appears to have poorer regulation than it actually has.



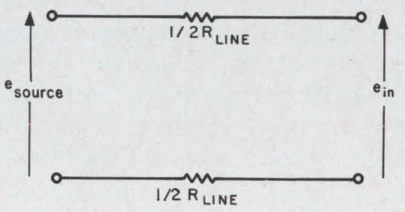
4. **Line regulation as a function of the parameters** and for various values of H_T. For any given regulation the best value of $h_{oe} \cdot R_{SPL}$ can be selected. Note the difference between the actual (λ) and approximate (λ′) solutions.

over-all line regulation:

$$\Lambda = E_{OUT}/e_{source}, \tag{13}$$

$$\Lambda = \lambda/[1 + h_{oe} R_{LINE} (1 - \lambda) + h_{oe} R_{LINE} \left(\frac{h_{fe}}{h_{fe}+1}\right) \left(1 - \lambda - \frac{H_T R_{SPL}}{R_{LOAD}}\right)] \tag{14}$$

The desired over-all line regulation of a transistor series regulator is realized by selection of an appropriate combination of R_S and h_{oe} (for a given R_{LOAD}) from Fig. 4. The R_o of the amplifier can then be designed for a suitable H_T to yield the required line regulation, λ. Using this and R_{LINE} in Eq. 12, the over-all line regulation, Λ, can be determined. If the output of the bias voltage supply varies with line-voltage variations, the line regulation will also be affected. In this analysis, it has been assumed that the operation of the amplifier is not affected by changes in the bias supplies. In any experiment or test, it is important to identify the portion of the output voltage error that accrues as a result of amplifier bias voltage variations. When these variations occur, they can be controlled by amplifier design, feedback, and better regulation of the bias voltage itself.



5. **Equivalent circuit of line resistance** between power source and series regulator. This resistance is included in the line regulation equation.

Design example regulates 75 amperes

As an example, take the design of a 6-V, 75-A series regulator with a line regulation of 0.5%. Assume the pass transistor selected for the application has these characteristics:

$$h_{oe}=5 \text{ mhos}; R_x=10 \text{ m}\Omega; h_{fe}=10.$$

The first step is to select an arbitrary value of H_T; assume H_T is equal to 0.5. From Fig. 4, $h_{oe} R_{SPL}$ becomes 10^{-2} when $\lambda=0.5\%$. Thus,

$$R_{SPL}=10^{-2}/5 \text{ mhos}=2 \text{ m}\Omega,$$

and

$$R_{LOAD}=6 \text{ V}/75 \text{ A}=80 \text{ m}\Omega.$$

From Eq. 8, the value of R_o (the output resistance of the error amplifier) is calculated to be 110 mΩ.

From Eq. 9, the value for R_S becomes 1.95 mΩ. These values are inserted in Eq. 6 and the equation is solved for the error amplifier gain, A. For these particular values, the gain turns out to be 99 and is well within the capabilities of most amplifiers. ■ ■

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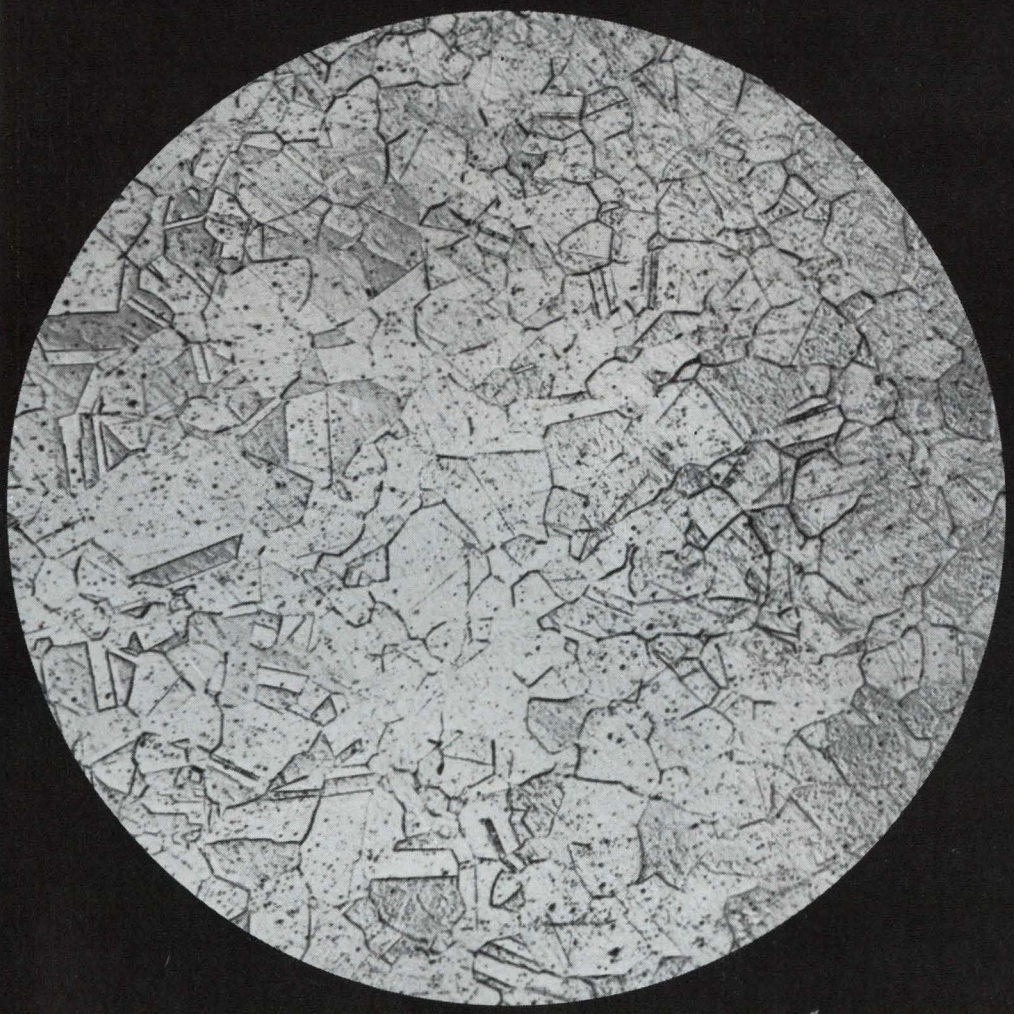

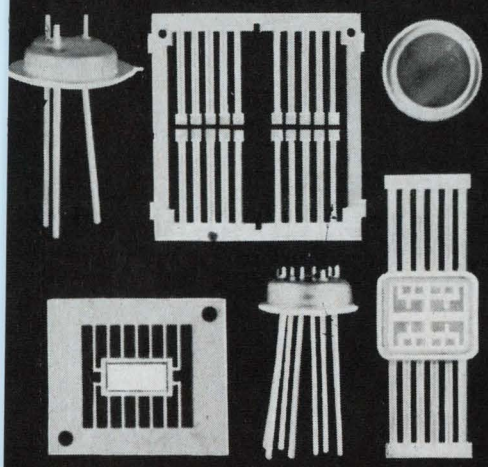

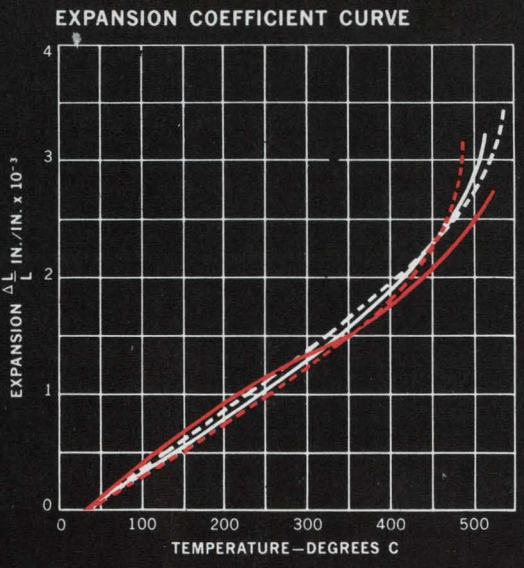

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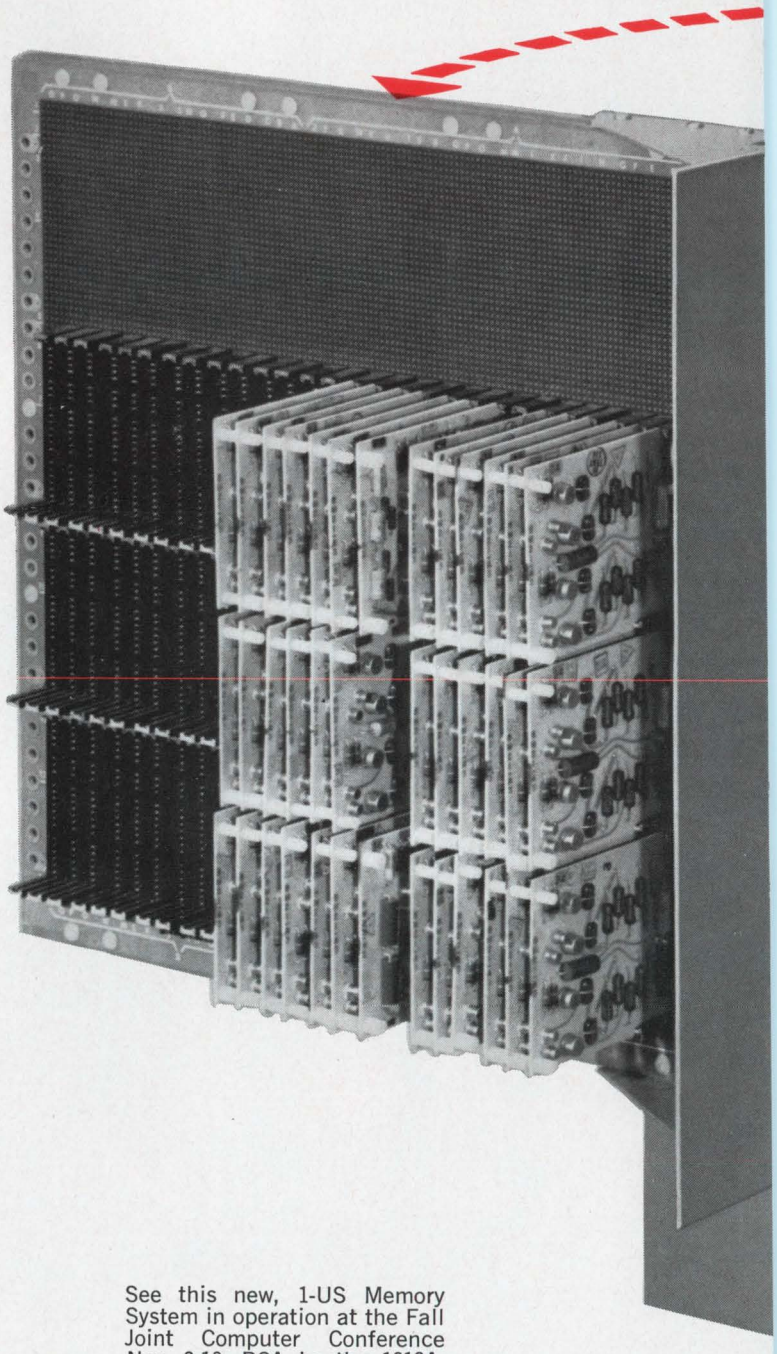

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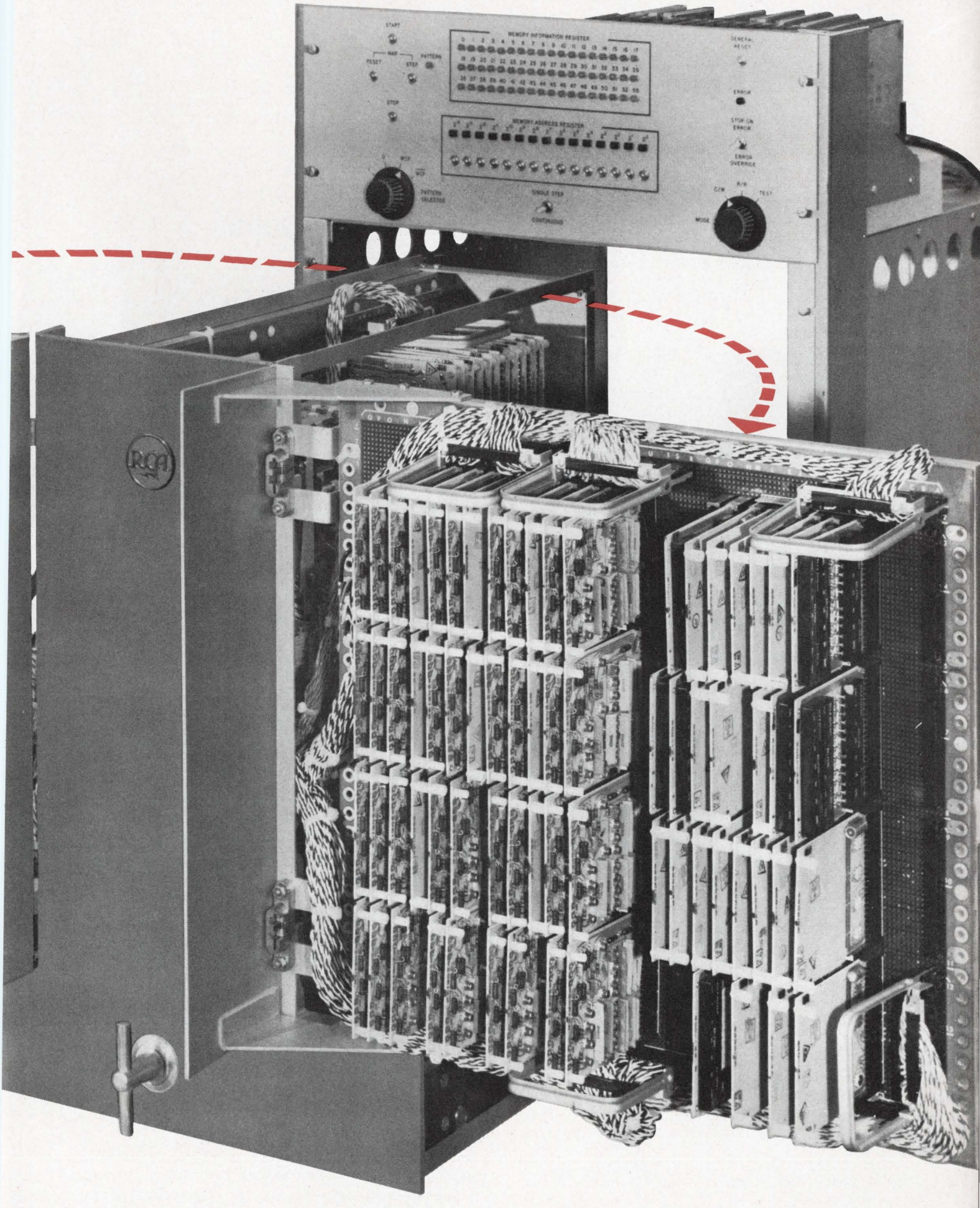
START
MEMORY INFORMATION REGISTER
GENERAL RESET
MAR
RESET
STEP
PATTERN
STOP
ERROR
MEMORY ADDRESS REGISTER
STOP ON ERROR
ERROR OVERRIDE
R/W
PATTERN SELECTOR
SINGLE STEP
CONTINUOUS
MODE
TEST
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Don't pay too much for stability in oscillators. A different approach to amplifier stabilization yields inexpensive and stable RC oscillators.

Usually RC oscillators are not considered for precise frequency generation. But an unusual design technique makes them unbeatable as inexpensive, easy-to-reproduce frequency sources and time-base generators.

The design approach differs from the conventional in that it uses a precisely adjusted amount of excess loop gain, rather than some form of multicycle level control, to achieve stable operation. The choice of a stable twin-T network and a gain-stabilized amplifier results in an oscillator that has better than 0.1% accuracy and a short-time stability of a few parts in 10^8. The temperature range is from -55 to $+71°C$.

Such oscillators are useful in many communication, switching or channel-selection applications, and in telemetry systems for subcarrier or composite signal generation. Stable time-base generators are also finding increased use in settable digital electronic timers for both civilian and military equipment.

The design approach has been carried out at 1000 Hz, although frequencies between 100 and 10,000 Hz may be generated by the choice of appropriate network components.

Why RC oscillators?

Inductance-capacitance oscillators were investigated first because they have already been used as precise audio frequency sources. An LC resonator, furthermore, presents favorable impedance interfaces to the amplifier in the frequency range of interest. But there are some practical difficulties that arise with this approach.

For small size, a permeable-core inductor must be used (usually toroidal) along with film capacitors of the wound type. Extensive testing has indicated that control of the temperature coefficients of these elements to the required accuracy would be extremely difficult on a production basis. To obtain 0.1%, an average LC temperature coefficient of 10 ppm/°C must be held to cover a temperature range of 100°C. Permalloy dust cores and polystyrene dielectric capacitors that approach this stability are available, but it is likely that each one of them would have to be tested individually.

Under shock and spin, both of these circuit elements may change typically as much as 0.25%, even when protected by special potting techniques.

These basic limitations make RC oscillators preferable. Precision wire-wound resistors are widely available with uniform temperature coefficients of less than 10 ppm/°C over the military temperature range. Coefficients as low as 2 ppm/°C can be obtained. Aging of wire-wound resistors of proper design is as low as 0.003% per year. Highly stable capacitors of suitable size with porcelain or ceramic dielectric are available from several commercial sources. One source supplies capacitors with specifications indicating 0 $\pm$25 ppm/°C temperature coefficient.

Capacitors of this type may also be obtained with the same temperature-coefficient tolerance but with temperature coefficients of $+105$ or -65 ppm/°C. Aging tests on these capacitors, conducted by the National Bureau of Standards and others show variations less than 0.1% in 10 years. Most of this variation has been found to occur in the first few months (following a time-logarithmic pattern) and may be considerably reduced by accelerated aging treatment.

The wire-wound resistors and ceramic capacitors withstand high setback accelerations with negligible changes, when appropriately potted.

Twin-T for frequency selection

There are two alternative frequency-selective networks in general use: a twin-T or a Wien bridge.

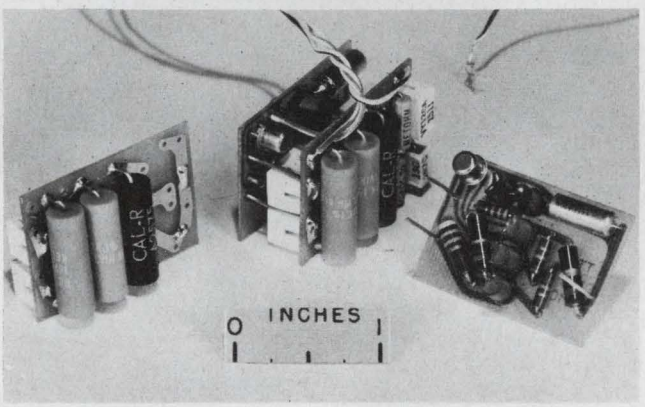
The twin-T outperforms the Wien bridge in

John M. Shaull, RD Supervisor, Harry Diamond Laboratories, Washington, D. C.

several areas.

- Input and output have a common terminal, which may be grounded.
- Input and output are less sensitive to loading, since the amplifier's input impedance does not appear directly across a single frequency-determining element.
- The twin-T may work directly into an emitter-follower that presents an input capacitance of C_{bc}, whereas the Wien bridge with the necessary common emitter input presents a C_{bc} multiplied by the gain factor of the input stage. The base-collector junction of the input stage for the twin-T thus has a low signal voltage impressed across it compared with the large ac voltage for the Wien bridge (equal to about one-third of the output voltage times first-stage gain).
- The twin-T network permits the use of a dc, unity-gain, direct-coupled amplifier which results in a high degree of bias stabilization. This can be achieved for the Wien bridge only with highly stable decoupling components that are relatively expensive and large, by a push-pull output, or by a three-terminal power supply.

A photograph of the 1000-Hz oscillator is shown in Fig. 1, with an unpotted unit in the center and the individual circuit boards at left (twin-T network) and right (amplifier). A potted unit of this type has a volume slightly greater than 1 cubic inch. A hybrid amplifier with integral film resistors, chip transistors, and slightly smaller network resistors can reduce the volume to about 0.5 cubic inch.

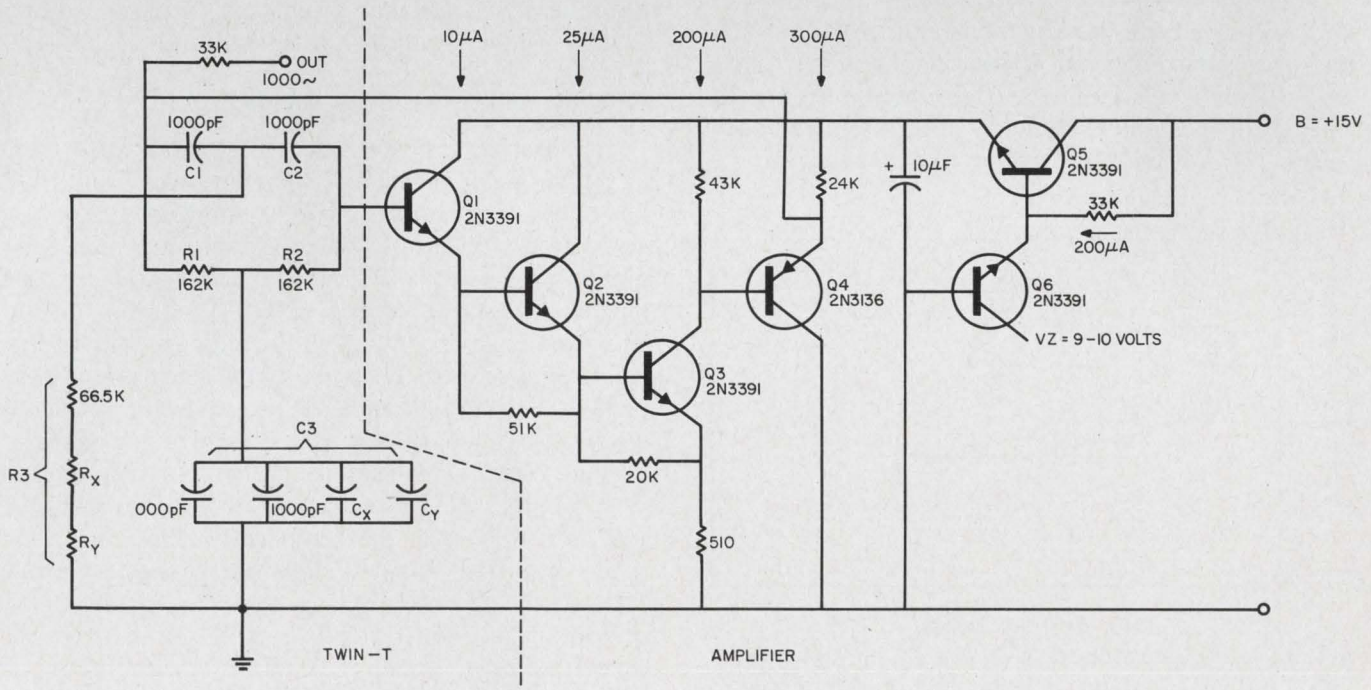


1. **Stable RC oscillator** (center) consists of two major stages: The twin-T network is at the left and the amplifier is at the right. The volume of the potted unit is slightly more than 1 cubic inch.

Low-cost transistors preferred

Inexpensive epoxy-cased transistors are recommended because they are extremely rugged and can be obtained with very high betas. They are very reliable and convenient for experimental high-shock design. Field-effect transistors have higher input impedance, but their ruggedness, stability, uniformity and cost need further improvements.

The circuit schematic for the oscillator is shown in Fig. 2. It consists of three sections: a regulator-filter, a twin-T frequency-selective network, and an amplifier. This circuit was designed for use with a power supply voltage of 15 ±3 V. An emitter-follower regulator-filter, using *Q5*, and the base-emitter junction of *Q6* as a zener diode, along with a 10-μF capacitor, isolate the oscillator from the power supply's voltage and impedance variations.



2. **Twin-T network** is inserted into the negative feedback loop of the amplifier. The regulator-filter (Q5 and Q6) isolates the oscillator from the power supply. The oscillator circuit is adaptable to monolithic techniques.

The base-emitter junctions of these transistors, when used as zener diodes, have extremely sharp break points down to 1 μA, and more than half of them have straight curves beyond the 400-μA maximum current required. The voltage change at the output of the regulator-filter is less than 1 V over the temperature range. A low-cost, rugged regulator-filter is thus obtained with isolation much better and response rate much faster than a simple RC filter. A resistor of several hundred ohms may be added in series with the 15-V lead, to protect against accidental burn-out of the regulating circuit if the battery polarity is reversed.

The oscillator proper consists of two parts—the twin-T filter network shown to the left of the dashed line in Fig. 2, and the amplifier, consisting of *Q1* through *Q4*.

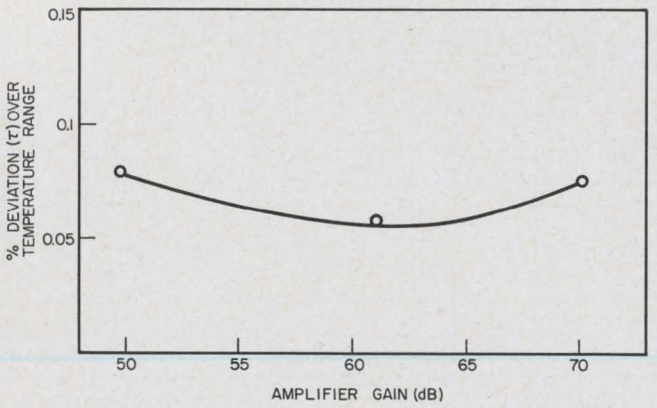
Twin-T into feedback loop

The phase-inverting, unbalanced, symmetrical twin-T, is inserted into the negative feedback loop of the amplifier. At dc, the network has nearly zero attenuation, which results in a dc amplifier gain of unity with high bias stability. At the notch frequency, the phase inversion in the network and the phase inversion in the amplifier result in the positive feedback necessary for oscillation. The network is unbalanced by changing *R3* or *C3* or both from their balanced values of $2R3 = R1 = R2$ and $C3 = 2C1 = 2C2$.

For the balanced, symmetrical condition, the notch frequency is given by:

$$F_o = \frac{1}{2\pi\, R1\, C1}. \qquad (1)$$

The general equation for the complex transmission loss of a twin-T network is lengthy and much has been written about its analysis and performance. The above simple equation may be used with the specified R and C ratios to obtain approximate values for *R1* and *C1*. Ordinarily, capacitors have been specified to $\pm 5\%$ and resistors to $\pm 1\%$ for the network elements. Fine tuning can then easily be done by adjusting the shunt arms of the network.



3. **Amplifier's gain should be around 60** for stable oscillation. At this point the gain of the amplifier becomes equal to the loss of the twin-T circuit, which results in an over-all gain of unity.

For phase inversion, the impedance in the resistive shunt arm (*R3*) must be slightly less than the impedance of the capacitive shunt arm (*C3*). Optimum over-all stability was obtained with a notch attenuation voltage ratio of about 50:1. Typical values for *R3* are about 70 kΩ and *C3* totals approximately 2200 pF at 1000 Hz.

To adjust the frequency, increase *C3* by capacitors C_x and C_y. *R3* may be adjusted by series resistors R_x and R_y which give an attenuation that is slightly less than the amplifier's gain at the desired frequency.

The network has maximum selectivity or phase sensitivity in the symmetrical state, but the curve is rather broad with respect to ratios of *R1*, *R2*, *R3* and *C1*, *C2*, *C3*. The amplitude and phase response is very sensitive to the degree of balance and reaches its peak as a null is approached. The equivalent Q of such a network, when compared with the phase response of a single tuned circuit, is about equal to the network loss (or amplifier gain) divided by four.

The importance of a high network Q is shown by the equation giving the fractional change in network drive frequency required to compensate for a change in amplifier phase shift:

$$\frac{df}{f} = \frac{d\theta}{2Q}, \ (\theta \text{ is in radians}). \qquad (2)$$

It may be used to compute the change in oscillator frequency resulting from phase changes in the amplifier. For a one-degree phase change in the amplifier, a fractional frequency shift of about 0.0006 would result for a network Q of 15.

Amplifier stages are direct-coupled

The amplifier is designed to have a minimum effect on the oscillation frequency. The amplifier has a wide bandwidth and thus small excess phase shift at the working frequency. Its input impedance is very high (20 MΩ) with respect to the output impedance of the twin-T; and its output impedance is very low (200 Ω) with respect to the input impedance of the twin-T filter. Thus, changes in these amplifier parameters with respect to variations in temperature or supply voltage result in minimum changes in the oscillation period. This design simplifies adjustments and is stable over the temperature range.

The amplifier consists of two cascaded emitter-followers, followed by a common emitter stage and an output emitter-follower. The stages are all direct coupled, which minimizes the number of components and provides excellent bias stability, because of the unity dc feedback through the

network.

Because of the dc coupling, the emitter voltage of *Q4* is approximately the same as the base voltage of *Q1*. This voltage is essentially the sum of the base-emitter drops of *Q1*, *Q2*, and *Q3*, which is about 1.7 V. The voltage on the collector of *Q3* must be this voltage less the base-emitter drop of *Q4*, or about 1.1 V. This voltage determines the maximum ac voltage swing of *Q3* without clipping. Since this voltage will vary considerably over the temperature range, the ac output will vary proportionately. This variation may be actually desirable for driving shapers or trigger circuits, since it helps compensate for threshold variations in the driven stage.

The ac gain of the amplifier is achieved in *Q3* and is approximately equal to the effective load resistance divided by the total emitter resistance (R_e+r_e), or about 65 at 25°C.

The stage currents are approximately 10, 25, 200, and 300 μA respectively, for *Q1* through *Q4*. The regulating diode of *Q6* draws about 200 μA at 15 V, which results in an over-all drain of about 735 μA.

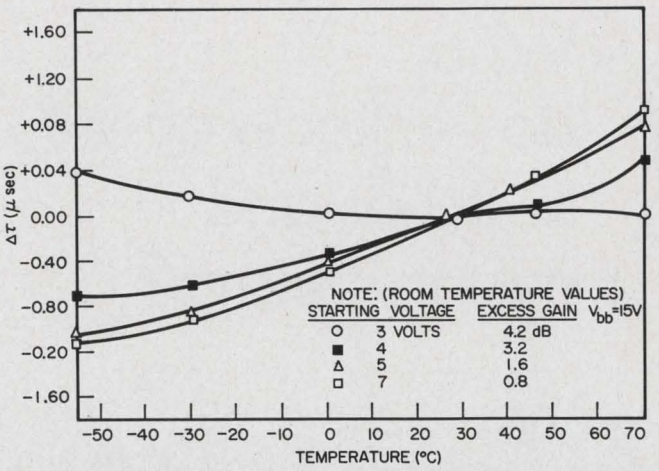
Excess loop gain stabilizes oscillator

The excess loop gain is the difference between the amplifier gain when it operates in the completely linear region and when it operates under a steady-state oscillating condition with the gain clamped by the collector saturation of *Q3*. In the latter case the gain of the amplifier is equal to the loss of the twin-T network and the gain around the loop is equal to unity, or zero dB.

The total period change over the temperature range is shown in Fig. 3 as the amplifier gain is varied and the excess gain is about 20% (1.6 dB). The maximum period stability occurs at a gain of about 60 dB. Moderate temperature deviations in either direction have only minor effects on the stability.

The excess gain can be computed if the value of the supply voltage where oscillation starts is known, since the gain is a function of the emitter current of *Q3*. The excess gain may be adjusted with *R3*, to change the period (Fig. 4). At any given temperature the variation of the period with the amplifier gain is less if the excess gain is not over 2 dB. For positive period-vs-temperature-slopes over-all compensation can be achieved by an increase in the excess gain. However, small gain variations could cause undesirable changes in the period.

To give the period maximum independence from the amplifier properties and yet ensure reliable starting, an excess gain of 1.5 to 2 dB seems optimum. If the excess gain is too low, the loop gain may drop below unity, and oscillation cannot start. For the circuit of Fig. 2 the proper



4. **The total period change** over the temperature range may be adjusted with the excess gain. The starting voltage is determined by the need for reliable starting. An excess gain of 1.5 to 2 dB seems optimum.

gain occurs with a bus starting voltage of 5 V, or a supply voltage of about 5.5 V. This value allows for a 0.5-V drop in the emitter circuit of the regulator, which operates below the zener-controlled point.

The excess gain may be expected to increase at low temperature. It can be accounted for by decreases in the intrinsic emitter resistances, r_e, and the collector resistances, h_{oe} or h_{oc}, of the transistors. Variations in other transistor parameters tend to decrease the gain.

The principal cause of gain variation is believed to be the variation in the internal emitter resistance of *Q3*. A thermistor could be used to make up a part of R_{e3} to improve gain stability. Because of the small change in gain and its significance, this expedient would prove useful only if high-stability resistors were used in the emitter.

The excess loop gain may be adjusted with R_x and R_y. Their values must be selected simultaneously with C_x and C_y, to yield the correct period of oscillation.

If the oscillator is to be potted, R_y and a resistor R_a (about 80 ohms and in series with the ground end of the emitter resistor of *Q3*) are left outside the potting compound. R_y is used to adjust the period and R_a to adjust the gain. After the fine adjustments these resistors may be potted. Since both of these resistors are gounded and have low impedances, they may be left unshielded.

An electrostatic shield is needed to isolate the high input impedance of the twin-T network and to permit precise calibration. A thin metal case, tied to ground, is acceptable and it may also serve as a potting container.

The potting material should have good mechanical properties, low and stable dielectric constant and low dissipation factor. Long, straight leads, cordwood construction and spaghetti should be avoided.

Tests prove stability

The measured amplifier phase shift was 181.0 degrees at 1000 Hz. This 1° variation from the nominal 180° value at dc will change somewhat with temperature. These changes thus have a slight effect (about 0.02%) on the oscillator frequency, but are fairly predictable and may be compensated for. More favorable or more stable amplifier properties may be obtained only with considerably more complex circuitry.

Temperature variations in the electrical properties of the potting material, rather than a lack of very high amplifier input impedance, may impose a lower limit on the usable frequency.

The amplifier seems easily adaptable to miniaturization by hybrid techniques and perhaps also to monolithic integrated form.

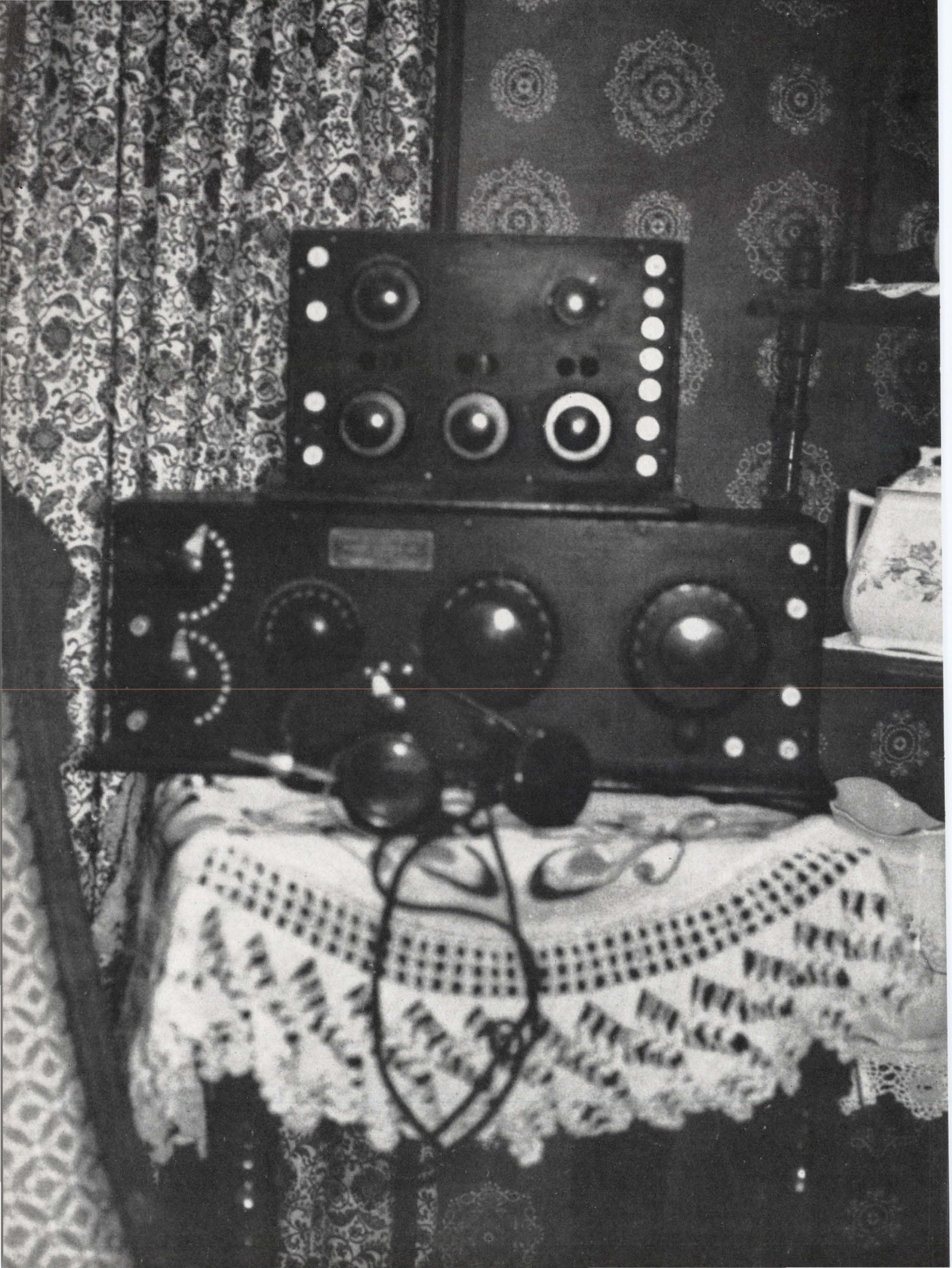
If all temperature compensation is to be effected by choosing the net TC of *C3*, the worst-case for attenuation change results if all *Rs* and all other *Cs* have the same TC sign. One may assume all *Rs* have +10 ppm/°C and all *Cs* +25 ppm/°C. *C3* has a zero TC. The period shift from +25°C would then be −2.21 μs, the attenuation change would be −0.08 dB at −55°C. To correct the period change to zero at −55°C, the net TC of *C3* must be chosen to be −106 ppm/°C. This will result in a network attenuation change of −0.49 dB in going from room temperature to −55°C. If the TCs are linear, an equal upper temperature excursion causes an attenuation change of equal magnitude but opposite sign. The ±106 ppm/°C for *C3* represents also the maximum net TC required of *C3* if all other randomly selected parts of the network have TCs of opposite sign within the specifications above, namely, ±10 ppm/°C for resistors and ±25 ppm/°C for capacitors.

In any large-quantity purchase of network components that are specified for zero TC tolerance, it is likely that about one-half of the items will have coefficients at either side of zero. Thus a simple pairing of favorable combinations could reduce both the attenuation changes with temperature and the net TC requirement for C3 to a small percentage of the above values.

Typical period-versus-supply-voltage performance of oscillators with voltage regulators was less than 0.02 μs change between 10 and 20 V. The period increased 0.15 μs when supply voltage was changed from 6 to 10 V.

Without the voltage regulator, the variation in period is less than 0.5 μs from 6 to 20 V or about +0.02 μs (0.002%) per volt. The regulator decouples the oscillator from phase-coherent interference, which might result in frequency pulling.

The start-up time for the oscillator with the regulator-filter attached is less than 0.8 ms (5-cycle excess with power applied at zero time, compared with a steady-state sampling). ■ ■



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Mix the old principle of ramp voltage comparison with modern integrated-circuit technology, and the result can be a fast, accurate, simple and cheap analog-to-digital converter.

The simplicity and low cost of this IC A/D converter make it especially suitable for multichannel applications. Conventional multichannel converters require some form of analog channel switching (commutation) to allow the various input signals to be connected to the processing circuitry. Using inexpensive ICs, one converter can be alloted to each channel, thus saving the cost of multiplexing and eliminating the errors usually generated in electronic commutators.

The accuracy of the multichannel IC converter is better than $\pm 0.05\%$ of full scale at room temperature, and the conversion rate is typically 1000 per second per channel. Parallel operation makes the conversion rate comparable to conventional high-speed converters.

Counter helps generate sawtooth

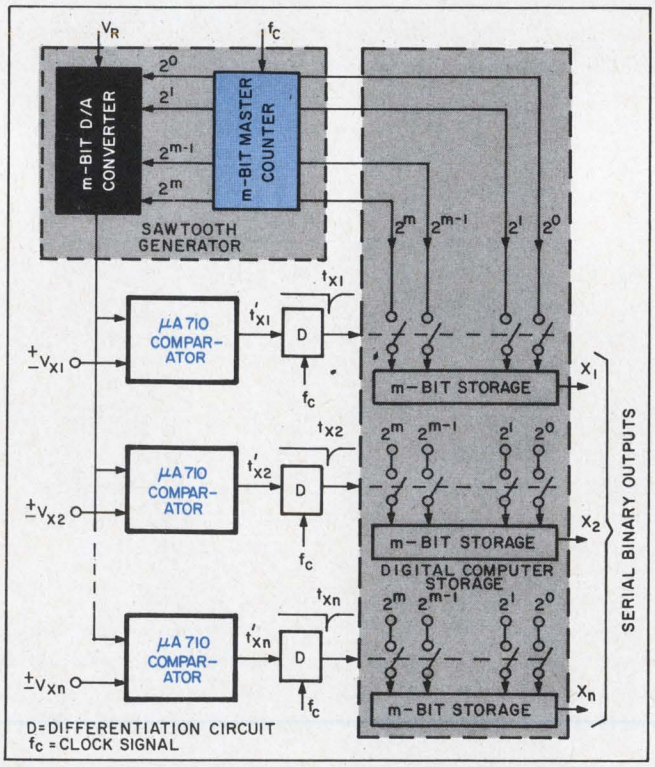
The block diagram of the complete n-channel analog-to-digital converter and required storage circuits are shown in Fig. 1. The storage circuits are usually already provided in special-purpose digital computers for input signal buffering.

The n-channel version of the converter comprises only one sawtooth generator, n-comparators, and n-differentiation circuits. Each of the n-input voltages V_{x1} to V_{xn} is connected to one input of a comparator, while the sawtooth voltage V_s is connected to the other input. When V_x is larger than V_s, the output of the comparator, t_x is $+V_B$; when V_x is smaller han V_s, the output level is zero. The comparator output is connected to a differentiation circuit, which produces a narrow pulse at the trailing edge of the t_x pulse signal. The start of this narrow pulse, which is coincident with a clock pulse, is used to parallel-transfer the content of the master counter into the appropriate storage circuit. This occurs just after the clock has changed the master counter. In the block diagram one m-bit shift register is provided in the digital computer for each conversion channel. These storage registers can be arranged to provide either serial or parallel output.

Most conventional sawtooth generators use analog integrators. The amplitude of the resulting sawtooth waveform. V_s, is thus a function of the integrating resistor, R, and capacitor, C, since:

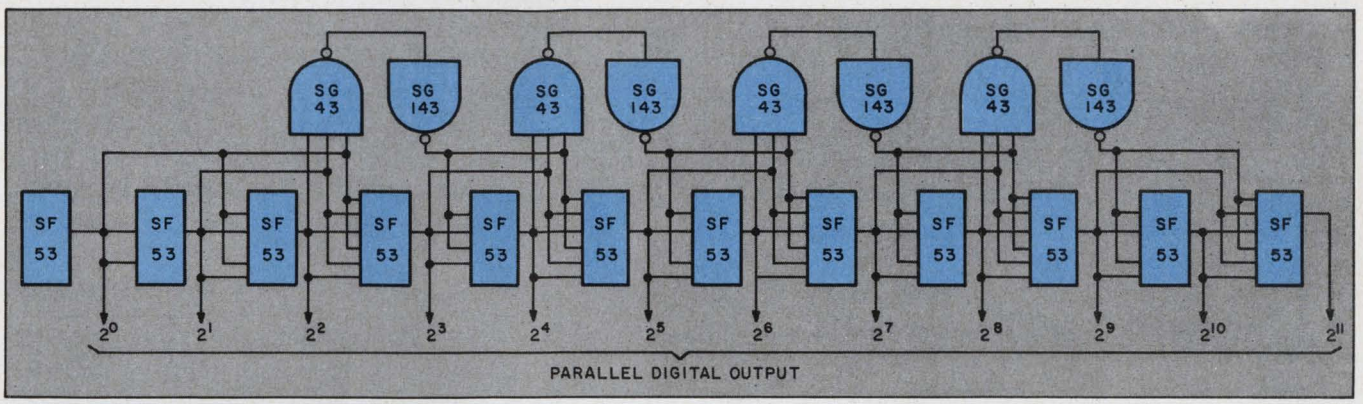
$$V_s = 1/RC \int_0^T V_e \, dt = V_c \, T/RC, \qquad (1)$$

where V_c is a constant voltage and T a constant time interval.



1. **Off-the-shelf microcircuits lower the cost** of this multichannel analog-to-digital converter. The sawtooth generator is freed from the need for an accurate, variable time constant by a D/A converter and a master counter.

Herman Schmid, Senior Engineer, General Electric Co., Johnson City, New York

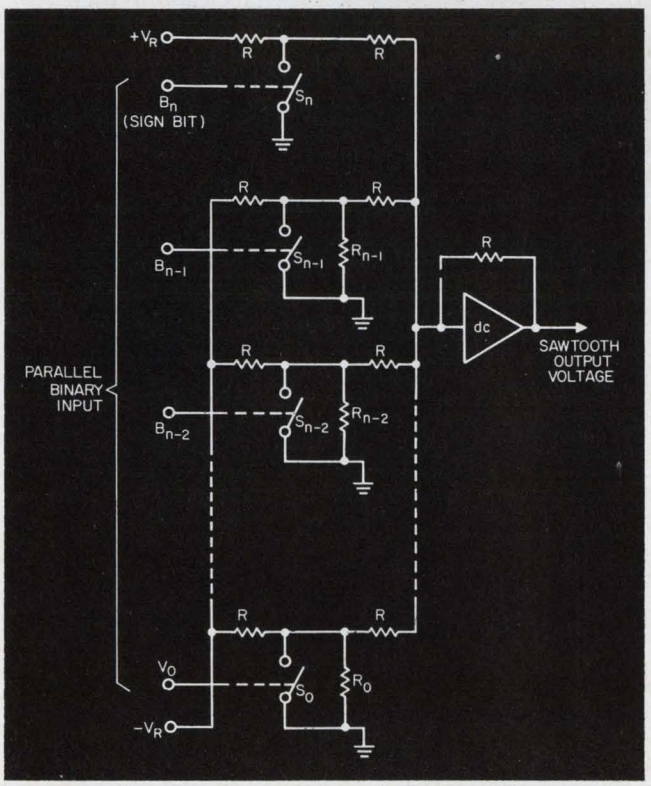


2. **Binary digital outputs from this master counter** drive the D/A converter which generates the sawtooth voltage needed for the ramp comparison technique. Counter outputs are gated into the digital computer storage circuits.

To overcome this dependency on components, and especially to eliminate the need for a precision capacitor, a sawtooth generator has been designed. It consists of a counter and a digital-to-analog converter.

The master counter operates continuously and provides as outputs binary digital signals that represent a linearly increasing number—from *000. . .00* to *111 . . . 11*. Here *000. . . 00* represents a maximum negative value, *111 . . . 11* a maximum positive value and *100 . . . 00* represents zero. A continuously operating counter can be regarded as a digital sawtooth generator, since it resets itself to *000 . . . 00* after it has reached *111 . . . 11*.

The conversion from the digital number to an analog sawtooth voltage is performed with a conventional D/A converter. With appropriate biasing, the output of the D/A converter swings between the negative reference voltage, $-V_R$, and the positive reference voltage, $+V_R$. Besides generating the sawtooth, the master counter outputs are also gated into the digital computer storage circuits. The number in the counter increases linearly with time; so the number transferred out at any given time is proportional to the time that has elapsed since the start of the counting cycle. By gating the controls of the master counter into the shift register at the end of the t_x pulse, whose width is proportional to V_x, a number proportional to V_x is transferred into the register.



3. **Combined with the counter of Fig. 2, this digital-to-analog converter** generates the sawtooth voltage, which is actually a staircase voltage with 4096 steps per cycle.

Careful circuit selection is a must

There are five basic circuits used in building the A/D converter:

- Master counter
- D/A converter
- Comparator
- Differentiator circuit
- Digital storage circuits

The circuits used were carefully selected to obtain the optimum trade-off between cost and performance. The features considered were:

The master counter must be capable of operating with a clock frequency of a least 4 MHz, must have a resolution of at least 12 bits and should operate synchronously with clock frequency. Each output of the master counter must be capable of driving n digital loads and one analog switch in the D/A converter. A typical design of such a counter with Sylvania's SUHL logic circuits is shown in Fig. 2. It requires a total of 15 off-the-shelf digital integrated circuits.

The D/A converter may be any one of three types: resistor ladder network,[1] weighted voltage or current divider. Each has the basic speed and accuracy capability and similar limitations. The weighted voltage D/A converter shown in Fig. 3, using discrete components, is the most economical

The ramp-conversion principle

The conversion from a dc voltage, V_x, to a digital signal, X, can be effected, as shown in the figure, by converting V_x first into a pulse-width signal, t_x, and then into a digital signal, X.

The dc voltage to pulse-width conversion is obtained by comparing V_x with a sawtooth voltage, $V_s = tV_R$. The output of the comparator is a rectangular wave with an ON-time t_x, and a repetition period T. The ON-time t_x is proportional to the voltage V_x, since:

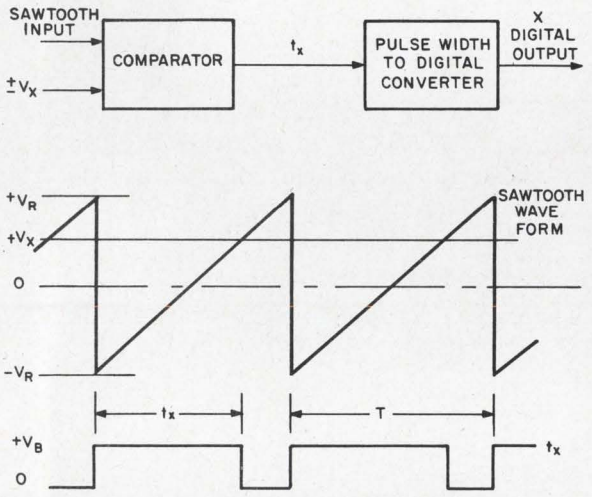
$$V_x = t_x V_R \qquad (1)$$

and

$$t_x = V_x/V_R \qquad (2)$$

where V_R is a reference voltage.

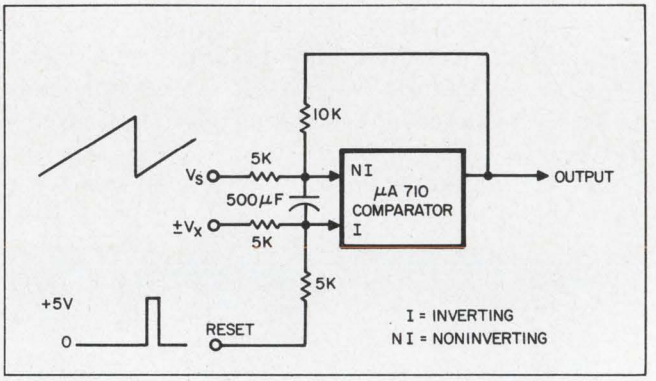
The conversion from t_x to X is accomplished by either counting the clock pulses during t_x or by transferring the contents of a master counter (which is synchronized with the sawtooth voltage V_S) into a storage circuit.



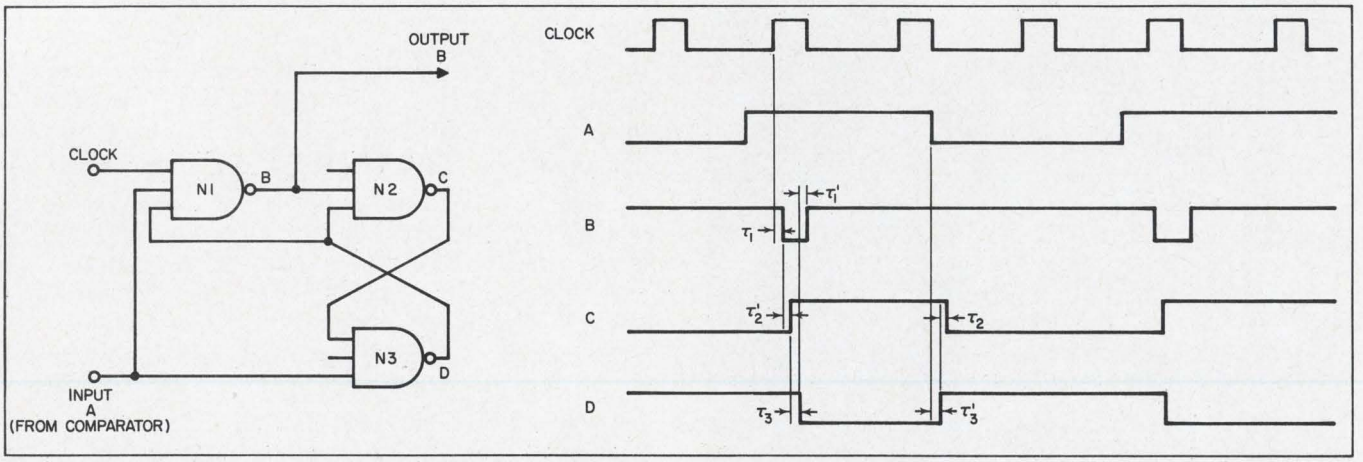
at present. However, the current divider D/A converter, when built with monolithics, will eventually offer the ultimate in economy. The weighted voltage converter is a modified version of the weighted resistor converter. It does not require series analog-voltage switches and therefore is free from loading caused by the low impedance of the resistors in the more significant stages.

