Is there a bug in your rug?
It's not as farfetched as you think. Hidden microphones and tapped telephones are becoming almost commonplace. And these electronic spies are often as sophisticated as the latest in aerospace and military equipment. For a probing report on these devices turn to page 34.
## AUDIO TRANSFORMERS

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| DO-TSH | Drawn Hipermallory shield and cover 20/30 db |  |

*DOCR is shown for single ended usage (under 5% distortion—100MW—1KC) for push pull, DOCA can be used at lower values taken by 3W transistors (under 5% distortion—500MW—1KC). DO-T & DI-T units designed for transistor use only. U.S. Pat. No. 2,949,551. Others pending.

**Series connected; **Parallel connected

---

**INDUCTORS**

- **INDUCTANCE**
  - H 12 Hys / 2 ma, 2 Hys / 6 ma 1275
  - OW Hy / 2 ma, .06 Hy / 3 ma 10.5
  - H 12 Hys / 2 ma, 2 Hys / 6 ma 1275
  - OW Hy / 2 ma, .06 Hy / 3 ma 10.5
  - H 12 Hys / 2 ma, 2 Hys / 6 ma 1275
  - OW Hy / 2 ma, .06 Hy / 3 ma 10.5
  - H 12 Hys / 2 ma, 2 Hys / 6 ma 1275
  - OW Hy / 2 ma, .06 Hy / 3 ma 10.5

- **POWER TRANSFORMERS**
  - **DO-T400** Pri 28V 380-1000 cycles, Sec 6.3V a 60 ma
  - **DI-T410** Pri 28V 380-1000 cycles, Sec 6.3V a 30 ma each
  - **DO-T420** Pri 28V 380-1000 cycles, Sec 6.3V a 20 ma (isol, Electrostatic Shld.)

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**UNITED TRANSFORMER CORP.**

150 VARICK STREET, NEW YORK 13, N.Y.

PACIFIC MFG. DIVISION: 3630 EASTHAM DRIVE, CULVER CITY, CALIF.

EXPORT DIVISION: 13 EAST 40TH STREET, NEW YORK 16, N.Y.

CABLE: "ARLAB"

ON READER-SERVICE CARD CIRCLE 232
100µV full-scale sensitivity from this new 20Hz-4MHz solid-state ac voltmeter

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 1% of reading + ½% of full scale. The 400F, Option 01., puts the db scale uppermost for greater db resolution ($30 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.
Just like a piggybank, our Digi-Twin 800-Series solid state counter really is a great place to save money. The reason is that big space where the plug-ins go. The two other big names in counters (Hewlett-Packard and Beckman) offer function plug-ins only. So you're stuck. That didn’t seem fair to us, so our Digi-Twin is the only counter offering **three frequency range plug-ins**: 25 Mc, 50 Mc, and 110 Mc. So if you now need only 25 Mc, why pay for 50 Mc? Then if your next project requires a different frequency range you can buy a whole new counter from them... or just an inexpensive 50 Mc or 110 Mc plug-in for ours. • Maybe it's our attitude in giving you the best instrument, without charging you all the traffic will bear, that has earned us our solid third place in counter sales. If so, maybe you'll be interested in our ripening plans to offer you more and better instruments. And not just counters, either! • Say, have you earned your Crusading Engineers medal yet? It's the newest status symbol given to honor engineers like you who have the guts to compare the performance specs of all three major brands of counters. After that it's up to you to decide which counter actually fits your needs best. Earn your medal by writing now for our technical catalog. It's free. Incidentally, this counter is delivered without the cash inside.

12973 Bradley • San Fernando, California • Phone (213) 367-2161 • TWX 213-764-5993

FUNCTION MODULES: Counter-Timer Function Module · Frequency-Period (2 modules available) · 600 Mc Heterodyne Converter · Integrating Digital Voltmeter · 100 Mc Direct Counting Adapter · Digital Phase Meter · More Functions Due Soon

COMPUTER MEASUREMENTS COMPANY IS A LEADING DESIGNER AND MANUFACTURER OF ELECTRONIC INSTRUMENTATION TO COUNT, MEASURE, AND CONTROL.

Speed Inquiry to Advertiser via Collect Night Letter
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21 Lack of inductors blocks microwave ICs
   Performance, not size reduction, will determine the fate of microwave ICs once the inductance problem has been solved.
23 Plastic fiber optics developed.
26 Spacecraft designers look ahead to Mars.
29 Washington Report
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   A report on the techniques and equipment that are being "borrowed" from the electronic and aerospace industries for private spying.
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82 Replace expensive coils with pulse transformers in phase-lock detectors that operate up to 20 MHz. The change will also simplify circuitry.
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92 Differentiator noise is no problem, if your application is low-frequency. In fact, the simpler the circuit, the better.
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Economical "briefcase-size" recorders. MODEL 7701A - 100 mm chart. Frequency Range DC to 30 cps. Linearity 0.5%. Sensitivity (depending on "8800" Preamp used) 1 uv/div to 5 v/div. Four chart speeds, 4 more optional. With case: $1150 plus preamp. MODELS 299, 301 - 32 mm chart. Frequency Range DC to 100 cps. Linearity 0.625%. Sensitivity 10 mv/div (Model 299), 10 uv rms/div (Model 301), 2 chart speeds. Model 299: $800, Model 301: $850.

In portable, rack-mount, or mobile cart units. MODEL 7702A - Two 50 mm channels. Frequency Range DC to 125 cps. Linearity 0.5%. Sensitivity (depending on "8800" Preamp used) 1 uv to 5 v/div. Four chart speeds, more on special order. Prices on request. MODEL 7712 - Uses "350" Preamps. Sensitivity 2 uv to 5 v/div. With mobile cart: $1,715, plus preamps. 320 SERIES - Two 50 mm channels. Frequency Range DC to 125 cps. Linearity 0.5%. Sensitivity: 0.5 to 20 mv/div and v/cm (Model 320), 10 uv rms/div to 2 mv/div (Model 321), 10 mv to 10 v/div (Model 322). Four chart speeds, more on special order. Model 322 has zero suppression. Prices with cases: Model 320: $1,650, Model 321: $1,650, Model 322: $1,385.

Sanborn MODEL 7714A recording system combines the convenience of horizontal table-top chart marking with the flexibility and high performance of interchangeable individual-channel 350 Series preamps. Four 50 mm channels. Frequency Range DC to 125 cps. Linearity 0.5%. Sensitivity (depending on "330" preamp used) 2 uv/div to 5 v/div. Nine chart speeds. With 4-channel cabinet, $3,970 plus preamps.
See all measurements—down to the last microvolt

with high resolution Sanborn thermal writing oscillography

Resolve and read the smallest variations in your test parameters—even at higher frequencies, small amplitudes, and at slow chart speeds. Sanborn heated stylus oscillographic recording on matching Permapaper® charts gives you an immediate, permanent and clear record of test variables...lets you make "straight across" comparisons and correlations of multiple channels quickly and accurately because of rectangular coordinate traces...lets you clearly see what happened—as it is happening, and at any future time for more study or proof of performance.

The advantages of Sanborn thermal writing are available in many combinations of standard catalog system choices. The extensive Sanborn line allows you to select the number of channels, chart speeds, and the type of signal conditioning circuits you need, and to choose the packaging method that best suits your facilities. The wide range of signal conditioners includes low-cost built-in units, all-channels-alike amplifiers in six or eight-channel modules, and two series of individual channel plug-in units—miniaturized solid-state signal conditioners and highly sophisticated, maximum performance units.

Check the brief specifications of the systems shown below or call the H-P field engineering office in your locality for complete technical data and application engineering assistance. Offices in 47 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.

HEWLETT PACKARD hp SANBORN DIVISION

SIX AND EIGHT-CHANNEL

These versatile recorders have a wide range of input capacities, are completely integrated from signal input to galvanometer, and field-proven electronics. Six channel systems have 50 mm charts, and eight channel systems have 40 mm charts. All have DC to 150 cps frequency range, Linearity 0.5%. Nine chart speeds, nine more optional. MODELS 7706A, 7708A—(depending on "8800" preamp used) Sensitivity 1 uv/div to 5 v/div. With 6-channel cabinet (7706A) $4,750 plus preamps, with 8-channel cabinet (7708A) $5,425 plus preamps. MODELS 7716A, 7718A—Sensitivity (depending on "350" preamp used) 2 uv/div to 5 v/div. With 6-channel cabinet (7716A) $5,225 plus preamps, with 8-channel cabinet (7718A) $6,250 plus preamps. MODEL 7728A—Sensitivity (depending on "950" amplifier used) 10 uv/div to 5 v/div. With 8-channel cabinet $3,300 plus amplifiers.

ON READER-SERVICE CARD CIRCLE 212
NAND logic is old hat.

We've invented SDS Natural Logic for our T Series integrated-circuit modules. It's a comprehensive set of gating structures that permit the terms of any Boolean logic equation to be converted directly into hardware.

Now you won't have to manipulate equations to make them fit the restrictions of NAND or NOR gates. With Natural Logic the hardware fits the equations without unnecessary inversions.

So you won't need nearly as many circuits to build your logic system. Your system will cost you a lot less. It will be faster and more reliable. It will be easier to mechanize. And it will take up less room.

Naturally.

Scientific Data Systems
1649 Seventeenth Street, Santa Monica, California
Offices in principal cities throughout the world
Philbrick has always produced a wide variety of cool, reliable, solid state operational amplifiers for measurement, computing, control, data processing and testing. They provide premium performance and are priced accordingly. Their specified operating temperature exceeds $-25^\circ$ to $+85^\circ$C. Now Philbrick also offers economical equivalents of many of the most popular types in a utility grade, at substantially reduced prices. Savings generally exceed 50%. Yet, these utility grade amplifiers have identical performance with their premium grade equivalents within a limited temperature range, usually 0° to 60°C, but operate over the full range. And they too carry a two-year warranty. For a chart giving detailed comparative specifications of more than 60 Philbrick Operational Amplifier types write, wire or phone: Philbrick Researches, 46-H Allied Drive at Route 128, Dedham, Massachusetts. Telephone (617) 329-1000.

**Engineering Representatives**


**PHILBRICK**

For ELECTRONIC ANALOG COMPUTING EQUIPMENT for MODELLING, MEASURING, MANIPULATING and MUCH ELSE
Would You Believe... $39.50?

It may be hard to believe that a microelectronic operational amplifier — which can outperform monolithic amplifiers in such critical parameters as noise figure, offset voltage drift, output voltage swing and slew rate — can still sell for as little as $39.50 in quantities of 100 and up. Nevertheless, General Instrument’s new PC-210 and PC-212 can and do.

A new method of employing thick-film/cermet resistors in these low noise, wide band multichip hybrid units provides an open loop voltage gain stability of $\pm 1.5$ dB over the entire military temperature range of $-55^\circ C$ to $+125^\circ C$, and a linear output voltage swing of $\pm 15$ volts (This appreciably exceeds swings available in monolithic amplifiers). Low noise, low offset voltages and input currents are obtained by extremely close matching of two high quality 2N930 transistors. For these reasons and others, GI’s PC-210/212 operational amplifiers are particularly suitable for low level pulse and high frequency signal amplification, and high speed voltage comparisons.

The table below shows how the PC-210 and PC-212 outperform the most popular operational amplifiers now in use. And you can believe the price. It’s only $39.50.

Available now in hermetically sealed flat packs from your authorized GI Distributor.

For full information call or write

GENERAL INSTRUMENT CORPORATION
SEMICONDUCTOR PRODUCTS GROUP
600 West John Street, Hicksville, L. I., N. Y.
ON READER-SERVICE CARD CIRCLE 5

ELECTRONIC DESIGN, June 21, 1966
...NOW IN A NEW MINIATURIZED SIZE

Hermetically Sealed
ERIE BUTTON MICA capacitores
designed for
-55° to +200°C at 2000 Mc.

Featuring 508 MECHANICAL VARIATIONS TO SUIT ANY HIGH TEMPERATURE—HIGH FREQUENCY CAPACITOR APPLICATION

With the addition of these new miniatures, Erie further broadens the most complete selection of Button Mica Capacitors in the industry. These new miniaturized micas provide 33% reduction in mounting area.

Erie Button Mica Capacitors are designed for use in radio frequency circuits for tuning, bypassing and coupling. The outstanding properties of metallized mica dielectric combined with the radial current pattern, make Erie Button Capacitors ideal for low inductance, high frequency applications.

These high quality capacitors are designed for microwave and filter applications, for use in carrier equipment, parametric and RF amplifiers, oscilloscopes... any application where high temperature and high frequency are factors.

The welded hermetic seal of these excellent broad frequency Gold Seal® capacitors for military and commercial use is 100% tested under pressure steam/salt water during production to guarantee a positive moisture seal.

Consider the advantages of Erie Button Mica Capacitors in the equipment you are designing. Write for Gold Seal Bulletin 500-2 or Resin Seal Bulletin 318-3.

GENERAL SPECIFICATIONS

Capacitance: 5 pf. thru 2500 pf.
Tolerance: 1% or .25 pf thru ± 20%
Working Voltage: 500 WVDC for ½" dia. units
250 WVDC for ⅛" dia. units
Frequency Range: to 2Gc and beyond
Operating Temp.: -55°C to +200°C
-55°C to + 150°C
-55°C to + 85°C
Q: per MIL-C-10950

MINIATURE BYPASS CAPACITOR SYSTEMS FOR TRANSMITTING TUBES...

Designed for the 10 to 3,000 megacycles range—and beyond
Erie now provides effective capacitive bypassing and coupling or filtering of all RFI signals in the range of 10 to 3,000 megacycles. Variety of systems to meet your requirements.

Write for Bulletin 525-R

ON READER-SERVICE CARD CIRCLE 6

Erie, Pennsylvania
644 West 12th Street
Formerly Erie Resistor Corporation
New from Sprague!

1966 SPRAGUE METFILM 'A' CAPACITORS

1944 OIL-IMPREGNATED PAPER CAPACITORS

1947 METALLIZED PAPER CAPACITORS

1956 METALLIZED POLYESTER FILM CAPACITORS

1963 ULTRA THIN METALLIZED POLYESTER FILM CAPACITORS

METFILM* 'A' CAPACITORS...
dramatically smaller in size, yet more reliable
than military-grade capacitors of the past!

Just a few years ago, the only 10µF capacitor considered dependable enough for military applications was Type CP70 (to JAN-C-25), and was a block-busting 3¾" wide x 1¾" thick x 4" high. Today, you can get a military-quality 10µF tubular capacitor measuring only ½" in diameter x 2¾" long. And it's more reliable than any capacitor of the past!

Sprague Type 680P Metfilm 'A' Metallized Capacitors meet all environmental requirements of MIL-C-18312, yet they occupy only one-third the volume of conventional metallized film capacitors of equivalent capacitance and voltage rating. Employing a new thin organic film dielectric system, Type 680P capacitors use a dual film totalling only 0.00008" thick, as compared to conventional polyester-film capacitors with a single film measuring 0.00015".

Another distinct advantage of the Metfilm 'A' dielectric system is minimum degradation of electrical properties during life.

Hermetically sealed in corrosion-resistant metal cases, capacitor sections are effectively of non-inductive construction, resulting in capacitors with performance characteristics superior to those of comparably-sized capacitors.

Type 680P Metfilm 'A' Capacitors are available with capacitance values to 10µF in both 50 and 100 volt ratings.


SPRAGUE COMPONENTS

- CAPACITORS
- TRANSISTORS
- RESISTORS
- INTEGRATED CIRCUITS
- THIN-FILM MICROCIRCUITS
- PULSE TRANSFORMERS
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ON READER-SERVICE CARD CIRCLE 7

ELECTRONIC DESIGN, June 21, 1966
News

Electronic snooping takes many forms. Even picture frames can be bugged. Page 34

Electronic typesetting combines computer and television techniques. Page 24

Laser holograms to print semiconductor etching patterns at reduced cost. Page 17

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- Microwave integrated circuits are here to stay. ... page 21
- Scientists look ahead to unmanned exploration of Mars. ... page 26
- Transistor failure predicted by heat aging. ... page 20
- Fiber-optic bundles use plastic instead of glass. ... page 23
New from Sprague!

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.

Designed for operation over the temperature range of $-10 \, ^\circ C$ to $+70 \, ^\circ C$, Trigate Pulse Transformers are available in 2-winding and 3-winding configurations for half-wave and full-wave applications. Both designs are rated for use with line voltages up to 240 VAC.


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OGO-3 upstaged by Surveyor 1; Gemini 9

Project officials for the Orbiting Geophysical Observatory (OGO-3), launched shortly after the flights of Surveyor 1 and Gemini 9, feel like the vaudeville performer who goes on after the animal act. Even a 100-per-cent performance will pale in comparison with the publicized success of Surveyor and Gemini.

Despite this lack of public acclaim, OGO is an integral part of NASA's Project Apollo plans, measuring as it will high-energy proton storms from the sun that could jeopardize astronauts bound for the moon. But it is the Surveyor and Gemini flights that have captured the public imagination and given tangible evidence of NASA's progress toward landing a man on the moon.

The Surveyor project was three years over schedule, almost ten times over budget and buffeted by mounting Congressional criticism. So unsure of initial success had project officials become that they labeled the first three Surveyor vehicles "engineering test vehicles." But almost overnight Surveyor 1's successful flight dispelled most of the criticism and all of the apprehension. In its first six days on the moon Surveyor 1 sent back almost 3000 pictures and responded to thousands of radio commands from Earth.

According to a spokesman at the Jet Propulsion Laboratory control center, Surveyor 1 is so successful that it is posing a problem. The center can either work it to death or give it an easy schedule to see how long it can last. After just one week the spacecraft and all its systems had exceeded all expectations and researchers were running out of new things to do with it.

If officials decide to prove the endurance of Surveyor 1, the most crucial test will be whether it can withstand the lunar night, when temperatures hit minus 300°F for as long as 14 days. There is fear that its batteries may freeze and crack under such conditions. The spacecraft is equipped with heaters, but prolonged use of them would be a large drain on the batteries.

The flight of Gemini 9, in spite of its vicissitudes, contributed many firsts to the manned space program. Even though final hook-up with the Augmented Target Docking Adapter (ATDA) vehicle was not made, three new rendezvous procedures were demonstrated. These were catching a target in only three orbits, finding the target without radar, and approaching the target from above rather than below.

In addition, astronaut Cernan set a record with his spacewalk, even though the walk was curtailed because of fogging of his suit visor. And lastly, Gemini 9 returned to Earth a mere three miles from the recovery ship and in full view of tv sets throughout the world.

The next Gemini flight, that of Gemini 10, is set to begin July 18. It will be a three-day mission.

Army goes Ivy League to study avionics

The Army's Electronics Command is establishing a research program in aviation electronics at Princeton University and the University of Pennsylvania. The government and the two participating universities will collaborate in joint research into aircraft communications, controls, navigation and instrumentation.

During the next three years, the government will provide nearly $3 million for the investigations, which will also include environmental sensing, man-machine integration and ground support systems, as well as instrumentation and controls for future vertical take-off and landing aircraft and helicopters.

The Electronics Command aims to use the talent of high-caliber civilian scientists and engineers who might not normally enter government service.

A new design

News Scope is a redesign of our former News Report column. Its purpose is to keep you up-to-date on the latest happenings in the electronics industry, with emphasis on their underlying causes and significance to the design engineer. We would appreciate receiving your comments on News Scope. Use the Editorgram at the rear of the issue.
NASA seeking jumbo solar cell arrays

The National Aeronautics and Space Administration is making final negotiations with the Boeing Co., Seattle, Wash. on a contract for a high-power array of solar cells.

The three-year contract allocates about $5 million for the design and fabrication of an experimental 1250-ft² panel. Covered with solar cells, the panel would have an output of 12.5 kW.

Four such panels, weighing less than 2500 lbs, would develop 50 kW, or 50 lbs/kW. The solar cells abroad Mariner IV weighed 100 lbs/kW.

NASA is trying to develop the technology needed for the power requirements of future space missions. This might include power for an electric propulsion system, NASA says.

Gold flow from NASA's coffers slackens slightly

The National Aeronautics and Space Agency dealt out contracts totaling $2.779 billion during the first half of 1966. This is 5% less than the same period last year, when the agency contracted for $2.927 billion of goods and services.

North American Aviation received the largest amount of contract money ($731 million) and maintained its lead over Boeing ($208 million). North America's contracts account for nearly 32% of all NASA expenditures.

The top four companies—all aircraft firms—were in the same order as last year (third and fourth are Grumman Aircraft Corp. and Douglas Aircraft Co.). Three firms leapfrogged up the list; General Motors moved from eighteenth last year to seventh this year; Vitro Corp. of America went from 72 to 33; and Telecomputing Services Inc., charged up the list from 100 to 48.

California again received more NASA dollars than any other state—a total of $1.1 billion.

By sea and air—electronic marketing is on the move

New innovations are made in the design and production of electronic products every day. Not to be outdone, the marketing arm of the electronic industry is likewise constantly developing and applying new tools and techniques. Traveling showrooms, in which a manufacturer stocks a truck or bus with his products and travels to the customer, have been around for some time. Now new dimensions are being added to the traveling showroom.

A floating showroom is being used by Hewlett-Packard to bring their equipment to Latin American customers. Several state rooms on the Moore-McCormack Lines' freighter Mormacwave have been remodeled to display a line of Hewlett-Packard scientific instruments at each port of call. Engineers, scientists, doctors and other professional people will be invited aboard to view the equipment.

Hamilton Standard will use a flying showroom to bring customers up to date on the latest advances in the company's aerospace products. The showroom will be a converted Douglas DC7 airliner specially fitted with displays. Fifteen cities in the United States and Canada will be visited by the flying showroom over a five-week period.

For computers to come bank signatures must go

Computer are invading the local bank, but attempts to automate banking and financial institutions completely are stymied by one deep-rooted fixture: the customer's signature.

Computers cannot, and will not for the foreseeable future be able positively to identify the scrawl of a human hand. And this “almost Biblical reverence for visual recognition” could inhibit the effects of the electronic age on banking, according to Raymond Hinton, director of Analysis and Network Engineering, Communication Systems, Inc., Paramus, N. J.

During a conference held by the American Bankers' Association, Hinton proposed that banking must adopt and legalize one of the myriad ways that an individual can be identified electronically in order to speed financial transactions.

Electrical signals could be used for the deposit, withdrawal and transfer of funds, he suggested. The new touch-tone telephones might make the perfect terminal device for the banking system of the future.

He noted several factors conducive to a fully automated banking system: the world-wide use of Arabic numerals, the growing availability of international communication links, and the compatibility of most data-handling systems in use throughout the world.

"American banks must take the lead in upgrading banking methods in the electronic age," he said.

An agreement to collaborate in the development, production and marketing of new and advanced medical devices has been announced by RCA and Hoffmann-La Roche, Inc., of Nutley, N. J. According to the two companies, "the agreement will bring together the scientific, technical, productive and marketing skills of a major electronics enterprise and a leading pharmaceutical company." Hoffmann-La Roche is the world's largest producer of vitamins.

Initial production of the Army's Chaparral air defense missile system will be carried out by Philco Corps' Aeronutronic Div. Chaparral is one of two systems recently selected by the Army for low-altitude air defense in forward battle areas. It uses the Navy sidewinder 1C.
It isn't that Stan takes nuclear radiation lightly. But his 5-amp silicon transistors do.

With power transistors like these, an applications engineer like Stan can afford to be nonchalant.

Take the new BR100A-F and BR101A-F series. (R stands for Radiation-Resistant.) With base transit times reduced to a maximum of less than 0.5 nanoseconds at one ampere collector current, they're perfect for use in advanced circuits hardened for application in nuclear radiation environments.

Case types? Six of them. All pictured below.

Stan's regular 3-, 5-, and 10-amp units are easy to take, too. B-3460 and B-3461 5-watt switches and B-3465 and B-3466 RF power amplifiers. (Plus 75 other type numbers specified for your application.) These low-cost epitaxial NPN transistors are already at work in such diversified applications as high-speed, high current core drivers, high-frequency pulse generators, high voltage nonsaturated switching applications, power supplies, relay and solenoid drivers, and power amplifiers and oscillators for HF/VHF communications transceivers.

Write or call our nearest sales office soon, won't you? See if Stan can't put his small wonders to work for you.

**3 AMP TYPES**

- **VCEO**: 40 V to 60 V
- **VCBO**: 80 V to 100 V
- **Pc**: 5 W to 7.5 W
- **VCE(s)**: 0.32 V Typ at IC = 1 A, IB = 100 mA
- **Switching Types**: \( t_{on} \leq 35 \text{ ns} \) at IC = 1.5 A, IB = 150 mA
- **Amplifier Types**: \( P_o \geq 4.5 \text{ W at } f = 50 \text{ MHz, } VCC = 28 \text{ V, } P_{in} = 0.5 \text{ W} \)

**5 AMP TYPES**

- **VCEO**: 40 V to 80 V
- **VCBO**: 50 V to 90 V
- **Pc**: 5 W
- **VCE(s)**: 0.4 V Typ at IC = 3 A, IB = 0.3 A
- **Switching Types**: \( t_{on} \leq 40 \text{ ns} \) at IC = 3 A, IB = 0.3 A
- **Amplifier Types**: \( P_o \geq 8 \text{ W at } f = 50 \text{ MHz, } VCC = 30 \text{ V, } P_{in} = 1 \text{ W} \)

**10 AMP TYPES**

- **VCEO**: 40 V to 80 V
- **VCBO**: 50 V to 90 V
- **Pc**: 25 W
- **VCE(s)**: 0.7 V Typ at IC = 5 A, IB = 0.5 A
- **Switching Types**: \( t_{on} \leq 40 \text{ ns} \) at IC = 3 A, IB = 0.3 A
- **Amplifier Types**: \( P_o \geq 25 \text{ W at } f = 50 \text{ MHz, } VCC = 30 \text{ V, } P_{in} = 5 \text{ W} \)

**RADIATION TYPES**

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New PAR Lock-In Amplifier Measures Signals in the Presence of Noise by Crosscorrelation

The PAR Model HR-8 Lock-In Amplifier represents a significant advance in signal processing equipment for experimentalists who must measure low-level signal intensities in the presence of noise. It employs the theoretically optimum technique for signal recovery, and can be incorporated into a large class of experiments in which the signal of interest is, or can be made periodic, and in which a reference voltage related in frequency and phase to the signal can be obtained. The Model HR-8 first amplifies and bandlimits the input signal and then crosscorrelates it with the reference signal, suitably phase shifted and shaped. The crosscorrelation of input and reference signals yields a DC output voltage proportional to the signal of interest, while the crosscorrelation of the reference and noise results in no net DC voltage. The system can also be described as a continuously integrating, highly sensitive, phase conscious voltmeter, the response of which is "locked" to that particular frequency and phase at which the signal information has been made to appear.