The converter in Fig. 3 employs only shunt analog-voltage switches, which are much easier to build. The penalty for using these simpler switches and the elimination of the switch loading problem is an increased number of precision resistors. The converter uses three resistors for each input channel, two of which form a voltage divider. The third resistor is used for summing the voltage. The resistors R_{n-1}, R_{n-2}, to R_0 are selected to produce the voltages of $1/2V_R$, $1/4V_R$, to $1/2^nV_R$, respectively. If the shunt switch is open, the voltage is connected to the summing point. If the switch is closed, the input is zero.

Connecting each of these binary voltages through a resistor, R, to the summing point, we get a sum of currents, and these, in turn, produce a



4. **Comparison between input voltage and sawtooth waveforms** is accomplished by the comparator circuit which uses an off-the-shelf IC differential amplifier.



5. **The narrow pulse (waveform B) generated by the differentiation circuit** is used to transfer the content of the master counter into the appropriate storage circuit. Interval τ_1 represents turn-on time of NOR gate N1 and τ'_1 is the turn-off time of N1. N1 must be able to drive **m** parallel switches in the digital storage circuit.

voltage at the output of the operational amplifier that is linearly proportional to the parallel binary input. The output of the amplifier must be able to drive the inputs of n comparators.

The comparator, shown in Fig. 4, is an integrated differential amplifier (Fairchild μA 710). When the voltage on the noninverting input is larger than +1 mV, and when the inverting input is connected to ground, the output voltage is approximately +3 V; when it is smaller than 1 mV, the output voltage is approximately −0.5 V. The input impedance, Z_i, of this comparator is a function of the input voltage, V_i; when $V_i >> 0$, Z_i is small; when $V_i << 0$, Z_i is high; and when $V_i = 0$, Z_i is typically 10 kΩ.

To make the input impedance more uniform a 5-kΩ resistor was connected in series with each of the two inputs. In addition, a small capacitor was connected directly across the two inputs to reduce the effect of noise on the input voltages.

The differentiation circuit, shown in Fig. 5, consists of three NOR or NAND gates interconnected to produce a narrow output pulse when the input signal, A, and the clock pulse change from zero to positive. The length of the output pulse, B, is determined by the delay in the three gating circuits. When the input signal, A, changes from positive to zero, the circuit resets, and is ready to generate the next narrow pulse. NOR gate *N1* must be chosen so that it can drive the m parallel transfer switches in the digital storage circuit.

The digital storage circuits are not a physical part of the A/D converter and are, therefore, not described in detail.

Unit has high conversion rate

Complete converter performance data were obtained with off-the-shelf linear integrated circuits (Fairchild μA 709 operational amplifier, the μA 710 comparator). The transistor switches were built with discrete components. The data were also taken with a conventional sawtooth generator, where the time constant had to be trimmed to the desired value. Finally, the circuit tested consisted of only three conversion channels.

With a sawtooth frequency of 1 kHz, the static accuracy at room temperature was better than 0.05% on all three channels. Over-all accuracy vs temperature tests have not been performed; however, the transfer characteristics of the μA 710 comparator have been examined both at high (+125°C) and at low (−55°C) temperatures and were found to shift by no more than 10mV; i.e., no more than 0.1% of the full-scale input signal. In the D/A converter, the output amplifier and, to a lesser degree, the switches and resistors are the only other circuits that can produce an error. Past experience has shown that the accuracy of the D/A converter can be maintained to within ±0.25% of full scale over a wide temperature range. Therefore, the complete A/D converter should operate from −55°C to +125°C with a static accuracy of better than ±0.5%.

No dynamic tests were performed. Dynamic performance, however, is largely a function of the sawtooth frequency: the higher the frequency, the higher the resulting band pass of the converter. In the system described the maximum possible sawtooth frequency is determined by the speed of the master counter and the D/A converter, and by the rate limitation of the D/A output amplifier. With a 1-kHz sawtooth frequency, the converter performs 1000 conversions per second per conversion channel. If the converter were to have 20 conversion channels, it would have an equivalent conversion rate of 20,000 conversions per second, comparable to some of the fastest A/D converters.

Once the first channel of the converter is built, it is possible to add additional channels at a cost of only $8.00 per channel, when the microcircuits are purchased in quantities of 100 or more. ■ ■

Reference:

1. A. K. Susskind, Notes on Analog-to-Digital Conversion Techniques (Cambridge, Mass.: The Technology Press, Massachusetts Institute of Technology, 1957).

Conventional A/D conversion

Today's high-speed analog-to-digital (A/D) converters employ the successive approximation technique,[1] which sequentially compares the unknown voltage V_X with a binary fraction of the reference voltage V_R. This type of A/D converter is a complex piece of equipment made up of a high speed comparison and summing amplifier, an error threshold detection circuit, a shift register, a digital-to-analog converter and digital logic circuits to control the sequential operation. Usually converters of this type can only be afforded for a multiplicity of input channels. Time-sharing of any A/D converter requires an electronic analog commutator, which connects the various input voltages to the converter sequentially in time. Such a commutator consists of a set of analog voltage switches with their associated drivers, a timing generator, one or several dc buffer amplifiers and control logic.

The size, weight and cost of such a converter-commutator combination depends largely on the required accuracy and speed, on the environmental specification, and on the number of voltages to be converted. Prices range between $2000 and $20,000. Size and weight often exceed that of the special-purpose digital computer they are built for, since only a small portion of the converter and commutator can be built with ICs.

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The use of EASTMAN 910 Adhesive is not suggested at prolonged temperatures above 175°F., or in the presence of extreme moisture for prolonged periods.

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		2,188	1 hr.
		2,700	48 hrs.
		2,800 (Tensile)	24 hrs.
Steel-Steel	2	1,362	10 mins.
		2,224	1 hr.
		2,800	48 hrs.
		5,030 (Tensile)	48 hrs.
Aluminum-Steel	10	84	10 mins.
		173	1 hr.
	½	1,007	10 mins.
	(with surface activator*)	1,653	1 hr.
Butyl Rubber-Butyl Rubber	½	51[1]	10 mins.
		63	4 yrs.[2]
Butyl Rubber-Steel	1	52[1]	10 mins.
		76[1]	4 yrs.[2]
Butyl Rubber-Aluminum	1	73[1]	10 mins.
		69[1]	4 yrs.[2]
SBR Rubber-SBR Rubber	½	90[1]	10 mins.
		56[1]	4 yrs.[2]
		88[1]	30 days, salt spray cycle (ASTM B 117-57T)
Neoprene Rubber-Neoprene Rubber	½	54[1]	10 mins.
		45	4 yrs.[2]
Natural Rubber-Natural Rubber	½	46[1]	10 mins.
		39	4 yrs.[2]
SBR Rubber-Butyrate	½	95[1]	10 mins.
		110[1]	2 yrs.[2]
		112[1]	30 days, salt spray cycle (ASTM B117-57T)
SBR Rubber-Phenolic	½	105[1]	10 mins.
		110[1]	2 yrs.[2]
Butyl-Polyester	½	102[1]	15 mins.
		154	2 yrs.[2]
Butyl-Phenolic	½	114[1]	15 mins.
		178[1]	2 yrs.[2]
Neoprene-Polyester	½	112[1]	15 mins.
		136	2 yrs.[2]
Nylon-Nylon	1	327	10 mins.
		1,400	48 hrs.
Nylon-Aluminum	1	500	10 mins.
		1,436	48 hrs.
		956	1 yr.[4]
		1,024	2 yrs.[4]
Phenolic-Phenolic	1	747	10 mins.
		600[3]	4 yrs.[4]
Phenolic-Aluminum	1	647	10 mins.
		920	48 hrs.
		348	2 yrs.[4]
Polyester-Stainless Steel	1	696	48 hrs.
		664	6 mos.[4]
		432	2 yrs.[4]
Acrylic-Stainless Steel	1	620[3]	6 mos.[4]
		484[3]	1 yr.[4]
		488	2 yrs.[4]
Flexible Vinyl-Aluminum	1	207[3]	6 mos.[4]
		192[3]	1 yr.[4]
		200[3]	2 yrs.[4]
Polystyrene-Polystyrene	2	327	10 mins.
		70	1 yr.[2]
	½	447[3]	10 mins.
	(with surface activator*)		
Polypropylene-Polypropylene	2	180	24 hrs.
	2	411[3] (Flame treated polypropylene)	24 hrs.
	½ (with surface activator*)	401[3] (Flame-treated polypropylene)	15 mins.

†Laboratory test results [1]rubber failure [2]weathered outdoors [3]plastic failure [4]50% Relative Humidity and 75°F.
*In certain cases, most notably those involving polystyrene, pickled or dissimilar metal surfaces, bonding with EASTMAN 910 Adhesive is sometimes slow. EASTMAN 910 Surface Activator is designed to restore the rapid polymerization of the adhesive. It is also quite valuable in maintaining consistent results in production line bonding situations. Further information on this product is available.

Other materials that can be bonded successfully with EASTMAN 910 Adhesive are: polyurethanes, acetal resins; most hard woods; brass, copper. Recent work indicates that polyolefin and acetal plastic bonds are significantly improved by flame treatment of the plastic material prior to bonding (shear strengths up to 500 psi).

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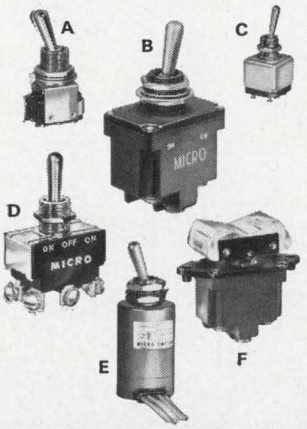
See Sweet's 1966 Product Design File 8a/Ea.

ON READER-SERVICE CARD CIRCLE 48



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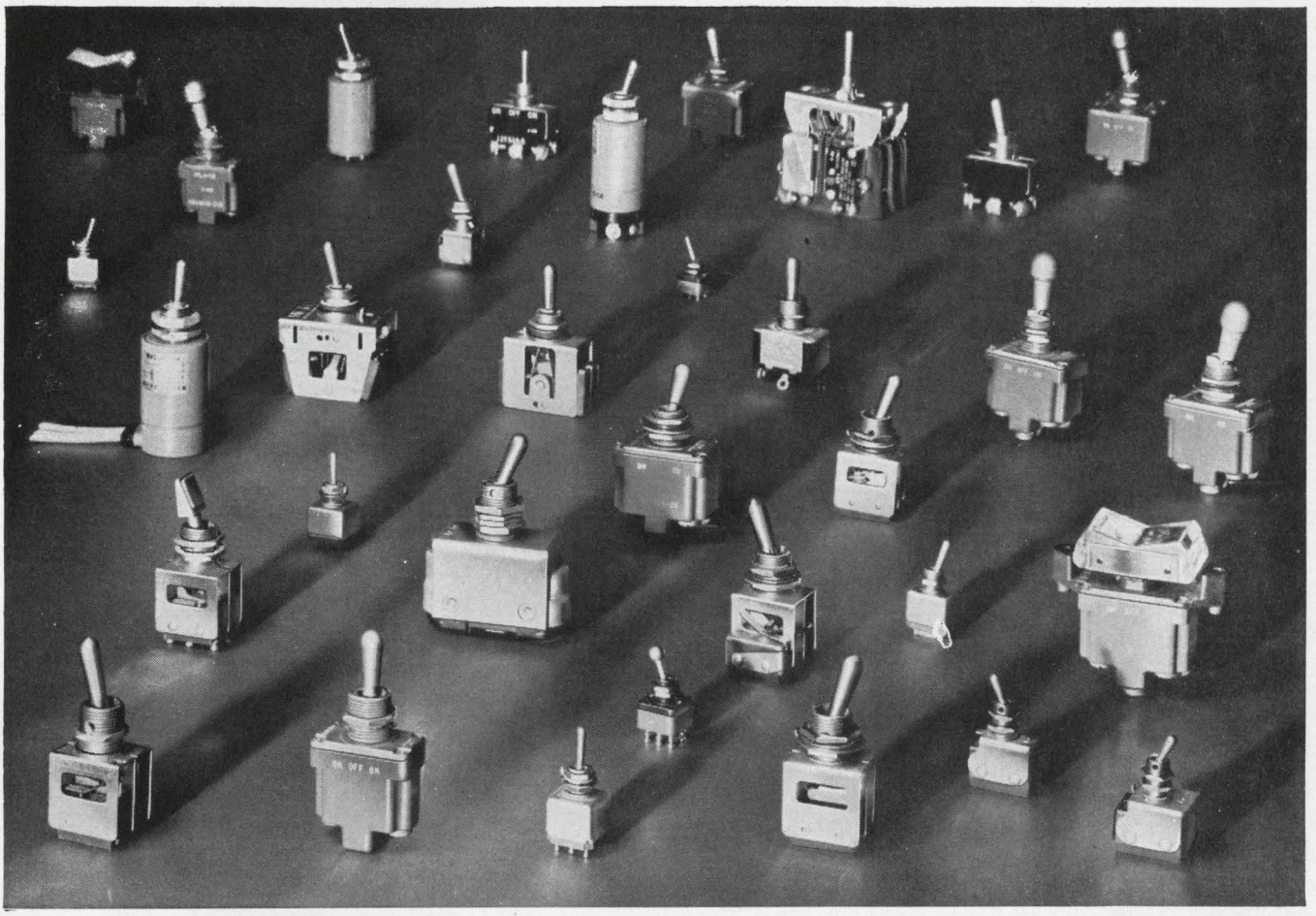
C TW Series—Miniature, 5 amp. SPDT or DPDT, 2 and 3 position.

D TS Series—Up to 25 amp. 1 or 2 pole.

E ET Series—Magnetic-hold, remote-release. Environment-proof.

F TP Series—Rocker-actuated, 20 amp. 1, 2, or 4 pole.



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Flexible circuit probe fits in small places

Here is a technique for fabricating a flexible probe that can simplify measurements on small assemblies. The probe is made from standard alligator clips and printed-circuit strips, and provides two separate connections to a common point.

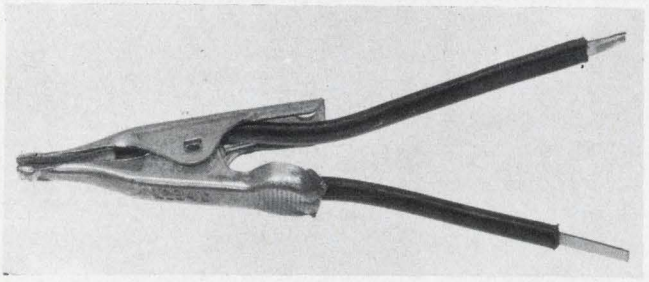
It is often very difficult to connect circuit probes to miniature switch assemblies for measuring contact resistance. The difficulty stems from the fact that such resistance is usually measured by metering the voltage drop and current separately. The accuracy of such measurements is increased by using separate contact points for each meter, which, effectively, gives a four-wire metering system. Most conventional means for four-wire hookups to very small assemblies are either too cumbersome or unreliable.

A convenient way to circumvent this problem is to use a homemade probe (see illustration) made from miniature alligator clips and double-clad flexible printed-circuit material. The flexible printed-circuit material (approximately 0.010 inch over-all thickness) should be gold-plated on both sides and cut into strips narrow enough to slip inside the jaws of the alligator clip.

One side of the clad material is soldered to the jaws, and an insulating sleeving is slipped over both leads. The inside surface of each copper-clad strip then becomes an electrically isolated conductor. Meter leads may be soldered to the free end of the strip. The alligator clip thus provides two separate connections to the contact terminal when it is attached.

Fred W. Kear, Engineer, Sparton Southwest, Inc., Albuquerque, N. M.

VOTE FOR 110



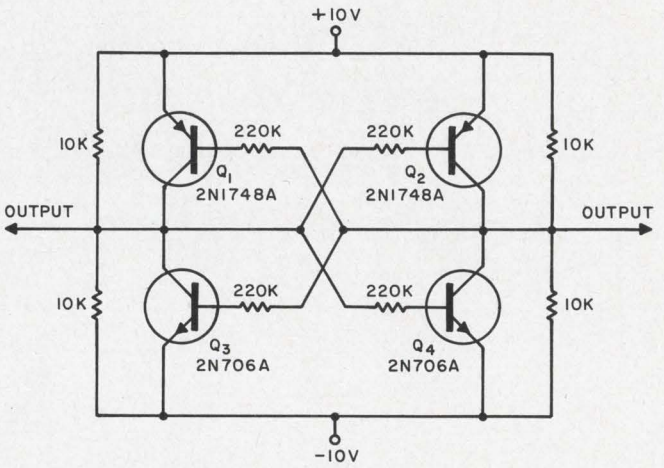
Flexible circuit probe is made from standard alligator clips and double-clad flexible printed-circuit material.

Double flip-flop has constant output impedance

In several applications involving reference-voltage switching, such as digital-to-analog conversion, it is desirable to have a flip-flop whose output impedance is low and does not depend on the state that the flip-flop is in. Such a circuit is made possible by the addition of two extra transistors to the conventional flip-flop (see illustration).

The circuit output switches between the plus and minus supplies and provides an output impedance of about 10 ohms in either state. the cross-coupling network is arranged so that only one npn stage (*Q3* or *Q4*) can be ON at a time. When one npn is ON, its associated pnp is OFF, and vice versa.

If only one output is to be used, one of the pnp transistors (*Q1* or *Q2*) can be replaced by a



Low output impedance is maintained by the double flip-flop regardless of its state.

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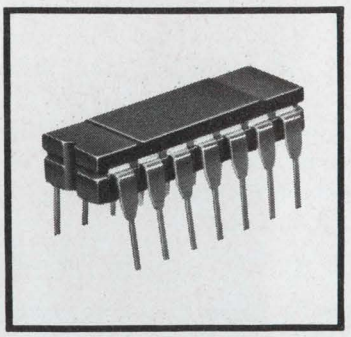

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resistor. Triggering can be accomplished by any conventional method, such as diode steering.

The technique, although shown for a flip-flop, is also applicable to the design of monostable and astable multivibrators.

Walter J. Guinon, Consultant, Boston, Mass.

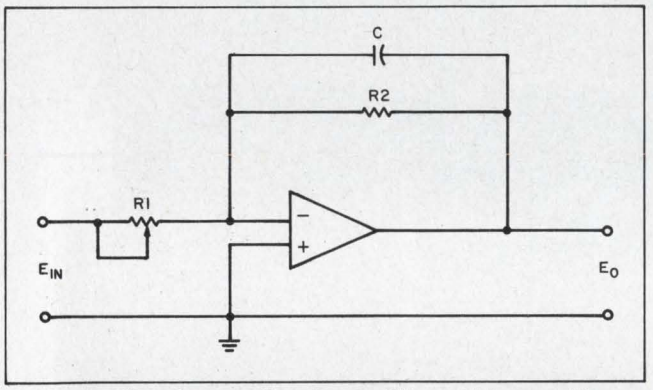
VOTE FOR 111

Operational amplifier attenuates faster with three added devices

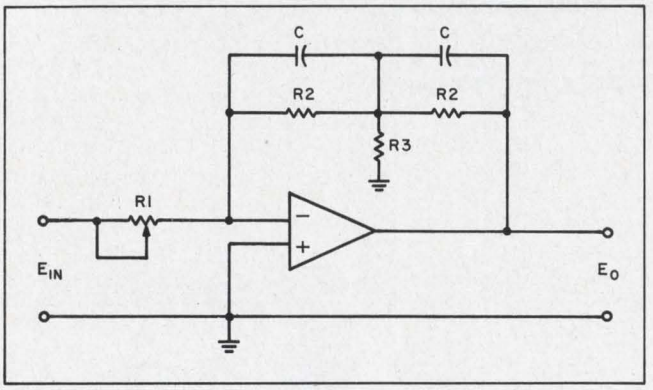
Doubling the attenuation rate of an operational amplifier, from 20 dB/decade to 40 dB/decade, can be achieved merely by the addition of one capacitor and two resistors to the feedback loop of the amplifier. The circuitry is much simpler and less expensive than the usual buffer stages that are employed.

The conventional operational amplifier (Fig. 1) attenuates at the 20-dB/decade rate and has the transfer function:

$$A = E_O/E_{IN} = 1/R_1[1/(1+j\omega R_2 C)].$$



1. **Conventional operational amplifier** achieves attenuation rate of 20 dB/decade. Rheostat R1 is a gain adjustment.



2. **Adding two resistors and a capacitor** doubles the attenuation rate to 40 dB per decade. More complicated methods for achieving equivalent performance require the use of active circuits.

Rheostat R_1 is a simple gain adjustment.

Addition of the three components shown in Fig. 2 increases the attenuation rate to 40 dB/decade, while the simple gain adjustment is retained. The transfer function for this circuit is:

$$A = K_1[(1+j\omega K_2 C)/(1+j\omega K_3 C)^2],$$

where

$$K_1 = (1/R_1)(2R_2 + R_2^2/R_3),$$
$$K_2 = 2R_2R_3/(R_2+2R\ ), \text{ and}$$
$$K_3 = R_2.$$

To obtain 40 dB of attenuation for the first decade above the desired corner frequency, K_3 must be at least 10 K_2 and the transfer function then becomes:

$$A = K_1\{[1+j\omega(0.1\,K_3)C]/(1+j\omega K_3 C)^2\}.$$

This represents a low-pass filter that has a corner at $\omega_{C_1} = 1/K_3C$ and attenuates at a rate of 40 dB/decade to the second corner, $\omega_{C_2} = 10^9/K_3C$. Above ω_{C_2}, the attenuation rate is 20 dB/decade. At frequencies very much less than ω_{C_1}, the gain is equal to K_1.

This circuit is being used to condition data, prior to A/D conversion and computer analysis, that are acquired from animals and humans subjected to acceleration and impact.

Paul L. Kittinger, Engineer, Systems Research Laboratories, Inc., Dayton, Ohio.

VOTE FOR 112

Small flasher circuit uses few and inexpensive components

A unijunction relaxation oscillator is the key element of a small, reliable flasher circuit, suitable for control panel indicator lamps. The circuit enables the lamp to give warning of malfunctions, indicate if an operation is complete, and show limits.

The oscillator, *Q1* in the Figure, drives the base of a switching transistor, *Q2*. The frequency of oscillation is determined by *R1* and *C1* in the emitter circuit of *Q1*. The given values yield a frequency of 2 Hz, which is quite adequate for most purposes. The pulses at base 1 drive *Q2* into saturation—provided, of course, that the emitter of *Q2* is returned to ground through the secondary indicator lead. When *Q2* saturates, the base of *Q3* is returned to ground through *R4* and *Q2*, reducing the base drive on *Q3* and extinguishing the indicator lamp. Capacitor *C2* in the base of *Q3* increases the time required to extinguish the lamp. When the circuit is initially energized, there is a delay in the turn-on of *Q3* because of the time constant of *R5-C2* and emitter resistor *R7*. This

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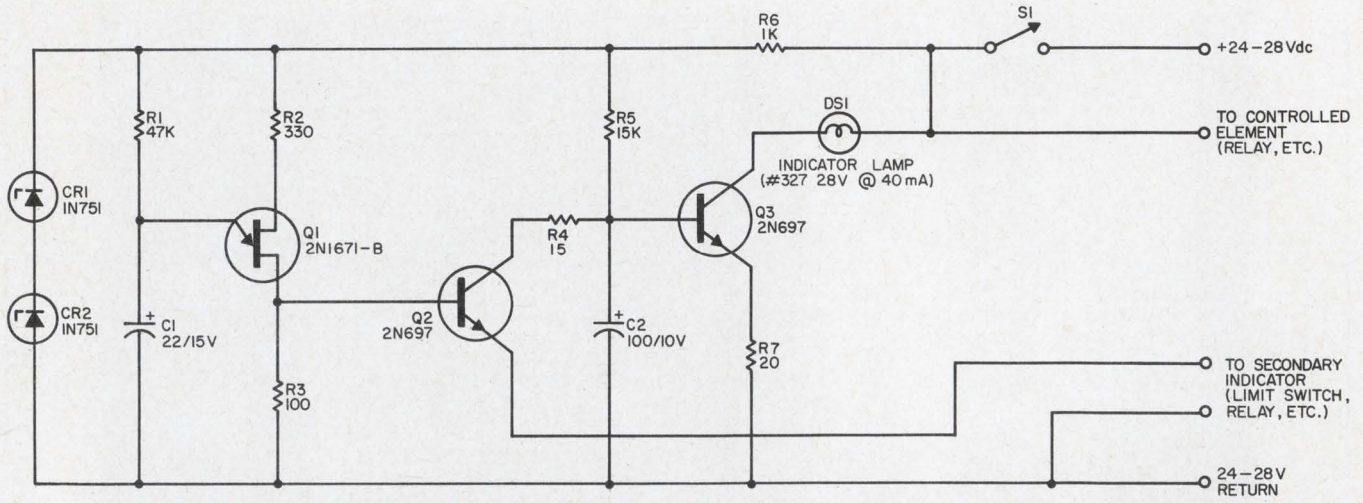


Flasher circuit uses a unijunction relaxation oscillator for a small and reliable system. The emitter of Q2 must be grounded through the secondary indicator leads. Simple regulator (R6, CR1, CR2) assures proper timing.

delay tends to limit the initial current surge associated with a cold incandesent lamp, which increases the reliability of driver transistor *Q3*.

The voltage-regulator network of *CR1*, *CR2* and *R6* maintains fairly constant voltage supply for the timing circuit and decouples the circuit from the usually noisy 28-V bus. In cases where a considerable amount of RFI is expected, further decoupling, such as a capacitor across *CR1* and *CR2*, could be employed.

Any number of secondary indicators, such as gyro erection-cutoff relays, mechanical limit switches, overheat relays, plate current relays, etc., are usable with the circuit, so long as they have the capacity to return the emitter of *Q2* to ground.

Jack K. Hickman, Engineer, Texas Instruments Inc., Dallas.

VOTE FOR 113

Resistor cuts saturation voltage of switching transistors

Reduce the saturation voltage of a switching transistor by putting an additional resistor into the circuit. In many switching applications it is necessary to produce a voltage level (*V1* in Fig. 1) by a simple voltage divider, and then to switch this output to zero volts. However, the troublesome saturation voltage keeps the zero output level at V_{sat} for this basic shunt switch.

The conventional solutions include selection of a transistor with a low V_{sat} (which is usually expensive), matching a complementary compensating pair, or making *R2* adjustable by returning it to a negative supply, which requires another resistor between the collector of *Q1* and the junction of *R1* and *R2*.

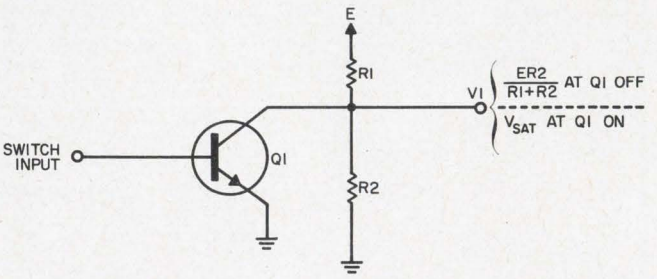
The simplest and easiest solution is to use a very ordinary switching transistor with the addition of *R4* as shown in Fig. 2, where (*R3* + *R4*) replaces *R1*. When *Q1* is OFF, the circuit functions exactly as that in Fig. 1. When *Q1* is ON, the saturation voltage at the output is now attenuated to:

$$V1 = V_{sat}\, R2/(R2+R4).$$

In a typical application, six of these circuits were used as inputs to an operational amplifier, which summed and amplified logic combinations of six dual-state *V1* levels. Because the attenuation of V_{sat} by 10:1 in the ON state is so simple and cheap, shunt-switching for A/D conversion proved to be practical.

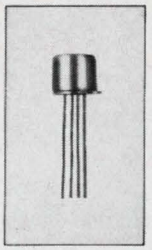
Circuit values are: *R3* = 33 kΩ, *R4* = 21 kΩ, *R2* = 2 kΩ, *E* = 28 V, *V1* is at 2 V when *Q1* is OFF and at 0.03 V when *Q1* is ON. *Q1* is a 2N910 transistor.

The only restriction seems to be that the attenuation of V_{sat} is limited to the ratio *E*/*V1* (OFF). Therefore *V1(OFF)* should be designed to a lower



1. **Basic shunt switch** is used in many applications to produce a voltage level, V1, and then switch the output to zero. However, in practice the zero level is not reached because of the saturation voltage of the transistor.

No other RF transistors can offer this performance at these prices!



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Min. Power Gain @ 450 MHz	11.5 dB	—	—	—
Max. NF @ 450 MHz	5 dB	—	—	—
Min. Power Gain @ 200 MHz	—	14 dB	11.5 dB	11.5 dB
Max. NF @ 200 MHz	—	4.0 dB	4.5 dB	4.5 dB
NF @ 60 MHz	—	3 dB max.	2.5 dB typ.	2.5 dB typ.
Max. C_{cb}	0.55 pF	0.55 pF	0.55 pF	0.70 pF
h_{FE}	60-250	60-200	40-150	25-150
Min. BV_{CEO}	30	30	20	15
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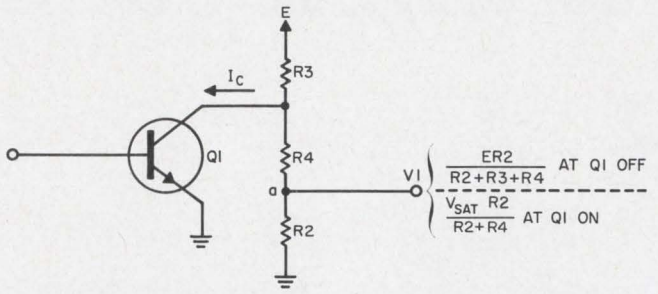


2. **A resistor, R4, attenuates** the saturation voltage. The amount of attenuation is limited by the ratio of E and V1 (OFF).

limit. *R3* optimizes I_c in the range of lowest V_{sat} from the V_{sat} vs I_c curves.

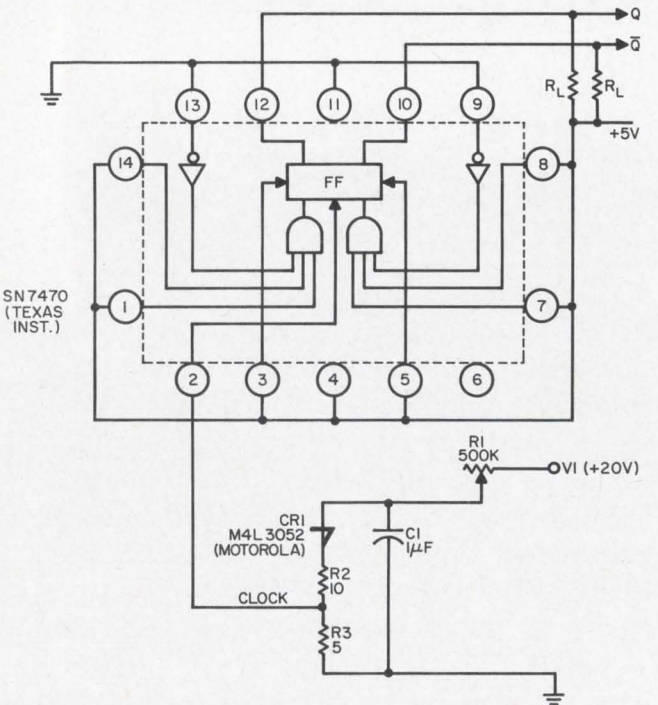
Charles H. Karr, Senior Engineer, Martin Co., Baltimore.

VOTE FOR 114

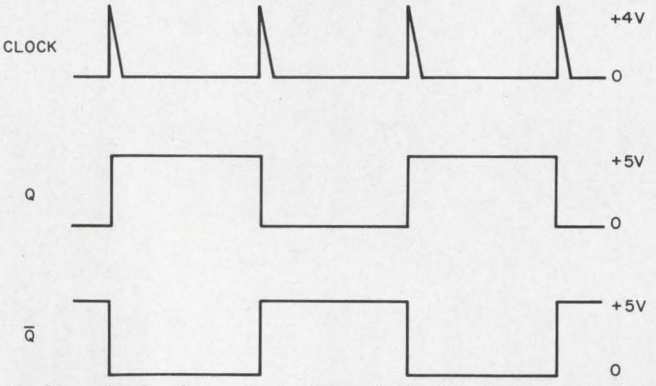
Variable square-wave generator combines IC with 4-layer diode

An integrated-circuit flip-flop and a multi-layered diode are the major components in this variable-frequency, square-wave generator. Cost, size, simplicity are some of the circuit advantages.

Any flip-flop could possibly be used, though the particular one shown in the schematic (Fig. 1) was selected for its high speed and edge triggering capabilities. The familiar relaxation oscillator, using a four-layer diode, is compatible with the rise-time requirements of the flip-flop; the flip-flop has a clock input rise-time specification of 150 ns max and the output of the oscillator has a 100-ns rise time, or less, depending on the circuit conditions.



1. **Square-wave generator uses four-layer diode** (M4L3052) in relaxation oscillator. Pulse output of oscillator triggers clock input of integrated-circuit flip-flop.



2. **Changes in the output state of the flip-flop** closely follow the input trigger from the relaxation oscillator. Output risetimes are on the order of 100 ns.

To operate the flip-flop in a continuous counting mode, the *J* and *K* inputs (pins 3 and 5) were placed at the logical "1" level. Also, in order to sustain oscillation, *V1* must be kept higher than the firing voltage of *CR1*, and the minimum value of *R1* must be large enough to prevent the current through *CR1* from reaching a "holding" value.

The completed generator is built on a one-inch-square printed-circuit board and costs about $12 in single quantities. The output waveform (Fig. 2) has a rise time of 100 ns and the square-wave frequency can be varied from 1 hertz to 200 kilohertz by choosing appropriate values of *V1*, *R1*, and *C1*. By adjusting the *R2*-to-*R3* ratio, the clock driving voltage may be varied without affecting the operating frequency.

Since this particular flip-flop can sink currents as large as 14 mA, the circuit is found extremely useful in a variety of switching and control applications.

C. Joseph Buttemeier, Senior Engineer, Litton Guidance and Controls Systems Div., Woodland Hills, Calif.

VOTE FOR 115

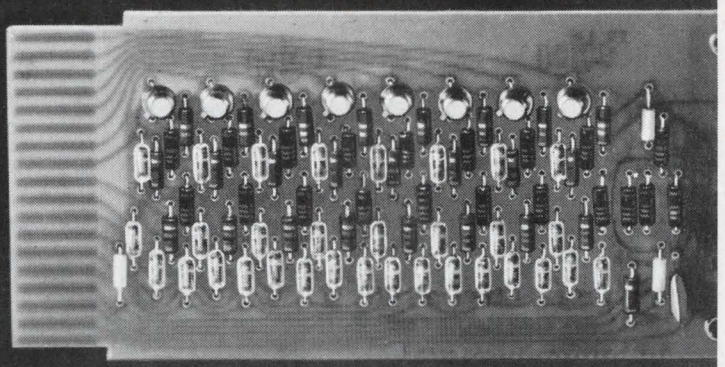
Optical diodes trigger stepping counter

A simple circuit permits the use of light as a control signal in electronic circuits. The circuit (see figure) employs the principle of a stepping type of frequency divider, except that it uses optically controlled SCRs as the bistable elements and is controlled by light pulses rather than volt-

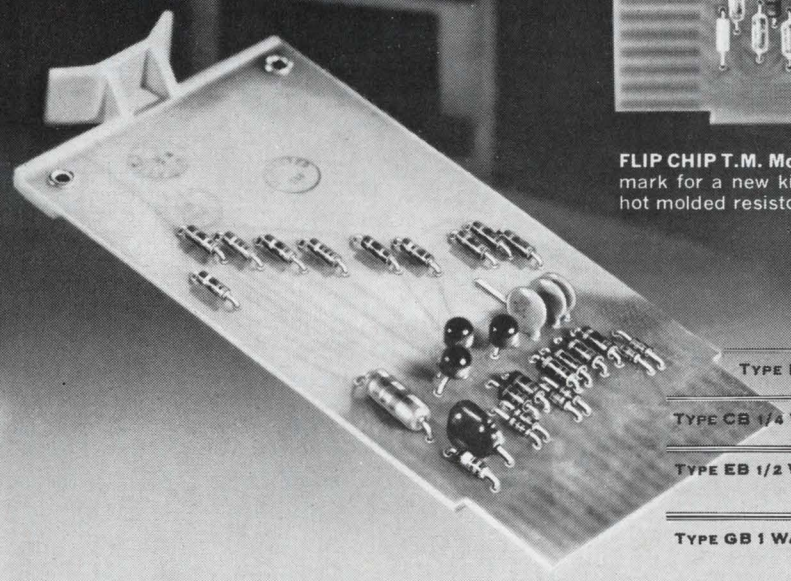
"When we use A-B hot molded resistors instead of some other make,

it's one less component we have to worry about"

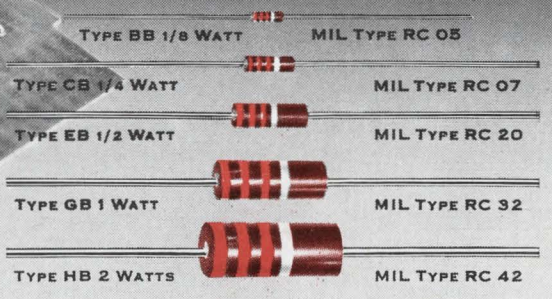
Digital Equipment Corporation



FLIP CHIP T.M. Modules—The Digital Equipment Corporation trademark for a new kind of digital system module uses Allen-Bradley hot molded resistors exclusively.



Digital Equipment Corporation's PDP-8 programed data processor, in which these modules are used, is a compact general purpose digital computer with a high speed, random-access, magnetic-core memory for engineering, scientific, and educational applications.



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■ Allen-Bradley hot molded resistors have established such a consistently superior performance record over the years that Digital Equipment Corporation uses them exclusively in their computers—with no substitutes permitted under any circumstances!

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The unvarying quality of Allen-Bradley resistors—million after million, year in and year out—results from an *exclusive* hot molding process. The precision automatic equipment developed and used only by Allen-Bradley produces such uniform properties that long term resistor performance can be accurately predicted. Please note, Allen-Bradley hot molded resistors have never been known to fail catastrophically in service.

For complete specifications on Allen-Bradley hot molded fixed and variable resistors, please write for Technical Bulletin 5050: Allen-Bradley Co., 1344 S. Second Street, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

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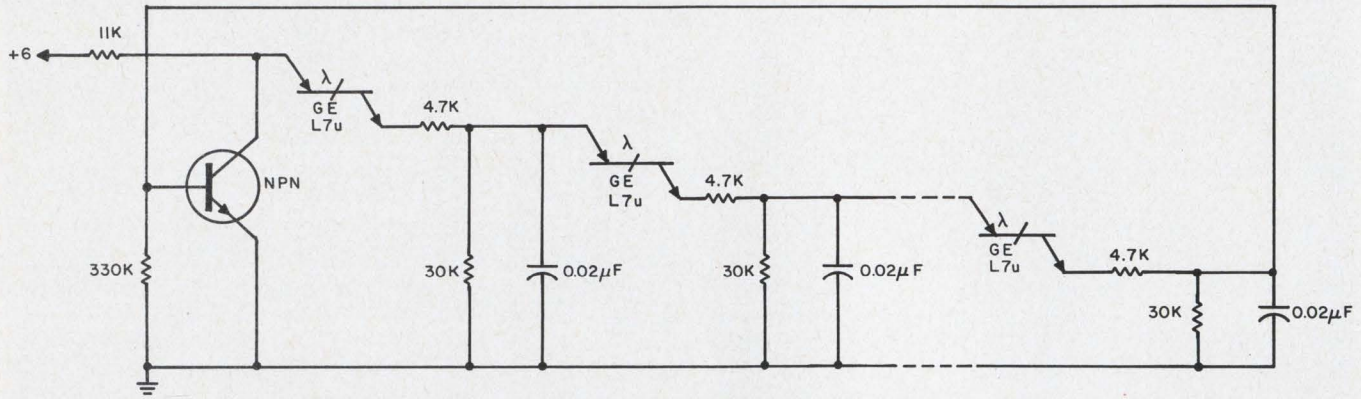


Light pulses replace voltage pulses as triggers for this stepping counter.

age pulses.

Operation is as follows: If all the light-controlled diodes are initially OFF, the first light pulse will trigger the first diode and extinguish before the voltage across the capacitor has built up enough to fire the next diode. This voltage will have built up by the time the next light pulse arrives, thus firing diode number two, and so on down the line until the last diode triggers the transistor, turning all the stages OFF to start over again.

Because of pulse deterioration down the line, this type of circuit is limited to about five stages for reliable operation, although it will operate at speeds up to 400 pulses per second, the limit of the General Radio "Strobotac" used as the light source.

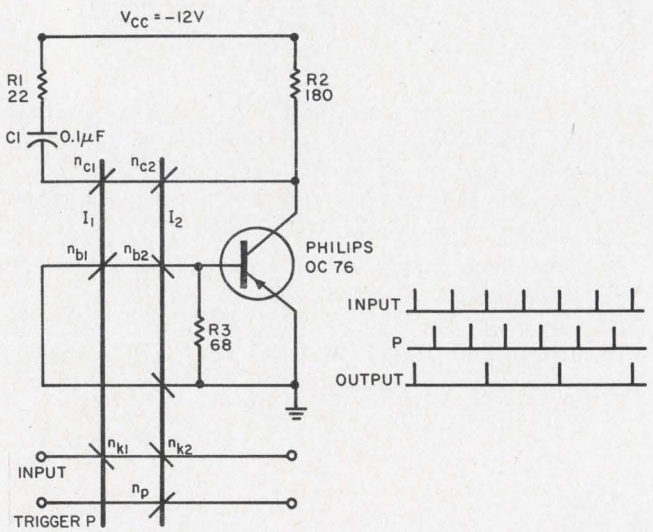
Robert C. Hayler, Design Engineer, New Shrewsburg, N. J.

VOTE FOR 116

Capacitor increases speed of transistorized core counter

A capacitor in the collector circuit of a transistorized counter enables it to count pulses up to 30 kHz.

To analyze the circuit's operation, assume that trigger pulse p activates core *I2* through winding n_p, making it appear as a logic *1*. Let core *I1* be a logic *0*. When the first input pulse arrives, *I2* returns to the *0* state because of the magnetic field generated by winding n_{k2}, and the transistor becomes conductive. The collector current divides between two paths, according to the ratio of *R1* and *R2*. Assuming that $R1 << R2$, the current through windings n_{c2}, n_{c1}, *C* and *R1* becomes much larger than the current through *R2*. Time constant *CR1* should be about one-third of the duration of the output pulse of the transistor. The magnetic field of winding n_{c2} couples to the base winding n_{b2}, maintaining the *0* state of core *I2* and the conductive state of the transistor until the next input pulse. After the capacitor is charged to a voltage of about V_{cc}, all the current passes through *R2* for the remainder of the duration of the pulse.



Transistorized magnetic core counter uses a storage capacitor to count pulses at frequencies up to 30 kHz.

The next input pulse cuts off the transistor and the capacitor discharges, with a time constant of $C1(R1 + R2)$, through the collector windings n_{c1} and n_{c2}, placing cores *I1* and *I2* into state *1*. The transistor remains cut off, since the base windings are still activated. The second trigger pulse maintains the state of *I2*. The next input pulse to be counted returns both cores to the *0* state. The third trigger pulse starts the procedure all over again. Resistor *R3* damps out undesired voltages due to the possible asymmetries of the base winding.

Dejan V. Glusac, Design Engineer, New Belgrade, Yugoslavia. VOTE FOR 117

IFD Winner for Aug. 2, 1966

Bert Pearl, *Project Engineer, Hallicrafters Co., Chicago, Ill.*

His Idea, "UJT, bipolars in compact, versatile generator," has been voted the $50 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.

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Bits and Pieces

Wisdom and levity, well-developed fruits of frustration, will rarely be found, except in bits and pieces.....

Have fare, will travel

Speak to any good top executive, and he'll tell you that every minute of a business trip can be used to advantage—both the company's and you own. The following tips, gathered during thousands of miles of business travel, may not be the ultimate in good advice, but they have served the writer well and represent some conservative guidance for beginners at the travel game:

- Before you start out, notify all parties with a stake in your trip. If there are local sales offices or representatives in the city that you are visiting, advise them in advance that you are coming. Let employees in your own offices know where you are going. Once on the road, spend some time with company representatives or their customers. Some on-the-spot technical advice can make you a hero to them and to the company.
- Plan your schedule. Sketch out a rough calendar and plan the seminars, sessions and exhibits that you will attend, if you are going to a convention. Then stick to your plan. Discipline yourself to work a full day. Slack afternoons can be usefully employed to scout the competition, consolidate your notes, contact your home office, etc.
- Keep good notes. Many in the home office didn't go to the convention. Your notes, either delivered at an informal session when you return or typed and circulated, will spread the benefits of your experiences to all associates. Note product features and prices displayed by the competition, and, if possible, collect data sheets for analysis by the technicians at your company.
- Be sure significant people can find you. Nothing is more frustrating than trying to locate somebody in a large city, especially if the need has been generated by some emergency in your family or at your office. Tell your hotel operator when you will return, tell your associates where you are going, and leave notes when you cannot speak with somebody. If you have been out of contact for more than a few hours, call your hotel for messages or call your office long-distance. Most times there will be no messages, but if there are, you'll be on top of any situation that develops.
- Keep a careful diary of expenses. Accounting departments are notoriously reluctant to accept your blanket assurances that you spent $300 in the "line of duty." They need actual receipts, statements of whom you met, and what you discussed. In many instances the exact locations of the meetings are required information. It may be a chore, but it is a necessary one. Remind yourself always to get a receipt and keep careful accounts.
- Enjoy yourself too. Every city has its own history, culture and problems. The list of things to see and do is endless. Weekends are never long enough to take it all in. And if you miss "sampling" the city you visit, you have cheated yourself, because this is another way to expand your horizons.
- Be courteous and considerate. We rarely give conscious thought to these traits, but politeness and consideration of others—service people, residents, other delegates at the convention, etc.—goes a long way to making your visit more enjoyable.

Richard L. Molay
Mountain View, Calif.

Have you got a contribution? We'll compensate. Be it a letter, commentary, puzzle, cartoon, or cartoon idea, send it along to: RC, Electronic Design, 850 Third Ave., New York, N. Y. 10022.

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The system, called Personnel Information Communications System, was recently announced by Western Union. It combines two capabilities: high-speed, real-time data processing (filing, sorting and seeking data) and a widely distributed

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	BS	MS	PhD	No Degree
Electrical/electronics engineers				
Average	$1033	$1175	$1556	$ 669
High	1764	2675	1750	1386
Low	600	440	1417	528
All Engineers (Average)	1046	1121	1530	784

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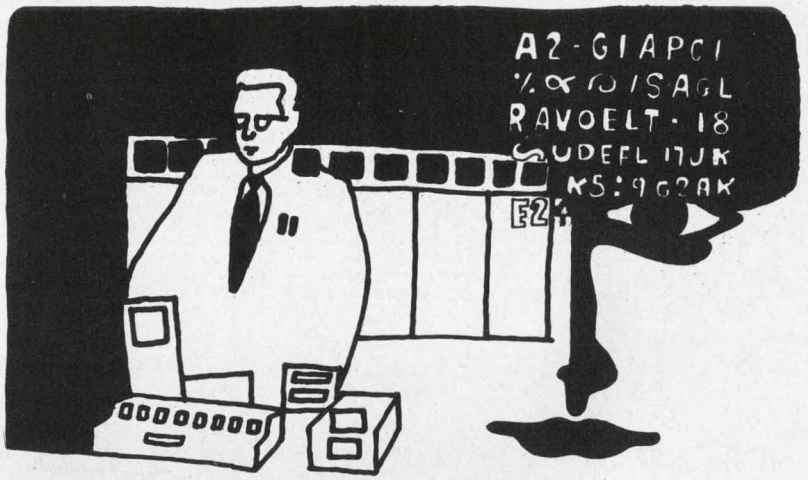
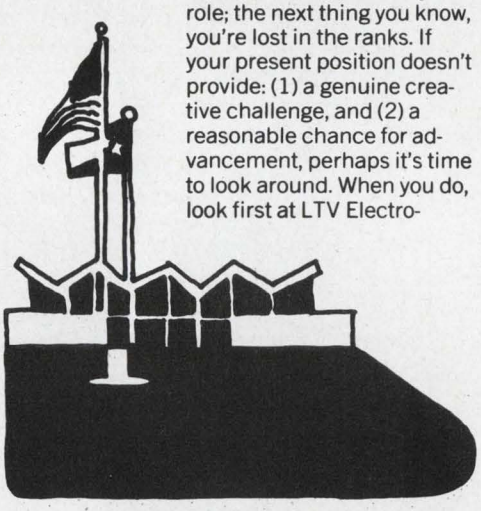


It's no fun to sit still. If your career has stalled, do something about it now. It's too easy to get sidetracked into a secondary role; the next thing you know, you're lost in the ranks. If your present position doesn't provide: (1) a genuine creative challenge, and (2) a reasonable chance for advancement, perhaps it's time to look around. When you do, look first at LTV Electro-



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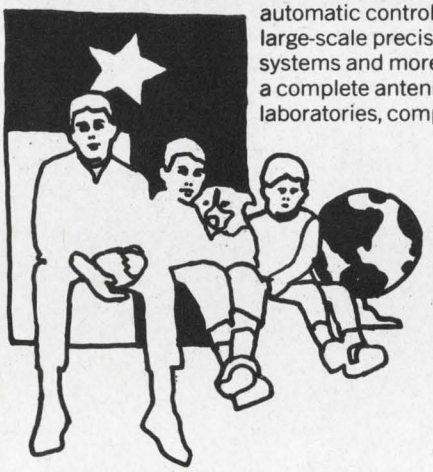

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Bits and Pieces CONTINUED

network of telegraph offices to collect the data rapidly.

Here's how the Personnel Information Communications System works. You, the job seeker, call Western Union and ask for Operator 77. She records your name, address, telephone number and occupation. Within a few days, information about the service, and a set of forms on which you list your background are sent to you. These résumés are returned to Information Services, Inc.—the company that developed and operates this service through Western Union—and the information is transferred to a central computer.

Employers get in touch with the system by dialing Operator 88. They in turn receive and fill out "recruitagrams," which detail job specifications, salary, required skills, etc. This information is coded and fed to the computer system, which sorts through the résumés and develops a list of qualified individuals. The selected individuals receive a detailed description of the job, if their salary requirements are met. The interested employer simultaneously receives their résumés. Though complete, these résumés omit the individual's name and present employer and are only referred to by a code number. If the company wishes to interview the applicant, and he does not object, his identity is then disclosed.

Aside from the membership fee, there are no placement fees for applicants. Employers, however, pay a fee for each computer run and an additional fee for each résumé-requirement match. As an additional service, members receive a quarterly report of salaries, as they relate to age, experience, profession and education. An abstract of part of this report is shown in the accompanying table.

Western Union is now undertaking an extensive development program to eventually transform itself into a national information utility. A network of computer centers will program process, store, retrieve and distribute the data on a real time basis.

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25

Name			**Home Phone**
Home Address (Street)	City	State	ZIP Code
Age	**U.S. Citizen** ☐ Yes ☐ No	**Security Clearance**	

Prime Experience	**Secondary Experience**

Desired Salary	**Availability Date**

Employment History – present and previous employers

Company			
City, State			
Dates	to	to	to
Title			
Specialty			

Education – indicate major if degree is not self-explanatory

Degree			
College			
City, State			
Dates	to	to	to

Additional Training – non-degree, industry, military, etc.

Professional Societies

Published Articles

Career Inquiry Numbers:

900	901	902	903	904	905	906	907	908	909
910	911	912	913	914	915	916	917	918	919

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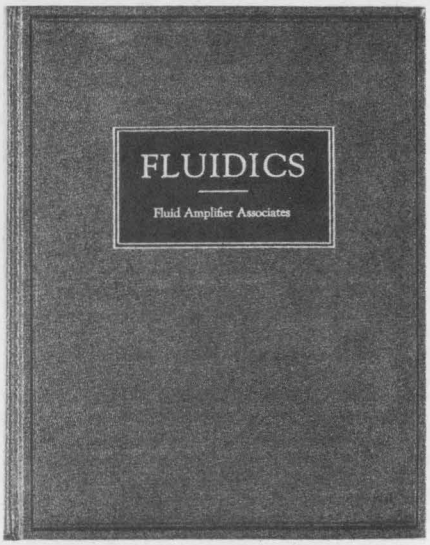
Book Reviews



Fluidics

Fluidics, ed. Eugene H. Humphrey and Dave H. Tarumoto (Fluid Amplifier Associates, Inc., Boston, Mass.), 268 pp. $28.00.