Technical Features:
Frequency Range: 1.5 cps to 150 KC continuously tunable in 5 ranges.
Time Constants: 11 values in 1-3 sequence extending from 0.001 to 100 seconds. Single or double section RC filtering.
Pre-Amplifiers: Interchangeable low-noise pre-amplifiers, operable either within the HR-8 or remotely, are used. Type A: Differential 10 megohm input. Type B: Low impedance transformer input for low source impedances.
Sensitivity: 21 calibrated full scale ranges in 1-2-5 sequence.
With Type A Pre-Amplifier: 100 nanovolts to 500 millivolts rms.
With Type B Pre-Amplifier: 1 nanovolt to 5 millivolts rms.
Output: ±10 volts full scale, single-ended with respect to ground. Will drive galvanometric and servo recorders.
Frequency Selective Amplifiers: Notch network in negative feedback loop used in both signal and reference channel tuned amplifiers. Reference channel Q of 10. Signal channel Q adjustable from 5 to 25 with calibrated dial (no gain change with Q adjustment).
Phase Adjustment: Calibrated 360° phase shifter, providing continuous rotation as well as a four position quadrant switch which shifts phase in 90° increments.
Price: $2,250 with either Type A or Type B Pre-Amplifier.

Contours of constant noise figure for a typical PAR Type A preamplifier plotted to show dependence on frequency and source resistance at 300° K. Amplifier operated single-ended.

Write for bulletin No. 120 on the HR-8 or ask for information on PAR's complete line of Lock-In Amplifiers and accessories.
Major advance in wafer-making forecast
Researcher sees use of laser holograms to print semiconductor etching patterns at reduced cost.

Roger Kenneth Field
News Editor

A breakthrough in semiconductor production—the use of laser holography to print etching patterns on wafers—is believed near.

The new method promises to reduce dust problems and eliminate expensive mask copies. Its ability to resolve one micron across a field of one centimeter may bring faster, smaller devices to the market.

Until now holography—a lensless method of three-dimensional photography that uses coherent light from a laser—has been merely an optical curiosity. But by this time next year holograms will be used in the semiconductor industry to print the etching patterns on wafers, according to Kenneth Poole, head of Bell Laboratories' optical device department.

Bell has already turned over to Western Electric the results of basic research it has been conducting, and Western Electric is now striving to adapt the technique to the production line.

One semiconductor specialist, Dr. Leland Seely, General Instruments' director of research, told ELECTRONIC DESIGN: "If it works, it's fantastic!"

Based on the research thus far, Poole is confident that it will work. He and his colleagues at Bell Laboratories have demonstrated that holographic reconstruction of real images can resolve one micron over an area of one square centimeter (see photos). Thus, for a reasonable cost, semiconductor manufacturers can now make a projection system that will offer resolution roughly equal to that of the photoresist on which the image is printed.

A spokesman for Fairchild called the development, "Quite a breakthrough." He added, "The masks would live forever and one of the biggest expenses for a semiconductor maker is replacing scratched masks. Also, any projection system makes automation a possibility whereas no one, to our knowledge, has truly automated the present contact printing method. By reducing foreign matter problems (hence increasing yield) and simultaneously reducing costs, the projection system may make possible an across-the-industry price reduction."

At present glass lenses can resolve only about 3000 lines across their field (by comparison, the hologram photos below resolve 10,000 lines). Because of this, manufacturers must make master etching masks with a step-and-repeat process.

In this process a microscope is set up in reverse of its normal operation: it reduces an image of the mask of a single device to the actual size of the device and projects it onto a photographic emulsion coated on an optically flat glass slide. Then an extremely fine lead screw moves the glass slide to a new posi-

Below, left: 441 test patterns were made by a hologram. A real image was printed on a high-resolution photographic emulsion of one square centimeter. Right: A photomicrograph of just a single pattern on the original negative. The diameter of the tiny dot in the center of the pattern is 2.5 microns, indicating a resolution of roughly one micron. The holographs were taken by Dr. L. H. Lin of Bell Laboratories, Murray Hill, N. J.
1. Holographs are exposed when an uninterrupted laser beam strikes the photosensitive surface at the same time as the laser light that diffuses from the surface of the object. Unlike photographs, which record amplitude patterns, holographs record both amplitude and phase in interference patterns.

2. An observer sees a virtual image of the object when the holograph is illuminated with laser light that strikes it at the same angle as it did during exposure.

3. Holograph can reconstruct real image (just like that of a slide projector) if it is reversed in its holder after it is developed. Images always appear on emulsion side of film. For the best resolution, holographs should be made on very slow spectroscopy plates with argon laser light.

4. Holographs resolve best when the angle they subtend at the wafer, \( \phi \), is large. But residual light from the laser beam (broken lines) must not fall on photoresist.

The process is continued, until anywhere from 100 to 1000 etching patterns are printed on the master mask. Copies of the master are used to make the wafers: Copies and wafers are placed in contact and illuminated. Herein lies the problem: contact printing is a method of reproduction that is not well suited to ultra-high resolution of extremely small images.

To get any decent resolution at all, the emulsion on the slide must be in intimate contact with the photoresist. The master masks and the copies are made on optically flat glass slides. But after the first diffusion, the surface of the wafer is no longer flat. Resolution of images in the troughs falls off. And repeated handling of the glass copy on the production line limits its usable life to a few dozen printings (it costs \( \approx $10 \).)

The slide must be placed in contact with the etched surface of the wafer. The slightest scratch—even dust that alights on its surface—impairs its ability to produce a flawless image. Any projection system would eliminate handling of the slide, but dust could still be a problem. In addition, if the system had a lens, then it, too, would have to be kept dust-free.

The hologram image is produced without lenses. Like a lens, its theoretical ability to resolve fine details is a direct function of the angle of incidence of light that arrives at a point on the image. But unlike a lens, this theoretical resolution is very nearly achievable in practice.

Until now the hologram has been used mainly to recreate three-dimensional objects in three dimensions. The recreation is a virtual image—it can be seen by the eye, but it can not be projected onto a screen. Holographers have devoted most of their efforts to perfecting and investigating these three-dimensional, virtual images. They have devised ways to store many images on one film. They can recreate images with only slightly coherent light or even with completely incoherent white light. They are able to recreate the object in full color, and recently they demonstrated a three-dimensional, color reconstruction with ordinary white light.
Sixty-nine millionths of an inch is the thinness to which The Arnold Engineering Company has precisely rolled metals and alloys as soft as copper. Alloys as hard as Type 302 stainless, Elgiloy, S-816, Nichrome V and other hard materials have been rolled to 0.0002" and less.

Orders to these specifications obviously aren’t average. Then Arnold isn’t average, either. The Arnold Engineering Company is fully equipped to roll ultra-thin gauges of ferrous and non-ferrous metals to extremely close tolerances. With dual source, non-contacting beta-ray gauges Arnold has held tolerances totalling 0.000017" on a week’s run of .0011 gauge.

Clean room techniques are observed in order that ultra-thin gauge foils for photo etching, shims, strain gauges, honeycomb structures, capacitors, etc. can be rolled virtually free of pin holes. All facilities housed in pressurized, air conditioned and filtered clean rooms to minimize foreign particles which could cause pin holes in finished work. Centerless grinding facilities to maintain complete control over roll grinding and lapping.

The Arnold Engineering Company has the capability of precision rolling over 55 different metals within tolerances of millionths of an inch.

Now’s the time to put Arnold engineering know-how to work for you.
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**ISOLAYER**

**DIFFERENTIAL AMPLIFIERS**

WITH

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**V_{BE}** voltage differential down to 3 mV

Tight beta matching · Low capacitance

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Sprague Electric also makes a broad line of standard differential amplifiers, pairs, quads, and Darlington amplifiers

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**NEWS**

**Heat-aging detects transistor failure**

Leakage-current measurements can forecast transistor failures well before they occur in germanium-alloy types, according to a recent study made at the National Bureau of Standards.

After aging the transistors for 1000 hours at 100°C their leakage currents were compared with comparable measurements made before the aging process. Transistors that show an increase in leakage current in excess of 1.6 times their earlier leakage current should be rejected.

The Bureau test results conclude that early increases in leakage current are consistently associated with the first of the transistors that fail. In one test batch of 160 transistors the first three failures would be expected within about four years of normal use.

In the testing procedure, the junction temperature can be raised to 100°C in two ways. The device can be made to dissipate continuously enough power to keep the junction at 100°C. The other way to bring the junction to this temperature is to raise the ambient temperature of the air in the vicinity of the transistor. The latter method gives far more reliable results, according to the study.

Failures were due to avalanche conduction, excess leakage current, and, possibly, physical damage during an aging period of 20,000 hours. —

Ten transistors in a plug holder are placed in thermostat-controlled aging chamber.
Microwave parley sees room for IC growth

Symposium hears of need for better inductances; Hybrid designs and switching advances described

Maria Dekany
Technical Editor

"Microwave integrated circuits are here to stay. They are not going to follow the tunnel diode [into obscurity]. But they will not replace TWTs either."

In these words, Dr. Robert L. Pritchard, professor at Stanford University, summed up the optimistic outlook for miniaturized ICs at the International Microwave Symposium, held in Palo Alto, Calif.

The pessimistic side was discussed, too. The major problem facing designers of integrated circuits is to increase the value of inductances while decreasing the inductor's size, Dr. Pritchard told the symposium. Present inductances are achieved at too great a cost in space, he said: Engineers are happy to get 1 nH per mm. They would, naturally, like to do better.

The Q of the inductance is already a problem at uhf, the Stanford professor reported. The deposited inductance over the glass substrate behaves like a distributed LC transmission line with a cutoff frequency of 100-200 MHz.

At microwave frequencies, the design of integrated circuits requires innovations instead of direct translation from discrete circuits, Pritchard went on. It is not the size reduction that is the main attraction of the IC, since most circuits must have a size of the order of $\lambda/4$. Performance is the major objective, he concluded.

The popular hybrid approach to microwave ICs was demonstrated by the spst switch-driver assembly, discussed by William J. Moronay, director, semiconductor development, and Alex T. Botka, manager, integrated control devices, of Microwave Associates, Inc. Burlington, Mass. (see Fig. 1). In hybrid design, the silicon chips, which contain the active devices, are mounted on a stripline or in a cavity. For the switch, a stripline is used with alumina as the dielectric. It has high dielectric constant, low loss, is stable and withstands high processing temperatures, Moronay explained.

The switch operates from 2 to 4 GHz with a minimum of 50 dB isolation and an insertion loss of 2 dB maximum. The switching speed is 50 ns.

Very fast switching with pin diodes in X-band was reported by Dr. Bernard C. DeLoach, head, microwave semiconductor device dept., Bell Telephone Laboratories, Murray Hill, N. J. Reproducible operation, ranging from 0.4 ns at the 1-mW level to 1 ns at the 1-watt level, has been observed, Dr. DeLoach reported, with specially fabricated pin diodes having 3000-GHz cutoff frequencies. The switch is unique, he said, in that it has very low loss (0.3 dB in the passband), is insensitive to junction parameters and is faster by an order of magnitude than other pin-diode switches.

Versatile GaAs

A new aspect of gallium arsenide—well known for the so-called Gunn oscillation—was disclosed by Dr. Basil W. Hakki, member, microwave bulk-effect device group, Bell Telephone Laboratories, Murray Hill, N. J.

A GaAs sample was operated simultaneously as a microwave amplifier, mixer and oscillator under cw conditions, he said. The implications of this performance are best illustrated by the heterodyne circuit based on the GaAs sample (see Fig. 2). The bulk sample generates a signal at 3.622 GHz that serves as the local oscillator. An external signal at 6.114 GHz, injected into the cavity holding the GaAs, mixes with the 3.622 GHz signal to produce the difference frequency at 2.492 GHz. This difference frequency is then amplified and detected. A maximum net conversion gain—from 6.114 GHz to 2.492—of 10 dB was measured, Dr. Hakki said. He noted that the oscillating and amplifying frequencies were not related harmonically. The only problem was the noise figure—about 20 dB at present, too high for most practical systems. However, programs are under way to reduce the noise to a more acceptable level, according to Dr. Hakki.

Miniaturization, if not integration, was apparent in the discussion of ferrite devices.

Ferrite phase shifter for L band

A phase shifter that combines the rapid switching speed for ferrite latching devices and the miniaturizing features of slow-wave strip transmission lines was described by the designer, Raymond R. Jones, an engineer with the Westinghouse Defense and Space Center, Baltimore. The 2-by-1-by-0.25-inch device provides between 145° and 170° differential phase shifter per inch over a 5.0-to-5.4-GHz range.

1. Integrated microwave switch and driver assembly operates from 2 to 4 GHz with a switching speed of 50 ns.

2. Simple heterodyne amplifier uses bulk GaAs as oscillator and amplifier simultaneously. The GaAs generates the local oscillator signal at 3.6 GHz; this mixes with the incoming signal (6.1 GHz). The resultant difference signal (at 2.5 GHz) is amplified. A conversion gain of 10 dB was measured at Bell Telephone Labs.
If you are involved in applications requiring electronic frequency control, the new Damon VCXO Brochure can help you. This Brochure is packed with technical data on applying Damon VCXOs to many modern electronic systems such as AFC, Coherent Radar, Phase Locked Receivers and Transmitters, Doppler Trackers, FM Generators Exciters, Frequency Synthesis and STALO. Damon VCXOs are available with peak frequency deviations from 20 cps to 2 mc and with center frequencies spanning 100 cps to 300 mc.

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240 Highland Ave., Needham Heights, Mass. 02194  Tel.: (617) 449-0800
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3. Slow-wave nonreciprocal phase shifter represents one approach to miniature ferrite devices. The meander line is the slow-wave structure.
Plastic used for fiber optics

Croton light guides provide an extremely flexible form of fiber optics.

Fiber optic bundles that use plastic as the light-transmitting medium have been successfully developed by the Du Pont Company and will soon be on the market.

The new devices, called "Croton" light guides, are tougher and more flexible than glass, which to date has been the primary material used successfully for fiber optics. An individual 0.010-inch fiber of a Croton light guide can reportedly be tied tightly in an overhand knot without breaking. This allows the light guides to be readily bent around a small radius. They may be subjected to repeated flexing and vibration safely.

Each plastic fiber in a Croton light guide has a core of Lucite sheathed with a plastic of a lower refractive index. The fibers are made up in bundles and jacketed in Du Pont's Alathon polyethylene resin. The number of strands in each bundle determines the amount of light that will be transmitted.

Unlike glass fiber optics, the plastic fibers can be manufactured in almost unlimited lengths. At present, limited quantities are available for development programs in lengths up to 5000 feet.

Preliminary studies for the applications of the light guides have been undertaken by Du Pont in cooperation with the Packard Electric Division of General Motors Corp. The first commercial application developed by Packard is the illumination of dashboard accessories on several leading 1967 model automobiles.

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An ac differential voltmeter, 50 mv-1000 V, ±0.05% of reading ±0.01% end scale

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Use in conjunction with new 463A Voltage/Power Amplifier to make measurements at: 100 mv at 0.07%, to 10 kHz; 10 mv at 0.16%, to 10 kHz; 1 mv at 0.36%, to 10 kHz. (Reduced specs to 100 kHz.) Features include overload indicator, output sensing, low-capacity ac probe. For a demonstration, call your Hewlett-Packard field engineer or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: Route des Acacias, Geneva.

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

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ELECTRONIC DESIGN, June 21, 1966
System conditions battery cells selectively

The useful life of secondary batteries used in aerospace vehicles can be extended by a new automatic charging system developed by Electro-Optical Systems, Inc.

The system selectively conditions each individual cell in a battery automatically until the electrical characteristics of all cells achieve a high degree of balance. Previous charge equipment for aerospace applications monitors the output of cells in series at the battery terminals only, without compensating for individual cell variations. This lack of total conditioning can cause some cells to reach charged or discharged voltage limits before others, and can result in an overcharged state, with subsequent battery failure through case expansion or loss of electrolyte.

The charging system operates essentially as a digital comparator. Automatic charge and discharge cycling of all cells is controlled by charge-discharge limits manually programmed in digital form into the battery level sense logic circuits. During cycling, cell potentials are scanned by the multiplexer and fed to the digital voltmeter, which delivers a binary-coded decimal output. The voltage level of each cell is then compared to the preset limit in the logic circuits. When coincidence is detected for a cell, the cycle for that cell is terminated.

After all cycles are completed, the logic section initiates a command to reverse the cycle.

All-electronic typesetter put on the market

A new system for setting printers' type electronically has been introduced by the Graphic Systems Div. of RCA. Called Videocomp, the system is the first commercially available typesetter to employ all-electronic character generation.

Characters corresponding to the letters of various type faces are stored in the unit's core storage unit. Approximately 3000 bits are used to store each character. When a character is taken from memory, it is written by means of its bits in a predetermined sequence of deflection orders on a high-resolution cathode-ray tube. As the character is written, it is projected through a precision lens and exposes sensitized paper or film.

Each character is written on the face of the tube and transferred to the film until a complete line is formed. Then the film is automatically advanced a line space and the next line is composed. Up to 600 characters a second, or 900 lines a minute, can be produced.

Type of up to four fonts can be stored in the Videocomp memory at one time. With a change in the deflection of the cathode-ray tube, any of the type faces can be written as normal, enlarged, condensed, extended or italic type.

Videocomp system produces electronically generated characters such as these.
Op Amp Based on Varactor Bridge Resolves $10^{-13}$ Amps, Accommodates $10^{10}$ Ohm Sources

Parametric amplification principle, embodied in Model 301's varactor bridge circuit, virtually eliminates 1/f noise (0.01 pa & $1 \mu V$ p-p), provides 100-fold better offset and drift specs than FET amplifiers (1 pa & 0.06 pa/°C at 25°C), and achieves common-mode performance of electro­meter tubes ($\pm 300 V_{cm}, 10^{11} ohms Z_{cm}$ & $10^7$ CMRR). Rugged, all-solid-state DC differential op amp is encapsu­lated into a 3 cu-inch, microphonic­free module that mounts directly onto P-C boards, operates from $-25^\circ$ to $+85^\circ$C.

Current amplifiers, differential ampli­fiers, logarithmic amplifiers, electro­meter amplifiers, plus various cate­gories of capacitor charging ampli­fiers, can all be based on Model 301, with advantages in performance, size, ruggedness and cost.

Offset variation of only 30 pa from $-25^\circ$ to $+75^\circ$C enables input re­sistors as high as $10^9$ ohms to be used with integrators, differential ampli­fiers, and circuits required to operate with high impedance sources. Large­value integrator input resistors allow time-constants to 1,000 seconds, permit­sample-and-hold amplifiers, differ­entiators, and charge amplifiers to be designed with unusual flexibility. Current-amplifiers, used typically with photomultiplier tubes and other cur­rent-source tranducers, depend upon Model 301’s 0.01 pa noise and 0.06 pa/°C offset at 25°C for ultimate sen­sitivity of $10^{-13}$ amps. Used with loga­rithmic feedback elements, the ampli­fier also permits a 9-decade (180db) input signal swing.

Another remarkable feature of the Model 301 is the $\pm 300$ volt common­mode rating, which enables differ­ence amplifiers to measure millivolt signals perched on 300-volt inputs. The $10^9$ ohm common-mode input impedance and $10^7$ CMRR also en­able Model 301 to be turned into a solid-state P-C mounting electrometer amplifier.

**MODEL 301 SPECIFICATIONS**

- **Max Offset**: 1 pa at 25°C, 30 pa at 75°C
- **Noise (DC – 1 Hz)**: 1 pa, $1 \mu V$ p-p
- **Max Voltage Drift**: 30 $\mu V$/°C ($-25^\circ$ to $+85^\circ$C)
- **Input Impedance**: $10^9$ ohms (Diff)
- **Output**: $\pm 10$ V, 2 mA
- **Open Loop DC Gain**: 120 db (10°)
- **Gain Bandwidth**: 500 KHz
- **PRICE (1-9)**: $155.00

**HOW MODEL 301 WORKS**

Amplifier input, $e_i$, varies varactor capa­citance, unbalances bridge, and develops pump voltage output proportional to bridge unbalance. After low-noise AC amplifica­tion, pump voltage is phase-sensitively de­modulated to restore correct polarity, then further boosted by DC amplifier. Final output is a replica of original input, amplified one million times.

Matched low-leakage varactors inherently eliminate 1/f or "flicker" noise, give excel­lent offset and drift specs, provide $10^9$ ohms differential input impedance. Transformer coupling contributes amplifier's advanced common-mode specs.

**COMMON-MODE VOLTAGE**

- of $\pm 300$ V, combined with low offset current, allows difference amplifiers to use $10^9$ ohm input resistors and resolve millivolt signals on 300 V inputs

**COMMON MODE IMPEDANCE**

- of $10^9$ ohms, $1 \mu V$ p-p noise, $10^7$ CMRR, and only 30 $\mu V$/°C drift, provides basis for rugged electrometers with $10^9$ ohms input impedance

**LOW OFFSET CURRENT**

- of 1 pa, plus $10^9$ ohms differential input impedance, permits 1,000-second integrator time-constants, also builds versatile sample-hold circuits

**OFFSET CURRENT CHANGE**

- of only 30 pa from $-25^\circ$ to $+75^\circ$C, with 0.01 pa noise spec, enables current amplifier to resolve $10^{-13}$ amps, builds 9-decade log amplifiers

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ON READER-SERVICE CARD CIRCLE 15

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Electronic Design, June 21, 1966
Scientists prepare to hunt for life on planets

Astronautical society meeting focuses on new equipment for unmanned exploration of Mars

Ralph Dobriner
West Coast Editor

As planning for Project Apollo rapidly nears a climax, many scientists are concentrating on what they believe will be the next important phase of space research: unmanned exploration of the planets.

This was indicated at the recent three-day American Astronautical Society meeting in Anaheim, Calif., which had as its theme “The Search for Extraterrestrial Life.”

Of the 24 technical papers delivered on the philosophical aspects, scientific motivation and proposed hardware of extraterrestrial missions, more than half referred to the planet Mars. The apparent reason was NASA’s proposed unmanned Voyager missions to the planet during the 1970’s and the belief that Mars is the most likely body within the solar system to harbor some lower form of life.

A “progressive and economical” proposal to send unmanned vehicles toward a soft landing on the Martian surface was put forward by C. de Moraes of the Martin Co., Denver.

The scientist wants to send a series of space “buses” to the planet during the 1970’s. His program would culminate in 1979 with two 3500-lb space buses flying by Mars, each launching a 650-lb capsule that would soft-land instruments on the planet. The vehicles would carry progressively more sophisticated instruments for life-detection and geological experiments and for high-resolution TV scanning of the immediate landing area, de Moraes said. The two final capsules would contain an automated biological laboratory and roving vehicles that would explore and gather samples at a distance from the landing area.

An automated biological laboratory (ABL) concept, under study for NASA at Philco Corp.’s Aeronutronic Div., Newport Beach, Calif., was described by W. Hostetler, space program manager.

The capsule, a potential Voyager payload, is being designed to carry out complex life-detection experiments on planetary surfaces. The experimental capacity of the ABL—an integrated system—is to be nearly double that of present capsules that weigh the same but are made up of separate experiments. The ABL is to weigh 715 lbs compared with the 1200 lbs of the average conventional payload, Hostetler said.

The complete system is to include sample acquisition, chemical processing and sample analysis, as well as computer control, power supply, communications and other supporting subsystems.

Thirty-five preprogrammed experiments would be done by the payload after it landed and was deployed on the Martian surface. Through radio links with the capsule, scientists on earth could command the ABL to perform additional tests as they interpreted data sent back by the capsule.

Robot is ultimate goal

Techniques being developed for the Voyager missions are part of a larger effort to develop a robot capable of carrying out preset programs and of self-programming within certain bounds.

Louis Sutro of MIT’s Instrumentation Lab., Cambridge, Mass., reported on efforts to develop a true robot with a limited self-programming capacity that could deal with a large sequence of choices and correct its own error of judgment.

According to Sutro, each experiment for Mars will require both a sensor system designed for the problem and a data-processing system to bridge the gap between the way the sensor system works and the way the human mind works. Data from the experiments would be put through a decision system similar to that of humans.

Automated biological laboratory, (ABL), similar to this model, may some day conduct life-detection experiments on the Martian surface under the control of scientists on earth. The model, developed for NASA by Philco’s Aeronutronic Div., shows the actual testing area of the ABL with chemical-storage area and mechanisms for moving samples, agents, chemicals and reagents from storage to test areas.
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You can drive sizable inductive, capacitive, or resistive loads directly with either of these two IC op amps. They're unmatched for "muscle". Using them, you can omit an intermediate driver stage or power amplifier in many applications.

The driving power of the WS 161 and WM 174 can make equipment smaller, simpler, and lower in cost. With this pair, you can fill virtually all integrated op amp requirements. They come in 14-lead, ⅛" x ⅛" Q-style packages.

If you want maximum unity gain bandwidth, moderate open loop gain, and very high current output with low voltage drift, no other IC op amp comes near the WS 161.

If you want maximum open loop gain, maximum output current, and very high unity gain bandwidth, the WM 174 is far and away your first choice.

Get the full data on these outstanding IC's now. They'll do difficult jobs for you. Call your Westinghouse distributor. Or write Westinghouse Molecular Electronics Division, Box 7377, Elkridge, Maryland 21227.

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After all, why waste money? The more components you use, the more your readout circuits cost.

Both binary-to-decimal circuits shown in Figures 1 and 2 will not only reduce your component counts and circuit costs, but will also provide the gain necessary to drive, directly, the lamps in the readout.

Take the Figure 1 circuit—a standard decoder with transistor drivers on the output. This circuit not only drives the incandescent lamps, but is excellent wherever projection-type displays are needed. Use a 2N3877A transistor in it and you'll find you can also use such high voltage indicators as gas-filled, cold cathode numerical types. The Figure 2 circuit, meanwhile, is designed for incandescent lamps specifically. You'll find it a bit different in that its transistor matrix permits the transistor to do both the amplifier and the logic job required. But you need far less input current with this circuit to drive the same size lamp shown in Figure 1. Each input turns on only one transistor.

Studying applications where the readout device is driven from a counter? Try the circuit shown in Figure 3. The key to component reduction, here, lies in the economical ring counter requiring only one active device per stage. Used to drive 250 millampere lamps, this circuit delivers outstanding savings through its use of both a G-E 2N3403 economy transistor and G-E C106 low-cost SCR. Try it. You'll find its maximum repetition rate is even greater than 2 kilohertz and that it will operate even with the lamp burned out.

Fig. 1. Binary-to-decimal converter with drivers

Fig. 2. Binary-to-decimal decoder drivers

Fig. 3. High current ring counter

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GENERAL ELECTRIC

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Big jump likely in P.O. use of electronics

The Post Office Department is expected to step up considerably its use of electronic hardware and R&D. P. O. officials say that this will be the natural consequence of a thoroughgoing shake-up that has put two strongly electronics-oriented engineer-administrators at the top of the Office of Research and Engineering.

The P.O. has been spending heavily on electronics for the last two years and has announced plans for even greater spending yet to come. The new Postmaster General, Lawrence F. O'Brien, has been receptive to Congressional pressure for increased spending on automation (ED 11, May 10, 1966, pp. 31-32). He also conceded privately that "some old-fashioned skulls around this place" might be knocked together.

Now he has begun knocking skulls—a few right out of the Department. The Office of Research and Engineering has a new director and deputy director and its functions have been split in two.

Dr. Leo S. Packer, engineering manager of Xerox Corp. since 1962, is the new Office Director; Paul G. Hendrickson, former assistant vice-president of Defense Electronics, Inc., is his new deputy and chief administrative officer. In addition, O'Brien has ordered the Office divided into two operating branches, each headed by an associate director. The branches are the Directorate of Research and Development and the Directorate of Construction Engineering. The reason for the split was twofold: to give more emphasis to the engineering of the specialized new buildings required for new equipment, and to permit the mushrooming R&D program to grow unhampered by construction-engineering demands.

The P.O. has been handing out new contracts liberally. The largest to date was $26 million in May to Honeywell and Control Data Corp. for equipment for the P.O.'s huge electronic source data complex. Recently, seven firms received $19 million for mechanization hardware ranging from letter sorters and sack-parcel sorters to stamp-sensing machines and ZIP-code readers. The firms included Aerojet General, Burroughs Corp., FMC and Philco.

Self-service is coming

The biggest electronic market for the P.O. is still in the shaping-up stage. This will be the do-it-yourself post office, the "self-service postal unit." Over the next nine months 100 shopping centers throughout the nation will acquire these units complete with stamp-, postcard- and envelope-vending machines, weighing machines and mail drops. Sites for 66 units in 58 cities have already been made public. They will afford 24-hour service seven days a week as nearly automatic as possible. There will moreover be a direct-telephone-line link between each unit and a continuously manned desk at the city's main post office. Eight firms have received contracts worth $800,000 to get the self-service unit concept under way.

The most recent P.O. contract went to Pitney-Bowes: $1,420,400 for 95 electronic facer-cancelers. The machines are fed an unsorted jumble of letters which they face all in one direction. A photocell then seeks out the stamps and the machine cancels them at the rate of 30,000 pieces an hour. At present, there are 205 facer-cancelers in use in 72 post offices.

Crime control going automated

The role of advanced technology—especially electronics—in crime control has lately been receiving more and more attention in Washington and in many state capitals and big cities. Probably the most widely publicized move to pit electronics against crime was California's experimental application of aerospace-industry skills to the solution of civilian problems. Space General Corp. set about tackling crime and delinquency as a result. Now the Justice Department and the White House Office of Science and Technology have jointly sponsored a symposium in the nation's capital on June 22 and 23.

Of 10 areas pinpointed by the Department for possible development and research all but one were largely electronic in nature. Only a
session to be devoted to seeking new, nonlethal weapons for police use against attackers and riots is not considered electronics-oriented.

Some 500 representatives of industry, higher education and criminal justice will attend the symposium. Both Attorney General Nicholas Katzenbach and Special Presidential Assistant for Science and Technology Donald Hornig unabashedly admit that the symposium is a plea for help: industry and university researchers will get a rundown of just what new tools and techniques are needed in the hope that they may soon be forthcoming.

One of the most intriguing areas for discussion is the identification of criminals by their voices, through recorded "voice prints." Some other, obvious electronics areas include expanded use of computers for record-keeping, analysis and decision-making by police, courts and prisons; more effective, and less expensive burglar alarms, especially of types that would trigger radio announcements; more efficient methods of retrieving court records; more efficient communications systems linking police headquarters and patrolmen; and communications systems to link the principals in court cases as their cases reach the trial stage.

Industry seeks role in urban programs

Industry is sending droves of representatives to Washington to try to define its role in the Government's urban development programs. The hugeness of the programs has industry convinced that there must be lucrative markets for both hardware and R&D—if they can be spotted. One senior vice-president of a major electronics firm was sent here by his company just "to look around." He has been given all the time he needs and virtually a blank check to find a role for his company.

Some harried officials immersed in the new programs welcome industry's interest. They own that an industry representative—admitted by both sides to be selling his company—can often turn up a fast answer to a problem or suggest an improved way of doing something. But not all government officials are so happy. They feel that the big corporations are in a good position to find out how the new urban money is to be spent—better, indeed, than the cities that the money is supposed to help. These officials fear that the companies may thus gain the city administrators' ears early and tell them only what the companies want them to hear.

Central computer urged for Congress

Rep. William Morehead (D.-Pa.) has proposed that a Congressional read-out station be linked to a gigantic central government computer so that Congress may "tap the memory of all the other computers in the Federal Government, not to secure privileged data, but to secure facts such as economic statistics, demographic profiles and figures on such things of daily concern to a Congressman's office as funds allotted to his district, and project and contracts awards." Eventually, he said, there could be a station in each Congressman's office and in each committee office.

Possibly with the Morehead proposal in mind, a House Post Office subcommittee listened attentively and apparently favorably as University of Pennsylvania Professor Adrian M. McDonough proposed a central Federal office to oversee research into the state of the information arts and sciences. He contended that such an office could identify critical problems and set priorities for R&D.
When you look at electronic components are you seeing only half the picture?

We're the last people to argue with component purchasers who put performance, price and delivery first — meeting these three basic requirements is what keeps us in business. But most engineers are also on the lookout for something more, and many of them find it at Mullard.

Take research and development for instance. Out of Mullard R&D have come outstanding devices such as the travelling wave tubes for the New York—San Francisco and Montreal—Vancouver microwave links. Production resources? Mullard plants are among the most efficient anywhere, with a reputation for the production of tight-tolerance devices to proved standards of reliability. As for circuit know-how, Mullard has the best equipped applications laboratories in Britain. And when it comes to technical services, you will find that Mullard provides the kind of comprehensive performance specs, survey documents and application reports that are just that much more useful.

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Bat-like detectors to direct N. Y. traffic

Small, gray boxes that operate like captive bats will soon help New York City speed its heavy traffic flow.

The boxes—each an ultrasonic antenna—will hang over busy intersections. They will count passing vehicles to determine traffic patterns and help regulate traffic lights. With the detectors in place, motorists will be able to whiz along with fewer stops and delays.

A continuous inaudible yodel is emitted from the antenna. Passing vehicles then return echoes to the antenna for use in counting and controlling traffic. The frequency-modulated probe signals have a center frequency of 40 kHz. This high frequency was selected to prevent false indications from such audio interference sources as motorcyles, sirens and whistles. Either the presence or motion of the vehicle is sensed in a manner similar to that used by bats.

The traffic detectors, developed by Sperry Gyroscope Company, are the first hardware to be delivered under a $5.4 million contract from New York City for an automated control center. The ultrasonic detectors, in conjunction with other sensing devices, will provide input data to a central traffic-control computer.

A complete detector consists of an antenna and cabinet. The antenna contains two piezoelectric crystals: one sends and the other receives. The cabinet, which may be placed up to 300 feet from the antenna, contains a solid-state transceiver. Circuitry within the transceiver generates the transmission signal and converts the returned signals into useful pulses. A 12-volt power supply and an output relay are also housed in the same cabinet.

No vehicle, not even a motor scooter, escapes detection. The presence or motion of a vehicle produces one relay closure. Even speeding cars cannot avoid the unseen monitoring beam—unless they are moving faster than 80 mph.

When set to detect vehicles' presence, the system produces a relay closure that lasts as long as the vehicle is in the detection zone. When set for motion detection, it produces one 0.3-second pulse for each passing vehicle.

The lightweight antenna may be mounted at the side of the street in a side-fire mount or over the street by means of span wires or a mast arm. Up to three lanes of traffic may be monitored, regardless of the direction of traffic flow.

New York City, which has ordered 1100 detectors, expects to install them this fall. Pittsburgh, Houston, Atlanta, Fort Lauderdale (Fla.) and Baltimore will also employ the detectors in their traffic-control systems.

Bedbugs may lead Vietnamese raids

In the jungles of Vietnam, where radars, lasers and infrared devices sometimes fail to locate hiding guerilla fighters, the Army is hopeful that the hungry bedbug will succeed.

Scientists are experimenting with the bedbug's ability to smell its human quarry at a distance. Hungry bedbugs move their legs excitedly when they sense flesh. With proper control of the air that the insect smells, a scouting party could keep them in small capsules, carry them ahead of the troops and use them to detect the unseen enemy.

The Army's Limited War Laboratory, Aberdeen, Md., has developed an amplification system that makes the insect's leg movements audible.

The bedbug is placed on a rigid screen mesh and sealed in a container. The mesh is attached to a piezoelectric crystal. When the insect moves its legs, the movement of the grid produces a voltage. This voltage, when amplified, alerts the Army scout through earphones.

It was once thought that dogs could be used to sniff out the enemy in Vietnam, but there is at least one major drawback to their use there: the Vietnamese consider dogs a delicacy, and the Army fears too many may end up on the dinner table instead of in the K-9 kennel.
"Only Allen-Bradley Type J pots give us the smooth control to maintain the high calibration accuracy of our instruments”

Krohn-Hite Corporation

This quickly locates the positions of the Type J potentiometers in the illustration below.

---

Krohn-Hite engineers have found that only Allen-Bradley Type J potentiometers provide the smooth control, low noise, long term stability, and low temperature coefficient they require for their precision instruments such as the variable electronic filter.

The Type J control has the resistor, terminals, faceplate mounting bushing, and insulating material hot molded into a solid integral unit. The solid resistance track assures smooth, quiet control that is free from the undesirable discrete steps of wire-wound units. On accelerated tests, Type J exceeds 100,000 complete operations with less than 10% resistance change.


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ADDITIONAL ALLEN-BRADLEY HOT MOLDED VARIABLE RESISTORS

**TYPE G CONTROLS** are only ½” in diameter. Quiet, stepless operation. Rated ½ watt at 70°C. Values to 5 megohms. Type L are similar in construction but rated ½ watt at 100°C.

**TYPE F CONTROLS** are for mounting directly on printed wiring boards by means of their terminals. Rated ¼ watt at 70°C. Values to 5 megohms. Type O are similar but rated 0.4 watt at 70°C.

**TYPE R ADJUSTABLE FIXED RESISTORS** are built to withstand environmental extremes. Only 1¾” in length. Have stepless adjustment. Watertight and can be encapsulated. Rated ½ watt at 70°C. Values to 2.5 megohms. Type N for less severe environments are rated ½ watt at 50°C.
Allen-Bradley Type R adjustable fixed resistors are unexcelled for holding precise settings through extreme conditions of shock and vibration. This unusual ruggedness is the result of a manufacturing process—perfected and used only by Allen-Bradley—which hot molds the resistance and collector elements, terminals, and insulating material into an almost indestructible component. Thus, the controls can be mounted by their own rugged terminals without additional support.

The solid resistance track assures such smooth control that it approaches infinite resolution. Its smoothness cannot be compared with the abrupt wire-wound turn-to-turn resistance changes which may cause circuit transients. Since Type R controls are essentially non-inductive and have low distributed capacity, they can be applied in high frequency circuits where wire-wound controls are impractical. The Type R molded enclosures are both dustproof and watertight, permitting encapsulation after adjustment.

Allen-Bradley Type R controls are suitable for use from −55°C to +125°C and are rated 1⁄4 watt at 70°C, 300 volts max. RMS. Available as standard in total resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% or ±20%. As special, can be furnished down to 50 ohms. Technical Bulletin B5205 contains complete specifications. Please send for your copy today: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, New York, U.S.A. 10017.

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Every G-E voltage stabilizer supplies constant output voltage to within ±1%—even with fluctuations up to 15%. For special economy, core-and-coil units provide the lowest cost voltage regulation obtainable. They help meet tight space requirements, make wiring connections easier, and provide all the mounting flexibility you can ask for. At General Electric, voltage stabilizers are available in ratings from 15 to 15000 volt-amperes in both standard and custom designed models. Ask your G-E engineer/salesman for publication GEA-7376 or circle magazine inquiry card Number 91 for all details.

Smaller size—yet higher power capability with this new Grid Pulse Triode

2.0 KW at 1090 MC or 2300 MC. Or a full 1.0 KW at 4300 MC. That's the capability of General Electric's new Y1549 ceramic triode for grid-pulse applications. Each new triode is rated at 2000 volts, 2.5 amps peak, 0.001 duty, and 0.5 microsecond pulse width. Significant performance improvements are a certainty with its new, specially tailored cathodes and high-performance grid construction. What's more, the Y1549 is extremely tolerant of adverse environments (as are all G-E planar ceramic triodes). Typical applications include airborne navigational and communication equipment, and L-, S-, and C-band radar beacons. Circle Number 92.

Try G-E high-voltage reed relays.

They're small . . . fast . . . and reliable

Rated up to 5000 volts or 50 volt-amps, these G-E reed relays are ideal for applications requiring high reliability and long life. Dimensions, excluding leads: only 0.70 inch tall, 1.09 inches wide, and 2.80 inches long. G-E Type 3SAS reed relays operate in 3 milliseconds maximum; release time: 100 micro-seconds maximum. Ask your G-E engineer/salesman about these high-voltage reed relays, or circle magazine inquiry card Number 93.

For those really tough applications—specify G-E Metallized Polycarbonate Capacitors

Designed for your most demanding circuits

They're 50% smaller than comparably-rated foil electrode units. Stable, too. A G-E metallized polycarbonate capacitor's maximum change (in percent of 25C capacitance) will not exceed -2.5% +2.0% over its temperature range from -55C to 125C. Ratings: 200, 300 and 400 VDC at 125C; 0.1 to 10.0 microfarads. And they're self-healing. Each features low dissipation factor, high insulation resistance and superior high-frequency characteristics. Ideal for many a-c applications. Circle Number 94.
New cooling fan assemblies for your equipment cabinets

For computers and electronic equipment

Test them yourself. They're new. They're able to generate up to 500 CFM air flow in either suction or blower applications. They're designed for all-angle mounting. Quiet, reliable G-E fan units come in either 115- or 230-volt ratings for 60-cycle operation. Each is equipped with a 10-inch diameter venturi for easy mounting. Its 5-blade fan is well-protected by a wire mesh front screen and heavy duty back grill. And the proven, unit-bearing motor insures many years of reliable operation. Optional designs are also available. Circle magazine inquiry card Number 95.

8 compactrons replaced 15 tubes in this color TV circuit

Depend on General Electric compactrons for circuit savings . . . for outstanding performance . . . for full-scale production availability. Nearly 60 different available compactrons are particularly suited to color TV receivers. Ask your G-E engineer/salesman about color-TV compactrons or circle Number 96 on the magazine inquiry card.

Many advantages offered by G-E fast-recovery rectifiers

Some applications are just too demanding for normal silicon rectifier diodes. Take advantage of reduced recovery transients, increased circuit efficiency, and low RFI. Try G-E fast-recovery rectifiers. General Electric offers a complete line of these devices in 6-, 12-, 20- and 30-amp ratings, and with maximum recovery time of either 100 or 200 nanoseconds. Applications where they're sure to be particularly useful include free-wheeling rectifiers, sonar and ultrasonic equipment, DC-to-AC inverters, and other systems requiring high-frequency switching. You'll like their prices, too. Circle Number 97.

New magnetic material breakthrough—improved Alnico 8

Given the right size, shape and directionalization, this new G-E magnetic material can produce a nominal coercive force of 1850 oersteds. This means that, in some applications, you can reduce the size of your mechanism as much as 40% . . . save dollars as well as space. Higher useful recoil energy is also a fact with improved Alnico 8. Ideally suited for motors, latching applications and torque drive devices. Ask one of our experts to help you design it into your newest application. Circle Number 98.

No separate driver needed for this incandescent bulb circuit

Combine the high gain of the 2N3415 economy transistor with the low-current requirements of the G-E #344 lamp in this circuit, and you've eliminated the need for separate driver stages to drive the incandescent bulbs. This circuit will continue to operate with either or both of its bulbs burned out. It can also drive other circuits just like it to form a binary counter chain. Circle inquiry card Number 99 to learn more about it.

WE MAY NOT OFFER EVERYTHING YOU WANT FROM ONE COMPONENTS SUPPLIER. BUT WE DO COME A LITTLE CLOSER THAN ANYONE ELSE.
Flat metal strips curl into antennas

Antennas for space vehicles can now be stored as compact rolls of flat metal strips which, as they are unrolled, curl into tubes.

These deployable antennas are being built for NASA by the Aerospace Division of the Westinghouse Defense and Space Center.

In developing the deployable antenna concept, Westinghouse designers solved two of the basic problems that have limited the potential of this type of extendable antenna for space use. A high strength-to-weight ratio was achieved by using special heat-treating processes and by putting a large number of holes in the strips. The holes also solved the distortion problem that occurs in space when the side of the antenna facing the sun is heated to a very high temperature, while the side away from the sun is cold. The holes are arranged in special patterns that allow the sun’s rays to pass through and heat the side of the antenna that is away from the sun. The entire antenna thus remains at the same temperature, and distortion is avoided.

Normally, about 15 per cent of the metal in the strips is removed to form the holes. However, more than 50 per cent can be removed when the application so requires. Each square inch of the strips usually has about 100 holes.

According to Westinghouse, the extendable tubing can also be used for the deployment of equipment or instruments from spacecraft or underwater vehicles, as well as for structural elements.
The eavesdroppers: ‘Fallout’ from R&D

Aerospace and military electronics spur two-way market in clandestine listening devices

S. David Pursglove
Washington Editor

Electronic eavesdropping has become so widely publicized in recent years that it is losing its glamour. Television spy serials, popular national magazines and Congressional hearings have dispelled the aura of mystery that once enveloped the field. Today even a schoolboy knows that a martini olive, a sugar lump or a businessman’s attache case can be turned into a mechanical spy—old-fashioned spies, by today’s standards.

As the technology and market grow steadily, technical advances—largely “fallout” from research in aerospace and military electronics—are producing equipment on two levels:

1. Highly sophisticated, expensive devices for use by professionals only. Such devices keep pace with the newest developments in microminiaturization, lasers and other techniques.

2. Relatively simple equipment for the general public. While not as expensive as that for professionals, it can still be high. In many cases the packaging is unique but the circuitry is fairly basic.

An example of highly sophisticated equipment is a transducer microphone built on the head of a pin for an intelligence agency. Some telephone taps, on the other hand, rank with relatively crude equipment. They are so simple that practically anyone can install them.

Great Seal sparked interest

Although the practice of electronic eavesdropping has been around for a long time, it was limited for the most part to cloak-and-dagger circles.

Then, in 1960, U.S. Ambassador Henry Cabot Lodge displayed the now well-known Great Seal bug to the United Nations as an example of Soviet spying on this country. With this dramatic revelation, bugging became almost a household word. Widespread public interest in the area has persisted since.

The Great Seal bug was presented to the U.S. Embassy in Moscow by a Ukrainian delegation. Its triumph was that it required no power source of its own. It had no wires that could be discovered, no batteries that could wear out. Its operation was controlled entirely from outside the embassy chancery.

The device, which Soviet agents hung within the carved wooden seal over the desk of our Ambassador to Moscow, was extremely simple. It was only a small copper cylinder—a can—with a nine-inch copper rod attached. The can, carefully turned to close tolerances and silver-plated for long life, was a sharply tuned (high-Q) cavity. The copper rod, also silver-plated, terminated inside the cavity, with its tip in the form of a plate. That plate was coupled capacitively with a “tuning post,” also inside the can. The tuning post, in turn, was capacitively coupled with a delicate metal diaphragm, three mils thick, that covered the can opening.

The can measured 11/16 inch long, with an inside diameter of 0.775 inch. The cavity inductance was 1/100 microhenry. The entire unit, including the nine-inch antenna, weighed 1.1 ounces. The operation of the bug was the essence of simplicity. An ultra-high-frequency signal from a van parked near the embassy building would reach the device. The bug would reflect the signal back to a receiver, after first modulating it with sound waves from conversations striking its diaphragm. The sound waves that struck the diaphragm caused it to move, and that movement changed the size of the tuned cavity slightly—just enough to modulate the signals effectively.

Tests prove operation

The bug was hidden behind a hollow in the beak of the eagle carved on the Seal. Tests at the State Department showed that the device worked well in free space but that
Eavesdroppers, continued

It was very sensitive to its environment. Performance fell off when it was placed in plaster or implanted near metal or other attenuating materials. But it operated essentially in free space in the very small hollow in the Great Seal.

The Great Seal bug is an example of how modern eavesdropping has progressed. A State Department official told ELECTRONIC DESIGN recently that the bug was originally developed by the Russians more than 20 years ago.

Laser bugs are next

Today eavesdroppers plan to use lasers to read window vibrations corresponding to conversations in a room. In theory, a laser beam originating hundreds of yards or even several miles away would strike a window, be modulated by voice vibrations also striking the window, and bounce back to the source where it would be "read."

Laser eavesdropping is very real—right now. The problem is that it works only under ideal conditions. Auto and airplane traffic also vibrate the same window pane that is being "read" and interfere with the eavesdropping. But specialists are ironing out the trouble. They expect within five years to be able to filter out or discriminate against extraneous vibrations to the extent that windows near normal voice conversations will be read well by lasers over 100 yards away in all but the noisy heart of a city.

R&D devices often ideal

Typical of routine operations today is the experience of a three-man electronics shop in Maryland. The National Aeronautics and Space Administration had a problem: It had to measure the flow rate of gases through tubes of very small diameter, but any available transducer was so large that its insertion into the stream disturbed the flow and presented distorted data. The Maryland company accepted the design challenge and developed an extremely small transducer that produced minimum distortion when placed in the gas stream. It worked very well.

An intelligence agency heard about the pinhead-sized transducer and recognized it as a potential pinhead-sized microphone. A trial in the company's office showed that the transducer, poked through the bottom of a conical paper drinking cup, easily picked up and clearly transmitted whispers 30 feet away.

The microphone was a miniature glob of lead zirconate, molded and coated with aluminum for shielding. It was mounted for free vibration. Wires so fine they could not be detected when running through the nap of a rug were soldered to the glob. Besides being buried in a rug, the pinhead mike could be embedded in a wood picture frame or a desk top and then polished over.

One was given to a caller for photographing. When, several months later, he telephoned the company to arrange the mike's return, he was told: "Keep it. It's obsolete; we've got a much smaller one now."

Market figures unreliable

Estimates of the present annual dollar volume of the electronic eavesdropping business are unreliable, to a large extent because of the surreptitious nature of much of the business. Specialists who presume to speak with authority put the design and production figure for the country at anywhere from $1.5 million to $20 million—a pittance in comparison with the more than $17 billion yearly output of the electronic industry.

But the market is expected to spurt when the long-range laser microphone is perfected and when many of the now sophisticated, expensive devices for federal agencies trickle down to local police departments, private investigators and industrial security officers.