This book was written by eight students at the Harvard Business School. It was intended primarily as a market survey of the field. Yet it does introduce anyone interested to a fascinating and useful field.

The first chapter describes fluidic devices and systems in detail. Though the language is simple and devoid of mathematical notation, it provides, very appropriately, a clear and lucid description of these conceptually simple and straightforward devices. Diagrams give an easy understanding of these devices and how they operate.

The manufacturing procedures, designs, and materials are covered carefully in the second chapter.

The bulk of the book is an estimate of the present and future market of these devices. Various areas are thoroughly and completely covered, i.e., consumer appliances, automotive equipment, aerospace systems, materials handling, machinery, and medical tools. The possible uses for fluidics in each of these areas is investigated, and the potential growth of all these areas is taken into account. One of the conclusions the book makes is that by the mid-1970s fluidics will be a several-hundred-million-dol-

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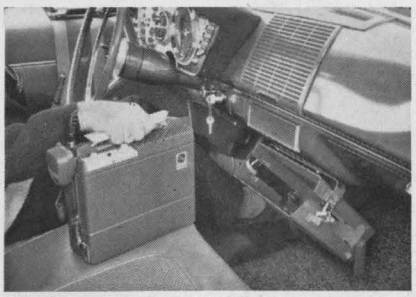

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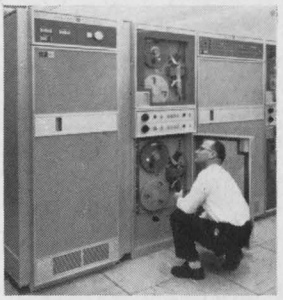
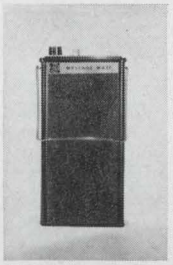


High Speed Data Communications Terminal—unique system extends computer processing facilities to remote locations via broadband transmission.



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Project Engineers—Digital Systems . . . For data communication and processing equipment design application and manufacturing. Responsible for equipment and software design, support and integration. BSEE/Physics.

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lar industry. A technical appendix contains 14 important papers in a field about which little has so far been published in book form.

—*Roger Kenneth Field*

Semiconductor electronics

Introduction to Semiconductor Phenomena and Devices, Lloyd P. Hunter (Addison-Wesley Publishing Company, Inc., Reading, Mass.), 218 pp. $8.95.

This senior-graduate-level book, requiring a background of modern physics and differential equations, is designed to be used as the basic textbook for a course in semiconductor electronics. Its purpose is to give a direct heuristic description of the physics of semiconductor electronics, together with an analysis of a wide variety of devices. The analytic approach used emphasizes the physical approach to the various devices and gives the student an appreciation of how to estimate the magnitude of a result which is to be expected, and further, how to refine this estimate to the desired degree of accuracy.

Computer operations

Computers Self-Taught Through Experiments, Jack Brayton (Howard W. Sams & Co., Inc. Indianapolis), 192 pp. $4.25.

This book helps you to learn about computers the easy way. It shows you through 28 low-cost construction projects the use of transistors in computers and describes the various individual computer operations in detail. Along the way it gives details for constructing actual working models of the computer circuits described. At the end of the book, construction details are given for a ten-stage adder/subtractor, complete with readout lamps.

Feedback circuit analysis

Feedback Circuit Analysis, S. S. Hakim (John Wiley & Sons, Inc., New York), 392 pp. $15.50.

This book is devoted to a detailed study of feedback theory as applied to linear electronic circuits. It has been written with two objectives in mind: first, to develop a generalized feedback theory which doesn't rely on the separation of a feedback circuit into an amplifier and feedback network component, but yet is capable of accounting for all the effects associated with feedback; second, to provide a broad view of stability and its relation to the closed-loop transient response, open-loop frequency response and driving-point impedances of the feedback circuit. This text is written at a level suitable for a final year electronics undergraduate or a postgraduate student. A list of references is included at the end of each chapter.

Electric machines

Electric Machines, George J. Thaler and Milton L. Wilcox (John Wiley & Sons, Inc., New York), 615 pp. $11.95.

This text is basically in two parts. The first gives a unified, analytical approach to the steady-state and the dynamic operating characteristics of rotating electric machines. The second is devoted to the selection and application of electric machines in engineering problems,

including feedback control systems. The authors provide a detailed and integrated mathematical description of the steady-state and dynamic terminal characteristics of machines by using a universal circuit model. This provides the student with a basic understanding of the operating characteristics that are important in the application of machines to engineering problems.

Electric networks

Electric Networks: Functions, Filters, Analysis, Henry Ruston and Joseph Bordogna, ("Electrical and Electronic Engineering Series" [McGraw-Hill Book Company, New York]), 552 pp. $12.75.

This book is designed for a second-year course in electric network theory for students who have completed a first course in network analysis. The basic approach is to develop a background in fundamental concepts through detailed discussion of each topic. Emphasis is placed on seven topics which are covered in depth: network functions; synthesis of two-element-kind one-ports; introduction of two-ports; filter design; network analysis; lattice networks; and network transmission characteristics.

Optimization

Recent Advances In Optimization Techniques, ed. Abrahim Lavi and Thomas Vogl (John Wiley & Sons, Inc., New York), 656 pp. $12.50.

This book of original articles discusses recent analytical studies and presents new practical methods of optimization. The results of the application of these methods to real life problems are presented. Actual working programs are described and their operation discussed. The articles cover two broad areas. The first involves design optimization of "static" systems, leading to nonlinear programing problems. The other involves performance optimization of dynamic systems leading to problems in the calculus of variations, dynamic programing and others. A bibliography of optimization techniques is included.

Introductory text

Circuits, Devices, and Systems, Ralph J. Smith, (John Wiley & Sons, Inc., New York), 776 pp. $11.95.

Important topics, techniques and terminology of modern electrical engineering are discussed in an integrated treatment of circuits, electronic devices, electromechanical devices and systems. The author emphasizes fundamental principles to provide a basis for further work and includes examples to provide motivation for students with various interests. A new physical concept is examined, its application in a device and the behavior prediction of an engineering system incorporating the device. Emphasis is given to the modeling process. Each chapter begins with an introduction and ends with questions, problems and exercises for 3 years' use without repetition.

Using your television

101 Ways To Use Your Color-TV, Robert G. Middleton (Howard W. Sams & Co., Inc., Indianapolis), 160 pp. $2.95.

This edition describes the many uses for various color, pattern, sweep and marker generators, and other equipment used to pinpoint color-TV problems more quickly. It takes up each type of equipment and shows the ways it can be used. Included are photographs of the waveforms that occur at various points and discussions of defects. Test setups, procedures and results are described and illustrated in detail. This book also tells how to test all types of circuits found in color-TV receivers.

Cryogenic engineering

Advances in Cryogenic Engineering, Volume 11, edited by K. D. Timmerhaus (Plenum Press, New York), 712 pp. $19.50.

This text contains 76 papers delivered at the Eleventh National Cryogenic Engineering Conference, held August 23-25, 1965, at Rice Uni-

(continued)

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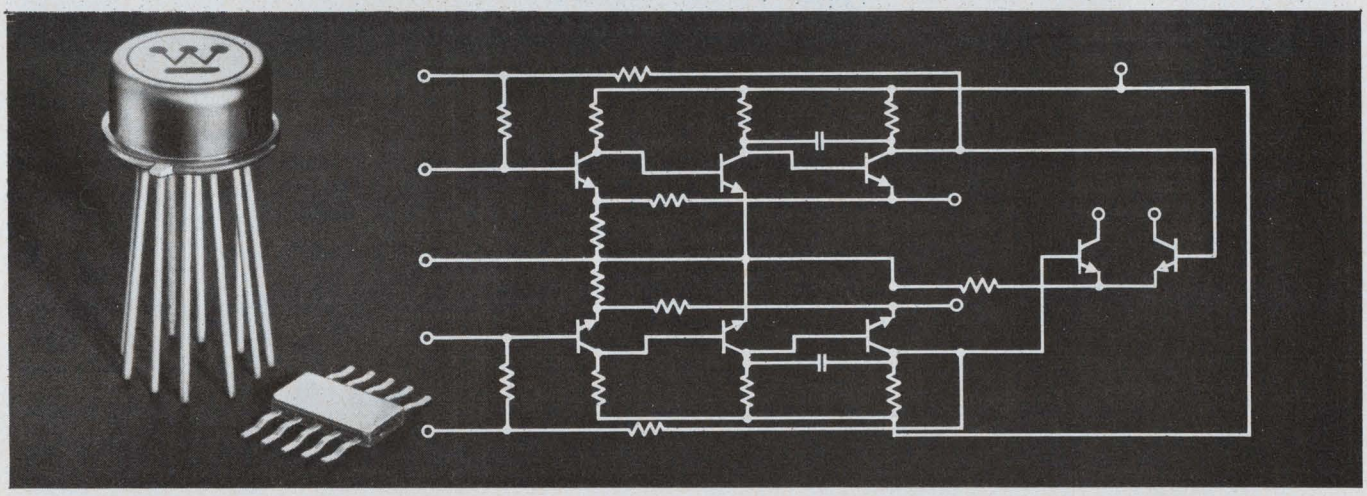

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versity, Houston, Tex. The NASA Manned Spacecraft Center is near the university, and many of the papers deal with cryogenics as applied to space systems. Multilayer, extremely lightweight, and foam insulating materials for use in space vehicles are discussed, as are self-sealing systems for micrometeorite protection, techniques for handling cryogenic slush, storage of propellants and life support system oxygen in space, and many aspects of the Saturn rocket system. Other papers deal with aspects of refrigeration cycles, properties of cryogenic substances, phase equilibria and thermodynamics, etc.

Understanding capacitors

ABC's of Capacitors, William F. Mullin (Howard W. Sams & Co., Inc. Indianapolis), 96 pp. $2.25.

Written in everyday language, this book explains how various types of capacitors are constructed, their characteristics and applications, points to consider when selecting replacements and several methods of testing and measuring capacitors. This text is directed at those who work with electronic circuits or anyone who needs an understanding of capacitors as an aid in troubleshooting, designing, or constructing electronic equipment. The author has provided a text which bridges the gap between engineering technology and circuit theory—making this a reference for technicians, servicemen, students.

Adaptive control systems

Optimal Adaptive Control Systems ("Mathematics in Science and Engineering," Vol. 25), David Sworder (Academic Press, New York), 187 pp. $8.50.

The basic method of approach in this volume is to identify the characteristics of a control system problem with those of a statistical game. This permits the engineer to employ some of the game theoretic results in the solution of the control problem. A knowledge of engineering statistics equivalent to graduate level is necessary.

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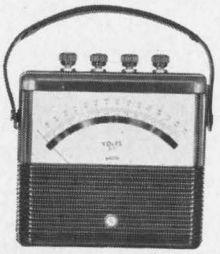
IBM®

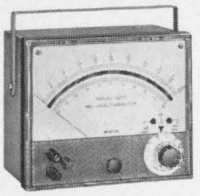
ON READER-SERVICE CARD CIRCLE 59

MODEL 901 DC SERIES: *Available with ¼% and ½% accuracy, self-shielding mechanism, exceeds ASA C39.1 specification requirements. Many multi-range combinations in stock.*

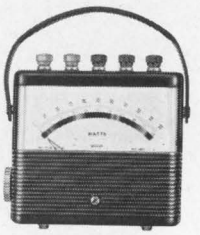


MODEL 904 AC SERIES: *½% accuracy with shielded radial vane, moving iron mechanism. Multi-range voltmeter available with self-contained ranges 750 /300 / 150 /75 /30 /15 /7.5 / 3 Volts full scale. Multi-range ammeter self-contained with ranges 200 /100 /50 /20 /10 /5 /2 amperes full scale. Other ranges and sensitivities available from stock.*

MODEL 1477 ELECTRONIC DC MILLIVOLTS/MICROAMPS & AMPLIFIER: *A portable electronic test instrument supplied in either potential or current ranges as low as 1 MV and 10 UA full scale. Typical self-contained range combination 1,000 /500 / 200 /100 /50 /20 /10 /5 /2 /1 Millivolts. Similar microammeters with ranges as low as 10 UA. Special feedback type amplifier assures extreme stability with virtually no energy drain from the input circuit. Terminals provided for 1 MA full scale output (on any range) into resistances as high as 5,000 ohms.*



MODEL 905 AC/DC SINGLE PHASE WATTMETERS: *½% accuracy true electrodynamometer shielded mechanism. Rated accuracy on AC or DC provides useful "transfer instrument". Full scale ranges from 5 Watts.*



MODEL 931 DC SERIES: *½% accuracy shielded type instruments stocked in many single and multiple range combinations. The most reasonably priced portable on the market for the quality and performance that is provided. Matching instruments also available for AC current voltage and single phase power measurements.*

MODEL 622 PRECISION DC SERIES: *¼% and ½% accuracy. Shielded permanent magnet mechanism. Many assorted range combinations from 5 UA full scale and up. Typical self-contained 20 range DC Volt-Milliammeter (¼% accuracy); 750 /300 / 150 /75 /30 /15 /7.5 /3 /1.5 Volts; 100 /50 Millivolts; 3,000 /1,500 /750 /300 /150 /75 / 30 /15 /7.5 Milliamps. Special RMS type thermocouple instruments with plug-in couples also available.*

These portables have made over 250,000 lasting friends

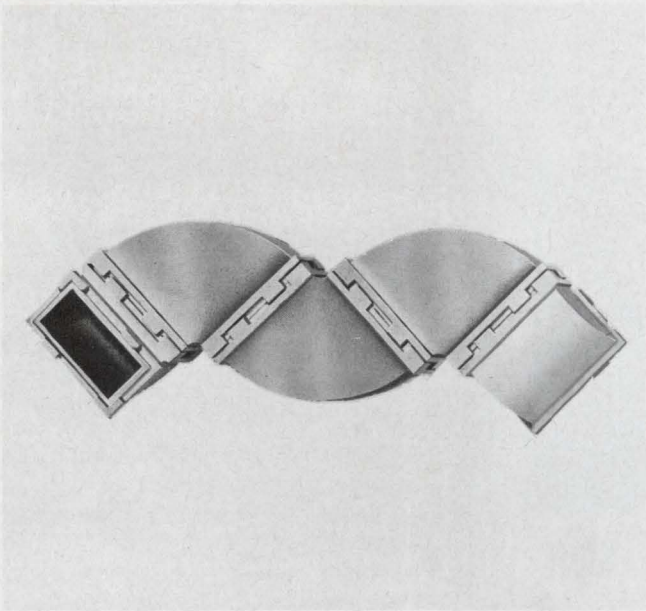
Yes, Weston has sold more than a quarter million of these portable instruments. Some of the reasons are apparent in these specs which cover a portion of Weston's broad line. Other reasons: year-after-year reliability (key to your zero-defect program) and distributors who carry in stock the industry's widest portable line. Call your Weston distributor today. He has complete information—and the instrument you need.

Weston Instruments, Inc., 614 Frelinghuysen Avenue, Newark, N.J. 07114

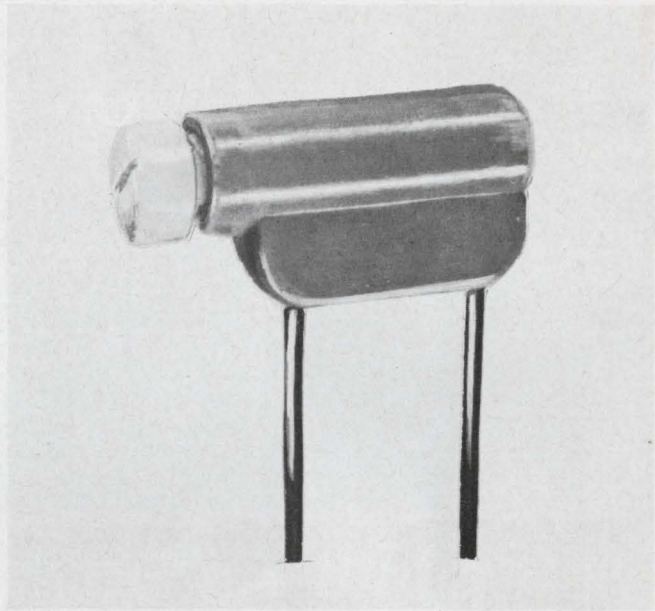
WESTON® *prime source for precision... since 1888*

ON READER-SERVICE CARD CIRCLE 60

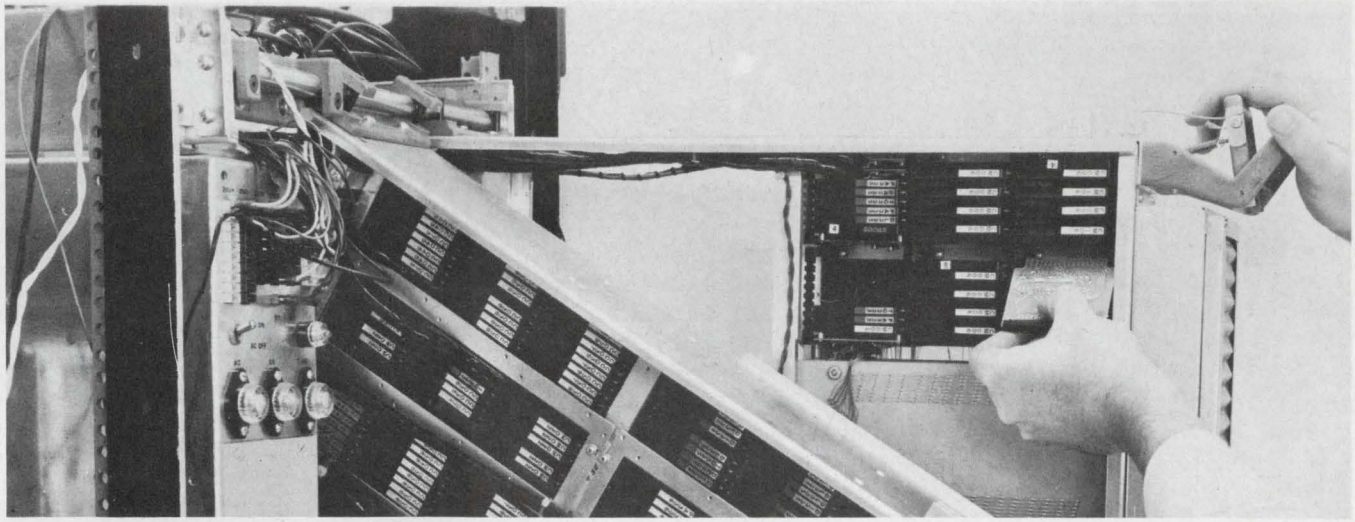
Products



Interlocking cast bends snap together to simplify the assembly of waveguides. Page 194



Micromin molded tank circuits represent 80% size reduction over TO-5 units. Page 186



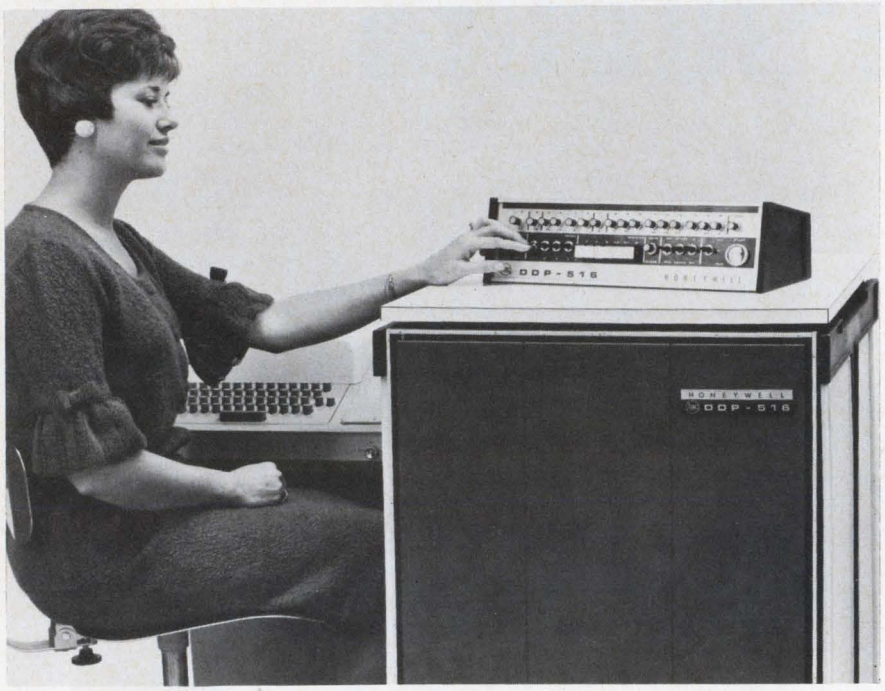
IC logic modules in tilt-out racks, are used exclusively in a new 16-bit, 960-ns computer. It is designed for a variety of real-time, on-line applications. Page 126

Also in this section:

Complex digital ICs save dollars and inches over single-function ICs. Page 142

Reactive ratio divider is driftless to 1 ppm with 0.3-ppm resolution. Page 162

RF power transistor guarantees 50 W at 50 MHz. Page 180



Small-scale control computer has all-IC logic, 960-ns cycle time

Honeywell Inc., Computer Control Div., Old Connecticut Path, Framingham, Mass. Phone: (617) 879-2600. P&A: $25,000 (with ASR-33 teletype); 90 days.

Computer Control Corp., the first concern to produce an all-integrated-circuit, general-purpose computer, joined Honeywell this May. The first product of the merger is a fast, low-cost IC computer for real-time and control applications. It is being shown at the Fall Joint Computer Conference in San Francisco and delivery is promised in 90 days.

The 16-bit, 960-ns DDP-516 is a third-generation all-IC computer. Its "250 program" software package has been proved in the field with Honeywell's existing DDP-116 in more than 125 real-time, on-line applications.

The DDP-516 features fully parallel organization, indexing, multilevel indirect addressing and a 72-command instruction repertoire, including byte manipulation capability. The memory capacity is 4,096 words, expandable to 32,768, and the cycle time is 960 ns. The standard main-frame includes two full-word arithmetic registers, a hardware index register, a "priority interrupt," power-failure protection and individually buffered I/O channels. Two-cycle I/O commands select device, test status and transfer data without I/O hold-off. The main-frame consists of three vertical leaves that contain the system power supply, central processor and the memory. Tilt-out construction provides easy access to both modules and inter-wiring. The entire computer may be rack-mounted in a standard 19-inch rack. The MTBF is two years under normal 40-hour week operations, or 4,000 hours.

Options include a direct multiplexed channel option to give multistation, time-shared I/O capability. Direct memory access is available when I/O word transfer rates of 1 MHz are needed. Other options are a high-speed arithmetic package, including hardware, double-precision memory lockout for program protection, memory parity and a real-time clock. All options are plug-ins.

The standard software program package includes a FORTRAN IV one-pass compiler that operates with a minimum of 8,192 words of core memory. A symbolic language assembly program (DAP-16) translates from the programer's language to machine language. A real-time monitor program automatically time-shares the computer between real-time and free-time tasks. A unique "desectorizing" loader allows the programer to address directly all of the memory, without regard for sector boundaries. A complete library of support programs is provided, including input-output selector routines, which allow for deletion, insertion or replacement of source programs.

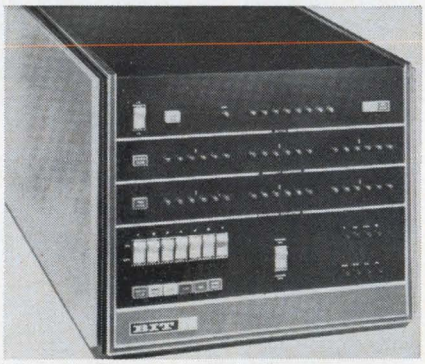
CIRCLE NO. 118

Desk-top computer is jack-of-all-trades

Business Information Technology Inc., 3 Erie Dr., Natick, Mass. Phone: (617) 235-6842. Price: about $9500.

In business, scientific and industrial use, the model 480 is designed to process both binary and decimal data. Standard features include variable word length, as many as 4 data channels, and an 8-μs core memory 1024 x 10 to 65,536 x 10. The 480 also accepts a wide range of input-output devices.

CIRCLE NO. 119



Modular multiplexer scans 20 channels

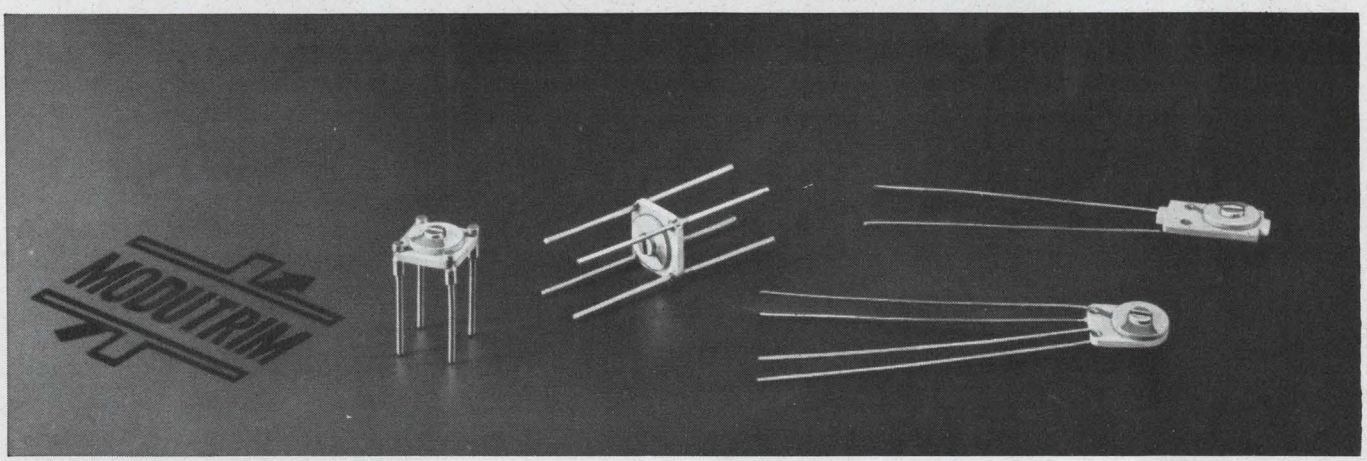
Roback Corp., Huntingdon Valley, Pa. Phone: (215) 676-4000. P&A: $2450; 6 wks.

A modular multiplexer, Model 902, scans up to 20 bipolar analog channels in either synchronous or asynchronous mode at speeds from 1 cps to 10 kHz. Max leakage current is 0.06 μA worst-case. Channel skipping speed is 4 μs/channel with normal switching speeds of 20 μs. Channel skipping can be controlled by either the front-panel switch or externally.

CIRCLE NO. 120

JFD Modutrim microminiature Ceramic Variable Capacitors...

Widest Δ Cs, highest stability and smallest size



Capacitors shown enlarged 30%

Modutrim microminiature ceramic variable capacitors offer micromodule and hybrid circuit designers a choice of wide Δ Cs in extremely small and stable units. MT 200 Series measures only 0.208 in. x 0.281 x 0.120 in. thick.

The excellent stability inherent in all MT Series is due to a unique rotor design utilizing a special proprietary ceramic material in a monolithic structure. Electrical characteristics are outstanding for components of this size and type—Q in excess of 500 measured at 1 MC for those values under 50.0 pf.

MT 100 Series' design is specifically for channel-mount and cordwood applications, as well as many other micromodule packages.

MT 200 Series offers further miniaturization, an answer to high component density problems and various LC networks packaged in TO-5 cans.

In order to make available superior mounting techniques for printed and modular circuitry, JFD has created two new series—MT 300 and 400...

MT 300 Series' 4 terminal lead configuration provides optimum mechanical support and is specifically designed for printed, microminiature and module circuit applications.

MT 400 Series is designed for cordwood and module applications. This configuration has 8 terminations for easy connection above and below the capacitor substrate.

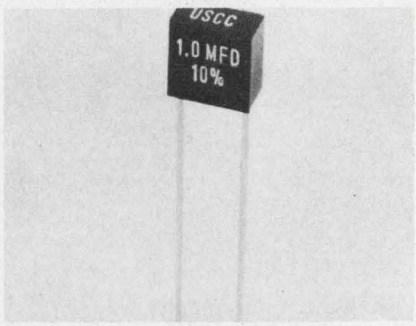
Write for Bulletin MT-65-2.

"TODAY'S COMPONENTS BUILT FOR TOMORROW'S CHALLENGES"

JFD

JFD ELECTRONICS CO. / COMPONENTS DIVISION • 15th Avenue at 62nd Street • Brooklyn, New York 11219 / Phone 212-331-1000
Sales Offices – Arcadia, California / Chicago, Illinois / Baltimore, Maryland / Saxonville, Massachusetts / Brooklyn, New York
New Hartford, New York / Cincinnati, Ohio / Philadelphia, Pennsylvania / Pittsburgh, Pennsylvania / Paris, France / Azor, Israel

ON READER-SERVICE CARD CIRCLE 61

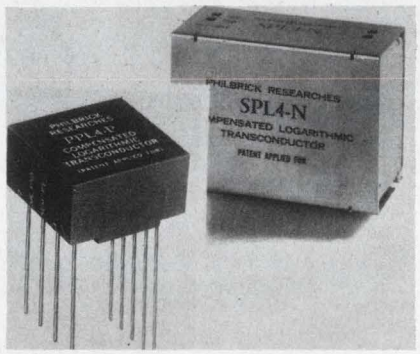


1 μF capacity in 0.0135 cu-in. case

U. S. Capacitor Corp., 2151 N. Lincoln St., Burburbank, Calif. Phone: (213) 843-4222.

A ceramic dielectric is used to deliver capacitance up to 1.0 μF in the miniature C12 line. For values of 0.18 to 0.47 μF, case measurements are 0.300-in. square by 0.1-in. thick. From 0.47 to 1.0 μF the thickness is increased to 0.150-in. Working voltages are 50 V at 125°C for values from 0.18 to 0.27 μF and 25 Vdc for 0.33 to 1.0 μF. Tolerances are 5%, 10% and 20% with 10% standard.

CIRCLE NO. 121

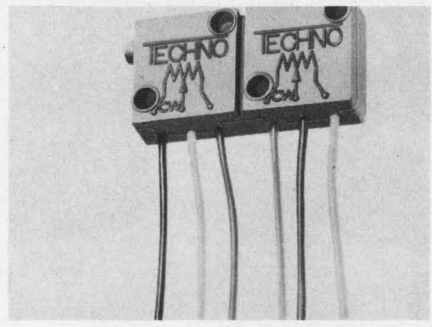


Log transconductors have 6-decade range

Philbrick Researches Inc., Allied Dr. at Route 128, Dedham, Mass. Phone: (617) 329-1600. Price: $59-$227.

With an over-all wide range of at least 6 decades, a series of adjustable log transconductors provide an accuracy of ±0.5% dB over at least 4 decades. The units are packaged in a wire-in module measuring 1-1/8 square by 5/8-in. deep. Applications include conversion of linear-scale instrumentation to log, power, decibel dBm scales and analog conversion of log-compressd signals.

CIRCLE NO. 122

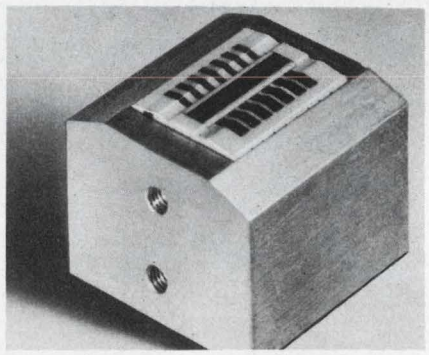


Nulling-circuit trimmer solves phasing problems

Techno-Components Corp., 7803 Lemona Ave., Van Nuys, Calif. Phone: (213) 781-1642.

A solution to the problem of correct phasing for nulling circuits is offered by the model 193 dual trimmer. The miniature unit has a single adjustment screw for two in-phase resistance elements. Wirewound resistance elements are available in a range from 10 Ω to 50 kΩ with a tolerance of ±5%. TC is rated 50 ppm/°C max and operating temperature range is −65°C to 175°C.

CIRCLE NO. 123



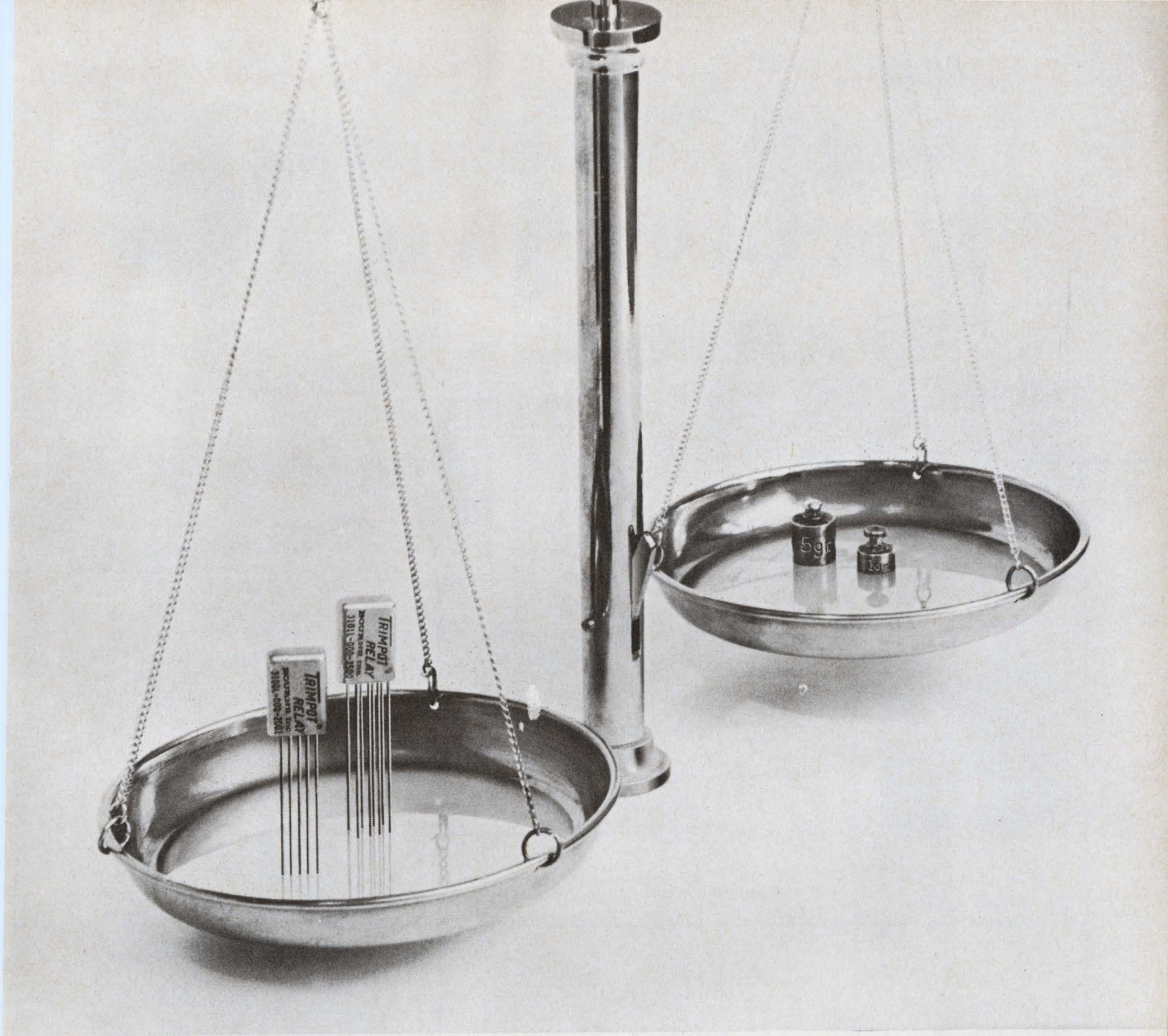
Magnetic tape head guaranteed 2000 hours

Ferroxcube Corp. of America, Saugerties, N. Y. Phone (914)246-2811.

All-glass bonding is credited with extending the life of the 4R5 ferrite recording head to over 2000 hours. The 7-track, IBM-compatible head is offered for standard record/reproduce tape applications. The all-glass bonding process combines pole pieces of the 4R5 ceramic ferrite and glass into a homogeneous structure with an all-ferrite recording surface. Neither relapping nor recrowning is involved in the 2000 hour life.

CIRCLE NO. 124

ON READER-SERVICE CARD CIRCLE 63 ➤



Relay Reliability in 3-Gram Packages

You can cut problems down to size with the Bourns TRIMPOT® Model 3100 SPDT and Model 3101 DPDT relays. These proven units give you MIL-Spec reliability and 160 mw sensitivity in a package size of less than 1/20 cubic inch. Punish them with 150G shock or 40G, 3000 cps vibration, and you still get the performance that's on the published data sheet. Features include highly efficient magnetic circuit, rotary balanced armature, hermetically sealed case and self-cleaning contacts. Environmentally they exceed requirements of MIL-R-5757D.

With these relays, there is little chance of "infant mortality" in your circuits. Bourns double-checks each unit with a 5000-operation run-in followed by 100% final inspection for all important characteristics, including mass-spectrometer leak testing. Furthermore, Bourns tests samples quarterly in the famous Reliability Assurance Program that it created for TRIMPOT potentiometers. In short, you can trust the name TRIMPOT in relays, too.

Other TRIMPOT relay products available from Bourns: Model 3105 subminiature AC DPDT and a full line of miniature adjustable time-delay and voltage-sensing relays and modules. Delivery is immediate. Write today for complete technical data.

Size:	0.2″ x 0.4″ x 0.6″
Max. operating temp.:	125°C
Contact rating:	1.0 amp resistive, 26 VDC
Pickup sensitivity:	100 mw (Model 3100) 160 mw (Model 3101)
Standard coil resistances:	50 to 2000Ω (Model 3100) 65 to 2000Ω (Model 3101)

Model 3100 (SPDT)

Model 3101 (DPDT)

units shown actual size

BOURNS INC.

TRIMPOT means BOURNS—BOURNS means QUALITY
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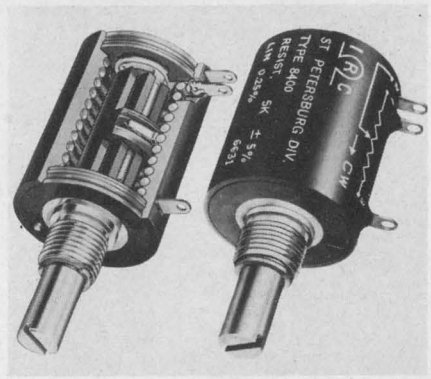
TRIMPOT® AND PRECISION POTENTIOMETERS — RELAYS — MICROCOMPONENTS: TRANSFORMERS, INDUCTORS, RESISTORS AND CAPACITORS



Multiturn 7/8-in. pot designed for industry

IRC Inc., 401 N. Broad St., Philadelphia, Pa. Phone (215) 922-8900. P&A: $5.25 (in 250 lots); 4 wks.

Military features are standard in the type 8400 potentiometer. The multiturn wirewound component has a molded thermo-plastic case with grooved interior and a low-TX wire element to provide 0.25% independent linearity. Resistance values are 100 ohm to 100 K with ±5% tolerance. Temperature range is −55° to +105°C with a rating of 2.0 W at 25°C.

CIRCLE NO. 125

Solid-state commutator meets IRIG standards

General Devices Inc., Princeton, N. J. Phone: (609) 924-2500. Price: below $1000.

Integrated circuit logic is said to allow the Series 2080 high-level commutator to adapt readily to various input channel configurations meeting IRIG telemetry standards. Up to 90 high-level inputs are converted to standard PAM, PDM and PPM output formats. Overall reliability is cited as particularly attractive in satellite testing, launch vehicles and aircraft testing.

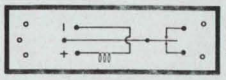
CIRCLE NO. 126

Adlake Mercury Wetted Relay — Application Data

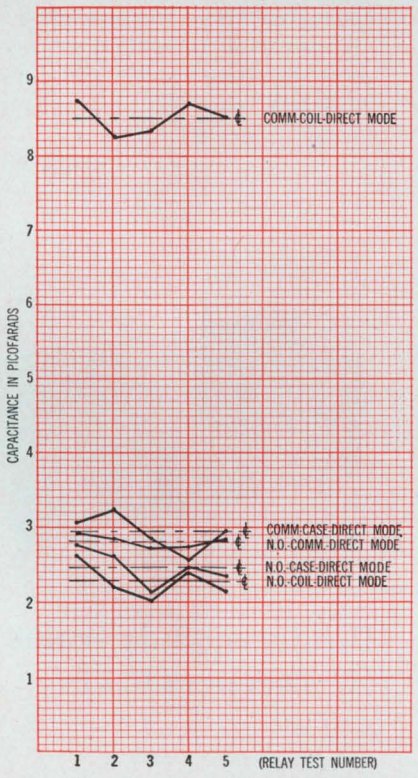
Capacitance of Adlake Mercury Wetted Contact Relays Applicable for Low Signal Applications

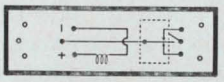
Typical Capacitance in Picofarads — Graphs illustrate typical capacitance values for Adlake AWCA-16000 series relays. Fig. 1 is for unshielded relays. Fig. 2: Electro-statically shielded switch brought out to a separate pin. Fig. 3: Electro-statically shielded switch with case and shield tied together at a common pin. Interelectrode capacitance across contacts of a bare switch, without external wires, is less than 1.0 picofarad.

Abbreviation COMM. stands for the Combination of the Armature and Normally Closed Contact. N.O. is the abbreviation for Normally Open Contact; whereas the symbol # is the mean average for the 5 relays. Graphs are available on other styles of Adlake Mercury Wetted Contact Relays upon request. (Please state wiring configuration.)

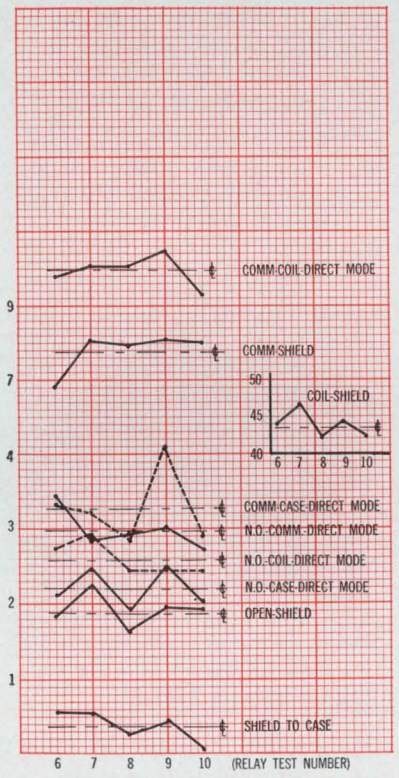


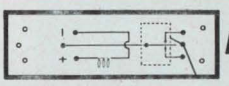
AWCA 16011-S
Fig. 1



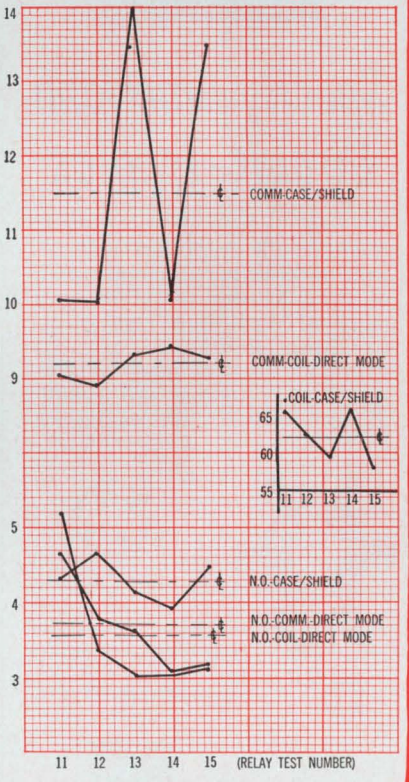


AWCA 16016
Fig. 2





AWCA 16018
Fig. 3



Data was obtained using a Booton Electronics Corporation Capacitance Bridge, Model 75-A-S8 at 1MHz

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

Adlake SINCE 1857

THE ADAMS & WESTLAKE COMPANY

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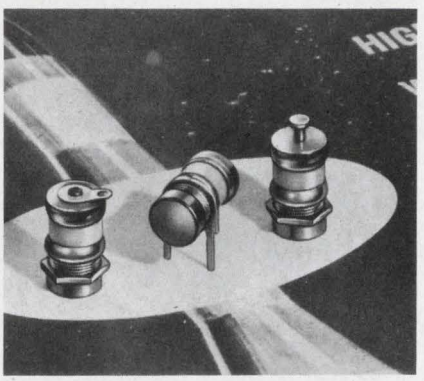
ON READER-SERVICE CARD CIRCLE 65

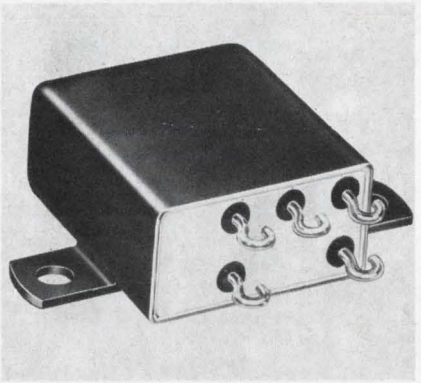


Variable air capacitor makes not a whisper

Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N. J. Phone: (201) 334-2676.

These variable air capacitors provide improved rotational life, "noiseless" contact during adjustment, greater stability under shock and vibration, broader operating temperature range and easier soldering. The 5200 series features: capacity, 0:8 - 10 pF; working voltage, 250 Vdc (test voltage, 500 Vdc); temperature coefficient, 0-30 ppm/°C; Q at 100 mHz > 3000; sinosoidal vibration > 60g; random vibration > 2.0g/cps shock > 275g (6 milliseconds).

CIRCLE NO. 127



Solid-state timer operates 1 million times

Hi-G Inc., Windsor Locks, Conn. Phone: (203) 623-2481.

A reliability factor based on a life expectancy of 1 million operations is provided in conventional timing operations by the Series 1850 type fixed timer. The new units have microsecond reset times with a timing range of 10 μs to 10 seconds. Operating temperature range is −55° to +85°C and unit's weight is 0.7 ounces.

CIRCLE NO. 128

Arbitrary function units have 10 breakpoints

Philbrick Researches Inc., Allied Dr., at Rte. 128, Dedham, Mass. Phone: (617) 329-1600. P&A: $195; 3 wks.

Ten breakpoints for straight-line approximations of algebraic functions are provided by the SPFX series of arbitrary function transconductors. The diode-resistor nets are available in both positive- and negative-going models and both are adjusted through potentiometers housed in the SPFX case.

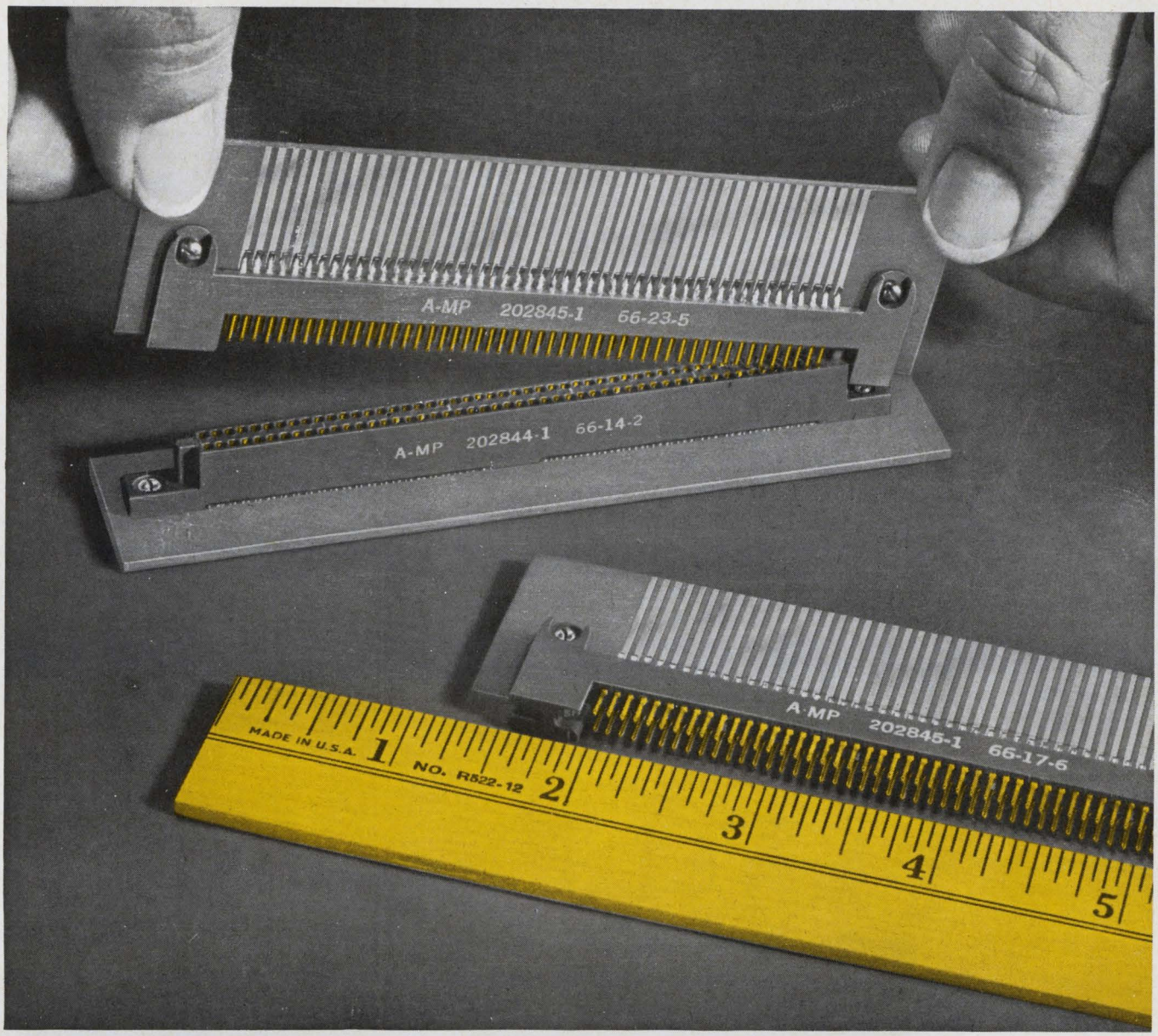
CIRCLE NO. 129

Divider module scales HF sweepers to LF

Aerospace Research Inc., 130 Lincoln St., Boston, Mass. Phone: (617) 254-7200. P&A: $99.50; stock.

Your standard HF sweeper or signal generator can be converted for use as a signal source in vlf, sonar or audio work through the SD-10 divider. Outputs are either 1/10, 1/100, or 1/1000 of input. This division is said to multiply the effective stability of your instrument in the process of translation, making narrow-band measurements feasible.

CIRCLE NO. 130



Dense between the ears—but what an I.Q.*!!

Between the ears of the A-MP* **750 Series** Box Contact Connector are 100 contacts in a space of less than 4 inches—that's pretty dense! Yet this connector offers you the industry's lowest per line applied cost for a highly reliable two-piece printed circuit connector —that's economy plus Installed Quality*!

High density is achieved with two rows of 50 box contacts located on .075″ centers. Receptacle contact tails are staggered to permit larger spacing between printed circuit wiring paths. Headers contain channel shaped pins which are latched in the header and have flat tails for easy connection to daughter boards.

The **750 Series** Box Contact Connector provides economy in overall applied cost. Socket contacts are highly flexible allowing wide margins of misalignment of pins and eliminating the need for costly precision card guides. Low insertion and extraction forces permit mating of a large number of contacts without mechanical screws or cams. The **750 Series** connector has contacts which can be easily replaced without removal of the connector.

High electrical integrity is assured by four elliptical spring beams arranged at right angles forming a box. These beams provide four areas of contact on the mating pin, whether it is square, round, rectangular, or channel shaped. The walls of the housing limit spring deflection and prevent overstressing of the contacts, even when subjected to severe shock and vibration.

This adds up to a rugged, tolerant miniature connector for your most demanding applications. Examine these unduplicated features:

- Contacts on .075″ centers
- High misalignment tolerance
- Latched-in contacts can be easily replaced
- Gold over nickel plated beryllium copper contacts
- Polarized housings
- Sturdy diallyl phthalate housings
- Four redundant contacts for high reliability
- Resistant to vibration and shock
- Low installed cost

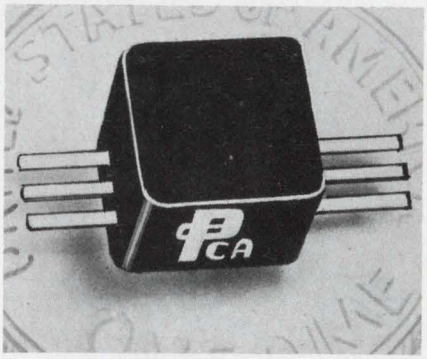
If your design calls for tight specifications requiring a tolerant, reliable, high density connector—all with an eye on economy, then the A-MP **750 Series** Box Contact Connector is for you. Write immediately for complete details.