One factor may slow the anticipated rise in business, however: Congress and other responsible bodies are looking into the rights and wrongs of electronic snooping and the question of whether strict federal controls are needed. At present such eavesdropping is conducted at the fringe of fuzzy state and local ordinances. The resulting infringement on private lives worries many legislatures and—at the other extreme—has given cartoonists and others bountiful material for humor.

Regardless of its current size, the bugging business is said to have rescued at least a few floundering small electronic R&D firms. It is a business in which there are still plenty of takers, and all the sales manager need do is to show up at the right conventions and drop the word that his firm is "open."

Among his potential customers will be private operatives, corporation security representatives, federal gumshoes (such as the Federal Bureau of Investigation, the Narcotics Bureau, and, nowadays, the Internal Revenue Service), and the
AGAIN, LET ME REMIND YOU THAT OUR COMPETITORS WILL STOP AT NOTHING!

I SAY OLD MAN, WHICH WAY DID YOU SAY IT WAS TO MOSCOW?
(eavesdroppers, continued)

cloak-and-dagger community, peo­
pred largely by the Central Intel­
ligence Agency and the Defense In­
telligence Agency.

Many of the firms that have de­
veloped electronic devices for a
space or military project, only to
find them in great demand by inves­
tigative agencies, occupy spots
along the Boston-Cambridge "Elec­
tronics Row," the Los Angeles R&D
community, and many small R&D
outlets in the suburbs of Washin­
ton, D. C.

One manufacturer who holds
open house with a traveling show of
electronic eavesdropping equiment
says that his most frequent visitors
are from the Air Force Office of
Special Investigations. Like cus­
tomers from other federal agencies,
he says, the Air Force agents "are
quite furtive in their visits but ob­
viously more concerned about being
spotted by another agency than by
the Reds or the public."

"They usually buy in quantity,
and they pay well," the manufac­
turer reports.

Big money in custom bugs

But it is not the representative
who visits the manufacturer's hotel
display room and places an order
for a half-dozen miniature tape re­
corders and a mobile trailing unit
who keeps the small R&D shop in
business. Rather it is the agent who
shows up at the laboratory late one
afternoon, displays his credentials,
warns the proprietor-chief engineer
that the "national interest" re­
quires the conversation to be held in
the strictest of confidence and pro­
ceeds to outline a problem that can
be solved only by custom design.

"We'd like to know what's going
on in a particular office," he might
say. "Somebody we know repairs
typewriters, and he has access to
the office."

The problem then is hide all the
components of a bugging transmit­
ter in various typewriter parts, and
do it in such a way that when the
parts are installed, they become a
working transmitter, picking up
and transmitting conversations in
the room. The "incentive money," as one of the agencies calls the fee,
might be $200,000.

Eavesdropping, like any other
electronic development, is following
a predictable business course. The
newer devices may be steeply priced
at the outset, but their costs are
dropping with mass output. And
with each step forward, the bugs
are becoming harder and harder to
detect.

One Florida manufacturer who
has been in the bugging business
since 1938 attests to the remarkable
progress in the "state of the art."

"In those days," he says of his
start in 1938, "a really small bug—
we didn't call them bugs then, be­
cause they were hardly small
enough to justify that kind of a
name—was about a foot and a half
long, a foot wide and about 10 inch­
es high. They would barely trans­
mit to the next room. And, boy, did
they heat up! We couldn't hide
them in a small space at all."

As he recounted this recently, he
fingered a cube-shaped transmitter
about a half inch in each dimension.
It had been developed for implant­
ing in a space-borne chimpanzee to
transmit data on weightlessness.

"We never would have developed
this," the Florida man said. "There
wouldn't have been a large enough
demand and not enough money for
development. It's funny, though;
now that the thing has been devel­
oped, there's an increasing demand
for them."

Even a harmless-looking stapler
can be bugged with a hidden microphone.

Electronic eavesdropping in hotel
rooms is made convenient with pic­
tures like this one. A microphone is
concealed behind the small hole.
Basic circuits turn into electronic spies

Professional eavesdroppers are firm believers in the adage, "You don't use a cannon ball to kill a fly." If a simple device will do the job, they use it. If the bug is likely to be suspected or encounter anti-bugging interference, more elaborate techniques are called for. Today's electronic eavesdropping equipment ranges from one-stage FM transmitters to microcircuits powered by radio waves from commercial broadcasting stations.

The circuits on these pages are typical of many basic types now in use. They can be built into extremely small packages. They may fall short of the requirements for international espionage, but businesses and suspicious husbands are using them in increasing numbers.

Devices like those shown here are subject to various laws and regulations. Reputable manufacturers normally point this out to all prospective buyers. For example, one manufacturer includes the following paragraph on all order forms:

"The use of unlicensed and/or un­certified low-power transmitters is specifically prohibited within the United States and its possessions except in the audio modulated broadcast range. (See Part 15, Volume II, of the Federal Communications Commission Rules and Regulations covering incidental and restricted radiation devices.)"

Spike mikes are used for listening to conversations in a room from an adjacent room. The spike is driven into the wall and picks up wall vibrations.

Audio amplifier for a "spike mike" can be inserted in plaster walls or doors along with the microphone. The spike pickup makes the microphone highly sensitive and difficult to detect (see above photograph).

Integrated-circuit transmitters such as this can be made extremely small and consume very little power. This one uses two Westinghouse ICs plus a few additional components and can transmit up to several hundred feet.
Beeper transmitter feeds audio pulses into a 27-MHz Citizen's Band oscillator. The device is often used for tracking a subject by placing it in his clothing.

Wireless telephone bug derives power and modulation from the telephone line. It is connected in series with either side of the telephone line.

The "wireless mike," an FM eavesdropper, operates in the 88-108-MHz band. Range is approximately 50 feet with a three-inch whip antenna.

AM room bug is usually concealed in a radio or TV. It can use the speaker as a microphone and the ac line cord as an antenna. Unit operates between 500 and 700 kHz.

FM bumper transmitter is used for surveillance of moving vehicles. The transmitter emits a shrill audio tone near the top of the 88-108-MHz band. Magnets on the case are used to fasten the device on to the inside of the bumper or under the gasoline tank of the vehicle to be tailed. The antenna is usually a three-inch whip wire.
Why snoopers favor telephone tapping

Frank Egan
News Editor

If there is any staple of professional eavesdropping, it is telephone-tapping. The reason for this is both social and technical. Social, in that telephones have become almost an omnipresent part of modern living, and technical because tapping is so extraordinarily simple. In effect, the person under surveillance talks directly into the tapper's microphone. The technique can be practiced by schoolboys as well as professionals.

The basic method of tapping is illustrated by the simplified schematic of a telephone circuit in Fig. 2. For tapping, the arrangement can be considered as a series circuit that is energized by a 48-volt battery at the central office when the telephone headset is removed from its cradle. Incoming and outgoing voice signals modulate the dc circuit current to produce an ac component in the frequency range of about 300 to 3500 Hz.

Various techniques are used

Any telephone tap involves three factors: (1) The method of coupling the voice signal from the line, (2) The way in which the tapped signal is transmitted to the tapper, and (3) Power for a radio transmitter, if one is used—whether self-contained battery power or dc power drawn from the telephone circuit.

One way of tapping that uses a self-powered radio transmitter is shown in Method 1 of Fig. 2. The voice signal from the line is noninductively coupled to the input of the transmitter, where it modulates the carrier generated by the transmitter. Since the transmitter contains its own battery, no dc is drawn from the telephone line. To avoid upsetting the normal impedance of the telephone line, which is about 900 ohms, the transmitter usually has a high input impedance. Although not easy to verify, this would indicate that FETs are looked upon with favor by the more sophisticated makers of tapping transmitters.

When tapping transmitters are designed to draw their operating power directly from the telephone line, they extract both dc power and voice modulation from the line. Because of this, they tend to upset the normal characteristics of the line more than transmitters that have their own batteries. As shown in Method 2 of Fig. 2, this type of transmitter can be connected directly across the line. Other units are designed to be connected in series with either side of the line.

Power drain is a factor

Low power drain is an important requirement of transmitters that operate directly from the telephone line.
Telephone tapping is widely used by eavesdroppers, mainly because it is convenient and simple.
The 7100 cures last digit jitters.
It corrects itself to compensate for component drift and noise.
It only measures the signal.
The secret is a measuring technique called Dual Slope integration. How it works is no secret.
We’ll give you all the details in our 7100 data sheet.
Get it.
The solitary bug maker: A profile

Roger Kenneth Field
News Editor

In a room on the fifth floor of an old office building in lower Manhattan, Manny Mittleman sits at a workbench and makes small electronic transmitters.

There's lots of space under and behind the dial of a telephone, and Mittleman hates to see it go to waste. Mittleman makes snooping devices. His customers are eavesdroppers who will pay a stiff price to satisfy their curiosity about the utterances and whereabouts of the public.

"I just make small electronic devices," says Mittleman, "and to what use people put them is no concern of mine."

Anyone who knows a little about electronics might easily conclude that Mittleman is given to understatement, for he tailors the leads to just the right length and ends them with precisely the right connector to facilitate installation in a phone without making a Federal case of it.

Mittleman works alone. He doesn't advertise his wares; he offers no brochures or catalogs. He claims to have made $40,000 last year, working day and night.

He makes two different transmitters to take up spare space in a telephone. One taps the telephone's line cord for power and signal and uses it for an aerial. Connected in series with the phone, the transmitter will broadcast over a range of about one-fifth of a mile. A conventional FM radio, suitably adapted by Mittleman, receives the tapped conversation.

Another device made by Mittleman permits a snooper to listen in, from anywhere in the country, to conversations in a room that has a telephone connection. Thus, the tapped phone never rings, but the snooper can hear everything said in the room.

Mittleman also makes transmitters to fill spare space in cars and rooms.

The car transmitter plugs into the antenna socket of the car's radio. The antenna, in turn, plugs into the transmitter, thereby restoring the radio's reception. One insulated wire taps the car's cigarette lighter for power. With a little practice, the eavesdropper can use the device to locate the car as well as to overhear every word spoken by its passengers.

The other transmitter contains its own batteries and can be placed anywhere in a room. Its tiny, magnetic hearing-aid microphone picks up the slightest noise in the room and triggers the device on; it turns off as soon as the noise ceases. It consumes several milliamperes when operating, but during standby its current drain falls to just a few microamperes.

Mittleman will sell these devices to anyone who can pay for them. He charges what he feels the traffic will bear: $250 for the phone bug, $300 for the room and car bugs, and $400 for the harmonica-triggered unit. All are made with standard parts and transistors. They are mounted in holes drilled in a thick lucite sheet and connected by hand-soldered wires.

Mittleman has taken his phone apart so many times to demonstrate his devices that the screws that fasten its case are practically threadless. His clientele is widely varied, because, as Mittleman points out, he doesn't ask too many questions. Not too long ago, for example, while a visitor was chatting with Mittleman in his work room, a lawyer entered and self-consciously asked to see some room-bugging equipment.

"Clients of opposing lawyers tend to watch their tongues when they see a microphone," the prospective customer said. "I thought that we might be able to record their conversation without causing them to become excessively defensive."

Mittleman reached for his screwdriver and started to open the bottom of his phone again.

Anyone for bugging—or anti-bugging?

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM transmitter for</td>
<td>$250</td>
</tr>
<tr>
<td>telephone tapping</td>
<td></td>
</tr>
<tr>
<td>Bug eliminator (noise generator)</td>
<td>$250</td>
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<tr>
<td>Pocket amplifier</td>
<td>$185</td>
</tr>
<tr>
<td>Pocket FM transmitter</td>
<td>$295</td>
</tr>
<tr>
<td>FM receiver (modified)</td>
<td>$195</td>
</tr>
</tbody>
</table>

These devices are examples of what might be called off-the-shelf, consumer bugging equipment. They can be bought by mail or cash-and-carry.

The prices reflect two things about the business: one is the relative lack of competition, which allows the manufacturers to charge what the traffic will bear; the other is the narrow extent of the market. The cost of any development work that goes into a device must be recouped over a limited number of sales.

Three of the companies that sell a wide range of bugging and anti-bugging devices are The Continental Telephone Supply Co. of New York City, Mosler Research Products, Inc. of Danbury, Conn., and Electronic Surveillance Equipment Co. of Miami, Fla.
Computer speaks with film vocal cords

Tireless ‘optical voice’ answers up to 72,000 stockbrokers’ queries an hour

Even when trading on the American Stock Exchange reaches fever pitch and brokers flood it with requests for stock quotations, a tireless “optical voice” gives quick, clear answers to every query.

The voice, called the Speechmaker by its manufacturers, Cognitronics Corp. of Briarcliff Manor, N. Y., is 63 audio signals recorded on as many tracks. These tracks are simply strips of photosensitive film.

During recording, the original signals modulate the intensity of a light source, thus varying the exposure of the emulsion on the moving film track.

The film is then developed, and playback is effected by shining a light through the track on to a photocell and amplifying the cell’s output. This same photographic or optical recording method was used to make early “talkies.”

The 63 tracks and one timing track are mounted round the cylindrical surface of a rotating drum. Light from a long tube shines through a slit on to this surface. Inside the drum the light, passing through the film, falls on the surface of a row of photocells—one cell for each track. The cells’ amplified outputs compose the message heard by the inquirer.

The tracks contain numerals, various common fractions and key words such as “high,” “low,” “closed” and “volume.” When a broker dials a quotation request, a computer locates the latest price in its memory. It then directs a series of solid-state switches to tap the tracks of the Speechmaker in an order that conveys the requested information. Up to 72,000 queries an hour can be handled.

For example, the broker might dial the computer and then the code number of a certain stock, say, Unexcelled Chemical. The computer would locate the latest selling price of Unexcelled Chemical in its memory and operate the Speechmaker’s switches to produce the following message: “U C TWO-TWO AND-ONE-EIGHTH, UP ONE-EIGHTH, VOLUME FIVE” (500 shares).

There are other drum systems that act as vocal cords for computers. These systems are magnetic and have a number of moving parts.

The new unit has no magnetic head to wear out, and the only moving part is the drum, which rotates at a uniform speed on a set of ball bearings.

The entire system, called “AmQuote,” was built and is operated by the Bunker-Ramo Corp.
Tenney couldn't let well enough alone.

When the Junior environmental chambers were first introduced, they were well in advance of the state-of-the-art. Yet our design engineers still wanted wider parameters, more precision, more economy of operation. The results of their labors are shown below:

**Tenney Jr. Bench Model**

**High-Low Temperature Test Chamber**

New Temperature Range From $-120^\circ$ F to $+350^\circ$ F! greater load dissipation. New fan guard. 2¢ per hour average operating cost! Hermetically sealed inside and out. Weighs only 200 lbs. Simple plug-in operation.

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**Space Jr.**

**Bench Model Thermal Vacuum Simulator**

Heat, Cold & Vacuum for the Price of Vacuum Alone! in. test area. High vacuum construction throughout. Self-contained, air cooled, plug-in design. Temperature surfaces are blackened for high emissivity.

Available for immediate delivery. *LN$_2$ shroud for lower temperature and other optional accessories*

To order, or for more information, write to

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Oldest and Largest Manufacturer of Aerospace and Environmental Equipment.

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**NEWS**

**Computer controls model railroad**

Computer-controlled railroads may be old hat but they're not too common a sight inside a convention hall. Visitors to last month's Spring Joint Computer Conference had an opportunity to see just such an indoor railroad. Computer Control Company, Framingham, Mass., exhibited an HO-gauge (approximately 1/87 actual size) railroad operated under control of its DDP-116 computer.

A miniature diesel locomotive selected box-cars from one or more of the railroads sidings until a train of desired length was made up. After pulling the train out of the sidings, the locomotive could then be directed to move the cars to an uncoupling ramp where the cars would be released one at a time and allowed to roll back into their proper siding track. If desired the entire train could be directed to run continuously around a closed loop.

All operations were under control of the DDP-116 computer. Changes in the railroads pattern of operation could be made by the operator using a teletypewriter connected to the computer's input.

Basic difference between the operation of the miniature set-up and its full-size counterpart is the method of sensing and identifying the cars. Where full-size automated railroads use photosensing to locate and uniquely identify a car, the miniature railroad used reed switches operated by magnets fastened to the underbody of each car. Also, the computer keeps track of the location of each miniature car rather than uniquely identifying it by photosensing.

**DDP-116 computer** was used to control all operations of this model railroad set-up.
**Dummy talks/hears for NASA studies**

NASA can now talk and listen to a plastic-coated replica of an average astronaut.

The dummy head and torso, complete with speaker "mouth" and microphone "ears," was fashioned by a Brooklyn, N. Y., sculptor, Bruno Civitico, to within one-tenth inch of the dimensions of an average astronaut. To simulate the acoustical properties of human skin, the dummy was coated by its makers, CBS Labs., Stamford, Conn., with a plastic compound.

The dummy will be used to test communications headgear such as space helmets, earphones and microphones. The ears are the acoustic equivalent of human ears. The dummy can speak as loudly as any astronaut and hear even a whisper.

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**Thermistor uses diamond element**

A diamond thermistor temperature sensing device that continuously senses temperatures from cryogenic to red heat has been developed by General Electric. The unit utilizes a specially-processed diamond crystal as the electrical resistance temperature sensing element, and is reportedly the only thermistor known today that can sense over such a wide temperature range without discontinuities. Engineering samples operating between -200°C and +650°C are scheduled for introduction in September.

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**Inland’s Standard DC Direct-drive Torque Motors Solve MOBIDIC Tape Transport Problems**

Inland’s Standard DC Direct-drive Torque Motors Solve MOBIDIC Tape Transport Problems

Faced with meeting the rugged requirements of military operation, Sylvania’s Electronic Systems Division of General Telephone & Electronics Corp. turned from conventional tape transport designs and developed a unique militarized system capable of optimum tape handling without damage or distortion. This modern, miniaturized design provides rapid reversal (less than 6 milliseconds) so programming is not restricted, high controlled acceleration and deceleration, (empty reel: 570 rad/sec², full reel: 270 rad/sec²), wide dynamic speed ranges (1000/1).

Sound impossible? Not to Inland Motor. Inland’s standard Model TT-4005, tachometer generator-torque motor combination surpasses these performance requirements. Featuring a peak torque output of 3.5 lb.-ft., the DC direct-drive torque motor, with damping enhanced by a DC directly-driven tachometer generator, furnished the linear speed/torque characteristics required over these ranges. Easily controlled by current limiting, it also provided the desired acceleration. Dynamic braking assisted the quick reversal. Since it was direct-drive, the operation was smooth and back-lash free.

Whatever your servo application may be, you can rely on INLAND to meet your most demanding requirements.

---

**TORQY SAYS:**

If you’d like complete details on this unusual application and other interesting facts on Inland direct-drive servo components, write today.

---

**INLAND MOTOR CORPORATION**

RADFORD, VIRGINIA

703-639-3973

SUBSIDIARY OF KOLLMORGEN

Speed Inquiry to Advertiser via Collect Night Letter

ON READER-SERVICE CARD CIRCLE 20
Letters

U.S. railroads run faster trains

Sir:

Your article “Full Speed Ahead of High Speed Trains” (ED 6, 3/15/66, p. 22) was extremely interesting. However, knowing your desire for accuracy in ELECTRONIC DESIGN, I feel I must point out one error.

The Canadian National Railway’s “Rapido” by no stretch of the imagination is the fastest train in North America. Its top speed of 93 mph (according to the January ’66 issue of Trains magazine, maximum allowable speed for this train is 90 mph) is below the regularly scheduled 100 mph hit by the Illinois Central R.R.’s Train No. 1, the “City of New Orleans”, near Kinnmundy, Ill.

Even the 67-mph average of the “Rapido” is nothing unusual. In the United States and Canada there were more than 22,000 miles of passenger runs made daily last year at average start-to-stop speeds in excess of 70 mph. To name but a few, the aforementioned I.C. Train No. 1 averages 79.5 mph over the 124.6 miles between Champaign and Centralia, Ill.; the Atlantic Coast Line’s “East Coast Champion” is scheduled for 76.0-mph average between Florence and Charleston, S.C., a distance of 95 miles; and one of the present long-distance speed champions, the Santa Fe’s “Super Chief”, covers the 100 miles between Garden City and Lamar, Kan., at a scorching 82.1-mph average.

Of course, all these runs will seem turtle-like once 160-mph trains are operating in the Northeast corridor.

W. E. Warden
Senior Design Engineer
Specialty Control Department
General Electric Co.
Waynesboro, Va.

People who live in glass houses . . .

Sir:

In your editorial, “Engineers are too often silent on major social issues,” you criticized a recent anti-Vietnam-war march down New York’s Fifth Avenue and a counter-demonstration by a group of “neo-Nazi hecklers” on the sidewalk.

Why is everyone who is against the “let’s surrender” groups sooner or later branded a Nazi or fanatic? You preach against warped judgment, but then you do the same thing. Were they a group of “neo-Nazi hecklers” or were they just people tired of seeing traitors and cowards use our streets to damage our reputation? If these people are afraid to join the service and fight for their country, why don’t they just admit it?

But to get back to you, the stable, considerate engineer with a cold, reasoned approach: Someone sick of demonstrators, in a momentary outburst, said, “Let’s shoot ’em down,” and do you coldly reason or do you jump up and down and shout, “Nazi”? Have you ever heard the old one, “Practice what you preach”? At least, don’t print it if you must babble.

Paul Doerr
San Francisco Bay Naval Shipyard
Vallejo, Calif.

All for Siemens

Sir:

Thomas Parsons has asked who Siemens was [ED 10, Apr. 26, 1966, p. 35] and his question deserves an answer. Werner von Siemens lived from 1816 to 1892; he was one of Germany’s great scientists, working in the field of high-current techniques. In 1866 Siemens discovered the dynamoelectric principle which became the basis for the construction of high-frequency transmitters around the turn of the century. His scientific research and a number of other inventions made Siemens’ name known round the world.

Both Ohm and Siemens were great scientists and it seems to me it was a matter of questionable taste to turn Ohm’s name upside (continued on p. 51)
3 times out of 4
our distributor has your
switch order in the bag.

The bag we call
Uni-Pak.

Your Cutler-Hammer Distributor sells
more than 10,000 different commercial
switches and military switches. One of
these will do your job, or we’re ready to
design the special that will.

More often than not, he can fill your
switch order from right off his shelf. Be­
cause of Uni-Pak.

What’s Uni-Pak all about?
First, Uni-Pak covers the 350 basic
commercial and military switch models
that account for 75% of our Distributors’
orders. Next, Uni-Pak is convenient pack­
aging: one switch with mounting hardware
per sealed plastic bag; 25 bags per carton.

Most important, Uni-Pak provides im­
mediate local availability of all these popu­
lar, conveniently packaged switches. Your
Distributor’s stocks are substantial. Our
factory back-up stocks truly enormous.

Now you have immediate switch selec­
tion without tying up dollars in inventory.
For prototype production. To cover un­
expected rush orders. The switches you
need today, you order today. Or yesterday
at the earliest.

Chances are excellent that our Uni-Pak
switch program can pay-off in better serv­
ice for you. Plan to discuss it soon with
your nearby Cutler-Hammer Distributor.
Alcoa Aluminum makes your choice easier when you must meet all 5 product-personality requirements.

Environment
Alcoa® Aluminum is durable. In the lab or in the field, lightweight, corrosion-resistant Alcoa Aluminum will stand up against everyday wear and tear. Pound for pound, it's stronger than steel. And Alcoa has the alloys that can meet your most exacting requirements.

Application
Alcoa Aluminum is versatile. It's nonmagnetic, nonsparking, dampens vibration and, since it is an excellent conductor of both heat and electricity, it's suitable for a wide variety of enclosed applications.
Aesthetics
Alcoa Aluminum is easy to finish. Either alone or in combination with many other materials, natural aluminum has a pleasing appearance that can be enriched by embossing the surface or by the addition of color—in a broad spectrum.

Production
Alcoa Aluminum is easy to fabricate. It can be cast, forged, extruded, machined or drawn... formed or fastened by practically any method, often at cost savings.

Customer Satisfaction
Alcoa Aluminum is oriented to your customer's needs. A wide variety of shapes and sizes, alloys and finishes, properly applied, assure the best performance of your product. For complete information on how to put aluminum's five-point personality into your product, contact your nearest Alcoa sales office. Or write: Aluminum Company of America, 1780-F Alcoa Building, Pittsburgh, Pa. 15219.

Change for the better with Alcoa Aluminum
Sir:

It is heartening to read Thomas Parsons' protest against the substitution of the siemens for the mho. Our peace of mind is likewise being endangered by a similar problem. We have been earnestly asking ourselves: "Who was Inch anyway? Who was Gallon or Ounce? What did they do?" We have not yet found anyone who knows, and this strongly suggests that their exotic names do not belong in the company of Liter, Meter and Pound.

We shall take energetic and decisive action to stamp out and eradicate all units that are foreign to us and that our national pride cannot put up with. There must be many means available for lodging a formal protest and putting a stop to the infiltration into Europe of the inch, gallon and ounce.

P.S. If Mr. Parsons is interested in logical arguments in support of his cause, he should not omit to look up The American People's Encyclopedia, Vol. XVII, p. 19.

Peter G. Olfs
Peter Neumann
Michael Niemeyer
Consulting engineers
Kemptenerstrasse 63
8 Munich 49
West Germany.

Letters (continued from p. 50)

down. So I must ask: "Mho, why? Siemens, why not?"

Dr. Karl G. Lickfeld
Klinikum Essen
West Germany.

Sir:

For the information of Thomas Parsons and for your other readers' as well, a few words about who Siemens was. The Encyclopaedia Britannica states that Ernst Werner von Siemens (1816-1892) gave the world many inventions and discoveries relating to telegraph apparatus; established methods for testing underground and submarine cables; devised apparatus for duplex and diplex telegraphy; invented the modern dynamo which was the beginning of the science of electrolytechnics.

He founded the firm of Siemens and Halske, which installed a complete telegraph line running between Berlin and Frankfurt in 1848 and demonstrated the first electric railway in 1866, among its other accomplishments.

While we do not wish to impose on anyone the use of the term siemens as a substitute for mho, we think it hardly fair to blame the suggestion on Siemens, who made no small contribution to science. All we can say is: "Have a hertz!"—Hertz is the German word for heart.

B. J. von dem Knesebeck
President
Siemens America, Inc.
New York, N. Y.

Degrees alone do not make an engineer

Sir:

I must commend your editorial, "Craftsmanship: the mark of the professional engineer" [ED 10, Apr. 26, 1966, p. 41].

From my personal experience over the years, I know that too few engineers match up to the title of "professional," let alone, "craftsman." Of course, engineering needs its specialists just like any other professional field. But it is not the specialist who gets the final job done, nor is it he who can look at a problem in its entirety and consummate a compatible, practical solution. It is the craftsman-professional engineer.

There is still available to our complex industry a relatively untapped store of these craftsmen, who in actuality can, and usually do, accomplish the real tasks unsung, while a specialist receives all the glory, as it were, for getting the job done, whether it was one of minor detail or one of the most complex design structure.

I am referring to the engineers without degrees, the men and women who have only a certain amount of higher education—not so much from the universities as in the school of hard knocks and experimen-
For almost two decades we have been privileged to work with manufacturers and users of electronic components in the design and manufacture of equipment to meet a variety of testing and inspection requirements. Complete electronic/mechanical systems have evolved as a result of this experience, and are now offered as standard units. Designs are thoroughly proven by actual operation.

Automatic testers generally consist of (1) the electrical and electronic circuitry required to perform the measurement involved, and (2) mechanical handling of the components to bring them to the test station, and to properly dispose of the tested components. We therefore can offer singular responsibility to customers for proper performance and operation backed up by engineering talent and manufacturing facilities experienced in the design and building of complete electronic/mechanical systems.

The units shown on this page are typical of those currently in use at some of the leading component manufacturing and user plants in the country. Our Engineering Department will be glad to study your specific requirements. Write today for a copy of our catalog describing our standard systems.
From the expanding line of Sigma relays...

New 2, 4 and 6 pole relays* you

Here's today's closest approach to a "universal" relay—the new Sigma Series 62. These versatile, miniature relays are being used in more than 1,001 applications. Ranging from communications equipment, data processing equipment and measuring instruments to process controls, recording devices, alarm systems and many more.

You get both electrical and mechanical versatility in the new Series 62 relays. They are available in 2, 4 and 6 pole versions for lower cost switching of multiple circuits. Installation is fast and simple with solder-terminal or printed-circuit-terminal sockets designed to provide maximum space for easy soldering.

*Order them off-the-shelf.
can use in 1,001 applications.

The new Series 62 exhibits excellent electrical and mechanical stability at low-level to 2 amp loads. It has an exceptionally long mechanical life of 100 million operations minimum. Each relay is available in all popular coil voltages.

There are more features you'll want to check-out in these new Series 62 "universal" relays. Your Sigma representative or distributor will be glad to help you.

**Free Catalog:** Contact Sigma direct. We'll send you our new 16-page Sigma Preferred Standard and Stock Relay Catalog and an up-to-date stock listing to help you select the relays immediately available in quantity.
Your Problem?

FORGET IT... you haven't heard about Borg-Warner Controls Model R-130 magnetic tape recorder with electronic bit de-jittering. Bit jitter stability, caused by transport wow and flutter used to mean magnetic tape recorders were unsatisfactory for pulse-code modulation data-storage telemetry. That was before Borg-Warner Controls engineers compensated for mechanical jitter and instability electronically. Ground station telemetry input pulses are aligned to crystal clock accuracy.

IRIG Telemetry Standard limits allowable bit jitter to ±10 per cent over a period equal to 10 times the word length. Tape transports cannot meet this requirement for any reasonable bit rate or word length—especially under environment. The BWC de-jittering buffer compensates for transport deficiencies and provides jitter free output. Send for BWC technical report 55-9401.

Solving instrumentation recorder problems through constant research is our vocation; building reliable magnetic tape recorders is our business. Tell us your recorder problems; we may have already solved them.

BWC means Built With Care

LETTERS

(continued from p. 54)

ence, the people who are sometimes "allowed" the titles of senior technician or, all too infrequently, junior engineer. For it takes craftsmanship, ability, ingenuity, inventiveness, stubbornness and, last but not least, fantastic pride in the job they do for these people to progress to any worthwhile level of recognition in this industry.

Let it be understood that I am by no stretch of the imagination attempting to suggest that the nondegreeed engineers should degrade the degreed engineers and scientists or usurp their positions. I ask merely that they be given their fair place in the sun. I am decrying the fact that too often are they stifled, that the inventiveness and craftsmanship that they may have had has been "schooled" out of them and replaced by a false notion that competence is "above them." Many times, too, the nondegree person has his desire to produce stamped out by his being hampered, overlooked, passed over whenever he tries to pursue his talents.

Thank goodness that there are those few left who, when told "no" or that they will never make it, set out to prove that they can and will, and do. These men have placed themselves among the leaders and giants of our industry and have earned their places.

W. B. Hollis
Chief Engineer
Miniquip, Inc.
Reno, Nev.

Readers split on federal auto safety measures

Sir:

I read with interest in your April 12 issue [ED 8, p. 36 ff.] the letters which criticized your stand on auto safety [ED 26, Dec. 20, 1965, p. 23]. I am as opposed to government controls per se as anyone, but I cannot in good conscience subscribe to a continuing policy of waiting for the auto industry to establish safety standards. It does not seem reasonable that an industry, which has not provided significant safety improvements until forced by legal action or the threat thereof for the past several years, should suddenly claim that government interest is unwarranted, that it will solve the existing safety problems by itself.

I was astonished to read the very positive comments to the effect that at least 90% of accidents are caused by human behavior. One gentleman even suggested that those who would support intervention haven't been reading the newspapers (he must be kidding). It is a bit optimistic to expect newspapers to blame accidents directly on cars. But how many reports of accidents have stated that "the car swerved suddenly," "the driver lost control" or some similar phrase, when there was no evidence of drunkenness, excess speed, etc?

I would expect engineers to take a more open-minded view of such matters. Persons interested in automobile safety should read Ralph Nader's much publicized book, Unsafe at Any Speed, and take notice of the accounts of manufacturers who call back cars for "minor adjustments," etc.

I have to agree that periodic auto inspections and vigorous law enforcement will help reduce the deaths and injuries caused by accidents, but before we rule out on principle the need for government intervention to guarantee safety standards, we had better make sure to know the facts—all the facts.

R. H. Zimmerman
Senior Engineer
Data Systems Div.
Litton Systems, Inc.
Van Nuys, Calif.
100 db single-step attenuation measurements

- to ±0.5 db accuracy
- down to -120 dbm
- at lowest cost for comparable specs

NOW... make attenuation measurements the direct and easy way. Use the new extended-capability PRD 915-A Microwave Receiver, which incorporates all the accuracy and advantages of parallel i-f substitution. The 915-A is a radiometric device with a signal sensitivity that greatly surpasses the standard superheterodyne receiver. It's a high-precision test instrument the average microwave measurement laboratory can afford.

- Measures attenuation from 10 Mc to above 40 Gc. Frequency range extended by new PRD Series 600 balanced mixers. □ Direct-reading, easy to use. No need for calibration curves or correction charts. □ Noise balance control for increased accuracy. □ Automatic range-switching for ease of operation. □ Adjustable reference oscillator allows faster measurements. □ Reference attenuator easily removed for calibration by NBS. □ For ultra-precision, NBS-designed and certified PRD 1904 Cutoff Attenuator provides digital readout to 0.001 db (interpolation to 0.0005 db). □ Price: PRD 915-A, $2,800. Immediate Delivery. □ Send for data.

1200 PROSPECT AVENUE, WESTBURY, L. I., N. Y. 11590

ON READER-SERVICE CARD CIRCLE 216

ELECTRONIC DESIGN, June 21, 1966
versatile switch...

for tight spots!

NEW G-E CR115 TYPE H LIMIT SWITCH OFFERED WITH SEVEN OPERATING HEADS FOR CRITICAL-SPACE, HIGH-SPEED JOBS

Space is tight, yet you need a solid limit switch to take the mechanical punishment of a repetitive, high-speed application. General Electric's new CR115 Type H limit switch is your answer. These solidly constructed switches (32 different enclosed forms in all) adapt to any job. Seven basic switch operators make it possible: (left to right above) roller plunger, roller lever, adjustable plunger, unidirectional roller lever, spring rod lever, plunger, and a palm operator for hand operation. A typical roller lever switch measures only 3 1/16 by 1 3/4 inches (a basic open switch form is even smaller). Side- and bottom-mounting further increases CR115 Type H versatility. Switches are available in general-purpose and oiltight enclosures, have heavy-duty pilot ratings: 15 amps, 480 volts maximum a-c; 0.25 amps, 250 volts maximum d-c. Your G-E Sales Engineer or Control Distributor can give you full details on these limit switches. Or write to General Electric Company, Section 811-66, Schenectady, N. Y. and ask for Pub. GEA-7312.
Progress Is Our Most Important Product

GENERAL ELECTRIC

ON READER-SERVICE CARD CIRCLE 236
mobility. The former could be regarded as a passive element in a physical sense, the latter as an active element in a lethal sense.

There can be no doubt at all that the safety of any device depends solely on the capabilities of its user and on the inherently designed-in protection that the device offers against accidental misuse.

What is so extraordinary and completely incomprehensible is the American public's obvious unwillingness to demand statistical information on road accidents, i.e.:

a) Physical condition of drivers involved (intoxicated, doped, sober, mentally or physically afflicted);
b) age, sex and occupation of drivers involved;
c) number of passengers in cars;
d) make of vehicle, type, model, year and size (weight);
e) condition of tires;
f) type of road on which the accident occurred;
g) condition of road, time of day;
h) cause of death (injuries);
i) state where accident occurred;
j) nature of legal action; and
k) nature of accident.

The data exist in every state and in the offices of the automobile accident insurance companies throughout the U.S. It is interesting to observe that, in spite of the recent hearings in Washington, D.C., and the avalanche of newspaper, magazine and TV editorials, such statistics were not compiled and offered to the public in general. There must be a pattern in this rising curve of fatal road accidents, a pattern that will pinpoint specific human and mechanical causes. In the case of human patterns, stricter enforcement of laws can and should be demanded.

It is fantastic to contemplate that in certain states a driver "under the influence" cannot be compelled by law to submit to a blood test unless involved in a fatal accident. In the case of mechanical patterns of defects in the road system itself or in the vehicle, Federal standards become inevitable. Here again, nobody ever bothered to associate low seating position with...
Hydro-Aire reports

Solutions to Interconnection Problems

Hydro-Aire reports

a 30% reduction in installed costs

with FLEXPRINT Circuitry

Hydro-Aire engineers turned to FLEXPRINT Circuitry instead of conventional wire for two reasons — reliability — economy.

Normally it takes at least 80 separate wires to interconnect three MS connectors and 5 printed circuit card connectors that go into a Hytrol aircraft anti-skid brake system. Now Sanders FLEXPRINT Circuitry replaces all this bulky hook-up harness, saves space and lowers the installed wiring cost of every unit by 30%.

Because FLEXPRINT Circuitry comes made to order, it assembles faster, eliminates rework time and increases reliability. There are no wires to cut, strip, tin, solder, color code or lace.

Whether your needs demand a simple circuit or sophisticated system incorporating many different components, Sanders can produce a FLEXPRINT Circuit that will make the whole package more economical. We’ve got the experience . . . we’ve produced more flexible printed circuits than anyone else in the business.

For detailed information on Sanders FLEXPRINT Circuitry, FLEXMAX flexible multilayer circuitry and INTRAMAX* multilayer hardboard, call your local Sanders representative or write Sanders Associates, Inc., FLEXPRINT Products Division, Nashua, New Hampshire 03060. Phone: 603-883-3321.

* T. M., Sanders Associates, Inc.
LETTERS

poor angle of sight, excessive glare and resultant fatigue symptoms.
Let us, therefore, clamor for these facts, let us demand the release of these statistics and let us have them now!

Fred R. Lesser
Electronic and electro-mechanical engineering representative
Bedford, Mass.

Sir:
I was reading your letters to the editor in the April 12, 1966, issue and came across Mr. Fleming's and Mr. Gitlin's efforts [ED 8, pp. 38 & 39] concerning federal control of auto safety.

I must say I cannot agree more with Mr. Fleming, who clearly stated the case against federal control of another industry. Mr. Gitlin, however, has my sympathy for having reached physical maturity yet having retained the naiveté of an adolescent. He says he thinks that it "is a possibility" that free enterprise will disappear, but that "checks and balances" will guarantee our systems.

Mr. Gitlin has obviously never heard of the insanity that is taking place every day in our courts. For example, General Motors was recently ordered not only to divest itself of a certain percentage of its bus business, but also to build a plant, sell it to a competitor and guarantee that the competitor would remain solvent. 'Nuff said on that point.

I have done considerable research into the relationship between faulty automobiles and accidents. It turns out that there is only a very slight correlation. As an example, Washington, D.C., has a strict, government-administered auto inspection system. It has an accident rate of approximately 1.0% due to mechanical failure. The state of Maryland up until recently had no inspection whatsoever, and the cries of its being "a dumping ground for D.C.'s derelicts" were insistently omnipresent. Maryland's accident rate attributable to mechanical failure is approximately 1.13%. This is a *reductio ad absurdum* and strengthens Mr. Fleming's argument that accidents are caused *almost entirely by bad driving*, not "unsafe cars."

Control is needed over automobile drivers, not automobile manufacturers. Perhaps some brilliant scientist or engineer interested in reducing the accident rate could devise tests that would accurately measure a potential driver's Immaturity Index instead of harassing the Big Three for making what their customers want. One simple way to keep any auto safe is to leave it in the garage. I have yet to hear of anyone killed by a speeding auto sitting at home.

As for the loss of free enterprise, I suggest that everyone who believes as Mr. Gitlin does should read *Atlas Shrugged* by Ayn Rand. Although I do not agree with everything she says, I feel her novel pointedly depicts what has happened and is happening here and now.

David Michael Myers
Systems Engineer
"Luftschloss"
Pomfret, Md.

Sir:
I would like to add my comment to those already expressed on your auto safety editorial. I want to answer the basic question raised by Mr. Donn [ED 5, Mar. 1, 1966, p. 32]: "Should the government 'play a part' in the economic affairs of our country?"

I agree with everything in Mr. Donn's letter, and I take exception to the fact that Mr. Gitlin would call me a "States' Rights man," if by states' rights he means that the state government should have the power to control *instead of* the Federal Government. As Mr. Donn points out, the purpose of a government in a free society is to "prevent the initiation of force." This applies to state as well as Federal government.

Mr. Gitlin thinks that "federal intervention, control, regulation, etc." will "maintain prosperity, a high standard of living . . ." and his other goals. Let us face reality, as he suggests. What is the source of prosperity and a high standard of living? Is it government regula-
IRC's low-cost METAL GLAZE® resistor for MIL-R-22684
NEW LOW-COST APPROACH
TO MIL-R-22684

- Uniform molded body
- Metal Glaze stability
- Power-safety factor

DIAMOND SPIRALLED METAL GLAZE ELEMENT
CERAMIC SUBSTRATE
HIGH CONDUCTIVITY PLATED-ON COPPER END CAP
HIGH TEMPERATURE SOLDERED TERMINATION
TIN-LEAD ELECTROPLATED COPPER LEADS
IRC, developer of the Metal Glaze resistance element, now offers a new, low-cost molded Metal Glaze resistor that meets or exceeds all of the tough performance and environmental requirements of MIL-R-22684. Value-engineered for optimum precision and reliability, it is the most economical MIL-R-22684 resistor available on the market today.

Load life stability is excellent. Resistance change is typically less than 0.5% after 1000 hours, 1/4-watt at 70°C. Four times better than MIL allowance. Even when subjected to high temperature operation, stability is well within the MIL requirement.

Its high performance is the direct result of IRC’s new thick-film Metal Glaze resistance element. 100 times thicker than conventional films, Metal Glaze resists catastrophic failure, withstands high temperatures and high overloads, and is impervious to environmental extremes.

A new, uniformly molded body makes automatic insertion fast and easy. Extremely rugged, it resists solvents, corrosion and the mechanical abuse of high-speed automatic machines.

With unmatched economy, this new IRC Metal Glaze resistor can upgrade circuit performance and reliability for an exceptionally wide range of applications.

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>MIL-R-22684B</th>
<th>IRC Type RG07</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESISTANCE TOLERANCES</strong></td>
<td>±2% and ±5%</td>
</tr>
<tr>
<td><strong>RESISTANCE RANGE</strong></td>
<td>51 ohms through 150K ohms</td>
</tr>
<tr>
<td><strong>POWER RATING</strong></td>
<td>1/4-watt at 70°C, derates to zero at 150°C</td>
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<tr>
<td><strong>MAXIMUM CONTINUOUS WORKING VOLTAGE</strong></td>
<td>250V</td>
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<tr>
<td><strong>DIELECTRIC WITHSTANDING VOLTAGE</strong></td>
<td>500V RMS at atmospheric pressure</td>
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<tr>
<td><strong>INSULATION RESISTANCE</strong></td>
<td>325V RMS at 3.4 inches of Mercury</td>
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<tr>
<td><strong>HOT SPOT SURFACE TEMPERATURE RISE AT RATED POWER</strong></td>
<td>10,000 megohms</td>
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<tr>
<td><strong>TERMINAL STRENGTH, 5 lb pull</strong></td>
<td>20°C</td>
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<tr>
<td><strong>EFFECTS OF SOLDERING</strong></td>
<td>dry</td>
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**PERFORMANCE TO MIL TEST**

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<tr>
<th>TEST</th>
<th>IRC METAL GLAZE PERFORMANCE (ΔR typically less than)</th>
<th>MIL-R-22684 (maximum ΔR)</th>
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<tbody>
<tr>
<td>TEMPERATURE COEFFICIENT, ppm/°C</td>
<td>±200</td>
<td>±200</td>
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<tr>
<td>LOAD LIFE</td>
<td>±0.5%</td>
<td>±2.0%</td>
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<tr>
<td>LOW TEMPERATURE OPERATION</td>
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<td>±0.5%</td>
</tr>
<tr>
<td>TEMPERATURE CYCLING</td>
<td>±0.2%</td>
<td>±1.0%</td>
</tr>
<tr>
<td>MOISTURE RESISTANCE</td>
<td>±1.0%</td>
<td>±1.5%</td>
</tr>
<tr>
<td>SHORT TIME OVERLOAD</td>
<td>±0.15%</td>
<td>±0.5%</td>
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<tr>
<td>TERMINAL STRENGTH, 5 lb pull</td>
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<td>±0.5%</td>
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<tr>
<td>EFFECTS OF SOLDERING</td>
<td>±0.15%</td>
<td>±0.5%</td>
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<td>SHOCK</td>
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</tr>
<tr>
<td>VIBRATION</td>
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**DIMENSIONS**

<table>
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<th>TYPE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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</thead>
<tbody>
<tr>
<td>RG07</td>
<td>.250 ± .015</td>
<td>.090 ± .008</td>
<td>.025 ± .001</td>
<td>1.50 ± .125</td>
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**STANDARD RESISTANCE VALUES**

(For 10 to 100 decade)

<table>
<thead>
<tr>
<th>RESISTANCE (in ohms)</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>22</td>
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tion, or is it men who have the ability to think, to produce a product, and to bring this product to a market where other men can buy it? Government regulation presupposes something to regulate. Can one imagine where the electronic industry would be if Edison hadn't invented the incandescent lamp, or if no one had then developed the diode and triode tubes? These inventions created an industry which has increased our prosperity and standard of living immeasurably. No amount of government regulation and intervention could possibly produce the wealth found in electronics today.

Mr. Gitlin "feels" that our elected officials would not do anything that would take our free-enterprise system away from us. Has Mr. Gitlin ever compared United States vs Aluminum Company of America, 1945, with the General Electric suit of 1961?

Alcoa held a monopoly in the field of primary aluminum by virtue of the fact that no one could compete with Alcoa's efficiency. What was Alcoa's reward for being the best in the industry? A lawsuit! Now look at the case of General Electric, Westinghouse, Allis-Chalmers, and the other smaller companies. They were charged with making secret agreements to fix prices and rig bids. If the large companies had not "conspired" with the smaller companies to fix prices, those smaller companies would not have been able to compete and would have been forced out of business. If this had happened, under the same Antitrust Act the large companies would have been charged with "intent to monopolize." The result of this trial: Seven men were sentenced to jail. Their crime: They produced Mr. Gitlin's toaster, refrigerator, electric stove, and generators to run them.

This is how our elected officials are protecting our free-enterprise system. What bureaucrat knows what is good for a business that he never created? By what right should he control a business whose success or failure would mean nothing to him? Should the government play a part? No! The government should control and prevent stealing, murder, graft and all other forms of coercive action by any individual or group against any other individual or group. I am not forced to buy any car, nor should I be forced to buy any particular accessories for that car. If I want to install any safety accessories I feel are necessary, that should be left to my own judgment, just as my choice of car is left to my own judgment. By wearing a seat belt, I will not save anyone's life but my own.

Robert L. White
Staff Assistant
Sandia Corp.
Albuquerque, N. M.

Sir:

As a general rule, I don't write letters either pro or con, but something in the April 12th issue must have struck a resonance. I like your editorials and I agree with them in general. In particular, I agree with the one on Auto Safety Legislation. It seems to me that there is really nothing that will induce the auto industry—a quasi-monopoly—to regulate itself. It hasn't happened yet and it is not likely to happen in the future without some sort of governmental regulation; and, if this regulation saves just one life a year, it would be worth it, to my way of thinking.

I would like, however, to disagree mildly with your editorial of April 12th: "Engineers are too often silent on major social issues" [ED 8, p. 43].

The letters to the editor in your publication only reinforce my opinion that there are more engineers who are narrow and conservative than liberal (broad-minded) and generous ones. I feel that if engineers as a group became socially and politically active—which, thank goodness, they are not, being busy with mechanical things—we would make social and political "progress" in a negative direction. Solutions to social problems require open-mindedness and generosity whereas engineers are trained to be conservative, economical and efficient.

Vladimir Kenn
11 College Road
Burlington, Mass.
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Varicap is the trademark of silicon voltage-variable capacitors manufactured by TRW Semiconductors Inc.
Training for tomorrow's jobs must begin today.

The electronic industry depends on workers of a wide variety of skills; yet the training of workers is usually a hit-and-miss affair that is done on the job. In fact, many electronic firms simply do not hire workers who haven't been previously trained.

How often one hears remarks like: "We just can't find any technicians or skilled machinists," at times like these when the industry is going full steam ahead. Investigation, however, generally reveals that despite this shortage problem the company is making no effort to break in any newcomer to the field.

But things don't have to be this way. There are in our industry a few companies where a "let's do something about it" attitude is paying rich dividends.*

Take Frank Burley, for example. Frank is the engineering superintendent of the Western Electric Co. plant in Indianapolis. To stem the tide of high-school drop-outs (Indianapolis had a rate of 35%) a General Advisory Committee for Vocational and Practical Arts Education was formed with Frank as chairman for 1963-1965.

Counselors were selected from various industries in the city; among them were several from Western Electric's engineering sections—designers, engineers, engineering associates, a department chief and a section head. These volunteers held semi-monthly sessions during school hours with groups of eight to 20 students selected by local high-school teachers. Instructors would give half-hour talks and then spend a further hour discussing types of jobs in industry, salary levels for graduates and nongraduates, and questions brought up by the youngsters.

It's impossible to assess how many students were kept at school as a result of the program. But the fact that the program is being expanded testifies to its success.

Sperry Gyroscope Co. of Great Neck, N. Y., in 1962 instituted a training program in co-operation with the local school system. Company employees and local residents can take 15-session courses, taught by Sperry personnel, in such subjects as basic electronics, transistor theory and applications, basic electro-optics and the use of digital computer equipment. Students who successfully complete a course have their tuition reimbursed by the company.

These are isolated examples, but they illustrate what can be achieved. Our growing industry will need more and more well-trained workers to meet its labor demands. It's up to every engineer and every firm to do all they can to ensure that these demands can be met.

*Details of the case histories cited here and others are available from STEP (Solutions to Employment Problems), National Association of Manufacturers, 277 Park Avenue, New York, N. Y. 10017.
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"A" Pkg.—1.5 x 1.5 x 0.4 inches, "B" Pkg.—1.8 x 1.2 x 0.6 inches, No Letter—1-1/8 x 1-1/8 x 5/8 inches. For complete specifications write for catalog listing the entire line of operational amplifiers available from UCE.
Threshold logic using tunnel diodes can serve to generate parity in a digital system. The circuitry is simple and straightforward and cuts hardware requirements. Page 70

Author shows how nonlinear techniques produce a linear relationship in a feedback amplifier. Page 76

Low-frequency amplifier circuits employ FETs like the one above. Page 86

Also in this section:

- Replace expensive coils with pulse transformers in phase-lock detectors . . . page 82
- Differentiator noise is no problem at low frequency . . . page 92
- Cure force-transducer inaccuracy in error-signal detection . . . page 98
- Ideas for design . . . pages 102 to 110
Neurons generate parity in simple and inexpensive systems. The circuits are designed with threshold logic and use tunnel diodes.