★Trademark of AMP INCORPORATED

AMP
INCORPORATED
Harrisburg, Pennsylvania

A-MP★ products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

ON READER-SERVICE CARD CIRCLE 67

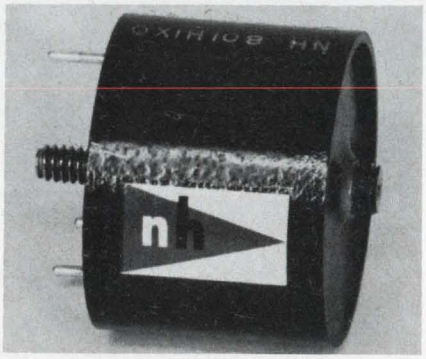


Pulse transformer for thin-film circuits

PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. Phone: (213) 362-0761.

Measuring only 0.217 x 0.260 x 0.260 inches, this sub-miniature coupling pulse transformer is designed for use in wide variety of welded-module, thin-film circuits. Weldable leads are gold-plated Kovar. Maximum ET constant: 40 V μs. With a primary inductance of up to several mH, transformers can operate in an environment from $-55°C$ to $+125°C$ and meet all MIL-T-27, grade 5 specifications.

CIRCLE NO. 131



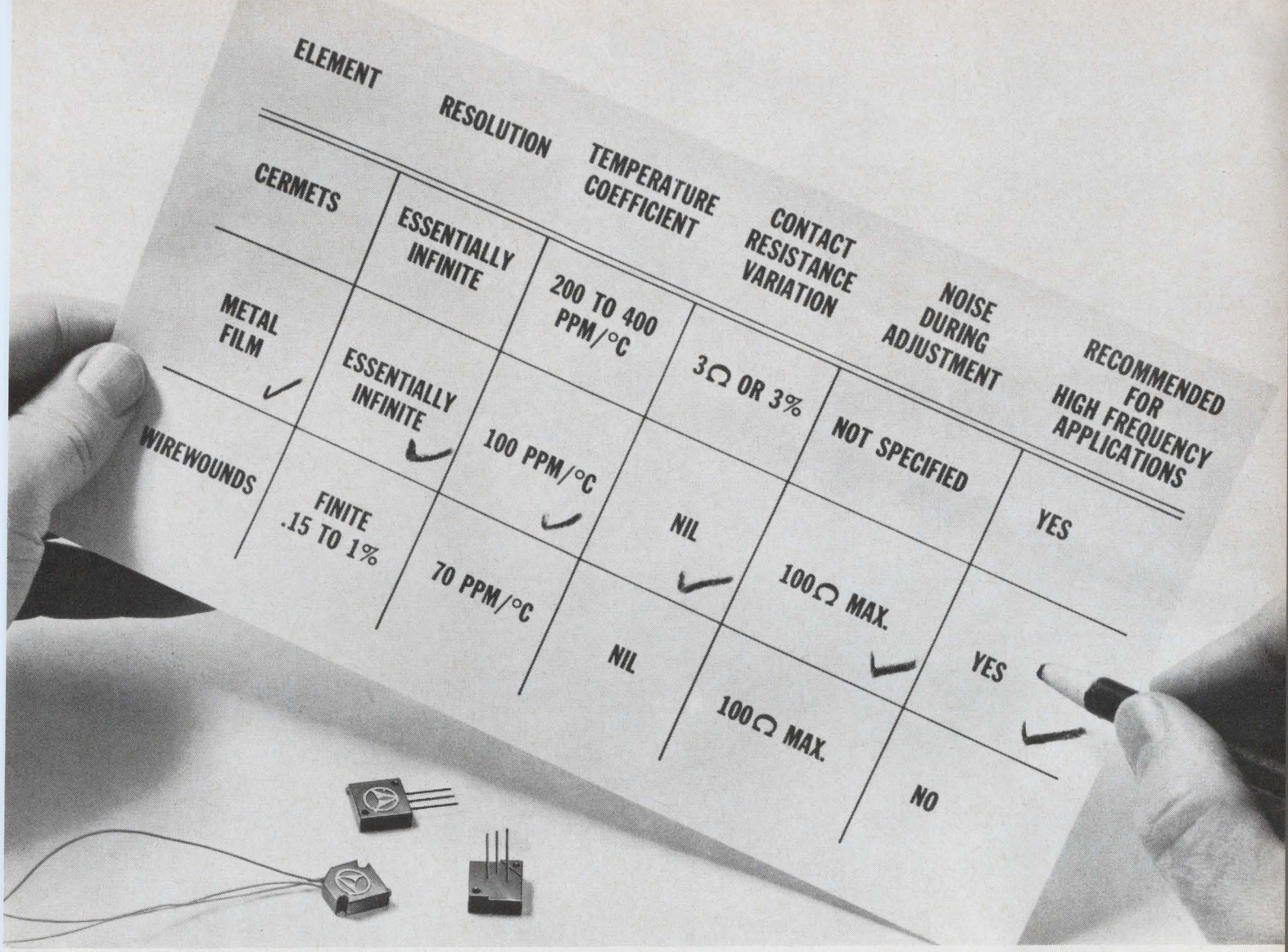
Variable inductors: low-temp coefficient

North Hills Electronics Inc., Alexander Pl., Glen Cove, N. Y. Phone: (516) 671-5700.

A line of ferrite pot core variable inductors are housed in sealed plastic cases with printed circuit terminals and sealed adjustments. It features low temperature coefficient, high Q and excellent stability. Coil inductance ranges from 1 millihenry to 1 henry, and can operate from audio frequencies up to 1 mHz. The type 801 units are for the lower and type 802 are for the higher frequency range.

CIRCLE NO. 132

ON READER-SERVICE CARD CIRCLE 69 ➤



Amphenol metal-film trimmers outperform cermets and wirewounds

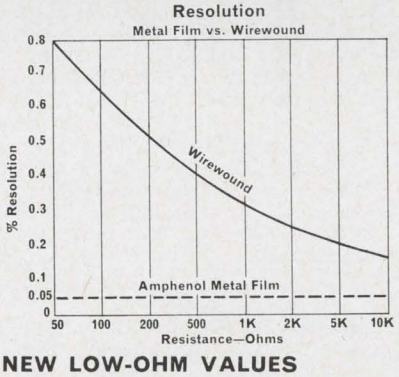
Compare metal-film trimmers to cermets and wirewounds and you get a picture like the one above. It makes a convincing story for Amphenol metal-film.

First note that Amphenol metal-film provides the temperature coefficient and noise characteristics of wirewound trimmers. (Check the high TC and noise levels of cermets.) Next note that metal-film offers the essentially infinite resolution of cermets.

Put the two together and you've got yourself quite a trimmer—one, for example, like Amphenol's 2901 metal-film trimmer. It's the only infinite resolution trimmer with a TC as low as 50 ppm/°C and zero noise level at the trimmed position. You just set it and forget it.

Other features of the half-inch square 2901 include a humidity-, vibration- and shock-proof case (it maintains setting through 50 g's). Silicon "O" Ring shuts out dust and humidity. Precious metal contact assures low contact resistance.

The 2901 is now available from your Amphenol Industrial Distributor. For more technical information, call your Amphenol Sales Engineer. Or write us in Janesville, Wisconsin.



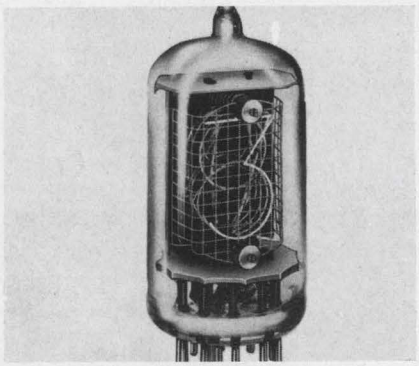
NEW LOW-OHM VALUES

Amphenol has just added three new low-ohm values—50, 100, and 200 ohms. The chart above shows how wirewound trimmers lose resolution rapidly in the lower ohmic values. Yet metal-film maintains infinite resolution across the entire resistance range.

AMPHENOL CONTROLS DIVISION
AMPHENOL CORPORATION

TM

Specify Amphenol . . . the leading name in cable, connectors, assemblies, RF switches, potentiometers, motors, microelectronics

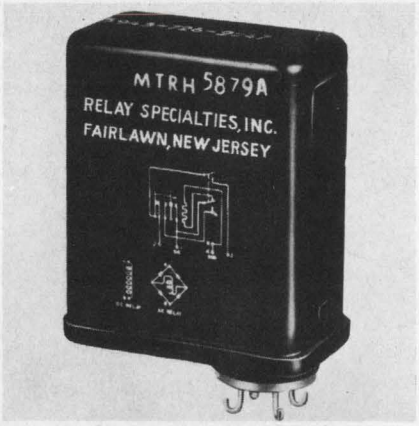


Digitubes can line up on 0.8 inch centers

Baird-Atomic, 33 University Rd., Cambridge, Mass. Phone: (617) 864-7420. Price: $4.95 (for 1000).

These new tubes have an envelope width of 0.75 in. allowing the tubes to be arranged at less than 0.80 in. center to center. All "840 series" digitubes are long life and side viewing. The BA-840 is a 10-character display tube, numerals 0 to 9; the BA-841 is a 10-character display tube, numerals 0 to 9 with an independent decimal point to the left of the numerals; the BA-842 is a 10 character display tube, numerals 0 to 9 with an independent decimal point to the right.

CIRCLE NO. 852

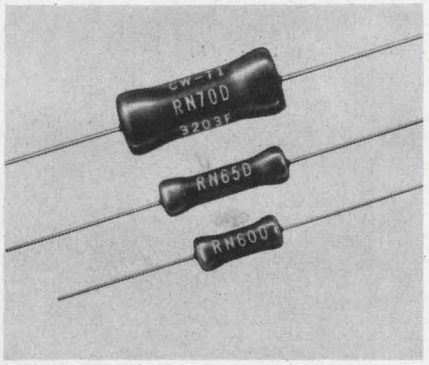


Time delay relays boast instantaneous return

Relay Specialties Inc., 3 Goodwin Ave., Fair Lawn, N. J.

Series MTRH 8 time delay relays feature instantaneous return time and accurate recycling periods obtained by utilizing both the heating and cooling time of a thermal element. The relay has a drop out time of only five milliseconds and may be immediately reoperated with virtually 100% rated time delay period.

CIRCLE NO. 853

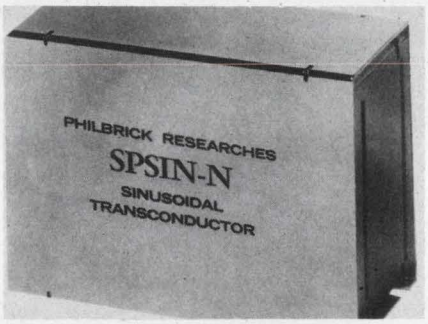


Metal film resistors can handle 1/2 watts

Continental-Wirt Electronics Corp., 26 W. Queen Lane, Philadelphia, Pa. Phone: (215) 848-7700.

Meeting MIL-R-10509, this line of metal film resistors includes both the T-1 model (TC/°C ±100 ppm) and the "D" characteristic (TC/°C +200, −500 ppm). MIL sizes of 1/8 watt, 1/4 watt, 1/2 watt are available. The body of the resistor is coated with multiple layers of epoxy. A high degree of stability is attained through improved methods of controlling film thickness during the deposition of the thin, evaporated, metallic film on the ceramic core in a vacuum chamber.

CIRCLE NO. 854



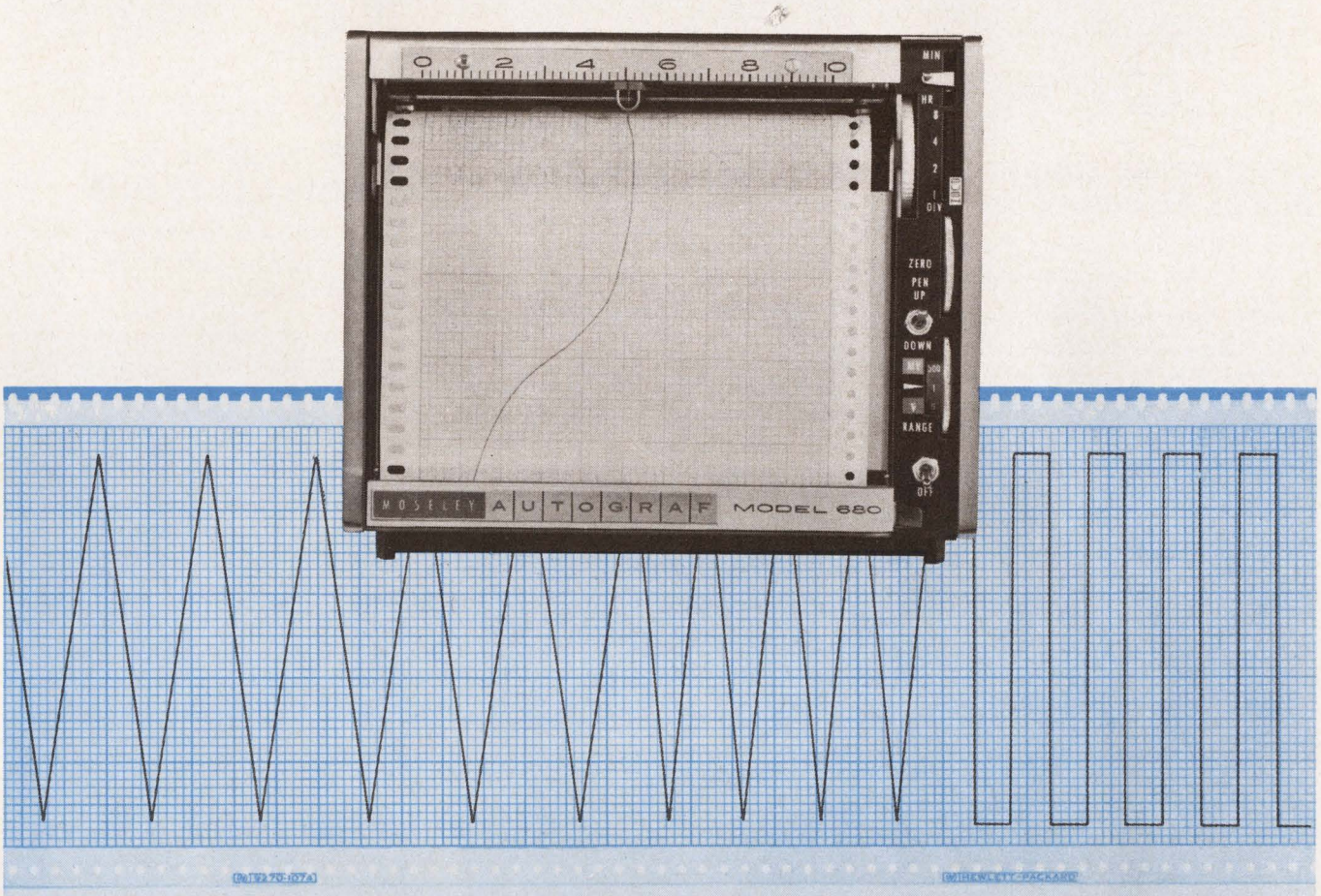
Trig function units are accurate 0.1%

Philbrick Researches Inc., Allied Dr., at Rte. 128, Dedham, Mass. Phone: (617) 329-1600. P&A: $195; 3 weeks.

Output currents proportional to the sine or cosine of the input voltage are provided by the SPSIN or SPCOS transducers in an operational amplifier circuit. In such applications as conversion of coordinate data from rectangular-polar presentation or conversion of linear-scale to angular displacement readings, the units have a response speed of 5° phase shift at 100 kHz and an accuracy of 0.1%.

CIRCLE NO. 855

INKLESS



NEW STRIP-CHART WRITING TECHNIQUE:

Ends pen clogging, ink drying
Gives clear, clean traces
Provides new economy

New Hewlett-Packard electrosensitive paper, available as a standard option on Moseley 680 and 7100 Series Strip-Chart Recorders, ends the problems associated with pen-and-ink writing techniques... at an economical price and without the disadvantages inherent in other available electric writing methods.

The Hewlett-Packard electrosensitive paper is a special electro-chemical coated chart paper. The coating is current sensitive, changing to a dark brown trace with application of voltage from the recorder stylus. The new technique eliminates the familiar arc method of electric writing on carbon-backed paper.

With Hewlett-Packard electric writing, you can use your strip-chart recorders for long-term, unattended monitoring, with increased performance at slow writing speeds, as well as at high writing speed. It is non-pressure sensitive, so that you can't damage or obscure your recordings.

Here's another advance in recording capability from Hewlett-Packard. Call your Hewlett-Packard field engineer for information on converting your strip-chart recorder to maintenance-free electric writing. Or write for information: Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice.

HEWLETT PACKARD hp MOSELEY DIVISION

1189

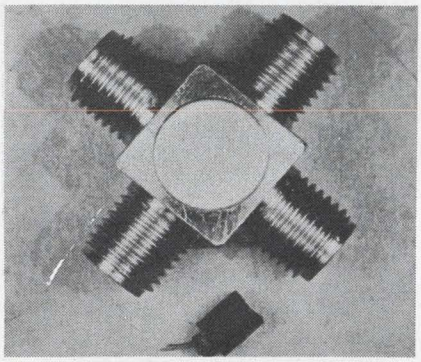
ON READER-SERVICE CARD CIRCLE 71

Interference suppressor blocks AF noise

Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000.

In measurements in the 0.01 to 12.4 GHz region, the Microline audio interference suppressor is said to effectively eliminate audio leakage along the transmission line. In effect, the unit is designed to increase measurement signal-to-noise ratios. Insertion loss is 0.5 dB and max vswr ranges from 1.3 to 1.5 max.

CIRCLE NO. 177

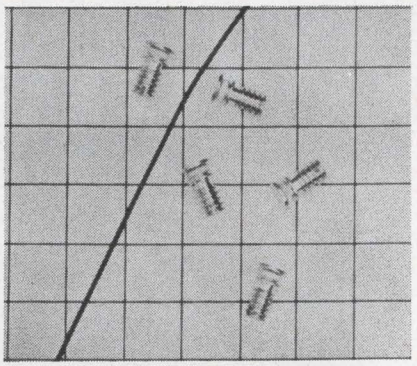


Lumped-element hybrid is 1/8 in. diameter

Merrimac Research & Development Inc., 41 Fairfield Pl., W. Caldwell, N. J. Phone: (201) 371-1616.

"The Pellet," a 1/8-in. diameter quadrature hybrid, operates at 2.1 to 2.3 GHz in such applications as image rejection mixers, phase comparators, SSB modulators and discriminator nets. Designed especially for PC use, it is available alone or inside the QHM-2 connector shown above. Specs include: bandwidth 10%, output equality ±0.3 dB, insertion loss typically below 0.3 dB and power at 5 W average.

CIRCLE NO. 178

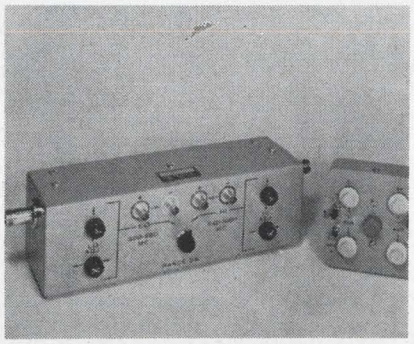


Multiplier diode yields X10 action in one stage

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $45 (in quantity); 2 wks.

An input of 15 W at 200 MHz nets 2 W at 2 GHz with an HPA 0300 step recovery diode. One of many applications for the new diode is expected to be 2-GHz telemetry. The devices are epitaxial, surface-passivated silicon construction with very abrupt junctions. Max power dissipation is 15 W at 50°C case temperature and the latest revisions of MIL-STD-750, MIL-STD-202 and MIL-S-19500 are met.

CIRCLE NO. 179

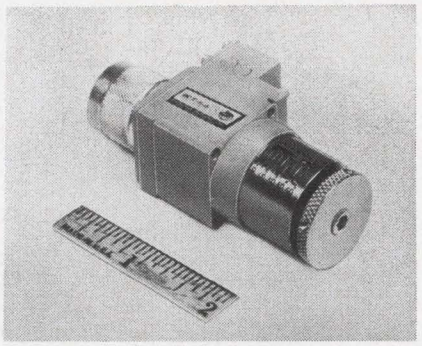


Impedance plotters range to 12 GHz

Texscan Corp., 51 S. Koweba Lane, Indianapolis, Inc. Phone: (317) 632-7351.

Both coax and waveguide units are available in a Smith-chart automatic impedance plotter line. Coax models cover a 3 to 1 frequency range with the highest frequency unit operating to 3000 MHz. Waveguide models begin at 350 MHz and cover the range to 12 GHz with each unit covering a full waveguide frequency band. The plotter kits include cables and accessories.

CIRCLE NO. 180

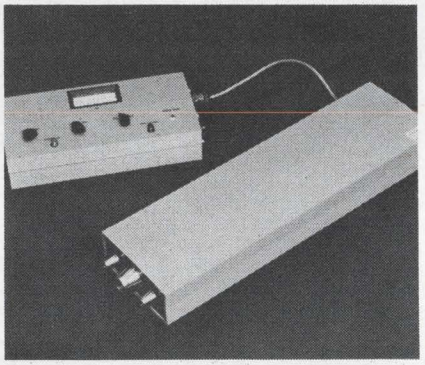


1-mW oscillators operate 4 to 13 GHz

International Microwave Corp., River Rd., Cos Cob, Conn. Phone: (203) 661-6277.

A line of precision, mechanically tunable tunnel-diode oscillators operate in the 4- to 13 GHz range. These units have FM noise equal to 2 or 3 Hz/kHz in a slot 70-kHz removed from the carrier. Frequency stability over the temperature range of −30 to 60°C is 0.02% min. Pushing figure is 0.1 MHz per 10% applied-voltage change and pulling is 0.01% into a short.

CIRCLE NO. 205



Two commercial lasers first of complete line

Hughes Aircraft Co., 11105 S. La-Cienega Blvd., Los Angeles. Phone: (213) 670-1515. P&A: $4000 and $5000; 60 days.

Two completely packaged pulsed lasers, first of a commercial and industrial line, produce outputs in the blue-green at 5146, 5017, 4965, 4880, 4765 and 4579 Å simultaneously. They are packaged in two units consisting of laser head and power supply, both using singly-ionized argon gas sources. Model 3040H provides 1 W power out and model 3041 provides 10 W. Both have pulse lengths of 50 μs.

CIRCLE NO. 206

ON READER-SERVICE CARD CIRCLE 73 ➤

For critical chopper applications... RCA's new MOS transistor will even work

UPSIDE DOWN

RCA's new 40460 is an N-channel, depletion type, insulated-full-gate MOS which, because of its symmetry, can be operated "upside down"...works equally well with either positive or negative incoming signals...*does the work of two bipolar transistors.*

RCA's full-gate MOS is especially useful for chopper applications at extremely low voltage levels... handles input signals from microvolts to volts. It has an inherent offset voltage of zero. This means that the RCA 40460 has none of the tracking problems of matched bipolar devices, caused by temperature changes and extended operation.

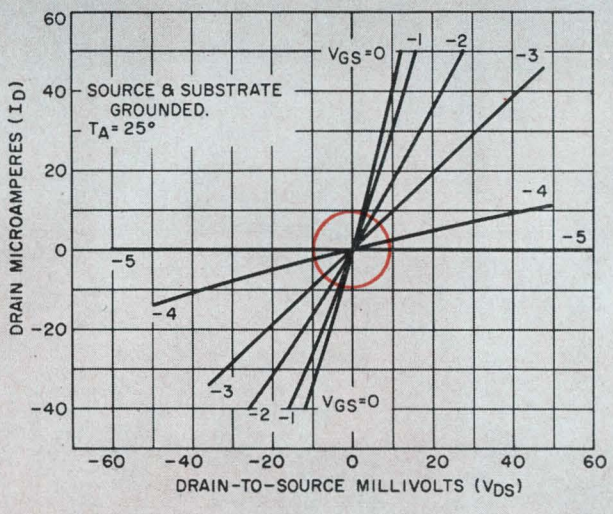
A high "off" resistance of 1000 megohms and a low "on" drain-to-source resistance of only 250 ohms make the RCA 40460 perform like a mechanical chopper, without its drawbacks. And you get all the advantages of solid-state reliability. In addition, long-term stability is assured by a fully metallized gate and a hermetically sealed JEDEC TO-72 4-lead metal case.

TO GET THE MOST FROM YOUR RCA 40460 CHOPPER, use the new RCA 40461 MOS transistor in your chopper amplifier stage, as well as for other critical audio and wideband applications.

Try these devices and see how they improve your chopper design. Check your RCA Field Representative for complete information. For technical bulletins, write RCA Commercial Engineering, Section CG11-2, Harrison, N. J. 07029.

ALSO AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

RCA's New 40460 MOS Transistor Features ZERO OFFSET VOLTAGE*

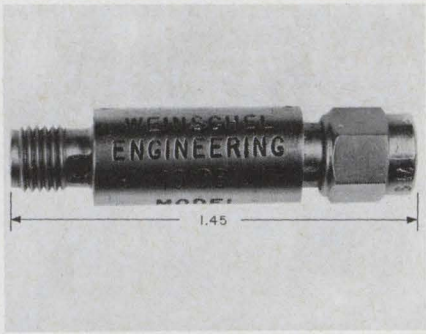


*Thermocouple effects and contact potentials may cause erroneous readings

RCA ELECTRONIC COMPONENTS AND DEVICES

RCA®

The Most Trusted Name in Electronics

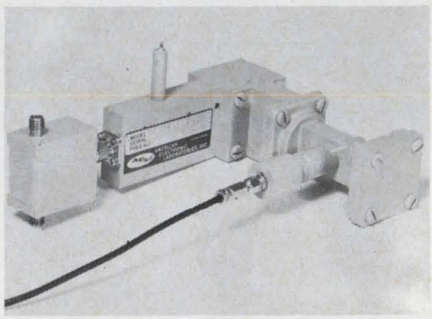


Miniature attenuator ranges dc to 18 GHz

Weinschel Engineering, Gaithersburg, Md. Phone: (301) 948-3434. Price: $88 (Model 3) and $125 (Model 4).

Miniaturization without the sacrifice of electrical specs is the lead feature of the models 3 and 4 fixed coax attenuators from Weinschel. The new units are said to be completely comparable to the older models 1 and 2 but the package has been reduced to 1.45- x 0.35-in. diameter. Each attenuator is supplied with a certificate of calibration stating accuracy, insertion loss and vswr.

CIRCLE NO. 207



S-band amplifier uses avalanche diode

American Electronic Labs. Inc., Richardson Rd., Colmar, Pa. Phone: (215) 822-2929. P&A: $4595; 90-120 days.

A low noise, compact solid-state S-band parametric amplifier uses an avalanche diode oscillator as a pump source. Designated the AEL model PAR 1612A parametric amplifier, this device is tunable over the 2.2 to 2.3 GHz telemetry band and has a maximum noise figure of 2.5 dB. A single, low level dc input of 60 V at 20 milliamperes operates the avalanche pump and provides bias for the parametric amplifier varactor.

CIRCLE NO. 208

(Microwaves continued on p. 194)

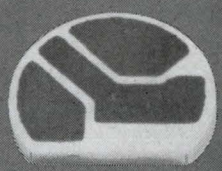
Heat Dissipation Bonus of Beryllia Worth An Extra Two Cents?

consider Coors metallized ceramics

Coors Beryllium Oxide Ceramic offers you the bonus of 10 times the thermal conductivity of aluminum oxide ceramic –approximately the heat transfer qualities of aluminum metal. Ordinarily, beryllia is thought to be too expensive, except for designs where maximum heat dissipation is an essential. However, we find the additional cost of using beryllia in small metallized assemblies adds only a few cents to the total cost of the completed part. For an "extra two-cents worth" Coors offers a beryllia-to-metal assembly that allows you to use more power . . . or allows you even further miniaturization than with alumina . . . or gives you longer component life–or a combination of all three. When you design micro-substrate assemblies–Consider Coors Metallized Ceramics –and get the bonus of beryllia's thermal conductivity. Write for Coors Metallizing Data Sheet 9502, or call the Coors "hot line"-- 303/279-4533, Ext. 351.

THIS COORS METALLIZED BERYLLIA MICRO-COMPONENT DISSIPATES THE SAME QUANTITIES OF HEAT

AS THIS COORS METALLIZED ALUMINA MICRO-COMPONENT



Coors

CERAMICS

ALUMINAS • BERYLLIAS • MAGNESIAS • SPECIAL OXIDES

Coors Porcelain Co., Golden, Colo.

Reduce circuit size and cost with complex function ICs

Texas Instruments Inc., P. O. Box 5012, Dallas, Texas, 75222. Phone: (214) 235-3111. P&A: (lots of 100 to 999) $5.75 for SN7482N; $8.15 for SN7483N; $8.30 for SN7492N; $8.30 for SN7493N; $10.50 for SN7441N. Evaluation quantities available immediately.

More for your money is the theme of Texas Instruments' latest product announcement—a line of complex function integrated circuits mounted in low-cost molded plastic packages.

An extension of the Series 54/74 digital ICs also manufactured by TI, the new additions are: Dual Adder (SN7482N): Quad Adder (SN-7483N); ÷ 12 Counter (SN-7492N); BCD-to-Decimal Decoder/Driver (SN-7441N).

Using Transistor-Transistor Logic (TTL), the circuits are suitable for high-frequency operation. General characteristics include a noise immunity of 1-V, an operating temperature range of 0° to +70°C, and a 5-V, + 5% supply voltage. Inputs are specified as "0" if V_{in} is less than 0.8-V and "1" if V_{in} is greater than 2.0-V. Outputs are "0" when V_{out} is less than 0.4-V and "1" when V_{out} is greater than 2.4-V.

The dual-adder (see Fig. 1a) adds a two-bit number, A_1A_2, to another two-bit number, B_1B_2. Provisions are included for a carry input, C_0 and a carry output, C_2; the carry from bit-one to bit-two is internally performed. Total time for a serial carry through both additions is 15-ns.

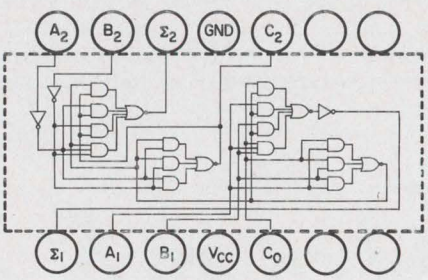
The monolithic chip for the dual adder (see Fig. 1b) is small enough to permit bonding two such chips into a single package. By appropriate interconnection this forms the SN7483N Quad Adder, which can add two four-bit numbers. The operation of this adder is otherwise similar to the dual adder. The serial carry propagation time for the four addition stages is 30 ns.

The Divide-by-12 Counter (SN-7492N) is a single monolithic silicon chip that divides frequencies up to 15 MHz by twelve, six, three or two. A feature on this device is the simultaneous independent operation of a divide-by-six and a divide-by-two counter.

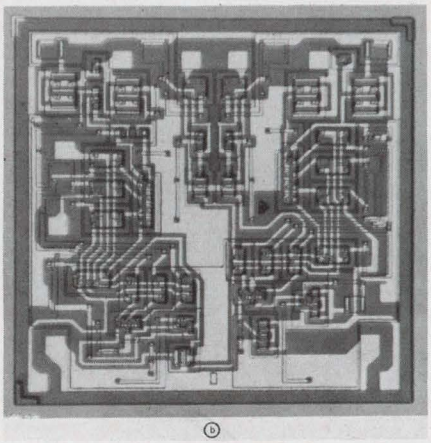
The Four-bit Binary Counter (SN7493N) can divide frequencies up to 15 MHz by either sixteen, eight, four or two when operating as a ripple through divider. Also possible is simultaneous independent division by eight or two.

The BCD-to-Decimal Decoder Driver (SN7491N) takes a BCD input, decodes it, and drives a gas-filled readout tube. The output driver transistors are guaranteed for 65-V operation and can be tied directly to the cathodes of the readout tubes.

CIRCLE NO. 209



(a)



(b)

Two-bit numbers are added in this Dual Adder (a) just announced by Texas Instruments. Entire circuit is monolithically integrated (b).

Does AE make the world's prettiest dry-reed switches?

Some of our customers think so. They go for the chic look of our PC Correeds on a printed circuit board.

Our designers are flattered. But they point out that the beauty of a PC Correed is more than skin-deep.

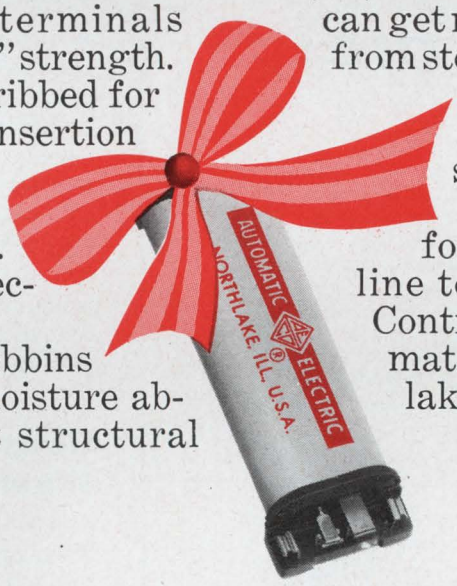
Take the contact leads. We keep them separate from the terminals—to eliminate strain. The terminals themselves have "I-beam" strength. They are longitudinally ribbed for extra rigidity—for easy insertion in PC boards.

The contact terminals are *welded*, not soldered. This makes a better electrical connection.

We filled the plastic bobbins with glass, to prevent moisture absorption. And to boost structural strength. You can pack these smart-looking switches as densely as you like. Because of their low profiles, magnetic shielding, and standard PC terminal spacing (multiples of 0.200″).

PC Correeds are available with 1, 2, 3 and 5 reedcapsules, in contact forms A, B, C and magnetic latching. You can get many of these modules right from stock. So it's easy to put a little beauty in your life.

Want some helpful new design information? Ask your nearest AE representative for Circular 1070-B. Or drop a line to the Director, Electronic Control Equipment Sales, Automatic Electric Company, Northlake, Illinois 60164.



AUTOMATIC ELECTRIC

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E

ON READER-SERVICE CARD CIRCLE 78

IC op-amp moderately priced

Amelco Semiconductor, 1300 Terra Bella, Mountain View, Calif. Phone: (415) 968-9241. Price: $46.80 (100 lots).

With a typical input offset of 1.0 V and 20 μA, the 807BE integrated operational amplifier is designed for high-performance applications. The circuit package is TO-5 or 10-pin ceramic flat-pack. Specifications of the devices include a typical common mode input range of ±1 V (V_{cc} = ±15 V) and a typical input impedance of 100 kΩ.

CIRCLE NO. 866

IC counters use J-K flip-flops

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 876-2800. P&A: from $45.05; stock.

J-K flip-flops provide counting rates up to 5 MHz in a line of DTL circuits. The line includes binary counters up to 8 stages of serial counting and a variety of 2, 3, and 4-stage combinations. The in-line packages are assembled on two-sided PC cards with edge-mounted connections. They are designed to be incorporated directly into data processing and formatting systems, computers, process controllers and display equipment.

CIRCLE NO. 867

General purpose amp sits on a single chip

Amelco Semiconductor, Div. of Teledyne, 1300 Terra Bella Ave., Mountain View, Calif. Phone: (415) 968-9241.

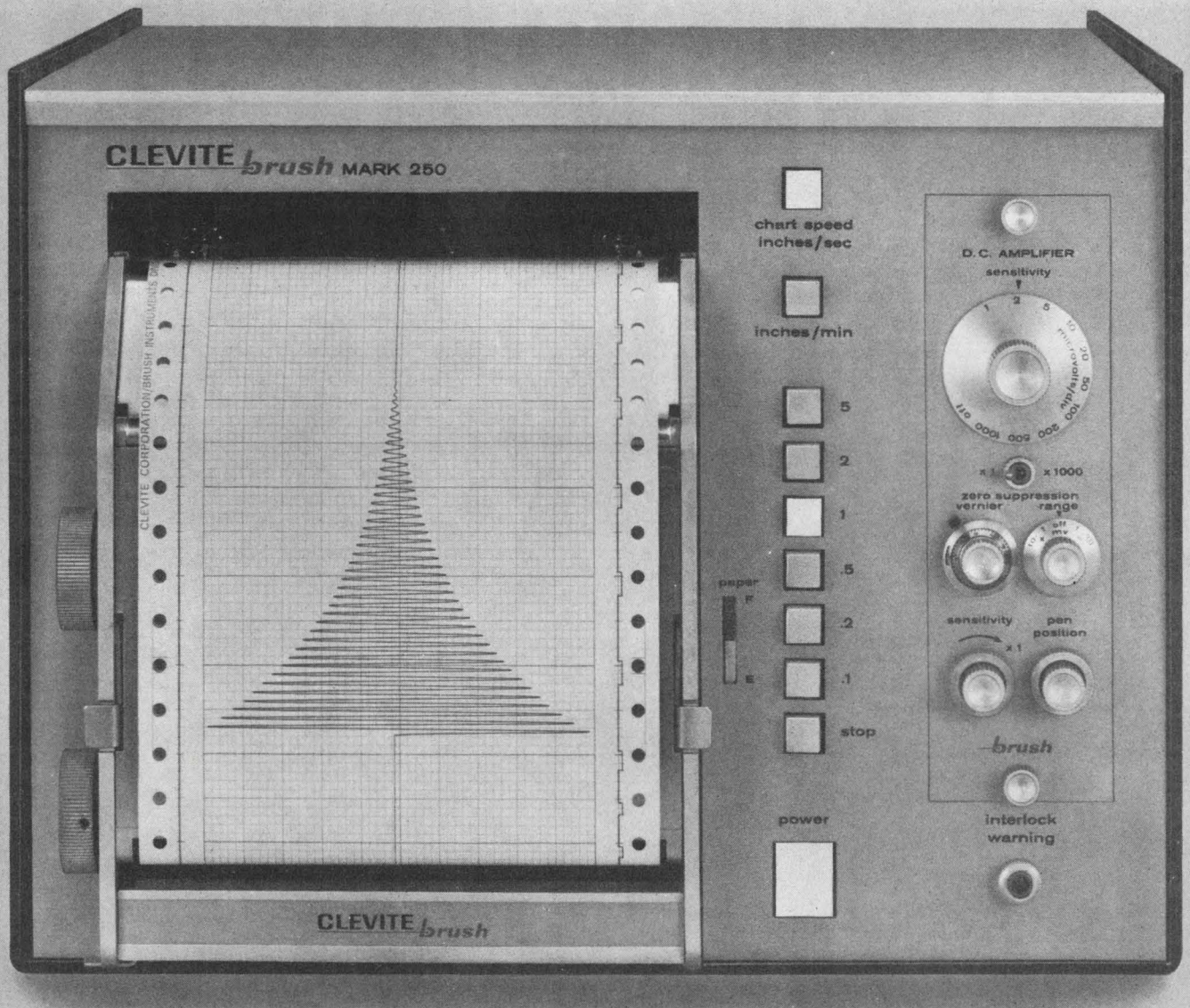
A new general purpose amplifier is constructed on a single monolithic silicon substrate. The amplifier is well suited for applications that require high input impedance, high output voltage swing, high gain, low offset and low drift. Specifications of the unit include an input impedance range from a minimum of 100 kΩ, with 500 kΩ typical; maximum input offset current is 200 nA. Open loop dc gain (no load) is typically 20,000 with 10,000 minimum; open loop bandwidth is typically 10 MHz.

CIRCLE NO. 868

ON READER-SERVICE CARD CIRCLE 80 ➤

Announcing the Brush Mark 250, first strip chart recorder for the perfectionists of the world.

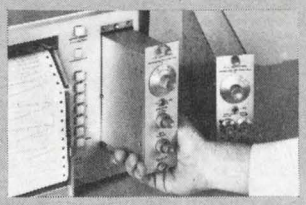
Shown with 1 μv preamplifier RD 4215-70; event markers optional.



Meet the fastest, most accurate strip chart recorder on record: The new Brush Mark 250. When you read about all the features you'll know why we call it the first recorder for the perfectionists of the world!

1 Unmatched frequency response. Flat to 10 cycles on full 4½" span! Useful response to 100 cycles. Nobody has a strip chart recorder in the same league.

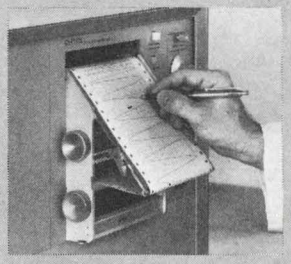
2 Wide selection of signal conditioners. Choose from 21 interchangeable preamps. Use one today; plug in a different one when your recording requirements change.



3 Crisp, clean rectilinear writing. Patented, pressurized inking system puts smudge-proof trace *into* the paper not just on it.

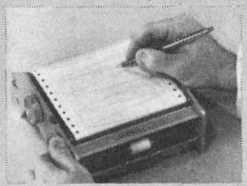
4 Contactless, non-wearing feedback system. Same one used in our multi-channel Mark 200 recorders. (No slide wires!) Accuracy? Better than ½%!

5 Multiple chart speeds. Pushbutton choice of twelve . . . from 5 inches/second to 1/10 of an inch/minute (up to 8 days of continuous recording).



6 Portable or Rack mounting. And either way you get the exclusive new dual position writing table.

7 Removable chart paper magazine. Great for desk top record reviews. Man-sized manual winding knobs let you roll chart forward *and* back. Chart reloading is a cinch.

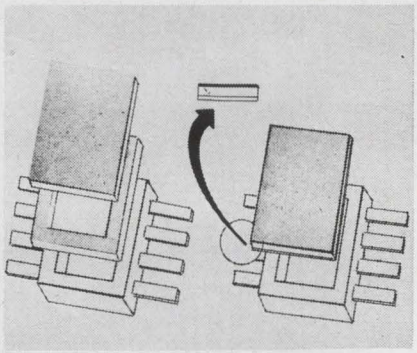


See what we mean? The Mark 250 is for the perfectionists of the world. Ask your Brush Sales Engineer for a demonstration. Or, write for chart sample and specifications. Clevite Corporation, Brush Instruments Division, 37th & Perkins, Cleveland, Ohio 44114.

CLEVITE

brush INSTRUMENTS DIVISION

The Brush Mark 250 First recorder for perfectionists

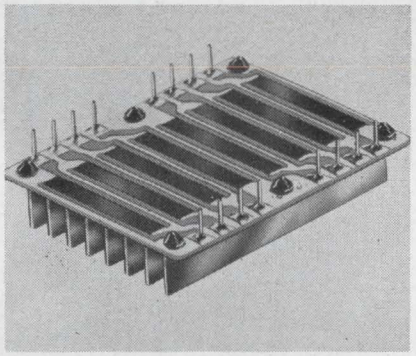


Flat pack covers need one solder joint

Semi-Alloys Inc., 20 N. MacQuesten Pkwy., Mt. Vernon, N. Y. Phone: (914) 664-2800.

Metal covers for sealing IC flat packs eliminate alignment problems and need only one solder joint rather than two as when a preform is used. The lids are Kovar with gold-tin eutectic solder (280°C) clad on one side and pure gold plated or clad on the other side. The covers can be held to a flatness as close as 0.0005-in. Also available are lids with gold-germanium eutectic solder (356°C) clad on one side.

CIRCLE NO. 894

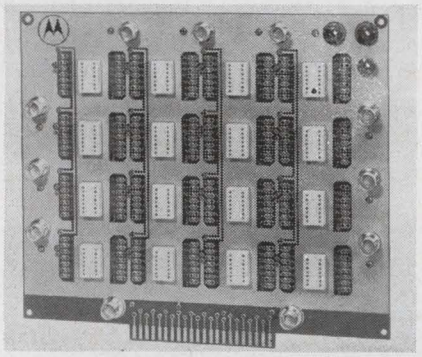


9-W cermet modules give ±1% tolerance

CTS Research Inc., Lafayette, Ind. Phone: (317) 743-9602.

Design simplicity and reduced production costs are cited as features of a resistor module than handles high power over a range of 20 Ω to 1 MΩ. Series 770 is designed for applications requiring a resistive tolerance of ±1% and a TC of ±200 ppm/°C. The modules are cermet with a copper heat sink bonded to an aluminum substrate and are available with up to 24 output pins on 0.125-in. centers.

CIRCLE NO. 895



IC breadboard accepts 14-pin dual in-lines

Motorola Semiconductor Products, P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $140 (over 25); stock.

For use with 14-pin, dual in-line plastic packages, the 16-socket XC73 breadboard permits rapid IC design and evaluation without damaging individual circuits. Little or no soldering is required. Continuous voltage planes on each side provide even voltage distribution and reduce signal crosstalk for high-frequency operation. Eleven BNC coax connectors and one 22-pin edge connector are provided.

CIRCLE NO. 896

100-MHz RF amplifier prices cut to $1.75

Radio Corp. of America, Electronic Components & Devices, Harrison, N. J. Phone: (201) 485-3900. P&A: $1.75; stock.

The price of RCA's CA3005 (100-MHz RF amplifier) IC has been reduced from $3 to $1.75 each in quantities of 1000 and up. The CA3005 is operable over a frequency spectrum from dc to over 100 MHz, and over a temperature range from −55 to 125°C. It can be used for mixer, limiter, modulator, agc, detector, wideband and narrowband amplifier, RF, IF, and video amplifier and cascode-amplifier applications. Typical characteristics are: 20-dB cascode power gain at 100 MHz, 16-dB differential power gain at 100 MHz, 101-dB common-mode rejection ratio at 1 kHz and −60-dB agc range at 1.75 MHz. The linear ICs are packaged in a TO-5 case.

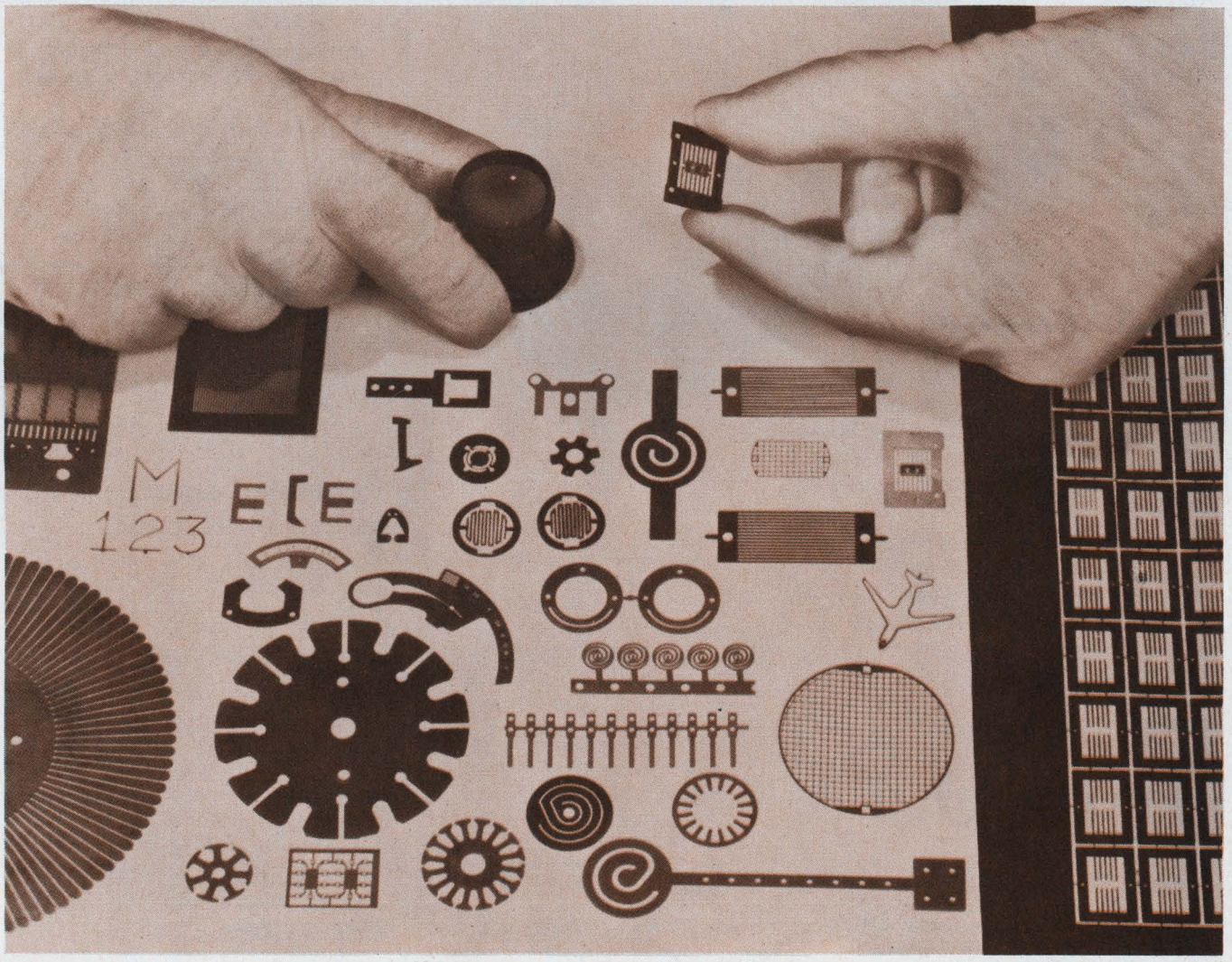
CIRCLE NO. 897

CHEMICALLY MILLED MAGNETIC LAMINATIONS & SMALL METAL PARTS

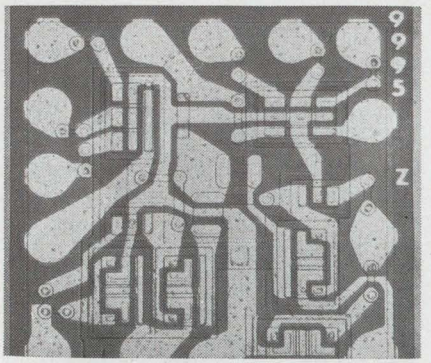
Chemical milling permits faster delivery of prototypes and far lower re-designing costs. The process produces flat, thin, burr-free, close tolerance parts which are too thin to produce by normal stamping methods.

Typical precision metal parts in gages from 0.0002" to 0.020" include miniature transformer and recording head laminations, mechanical and semiconductor strain gages, micromodules with integrated circuitry used in the new flat packs, metal and glass masks used for semiconductor product manufacturing, electrical motor laminates and electrical contacts. Other precision devices made by this process are tube grids and CRT screens, alpha-numeric symbols and letters for electronic display tubes and devices, light attenuation masks (optical filters) and photographic shutters. The process also lends itself to fabrication of small metal parts using non-magnetic materials such as Beryllium Copper, Tungsten, Kovar and Alloy 52.

ARNOLD
SPECIALISTS in MAGNETIC MATERIALS
THE ARNOLD ENGINEERING COMPANY, Main Office: MARENGO, ILL.
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES



ON READER-SERVICE CARD CIRCLE 82



Dual RTL ICs shrink digital systems

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $10 to $10.70 (100 to 999); stock.

A family of multiple complexity dual RTL ICs consists of four planar epitaxial monolithic circuits. They feature high noise immunity (300 mV), low propagation delays (12 ns) and positive NOR or negative NAND logic, hermetically sealed packaging and military or industrial temperature range capability.

Units include a quad 2-input gate (9991), a quad 2-input expander (9992), a dual 2-input gate and dual expander (9993) and a dual buffer, dual 3-input gate (9995). They are rated over −55 to 125°C in the 1/4 x 1/4-in. flat pack and over 0 to 70°C in the ceramic dual in-line package. The entire family is designed for system operation with supply voltage of 3 V ±10%.

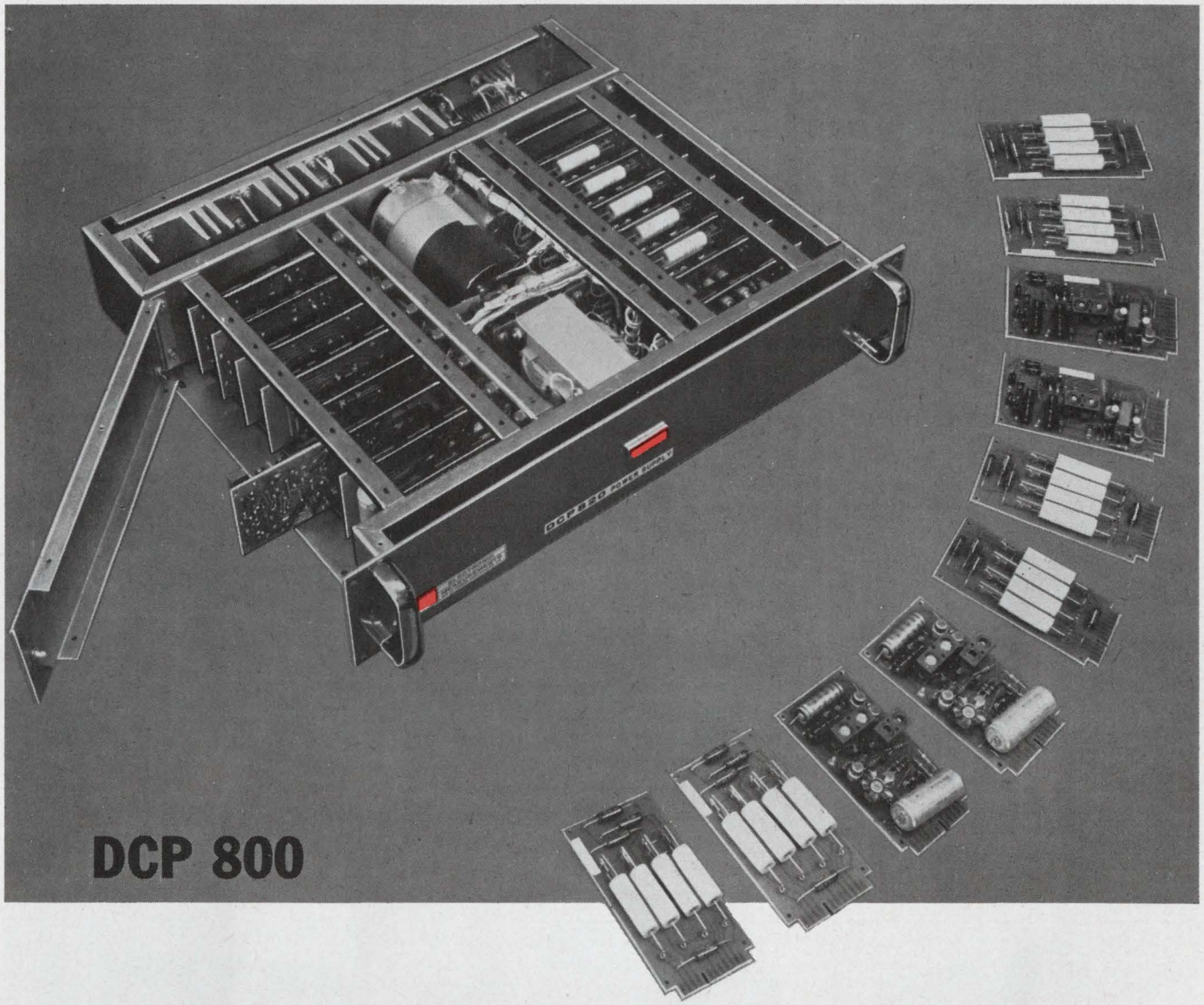
CIRCLE NO. 147

Regulated sources mount on IC cards

Dressen-Barnes Electronics Corp., 250 N. Vinedo Ave., Pasadena, Calif. Phone: (213) 795-7731.