By generating parity with threshold logic, the designer of a digital system can simplify his design and cut his hardware costs. The threshold logic is incorporated into neuron circuits that are built with tunnel diodes.

Parity is used as a machine self-check. A digital word is assigned a parity bit that is either zero or one, depending on whether the number of ones in the digital word is odd or even.

To appreciate the simplicity of threshold logic, consider the circuitry required to generate parity for a six-bit word with conventional techniques. Conventional parity generation would require many AND gates and one OR gate. Or, by separating the word into two groups of three bits each, six AND gates and a single half-adder could be used. In addition to these circuits, the complement of each bit is needed, calling for additional hardware.

By contrast, parity for a six-bit word can be generated with threshold logic in the relatively simple circuit shown in Fig. 1.

The circuit effectively counts the number of ones in the input digital word. If it contains an even number of ones, the output of the divide-by-two circuit becomes a logical 1, and for an odd number of ones, the output becomes zero. This counting and indicating operation requires the transformation of the input digital word into a serial chain of ones. The circuits A through F, called neurons, A tunnel-diode bistable version of such a circuit is shown in Fig. 3. The choice of tunnel diodes is purely discretionary. Backward diodes may do equally well. In general, the higher peak-current devices are recommended in a noisy environment, because of their stability. In Fig. 1 a 5-mA peak current device is suitable.

Let’s see how the neurons generate the proper parity bit. Assume that there is an input at $t=t_0$, of the form $101101$. This digital word sets neurons A, C, D and F to the high state and leaves B and E in the low state.

All neurons in the high state will provide outputs for the OR gates at $t=t_0$, resulting in a one output pulse from T. This sets the $\div \, 2$ into the high state, making S a logical 1.

The next pulse will arrive at the input of T, at $t=t_{50}$, from neuron B, since B is switched to the high state by A after 50 ns. The pulse from B, through T, sets the $\div \, 2$ into the low state, changing S to zero. The last pulse for the input digital word comes from E, at $t=t_{200}$, since D propagates to E in 200 ns. This pulse resets the $\div \, 2$ into the high state, making S again a logical 1. Note that even though C propagates to D in 150 ns, D is in the refractory period at $t_{50}$ and not capable of switching and providing an output. Hence, T has three output pulses, at $t_{t_0}$, $t_{50}$ and $t_{200}$ (Fig. 2).

To sum up the operating sequence, we can consider the serial interpretation of the digital word.

The neuristor concept is put into practice in

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Carl A. Budde, Member, Technical Staff, Electronic Specialty Co., Los Angeles.
clude that: The pulse generated at \( t_0 \) sets the \( \pm 2 \) into the high state; the pulse at \( t_{50} \) resets \( \pm 2 \) to the low state, and the pulse generated at \( t_{200} \) sets \( \pm 2 \) back to the high state.

The final output of \( S \) is the parity bit. In this example we end with a logical one, representing an even number of ones in the digital input.

**Why use three OR gates?**

The gates \( I, J \) and \( T \) are monostable circuits, triggered by the outputs of \( A \) through \( F \).

The OR gate \( T \) in Fig. 1 is sufficient to insure operation. However, because the peak current of the tunnel diodes in the circuits is a function of temperature, the tolerances on the input currents can become critical when too many inputs are converging into a single junction. To ease tolerance requirements, OR gates \( I \) and \( J \) should also be added. The result is reduced fan-in to OR gate \( T \) and increased reliability over the temperature range of \(-20\) to \(+75^\circ\text{C}\).

The design of the bistable neurons involves only straightforward circuit analysis. Fig. 3 illustrates a typical circuit.

When the input current to \( TD_1 \) plus the bias current (supplied by \( R_1 \) and \( V_a \)) exceeds the peak current, \( TD_1 \) switches to the high state (\( V_F \) in Fig. 4) and generates an output. The dc component is coupled out by \( TR_1, L_1 \) and \( R_1 \), while the ac component to the OR gates is taken from the junction of \( C_1 \) and \( R_3 \) through \( TR_2 \).

\[
R_1 = \frac{V_a - V_1}{I_b},
\]

where \( I_b = 0.8 I_p \), and \( V_1 \) is the voltage at \( I_b \) (see Fig. 4). Let \( (V_a - V_1)/R_1 + (V_n - V_I)/R_2 \) exceed \( I_p \) by 10\%. Then:

\[
R_2 = \frac{V_a - V_1}{0.1 I_p + I_b}.
\]

Assume that the tunnel diodes are matched to within \( \pm 5\% \) of the peak current. The current changes about \( \pm 5\% \) over the temperature range, and so does the forward voltage. The total variation in the operating point is therefore about 15\%.

The fact that \( I_b \) is equal to 0.8 \( I_p \) allows for a 5\% safety margin. Having the input current exceed \( I_p \) by 10\% is a good derating factor.

The amount of current, transferred to the load, must exceed \( I_p \) by 10\%, where the load, \( R_L \), is \( V_1/I_b \) and \( I_b \) is equal to \((0.1 I_p + I_b) - I_b \). If the voltage drop \( (V_{TR}) \) is about 100 mV across the tunnel rectifier, \( TR_1 \), at the current level \( I_b \), then:

\[
R_4 = \frac{V_2 - V_{TR}}{I_1} - R_L
\]

After \( R_4 \) has been calculated, and since \( R_L \) is given, the selection of \( L_1 \) is given by the approximation \( \tau (R_4 + R_L) \) where \( \tau \) is the chosen interneuron delay.

The delay in the current rise through the inductor, \( L_1 \), in Fig. 3 is given by:

\[
\tau = \frac{T}{ln \left[ 1 - \frac{I_p - I_b}{I_p} \right]}
\]

3. **Basic neuron circuit** is used in propagating chain and in circuits that couple to OR gates.

4. **Dynamic and static load lines**, voltages and currents of neuron circuits are valid for tunnel-diode types.
5. **Monopulsing OR gate** uses tunnel diodes (a). The dynamic load line (b) results from the clamping action of the rectifier TR1. The output pulse width depends on the inductance of L1.

6. **Divide-by-two circuit** isolates the input and output. It operates at a rate that is the inverse of the minimum delay period.

7. The equivalent circuit of the tunnel-diode and differentiating circuit, C1, R1, in Fig. 5. It helps to find the charging time constant and parameter values.

**OR gates are triggered by neurons**

The monopulsing OR gates, J and I, are also built with tunnel diodes (Fig. 5).

Here again \( I_b = 0.8 \) \( I_p \) and \( I_p = (0.1 \ I_p + I_f) - I_b \), or \( 0.8 \ I_p \). The voltage \( V_2 \) is chosen to be \( 1/2 \ (V_F + V_p) \). \( V_p = V_2 - V_{TR} \), where \( V_{TR} \) is the voltage drop across the tunnel rectifier, \( TR_1 \), at a current level of \( I_b = I_v \).

When an input switches \( TD_1 \) of an OR gate to the high state \( (V_F) \), the current through the inductor \( L_1 \) will start to decay, since \( V_b + V_{TR} < V_F \). When it has decayed to a point below \( I_v \), the valley current, \( TD_1 \) will switch off (Fig. 5b). The inductance \( L_1 \) determines pulse width at the output of the OR gate.

The value of \( L_1 \) may be solved by the simple approximation:

\[
L_1 = \frac{\tau_w}{C TR (I_b - I_v)}
\]  

(5)

where \( \tau_w \) is the pulse width at the output of the OR gate. The recovery time of the OR gate is:

\[
t_r = \frac{L_1}{R_T} \ln \left[ \frac{V_3 - R_T I_r}{V_3 - R_T I_p} \right],
\]  

(6)

where

\[
R_T = \frac{V_2}{I_b} + \frac{V_{TR}}{I_b - I_v}.
\]

The pulse width plus the recovery time \( \tau_w + t_r \) must be less than the minimum delay period. A good rule of thumb is that the recovery period will be 3.5 times the pulse width.

**Divide-by-two circuit must be last**

The last circuit to consider is the divide-by-two. It must be capable of operating at an input rate equivalent to the inverse of the minimum delay period. For example, if \( A \) propagates to \( B \) when \( B \) is in a nonrefractory mode, the \( +2 \) will be triggered twice in 50 ns, or whatever the minimum delay happens to be.

To isolate the input and output, and to avoid the introduction of tight design requirements or additional loading, the circuit in Fig. 6 is recommended. The biasing for this circuit is the same as for the neuron.

The transistor in the \( +2 \) circuit must have a \( V_{BE} \) of less than \( V_F \) of the tunnel diode, which is approximately 450 mV. Therefore a germanium transistor is chosen \( (V_{BE} \approx 350 \) mV). For satisfactory operation, it should have an \( f_j \) about 10 times the reciprocal of the minimum delay period.

The output of OR gate \( T \) is differentiated by
8. Combination of static characteristics of the tunnel diode and the transistor in Fig. 5 yields the operating curve.

$C_1 R_1$ and coupled to $TD_1$ in the $\pm 2$ circuit. The leading edge of the pulse supplies a current ($0.1 I_p + I_p$) to $TD_1$. The positive-going pulse differentiated by $C_1 R_1$ switches $TD_1$ to the high state. Before a significant amount of bias current can be diverted to the transistor through $L_1$, the trailing edge of the input pulse will have terminated. Therefore $TD_1$ will remain in the high state. Since a large portion of bias current is being supplied to $Q_1$ (Fig. 6), the trailing edge of the next differentiated positive-going input pulse will turn off $TD_1$.

The value of $R_2$ is given by:

$$R_2 = \frac{V_a - V_i}{0.8 I_p} \quad (7)$$

The equivalent model of the tunnel diode and the differentiating network in Fig. 7 is useful to determine the values of $C_1$ and $R_1$ that satisfy the input current requirement.

Equivalent circuit helps find time constants

For simplification, $-r$ may be neglected, and $R_g$ and $R_s$ can be assumed to be identical:

$$R_g = R_s = \frac{V_p}{I_p}$$

The charging time constant for the tunnel diode and the differentiating circuit in the $\pm 2$ stage becomes:

$$t_c = R_s (R_s + R'_s) C_1 C_j \frac{R_c}{R_s + R'_s + R_c} C_1 + C_j \quad (8)$$

where

$$R'_s = \frac{V_i}{I_b}.$$

Assume that $C_j < C_1$ and $R'_s < R_1$. Then the voltage developed at point $A$ (Fig. 7) will be about $V_p/2$, if the charging time constant is short compared with the rise time of the OR gate’s output pulse. This voltage, $V_a$, divided by $R_s + R_c$, should be about equal to $I_1$.

When $TD_1$ is in the high state, its equivalent impedance is equal to $R_s$ (or $R_p$). The voltage developed at point $A$ when the OR gate is turned off will be approximately $2/3 V_p$, provided $R_1 = R_s = R_p$.

When $TD_1$ is switched to the high state, current is diverted from $TD_1$ through $L_1$ to $Q_1$. The output level goes from the peak voltage ($V_p$) to a point $a$ in Fig. 8, then slides down the composite curve and comes to rest at point $b$. (The reason for the composite is that $V_{BE}$ of the transistor is less than $V_p$ of the tunnel diode.)

The current decreases through $TD_1$ at the following rate:

$$I_d(t) = I_b [1 - e^{-t/t_d}], \quad (9)$$

where

$$t_d = \frac{L_1}{1 + \frac{h_{ie} h_{re} - h_{fe} (1 + h_{fe})}{h_{ie} + h_{re} + Y_1 (1 + h_{fe}) h_{fe}}} \quad (10)$$

or,

$$t_d = L_1 (\frac{V_{eb}}{I_e}).$$

If the current’s rate of change in $L_1$ (or away from $TD_1$) is greater than the pulse width from the OR gate $T$, the trailing edge of the pulse will turn $TD_1$ back off. Therefore let $t_d = 1/3 t_{(min)}$, where $t_{(min)}$ is the minimum delay period.

The inductance in the $\pm 2$ circuit is

$$L_1 = t_{(min)} \frac{V_{eb}}{I_e},$$

if $I_e = I_b - I_v$.

The load resistor, $R_3$, of $Q_1$, is

$$R_3 = \frac{-V_d}{a I_{c1} - \frac{\alpha}{1 + \beta}}, \quad (12)$$

The emitter resistor of $Q_2$ is

$$R_e = \frac{-V_d + V_{be}}{2 I_{c2}}, \quad (13)$$

and the collector load is

$$R_4 = \frac{V_a - V_{CE(sat)}}{I_C}. \quad (14)$$

The above equations completely determine the $\pm 2$ circuit. ■

References:


Electronics Design, June 21, 1966
Reduce system costs with TI

TI linear integrated circuits mean fewer system components, less assembly and test time, increased manufacturing efficiency. In short — reduced system costs. Now you get improved performance and increased reliability, too, in such circuits as the Series 75 and Series 72 amplifiers described here.

Series 75 magnetic-core sense amplifiers

Each of these new amplifiers for magnetic core memories replaces a whole circuit board of transistors and passive components. The SN7501 circuit shown in Figure 1, for example, contains 18 transistors, 25 resistors, four diodes and one capacitor in a single tiny chip of silicon. Cost is only about 80 percent of a comparable discrete-components circuit. Soldered connections are reduced by more than 90 percent — resulting in greatly improved reliability.

Performance is excellent, as shown in Figure 2. Series 75 sense amplifiers are recommended for core memory applications with cycle time as low as 0.7 µsec.

The SN7500 is a complete monolithic sense amplifier that includes both strobe gate and pulse-shaping output circuits as shown in Figure 3. It detects low-level bipolar differential input signals, discriminates between those representing logical “1” and logical “0”, and converts them to logic levels compatible with standard integrated circuit logic, including TI’s Series 54 TTL.

The amplitude-discriminating sense amplifier incorporates a threshold circuit with a narrow region of uncertainty. A strobe input is provided so the threshold detector can be activated when the signal-to-noise ratio is at maximum during the system read cycle, and is inhibited during the write cycle.

The SN7501 performs a similar sense amplifier function, but also includes an externally adjustable threshold voltage and a flip-flop output. Since the flip-flop is externally set at zero, the output pulse width can be accurately controlled. The flip-flop can be used for temporary data storage.

The SN7502 sense amplifier includes an internal one-shot multivibrator, providing a negative-going output pulse when triggered by the threshold detector. The single-ended output lends itself readily to performing DOT-OR logic.
linear integrated circuits

Series 75 circuits are available in the standard TO-84 flat pack, or the transistor-type TO-100 package shown in Figure 6. The SN7500 is also available in a military version (SN5500) for operation in environments of -55°C to +125°C. Severe temperature versions of the SN7501 and SN7502 are also available.

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Series 72 high-performance differential/operational amplifiers

Now you can get both discrete-component performance and integrated circuit reliability in differential/operational amplifiers from Texas Instruments. Figure 7 shows that performance of SN725 and SN726 integrated circuits are comparable to discrete-component amplifiers.

The SN725 differential amplifier features an open-loop gain of 88 dB, yet it is unconditionally stable when used with two external capacitors in the frequency-response-shaping network.

The SN726 high-performance operational amplifier features a class-B output stage to give a 10 V swing with a 600-ohm load. A Darlington-connected transistor pair gives an extremely high input impedance.

In both circuits, transistor pairs are close together for improved differential-input voltage offsets and temperature-drift characteristics. Improved collector saturation resistance provides high output current and voltage capability. Both amplifiers allow ±5 V common-mode input signals before overloading, and there is no danger of latch-up from noise or output feedback.

For less demanding applications, the SN723 differential amplifier or SN724 operational amplifier may be used at a considerable saving in cost.

TI differential and operational amplifiers are available for two temperature ranges. Series 72 is recommended for 0°C to +70°C, while Series 52 covers the full military range of -55°C to +125°C.

Circle 26 on Reader Service card for more information on Series 72 and 52 integrated circuits.

Choice of Packages

TI linear integrated circuits are available in either of the package types shown in Figure 6 — The time-proven TO-89 flat pack or the transistor-type TO-100 package. Both packages feature hermetic seals for high reliability in severe environments.
Nonlinear design yields linearity—
a Zener-switching, nonlinear feedback amplifier gives a linear relationship between output power and input voltage.

Try using nonlinear techniques to obtain a linear relationship between load power and dc voltage input signal. When Zener diodes are used as switches in the nonlinear feedback loop, this method becomes especially attractive because of its simplicity and low cost.

Linearity can be achieved with nonlinear amplifiers in both ac and dc systems. The method consists of employing a number of linear load-line elements to fit a specified nonlinear curve or transfer characteristic.

Lining up the linear requirements

To test the practicality of this approach, a nonlinear feedback amplifier was designed to provide a linear relationship between the power delivered to a resistive load and the dc voltage input to the amplifier.

Figure 1 shows the desired relationship between the output power and input voltage. Since the amplifier had to deliver power to a resistive load, the output voltage for a given input voltage was calculated as follows:

\[ P_{out} = kV_{in} \] (1)
\[ \frac{V_{out}}{R} = kV_{in} \] (2)
\[ V_{out} = \sqrt{kRV_{in}} \] (3)

where \( k \) in watts per volt is the slope of the power-voltage characteristic.

Equation 3 completely specifies the relationship between all values of input and output voltage for the range in question. The technique of linear approximation was applied to the input-output voltage characteristics (Fig. 2) of the amplifier function specified by Eq. 3. Four approximations were found to be more than adequate to meet the design specifications. The values of the closed loop amplifier gain were:

\[ A_1 = \frac{V_{02} - V_{01}}{V_{in2} - V_{in1}} \] (4a)

\[ A_2 = \frac{V_{03} - V_{02}}{V_{in3} - V_{in2}} \] (4b)

\[ A_3 = \frac{V_{04} - V_{03}}{V_{in4} - V_{in3}} \] (4c)

\[ A_4 = \frac{V_{05} - V_{04}}{V_{in5} - V_{in4}} \] (4d)

The change in closed-loop amplifier gain was accomplished by using Zener diodes in the feedback loop to step up the amount of feedback as output voltage increased. The simplified amplifier configuration is shown in Fig. 3a. The complete nonlinear amplifier appears in Fig. 3b. Note that the forward loop of the amplifier is dc-stabilized.

Outlining role of Zener elements

The Zener diode used in the feedback loop had to have a sharp knee to eliminate the effects of a varying Zener resistance as the diode was brought into conduction. This variation of Zener resistance would lead to distortion in the closed-loop characteristic of the amplifier and, in fact, is an indeterminate quantity that varies not only from unit to unit.

Achieve linearity via nonlinear amplification. Author Litwak shows how to go about it.

M. Litwak, senior associate engineer, Systems Development Div., IBM, Poughkeepsie, N. Y. (A portion of the work described in this article was conducted while Mr. Litwak was with General Precision Co., Inc., of Little Falls, N. J.)
unit but also with temperature. By using a “passivated” Zener diode with the characteristic that a maximum of 50 nA would flow through the diode at 80 percent of its Zener voltage—the diode can be considered to have only two states: conduction and non-conduction.

Since the Zener resistance in the conducting state is negligible in comparison with its associated series resistance, and since the Zener can be considered an open circuit in the non-conducting state, the diode can be regarded as an ideal switch.

The Zener voltage is calculated to be the difference between the breakpoint voltage \( V_{b} \) and the voltage at the emitter, \( V_{e} \). The feedback resistors can now be calculated by application of standard feedback techniques and use of the following formulae:

\[
A_i = \frac{A_o}{1 - A_o B_i},
\]

\[
A_2 = \frac{A_o}{1 - A_o B_2},
\]

\[
A_3 = \frac{A_o}{1 - A_o B_3},
\]

\[
A_4 = \frac{A_o}{1 - A_o B_4}.
\]

In Eqs. 5a-5d, \( B \) is a voltage-divider term given by:

\[
B_i = \frac{R_e}{R_e + R_i},
\]

\[
B_2 = \frac{R_e}{R_e + R_2},
\]

1. **Voltage-power characteristics**, although linear, are met by a nonlinear feedback amplifier that uses Zener diodes in the feedback loop.

2. **Output voltage vs input voltage** relationship is actually a sum of linear approximations.

3. **Nonlinear feedback amplifier** uses Zener diode switches in the feedback path (a). Complete amplifier (b) has 2% linearity over the range \(-55^\circ C \text{ to } +125^\circ C\) and delivers up to 20 W to a resistive load.
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4. **Nonlinear gain characteristics** in an ac system can be achieved with the nonlinear dc amplifier. The dc type is employed as a stage between the demodulator and modulator circuits in this ac cascade.

\[
B_3 = \frac{R_E}{R_E + R_1//R_2//R_3},
\]

\[
B_4 = \frac{R_E}{R_E + R_1//R_2//R_3//R_4},
\]

and \( A_0 \) is the open-loop gain. Use of standard linear amplifier techniques will guarantee ac stability for all values of feedback.

The nonlinear amplifier, as described, operated within an accuracy and linearity of 2% over the temperature range -55°C to +125°C. The amplifier is capable of delivering from 1 to 20 watts linearly to the resistive load.

**Design technique offers flexibility**

The advantage of this design technique is that it can be used whenever a monotonically decreasing gain function is desired. The over-all characteristics of the amplifier must be dc for the Zener diodes to switch at the appropriate levels. The internal section of the dc amplifier, however, can be a compensated dc amplifier, a differential amplifier, a chopper-stabilized amplifier, a modulator-demodulator amplifier, or any other configuration that is innately dc-stable.

A nonlinear ac gain can be achieved if the over-all ac gain characteristics are considered to be the product of individual gains, with one of these gains resulting from the nonlinear dc amplifier already described. The over-all amplifier, therefore, would consist of a cascade of stages that would include an ac amplifier, the nonlinear amplifier and a combination demodulator (signal-detector) and modulator for ac-dc compatibility (Fig. 4). It may prove unnecessary in some cases to include two ac amplifiers, since the over-all ac gain may be produced in the dc amplifier alone.

The precise duplication of the desired nonlinear characteristic is a direct function of the number of linear approximation segments used, with each new breakpoint requiring a resistor and a Zener.

Although the amplifier in Fig. 3a is a series voltage-feedback type, the desired nonlinear characteristics can also be achieved by any other feedback amplifier technique in which the feedback element is made a function of the output voltage.
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Electronic Design, June 21, 1966
Replace expensive coils with pulse transformers in phase-lock detectors that operate to 20 MHz. The change will also simplify circuitry.

A pulse transformer, instead of a specially wound high-frequency coil, is the key feature of a design for a phase-lock detector operating up to 20 MHz. This design is simple and inexpensive but still maintains required sensitivity. The detector (Fig. 1) can work with 40-nV signals at a signal-to-noise ratio of 6 dB.

The problem of precise detection of a null condition is fairly common. The accuracy of data obtained from experiments involving balanced resistance or inductance bridges, for instance, is directly dependent on the sensitivity of the null detector. Large line-frequency and/or quadrature signals will often interfere with determination of the null point. The designer has to provide a device which possesses a low noise figure, good line-frequency rejection, and the ability to reject a signal in quadrature with the desired signal. Such a device, known variously as a phase-lock detector, lock-in detector, or phase-sensitive amplifier, consists of a low-noise amplifier and a phase-discriminator circuit.

The design concept is applicable for operation at frequencies in the range from a few cycles to about 20 MHz.

For phase detection, low capacitive coupling

A phase discriminator locks onto a signal having a particular phase and produces a stable dc output proportional to the desired input signal. Signals whose phase differs from that of the phase-locked signal are attenuated according to the amount of phase difference. An external reference voltage determines the phase to be passed.

Design of such a circuit for operation at low frequencies involves no special considerations, but operation in the megahertz range requires careful evaluation of the transformers.

The two major points are:
- The self-resonant frequency of the secondary windings must be well above the operating frequency to prevent instability of the dc output.
- Low capacitive coupling from primary to secondary is essential to prevent unbalanced voltages at the secondary.

These requirements are usually fulfilled with specially wound coils, but commercially available pulse transformers are quite capable of handling them at high frequencies (Fig. 2). Ferrite-core pulse transformers have low capacitive coupling, but there is no well-defined way to find the best transformer—only experiments can help the designer here.

Input noise limits amplifier

The low-frequency narrow-band amplifier (Fig. 3) has a circuit Q of 400 with simple RC frequency-selective circuits. Its center frequency is at 400 Hz. The operating principle is useful for low-frequency detectors.

The ultimate sensitivity of a low-noise amplifier depends upon the noise generated at the input terminals. The smallest conceivable value of input noise is that attributable to the thermal noise of the source resistance. The input noise can be minimized by judicious choice of the input tube and the operating point.

The equivalent noise resistance of a vacuum tube is directly proportional to the plate voltage and inversely proportional to the plate current, owing to the dependence of noise on $g_m$. The input

Wayne A. Rhinehart and Louis Mourlam, Jr., Associate Engineers, Institute of Atomic Research, Iowa State University, Ames.

1. Internal view of a 2-MHz phase-lock detector, designed with a commercially available pulse transformer. The null detector picks up signals as low as 40 nV, with a signal-to-noise ratio of 6 dB.
2. **Pulse transformers** replace special high-frequency coils in phase-lock detectors operating at 2 MHz. Their low capacitive coupling from the primary to the secondary side makes the change possible.

The tube should have high transconductance and low microphonics.

The operating point must be carefully selected. It isn't always practical to operate at zero bias for high plate current, nor in general at low plate voltage. Though operation at zero bias yields least noise, it also results in the lowest input impedance. Low plate voltage results in undesirable low gain in the input stage which may render the noise of succeeding stages significant.

Since narrow bandwidth is a primary design requirement, any practical circuit should include high-Q, frequency-selective filters. In the frequency range of a few Hz to 20 kHz, parallel-T filters, arranged in a negative feedback configuration, have proved satisfactory. The value of $R_{IN}$ can be chosen to fit the input impedance requirements of the particular application. It is extremely important that the parallel-T filter be loaded as little as possible. To get maximum circuit Q, the grid resistor should be larger than 1 MΩ, since the loading of the parallel-T filter broadens its bandwidth. Two of these loops cascaded provide a gain of approximately one million.

The nuvistor was chosen for the input stage because of its low noise and low microphonics. The parallel arrangement of the nuvistors yields better rejection of 60-Hz signals and narrower bandwidth than the often-used cascode configuration.

The circuit in Fig. 3 can be used for frequencies above 20 kHz, if a tuned circuit more suitable to those frequencies—such as a bridged-T LC circuit—is substituted. A simpler configuration for higher frequencies is the standard plate-tuned amplifier.

### Output does not depend on reference

The general expression for the dc output voltage of the phase-discriminator circuit is:

$$V_o = k \left[ E_r \sin \left( \tan^{-1} \frac{-E_s/E_s + \phi}{E_s + \sin\phi} \right) \right.\left. -E_s \sin \left( \tan^{-1} \frac{-E_r/E_s + \phi}{E_s + \sin\phi} \right) - E_s \sin \left( \tan^{-1} \frac{-E_r/E_s + \phi}{E_s + \sin\phi} \right) \right]$$

where

- $K$ = detection coefficient, to account for losses in the detector
- $E_r$ = peak signal voltage
- $E_s$ = peak reference voltage
- $\phi$ = phase difference between signal and reference.

The expression shows that the dc output voltage is a function of the reference voltage as well as the signal voltage. This is undesirable since the output should be related only to the signal input. To solve

3. **Low-noise, narrow-band amplifiers** in detector use nuvistors in the input stages. The circuit may be used at 2 MHz if proper tuning circuits are used, for example, a bridged-T LC circuit.
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4. The output voltage is a function of the phase difference between the incoming and the reference signals (color). It also depends on the ratio of the two signals' frequencies.

5. A 400-Hz detector, designed with conventional components, has a 1-Hz bandwidth and a 60-Hz rejection of 100 dB. The least detectable signal is 60 nV with a signal to noise ratio of 6 dB.

this, make the reference voltage amplitude large with respect to the signal voltage amplitude. The expression for $V_o$ then becomes:

$$V_o \approx K \left[ 2E_s \sin \left( \frac{E_r}{E_s} \cos \phi / \sin \phi \right) + \phi \right]$$

A voltage ratio of ten or greater is normally sufficient. The output voltage ($V_o$) vs the phase difference and the signal-reference frequency ratio is shown in Fig. 4.

The low-pass filter across the detector output allows a compromise between response time and bandwidth, depending on the application.

A practical circuit, using a plate-tuned amplifier and the high-frequency discriminator, provides a complete phase-lock detector for operation at 2 MHz. The unit has been used to record weak signals from a pick-up coil in experiments for determining the magnetic susceptibility of metals. The circuit has a maximum center frequency gain of 1 million and a 60-Hz rejection of 120 dB. The smallest detectable signal is 40 nV with a signal to noise ratio of 6 dB.

The design principle of the low-frequency phase detector (Fig. 5) is similar to that of the high-frequency type. It has been used as a 5% ac microvoltmeter in low-temperature specific heat tests.

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Part 3 of a three-part article

Low-frequency FET amplifier circuits—as opposed to general-purpose and higher-frequency types—have a design procedure all their own. To establish the circuit requirements quickly and easily, design prescriptions have been developed on the basis of the governing parameters for these applications.

This parameter analysis will bring out the suitability of FET devices for these amplifiers. It will also distinguish those characteristics of major importance from those which apply to the devices in general and/or to other applications.

The study of FET amplifiers concludes* with the differential and single-ended (both conventional and low-drift) types. These applications are characterized by operation at lower frequencies (including dc)—usually 1 kHz or below.

Refer to the appendix at the end of this article for definitions of the FET terms used and how they are measured.

Pairing FETs for differential amplifiers

Two differential amplifiers using FETs appear in Fig. 1. Circuit (a) is a pair of matched source-followers used for impedance match purposes only. The circuit in (b) is a true source-coupled differential amplifier which provides voltage gain. In either circuit, one gate (for example, that of Q2) may be grounded for a single-ended input. In (a), the FET with grounded input is then required merely to compensate for temperature drift of the other.

In (b), the FET with the grounded input continues to act as an amplifier, but it must also exhibit equal drift with temperature. For good linearity, the transconductance of the two FETs should be nearly equal at the operating point. If the gate-to-source voltages of the two FETs (offset voltage) were identical at equal drain currents, $R_s$ would not be needed in either case. Since this condition is rarely met, $R_s$ is often included in the circuit to equalize the $V_{gs}$ of the FETs when a zero offset is required.

Important circuit parameters in the selection of differential FET pairs (operation at dc or low frequency is assumed) are:

- $|V_{gs1} - V_{gs2}|$ — Offset.
- $|V_{gs1} - V_{gs2}|/\Delta T$ — Drift.
- $|I_{o1} - I_{o2}|$ — Differential gate current.
- $g_{fs1}/g_{fs2}$ — Transconductance match at operating point.

It is to the user's advantage if all matching characteristics are specified under recommended operating conditions. The subscript notation "x" in $g_{fsx}$ may be used to denote biasing conditions other than at $V_{gs} = 0$. Specifications for differential amplifiers are generally given for a particular $V_{dd}$ and $I_d$ recommended for general use. Often, the $g_{fs}$ match is specified only at $V_{gs} = 0$. This does not necessarily ensure a match under operating conditions.

However, if $g_{fs}$ at $V_{gs} = 0$ and $I_d = I_{oss}$ are both well matched, the chances for a $g_{fs}$ match at $I_d < I_{oss}$ are very good. In fact, the match under operating conditions may be substantially better than at $V_{gs} = 0$. It is reasonable to operate at other voltages and at lower $I_d$ than those specified. However, operation at higher $I_d$ may cause forward biasing of the gate-source junction in order to maintain a set $I_d$ at the highest operating temperatures. That is, $V_{gs}$ may approach zero and invert. This possibility is most likely in

*See Parts 1 and 2 ED 13, May 24, p. 38 ff., and ED 14, June 7, p. 40 ff.) for details of the other FET amplifier categories—general-purpose, low-noise and high-frequency. Also, see ED 12, May 17 Semiconductor reference issue, pp. 94-102, for additional design information, parameter evaluation and circuit contrasts involving field-effect devices (FETs and MOSs).

James S. Sherwin, Senior Applications Engineer, Siliconix, Inc., Sunnyvale, Calif.

Author Sherwin ponders a FET circuit problem. In this article he tells how he tackles the tough ones at low frequencies.
1. Matching minimizes the differences of FET pairs in differential amplifiers. Shown are a source-follower pair for impedance-matching (a), a source-coupled circuit for units having \( I_{dss} \) values just greater than the operating \( I_d \), and is due to a decrease in \( I_{dss} \) as temperature is increased. The match in gate currents, \( I_{g1} - I_{g2} \), is normally specified at an elevated temperature near 100°C. The \( I_g \) match is important to ensure equal voltage rise due to \( I_g \) in the gate resistors as temperature increases.

The differential FET pair chosen for any particular application will, of course, be specified only for that degree of match which is consistent with the application requirements. It is very important not to over-specify either the \( V_{bs} \) match or the differential \( V_{gs} \) drift for a given application. This affects cost and can delay delivery, even on relatively small quantities.

Designing bench-type FET voltmeters

To demonstrate the simplicity of FET differential amplifier design, we will use a bench-type voltmeter application (Fig. 1c). The design of differential amplifiers may be executed quite quickly by direct use of the information on the manufacturers' specification sheets. Gain for each half of the differential source-follower and operating point are determined in a manner similar to that used in general purpose amplifiers.* For FET voltmeter circuit, the design approach would be as follows:

1. Select a supply voltage. Let us use 9 volts.
2. Select a FET with \( V_{gs}(off)_{max} \) less than about half the supply voltage. If the FET has a maximum \( V_{gs}(off) \) of 3 volts, a positive supply voltage \( V_{dd} \) of 4 volts is satisfactory. Then the negative supply, \( V_{ss} \), will be 5 volts. The requirement is that \( V_{dd} > V_{gs}(off) \) for operation in the saturated region.
3. Choose \( R_s \) so that \( I_d \) on the minimum \( I_{dss} \) device is sufficiently below its zero \( V_{gs} \) drain current \( (I_{dss}) \) to allow for an \( I_{dss} \) decreasing with temperature (Fig. 2). Use the relationship

\[
R_s < \frac{V_{ss}}{I_{dss(min)}}. \tag{1}
\]

4. Choose \( R_o \) such that a reasonable match in \( V_{gs} \) is required. Using the values shown in Fig. 2, a \( V_{gs} \) match of approximately 0.3 volt is all that would be necessary.
5. Determine allowable differential \( V_{gs} \) drift according to the application. For a bench instrument, the operating temperature range is small, so that the \( \Delta V_{gs} = V_{gs2} - V_{gs1} / \Delta T \) requirements would be moderate in this application.
6. Determine allowable \( I_o \) for the value of \( R_o \) to be used and the acceptable zero shift. Use

\[
I_{o(max)} < \frac{V_{zero \ shift}}{R_o}. \tag{2}
\]

This would account for a zero shift when \( R_s \) is shunted across \( R_o \). Note that the \( I_{o(max)} \) value must be determined at the highest operating temperature.

Higher complexity in low-drift type

The design of a low-drift differential amplifier (Fig. 1B) is complex in comparison to the conventional type. The approximate gain function is given by

\[
A_v = -g_{fs} / (g_{oss} + G_o), \tag{3}
\]

if \( R_o = 0 \) and \( g_{fs} = g_{fs2} \).

The step-by-step design procedure resembles that used in the FET voltmeter:

*See part 1 of this article.

---

2. FET transfer characteristic curves are used to find the value of source resistance \( (R_s) \) for a simple voltmeter application (see Fig. 3a). Intersections of the proposed resistive load lines with the \( I_{dss}(MIN) \) curve of both min and max units are necessary. The load lines must pass beneath \( I_{dss}(MIN) \) point to allow for temperature changes in that parameter.
1. Choose the operating point at or below the $I_D$ value recommended in the device specifications (at least 25 percent below $I_{DSS}$ in any case).
2. Determine $R_s = V_{SS}/2I_D$, or use a constant-current supply to increase the common-mode rejection.
3. Determine $R_D$ using
   \[
   R_D + R_s = \frac{(V_{DD} - V_{SS} - V_{DS^+})}{I_D^*}.
   \] (4a)
   An approximate value may be determined in most cases by using
   \[
   R_D < \frac{V_{DD} - V_{GS(OFF)\text{max}}}{I_D + g_p v_{in}}.
   \] (4b)
4. Choose a device to meet the stipulated offset $V_{GS^+}$ and drift $\Delta|V_{GS1} - V_{GS2}|/\Delta T$ performance requirements.
5. If exactly zero offset is required $R_o$ is determined by using:
   \[
   R_o = \frac{|V_{GS1} - V_{GS2}|\text{(specified)}}{I_D}.
   \] (5)
   Note that the addition of the component, $R_o$, will decrease the common-mode rejection.
6. Resistor $R_o$ is calculated from the allowable drift with temperature limits (due to the differential $I_o$). Or, conversely, $|I_{G1} - I_{G2}|$ is established by allowable temperature drift with a given $R_o$. In evaluating device specifications for Item 4, allowance must be made for the sum of $\Delta I_{G1} - I_{G2}/\Delta T$ and $R_o |I_{G1} - I_{G2}|$ at the highest operating temperature.

**Bias critical in single-ended amplifier**

Nearly any FET may be operated as a single-ended, low-drift amplifier when it is biased to a zero temperature-coefficient point. The conditions which set the zero temperature-coefficient operation were outlined in Part 1 of this article. This point is usually found at a $V_{GS}$ bias of from 0.6 to 0.8 volt less than the $V_T$ value. That is, a device with $V_T$ of 3 volts would be likely to have a zero temperature coefficient operation is given by:

It is often more convenient to bias at a specific value of $I_D$ at which the zero temperature coefficient occurs. The approximate $I_{DR}$ for zero temperature coefficient operation is given by:

\[
I_{DR} \approx \frac{0.4 I_{DSS}}{V_T}.
\] (6)
Observe that $I_{dS}$ decreases with increasing $I_{dSS}$ because the $V_f - I_{dSS}$ relationship is such that $V_f^2$ increases at a greater rate than does $I_{dSS}$ for a given FET geometry or device type.

In the low-drift circuits (Fig. 3), either a constant-current supply (a) or a large $R_s$ returned to a large $V_{ss}$ (b) may be used to current-bias at the zero temperature coefficient point. In theory it is practical to operate a FET having a $V_f \approx 0.6$ volt at zero bias to realize a source-follower matching circuit with a zero temperature coefficient and zero offset.

In fact, however, the gate-source voltage for a zero temperature coefficient value of $V_{gs}$ exhibits a spread, so that $V_{gs}$ is not always equal to $V_f - 0.6$ volts. Thus, it is not practical to select accurately for zero temperature coefficient exclusively on the basis of $V_f$. The range of $I_{dS}$ may be specified by the manufacturer, or it may be approximated from Eq. 6 after measuring $I_{dSS}$ and $V_f$. Alternatively, it may be measured directly. In actual designs, empirical methods must be used to establish the exact zero temperature-coefficient point.

The simplest method of measuring $I_{dS}$ is to plot the $I_d - V_{gs}$ transfer curve of the FET on an X-Y plotter (Fig. 4a). Then, carefully heat the FET with a soldering iron or any other convenient means and replot the transfer curve. The $I_{dS}$ and $V_{gs}$ may then be read directly from the $I_d$ and $V_{gs}$ scales at the intercept of the two curves. The temperature to which the device is heated is not important, only the change in the curve due to the heat applied counts. This is easily understood if a third curve is plotted at another temperature. If that is done, the third curve will pass through the same zero temperature coefficient point.

**Zeroing in on key parameters**

After the zero temperature-coefficient point is found, it is wise to measure the temperature coefficient of $V_{gs}$ prior to final selection of the individual FET. This is necessary to ensure that $V_{gs}$ behaves well at the zero temperature-coefficient point. Occasionally, a particular FET may drift several millivolts over a $50\degree$ range. However, when accurately biased, performance as indicated in Fig. 4b may be expected.

For any given low-drift, single-ended amplifying application, the design characteristics of importance are:

- $I_{dS} = I_d$ for zero temperature-coefficient operation.
- $V_{gs} = V_{gs}$ at zero temperature-coefficient bias.
- $g_{fs} = g_{fs}$ at zero temperature-coefficient bias.
- $I_{dS} = I_d$ at zero temperature coefficient bias.

The design procedure is as follows:
1. Select a FET with a $g_{fs}$ high enough to suit the application.
2. Select for $V_{gs}$ low enough to suit the input-output offset requirements.
3. Determine $I_{dS}$.
4. Select $R_s$ and $V_{gs}$, or a current source, to provide the proper bias. Use

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ON READER-SERVICE CARD CIRCLE 38
\[ R_s = \frac{(V_{gs} + V_{gsz})}{I_{dz}}. \] (7)

If very accurate zero temperature coefficient operation is desired, \( R_s \), \( V_{gs} \) and/or the current source must be temperature compensated. One method of providing a zero temperature coefficient

### APPENDIX-HOW FET PARAMETERS ARE SPECIFIED

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions (must be specified)</th>
<th>Meaning of specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_{gs} )</td>
<td>( V_{gs} ), ( V_{gs} = 0 )</td>
<td>Gate-channel leakage with ( V_{gs} = 0 ). This represents total gate leakage current at a point below breakdown voltage. Specified at ( \frac{1}{2} ) to 1 times the minimum specified ( BV_{gs} ). When specified at min ( BV_{gs} ), ( I_{gs} ) may replace the ( BV_{gs} ) specification in that ( I_{gs} ) is (&lt; I_0 ) in the ( BV_{gs} ) specification.</td>
</tr>
<tr>
<td>( I_{do} )</td>
<td>( V_{ds} ), ( I_d = 0 )</td>
<td>Drain-to-gate leakage current with source open. As ( V_{gs} \approx BV_{gs} ), ( I_{do} ) is ( I_{do} ) [at specified ( V_{gs} ) + ( I_{gs} ) [at ( V_{gs} \approx \max BV_{gs} )]. ( I_{do} ) is representative of ( I_d ) under worst probable operating conditions when ( V_{gs} \approx \max BV_{gs} ), ( I_{ds} = \max BV_{gs} ) allowable.</td>
</tr>
<tr>
<td>( I_d )</td>
<td>( V_{ds} ) or ( V_{ds} ) ( V_{gs} )</td>
<td>Gate leakage current under certain operating conditions. ( I_d ) is usually somewhat lower than ( I_{do} ) since ( I_{do} ) is the limiting case of ( I_d ).</td>
</tr>
<tr>
<td>( I_{ds} )</td>
<td>( V_{ds} ) ( V_{gs} = 0 )</td>
<td>Drain saturation current, the value of ( I_s ) measured above the knee of the ( V_{ds}-I_s ) characteristic curve, where ( I_s \approx V_{ds} ). ( I_{ds} ) is actually defined as ( I_{ds} ) at the ( V_{ds} ) required for channel pinch-off when the two gate-channel-junction depletion regions meet near the drain. ( V_{ds} ) must be zero. At this point ( I_d ) is self-limiting, and any increase in ( V_{ds} ) causes only slight increase in ( I_d ). In Type-C MOS devices, ( I_{ds} ) essentially the drain-substrate leakage plus any residual drain-source channel current.</td>
</tr>
<tr>
<td>( I_o )</td>
<td>( V_{ds} ) or ( V_{ds} ) ( V_{gs} )</td>
<td>Drain-source current under certain specified operating conditions. ( I_o ) is essentially ( I_o ) but a particular set of operating conditions is implied.</td>
</tr>
<tr>
<td>( I_{ox} )</td>
<td>( V_{ds} ) or ( V_{ds} ) ( V_{gs} )</td>
<td>Same as ( I_o ) but often used to denote drain current for zero temperature-coefficient operation.</td>
</tr>
<tr>
<td>( I_{dz} )</td>
<td>( V_{ds} ) or ( V_{ds} ) ( V_{gs} )</td>
<td>Same as ( I_{ox} ) but often used to denote drain current for zero temperature-coefficient operation.</td>
</tr>
<tr>
<td>( V_{gs} )</td>
<td>( V_{gs} ), ( I_d )</td>
<td>Gate cut-off voltage. Gate-source voltage required to cut-off channel current.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions (must be specified)</th>
<th>Meaning of specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_p )</td>
<td>Pinch-off voltage, interchangeable with ( V_{gs} ).</td>
<td></td>
</tr>
<tr>
<td>( V_{gb} )</td>
<td>( V_{gb} ) ( I_d )</td>
<td>Gate-source voltage at any given operating point.</td>
</tr>
<tr>
<td>( V_{gxx} )</td>
<td>( V_{ds} ) or ( V_{ds} ) ( I_d )</td>
<td>Same as ( V_{gb} ) but a particular set of operating conditions is implied.</td>
</tr>
<tr>
<td>( V_{gs} )</td>
<td>( V_{gs} ) ( I_d )</td>
<td>Same as ( V_{gxx} ) but often used to denote ( V_{gs} ) for zero temperature coefficient operation.</td>
</tr>
<tr>
<td>(</td>
<td>V_{gxx}-V_{gs}</td>
<td>)</td>
</tr>
<tr>
<td>( \Delta V_{gs} )</td>
<td>( V_{ds} ) ( I_d ) or ( I_d )</td>
<td>Change in ( V_{gs} ) over given temperature range.</td>
</tr>
<tr>
<td>( \Delta V_{gxx} )</td>
<td>( T_{A} ) &amp; ( T_{A} )</td>
<td>Incremental change in ( V_{gs} ) ( V_{gs} ) expressed in ( \mu V ) / °C.</td>
</tr>
<tr>
<td>( I_{ds} )</td>
<td>( V_{gs} ) ( V_{gs} = 0 )</td>
<td>Match in ( I_{ds} ) of differential pairs, expressed as a fraction.</td>
</tr>
<tr>
<td>( I_{ds} )</td>
<td>( V_{gs} ) ( I_{ds} = 0 )</td>
<td>Match in ( I_{ds} ) for differential pairs. Usually specified at an elevated temperature near 100°C.</td>
</tr>
<tr>
<td>( r_{ds(on)} )</td>
<td>( I_d ) ( V_{ds} ) &amp; ( I_d ) ( V_{ds} ) &amp; ( I_d )</td>
<td>Static drain-source resistance when biased to full ON condition (maximum operating ( I_d )).</td>
</tr>
<tr>
<td>(</td>
<td>g_{rs}</td>
<td>)</td>
</tr>
<tr>
<td>(</td>
<td>g_{rs}</td>
<td>)</td>
</tr>
<tr>
<td>(</td>
<td>g_{rs}</td>
<td>)</td>
</tr>
<tr>
<td>( g_{rs} )</td>
<td>Match in ( g_{rs} ) for differential pairs.</td>
<td></td>
</tr>
<tr>
<td>( g_{rs} )</td>
<td>Same as ( g_{rs} ) but often used to denote ( g_{rs} ) when biased for zero temperature coefficient operation.</td>
<td></td>
</tr>
<tr>
<td>( g_{ms} )</td>
<td>Mutual conductance. Sometimes used in lieu of ( g_{rs} ).</td>
<td></td>
</tr>
<tr>
<td>( g_{ms} )</td>
<td>Common-source output conductance with input shorted.</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>CHECK YOUR</th>
<th>&quot;DC&quot; ACCURACY</th>
<th>&quot;AC&quot; ACCURACY</th>
<th>DECADES OF RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODE</td>
<td>(+5 µV)</td>
<td>(+25 µV)</td>
<td></td>
</tr>
<tr>
<td>DC-100B</td>
<td>±.05%</td>
<td></td>
<td>$455.00</td>
</tr>
<tr>
<td>DC-100B-1</td>
<td>±.05%</td>
<td>±.20%</td>
<td>855.00</td>
</tr>
<tr>
<td>DC-110B</td>
<td>±.02%</td>
<td></td>
<td>575.00</td>
</tr>
<tr>
<td>DC-110B-1</td>
<td>±.02%</td>
<td>±.10%</td>
<td>995.00</td>
</tr>
<tr>
<td>DC-150B</td>
<td>±.01%</td>
<td></td>
<td>775.00</td>
</tr>
<tr>
<td>DC-150B-1</td>
<td>±.01%</td>
<td>±.10%</td>
<td>1190.00</td>
</tr>
<tr>
<td>DC-200B</td>
<td>±.0075%</td>
<td></td>
<td>965.00</td>
</tr>
<tr>
<td>DC-200B-1</td>
<td>±.0075%</td>
<td>±.10%</td>
<td>1390.00</td>
</tr>
<tr>
<td>DC-210B</td>
<td>±.005%</td>
<td></td>
<td>1480.00</td>
</tr>
<tr>
<td>DC-210B-1</td>
<td>±.005%</td>
<td>±.10%</td>
<td>1925.00</td>
</tr>
</tbody>
</table>

*Accuracy specified over temperature range of 15°C - 35°C

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ELECTRONIC DESIGN, June 21, 1966

ON READER-SERVICE CARD CIRCLE 39
Differentiator noise is no problem, if your application is low-frequency. In fact, the simpler the circuit, the better.

Analog differentiators, which many engineers avoid using because of inherent noise problems, can be simply modified to reduce noise to as low as 15 mV. Application is limited to low-frequency operation, but circuit economies make the pure differentiator worth considering. Only one operational amplifier need be used to achieve the cited noise level, instead of complex “quasi-differentiation” circuits.

Usually a rearrangement of the design can eliminate the need for differentiators. Less noisy integrators can be used instead. But in at least one case the designer must ordinarily cope with them, like it or not: when it is necessary to develop the first derivative of a given analog signal, such as a process variable.

Three circuits are basic

An analysis of the noise characteristics and transfer functions in three basic differentiator circuits will prove that the simplest circuit may be the best for your application. Many other differentiator circuits have been discussed in the literature, but they are, in general, modifications of the fundamental circuits shown in Table 1.

Circuit I is the simplest, most straightforward method, with only one operational amplifier. Circuit II uses another network to generate the transfer function (1 + sT). The required function sT is obtained by adding the input voltage $E_s$ to the output of the first operational amplifier. Finally, in Circuit III, differentiation is gained by putting an integrator into the feedback path of a closed loop. The output of this integrator is forced, by feedback action, to be identical with the input signal $E_s$; thus the integrator input is obviously the derivative of the input signal.

To test their relative noise sensitivity, the performance of the three basic circuits was analyzed by introducing additional noise sources to simulate worst-case conditions at the inputs of the operational amplifiers. Amplifier noise and noise picked up by the circuit (mainly hum) were taken into account. The test proved noise to be handled in almost the same way by all three circuits.

Instability then is the real villain. An inspection of the transfer functions of the basic configurations reveals that all are either unstable or operate near the limit of stability. Most inherent noise in differentiators is amplified by this tendency to instability, since damped oscillations are likely to be triggered by even the smallest noise peaks. To ensure stable operation, the true differentiation is normally dropped and the ideal transfer function, sT, replaced by sT/(1 + ksT).

This had the same effect for all three circuits, and no reason could be found for abandoning the simple one-amplifier circuit in favor of other circuits requiring two or more operational amplifiers.