A simple way to distribute regulated dc to IC cards is offered by 250 series regulators. The 1.5 x 2 x 3-in. units mount directly on the cards and the power distribution system handles only unregulated dc. Output ratings up to 3 A are available. Voltage regulation is to 50 mV for a 10-V change. Voltage ripple is reduced 100 to 1 min with 200 to 1 cited as typical.

CIRCLE NO. 148



The DCP 800 Power Supply is a high performance, solid state DC power supply with exceptional versatility. It is a digitally programmed unit suitable for automatic test equipment. It provides automatic crossover from regulated voltage to regulated current.

POWER INPUT:

105-125 Volts — 50-63 cps — single phase.

CONTROL INPUT:

Voltage — Binary Coded Decimal Five Digit Programming in 1 mv steps.
Current — Binary Coded Four Digit Programming in 1 ua steps with 10 to 1 and 100 to 1 range expansion. The DCP-812 only has a 10 to 1 range expansion.
Excitation — Provided by 24 Volts to Reed Relay Input Circuit.

OUTPUT:	**DCP-812**	**DCP-813**	**DCP-814**	**DCP-820**	**DCP-821**
Voltage	0-100V	0-50V	0-100V	0-.50V	0.100V
Current	0-0.1A	0-1A	0-1A	0-0.5A	0-0.5A

ABSOLUTE VOLTAGE ACCURACY: 0.1% or 1.5 mv. Includes:

Line regulation measured for an input voltage step change of 105-125 Volts at 50-63 cps.
Load regulation measured for a no load to full load or full load to no load change within range.
Stability for 8 hours after 30 minutes warm-up.

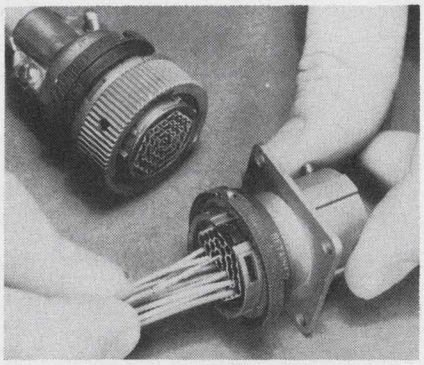
ABSOLUTE CURRENT ACCURACY: 0.35% or 0.25 uamp. Includes:

Line regulation measured for an input voltage step change of 105 to 125 Volts at 50-63 cps.
Load regulation measured for 100 Volt step change increase or decrease.
Stability for 8 hours after 30 minutes warm-up.

Write for more information.

THE ROWAN CONTROLLER COMPANY • ELECTRONIC MEASUREMENTS DIV.
OCEANPORT, NEW JERSEY 07757

ON READER-SERVICE CARD CIRCLE 84

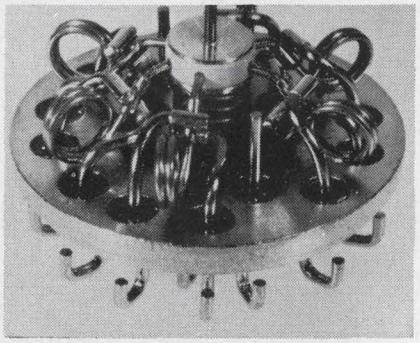


Circular connector needs no retention clips

Amp Inc., Harrisburg, Pa. Phone: (717) 564-0101.

Rotating a ring on the rear of the CH-AMP connector simultaneously locks all of its contacts against a rated minimum of 15 pounds push-out force. The design also permits contact release and extraction without tools. The size 16 shell CH-AMP houses 58 #22 contacts on a 0.085-in. spacing. A single insert accepts AWG #22 to #30. Another insert accepts either submin coax or wire sizes from AWG #16 to #20.

CIRCLE NO. 149

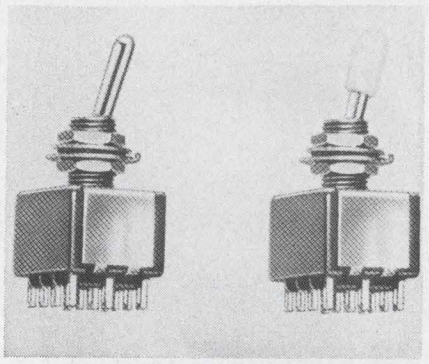


'Wedge-action' relays miss once in 10 million

Electro-Tec Corp., P. O. Box 667, Ormond Beach, Fla. Phone: (305) 677-1771.

"Wedge-action" relays boast a failure rate of one in 10 million cycles. Contact resistance is 0.012 to 0.015 mΩ, constant within 15 mΩ for more than 100,000 operations. In the "Wedge-action" design, each moving contact is mounted between two stationary contacts. They drive into the stationary contacts, developing a positive wedge/wipe action that increases contact pressure during overtravel.

CIRCLE NO. 152

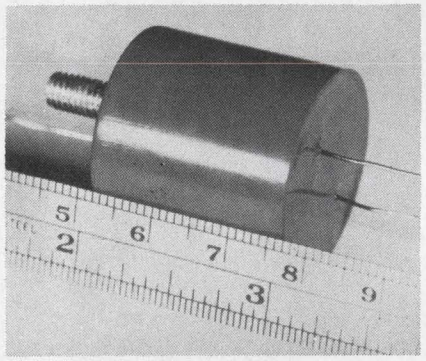


Submin 4pdt toggles 40,000 times

C&K Components Inc., 103 Morse St., Watertown, Mass. Phone: (617) 926-0800.

In data processing, communication and computer systems applications, model 7401 submin toggle switch is rated for a 40,000-cycle minimum life. Bat-handle operating levers are standard for the model but plastic caps in 10 colors are available. Initial contact resistance is 20 mΩ at 2 to 4 dc, 1 A. Contact rating is 5 A resistive and contacts and terminals are coin silver.

CIRCLE NO. 154

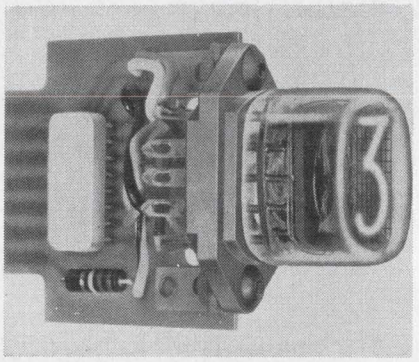


Current regulator operates in series

Electronic Modules Inc., 2560 E. Foothill Blvd., Pasadena, Calif. Phone: (213) 795-4231. P&A: $20 to $36; 2 to 3 wks.

Operating in series with the current line, a new constant-current regulator needs no reference to ground. The unit is all silicon solid state. Temperature coefficient is 0.03%/°C, threshold is at 8 V, current stability to voltage change is 1% and max power dissipation is 8 W. Current level is factory set to 50 to 250 mA ±1%.

CIRCLE NO. 151

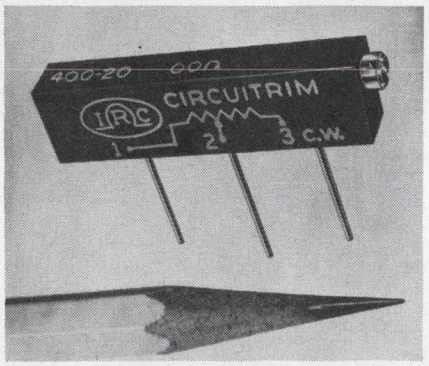


Decoder/driver modules use TTL integrateds

National Electronics, Inc., Geneva, Ill. Phone: (312) 232-4300.

Considering its scarcity, control-panel space seems a logical place for IC logic. Following this line, the NL-M100 decoder/driver and NL-M201 decimal counter/driver use monolithic TTL logic. The M100 decodes 4-line BCD signals and drives a numerical read-out tube. The M200 is a 15-MHz decimal counter that displays directly on its read-out tube. Both require 200 V for tube drive and accept logic 1 voltage 5 V with logic 0 at ground.

CIRCLE NO. 153



MIL-R-27208 wirewound size reduced by 30%

IRC Inc., 401 N. Broad St., Philadelphia. Phone: (215) 922-8900. P&A: $3.56 (100 lots); 4 wks.

Without sacrificing MIL-R-27280 specs, the "thin-line" type 400-20 wirewound trimmer represents a 30% size reduction over the manufacturer's present RT-11 military style. The trimmer has offset PC pins and is completely interchangeable with the RT-11. Type 400-20 is available from 10 Ω to 50 kΩ with a ±5% tolerance and is rated 1 W at 70°C.

CIRCLE NO. 155

ON READER-SERVICE CARD CIRCLE 85 ➤

INSTRUMENTATION SPECS in 250 KC tape recording

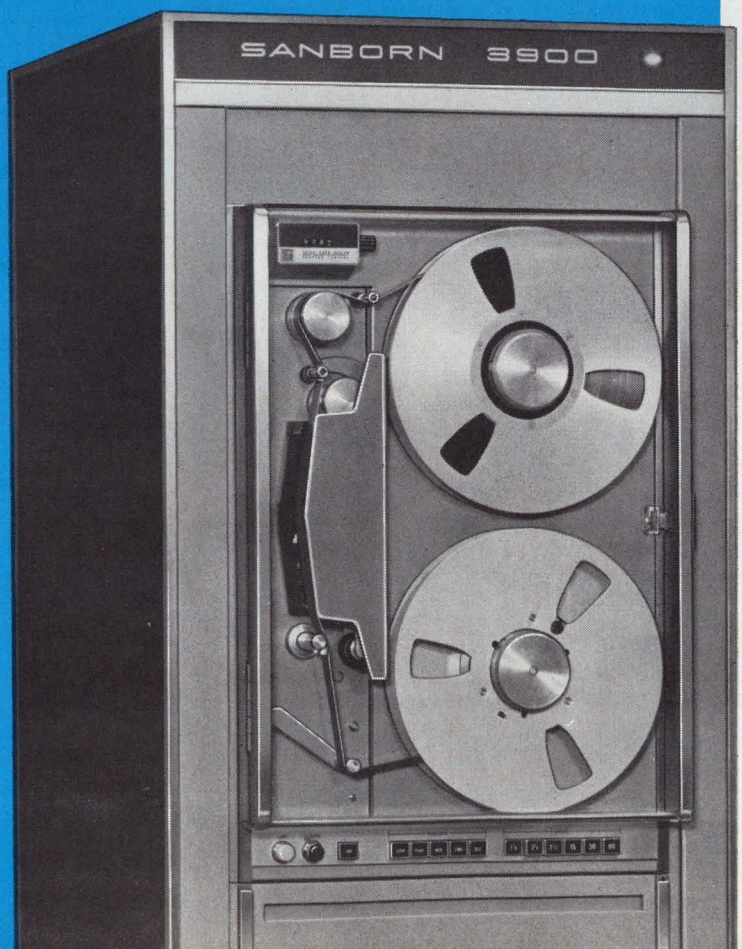
...now start at under $9966

(7 CHANNELS, 6 SPEEDS, DIRECT MODE)

The design approach that made possible Sanborn true IRIG *instrumentation* performance at *lower cost* in low bandwidth tape recording is now available in intermediate band systems. Sanborn Models 3917B and 3924B 7- and 14-channel systems record and reproduce data up to 250 kc in direct mode, to 20 kc in FM mode. Pulse mode enables digital information as short as 2 μsec wide to be recorded and reproduced. *A complete 6-speed system ready for direct recording/reproducing costs $9966 for 7 channels, $15,977 for 14 channels.* (Same systems may be ordered with fewer tape speed plug-ins, at correspondingly lower costs.)

These new systems have the same improvements in performance, reliability and operating ease as the low bandwidth models, for instrumentation tape recording with complete IRIG compatibility. The tape transport, key to superior system performance, is of a rugged and simple Hewlett-Packard design which reduces costs without sacrificing uniform tape motion; six electrical speeds are pushbutton-selected (1⅞ to 60 ips) without idler or capstan change. Other standard features include provision for edge track for voice commentary, adjustable input/out levels, built-in 4-digit footage counter accurate to 99.95%, and easy snap-on reel loading. The transport needs no maintenance except occasional cleaning of the tape path.

Check the system specifications here and call the H-P Field Engineer in your locality for complete technical data and application engineering assistance. Offices in 48 U.S. and Canadian cities, and major areas overseas. Sanborn Division, Hewlett-Packard Company, Waltham, Massachusetts 02154. Europe: Hewlett-Packard S.A., 54 Route des Acacias, Geneva, Switzerland.



representative specifications

DIRECT MODE

Tape Speed	Bandwidth	Frequency Response	S/N Ratio Filtered	Minimum RMS Unfiltered
60 ips	300-250 KC	±3 db	35 db	29 db
15 ips	100-62.5 KC 300-44 KC	±3 db	32 db 38 db	27 db
1⅞ ips	50-7 KC 300-5 KC	±3 db	30 db 39 db	26 db

**Measured with bandpass filter at output with an 18 db/octave rolloff*

FM MODE

Tape Speed	Bandwidth	Frequency Response	FM Center Carrier Frequency (Nominal)	S/N Ratio* Without Flutter Comp.	Total Harmonic Distortion
60 ips	0-20 KC	+0, −1db	108 KC	45 db	1.5%
15 ips	0-5 KC	+0, −1db	27.0 KC	45 db	1.5%
1⅞ ips	0-625 cps	+0, −1db	3.38 KC	40 db	1.8%

**Noise measured over full bandwidth, min. rms at zero freq. dev., with lowpass filter placed at output. Filter has 18 db/octave rolloffs.*

TAPE TRANSPORT

Maximum Interchannel Time Displacement Error: ±1 microsecond at 60 IPS, between two adjacent tracks on same head.

Tape Speeds: 60, 30, 15, 7½, 3¾, 1⅞ ips standard; 0.3 to 120 ips optionally available.

Tape: 3600 feet, 1.0 mil, ½" (7 channel), 1" (14 channel).

Controls: Line (Power), Stop, Play, Reverse, Forward (fast) and Record are pushbutton relays. A receptacle at the rear of the transport is provided for remote control operation.

Drive Speed Accuracy: ±.25%.

FLUTTER

Speed	Bandwidth	Flutter (p-p)
60 ips	0-200 cps 0-10 KC	0.2 % 0.6 %
30 ips	0-200 cps 0-5 KC	0.2 % 0.8 %
15 ips	0-200 cps 0-2.5 KC	0.25% 0.6 %
7½ ips	0-200 cps 0-1.25 KC	0.5 % 0.65%
3¾ ips	0-200 cps 0-625 cps	0.5 % 0.8 %
1⅞ ips	0-200 cps 0-312 cps	0.8 % 1.2 %

HEWLETT PACKARD hp SANBORN DIVISION

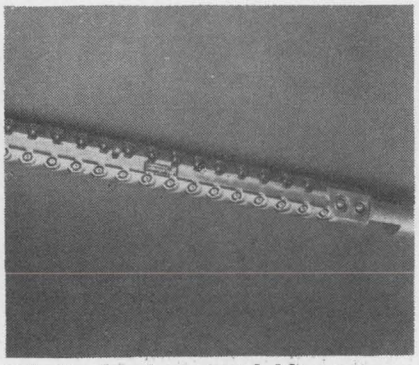
Solid-state device converts for sin, cos

Transmagnetics Inc., 134-08 36th Rd., Flushing, N. Y. Phone: (212) 539-2750. Price: $350.

As a replacement for mechanical resolvers and synchro computing servos, Model 670 function generator responds to dc inputs representing angles of 380° of arc. Output is ±10 Vdc, proportional to the sine and cosine of the input. Conformity is rated better than 15 minutes.

Among other applications cited for the unit are replacement for a conventional sine-cosine pot, coordinate axes rotation and rectangular/polar transformations.

CIRCLE NO. 156

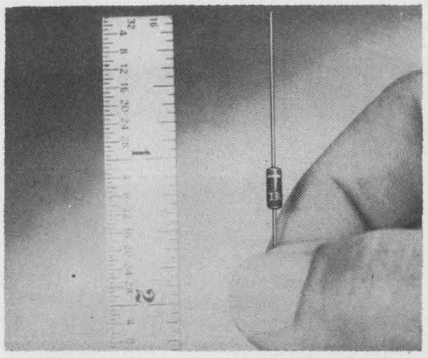


Digital phase shifter for 1500-W S-band use

Microwave Associates, South St., Burlington, Mass. Phone: (617) 272-3000.

An array of these digital phase shifters replaces conventional electromechanically driven antennas. The MA-8357-8S1S features reciprocal operation and high power capability at 15-kW peak and 500-W average operating power levels with a burnout level of 30 kW. Phase accuracy is maintained at ±3° and bandwidth is 10% within any 2- to 4-GHz range. Pin diodes are mounted iteratively and switched in combinations to provide a maximum of 360° phase shift in a minimum of 22.5° increments. Insertion loss is 2 dB max and 1.5 dB average; vswr is 1.35 max and 1.15 average.

CIRCLE NO. 157

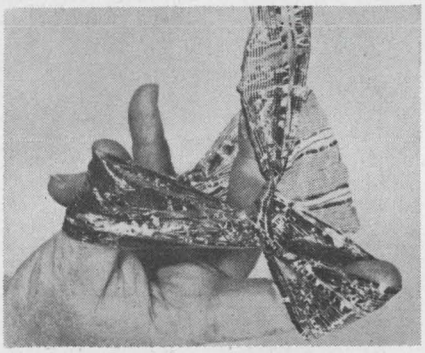


1-W glass zeners are lifetime guaranteed

International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281. PA: $0.73 &(100 to 999); stock.

Glass zener voltage regulators G3 through G12 are designed for regulator and other applications where stable long-term operation is required. The glass configuration offers small size (DO-7) for high density packaging applications. The 1-W voltage regulator series offers a nominal zener voltage range from 3 to 12 V with tolerances of ±20, ±10 and ±5%.

CIRCLE NO. 158

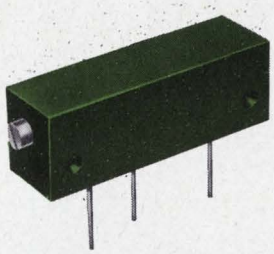


Thin-clad laminates for knotty problems

G. T. Schjeldahl Co., Electrical Products Div., Northfield, Minn. Phone: (507) 645-5633.

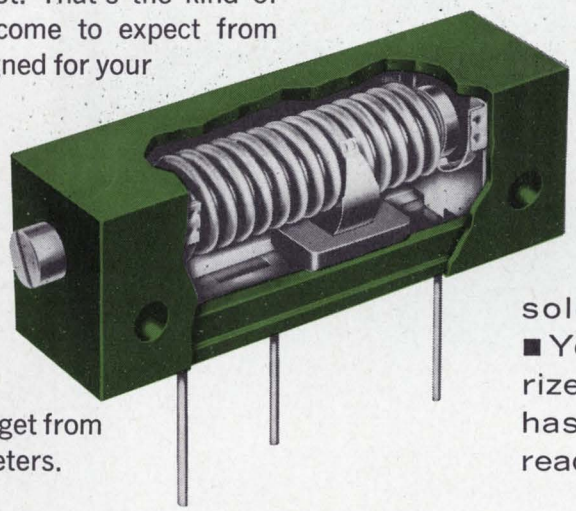
While most circuit routings are somewhat simpler, these ultra-thin laminates could be tied in knots without breaking their electrical integrity. The laminates are 0.5-oz. electrodeposited or hard-rolled copper on polyester film from 0.001 down to 0.00015-in. thin. Dielectric strength for the 0.0015 film is 1500 V.

CIRCLE NO. 159



what's in it for you?

Just this... 15 times the winding length and 10 times the resolution in the Clarostat Series 76JA Trimming Potentiometer... and it looks and mounts like any ordinary trimmer pot. That's the kind of superb engineering you've come to expect from Clarostat. Naturally, it's designed for your needs; production time is reduced by eliminating critical mechanical settings, and you enjoy more mechanical freedom than with bulky multi-turn pots. Completely interchangeable with other trimmers. But most important... resolution is ten times better than you can get from ordinary trimming potentiometers.

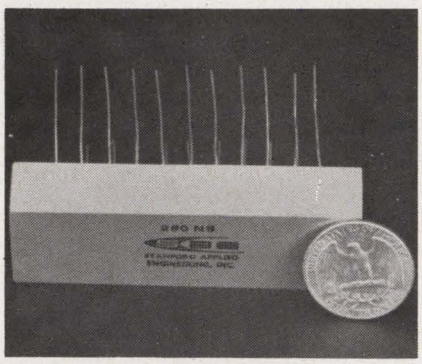


SPECIFICATIONS: Mechanical Travel: 12 turns approximate; ■ Effective travel: 11 turns (±¼); ■ Resistance Range: 100 ohms to 20,000 ohms; ■ Resistance Tolerance: ±5%; ■ Power Rating: .75 watts @ 85°C. derated linearly to zero power @ 150°C. ■ Available with printed circuit or solder lug terminations. ■ Your local Clarostat Authorized Industrial Distributor has the Series 76 in stock ready for immediate delivery.

CLAROSTAT

CLAROSTAT MFG. CO., INC. DOVER, NEW HAMPSHIRE

ON READER-SERVICE CARD CIRCLE 87

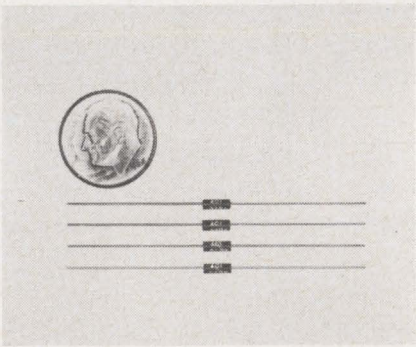


Tapped delay lines solidly encapsulated

Stanford Applied Engineering, 340 Martin Ave., Santa Clara, Calif. Phone: (408) 243-9200.

Optimum pulse performance from the S-series tapped delay lines is said to be provided by a careful adjustment of phase and amplitude characteristics. Though no larger than your thumb, the components meet the requirements of MIL-STD-202A. Typical specs run; 250-ns delay within ±10 ns, max rise of 25 ns, bandwidth of 16 MHz and working voltage at 300 Vdc.

CIRCLE NO. 138

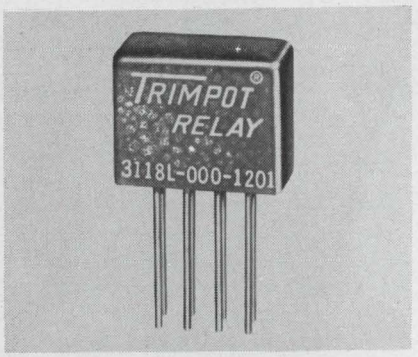


MIL-C-11015C capacitor stands X15 overvoltage

American Components Inc., 8th Ave., at Harry St., Conshohocken, Pa. Phone: (215) 828-6240.

Voltage breakdown is said to run as high as 15 times the rated voltage of the ceramic C-02 capacitor. The component is molded uniformly for use in automatic-insertion equipment and specifications meet MIL-C-11015C. Capacity ranges are from 100 to 2200 pF and 2700 to 470 pF at 100 and 50 V respectively with operating temperatures from −55 to 125°C.

CIRCLE NO. 139

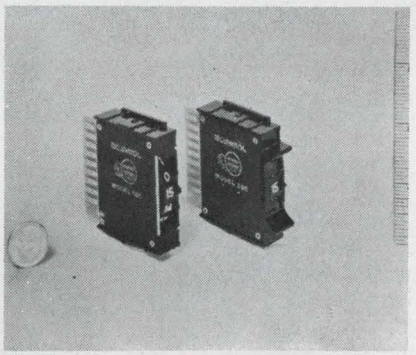


Submin industrial relay meets MIL-R-5757D

Bourns Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700.

Though designed as a low-cost industrial relay, the model 3118 meets the environmental specs of MIL-R-5757D. The 1/6 crystal-can relay also features a balanced armature design, rated for 50-G shock and 10-G vibration. Action is dpdt with a contact rating of 1 A and a pick-up sense of 200 mW max. Operating temperature range is −25 to 85°C in an unsealed plastic enclosure.

CIRCLE NO. 140

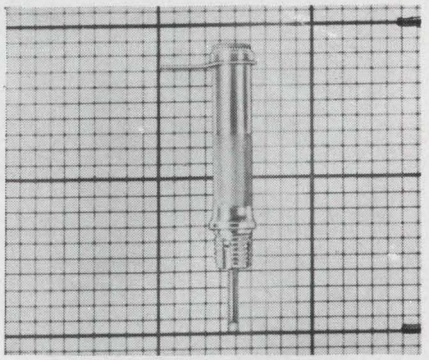


Rotary thumbwheel indexes 16 positions

Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Ana, Calif. Phone: (714) 547-5651.

An indexing system of sixteen 22.5° positions is the latest addition to the manufacturer's 200 series. Compatible wheel marking permits this switch to be used with 8, 10 and 12-position switches of the same line. All standard options of the series apply to the new addition as well.

CIRCLE NO. 141

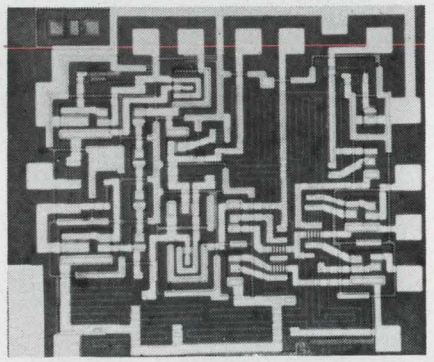


Infinite resolution pot has vernier-lead screw

Waters Mfg. Inc., Boston Post Rd., Wayland, Mass. Phone: (617) 358-2777.

Infinite resolution with a vernier lead screw adjustment is provided by the RM11 rectilinear trimmer potentiometer. Based on a thin-film resistance element, MystR, the units provide resistance ranges from 500 Ω to 50 kΩ at ±10% and from 51 kΩ to 1 MΩ at ±20%. They are housed in plastic casings and have neither pressure or solder connections.

CIRCLE NO. 142



Tuning-torque varies in piston capacitors

Cambridge Thermionic Corp., of Canada, Ltd., 144 Ronald Dr., Montreal West P. Q., Canada.

A tensioning device varies the tuning-torque of a line of glass-piston capacitors, allowing easy tuning but preventing subsequent detuning by shock or vibration. Max above-the-board mounting height of the components is 1.235-in. Capacitive ranges run 2.5 to 9 pF to 2.5 to 60 pF. Suggested applications are in the areas of instrumentation, communications and systems.

CIRCLE NO. 143

ON READER-SERVICE CARD CIRCLE 91 ➤

Put out because you can't get a reliable 10 amp magnetic latch relay? Next time call Leach!

Our 10-amp, 2 pdt, CL Series is just the answer. Of course we can't deliver bundles right now (it's just going into production), but we can meet your prototype requirements. And immediately.

This relay not only meets MIL-R-5757, but it's been tested against all your previous magnetic latch relay complaints. And it more than stands up to all of them.

For example, the CL magnetic assembly is a closed loop design which minimizes interaction with magnetic fields or other relays. And it only takes a 15*m*sec pulse to switch and hold—no continuous power is required

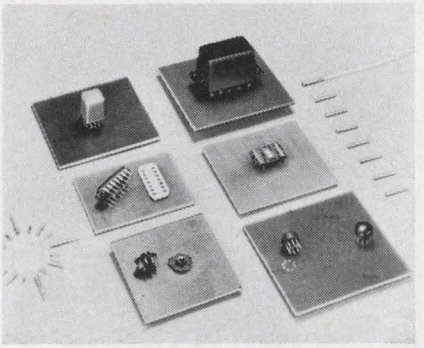
It's the smallest (1.100 high). The lightest (1.6 oz.). And directly interchangeable with other magnetic latch relays.

The CL Series is rated at 50g shock; 30g at 2000 cps vibration. Pretty tough. And construction is all welded and sealed, contaminant free, with an electron beam.

So don't be soured by other types you might have tried. Order ours. You'll get them. No ifs, ands, or . . .

Call Leach Corporation, Relay Division, 5915 Avalon Blvd., Los Angeles, California 90003.
Phone Area code (213) 323-8221
Export: LEACH INTERNATIONAL, S. A.

LEACH

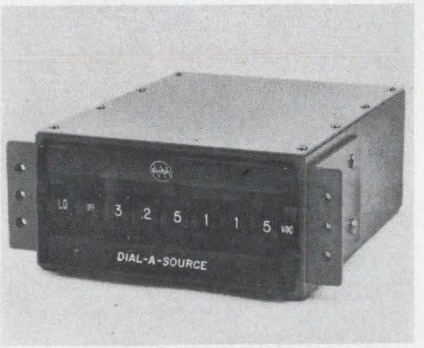


IC spring sockets aid packing, handling

Amp Inc., Harrisburg, Pa. Phone: (717) 564-0101.

Those bendable IC leads are the target of a new type of packing and testing socket from Amp. For dual in-line and TO-5 modules, the A-MP miniature spring sockets can be installed directly in PC laminates. A "funnel-mouth" closed-entry lip feature is offered to ease the insertion problem. When the device is seated in the socket, the insertion lip acts as a stop.

CIRCLE NO. 144



Precision resistor adjustable in-circuit

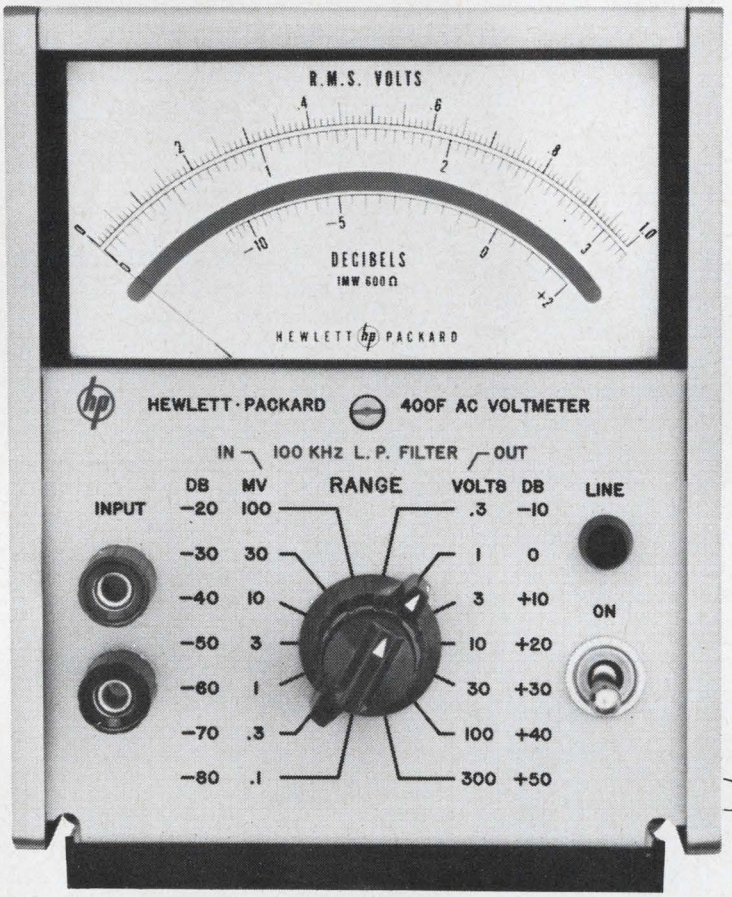
Radio Products International, 1501 S. Hill St., Los Angeles, Calif. Phone: (213) 746-0325.

Sometimes you need a little "fudge-factor" in a circuit and the "VariZitor" can provide just that. This precision resistor varies its resistance ±20% as the housing is moved, wiping across the internal resistance element. Once set, the resistance value can be fixed by simple nail polish, soldering or encapsulation. 42 models are available with center ratings from 0.5 Ω to 1 MΩ.

CIRCLE NO. 145

(components continued on p. 184)

100 μv full-scale sensitivity from this new 20 Hz-4 MHz solid-state ac voltmeter



- 100 μv sensitivity—for unprecedented low-level ac measurements
- Fast response—a reading in less than 2 seconds after turn-on; fast overload recovery, too
- 80 db low-noise amplifier, 1 v f. s. output, all ranges
- Accuracy ½% of reading + ½% of full scale
- Low-pass filter for controlling bandwidth of noise
- 10 Meg input impedance for minimum circuit loading (10-25 pf capacity)
- Uses all Hewlett-Packard accessories, such as current shunts, voltage dividers
- Special meter scales available for db measurements

The highest level of performance available today is yours with the new hp 400F/FL General-Purpose AC Voltmeters. Measure 100 μv to 300 v full scale on an individually calibrated linear meter that lets you measure as low as 10 μv with 1 μv resolution. The 400FL, $285, offers a *linear* 12 db log scale with accuracy of 1% of reading. Specified accuracy of the 400F is ½% of reading plus ½% of full scale. The 400F, Option 01., puts the db scale uppermost for greater db resolution ($10 extra).

As a low-distortion amplifier, the 400F/FL has a noise spec <5 μv referred to input, typically 3.5 μv. The instrument can be battery operated through rear-panel terminals. The 1 v ac output is available on all ranges.

The low-pass 100 kHz filter, activated by a front-panel switch, reduces the effect of unwanted high frequencies for low-level audio measurements. The 11074A Voltage Divider Probe (10:1) is available.

The front panel shows the ease of use that's yours with this truly state-of-the-art ac voltmeter. Ideal for low-level audio, servo, communications measurements . . . one instrument for the widest variety of applications. For complete specifications . . . or for a demonstration . . . call your Hewlett-Packard field engineer. Or write Hewlett-Packard, Palo Alto, Calif. 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

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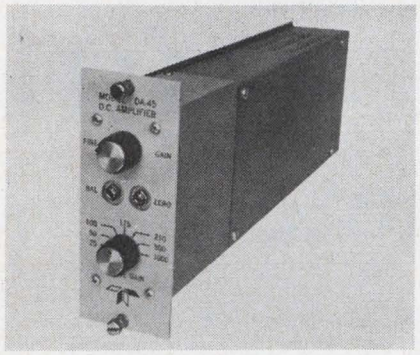
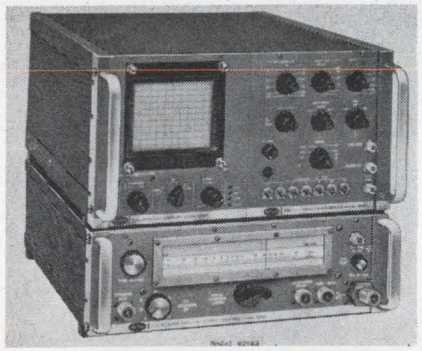
ON READER-SERVICE CARD CIRCLE 93



Dc amplifier has automatic gain switch

Teledyne Telemetry Co., 12964 Panama St., Los Angeles. Phone: (213) 398-6229.

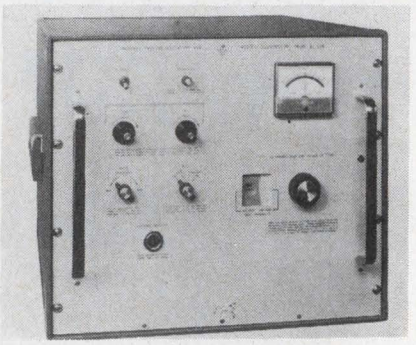
In data acquisition systems measuring input signals over a wide dynamic range, the DA-45 dc amplifier automatically ranges its gain in three discrete steps. This automatic stepping operation allows the amplifier gain to remain known at all times, aiding in the reduction processing. These amplifiers are direct-coupled and accept inputs in the 10- to 400-mV range. Bandwidth is 200 kHz. **CIRCLE NO. 160**



Spectrum analyzer covers 10 MHz to 40 GHz

Polarad Electronic Instruments, 43-20 34th St., Long Island City, N. Y. Phone: (212) 392-4500. P&A: $6300; 30 days.

With primary accent on price, the model 2882 spectrum analyzer covers applications in the 10- to 40-GHz range with nine dispersion ranges from 10 kHz to 100 MHz. The instrument is modular in design and compatible with the seven other types in the manufacturer's line. Among the important features of the 2882 are its automatic bandwidth selection and calibrated crystal markers. **CIRCLE NO. 161**

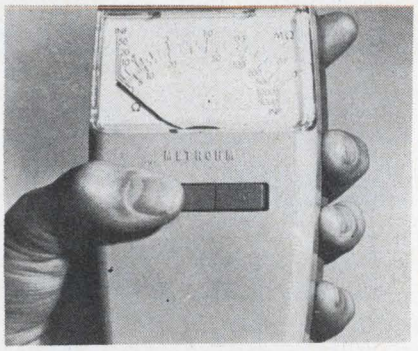


Phase/time detector uses signal comparison

Ad-Yu Electronics Inc., 249-259 Terhune Ave., Passaic, N. J. Phone: (201) 472-5622. Price: $3575 and $3985.

Using signal comparison rather than conventional detection, 206B3-4 phase and time detectors are said to avoid errors due to meter lag and circuit-element tolerance. One input is shifted 90° by a variable waveguide delay line, then fed to a sum/difference net. A second input is fed directly to the net. Isolated sum/difference outputs are rectified and fed into an appropriate null detector. Type 206B3 operates at X-band and 206B4 is Ku-band.

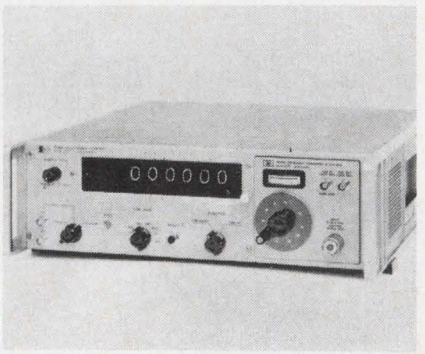
CIRCLE NO. 211



Insulation tester barely a handful

Edgcumbe Peebles Ltd., Prudential House, Wellesley Rd., Croydon, Surrey, England.

An instrument for insulation and continuity measurements, the Metrohm, is packed in a 20-oz. plastic case that fits easily into one hand. By mounting the movement on filaments rather than pivots, the Metrohm withstands an acceleration of 40 G in three planes. Four models are available from 1 kV to 100 V with ranges of 0 to 50 to 0 to 10 MΩ. **CIRCLE NO. 212**



50-MHz counter goes to X-band with plug-ins

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1800; stock.

This low-cost 50-MHz counter can measure to 12.4 GHz with available plug-in heterodyne frequency converters. It has a full complement of gate times from 1 μs to 1 s. The counter can measure directly up to 350 MHz with a prescaler plug-in, operate with a 1-mV sensitivity with a preamp plug-in (basic counter sensitivity is 100 mV), normalize readings with a preset counter plug-in, or measure time intervals from 1 μs to 10^6 s and make digital voltage measurements to 1000 V with two other plug-ins. Input impedance of the dual FET amplifier input is 1 MΩ shunted by 25 pF for all signal levels up to 1 V independent of frequency to 50 MHz. With the constant high input impedance, vswr is low when the input is connected to a terminated line and it is possible to use a scope-type probe when voltage attenuation or a 10-MΩ, 10-pF input is desired.

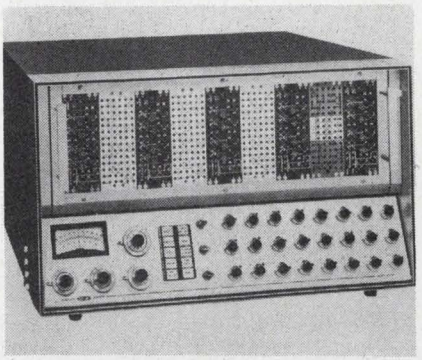
CIRCLE NO. 213

Circuit printer has accuracy to 0.002 in.

Rondec Screen Process Ltd., 134 King St., London W. 6, England.

This machine prints circuits onto ceramic substrates with an accuracy of registration to within ±0.002 in. Each of two lines has a speed of 1500 print strokes/h. The ceramic substrates are loaded into two hoppers and carried along the bed to the print station. Here, they pass over holes in a vacuum plate which, when covered, have a progressive braking effect.

CIRCLE NO. 214

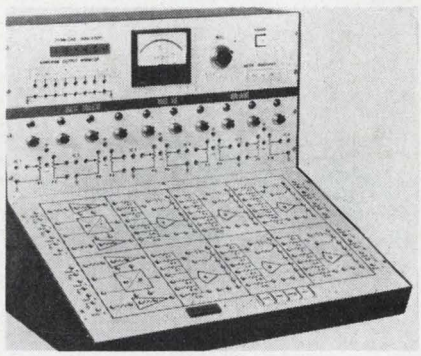


Portable computer expands to 20 amplifiers

Systron-Donner Corp., 888 Galindo St., Concord, Calif. Phone: (415) 682-6161. P&A: $7300 (12 amplifiers); December.

Designed to simplify patching computer circuits to match more sophisticated computers, the ±100-V SD10/20 has built-in digital logic, electronic mode control and slaving capability. The removeable problem board has visual computer circuits to aid new operators. The design permits full trade-in to the larger 84-amplifier SD40/80.

CIRCLE NO. 162

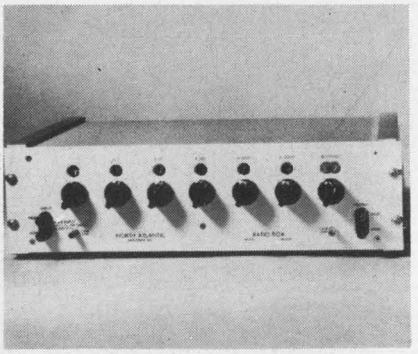


Analog simulator for lab, plant training

Burr-Brown Research Assocs., International Airport Industrial Pk., 6730 S. Tucson Blvd., Tucson, Ariz. Phone: (602) 294-1431. P&A: $3980; 3 to 4 months.

Designed for undergrad courses, Model 600 is also suitable for in-plant training in analog computer techniques. The ± 10-V unit features 10 amplifiers, 2 multipliers, 10 coefficient pots, voltage references and null pot. Two or more computers can be slaved together for problems of greater complexity.

CIRCLE NO. 163



Reactive ratio divider driftless to 1 ppm

North Atlantic Industries Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600. P&A: $890; stock.

Accuracy of the model RB-504T is basically a function of the number of turns of wire on the solidly encapsulated reference element.

The instrument functions similarly to a Kelvin-Varley divider; it is described as the equivalent of an autotransformer with 100,000 taps.

A handy feature of the RB-504T is an optional transformer that provides negative (phase reversed) ratios. When the unit under test has a neutral point, negative ratio capability allows plotting through the phase reversal point.

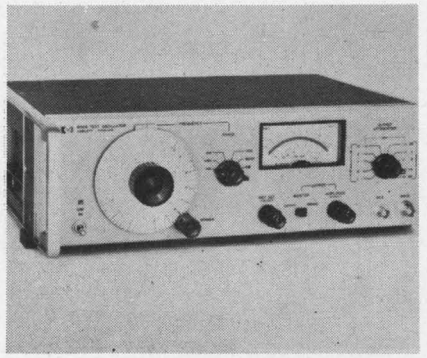
Basic accuracy is rated at 1 ppm, traceable to NBS, and the instrument spans a ratio range of -1.111110 to $+1.111110$ with 0.3-ppm resolution.

Among the features of the unit are relative immunity to tempera ture changes, low output impedance and high input impedance (200 kΩ).

Output impedance rises from a max of 8.5 Ω without the transformer, to a max of 10 Ω when the transformer is introduced. Phase shift with or without the transformer is less than one minute of arc.

Applications include measurement of gain, phase shift, and linearity of amplifiers and repeaters, measurement of attenuation and frequency response of filters and other networks, developing variable ac reference voltages from stable frequency sources and checking resolvers.

CIRCLE NO. 215

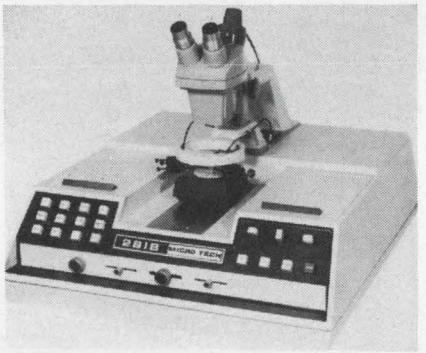


Test oscillator flat ±0.25% 10 Hz to 10 MHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $275; 4 to 12 wks.

Test oscillator 652A is specifically aimed at making quick, accurate wideband measurements. Measurements can be made over a range of 10 Hz to 10 MHz with 0.25% resolution. For quick reading, the uppermost scale is the expanded range, centered on zero. Applications include testing ac voltmeters, TV amplifiers, audio amplifiers, filter nets and tuned circuits.

CIRCLE NO. 216

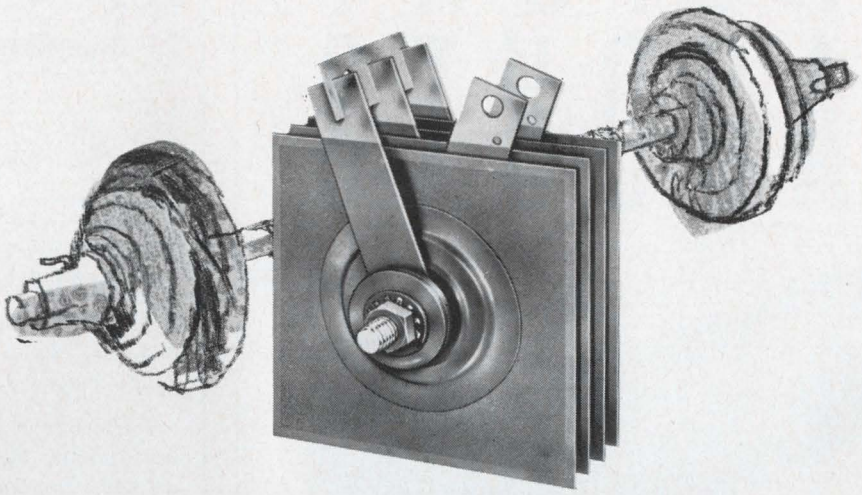


Chip probing system completely automated

Micro Tech Mfg. Inc., 703 Plantation St., Worcester, Mass. Phone: (617) 755-5215.

From first test to completed wafer, semiconductor testing is fully automated by the model 2818 probing system. Operating at four steps/second, it uses a grid-mask and photo detector to position the chip within 0.0002-in. Chips up to 2-in. in diameter can be accomodated. When a negative result is taken, the system punches a card, the card is placed over the wafer and the wafer inked through the punch to mark it.

CIRCLE NO. 217



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The current carrying capability of this new product makes possible reduction in cell sizes never before achieved.

Available in all cell sizes with voltage ratings as high as 45 volts.

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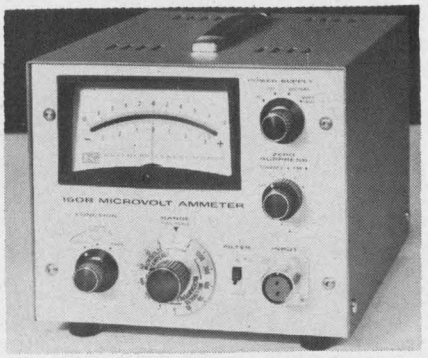
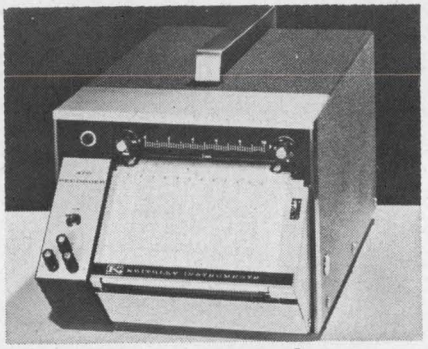


Microvolt-ammeter drifts 0.1 μV/day

Keithley Instruments; 12415 Euclid, Cleveland. Phone: (216) 795-2666. Price: $825.

Particularly useful as an IC lab instrument, model 150B microvolt-ammeter has 14 overlapping voltage ranges from 0.3 μV full-scale to 1 V on a zero-center meter. Meter accuracy is ±2% full-scale and voltage output is ±1%, 1 V or 100 mV. Zero drift is 0.1 μV/day, non-cumulative. As an ammeter, range is 3 x 10^{-10} to 10^{-3} A on 14 ranges with an accuracy of ±3% on the meter and ±2% at the output terminals.

CIRCLE NO. 218

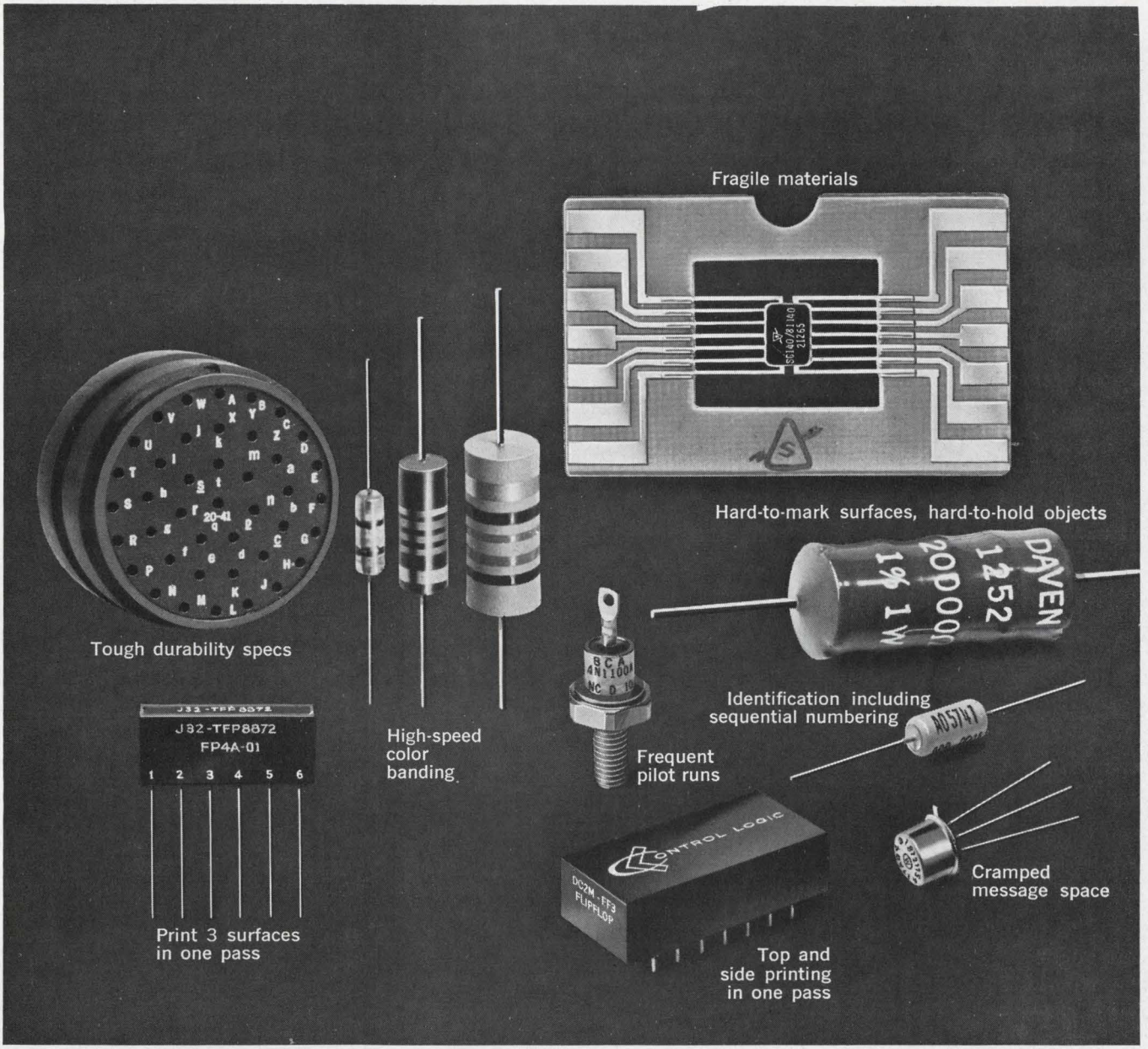


Strip-chart recorder engineered for people

Keithley Instruments Inc., 12415 Euclid Ave., Cleveland. Phone: (216) 795-2666. P&A: $695; 30 days.

Model 370 recorder has its operating controls on the front of the panel, as are the input posts. The chart is driven over a sloped Mylar writing surface. General specs run: ten speeds, 0.5-s response, ±1% of full scale linearity, 6-in. rectilinear chart with an active width of 4.5-in., chassis-to-ground isolation of 10^{10} Ω shunted by 500 pF and a float capability to ±500 V. Input is a minimum 1 V at 1 mA.

CIRCLE NO. 219



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Call in a Markem man and get acquainted with today's broadest line of marking equipment. New high-speed color banding machines — some capable of putting three tiny bands on a miniature diode. Machines that combine sequential numbering with identification. Type so small you can print 14 characters plus trademark in an 0.125″ diameter area. Quick-change type for short or pilot runs. New techniques combining special ink with flash-curing to help you meet severe durability specs. A production-speed imprinter so gentle you can safely mark flat pack ceramic components. And many other machines, specialty inks and printing elements.

Right now our research engineers and chemists are working on even better ways to mark components. We'd like to be working with you. Markem Machine Company, 319 Congress St., Keene, N.H.

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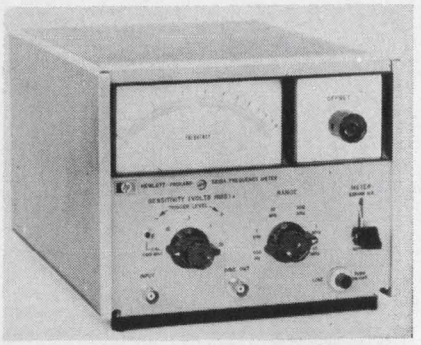
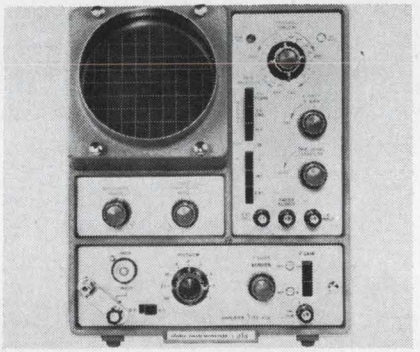


Freqmeter, discriminator functions up to 10 MHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $575; stock.

Rapid frequency deviations in signals can be measured quickly by the 5210A analog frequency meter. The instrument functions as a wide-band discriminator that demodulates signals in the 3-Hz to 10-MHz range at deviations up to 1 MHz. As a discriminator, linearity is over 0.025% of full scale to 100 kHz. Frequency readings are typically 1% accurate with 0.1% accuracy quoted for difference readings.

CIRCLE NO. 220

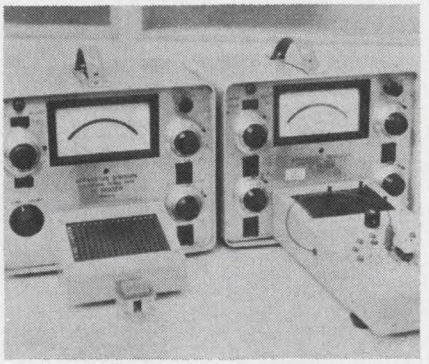


Economy scope ranges to 25 MHz

Data Instruments Div., 7300 Crescent Blvd., Pennsauken, N. J. Phone: (201) 662-3031. P&A: $420 (main-frame), $85 to $170 (amplifiers).

Offered as a low cost addition to the manufacturer's 43 series, the S43a is a general-purpose, single-beam scope for both lab and production applications in the 25-MHz region. The instrument is based on the manufacturer's S43 design. It uses a 4-in. flat-face CRT with an edge-lit graticule and it will accept standard Data Instruments amplifiers.

CIRCLE NO. 221

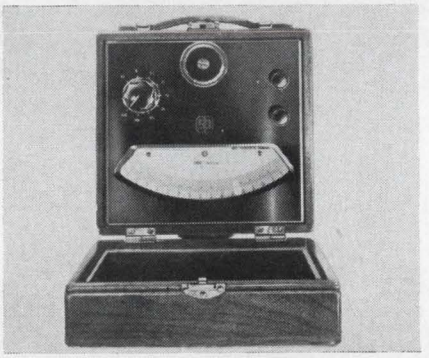


IC tests made with one socket insertion

Continental Device Corp., 12515 Chadron, Hawthorne, Calif. Phone: (213) 772-4551. P&A: $1495; 1 to 4 wks.

A "dynamic" test socket, in conjunction with the manufacturer's integrated circuit testers, allows direct measurements of both response and dc parameters with a single insertion. Frequencies available in the standard ac test head are 1 MHz with 500-μs pulse width, 100 kHz with 1-μs pulse width and 10 kHz with 1-μs pulse width.

CIRCLE NO. 222



Portable ammeter ranges 1μA to 10 A

Greibach Instruments Corp., 315 N. Ave., New Rochelle, N. Y. Phone: (914) 633-7900. P&A: $705 to $840; stock.

A broad range of current measurements from 1 μA full-scale to 10 A full-scale can be made with the model 500VS101-22. The instument incorporates a filament-suspension movement and a non-parallax light beam pointer. Your choice of 0.5% or 0.25% accuracy is offered in the same portable design.

CIRCLE NO. 223

GET SET...

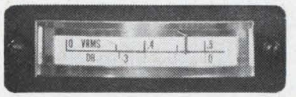
Kay 121-C
500 KHz to 1700 MHz

This solid-state instrument is an electronically swept VHF-UHF wide-sweep and marker generator which accepts a variety of UHF plug-ins to provide extended frequency ranges and sweep widths. With its plug-ins, the 121-C covers a range of 500 KHz to 1700 MHz, offers octave-wide sweeps at low UHF frequencies where most generators in this range are limited to narrow widths. Narrow sweep and wide sweep plug-ins cover special applications such as UHF-TV — full 440 to 920 MHz in a single wide sweep. A digital frequency dial provides smooth center frequency control and remarkable vernier adjustment for narrow sweep operation.

Performance characteristics include line-lock, cw, manual and variable sweep rates, and external input.

External modulation from dc up to more than 15 KHz, a built-in detector and switched attenuator are standard features.

Wide-Sweep



RF OUTPUT... *Set*

0.5 volt rms into 50 ohms
Flat: ± .25 db to 800 MHz
± .5 db to 1700 MHz

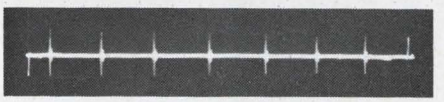
FREQUENCY... *Set*

digital frequency dial;
vernier control at all frequencies

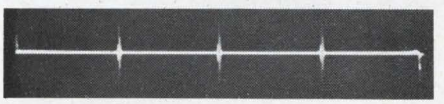
SWEEP WIDTH... *Set*

5 KHz to 500 MHz
VHF: 50 KHz to 300 MHz
UHF: *P-121 — 124 Plug-ins

Marker Generator



harmonic (picket) birdie markers



single-freq. type birdie markers

***P-121:** 200 MHz to 1050 MHz
Sweep: 35 KHz to 350 MHz @ 800 MHz
5 KHz to 50 MHz @ 220 MHz

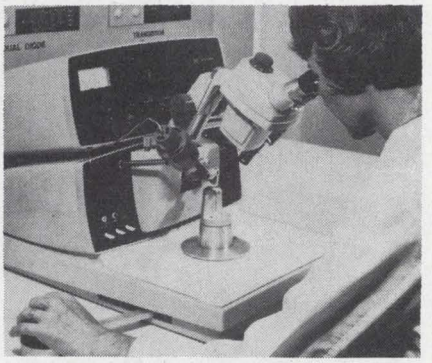
***P-122:** 900 to 1300 MHz
Sweep: 200 KHz to 400 MHz

***P-123:** 100 to 1000 MHz
Sweep: 5 KHz to any octave

***P-124:** 1300 to 1700 MHz
Sweep: 500 KHz to 400 MHz

KAY ELECTRIC COMPANY
Pine Brook, Morris County, New Jersey • (201) 227-2000

ON READER-SERVICE CARD CIRCLE 182

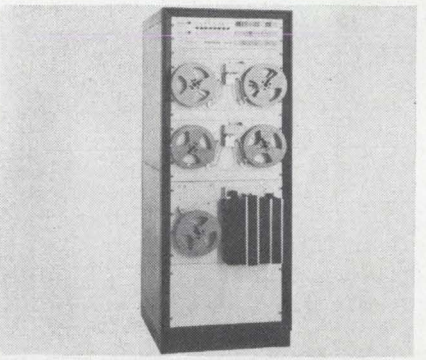


Ultrasonic bonder handles hybrids, ICs

Hughes Aircraft Co., 500 Superior Ave., Newport Beach, Calif. Phone: (714) 548-0671. Price: (without optics) $4100.

Model 2905 production bonder, designed for wire bonding of hybrid circuits, can also handle bonding and die mounting of transistors and ICs. Leading feature is a movable work station which can be manipulated over a 1.1-in. square. Pushbuttons allow the station to be rotated 360° in either direction and templates can be used to locate bonding points rapidly.

CIRCLE NO. 164



Eight-channel tapes verified and duplicated

Tally Corp., 1310 Mercer St., Seattle, Wash. Phone: (206) 624-0760. P&A: $6995; 8 wks.

Whimsically called the "Super-Duper," a perforated tape verification and duplication system handles tapes from one through eight channels in any code structure at a speed of 120 characters/second. The station operates in five different modes: duplicate, verify, verify/duplicate, bit echo/duplicate and bit echo. The system consists of 2 readers, a perforator and logic module.

CIRCLE NO. 165

program your Tektronix Type 561A or 564 oscilloscope for DC-to-15 MHz applications

Here's new convenience for many Type 561A or 564 applications.

You can program the Tektronix oscilloscope for 6 measurement setups—using the new Type 263 Programmer and the Types 3A5 and 3B5 Automatic/Programmable Plug-In Units.

PUSHBUTTON PROGRAMMING

In this mode, both plug-ins can be programmed using the Type 263 Programmer, which accepts up to 6 plug-in type program cards. Each program card, after initial set-up, establishes the plug-in control functions required for a particular test or measurement . . . with actual measurements made conveniently from the CRT display, as usual. Any number of programmers can be cascaded for applications requiring pushbutton control of more than six measurement set-ups. In REMOTE PROGRAMMING mode, the deflection factor is 10 mV/div to 50 V/div and sweep range is 5 s/div to 10 ns/div.

Programmable Functions: **from Type 3A5**—V/div, 10X probe indication, and AC, AC Trace Stabilized, or DC coupling, by program card jumper connection . . . vertical positioning by program card potentiometer setting; **from Type 3B5**—Time/div, X10 or X100 magnifier, trigger mode with coupling, and trigger slope, by program card jumper connection . . . horizontal positioning, trigger level, and magnifier delay, by program card potentiometer setting.

AUTOMATIC SEEKING

In this mode upon SEEK command from the probe or the plug-ins, the oscilloscope automatically presents an optimum display. The SEEK command to the plug-in units automatically adjusts the time and amplitude settings and automatically checks the trigger logic — switching to auto trigger mode, if not correctly triggered, to present a stable display whenever possible. Indicators on the plug-ins light automatically to show the time and amplitude settings. Measurements can then be made quickly and accurately from the CRT display. In AUTOMATIC SEEKING mode, the deflection factor is 10 mV/div to 50 V/div and sweep range is 5 s/div to 0.1 μs/div.

MANUAL OPERATION

In this mode, both plug-ins are controlled conventionally. Indicators on the plug-ins show the time and amplitude settings. In MANUAL OPERATION mode, deflection factor is 1 mV/div to 50 V/div (5 MHz bandwidth at 1, 2 or 5 mV/div and 15 MHz at 10 mV/div to 50V div) and sweep range is 5 s/div to 10 ns/div.

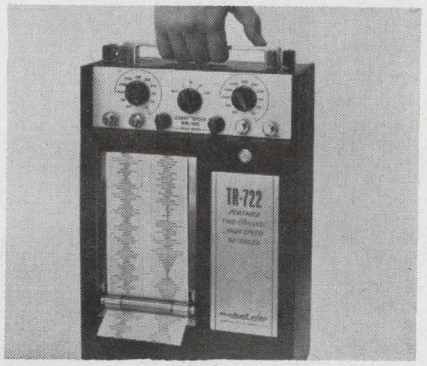
Type 263 Programmer (complete with 6 program cards)	$325
Type 3A5 Automatic/Programmable Amplifier Unit	$760
Type 3B5 Automatic/Programmable Time-Base Unit	$890
Oscilloscopes which accept both Automatic/Programmable Plug-Ins:	
Type 561A Oscilloscope	$500
Type RM561A Oscilloscope	$550
Type 564 Storage Oscilloscope	$875
Type RM564 Storage Oscilloscope	$960

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

Tektronix, Inc.

For complete information, contact your nearby Tektronix field engineer or write:
Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005

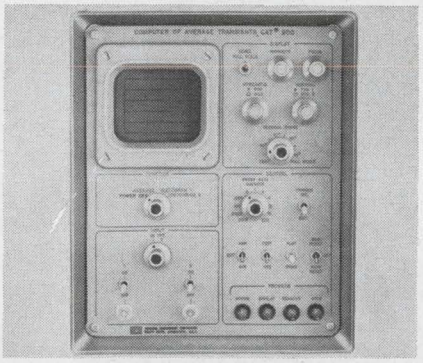
ON READER-SERVICE CARD CIRCLE 185



Two-channel recorder 4 speeds, will travel

Techni-Rite Electronics Inc., Techni-Rite Industrial Pk., Warwick, R. I. Phone: (401) 737-2000. P&A: $995; 15 to 30 days.

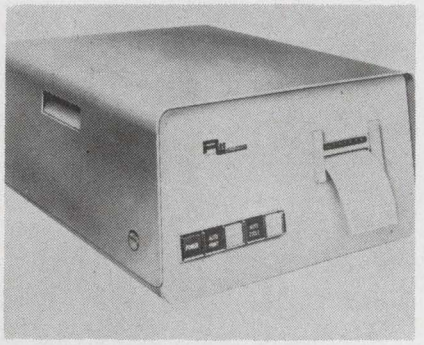
Primarily intended for use in the lab, hospitals or on the production line, TR-722 recorders cover a frequency range of dc to 125 Hz on two channels. The instrument records in rectilinear coordinates on heat-sensitive recording paper. The portable package measures 4-3/4 x 10 x 14-in. and weighs 25 pounds. Chart speeds range from 1 to 100 mm/s. **CIRCLE NO. 166**



On-line computer reduces random data

Technical Measurement Corp., 441 Washington Ave., N. Haven, Conn. Phone: (203) 239-2501.

A simplified digital computer, the CAT 900 uses signal averaging for on-line reduction of random data. Signal-to-noise improvement is attained bystoring digital samples in a core memory where random background is cancelled, isolating the intelligence. Standard features include dual-input provisions, ±0.2% linearity, an internal CRT and outputs for analog or digital recording. **CIRCLE NO. 167**

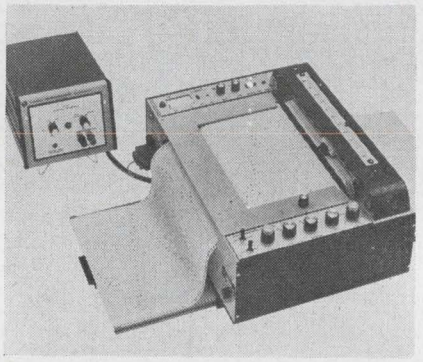


Data printer has integral digital clock

Spectra-Strip Corp., P. O. Box 415, Garden Grove, Calif. Phone: (714) 892-3361.

This 2-line/s data printer incorporates a digital clock and reads out and prints out either simultaneously or separately. The printer accepts any 4-line BCD code, any 10-line input, any logic level, any logic polarity and any inhibit level at any polarity. All semiconductors are silicon, and the roll-fed inkless unit prints up to 36 columns.

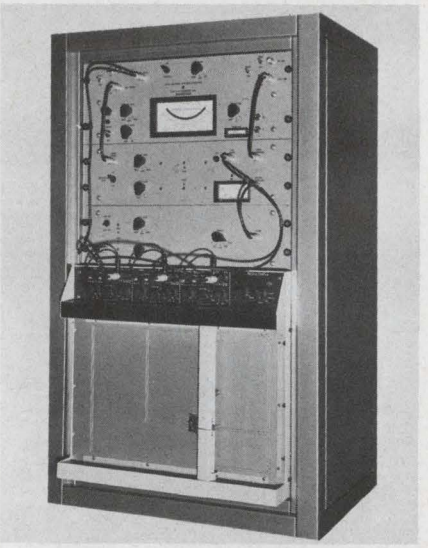
CIRCLE NO. 168



Plotting system accepts digital data directly

Houston Omnigraphic Corp., 4950 Terminal Ave., Bellaire, Tex. Phone: (713) 667-7403. P&A: $3725; 45 days.

Model 6710 digital plotting system operates directly from computers, counters, DVMs, or any source generating parallel binary or BCD data. Three decades are presented on a 10-in. x 144-ft. "fan-fold" recording surface with 0.1% resolution. The system requires 1.5-μs data access as it incorporates a 3-decade single-point memory. A maximum of 1200 points/min. may be plotted with 0.2% full-scale accuracy. **CIRCLE NO. 169**



Frequency response analyzed with tester

Procedyne Corp., 221 Somerset St., New Brunswick, N. J. Phone: (201) 249-8347. Price: $13,950.

A new frequency response analyzer operates in the range of from 1 Hz to 50 kHz. The analyzer simplifies the frequency response analysis of systems and devices including, filters, equalizers, amplifiers, transformers, servo-mechanisms, and all other audio devices. Operating as a two channel device, the model FR-201 gives as an output, the phase shift between two sinusoids, the amplitude ratio for the two sinusoids, and the frequency. The phase angle and the amplitude ratio are available both as direct readings on a meter, and as dc outputs for recording purposes. **CIRCLE NO. 275**

Color pulse generator measures envelope delay

Videometrics Inc., P. O. Box K. Brightwaters, N. Y. Phone: (516) 665-9231.

A new color pulse generator, permits the direct measurement of envelope delay between luminance and chrominance channels using existing oscilloscopes as the sole detector or measuring device. Its measurement resolution if ±10 nanoseconds with delays down to 30 nanoseconds. The company believes this generator will save time and expense as compared to previously available envelope delay measuring equipment. **CIRCLE NO. 276**

OHMICONE®
SILICONE-CERAMIC
COATED AXIAL LEAD
RESISTORS

two Choices from OHMITE

1

MOLDED

SERIES 88 • MOLDED OHMICONE®

Coating is uniformly thick, dense and smooth. Meets 1000 VAC insulation test. Consistent form and size make these resistors highly suitable for rapid automated assembly techniques and also permit firm mounting in clips for significant heat-sink advantages. Available in commercial, military, precision, and non-inductive types. Can be provided to meet new Char. U of MIL-R-26. Solderable or weldable leads. **(Bulletin 101)**

Wattages (Commercial): 1.5, 2.25, 3.25, 6.5, 9, 11 watts at 25°C.
Resistances: 0.1 to 226K ohms.
Tolerances: To 0.05%; standard commercial, 3%.
Low Temperature Coefficient of Resistance: 0 ± 20 ppm/°C, 10 ohms and above.

2

CONFORMAL

SERIES 44 • CONFORMAL OHMICONE®

Same basic high quality wire-wound resistor as above, but with a conformal coating (1000 VAC rating). While it does not have the uniform shape and dimensions of the molded Series 88, the Series 44 is available with the same close, standard tolerance and low TC. It is supplied in commercial and high precision types. Can also be furnished to meet MIL-R-26 requirements. **(Bulletin 109)**

Wattages (Commercial): 1.5, 3.25, 6.5, 11 watts at 25°C.
Resistances: 0.1 to 442K ohms.
Tolerances: To 0.05%; commercial, 3% for values above 1 ohm.
Low Temperature Coefficient of Resistance: Standard is 0 ± 20 ppm/°C for 10 ohms or more.

OHMICONE Silicone-Ceramic—Not just a conventional silicone coating, but rather silicone combined with a ceramic compound. Blending the two materials provides a coating which has the best characteristics of each. Developed and patented by Ohmite, *Ohmicone* envelopes a wire-wound resistor in an unusually tough, resilient jacket that has high moisture resistance and excellent dielectric properties, plus good stability and low temperature coefficients. Choose either the molded or conformal coating in accordance with your requirements.

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS • SEMICONDUCTOR CONTROLS • R.F. CHOKES

OHMITE MANUFACTURING COMPANY
3643 Howard Street • Skokie, Illinois 60076
Phone: (312) ORchard 5-2600

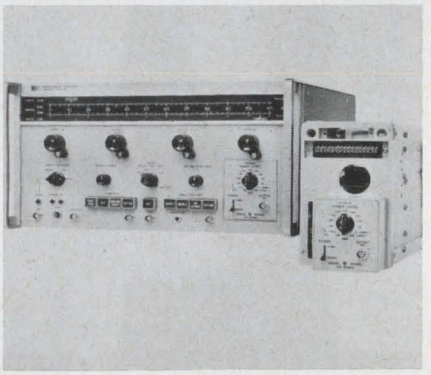
ON READER-SERVICE CARD CIRCLE 186

This FET Voltmeter is jack-of-all tests

Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7351. P&A: $239; 4-6 weeks.

In one portable instrument, the DV-93 combines the features of a VOM, a VTVM and an ohmmeter. It is a dc voltmeter, an ac voltmeter, an RF millivoltmeter and an ohmmeter. ac bandwidth is 3 MHz at full accuracy but usable to 5 MHz. Most sensitive scales are 50 mV full-scale for dc, 15 mV for ac, and 25 ohms mid-scale for resistance. Meter is taut-band, mirror-backed.

CIRCLE NO. 133



Plug-in scales-down MW sweep generator

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

The manufacturer's HP sweep oscillator can be converted to RF-level operations through the model 8698A plug-in. The plug-in covers the frequency range from 100 kHz to 110 MHz in two 110-1 ranges. Instrument performance features such as flexible sweep functions, variable sweep-rates, tuned markers, and leveled outputs are not affected. Sweep linearity is 99.5% accurate.

CIRCLE NO. 134

PNP

silicon transistor

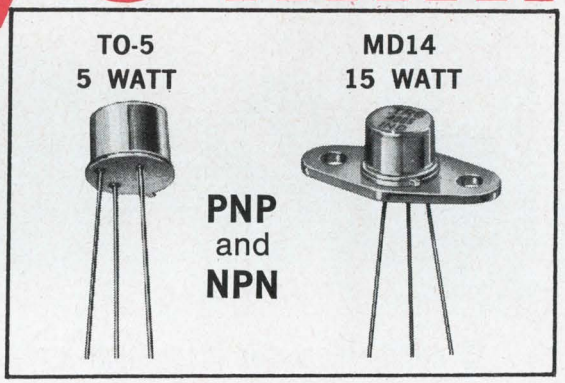
BV_{CEO} = 200-500V.

H_{FE} = 30 min.

f_T = 30 Mc/s min.

plus

NPN



300V TO 1000V

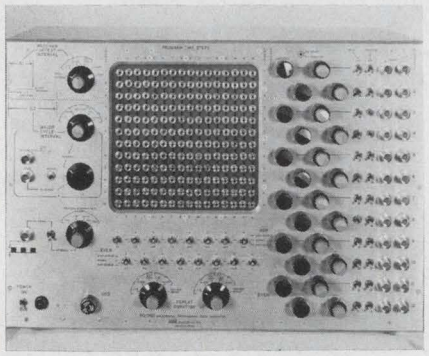
50Mc GBW

5-15 WATTS

INDUSTRO
TRANSISTOR CORPORATION

35-10 36th Avenue, Long Island City 6, N. Y. • EXeter 2-8000

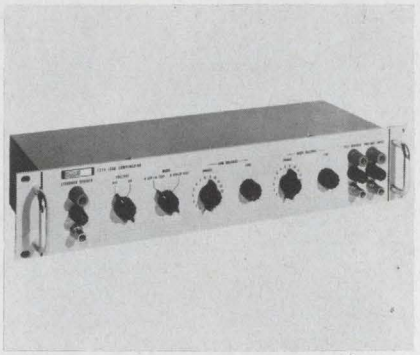
ON READER-SERVICE CARD CIRCLE 188



Generator pulses into 12 output channels

Adar Associates Inc., P. O. Box 27, Lincoln, Mass. Phone: (617) 623-3131. Price: $5600.

As a clock and controller in any sequencing system, the SQ-260 provides pulses on 12 parallel output channels. Programing is accomplished by diode pins in a 12 x 16 matrix. Stepping rates are 10 MHz to 1 KHz. The cycle can be started by either an external pulse or a built-in 1 MHz to 10 Hz clock. The step-repeat switch has an "endless" position allowing an operator-controlled long step or pair repeat period. **CIRCLE NO. 135**



Lead compensator resolves to 0.1 milliohms

John Fluke Mfg. Co., Inc., P. O. Box 1428, Seattle, Wash. Phone: (206) 774-2211. P&A: $245; 90 days.

Lead compensation, where ratios between standard and test dividers are as great as 4000:1, is possible with the model 721A compensator. A mode switch reverses the divider terminals so that dividers can be connected without regard to the divider with the higher resistance. Resolution is rated 0.1 milliohms and max allowable lead resistance is 150 milliohms. Max divider voltage is 1500 Vdc or peak ac.

CIRCLE NO. 136

AF response meter covers 20 Hz to 20 kHz

Waveforms Inc., 333 Sixth Ave., New York. Phone: (212) 929-2795. P&A: $600; late 1966.

In testing frequencies from 20 Hz to 20 kHz, the 620B audio response meter needs neither markers nor physical connection between generator and meter to draw accurate response curves. The instrument module combines a log frequency meter and a log volt meter. Readout is provided by a fan type meter with 0 dB center. Analog dc voltages for both signal frequency and voltage are brought out for drives, recorders or scopes. **CIRCLE NO. 137**

Fast, convenient direct reading measurements of impedance and phase angle 500 kHz to 108 MHz...

THE 4815A RF VECTOR IMPEDANCE METER

This new Vector Impedance Meter is a versatile instrument that provides fast, direct reading measurements of impedance and phase angle over the frequency range from 500 kHz to 108 MHz. It is continuous tuning over this frequency range, and does not require balancing or data interpretation. Thus, it is an extremely useful tool for the evaluation of the complex impedance of both active circuits and components. The convenience of probe measurement, ease of operation, and direct reading features make the instrument equally useful for laboratory, receiving inspection or production line measurements.

The 4815A is a convenient and powerful measuring tool for any application involving measurements over a band of frequencies or in-circuit measurements. It may be used to determine the self-resonance point of capacitors, the series and parallel resonance points of crystals, or the characteristics of high frequency transformers and transducers. Price: $2650 f.o.b. factory. For complete specifications, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Rockaway Division, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

Advantages:

Fast, continuous tuning from 500 kHz to 108 MHz

Provides data directly in impedance and phase angle, 1 ohm to 100K ohms 0 to 360°

Convenient probe for in-circuit measurements

Analog outputs permit permanent data recording

Self calibration check provides measurement confidence

Low-level test signal minimizes circuit disturbance

HEWLETT hp PACKARD

An extra measure of quality

ON READER-SERVICE CARD CIRCLE 191

Developmental IGFETs rate high on stability

Sprague Electric, Semiconductor Div., Concord, N. H.

Pentode applications demanding stability despite voltage and temperature stress are seen for the p-type TXF-200 insulated gate FETs. Combining the intrinsic IGFET features (high input impedance, low cross-modulation and low control power) with enhanced stability is said to expand the device's applicability in choppers, modulators, agc amplifiers, differential amplifiers, etc. Threshold voltage ranges from 1.5 V to 4 V with I_{DS} at 10 μA and V_{DS} at -10 V. Transconductance is 1000 μmho with V_{DS} and V_{GS} at -15 V and f_t at 1 kHz.

CIRCLE NO. 224

Planar audio transistors are tiny and quiet

Amperex Electronic Corp., Slatersville, R. I. Phone: (401) 762-9000.

Microminiature silicon planar epitaxial audio transistors, types A151, A152 and A153, feature a noise figure of 1.5 dB and leakage of 10 nA. The small package size (0.078 x 0.071 x 0.071-in.) make them ideally useful in hearing aids, tape heads or phone pick-ups. The current gain characteristics are maintained over a range of collector currents from 20 to 2000 μA. Mounted on a ceramic substrate, the units have been designed with extra rigid leads.

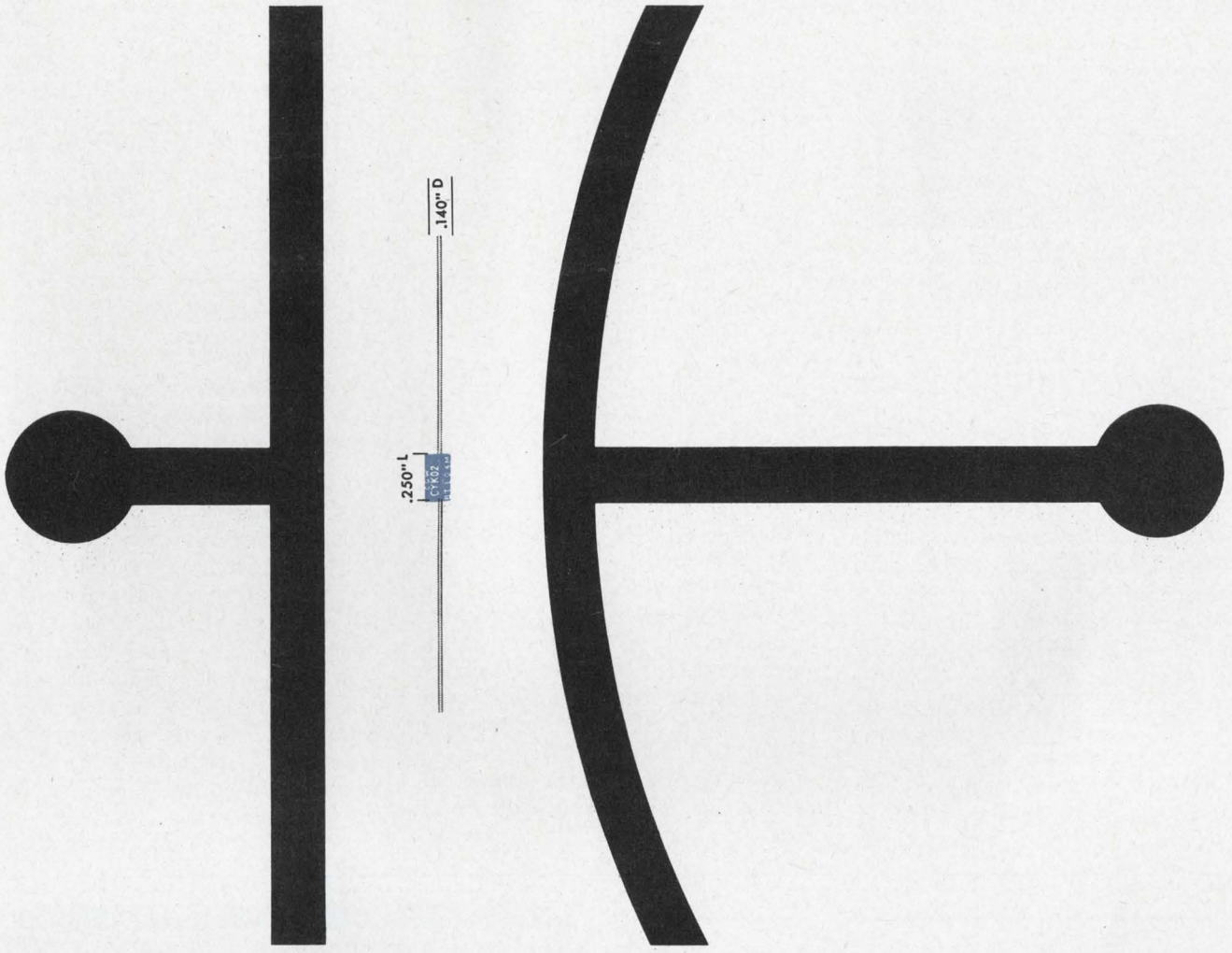
CIRCLE NO. 225

Miniature pnpn switch up in power and voltage

Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404. Price: about $5.

Miniature, except in ratings, recent additions to the Unitrode four-layer diode line have continuous current ratings as high as 1.5 A and firing voltages as high as 100 V. Typical of the Unitrode line, these new devices have terminal pins metallurgically bonded to the silicon element. Operating efficiency is said to be unaffected by continuous overloads or by temperature cycling within a -195 to 300°C range.

CIRCLE NO. 226



Only the CORNING® GLASS-K can cram 100,000 pf into this

Now the stability you associate only with glass comes to you from 1,000 to 100,000 *p*f in a size even smaller than conventional CK types.

We treat our high-dielectric-constant glass to a heating to produce a microcrystalline structure in the Glass-K material. The dielectric has no room for holes, so we can slice it thinner, put more *p*f in a smaller case size.

No holes also means more environmental stability, less chance for failure.

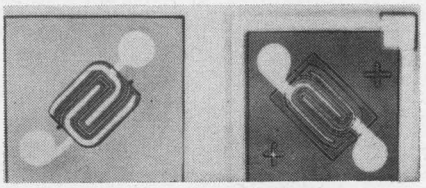
Capacitance change after load-life with the Glass-K unit is less than 2% and dissipation factor is less than 1.0% for values to 20,000 *p*f.

With all its obvious material advantage, the Glass-K has a price that's competitive.

Why risk an entire system on a capacitor that can't give you the assurance of Corning dielectric stability? Get complete Glass-K Capacitor data in our new CORNING® Glass Capacitor Guide. Send to Corning Glass Works, 3909 Electronics Dr., Raleigh, N. C.

CORNING
ELECTRONICS

ON READER-SERVICE CARD CIRCLE 193



J-FET pair for linear amplifiers, switches

Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-1000. P&A: $14.90 (100-up); stock.

The 2N4339/FP4339 and 2N4340/FP4340 complementary n and p-channel junction FET pairs are designed for zero-offset source followers, low spiking choppers and controlled resistors. They feature a narrow three-to-one range of V_P, I_{DSS} and g_{fs}; each pair is matched in I_{DSS} to 5% and in V_P to 30%. Maximum V_P is 1.8 and 3 V, minimum I_{DSS} is 0.5 and 1.2 mA; minimum g_{fs} values are 800 and 1300 μmho. Each device is packaged separately, in a TO-18 and a TO-72.

CIRCLE NO. 227

Double-gate MOS-FETS outdo bipolars at uhf

RCA, Electronic Components and Devices, 415 S. 5th St., Harrison, N. J. Phone: (201) 485-3900. Availability: Evaluation quantities immediately.

Developmental insulated double-gate MOSFETS, type TA7010, are intended for vhf/uhf communications receiver amplifiers at frequencies up to 500 MHz. The internal circuit configuration and performance of these devices are similar to those of two vacuum tube triodes in a "cascode" arrangement. They feature extremely low gate leakage currents, feedback capacitance in the order of 0.01 pF, high transconductance (10,000 μhmo at a drain current of 7 mA) and a square-law transfer characteristic which makes them superior to bipolars as far as cross-modulation.

The TA7010 is an n-channel, depletion-type silicon transistor packaged in a four-lead TO-72 can. At 200 MHz typical power gain is 20 dB and noise figure is 2.8 dB. At 400 MHz typical gain is 13 dB and noise figure is 4.5 dB. These characteristics make the device exceptionally well suited for receiver front-end and IF amplifier circuits.

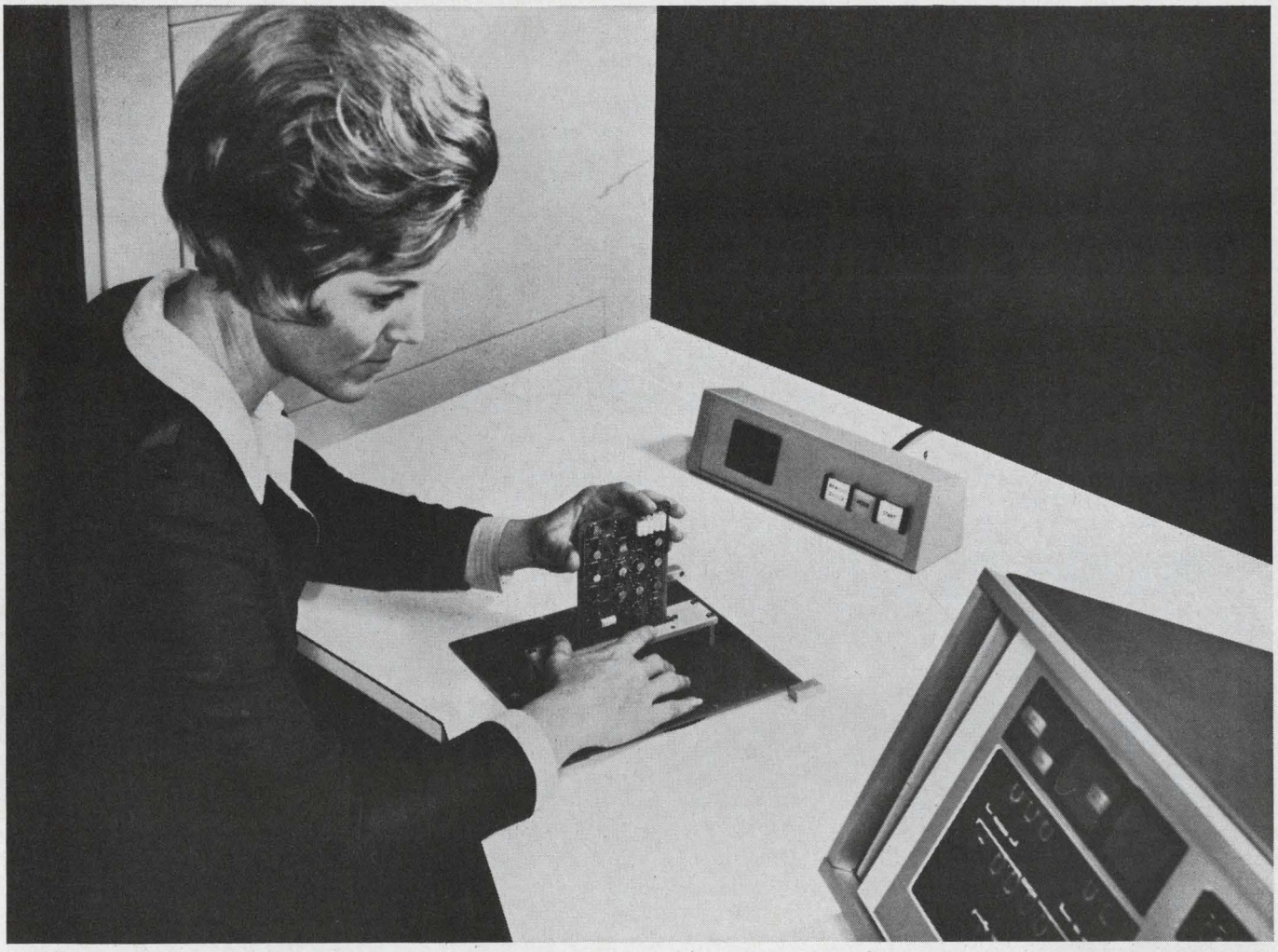
CIRCLE NO. 228

FET doubles as switch or SCR

Atlantic Instruments & Electronics Inc., 103 N. Beacon St., Boston, Mass. Phone: (617) 254-0465.

Aimed at the industrial and commercial markets, the Fieldtron FET type 15P1 operates as a switch or an SCR. Switching "on-time" is in the order of 1 μs and "off-time" is 0.1 μs. Since the device acts as a diode in the conducting state but as a cutoff pentode when pinched, it can also double as a proportional controller. Among the important specs are a continuous current rating of 10 A, break capability over 15 A and duty voltage of 150 V.

CIRCLE NO. 229

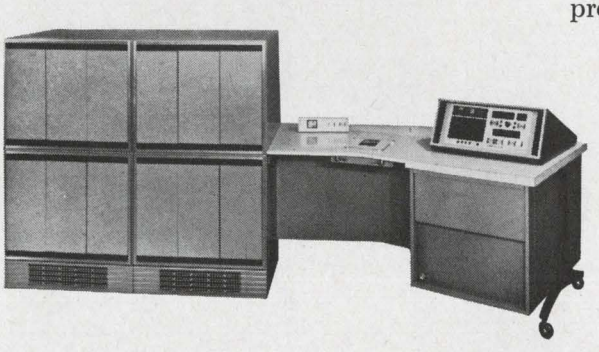


How to decide if you need an automatic test system for modules and ICs that will save you over $100,000...

Make a quick check! Answer these four questions:

1. Are your test specifications based on present test equipment capability, rather than true performance of the unit under test?
2. Are results of your present testing free of human errors and subjective evaluation?
3. Will present test equipment hamper your future billings schedules, due to more complex test requirements?
4. Does your present test routine require 30 minutes or more to adequately test a printed circuit card or integrated circuit?

If you answered "yes" to any one of those questions, you probably need a 553 Dynamic Test System.

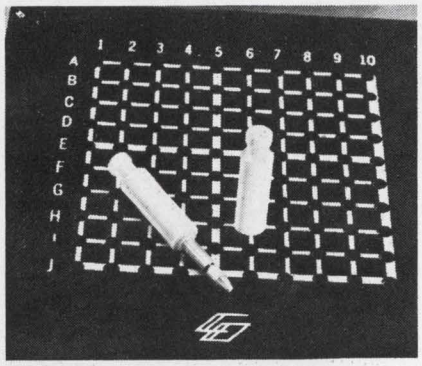


Now it's *your* turn to ask questions. We have test instruments and systems to help you save testing time and money. Contact your nearest TI Field Office, or get in touch with us at the Industrial Products Group, 3609 Buffalo Speedway, Houston, Texas 77006. If you're in a hurry, our phone number is 713-782-9661.

TEXAS INSTRUMENTS
INCORPORATED

820

ON READER-SERVICE CARD CIRCLE 196

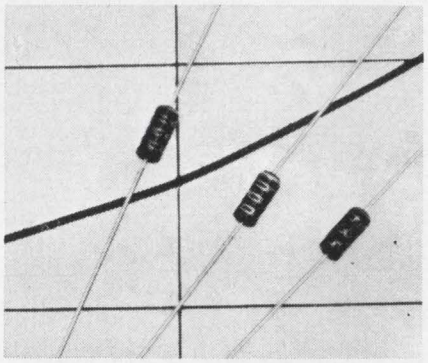


Diode pin eases component insertion

Co-Ord Switch, 102-48 43rd Ave., Corona, N. Y. Phone: (212) 899-5588. P&A: $0.76; stock.

Components are easily inserted into two level (X-Y) matrix program boards when mounted in these holders. They feature a 0.106-in. diameter, 0.5-in. long pin with high bending resistance. The diode is crimped into the pin, thus eliminating diode failures due to soldering heat. Maximum component size installable is 0.16-in. diameter x 0.37-in. long.

CIRCLE NO. 230

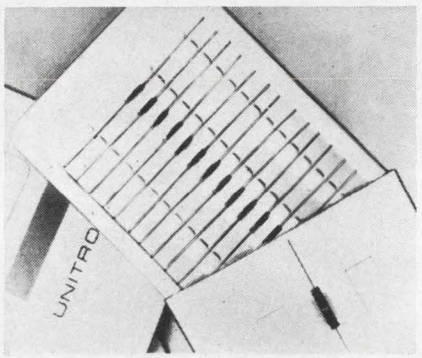


Hot carrier diodes are quiet beyond 8 GHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $29.75 to $79.05 (10 to 99); 2 wks.

In mixer/detector service beyond 8 GHz, series 2600 hot carrier diodes have maximum ssb noise figures of 7 or 7.5 dB with a 1-mW local oscillator and a 30-MHz, 1.5-dB IF amplifier. The diodes are metal/silicon Schottkies for use through 10 GHz, intended to replace point contact diodes. Cw power dissipation at 25°C is 125 mW.

CIRCLE NO. 232

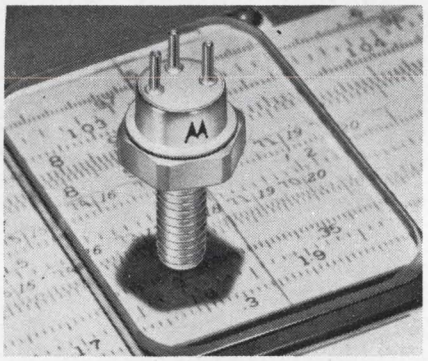


Silicon thyristor diodes fire at 40 to 300 volts

Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404. P&A: $5 to $15, 1 to 2 wks.

High power, high voltage thyristor diodes are available with voltages from 40 to 300 V. Continuous current is 1.5 A and short duration surges as high as 500 A can be withstood, with an 8.3-ms surge rating of 15 A. The body size is less than 0.25-in. long with 0.085-in. diameter. They are constructed using two cylindrical metal pins bonded to both faces of a silicon die.

CIRCLE NO. 231



Power transistor offers 50 W at 50 MHz

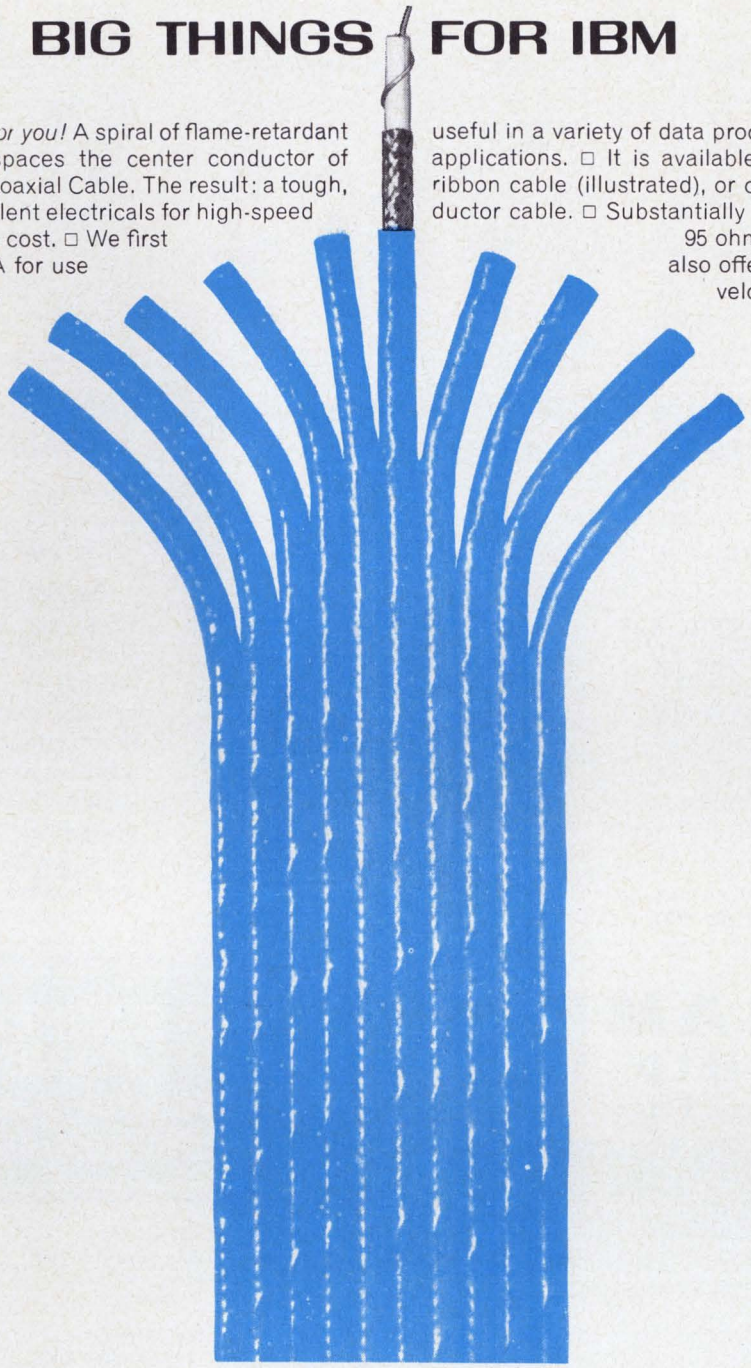
Motorola Semiconductor Products, P. O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900. P&A: $22.80 (100-up); stock.

Type 2N3950 RF power transistor provides a guaranteed 50-W continuous power output at 50 MHz with a minimum power gain of 8 dB. The device is characterized for Class C operation, but can also be operated Class A or B to meet high-power single sideband requirements through 76 MHz. The multiple-emitter transistor is mounted in a grounded-emitter TO-60 package.

CIRCLE NO. 233

THIS LITTLE THREAD HE LPS OUR AIR-SPACED COAX DO BIG THINGS FOR IBM

Our coax can do the same for you! A spiral of flame-retardant polyethylene thread air-spaces the center conductor of Brand-Rex Turbo® 209A Coaxial Cable. The result: a tough, miniature coax, with excellent electricals for high-speed transmission, at moderate cost. □ We first developed the Turbo 209A for use in the IBM Computer/360, but you may find this space-saving performer useful in a variety of data processing and communications applications. □ It is available as single cable, cemented ribbon cable (illustrated), or conventional round multiconductor cable. □ Substantially lower in price than standard 95 ohm High Temperature types, it also offers lower attenuation; higher velocity of propagation. A spiral drain wire under the shield simplifies termination.



Check the specs. Sound good? Write for full information.

Brand-Rex Turbo 209A Coax U.L. Approvals. Style 1354 (single), Styles 2384, 2385, 2386, 2387, 2388 (cable).

Nominal voltage: 600 volts rms.

Nominal impedance: 95 ohms, +6 −4.

Nominal capacitance: 13.5 pf/ft.

Max. attenuation: 14 db/100 ft at 400 Mc.

Velocity of propagation: 80%.

Inner conductor: #29 AWG silver-coated Turballoy C.

Cable core: Air-spaced, flame-retardant polyethylene. 0.072/0.078″ O.D.

Drain wire: #29 AWG silver-coated Turballoy C spirally applied for flexibility and fatigue resistance.

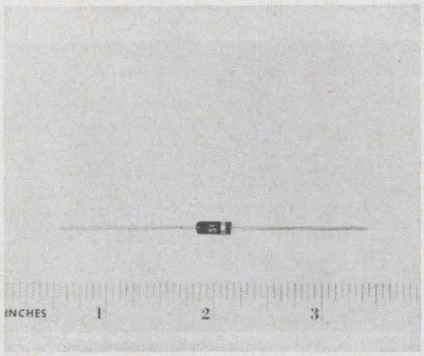
Shield: #38 AWG tinned copper braid, providing 90% min coverage.

Jacket: High-density vinyl, 0.112″ nom. O.D.; 0.122″ max O.D. at drain wire points.

AMERICAN ENKA CORPORATION
BRAND-REX DIVISION
Willimantic, Connecticut 06226
Phone: (203) 423-7771

BRAND REX

ON READER-SERVICE CARD CIRCLE 198

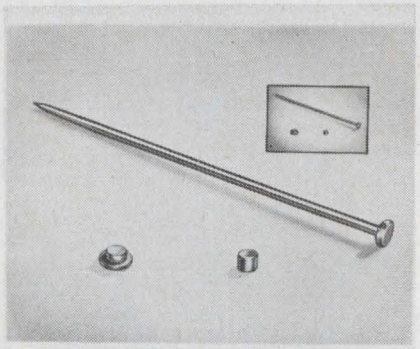


Micromin glass rectifiers withstand 50-A surges

Semicon Inc., Sweetwater Ave., Bedford, Mass. Phone: (617) 275-8542. P&A: $0.25 in production quantities; stock.

New glass rectifiers feature a one-piece glass hermetic seal with diffused junction. Five JEDEC types, 1N4383, 4384, 4385, 4585 and IN4586, provide high forward conduction, low voltage drop and a 50-A one-cycle surge rating. Maximum recurrent PRVs are 200, 400, 600, 800 and 1000 V.

CIRCLE NO. 234

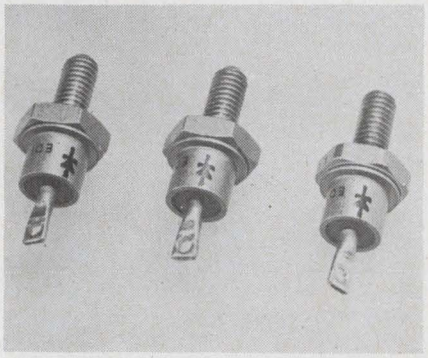


GaAs, Si Schottky diodes have tiny L and C

Gemini Semiconductor Inc., 482 Ridgedale Ave., Hanover, N. J. Phone: (201) 887-8181. Price: $200 (GaAs), $25 (Si).

Gallium arsenide and silicon Schottky diodes, rated at 10μA at 14 and 40 V respectively, have low package capacitances (0.22 pF) and inductances (0.05 nH). Noise figure of the AR2A35 GaAs diode at 35 GHz is 9 dB and cut-off frequency is 1200 GHz. Reverse current of the 2A414 Si diode is 1.6 x 10^{-4} μA.

CIRLCE NO. 235

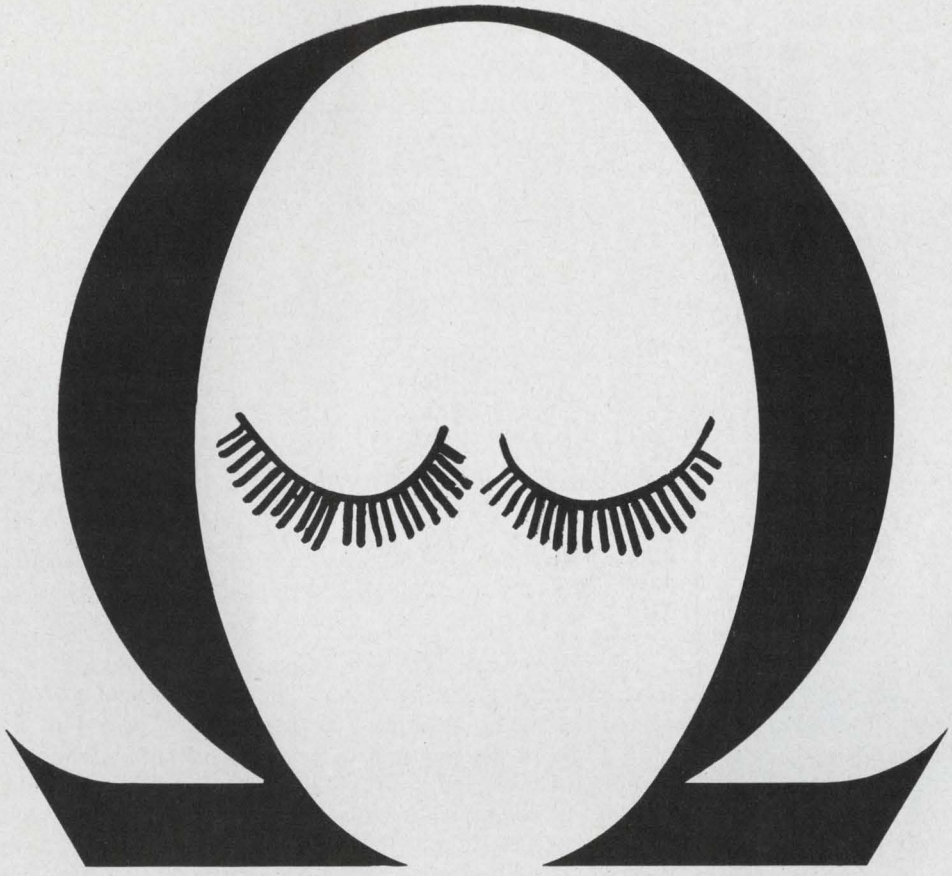


JAN stud rectifiers available to 1000-V PIV

Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N. Y. Phone: (914) 965-4400.

The 800 PIV and 1000 PIV 7/16-in. silicon stud rectifiers JAN 1N-3649 and 3650 are offered. Both cathode-stud and anode-stud polarity are available. Applications for the medium-power rectifiers include military communications equipment such as receivers, transmitters and low-power radar. The devices are also useful in signal generators and scopes.

CIRCLE NO. 236



The Absolute Ohm

How a classic ESI system can bring you closer to the absolute in resistance measurement, and why it can be of more than academic interest in many electronic labs and plants.

The Absolute Ohm is a theoretical ideal, which can be ever more closely approached, but never attained.

Its legal value is the resistance standard maintained by The National Bureau of Standards. The accuracy of your resistance measurement depends on the degree of "direct traceability" to this NBS standard.

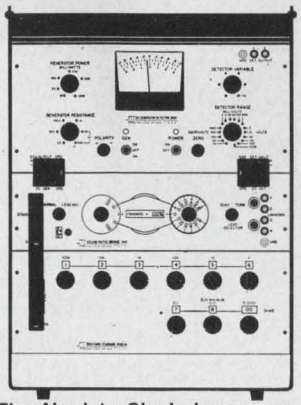
The ESI 242 Resistance Measuring System permits a chain of measurements to any resistance level from a single, directly traceable reference standard—with comparison accuracies of 1 ppm. Measurements can be made swiftly and simply; results are read directly, without calculation.

The legal residence of The Absolute Ohm is Washington, D.C.—at the National Bureau of Standards.

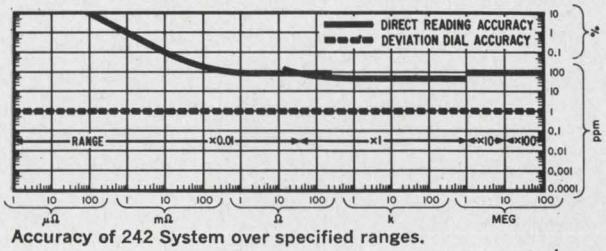
Even when you are not looking for greater accuracy in your resistance measurement and calibration, you may have good reason to consider our 242. It could help you speed up the pace of lab or quality control operations. Or increase reliability. Or get better results from less experienced people on your production line.

The 242 includes Ratio Bridge, Decade Standard, Generator-Detector and 4-Terminal accessories.

We can't promise The Absolute Ohm in resistance measurements. But with the 242, we do offer The Definitive System. ESI, 13900 NW Science Park Drive, Portland, Oregon (97229).



The Absolute Ohm's home away from home — our 242 Resistance Measuring System. Price: $3400.

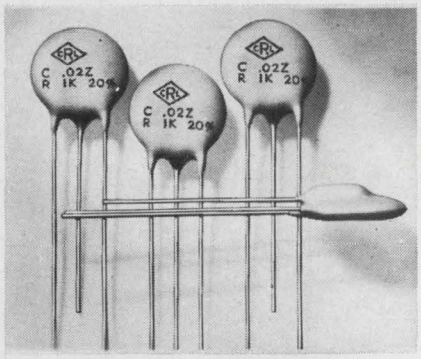


Accuracy of 242 System over specified ranges.

Electro Scientific Industries esi®

ON READER-SERVICE CARD CIRCLE 201

(continued from p. 158)

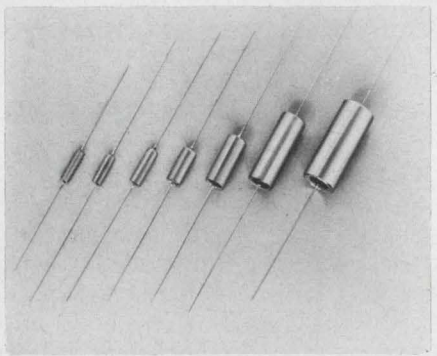


Miniature R-C networks to 22 MΩ, 0.2 mF

Globe-Union Inc., P. O. Box 591, Milwaukee. Phone: (414) 962-9200. Price: from $0.08.

Discrete components are assembled and then Durez coated and waxed, to form series R-C devices with high insulation resistance. A ceramic disc capacitor of 14 pF to 0.2 mF is combined with a 1.2-W resistor of 1Ω to 22 MΩ. The 3-terminal disc-configuration network has voltage ratings from 16 V to 6 kVdc and capacitance tolerances from 5%. Disc diameter varies from 0.59 to 0.92-in. and thickness from 0.3 to 0.5-in.

CIRCLE NO. 237

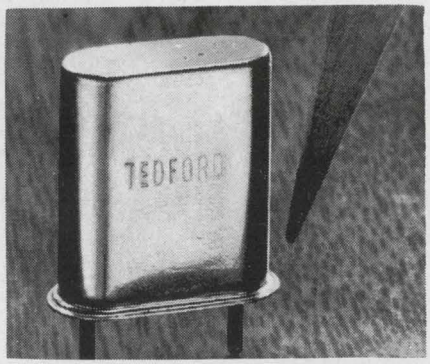


Metallized polycarbonate sealed in metal

Gudeman Co., 340 W. Huron St., Chicago. Phone: (312) 337-7400.

For high-temperature stability in miniaturized circuitry, a line of polycarbonate capacitors are available in hermetically sealed tubular metallic cases. Voltage ranges are from 100 to 400 Vdc and dissipation factor at 25°C is less than 0.3% at 1 KHz. No voltage derating is required over the unit's operating range.

CIRCLE NO. 238

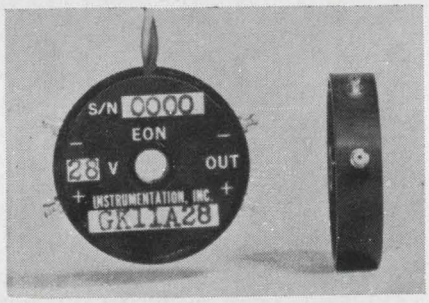


Sealed quartz crystals meet MIL stability specs

Tedford Crystal Labs., Inc., 4126 Colerain Ave., Cincinnati. Phone: (513) 542-555.

"Koldweld" quartz crystal units for frequency control are hermetically sealed in a nickel can with a nickel-plated, copper-clad Kovar base. The sealing process eliminates contaminants, prevents crystal frequency shift associated with solder heat and flux and provides ultra-stable units with aging rates of 0.03 ppm/wk at 75°C. Frequency ranges are 1 to 30 MHz for fundamental types and up to 210 MHz for overtone types.

CIRCLE NO. 239



Reference junction is electrically compensated

Eon Instrumentation Inc., 15547 Cabrito Rd., Van Nuys, Calif. Phone: (213) 781-2185. P&A: $68.50; stock.

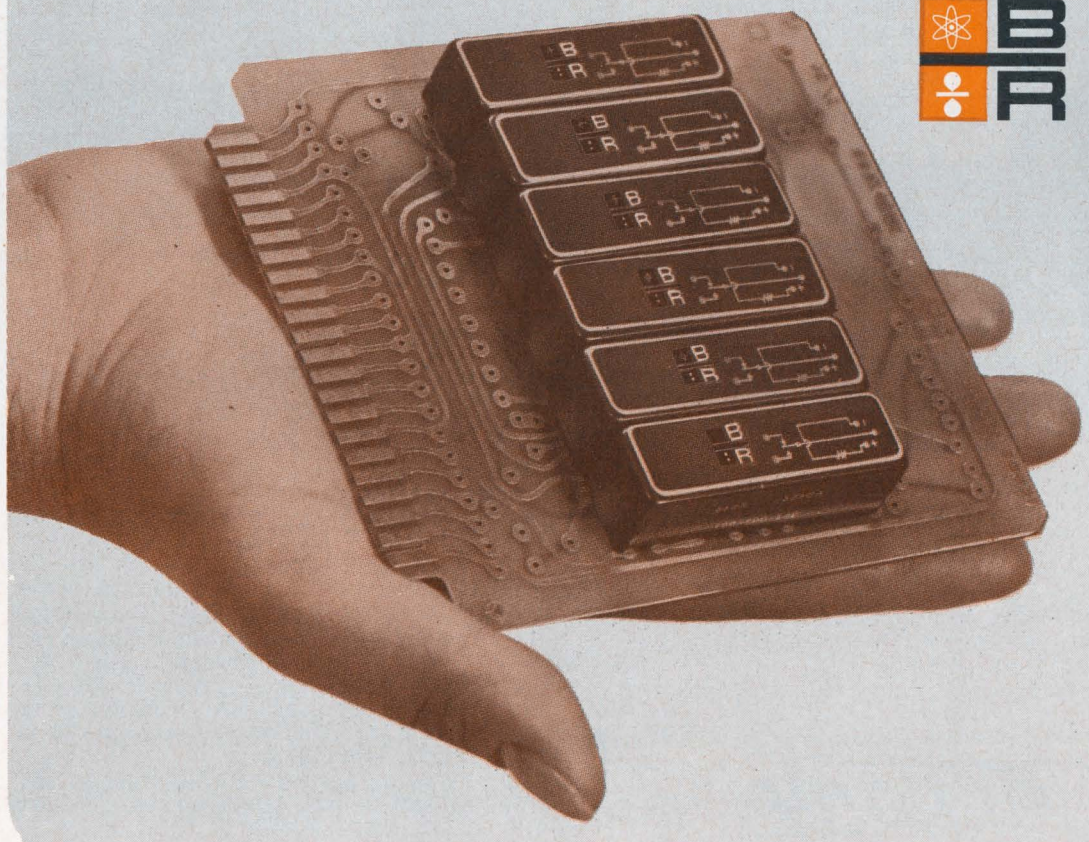
Designed to replace ice baths and reference ovens, this electrically compensated reference junction will make ambient correction of an electrically established reference temperature within the measuring circuit. Measuring only 1 x 0.23-in. it is accurate to within 1% from −65 to 165°F. Power drain is 50 mW and excitation may be specified from 1 to 99 Vdc. **CIRCLE NO. 240**

Babcock mercury-wetted relays... much more sensitive!

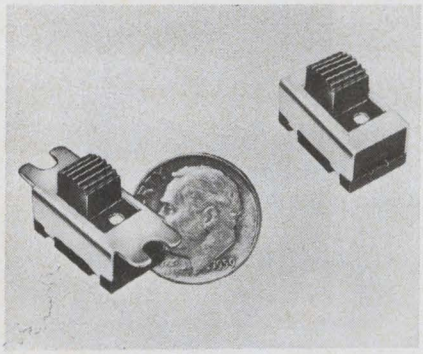
Power at a premium? You'll find Babcock Series BW Mercury-Wetted non-bridging relays more sensitive to your system requirements, providing billions of trouble-free operations on a mere 1.2 milliwatts or less. And more...the industry's most efficient magnetic circuit. Two independent permanent pole magnets are used, with separate induction bars for better magnetic field return. Whatever your system application—chassis or circuit-board components, or complete control board modules—you'll find a Series BW unit to your liking. Get the complete story today—write Babcock Relays, Division of Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif; (714) 540-1234.

SPECIFICATIONS

MUST-OPERATE POWER: Low as 1.2 mw.	CONTACT ARRANGEMENT: 1 Form C
CONTACT RATING: 2 amps.	CONTACT RESISTANCE: 25 milliohms, Typ.
OPERATE SPEED: To 1 ms.	NO CONTACT BOUNCE



ON READER-SERVICE CARD CIRCLE 784

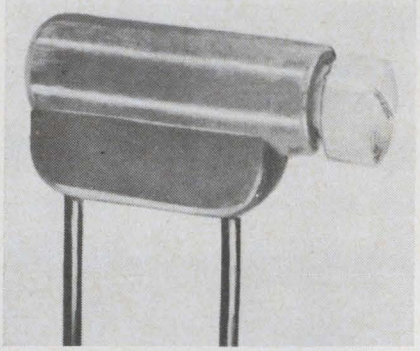


Snap-action slide switch is sub-submin

F & F Enterprises, Chicago Switch Div., 2035 Wabansia Ave., Chicago. Phone: (312) 489-5500.

The sub-subminiature "Mini-Slide Snap Switch" with a total stroke of 0.115-in., is designed for signal and moderate power circuits, and is claimed to be 1/4 the size of the next smallest. The spdt, 4-pin 1A, 1B or 1C circuits have a rated life of 250,000 operations. Contact rating is 2 A at 120 Vac or 0.5 A at 120 Vdc.

CIRCLE NO. 241

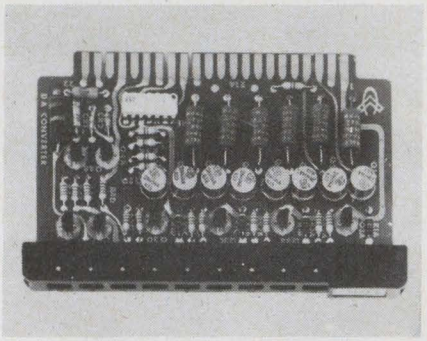


Micromin tank circuits are 1/5 TO-5 can size

Piconics Inc., North Billerica, Mass. Phone: (617) 663-4862. P&A: $17.50; 2 wks.

Weighing but 1/175 oz, low-cost tank circuits in a molded diallyl phthallate case represent an 80% size reduction over TO-5 size units. The stable capacitor and 65 ppm/°C inductor used give a typical temperature coefficient of 100 ppm/°C from −55 to 125°C. Frequency range extends to 250 MHz with an average Q of 60 at 60 MHz.

CIRCLE NO. 242



D/A converter cards supply 0 to 10 V

Control Logic Inc., 3 Strathmore Rd., Natick, Mass. Phone: (617) 655-1170. P&A: $150 (CAC-101) and $345 (102); stock.

Two D-to-A converter circuit cards, models CAC-101 and 102, are designed for analog interfacing in systems design or for A/D or D/A functions in instrument assemblies. Model CAC-101 converts with 0.05% accuracy; model CAC-102 at 0.01% over 0 to 50°C. In both, settling time is 10 μs/bit to rated accuracy.

CIRCLE NO. 243

Helipot's side-adjust Helitrim® cermet trimmer-world's smallest-costs as little as $1.50 in quantity.

Helipot's side-adjust Helitrim® cermet trimmer-world's smallest-costs as little as $1.50 in quantity.

Helipot's side-adjust Helitrim® cermet trimmer-world's smallest-costs as little as $1.50 in quantity.

The Model 62PA side-adjust is a new easy-access cermet trimmer with these quality features: virtually infinite resolution; excellent high frequency characteristics; and standard resistance from 10 ohms to 1 megohm. Its rugged cermet resistance element gives you long, trouble-free life and freedom from sudden failure. Inside its plastic case is a sealed metal housing identical to the popular ¼" top-adjust Model 62P.

Focus in on delivery advantages, too... immediate stock availability. Call your Helipot sales rep for full specs.

Beckman® INSTRUMENTS, INC.
HELIPOT DIVISION
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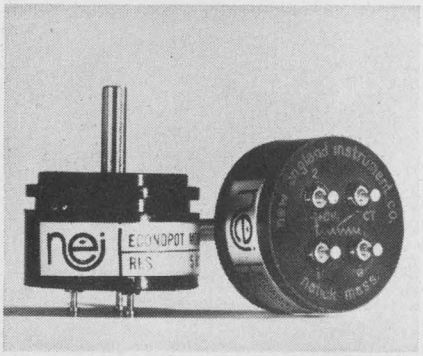
ON READER-SERVICE CARD CIRCLE 787

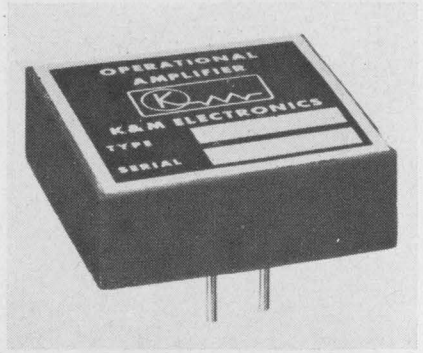


Conductive plastic pots offer center-tap option

New England Instrument Co., Kendall Lane, Natick, Mass. Phone: (617) 655-1411. P&A: $11.55 to $19.55 (untapped), $2 to $5 extra (center tapped); stock to 1 wk.

Center-tap options are available in a line of low-cost conductive plastic potentiometers. Center taps can be maintained within 50% of the applied voltage, plus or minus the specified linearity tolerance. The "Econopot" line includes 18 models (9 servo and 9 bushing) with total resistances of 1, 5 and 10 kΩ.

CIRCLE NO. 244

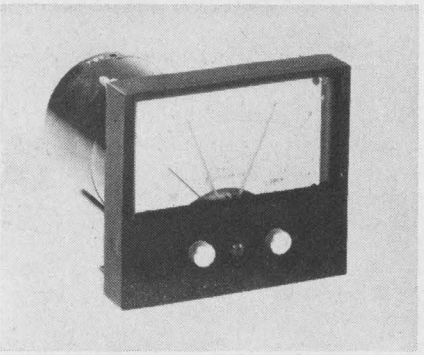


Flat-pack op-amp priced at $10

K & M Electronics Corp., 102 Hobart St., Hackensack, N. J. Phone: (201) 343-4518. P&A: from $10; stock.

Low-cost operational amplifiers in a flat-pack are designed for industrial and commercial use in analog computers, high-gain/low-drift servo preamps, ac amplifiers, voltage comparators, and instrumentation amplifiers. Features of the KM-20 op-amps are input impedance of 500 MΩ, typical open loop voltage gain of 10^6 and drift of 3 μV/°C.

CIRCLE NO. 246

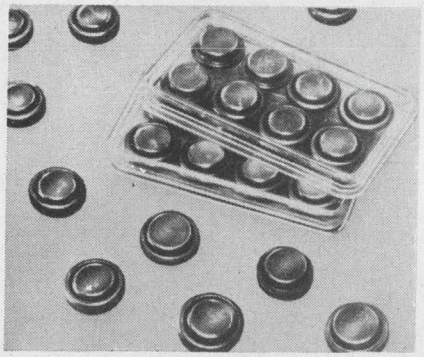


Solid-state control meter uses no relays or contacts

PMF Electronics Inc., 124 E. Third St., Dayton, Ohio. Phone: (513) 224-1948.

Contactless, all solid-state control meters have a barrel length of 4.65 in. Using no relays, they are capable of full-wave spst switching at 3 A, 110 Vac. The units are suited for closed loop applications and have a zener regulation circuit to ensure accuracy despite ac line variations. The meters are available with taut band or pivot and jewel suspension.

CIRCLE NO. 248

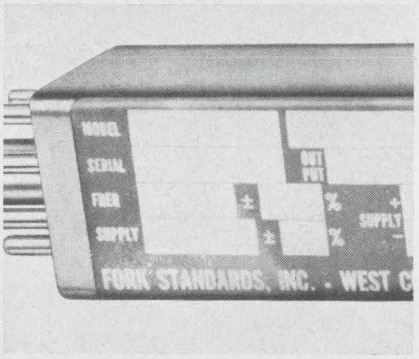


Silver/zinc batteries outdo Ni/Cd, Ni/Fe

Epic Inc., 150 Nassau St., New York. Phone: (212) 349-2470. P&A: $7.50, $8.50, $11.50 (lots of 6); stock.

As a power supply for solid-state equipment, these chargeable batteries have solid pure silver and zinc electrodes. Energy storage capacity compared to Ni/Cd or Ni/Fe cells is 2.5:1. Internal resistance is low so that the cells can be overloaded. Three models are available with rated capacities of 50, 80 and 300 mA-hours and 1.5-V rated voltage.

CIRCLE NO. 245

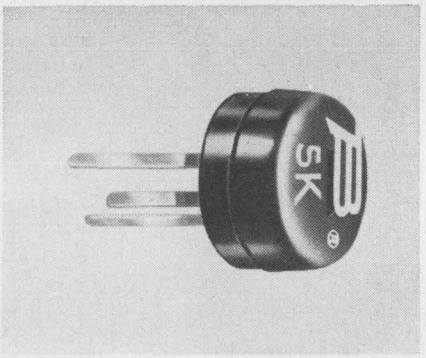


Tuning fork oscillator for long-term stability

Fork Standards Inc., P. O. Box 177, West Chicago, Ill. Phone: (312) 231-3511. P&A: $29; 1 wk.

For high long-term stability with medium accuracy, this tuning fork oscillator replaces comparably priced RC and LC oscillators. It has a low TC tuning fork for long-term stability, all silicon transistors, and is hermetically sealed. Any frequency from 800 to 6000 Hż is available with accuracy of 0.02% at 25°C and 0.1% from 0 to 65°C. Output is an 8-V p-p square wave with a 12-V supply.

CIRCLE NO. 247



Tiny single-turn pot has top or side adjustment

Bourns Inc., Trimpot Div., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. P&A: $2.64 (100 to 249); 3 wks.

Single-turn micromin (3/16 x 0.105-in) potentiometers are available in two versions, 3317-P for top adjustment and 3317-W for side adjustment. Resistance range is 20-Ω to 5-kΩ with a ±10% tolerance and power rating is 0.2 W at 25°C. Multiple wire-welded terminations and flat leads improve solderability and weldability. Stops are provided.

CIRCLE NO. 249

ON READER-SERVICE CARD CIRCLE 788 ➤

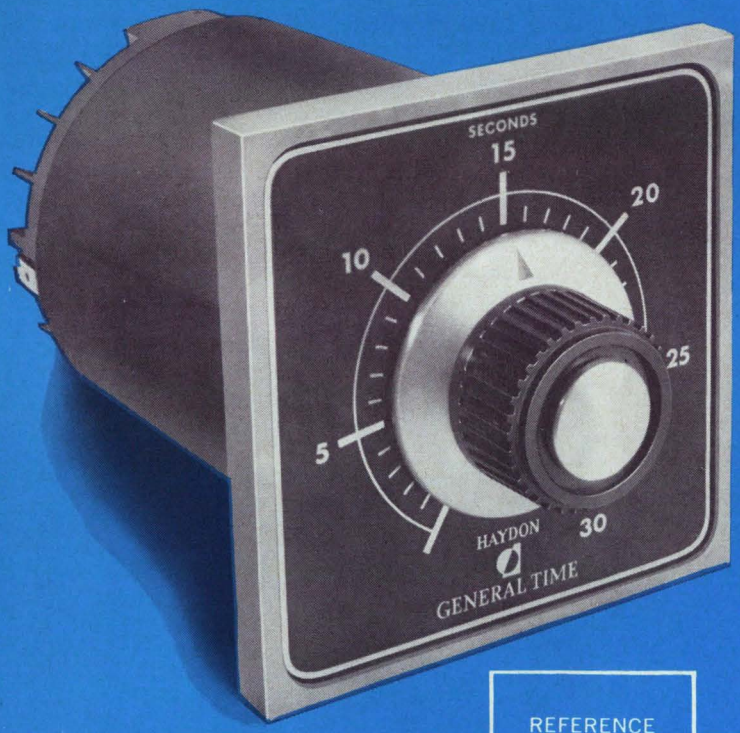
Degrees and Minutes

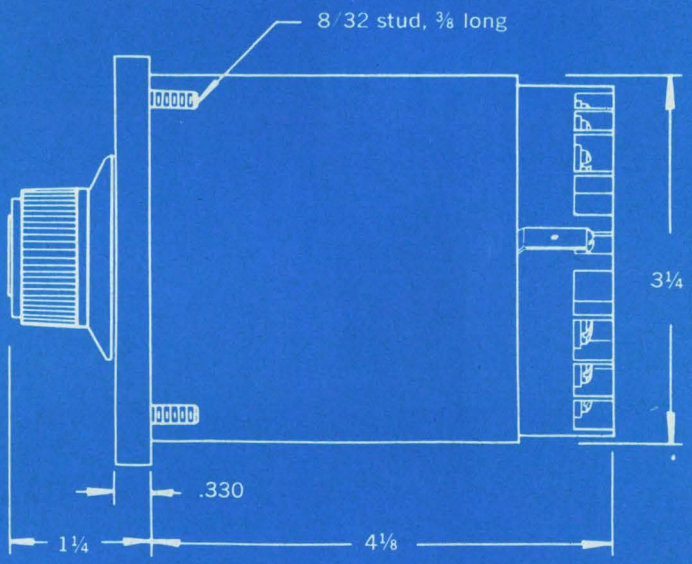
Not angles. Temperature. Time. Wherever more accurate, more sophisticated high speed time-control devices are called for, as in critical process control applications, the new HAYDON QT Solid State Delay/Interval Timer is meeting the demands of design engineers. Completely interchangeable and compatible with the full line of HAYDON Panel Mounted electromechanical timers, the QT Solid State Timer assures such important advantages as accuracy specified at set value rather than full scale, and absolutely dependable accuracy at constant voltage and temperature. Unlike unijunction transistor and thyratron-controlled units, interruptions of timing do not cause momentary closing of relay contacts with resultant shortening of the next time interval.

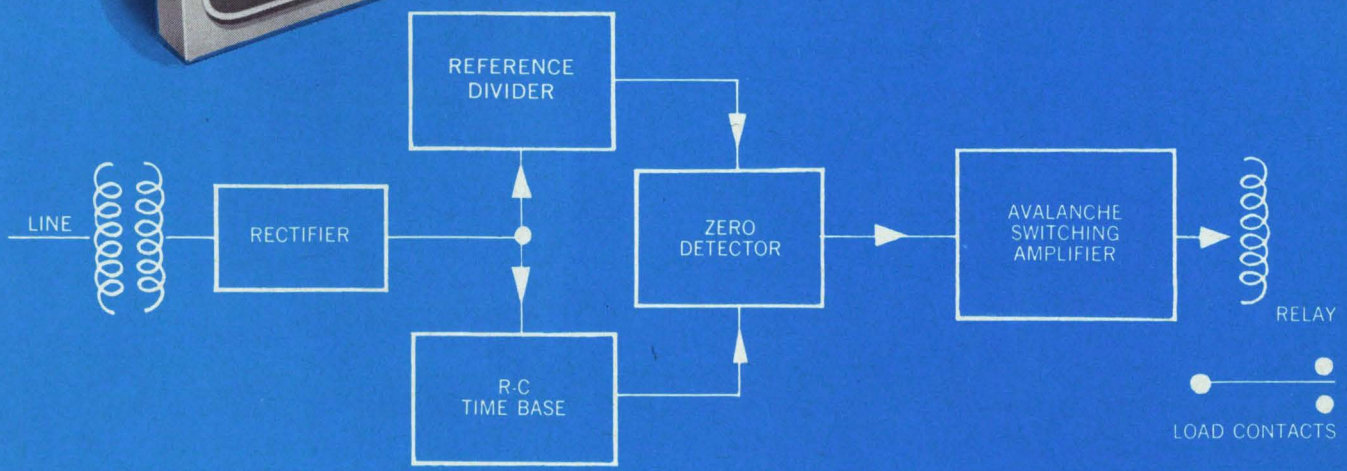
As specialists in timing *and* application skills, HAYDON engineers are at your call —ready to assist you with any time problem. To put HAYDON and time to work circle the number on the card, phone or write today.

Important Features

- Completely new approach to Solid State timing circuit design.
- Fully compatible with all HAYDON Panel Mounted timers. Complete interchangeability with other HAYDON units.
- Life expectancy 10 million mechanical operations.
- Voltages: 20VDC; 117,230 VAC, 50/60 cps. Power requirements approximately 3 watts.
- Comparatively insensitive to shock and vibration. Compensates for voltage variations.
- Not damaged by X-ray radiation or voltage spikes.
- Instantaneous reset even within a timing cycle. Repeat accuracy for Delay/Interval Timers is specified as "percent of set value" rather than the more customary "percent of full scale" with the resulting user benefit.
- Delay/Interval Timer; Full Scale—30 sec. maximum. Repeat accuracy —±2% of set value above 1 sec for temp range of 0° to 60°C, & operating line voltage within ±10% of rated value.

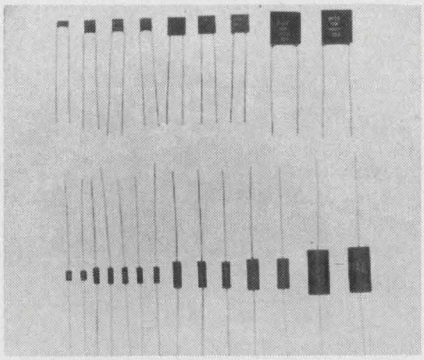






HAYDON PRODUCTS / INDUSTRIAL CONTROLS DIVISION
Thomaston, Connecticut

GENERAL TIME
Progress in the World of Time

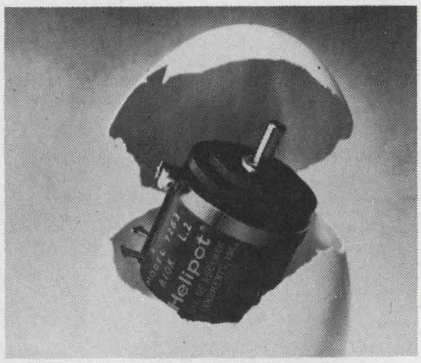


Ceramic capacitors have tiny TC

Marshall Industries, 1960 Walker Ave., Monrovia, Calif. Phone: (213) 359-8281.

"Zero TC Series" capacitors have a temperature coefficient of 0 ± 25 ppm over −55 to 125°C. Capacitance is unaffected by any change in ac or dc voltage or in voltage-temperature combination. Ratings of 50 and 100 Vdc in both radial-leaded and cordwood styles are available from 1 to 10,000 pF. Dissipation factor is 0.2% at 1 kHz and charge rating exceeds 5000 at 1 MHz.

CIRCLE NO. 250

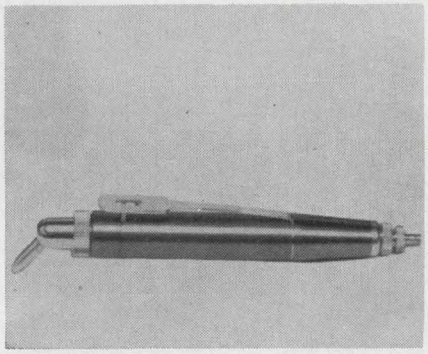


10-turn servo mount pot measures 7/8-in. long

Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848. P&A: $20; 6 wks.

Wirewound 7/8-in. diameter, 10-turn servo mount pots measure only 7/8-in. long. Standard resistance values are 10 Ω to 125 kΩ with independent linearity of ±0.2% and standard tolerance of ±3%. Power rating is 2 W at 40°C, derating to 0 at 85°C. Model 7263 has molded plastic housing and gold-plated terminals.

CIRCLE NO. 251



Vacuum pickup for micromin components

Eric Sobotka Co., Inc., 110 Finn Ct., Farmingdale, N. Y. Phone: (516) 293-9272. Price: $22.50.

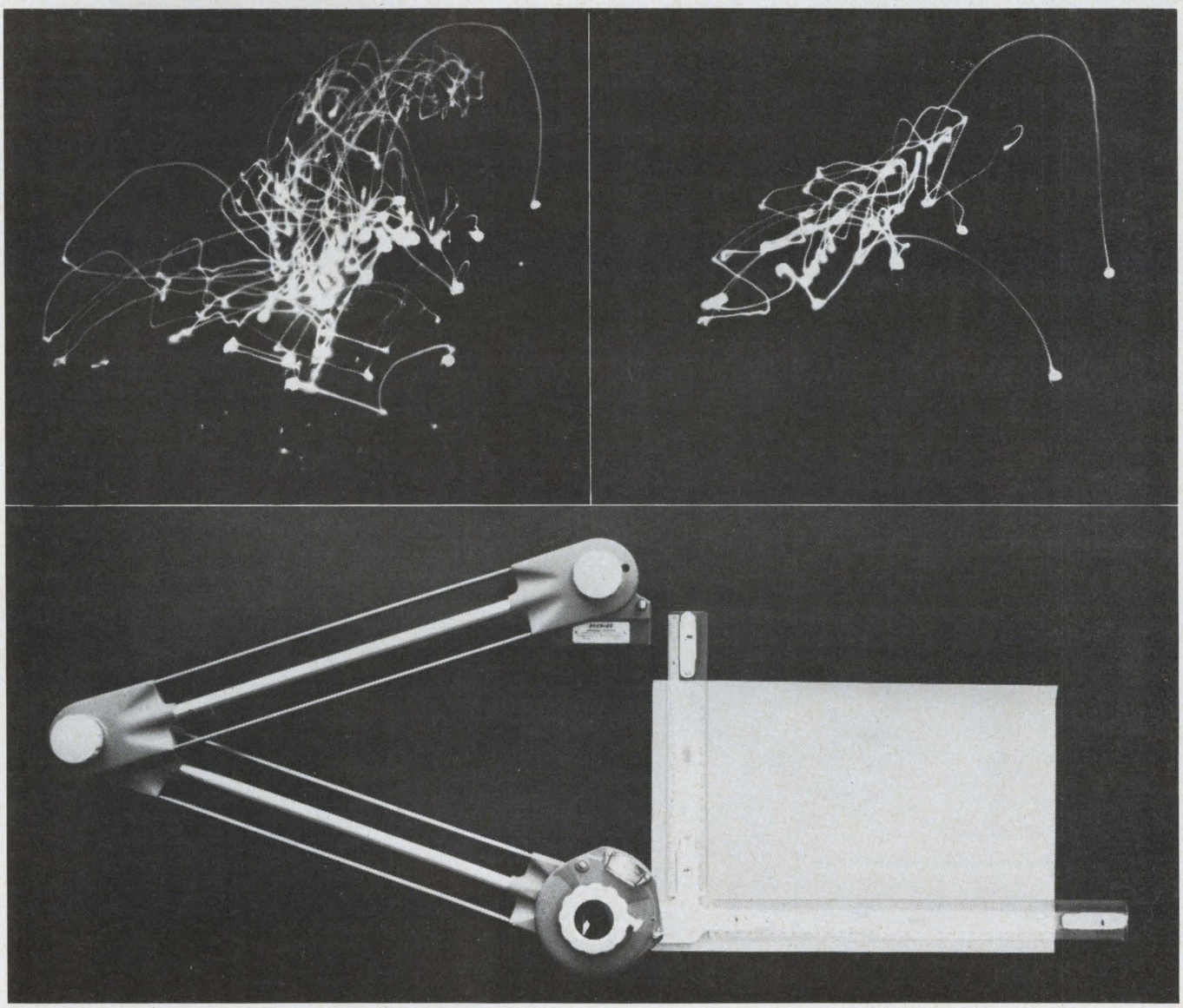
In conjunction with a vacuum source, this pencil-shaped pickup is for moving, holding, and picking up small components. The aluminum pick up tool is operated with one hand. Thumb pressure on a spring-loaded valve adjusts the vacuum for pickup or release. An integral screen filter and plenums trap dust and dirt. Three interchangeable heads rotate through a 45° arc.

CIRCLE NO. 252

Does a Bruning drafting machine really save time and labor? Here's proof!

The top two pictures were taken with a time exposure and lights on the wrist of a draftsman. Here are the number of movements necessary to make a simple drawing with a T square, straightedge, triangle, protractor and scale. *Time: 2 hours, 11 minutes.*

Here the same drawing was made with a Bruning Equipoise drafting machine. Note that considerably fewer movements were required. Greater accuracy was also obtained. *Time: 1 hour, 31 minutes.*



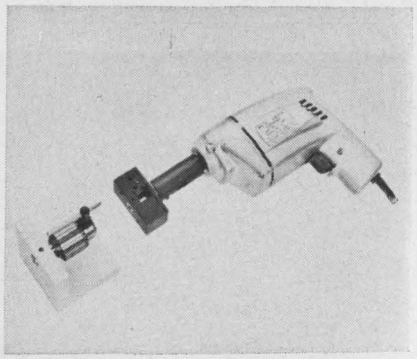
The Equipoise drafting machine (available in right- or left-hand models) is only one of several drafting machines made by Bruning. All of them save you time and labor. Want to find out more? Call your Bruning man. He's listed under Bruning or Addressograph Multigraph in the telephone directories of 155 major cities. Or write Dept. D, Mt. Prospect, Illinois.

Bruning

Division of Addressograph Multigraph Corp.

Bruning is a U. S. Reg. Trademark of A.M. Corp.

ON READER-SERVICE CARD CIRCLE 791

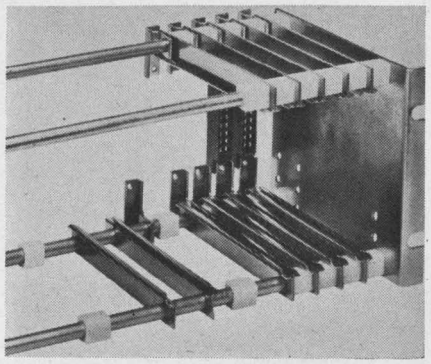


Portable stripping tool removes sheathing

Scientific Engineering & Mfg. Co., Inc., 11505 Vanowen St., N. Hollywood, Calif. Phone: (213) 982-1400.

This portable stripping tool removes metal sheath from thermocouple materials, heating elements and cables. The unit operates at 115 Vac with speed regulated by a "trigger control." Normal range of material that can be stripped is 0.04 to 0.25 in. OD. Interchangeable cutting heads and two types of holding devices, a jacobs chuck or a two-piece clamp are available.

CIRCLE NO. 253

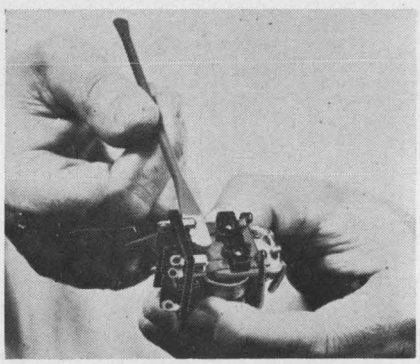


PC board racks built with do-it yourself kit

Birtcher Corp., 745 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 268-8584.

A "do-it-yourself kit" for prototype PC board racks contains side plates and support rods, card spacers and guides and connector brackets. Side plates can be adjusted to accommodate cards 3 to 4-1/2-in. high, with card guides 3 to 6-in. long in 1/2-in. increments. Support rods may be cut off to rack lengths up to 19-1/2-in. Aluminum or plastic spacers permit any center line dimensioning from 3/8-in. up.

CIRCLE NO. 255

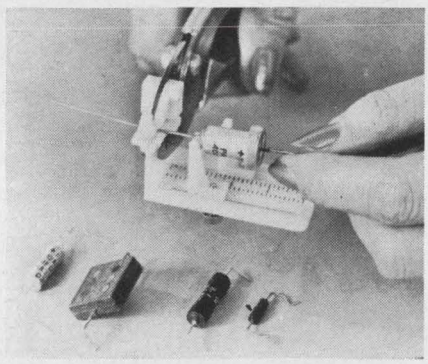


Metal/diamond spatula cleans contacts quickly

Electronic Space Products Inc., 854 S. Robertson Blvd., Los Angeles, Calif. Phone: (213) 657-5540.

The "Diacrom" is a metal spatula upon which diamond powder has been deposited on a layer of chromium. Since the cutting edges are very close to the layer, deep scratches cannot be produced. Contacts are cleaned and polished by a brushing motion. The shaft is flexible nylon for accessibility to awkward areas. The shafts are supplied in three different colors.

CIRCLE NO. 254

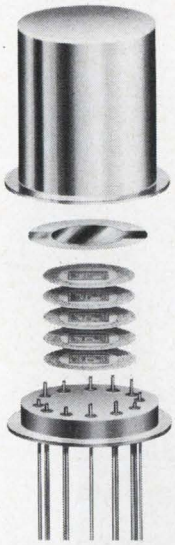


Cut-and-form pliers for component leads

Henry Mann Co., P. O. Box 104, Cornwells Heights, Pa. Phone: (215) 639-4048. P&A: $15; stock.

Accurate "one-shot" forming and cutting of component leads is easy with this pair of pliers. The single cut-and-bend pliers has Delrin jaws to eliminate scratching, nicking or flattening of lead wires (there is no metal-to-metal contact). The pliers have cushion grip handles and a return spring. Replacement jaws are available.

CIRCLE NO. 256



REEVES-HOFFMAN

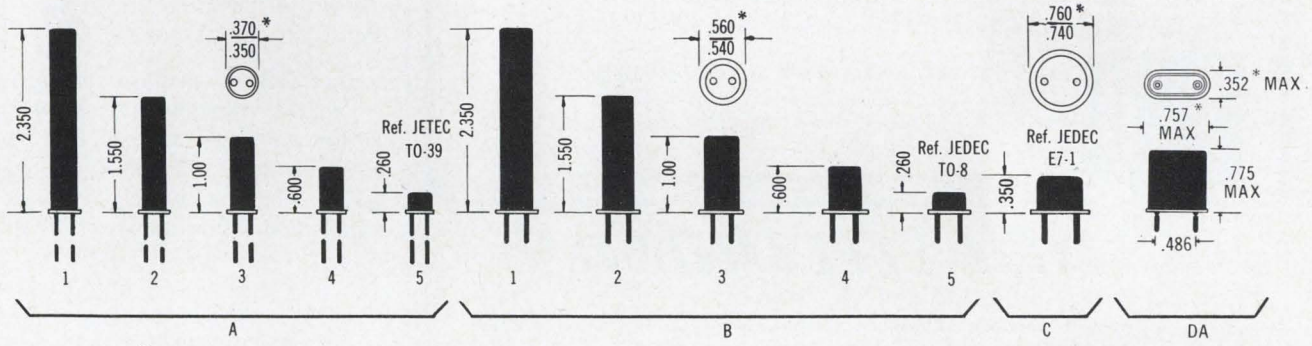
"chips" away at the space problem with new

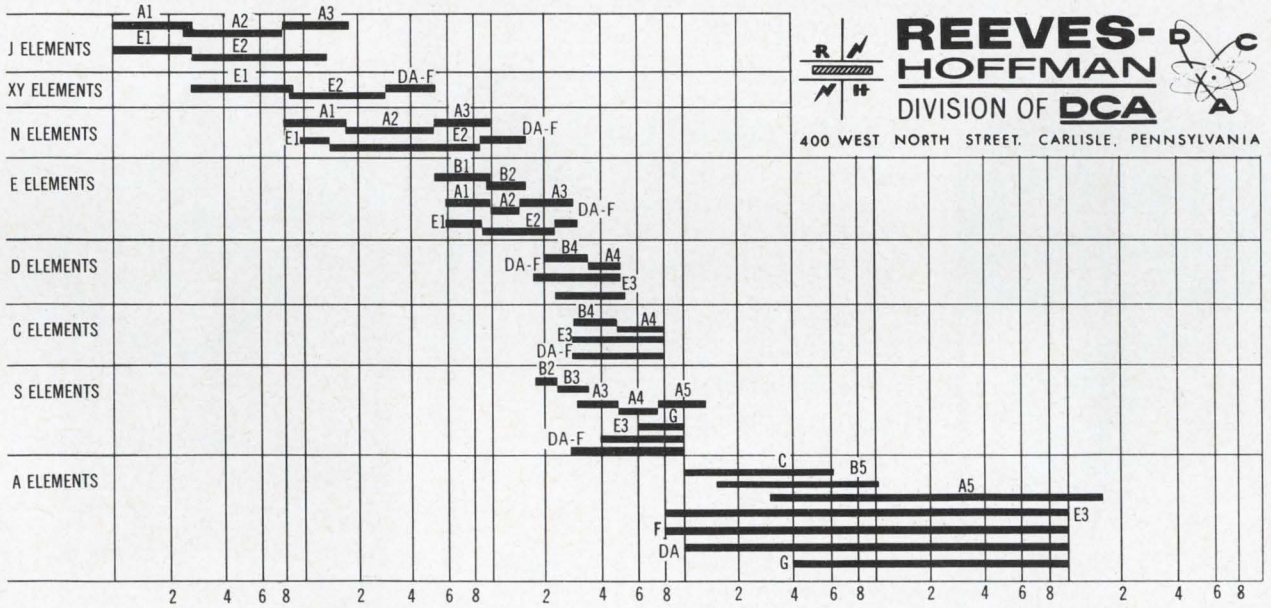
COLD-WELDED CRYSTALS

Reeves-Hoffman's newest series of crystals, packaged in cold-welded TO-5 transistor cans, are designed for operation at frequencies from 3 to 125 MH_Z. Frequency tolerance over the temperature range from —55°C to +105°C is ±0.004%. (Upon special request, ±0.0025% can be provided.) Shock and vibration ratings exceed the requirements of MIL-Spec 3098D. Aging at 65°C is 6 parts in 10^6 per year.

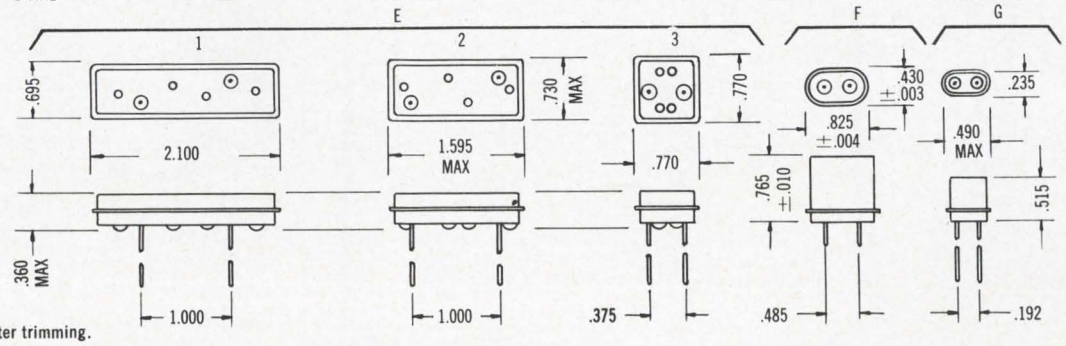
Cold welding eliminates solder and attendant flux and heat, removes undesirable damping and corrosion, solves problems of thermal isolation. Leak rate is better than 10^{-9}cc of helium per second. The results: substantial increases in the reliability and stability of crystal units, oscillators and filters; further opportunity for miniaturization.

For example, by using microminiature circuitry "chips," it is possible to produce a cold-welded crystal oscillator that occupies the space normally used for the crystal alone. The oscillator shown at left, for example, is in the A-4 holder shown below. Can this new micromodule technique solve space problems for you? We invite your inquiry.





REEVES-HOFFMAN
DIVISION OF DCA
400 WEST NORTH STREET, CARLISLE, PENNSYLVANIA



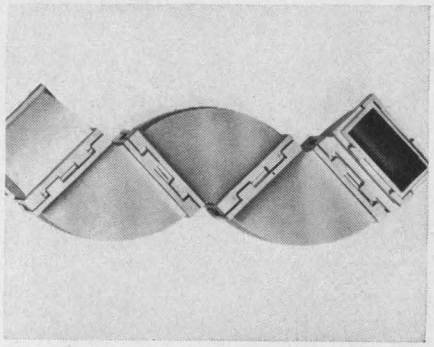
*Dimensions after trimming.

CW-166

ON READER-SERVICE CARD CIRCLE 793

MICROWAVES

(continued from p. 140)

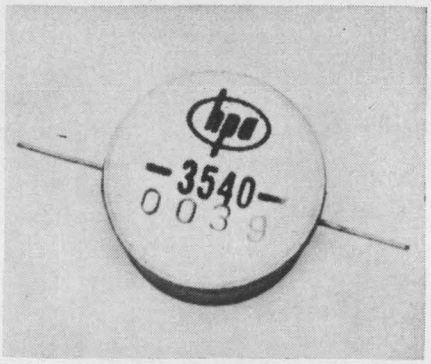


Cast bends speed waveguide assembly

Datapulse Inc., Demornay-Bonardi Div., 1313 N. Lincoln Ave., Pasadena, Calif. Phone: (213) 681-7416. P&A: $5.50 (X-band); stock.

Interlocking cast bends featuring a "corral" design are snapped together to speed assembly of waveguide systems. The need for waveguide sections between bends is eliminated. Aluminum and beryllium copper types are available in 30°, 45° and 90° for E and H planes. Vswr is 1.05 max and insertion loss is 0.2 dB.

CIRCLE NO. 257

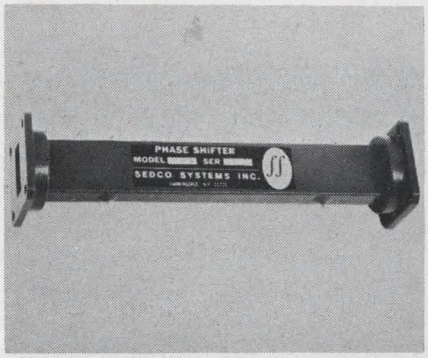


X-band switches have 10-ns rise and fall

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $157.50 (25 to 99); 2 wks.

Broadband solid-state spst switches have 10-ns rise and fall times and are useful from dc to 12.4 GHz. Insertion loss is 0.5 to 2 dB and isolation is 20 to 45 dB. The HPA 3540 switch consists of two oxide-passivated silicon pin diodes integrated into a broadband 50-Ω structure for use in 50-Ω stripline. Switching is accomplished by changing conductor bias.

CIRCLE NO. 258



Phase shifters use flux transfer for low vswr

Sedco Systems Inc., 130 Schmitt Blvd., Farmingdale, N. Y. Phone: (316) 694-7440.

Applying the principle of flux transfer, X-band phase shifters have extremely low insertion loss (0.06 dB) and low vswr (1.2). The units are for use in phased-array radar where thousands of little dipole antennas are fed from a common source through the phased devices to obtain the sweeping action of a moving antenna.

The driver (control) circuit is part of the assembly. In operation, the shifters are signaled to a particular phase shift, remaining at that shift even though control power is removed. They must then be forcibly re-zeroed prior to applying a new phase shift command. The driver circuit must, therefore, match both the phase shifter control characteristics and the characteristics of the input command signal. The 2003X can handle 2 kW peak power and 20 W cw without cooling. C and S-band units are available.

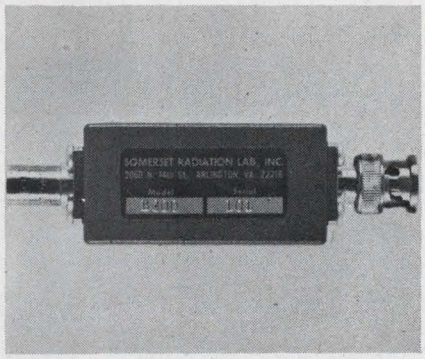
CIRCLE NO. 259

Folding filter saves component space

I-TEL Inc., 10504 Wheatley St., Kensington, Md. Phone: (301) 946-1800.

Length is said to be the only important specification affected by folding a new microwave filter. With a unit weight of only 18 grams, the filter is specially designed to fold in the center as a convenience feature. Units are available in ranges from 60 MHz to 1 GHz. Special mounting can be provided and most common connector types are available.

CIRCLE NO. 260

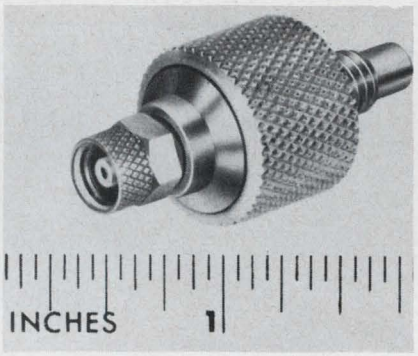


High-sensitivity limiter has 100-ps recovery

Somerset Radiation Lab., Inc., 2060 N. 14th St., Arlington, Va. Phone: (703) 325-4255. P&A: $183; 2 wks.

The 100-ps recovery time of this uhf limiter is 100 times faster than that of existing solid-state limiters. In addition, limiting threshold (1 dB above insertion loss at 0 dBm) is 10 times more sensitive. This combination compresses ns spikes to protect mixer diodes and insures instant response to low-level signals. Over 450 to 1050 MHz, insertion loss is less than 0.3 dB and isolation is 13 dB at 25 dBm input.

CIRCLE NO. 261

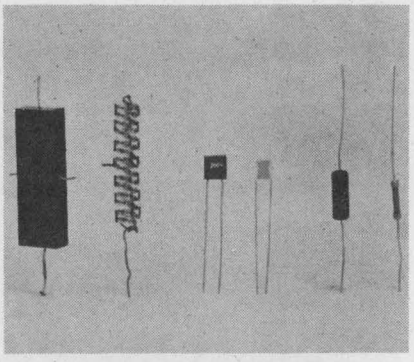


Coaxial attenuator operates dc to 6 GHz

Micron Electronics Inc., Roosevelt Field, Garden City, N. Y. Phone: (516) 741-4480. P&A: $68.75; 4 wks.

Power rating of the AT-00-1000 precision fixed coax attenuator is 1 W. Power surges to 2 kW can be handled by the 50-Ω unit with an operating range of dc to 6 GHz. Standard values are available at 1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30 and 40 dB. Vswr is rated at 1.1 to 1.3 through 6 GHz. Unit measurements are 1.245 x 0.5-in. diameter.

CIRCLE NO. 262

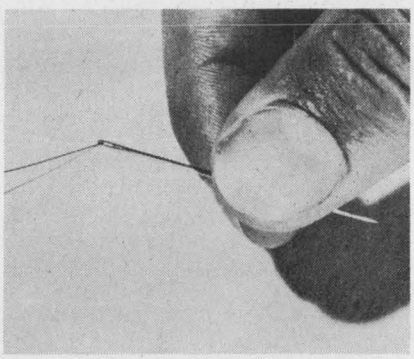


Decapsulant removes epoxy nondestructively

Henry Mann Co., P. O. Box 104, Cornwells Heights, Pa. Phone: (215) 639-4048. P&A: $10/quart to $18/gallon; stock.

Cured epoxy or other thermosetting resins may be removed from encapsulated components without damaging them or corroding the metallic connections and lead wires. "Decap" causes the epoxy to flake off the component. Heat may be used as a catalyst. The solution may be re-used 3 to 4 times if the residue is filtered out.

CIRCLE NO. 263



Semi-rigid 50-Ω coax has 8-mil OD

Uniform Tubes Inc., Collegeville, Pa. Phone: (215) 489-7293.

Subminiature 50-Ω coax is designed for use in high-density circuits, particularly in computers, where complete RF shielding is necessary. The cable has an 8-mil solid jacket of drawn copper tubing and is flexible enough to bend on a 1/16-in. radius. Center conductor is 2-mil copper and insulation is Teflon. Capacitance is 29.3 pF/ft. The cable is available in lengths to 10 ft.

CIRCLE NO. 264

Nailhead diode lead eliminates preform discs

Alpha Metals Inc., 56 Water St., Jersey City, N. J. Phone: (201) 242-3320.

Replacing four parts with two in the manufacture of diodes, a solder-coated "nailhead" lead is said to eliminate the need for preforms between the lead and the chip. This process also insures that the solder completely coats only the head, preventing both "drys" and "shorts" due to too little or too much solder. Also, the absence of flux means a reduced chance of contamination.

CIRCLE NO. 265

High-temperature epoxy withstands 500°F

Emerson & Cuming Inc., Canton, Mass. Phone: (617) 828-3300. P&A: $2.50/lb.; stock.

A two-part potting and encapsulating epoxy system is designed for high-temperature use. Where use temperatures are in the 400 to 600°F range, a step-wise cure yields optimum results. "Stycast 2762" withstands a 700°F environment for a few hours and a 600°F environment for much longer periods without deformation. Weight loss at 570°F is 0.3% in 3 days.

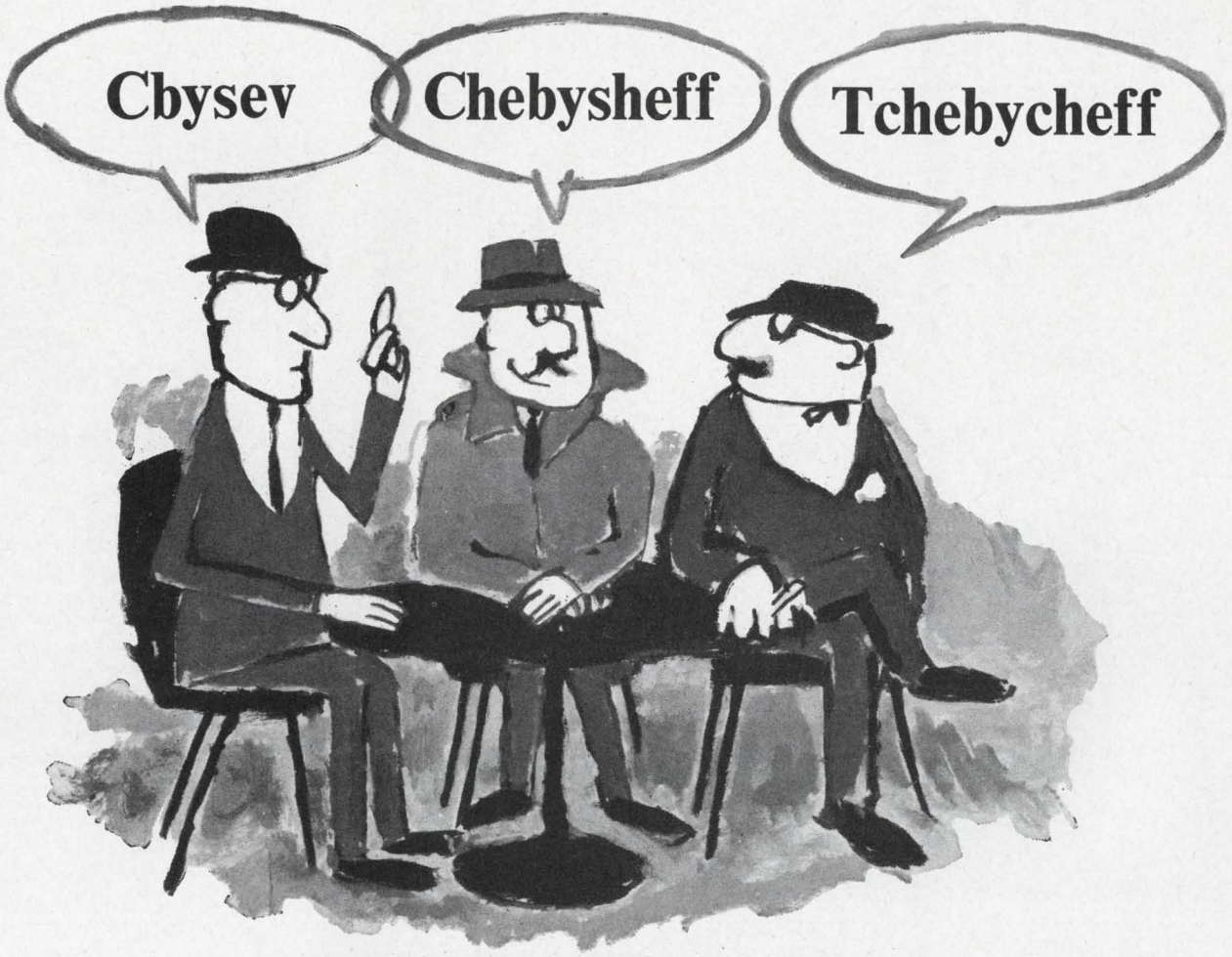
CIRCLE NO. 266

Etch resist, coating from the same can

Alpha Metals Inc., 56 Water St., Jersey City, N. J. Phone: (201) 242-3320.

A non-activated resin-base etch resist doubles as a solderable protective coating in PC board manufacture. Etchcoat #934 is applied as an etch resist after degreasing and tarnish-removal. After etching, boards can be soldered at once or stored for extended periods without any further treatment. Typical cure time is five minutes at 93°C. The material is available in quarts, gallons, or five-gallon containers.

CIRCLE NO. 267



SCHMEBICHEFF???

WHO CARES as long as you get attenuation!
If you are tired of maintaining the Status Kuo
If, when it comes to filter design, you are a Cauer-d
If, you are worried about the Worth of Butter . . .

Ask Aladdin for a QFS*

We not only know how to design and build filters, we handle your problems in a businesslike, straightforward way.
Here are the steps in the plan that goes into action as soon as you send us a description of your requirements.

First, the feasibility study. A free service. It amounts to a computerized analysis that tells whether one of Aladdin's "standard" types will meet your specs, *using stock components.*

Second, if the feasibility study is affirmative, you receive a quotation on a sample lot of Aladdin filters which *will meet your specs.*

Third, along with your quote and before we even make the samples—a quote on production quantities just like the samples. In short, we are not going to hem and haw and weasel word our estimate of the quote, even on a prototype design we have never made before. You know before you test the samples that if they turn out to be what you want you have a firm price on production quantities.

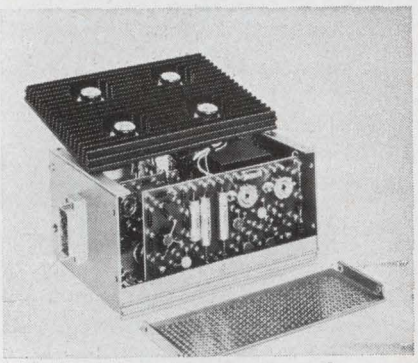
Fourth—if you order the sample lot—quick service . . . because we combine stock components and hardware with Aladdin tailored inductance values.

where the magic of magnetics is a science...™

Aladdin® electronics / 703 Murfreesboro Road, Nashville, Tennessee

***Quick Feasibility Study**

ON READER-SERVICE CARD CIRCLE 825

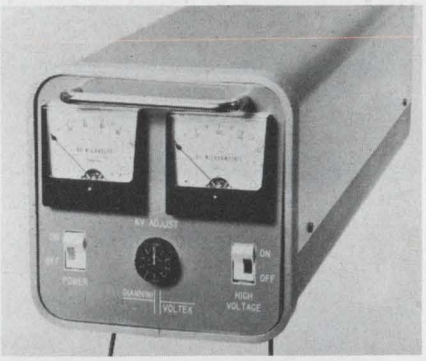


10-A dc source needs no heat sinking

Power Designs Inc., 1700 Shames Dr., Westbury, N. Y. Phone: (516) 333-6200. P&A: $245; 3 to 4 wks.

Requiring no external heat sinking or blowers, this 10-A unit supplies 3, 4, 5 or 6 Vdc. The unit operates from 0 to 60°C. Regulation is 0.01% ±2 mV, ripple is below 1 mV p-p and output adjustment is ±1/2 V of programed value. Stability is 1 mV/8 hours, using a high-voltage, temperature-compensated zener voltage reference and an integrated differential amplifier input.

CIRCLE NO. 268



Electrostatic supply yields 100 kV

Giannini, 12140 E. Rivera Rd., Whittier, Calif. Phone: (213) 723-3371. P&A: $3000; 30 to 120 days.

A portable electrostatic generator provides 100,000 V at 300 μA. The portable (under 50 lbs) unit is a dc generator of the drum type and uses no electronic conversion. High stability options are available to provide ripple as low as 0.001% and drift of 10 V/hr. In this configuration, a load regulation is 1 V in 100,000 and 0.01% for a 5% change in line.

CIRCLE NO. 269

EIMAC 15 kW tetrode offers high power gain for advanced transmitters

Most new high-power 20 kW FM transmitters use the EIMAC 4CX15,000A tetrode for service as a Class-C amplifier. The tube features a new internal mechanical structure which minimizes rf losses, and is capable of operation at full power ratings to 110 MHz. EIMAC also recommends the 4CX15,000A for 220 MHz operation at lower power levels for VHF-TV transmitters. ■ EIMAC's long experience in tube technology and ceramic-to-metal sealing leadership have combined to produce a tetrode of optimum design and structural integrity. That's why the 4CX15,000A is used in more new transmitters than any other ceramic tetrode with similar characteristics. For more information write Product Manager, Power Grid Tubes, or contact your nearest EIMAC distributor.

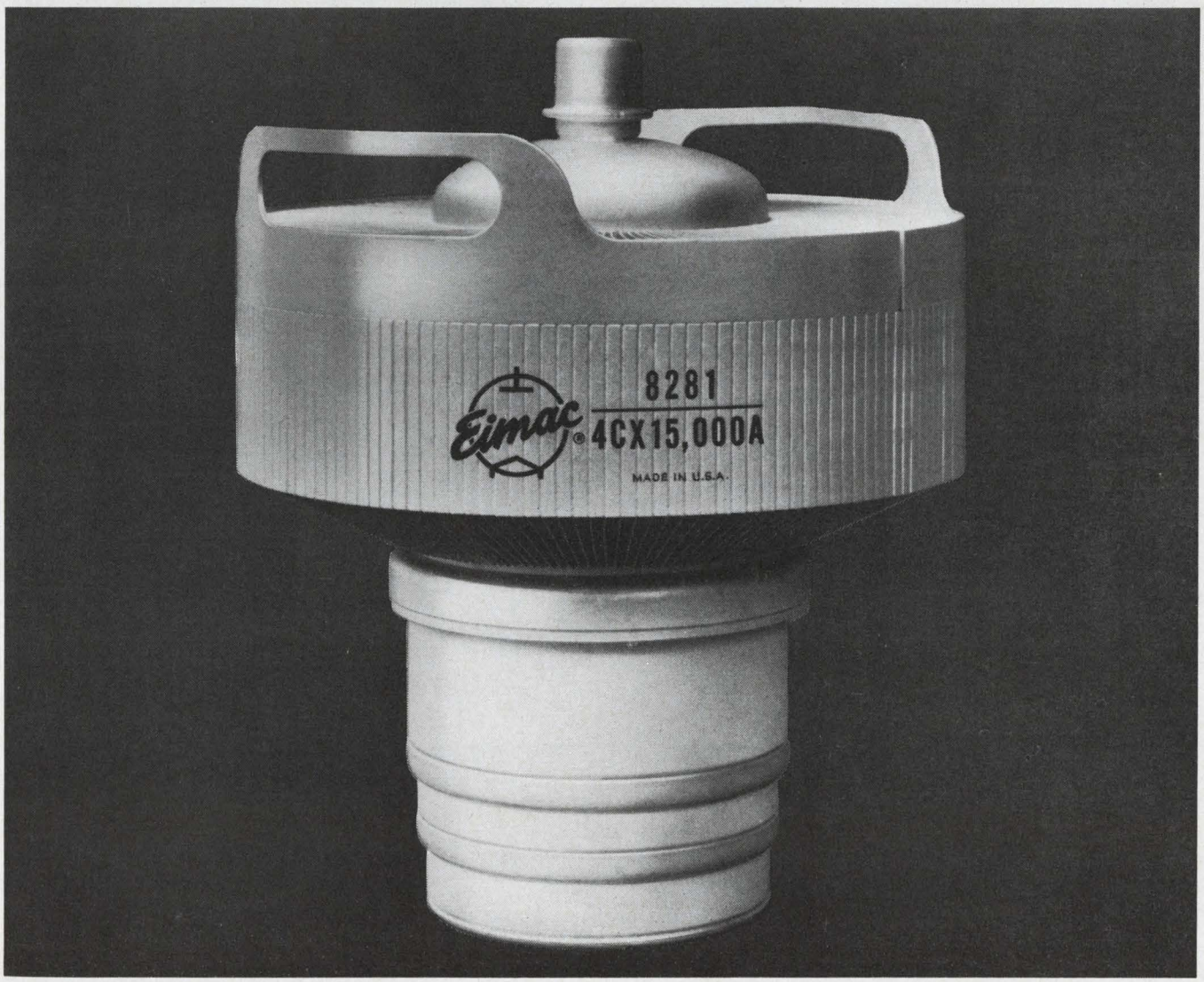
RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions)

MAXIMUM RATINGS

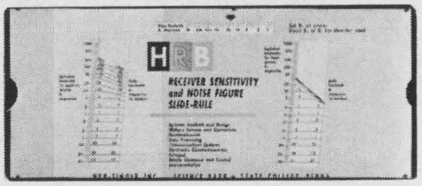
DC PLATE VOLTAGE	10,000 MAX. VOLTS
DC SCREEN VOLTAGE	2,000 MAX. VOLTS
DC PLATE CURRENT	5.0 MAX. AMPS
PLATE DISSIPATION	15,000 MAX. WATTS
SCREEN DISSIPATION	450 MAX. WATTS
GRID DISSIPATION	200 MAX. WATTS

EIMAC
Division of Varian
San Carlos, California 94070



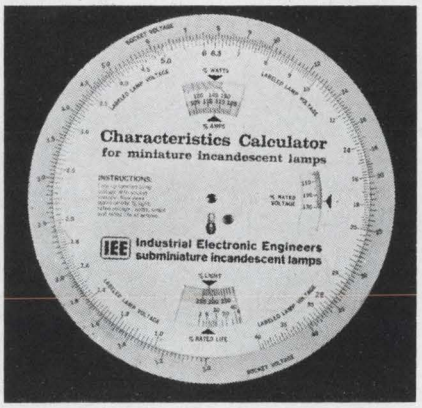
ON READER-SERVICE CARD CIRCLE 828

Design Aids



Sensitivity, noise figure rule

Receiver sensitivity and noise figure can be calculated using this slide chart. By chosing a video bandwidth from 0.01 to 1000 MHz, equivalent bandwidth for a quadratic detector or linear detector and corresponding radio bandwidth is found. For a tangential sensitivity between −120 and −20 dBm or 0.1 to 10,000 μV, noise figure is given for quadratic or linear detectors which range from 0.01 to 1000 MHz. HRB Singer, Inc. **CIRCLE NO. 270**



Miniature lamp calculator

This circular characteristics calculator for miniature incandescent lamps determines ratings of 1- to 40-V subminiature lamps. By lining up the labeled lamp voltage scale with the socket voltage scale, approximate per cent light, rated voltage, watts, amps and rated life are read at the arrow in the appropriate window. The reverse side of the calculator gives common lamp configurations. Industrial Electronic Engineers, Inc. **CIRCLE NO. 271**

Manual of conversion factors

From abcoulomb and atmosphere to weber and yard; they're all covered in this 12-page book of conversion factors. The handy, pocket-sized manual lists approximately 1000 alphabetically arranged conversion factors. Amp, Inc.

CIRCLE NO. 272

CATV cable calculator

Seven scales determine attenuation and dc resistance for CATV cable on this three dial/cursor circular slide rule. Attenuation scales determine attenuation at any frequency, at any given length or at temperatures (−60 to 140°F) other than 70°F. Resistance scales determine dc resistance for any given length of a given cable. The reverse side of the calculator is complete with instructions for operation and sample problems and solutions. Jerrold Electronics Corp.

CIRCLE NO. 273

Power supply design

This guide is aimed at designers of system power supplies. In addition, it is intended to aid in writing specs that are free from loop-holes and "bugs." The cost factor is covered and suggestions are offered for minimizing expense. Circuit and block diagrams aid in the discussion. Trio Laboratories, Inc.

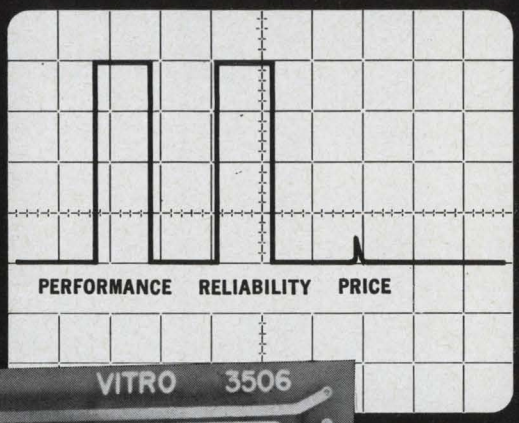
CIRCLE NO. 274

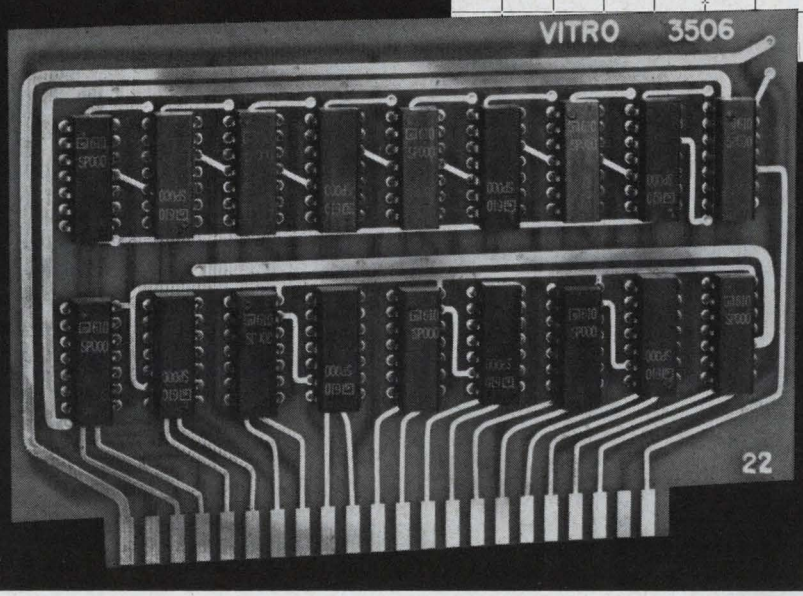
Arc welding handbook

The "Miniature Precision Arc Welding Handbook" describes the application of tungsten inert gas arc welding to the joining of small and thin electronic parts. The 54-page handbook illustrates typical applications of miniature precision arc welding and provides basic arc welding theory. Materials suitable for the process are discussed. Costs are considered and compared to other joining processes.

Available for $1 from Precision Arc Co., 785 Woodend Rd., Stratford, Conn.

VITRO Micro Modules MEASURE UP...





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The logic implementation on all Vitro boards has been standardized for positive NAND logical functions at a voltage swing from 0 to +3 volts. The diode-transistor logic devices employed have individual circuit speeds up to 10 MHZ, and equipment speeds above 5 MHZ. These circuit boards can be provided as directly off-the-shelf logic, with standardized performance to simplify a logic design application, or can be custom-built according to customer specifications. High density packaging is utilized providing up to 18 removable microcircuits on a single card. Ease of maintenance is assured since all dual in-line circuit packages can be easily removed and replaced in the field. To further simplify maintenance, Vitro-supplied chassis configurations are constructed of standard components assembled on a building block principle.

For further information on the complete line of Vitro microcircuits, mounting hardware, card files, wiring accessories, and power supplies, contact the Micromodule Sales Department, VITRO ELECTRONICS, 919 Jesup-Blair Drive, Silver Spring, Maryland 20910, Phone No. (301) 585-1000.

Vitro ELECTRONICS A Division of Vitro Corporation of America
Producers of **NEMS-CLARKE** Equipment V-23

ON READER-SERVICE CARD CIRCLE 884

Application Notes

Piezoelectric Accelerometer

Want to know all about piezoelectric accelerometers, how they work and their applications?

"The Piezoelectric Accelerometer Users Handbook" a 24-page publication put out by the Consolidated Electrodynamics Corp., Pasadena, Calif., is said to be one of the most comprehensive in the field.

A piexoelectric accelerometer, according to the company, is essentially a transducer that converts mechanical forces, such as vibration, pressure and acceleration, into electrical energy.

The device consists basically of a crystalline material—quartz, lead zirconate or lead titanate—that generates a charge when force is applied. The incorporation of a mass in direct contact with the crystal produces an acceleration transducer. When a varying acceleration is applied to the mass-crystal assembly, the crystal is subjected to a varying force (F-Ma) that causes a changing electrical charge across the crystal, or

$$q\text{-}dF - dMa,$$

where d is the piezoelectric constant. Thus the electrical charge (q) is directly proportional to the acceleration of the transducer.

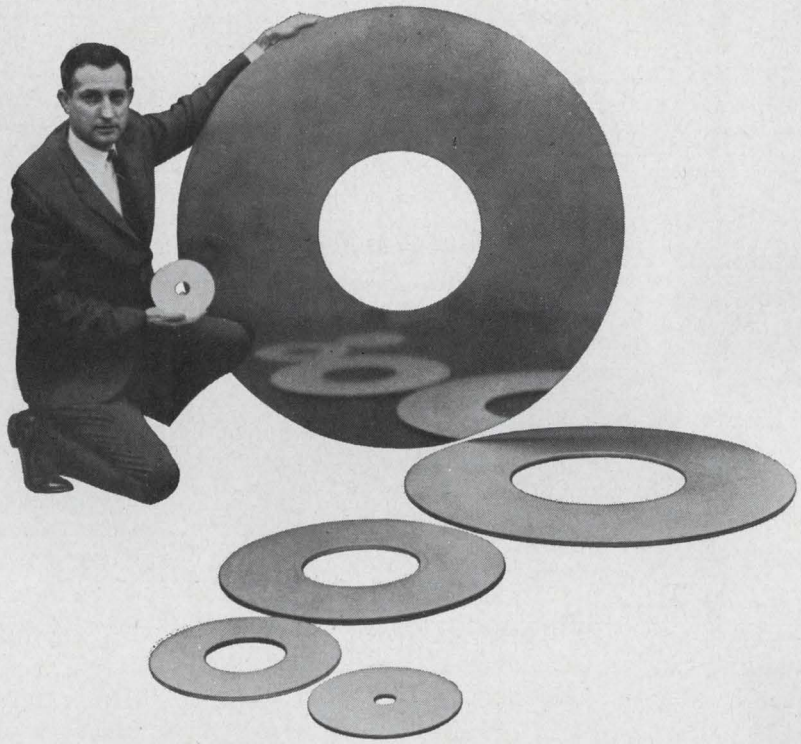
According to the company, piezoelectric transducers are superior to other types of vibration-measuring devices in key areas.
They are described as:

- Self-generating.
- Of wider frequency reponse.
- Without phase shift in the frequency range of interest.
- Of small size.
- Providing an electrical output directly proportional to acceleration.

The handbook presents an evaluation of current design, materials, theory and the applications of low-impedance piezoelectric accelerometers. The amplifier requirements of conventional high-impedance piezoelectrics are also covered. Included are associated diagrams, curves, useful formulae, and definitions of terminology.

CIRCLE NO. 277

No one has a larger line of disc memories.



See the largest line of disc memories available at the Spring Joint Computer Conference, Booth 913-916

Whether your information storage requirements are small or require data stored in millions of bits, Librascope Group of General Precision, Inc., has a disc memory system for every application. These systems have a proven history of reliable performance in computing systems designed for military, business, engineering, and educational applications.

LIBRAFILE mass memories: Large-capacity, high-speed, random-access information storage systems. Two disc sizes available. 48″ discs capable of storing up to 400 million bits. 38″ discs with a capacity of 200 million bits. LIBRAFILE mass memory information retrieval is either fixed-address search or search-by-record content. Access time less than 20 ms. Data transfer rates in the megacycles.

Militarized disc-memory systems: High-speed, random-access, information-storage systems. Consists of disc memory for data storage and an electronic subsystem that provides complete interface, control, and read/write electronics. These systems can be used as a data base for shelter, van, or shipboard applications. Storage capacity of 25 million bits on 24″ discs. Customized capacity up to 80 million bits.

L-400 magnetic-disc memory systems: Provide data storage and transfer in computer systems, peripheral equipment, and other systems where rapid-access memory is a requirement. 24″ disc storage capacity up to 36 million bits.

Airborne disc file: Small, compact file designed for airborne (MIL-E-5400 class 2) applications, as well as for shipboard and mobile field operations. 6¼″ disc with capacity of 1 million bits. Customized airborne memories available with capacity up to 50 million bits.

L-300 disc memory: For use in computer systems and peripheral equipment as main storage, buffer storage, or as a supplemental memory. 10″ disc with a capacity of 275,000 bits.

For complete details, write for our technical bulletins.

Engineers: For career openings, call or send resume in confidence to B. Larson, General Precision, Inc., Librascope Group, 808 Western Avenue, Glendale, California 91201. An equal opportunity employer.

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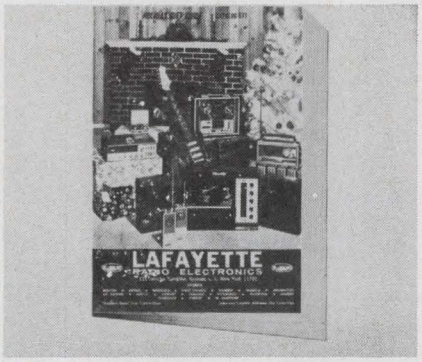
ON READER-SERVICE CARD CIRCLE 886

New Literature



Radio electronics catalog

Lafayette's 1966 Christmas gift catalog covers the latest in electronics and stereo hi/fi equipment. A complete selection of stereo hi/fi components, citizen band 2-way radio, tape recorders, ham gear, test equipment, radios, TVs and accessories are included. Lafayette Radio Electronics.

CIRCLE NO. 278

Plastic semiconductor lines

A broad line of plastic-encapsulated economy semiconductors is described in this 12-page booklet. The data covers product characteristics, applications, advantages and typical uses for commercial, military and industrial purposes. Among the devices described are silicon and germanium bipolar and field-effect transistors, unijunction and power transistors, silicon rectifiers and monolithic ICs. Texas Instruments Inc.

CIRCLE NO. 279

Pill terminations

Literature describing "Pill" terminations and stripline application techniques is offered. The illustrated bulletins cover a line of terminations, attenuators, resistors, shorts, capacitors, dc blocks, coax rod and disc resistors. EMC Technology Inc.

CIRCLE NO. 280

Dual-in-line IC logic

This 20-page catalog describes dual-in-line integrated circuit logic cards. The catalog includes physical characteristics, operating specs, data sheets and related equipment. Engineered Electronics Co.

CIRCLE NO. 281

Ceramic disc capacitors

Full specifications and selection tables describing ceramic disc capacitors are offered. The types include temperature compensating 500-Vdc, general-purpose high-capacitance 12 and 30 Vdc, by-pass coupling 50 Vdc and by-pass coupling 500 Vdc. Nucleonic Products Co.

CIRCLE NO. 282

IC digital assemblies

This portfolio of data sheets details a line of DTL IC logic assemblies. Included in the folder are basic NAND gates and J-K flip-flops, binary-to-octal, binary-to-hexadecimal, and BCD-to-decimal decoders, BCD and binary up-down counters and shift registers and arithmetic/logic circuits. Cambridge Thermionic Corp.

CIRCLE NO. 283

Semiconductor procurement

The 1966-67 semiconductor procurement directory is a 12-page booklet covering more than 6000 of the popular types and brands. Prices listed are, in most cases, below prevailing factory prices. MIL-type diodes and transistors are also included. Corvair Electronics, Inc.

CIRCLE NO. 284

Electron tube catalog

Containing descriptions and basic specs of the full line of Amperex tubes, this catalog serves as a quick reference guide for OEM designers as well as for replacement tube buyers. The full line consists of power tubes, thyratrons, subminiature tubes, entertainment and audio tubes, tuning indicator tubes, uhf special purpose tubes, rectifiers, diodes, counting, selecting and indicating tubes, CRTs, ignitrons, voltage reference and regulator tubes, vidicon tubes and cold cathode indicator diodes. An insert covers pulse magnetrons, continuous wave magnetrons, BWOs, klystrons, disc-seal triodes and TWTs. Amperex Electronic Corp.

CIRCLE NO. 285

Scientific equipment

New, surplus, hard-to-find and desirable items for optical, mechanical and electrical use are covered in this catalog. New and interesting among the 4500 items in the 1967 catalog are plastic fiber optics light guides, holograms, and a solid-state thermoelectric cooling system. Edmund Scientific Co.

CIRCLE NO. 286

RF terminations

This 4-page short form catalog covers RF coax load resistors. The brochure lists a line of dry and oil-cooled terminations ranging from 5 to 600 W. Bird Electronic Corp.

CIRCLE NO. 287

Electronic kits catalog

The 1967 edition of the Heathkit catalog, illustrating over 250 electronic kits, is available. The 108-page book contains complete lines of stereo/hi-fi components, amateur radio equipment, marine electronics, test and lab instruments, citizen's band radio, photographic aids, educational kits and many home and hobby items. Heath Co.

CIRCLE NO. 288

Get immediate delivery of P&B Precision Switches from authorized P&B distributors Factory Prices too*

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PRECISION MINIATURE

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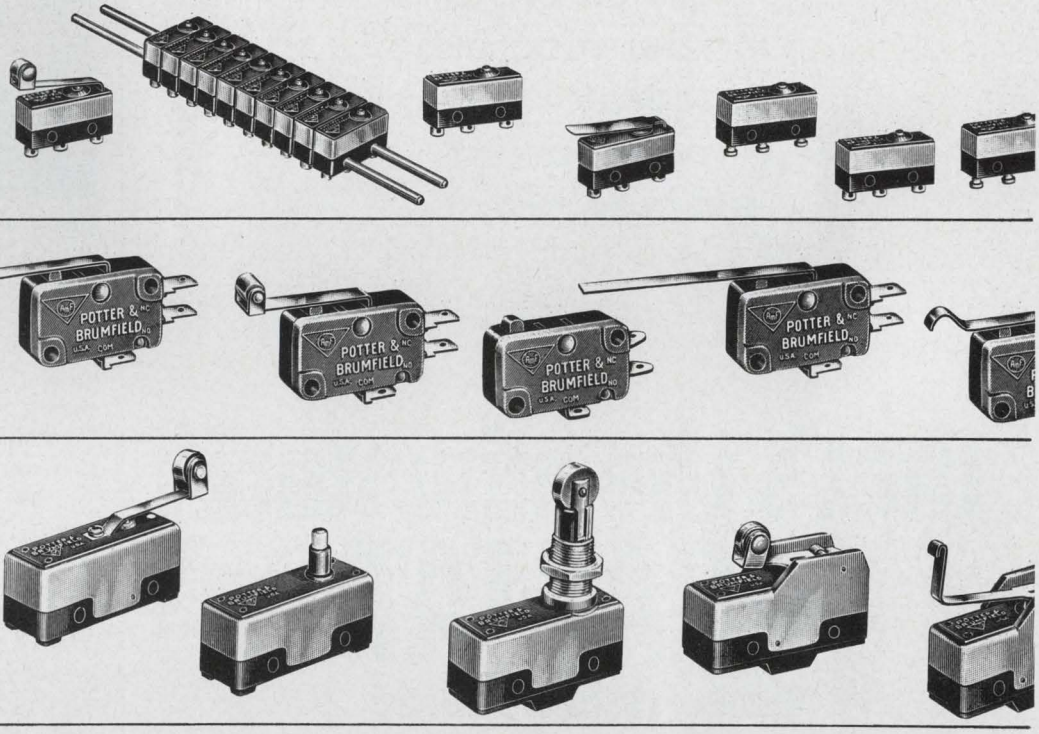

Your authorized P&B switch distributor has a wide variety of P&B precision snap-action switches on his shelves. You can get immediate delivery at factory prices. Included are general purpose, miniature and subminiature switches in a wide choice of actuators, contact arrangements and terminations. Most are directly interchangeable with competitive types. All meet U/L and CSA requirements. Mounting dimensions and materials meet military specifications.

** Call your P&B representative for distributor nearest you or write us direct for his address.*

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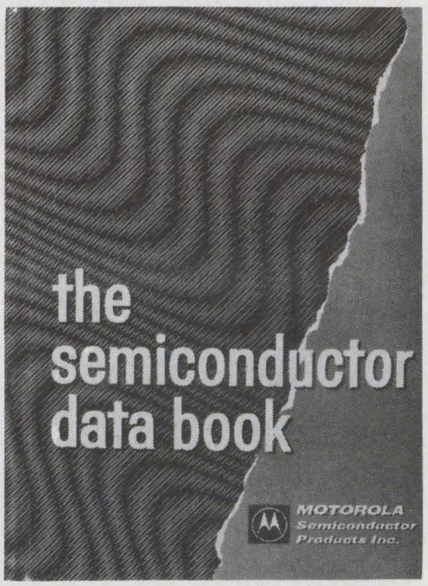


Semiconductor specifications

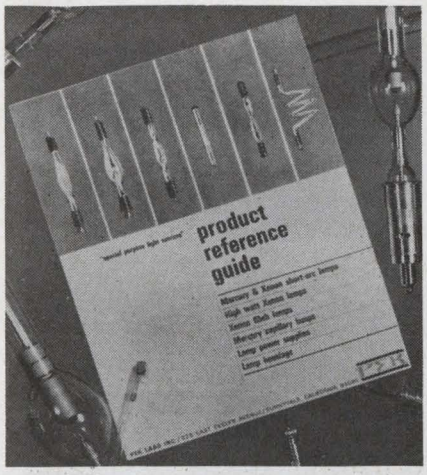
Over 1500 pages of up-to-date information, including 16 edge-referenced sections containing complete data sheets for more than 2800 devices from diodes to ICs, are contained in this hard-bound volume. In addition, the general information section boasts short-form specs for more than 10,500 EIA-registered 1N, 2N and 3N devices. The index identifies the semiconductors by major application and gives the type numbers of recommended replacements. The data sheets are arranged in 12 sections, each prefaced with application-oriented quick selection guides. Application notes in the last section are outlines of general design procedures, rather than specific circuits.

Available for $3.95 from Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix.

Solid-state sidelights

The latest issue of the "Tip-Off," the second in a series entitled "The Semiconductor Story," contains a background of the development of the "Solid State Age." The 8-page note details early innovations and presents glimpses into the lives of early experimenters such as Armstrong, deForest and Pikard. The issue includes charts, diagrams and photographs of early equipment and the men responsible. Schweber Electronics.

CIRCLE NO. 289



Light source reference guide

A new 6-page color product reference guide covers a line of lamps, power supplies and related equipment. The publication gives general and technical information on short arc, capillary and flash lamps, power supplies, pulse generators and lamp housings. The brochure also provides applications information. Pek Labs Inc.

CIRCLE NO. 290

Basic timer principles

"Magnetic Timer Principles" is a 12-page booklet discussing magnetic materials and timer components. A companion 8-page booklet discusses the manufacturer's magnetic core counter timer. The bulletin analyzes diamagnetic, paramagnetic and ferromagnetic materials and associated magnetic field effects. It illustrates and describes the basic components required for a magnetic time delay relay and compares magnetic and RC units. Finally, it discusses various applications, both simple and complex, for magnetic timers. ESNA, Agastat Div.

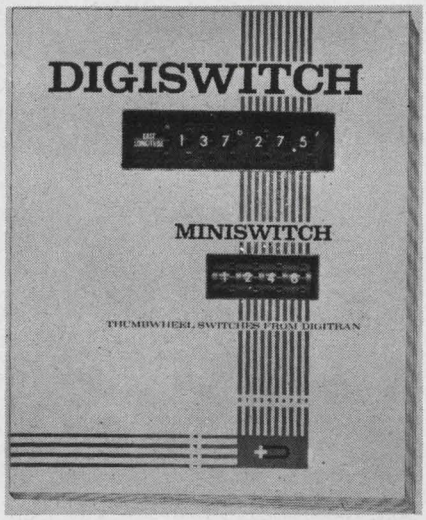
CIRCLE NO. 291

Tape data charts

Typical properties of 41 different tapes are listed in this electrical tape data and sample chart. The chart includes sample strips of each tape and includes such information as thickness, tensile strength, elongation adhesion, electric strength, temperature class, insulation resistance, electrolytic corrosion factor, MIL-spec and cost. 3M Co.

CIRCLE NO. 292

NEW LITERATURE



Thumbwheel switch catalog

This 54-page thumbwheel switch catalog has complete technical data on a line of switches. Codes and electrical output configurations, dimensional sketches, standard performance specifications, prices and typical applications are included. Digitran Co.

CIRCLE NO. 293

Gas discharge noise sources

History, fundamentals, characteristics and applications information on gas discharge noise sources are summarized in this 16-page brochure. Included in the brochure are definitions of noise sources and noise generators, as well as a brief history of noise source measurements. Discussions on noise power, excess noise ratio calibration, methods of operation and microwave characteristics are accompanied by applications photos, circuit diagrams, noise vs noise source graphs and tube drop vs tube current graphs. Signalite Inc.

CIRCLE NO. 294

Radio/TV equipment

The need for consumer education in TV/radio and other home entertainment equipment has mounted. This booklet, in clear and uncomplicated terms, states that there is more to TV/radio than just buying it and putting a plug into a wall socket. The 12-page brochure goes on to answer many of today's common questions. NATESA.

CIRCLE NO. 295

Magnetic components folder

"Magnetic Components for Commercial and Aerospace Applications" is a 6-page folder covering components such as power transformers, inductors, saturable reactors, audio transformers, pulse transformers and coils. Transonic Inc.

CIRCLE NO. 296

Radar test equipment

Typical radar test and simulation equipment is described in this 2-color folder. The equipment is designed for military tactical use, aerospace operations support, radar system design evaluation and operator training. Canoga Electronics Corp.

CIRCLE NO. 297

Custom power supplies

Custom-designed power supplies are described in this 24-page brochure. The bulletin includes examples of design, prices, specs, photographs and products. In addition, the brochure contains a glossary of electronic terms. Sola Basic Industries.

CIRCLE NO. 298

Rotating servo components

A 100-page catalog gives specifications, performance and application data, schematics and dimensions of a comprehensive line of rotating servo components. Included are servo, stepper, and synchronous motors, motor/generators, gear trains, synchros, and resolvers. Most components are listed in sizes from 5 to 23. Harowe Servo Controls, Inc.

CIRCLE NO. 299

TV/FM distribution gear

A full line of all-channel, all-solid-state distribution equipment is covered in this catalog. The booklet includes amplifiers and preamps, vhf, uhf and FM, mixing networks, tap-offs, splitters, filters, cable equalizers, terminating units, attenuators, matching transformers and low-loss cable. Jerrold Electronics Corp.

CIRCLE NO. 300

NEW LITERATURE

Capacitor catalog

Marshall's major capacitor series and styles are summarized in this catalog. These include metallized mylar, metallized polycarbonate, mylar and foil, polystyrene and foil, metallized paper and ceramic capacitors. Standard styles include wrap-and-fill, epoxy case radial and axial lead, and hermetic seal round and rectangular. General specs, performance curves and environmental data are given along with parametric trend curves and acceptance criteria. Marshall Industries.

CIRCLE NO. 301

"How-To" electronic library

The first 12 volumes in a library of "How-To" electronics books includes titles such as "Diodes," "The Volt-Ohm-Milliammeter," "Basic Alternating Current," "How To Read Circuit Diagrams," "Basic Electronics Math," "Handbook of Transistor Circuits," "Learn Electronics In 5 Minutes, 37 seconds," "The Oscilloscope," "The Vacuum-Tube Voltmeter," "Elements of Electronics," "How To Use and Enjoy Your Tape Recorder" and "Practical Radio." The library will consist of 103 books when it is completed.

Available for $1.25 each from IRC Inc., 414 N. 13th St., Philadelphia.

Indicator lights

Data, drawings and catalog numbers for the company's subminiature and minature indicator lights are included in this catalog. Also given are lamp selection charts for the lamps employed by these indicators. Also included is a discussion of the safety factors provided by the assemblies and the mechanical shutter dimming available with various units. Dialight Corp.

CIRCLE NO. 302

Relay catalogs

Mercury-wetted contact relays are covered in a 22-page catalog. Dimensional diagrams and photos accompany descriptions of epoxy and encapsulated types, polarized and sensitive or bistable types. The second catalog covers mercury displacement relays. Information includes applications, selection factors, construction features, dimensional drawings, and performance characteristics of time delay and load units. Adams & Westlake Co.

CIRCLE NO. 303

Technical information service

This brochure describes its publisher's information services, available in cumulative or journal form. Technical information from journals, books, magazines, research reports, conference preceedings, patents and theses are continually scanned and abstracted for the solid-state, electronics and computer fields. Subject areas are divided into categories and sections, all of which are described along with their subscription charges. Cambridge Communications Corp.

CIRCLE NO. 304

Ge transistor applications

A comprehensive "Germanium Transistor Application Guide" lists over 130 transistor types. The guide keys individual transistor types to product family, performance range and specific circuit application. General Instrument Corp.

CIRCLE NO. 305

Printed circuit products

Over 20 product families are described in this 60-page guide. Detailed specs, plus application and dimensional data, are included for two-piece connectors, card-edge connectors and single-lead connectors. Complete packaging concepts such as modular interconnection systems, cellular packaging techniques and reusable component receptacles are explained. Hand tools for maintenance and production of interconnection systems, as well as automatic and semiautomatic production machinery are also described. Amp Inc.

CIRCLE NO. 306

NEW LITERATURE

Diode reliability

Gallium arsenide hot carrier diode reliability is discussed in a 4-page report. The results of GaAs hot carrier diodes tested for 2000 hours at 150°C are given. International Semiconductor, Inc.

CIRCLE NO. 104

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service Card.

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Keeping a CRT's Spot on Focus (No. 308)

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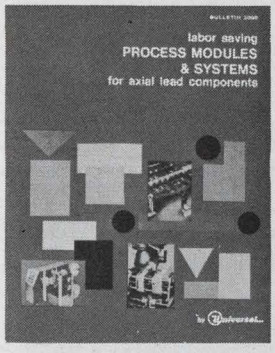

Universal continuous process systems can combine almost any functions—with a big advantage in *labor savings*. This new 20-page bulletin illustrates how to feed raw materials . . . assemble . . . coat . . . test . . . sort . . . code and package finished axial lead components automatically. By combining processing steps into complete systems, Universal enables you to maintain physical control from one function to the next. Standard modules can be combined with customized units for systems designed to meet special requirements. Send for this valuable engineering reference.

Universal Instruments Corporation
E. Frederick St., Binghamton, N. Y.
(607) 772-1710

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Piezotron® Quartz Accelerometer

Four-page illustrated Bulletin 321466 on Model 818 quartz accelerometer describes Piezotron principle which eliminates need for costly amplifiers and permits use of just one single-wire shielded cable for both power and signal. Bulletin also describes how base strain sensitivity ground loop, cable noise and insulation resistance problems are prevented. Diagrams of the basic circuit and a typical system show operation. Performance data is graphically displayed. Complete specs and ordering information are included.

Kistler Instrument Corporation
8969 Sheridan Drive
Clarence, N. Y. 14031

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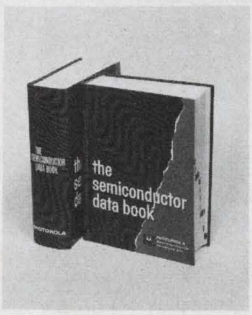
Free Semiconductor Data Book



Free only from Schweber Electronics with each 250 dollar purchase of semiconductors, a valuable data book that will enable you to SELECT the one unique device for your design, rather than SETTLE for a stereotyped compromise. A durable, cloth bound book of 1526 pages. Thoroughly indexed for easy reference, from zener diodes to integrated circuits, plus more than 100 pages of application notes. Every engineer has been waiting and hoping for such a book to come along. Don't miss it.

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Nov. 8-10

1966 Fall Joint Computer Conference (San Francisco) Sponsor: American Federation of Information Processing Societies; W. Estler, 965 Lincoln Ave., Palo Alto, Calif.

Nov. 14-17

19th Annual Conference on Engineering in Medicine and Biology (San Francisco) Sponsor: IEEE and ISA; T. Weber, Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif.

Nov. 15-17

Fifth Annual Symposium on the Physics of Failure in Electronics (Columbus, Ohio) Sponsor: USAF and Battelle Memorial Inst.; T. S. Shilliday, Battelle Memorial Inst., 505 King Ave., Columbus, Ohio.

Nov. 15-18

Twelfth Annual Conference on Magnetism and Magnetic Materials (Washington, D. C.) Sponsor: IEEE and the American Inst. of Physics; V. J. Folen, Code 6452 NaS., Naval Research Lab., Washington, D. C.

Nov. 16-18

1966 Eastern Analytical Symposium (New York City) Sponsor: American Chemical Society, American Microchemical Society, and Society for Applied Spectroscopy; Ivor L. Simmons, M&T Chemicals, Inc., P. O. Box 471, Rahway, N. J.

Nov. 29-Dec. 2

AIAA Third Annual Meeting and Technical Display (Boston) Sponsor AIAA; Vincent J. Coates Jr., Avco Everett Research Lab., 2385 Revere Beach Pkwy., Everett, Mass.

Dec. 7-9

15th Annual Wire and Cable Symposium (Atlantic City, N. J.) Sponsor: Army Electronics Command; J. Spergel, Wire and Cable Symposium, U. S. Army Electronics Command, Fort Monmouth, N. J.

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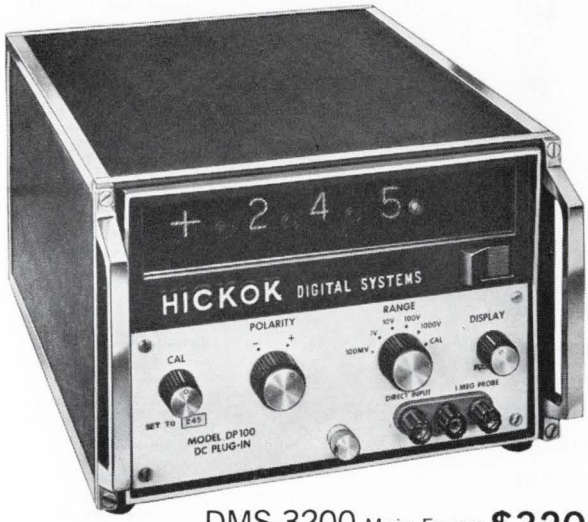

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Range 0.1 millivolts to 1000 volts
Accuracy ±0.1% FS, ±0.1% of reading
True integrating voltmeter design
10 megohms input impedance at all times

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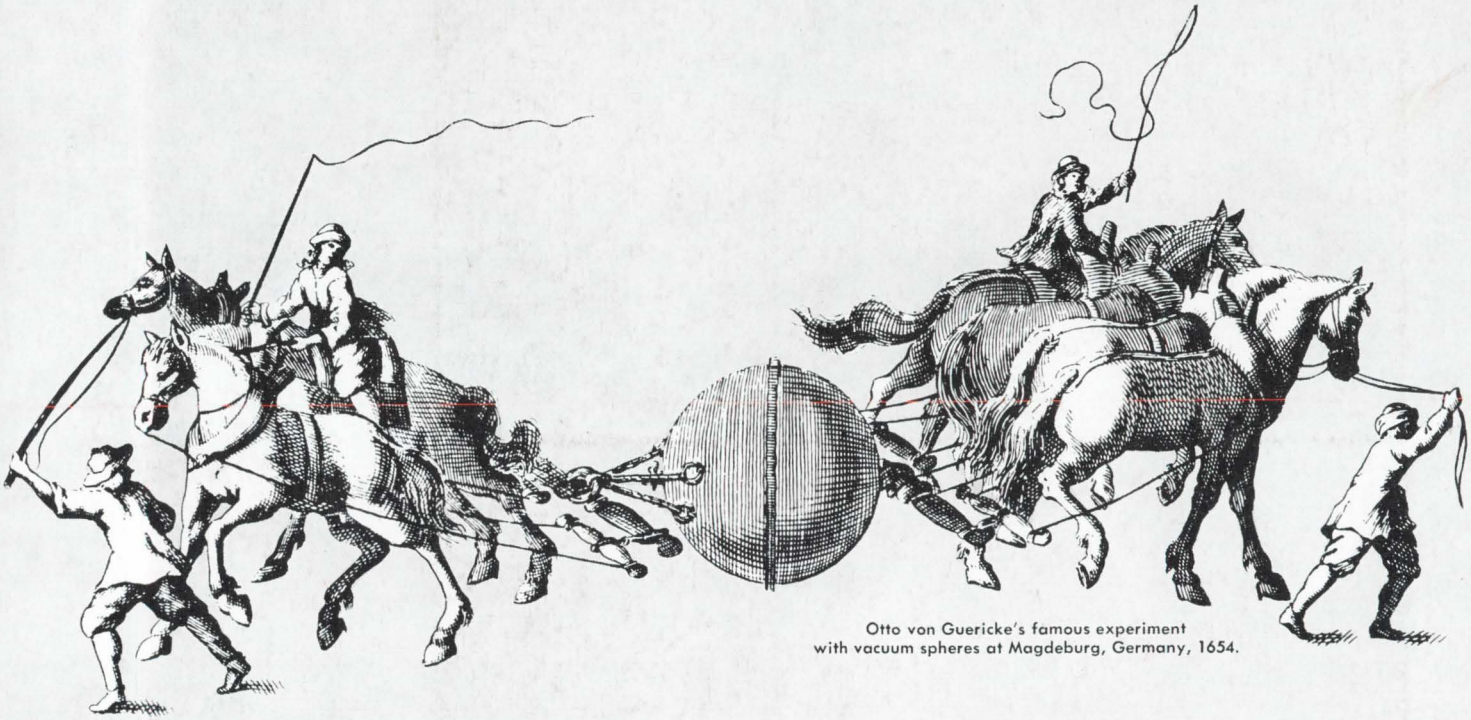

Otto von Guericke's famous experiment
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