General transfer function for noise

A generalized equivalent circuit of an operational amplifier allowing for both signal and noise is shown in Fig. 1. For a complete analysis, two noise generators are introduced: both voltage and current. The noise voltage generator, $E_s$, represents induced noise of low internal impedance, e.g., as produced by inductive pickup. The noise current generator, $I_N$, accounts for disturbances of high internal impedance such as capacitive coupling. The output voltage of the circuit is:

$$E_o(s) = -\frac{1}{1 + \frac{Z_f}{A} + \frac{Z_f}{Z_i} + \frac{Z_f}{Z_i} E_s + \frac{Z_f}{Z_i} I_N + Z_f I_s}.$$  (1)

Within the useful frequency range of the amplifier, $A \to \infty$, and the above expression may be simplified to:

$$E_o(s) = -\left( E_s \frac{Z_f}{Z_i} + E_N \left[ 1 + \frac{Z_f}{Z_i} \right] + I_s Z_f \right).$$  (2)

The three basic differentiator circuits shown in Table 1 also include noise sources. The noise circuit generator at the operational amplifier in Circuit III, however, is omitted, since amplifier 1 is driven from low-impedance sources. The output voltage of each circuit, as derived by Eq. 2, is also noted in Table 1. The output noise level is most favorable for circuit I, and worst for circuit II, since both the noise voltage $E_{x1}$ and the noise current $I_s$, are

Roland E. Best, Electronics Laboratory, Sandoz, Ltd., Basel, Switzerland
Table 1. Noise transfer functions

<table>
<thead>
<tr>
<th>BASIC CIRCUIT + NOISE SOURCES</th>
<th>BASIC TRANSFER FUNCTION</th>
<th>NOISE TRANSFER FUNCTION (T=RC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Circuit I" /></td>
<td>$E_0 = -sTE_0$</td>
<td>$E_0(S) + sTE_0 - (1+sT)E_N - R_{I_N}$</td>
</tr>
<tr>
<td><img src="image2" alt="Circuit II" /></td>
<td>$E_0 = +sTE_0$</td>
<td>$E_0(S) + sTE_0 + sTE_{NI} - (1+sT)E_{N2} - R_{I_{N2}}$</td>
</tr>
<tr>
<td><img src="image3" alt="Circuit III" /></td>
<td>$E_0 = -sTE_0$</td>
<td>$E_0(S) + sTE_0 - (1+sT)E_N - R_{I_N}$</td>
</tr>
</tbody>
</table>

**differentiated.**

**Phase shift causes instability**

Applying the servo philosophy to circuit I, the differentiator represents a closed loop consisting of an RC-lag network connected in cascade with the operational amplifier. Generally, the voltage transfer function of an operational amplifier is given as:

$$A = \frac{A_o}{1 + sT_o}.$$ (3)

The frequency response is shaped by passive networks to have a constant-gain rolloff of 20 dB per decade of frequency above the corner frequency, $\omega_o = 1/T_o$. Consequently, the phase shift will approach asymptotically $-90^\circ$ at frequencies higher than $\omega_o$. The RC-lag network also contributes a $-90^\circ$ phase shift at higher frequencies. Theoretically, the total phase shift cannot exceed
Table 2. Basic circuits modified for low noise

<table>
<thead>
<tr>
<th>MODIFIED CIRCUIT</th>
<th>MODIFIED TRANSFER FUNCTION</th>
<th>MEASURED NOISE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Image of circuit Io" /></td>
<td>[ E_0 = -\frac{sT}{1+skT} E_S - \frac{1+st(1+k)}{1+skT} E_N - R_1 I_N ]</td>
<td>30 mVp-p</td>
</tr>
<tr>
<td><img src="image" alt="Image of circuit Ib" /></td>
<td>[ E_0 = -\frac{sT}{1+skT} E_S - \frac{1+st(1+k)}{1+skT} E_N - R_1 I_N ]</td>
<td>20 mVp-p</td>
</tr>
<tr>
<td><img src="image" alt="Image of circuit Ic" /></td>
<td>[ E_0 = -\frac{sT}{1+skT} E_S - \frac{1+st(1+k)}{1+skT} E_N - R_1 I_N ]</td>
<td>15 mVp-p</td>
</tr>
<tr>
<td><img src="image" alt="Image of circuit Iii" /></td>
<td>[ E_0 = +\frac{sT}{1+skT} E_S + \frac{2+st(1+k)}{1+skT} E_N1 + \frac{3+2skT}{1+skT} E_N2 - 4R I_N2 ]</td>
<td>50 mVp-p</td>
</tr>
<tr>
<td><img src="image" alt="Image of circuit Ivi" /></td>
<td>[ E_0 = -\frac{sT}{1+skT} E_S + \frac{sT}{1+skT} E_N1 - \frac{1+st(1+k)}{1+skT} E_N2 - R_1 I_N2 ]</td>
<td>50 mVp-p</td>
</tr>
</tbody>
</table>

*Measured with input grounded, \( T = 1 \text{sec}, k = 0.0015, E_S = 0 \)*

**ELECTRONIC DESIGN, June 21, 1966**
180°, below which point the circuit would be stable. In practice, however, the phase shift of operational amplifiers can slightly exceed the theoretical limit of -90° due to component variations. If this occurs at a frequency where the total gain is larger than 0 dB, the system becomes unstable. But even when the phase shift of the amplifier is less than 90°, the stability of the differentiator is borderline.

The damping factor, $\xi$, is often used as a quantitative measure of system stability. The damping factor can be obtained from a Bode plot of the closed-loop transfer function by means of the formula, $\xi = \frac{a}{3n}$, where $a$ is the phase crossover in degrees and $n$ is the slope of the gain curve with the unit dB/decade. Since $a$ is near 0°, the damping factor also approaches 0.

The same considerations apply to the other circuits of Table 1. In order to achieve satisfactory operation, the basic differentiator circuits have to be modified by the addition of compensating elements. These will provide additional phase-lead at higher frequencies, thus increasing the phase crossover $a$ and the damping factor $\xi$, and thereby improving stability.

**Simple modification achieves 15-mV noise**

Five modified versions of the three basic differentiator circuits are shown in Table 2, along with the transfer functions for signal and noise. The transfer functions for the signal $E_s$ are the same for all circuits with the exception of circuit lc which exhibits one additional phase lag. The transfer functions for the noise terms are somewhat different. The signs of the noise terms can be ignored, since in order to calculate the total output noise voltage, it is necessary to sum up the rms values of the terms.

In order to verify the noise performance predicted by the formulas in Table 2, the differentiator circuits were built experimentally. For all five circuits the noise voltages at the output were measured peak-to-peak with the input shorted and under the same conditions of hum pickup for all circuits. The measured values are listed in Table 2. The magnitudes of the noise voltages correspond well with the theoretical results. For comparison, noise figures measured in the unmodified circuits were typically 0.3 V p-p for circuit I, 10 V for circuit II and 0.35 V for circuit III.

**References:**

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ON READER-SERVICE CARD CIRCLE 42
Cure force-transducer inaccuracy in error-signal detection by using a pulse-width multiplier to broaden the response time. It's a simple, inexpensive remedy.

Many control systems often use force transducers to handle error-signal information in pulse form. The weak spot in this data-processing link is usually the transducer's response time: It may be the cause of inaccurate outputs or a total lack of response dead-band at low-level pulse inputs. The use of a pulse-width-multiplier (PWM) stage overcomes this liability.

The PWM multiplies the widths of error pulses by a constant, which can be changed to meet the demands of a particular force transducer's response time. In comparison with other means for achieving this pulse conversion (such as a pulse-train-to-dc converter), the PWM approach is simple and inexpensive. The PWM, which contains three basic switching units and one energy-storing element, can also be employed in digital computer systems. It can convert digital outputs directly into analog pulses, which in turn are used in conventional control systems.

Sensing out the transducer problem

The need for a PWM system became apparent in a project involving a horizon scanner and its associated attitude sensors. The form of the basic output from most spacecraft attitude sensors is such that it must be modified to activate the vehicle's force transducers. The resulting signal must be accurately used in the vehicle's control system.

In an infrared horizon scanner developed at the Langley Research Center, the basic output was in the form of pulses whose width was proportional to the pointing error. The problem here was that with very small attitude errors, the pulse width output might go as low as 0.5 ms. This was, of course, below the response time of conventional force transducers.

A simple PWM was developed to solve the problem. It overcame the need for a more complicated pulse-width-to-dc conversion at the low-frequency (2 Hz) region of the scanner output.

The PWM (Fig. 1a) consists of a capacitor, a charge source, a discharge source and a level detector. The detailed circuit diagram is shown in Fig. 1b.

Here \( C_1 \) is the capacitor and \( R_2 \) the charge source. Transistor \( Q_4 \), zener diode \( Z_1 \) and resistor \( R_3 \) form the discharge source, and the Schmitt trigger formed by \( Q_2 \) and \( Q_3 \) is the level detector. Transistor \( Q_1 \) merely serves as a switch to refer-


1. Pulse-width-multiplier system broadens the operating range and improves the low-level accuracy of force transducers. In the block diagram (a), input pulses are stretched so that output signals are within the response-time limits of the transducer. Complete circuit diagram (b) uses \( Q_1, Z_1 \) and \( R_3 \) as the discharge source, \( R_2 \) as the charging source, \( C_1 \) as the capacitor and the \( Q_2-Q_3 \) Schmitt trigger for the level-detection function.
ence the output to ground.

Under quiescent conditions $Q_1$ is off, and $C_1$ is charged through $R_2$ to the zener voltage of $Z_2$. This causes the Schmitt trigger to be in the ON state and, consequently, $Q_1$ is cut off. When a square wave pulse is applied to the input terminal, the leading edge turns on $Q_1$, which in turn discharges $C_1$ through $R_2$. Note that the voltage across $R_2$ is clamped to a level determined by $Z_2$, thus producing a fairly linear discharge of $C_1$.

Since the Schmitt trigger has practically zero hysteresis (because of $Z_2$), it changes state almost immediately after $C_1$ begins discharging. This turns $Q_1$ on and produces the leading edge of the output pulse. At the termination of the input pulse, $Q_1$ is returned to a cut-off state, and $C_1$ begins to recharge through $R_2$. When the voltage on $C_1$ reaches the zener voltage of $Z_2$, the Schmitt again changes state and cuts $Q_1$ off. This action produces the trailing edge of the output pulse.

**PWM stretches pulse duration**

Figure 2a shows the relationship between input and output for two different input pulse widths. Figure 2b shows the relationship between input pulse width, capacitor voltage and output pulse.

Rise and fall time for the output pulse was found to be 0.2 $\mu$s and 1.0 $\mu$s, respectively. A graph showing the measured relationship of input pulse width to output pulse width over a range of 5.0 $\mu$s to 0.6 ms, with a pulse-repetition rate of 30 pps and pulse height of 20 volts, appears in Fig. 3. The multiplication factor was set at 50 with a 0.1-ms input pulse width. As can be seen, the curve is essentially linear, except for small pulse-width inputs. The over-all linearity results from use of only a small portion of the almost linear part of the charge curve of $C_1$.

The pulse-stretching ability and broad range of the PWM system can be seen in the performance data. The multiplication factor itself can be varied (via $R_2$) from unity to a maximum determined by the input pulse width and the pulse-repetition rate. The pulse range over which the PWM will operate on an essentially linear curve is established by potentiometer $R_3$.

---

2. Pulse-stretching ability of the PWM system is demonstrated in the waveform (a). The upper trace in each photograph is the input pulse, and the lower trace displays the resulting output pulse for various multiplication factors. Shown are a 2 $\mu$s/cm-scaled input and the resulting output on a 0.1 ms/cm scale (A1 and A2, respectively); also, a 20 $\mu$s/cm-scaled input and its 0.5 ms/cm-scaled output (A3 and A4). The switching relationships are demonstrated in (b), where the input (top), capacitor voltage (middle) and output (bottom) are synchronized to a 2.0 ms/cm scale.

3. Linearity over a major portion of the input range is another feature of the PWM system. A different multiplying factor can be used in the non-linear portion to provide over-all accuracy.
New solid-state audible signal has low current drain, high reliability

The Sonalert® signal is a unique solid-state device which produces a compelling tone on as little as 3 milliamps. It consists of a piezoelectric transducer driven by a transistorized oscillator. It has no arcing contacts which cause explosion hazard and RF interference.

Sound intensity varies with applied voltage, and ranges from 68 to 80 db. Frequency is fixed by transducer characteristics, cannot be altered by external means, and is not affected by voltage. The device operates over a wide range of applied voltage.

Starting current is the same as operating current, and is exceptionally low. The 6 to 28 volt model draws only 3 milliamperes at 6 volts. The 110-volt AC model draws only 14 milliamperes (about the same as a neon pilot lamp).

Standard frequency is 2800 ±300 cycles; a 4500 ±500 cycle model is also available. AC and DC models are available, operating over the range from 6 to 28 volts; also a 110-volt AC model. A pulsed model produces “beeps” at a rate of 3 to 5 pulses per second. The high and low frequency units can be used in combination to indicate high or low limit alarms, or they can be used simultaneously to deliver a beat frequency signal.

Because of its solid-state design, the Sonalert has maximum reliability. It is being used as an overvoltage or undervoltage failure alarm on computers, as a “wheels down” signal on aircraft, as a security or overheat alarm. Because of its low power requirements, it can be actuated by batteries, directly by photo-sensitive devices; and it can be connected in fail-safe circuits where breaking a safety switch will apply full voltage across the Sonalert. Operating temperatures from -60 to +120°F are permissible. The complete unit is compact and is mounted on a single 1¾” panel hole.

New polystyrene film capacitors have superior stability, low cost

Now available from Mallory is a line of polystyrene capacitors which have temperature and life stability exceeding that of polyester film types. They are made of a unique form of stretched polystyrene film and high purity aluminum foil. The manufacturing process fuses the polystyrene to form a self-sealed case with excellent humidity protection.

Insulation resistance of these capacitors is exceptionally high—in the order of 100,000 megohms—and stays high throughout life. Temperature stability is excellent: from -10°C to +70°C, total capacitance change is less than -1.3%. Temperature coefficient is -150 ppm/°C, ±60 ppm/°C. Dissipation factor is less than 0.05%, and is constant over this temperature range.

Temperature stability of Mallory Polystyrene Capacitors compared with polyester film capacitors.

73 standard ratings from 5 pf to .01 mfd, all at 600 volts DC, are available. Standard tolerance is ±5%. Maximum operating temperatures are -40°C to +85°C. Production quantities can be obtained immediately from franchised Mallory Distributors, at prices below polyester film capacitors.

UL-recognized switch and control for light dimmers

A combined push-push three-way switch and intensity control, especially designed for use in light dimmers, is now available from Mallory Controls Company. The front section carbon control and the integral switch are both designed to meet Underwriters’ Laboratories requirements for voltage breakdown test and for dimensional spacing for use in electronic light dimmer controls.

The intensity control is rated 1 watt nominal, and is supplied in values from 100 to 10,000K ohms, in standard linear taper... also with other tapers and with fixed end resistances. The switch is single pole double throw, permanently attached to the same shaft with the control. It has been designed to handle dimmer loads up to 5 amperes at 117 volts, 60 cycles. 
Wet slug tantalum capacitors are best choice for timing circuits

Compare charging current-time traces, reproduced from oscilloscope photographs. Sweep speed: 20 millisec/div. Vertical sensitivity: 3 \mu a/div.

In an RC timing circuit, the value of time constant is usually calculated from the nominal value of capacitance and the value of the timing resistor. When tantalum capacitors are used in timing circuits, the effects of error introduced by DC leakage should be considered. Wet slug tantalum capacitors, because they have DC leakage in the order of 10% that of solid electrolyte types, have inherently far lower time error.

The effect of the leakage resistance path, in parallel with capacitor terminals, is to cause an apparent increase in time constant. The time error is, of course, zero in a perfect capacitor where the leakage path has infinite resistance... and increases as leakage resistance approaches the value of the timing or series resistance of the circuit.

For this reason, Mallory engineers often recommend wet slug tantalum capacitors for use in timing circuits where maximum precision is required. We have an engineering report on this subject, and will be glad to send copies on request.

ON READER-SERVICE CARD CIRCLE 194

World's Smallest Primary Battery

Mallory can now offer electronic designers the world's smallest primary cell actually in production. Only 0.130" high by 0.225" diameter, this 1.35 volt miniature power source is rated to produce 16 milliampere hours.

Because the battery energy is created through Mallory's mercuric oxide-potassium hydroxide-zinc system, voltage is extremely accurate and stable, and shelf life extraordinarily long.

Among the possible applications for the battery (designated as Mallory RM-212) are hearing aids small enough to hide inside the ear canal, "radio" capsules to transmit information from inside the body, and extremely small proximity fuses and telemetry devices.

If you're looking for extremely small power sources, this may be it. Or perhaps this breakthrough in battery size suggests designs not possible until now.

ON READER-SERVICE CARD CIRCLE 195

New small-size, low-price silicon rectifier line

The Mallory Type B rectifier is specifically designed for applications which require current capability up to 1 ampere in minimum size. It uses a passivated silicon junction for high temperature stability.

It's a new shape in rectifiers: the epoxy package is only .275" long and .350" maximum diameter, self-supported on .032" diameter axial leads. It needs no heat sink other than its own leads. Yet in this tiny size, it affords ratings of \( \frac{3}{4} \) ampere and 1 ampere, at 50°C ambient. Peak inverse voltage ratings from 50 to 1000 volts are available.

Forward drop is only .9 volts for the 1-ampere units, and 1.0 volts for the \( \frac{3}{4} \)-ampere type, at full rated current. Maximum surge current (4 millisecond) is 35 amperes. Accelerated environmental tests have demonstrated the Type B's ability to withstand severe humidity exposure.

Prices are as low as 10 cents in quantities of 100,000.

ON READER-SERVICE CARD CIRCLE 196
Avalanche circuit produces ultrafast light pulses

A light-emitting diode (LED) driven by an avalanche transistor can be used for avalanche relaxation oscillators with very fast rise times. Such a circuit is simple to construct and features rise times in the sub-nanosecond region for pulse durations of a few nanoseconds.

Fast-rise-time, nanosecond-duration light sources are extensively used for testing laser range-finder receivers and other electro-optical applications. Such light pulses usually are obtained with bulky apparatus, such as triggered spark gaps, flash tubes, Kerr cell modulators. Consequently, it may take a lot of time, space and equipment to produce a good light pulse. A more straightforward approach where infrared light pulses can be used is to drive an inexpensive, non-coherent LED with an avalanche transistor.

Figure 1 shows such an avalanche relaxation oscillator. Light power output is on the order of a few milliwatts with a pulse repetition frequency of a few kilohertz. Pulse rise time is typically less than one nanosecond.

Figure 2 shows an avalanche blocking oscillator driving an avalanche transistor. The circuit pulses only when driven by a relatively slow-rise-time positive input signal (+2.0 volts), such as derived from the square-wave calibration signal obtained from an oscilloscope. Pulse rise times here may be several nanoseconds. Parameters for the constant voltage regulators for \( Q_1 \) and \( Q_2 \) should be chosen such that the regulator voltage is approximately \( BV_{ces} \) for each transistor.

Substitution of a small-value resistance, such as 10 ohms, for the LED converts the light pulse into a handy voltage generator. Pulse amplitudes are 10 to 20 volts with sub-nanosecond to nanosecond rise times, depending on circuit layout and the components used. Both circuits are small, inexpensive, and easy to construct as long as good vhf construction techniques are followed.

Burton E. Dobratz, Aerospace Group, Hughes Aircraft Co., Culver City, Calif.

**FET-bipolar oscillator features notch network**

An n-channel FET, driving a bipolar emitter-follower, forms an oscillator. The high \( Z_{in} \) of the FET enables a "notch" network to be used in the degenerative loop.

Regenerative feedback from the emitter of \( Q_2 \) (see schematic) through a tungsten filament lamp gives the amplitude-limiting necessary for output stability. \( Q_2 \) is a high-input-impedance, bootstrapped emitter-follower that properly loads \( Q_1 \). It provides the low output impedance necessary...
If you've been wishing for a new source of silicon planar general purpose amplifiers or high speed switches, ITT has now provided the answer.

ITT is in full production on the popular 2N2222 amplifier family and the 2N2369 high-speed switching family. You can have the same transistor performance you've been getting from other suppliers, plus the supplier performance you can only get from ITT.

If you're buying silicon planars from either of these families, evaluate the new source. Order them today . . . get them today . . . from any distributor of ITT Semiconductors. ITT Semiconductors, 3301 Electronics Way, West Palm Beach, Florida, is a division of the International Telephone and Telegraph Corporation.
N-channel FET and emitter-follower are employed in this oscillator circuit. Notch network and lamp form degenerative and regenerative feedback loops, respectively. The latter feedback is used for output stability.

for driving the parallel combination of the notch network and the low resistance of the lamp.

Resistor $R_s$ should be adjusted for approximately 2.5 volts at the oscillator output. The distortion at higher frequencies will be very low; but at lower frequencies (below 25 Hz), the lamp will cause some distortion. However, the distortion at 12.5 Hz measured less than 0.5 per cent.

Source resistor $R_s$ must be adjusted for maximum output. This in turn will be the optimum bias for $Q_1$. This can be done simply by disconnecting $C_s$ from the emitter of $Q_1$, exciting the FET gate with an oscillator, and then adjusting $R_s$ for maximum signal output. Part of $R_s$ contributes to this bias operation point and the adjustment of $R_s$ will be affected if $R_1$ (output level adjustment of oscillator) has to be changed. All resistors are rated at 0.5 W.

The frequency of oscillation is given by:

$$f = \frac{1}{2\pi RC},$$

where $C = \sqrt{C_1C_2}$.

Jack A. Bryant, Engineer, National Tape Service, Inc., Parsippany, N. J.

Current transformer protects regulator against overloads

A current transformer can be used in high-voltage transistorized power supplies as a more effective short-circuit protection than conventional means. The latter often are inadequate because large values of current in conjunction with high voltage quickly exceed the control transistor’s power capability. But if a current transformer is used to sample overloads, the power expended in the control transistor during overloads is small.
How to spot the highest-power 400 MHz transistor available

Look for the one with the strip line leads — ITT's 3TE440. The 3TE440 delivers 15 watts minimum at 400 MHz with 8.6 dB gain. The low-inductance strip line package provides greatly-improved stability and circuit bandwidth. Typical efficiency is 60% when $P_{oe} = 10$ watts at 400 MHz.

The planar passivated, interdigitated 3TE440 has a $BV_{CEO}$ rating of 80 V, allowing better up-modulation and reducing danger of damage from transients. Resistor stabilization provides high second breakdown characteristics and built-in bias stability for Class A and AB amplifiers. In many applications, the 3TE440's higher performance can reduce the number of transistors required.

It is now available off the shelf. Contact any ITT distributor or your ITT factory representative. ITT Semiconductors, a division of International Telephone and Telegraph Corporation, 3301 Electronics Way, West Palm Beach, Florida.
The current transformer, CT₁ (see schematic), is used to sample the current supplied to the voltage regulator. Diode D, rectifies the sampled current which in turn produces a voltage drop across R₁. Resistor R₁ is adjusted to trigger SCR₁ when a predetermined value of overload current is reached. Capacitor C₁ serves as a filter for the rectified signal.

When a current overload occurs, the additional voltage generated across R₁ triggers SCR₁ ON. When SCR₁ is conducting, no base current is made available to control transistors Q₁ and Q₂, and they are thus turned OFF. With Q₁ OFF, the transistor is required to sustain only the unregulated voltage, Eᵢᵣ, and its expended power is thus reduced to a negligible amount.

The circuit can be reset by removing the input voltage; this will eliminate the holding current of the SCR. If a manual reset switch, SW₁, is provided to shunt the SCR, the holding current will also be dropped below the SCR's sustaining needs.

Typical component values with 0.5 A as the maximum overload current conditions are: SCR₁—MCR 2304-4; D₁—IN457A; C₁—1.0 µF/50V; R₁—20 Ω; and CT₁ (turns ratio)—1:10.

S. J. Arnold, Senior Engineer, Welex, Houston, Tex.

**Phase-shift oscillator measures inductance precisely**

A decade oscilloscope preamplifier, counter, potentiometer, two diodes and a precision capacitor comprise a high-accuracy inductance-measuring system. A measurement accuracy of ±0.1 percent accrues with this phase-shift system.

A reliable system was needed to inspect precision iron-core inductors for the correct value of inductance. Because large quantities of parts were involved, the system had to be fast, accurate, and usable by unskilled personnel.

A system that fulfills these requirements is shown in the accompanying diagram. When the test inductor is connected into the circuit, the audio amplifier oscillates at a frequency fₒ. This oscillation occurs only when the phase shift through the series RLC feedback loop is zero degrees. This occurs when fₒ = 1/2 π √LC. Therefore, limits for fₒ may be calculated for any tolerance limits of inductance when C is known.

Frequency fₒ is then read out by a precision digital frequency counter or frequency meter. The accuracy of results depend above all on the accuracy of frequency measurement and the precision to which C is known.

To function properly, the audio amplifier must

---

**Phase-shift oscillator arrangement provides very accurate measurements of inductance. Feedback loop is formed by RLC phase network.**
Evaluate ITT
have negligible phase shift at $f_0$ and be a noninverting type. The output impedance should be low enough to drive $P_1$ as a load. $D_1$ and $D_2$ are back-to-back germanium signal diodes which prevent saturation of the amplifier.

The value of $P_1$ is not critical, but should not exceed $\sqrt{L/C}$. Once the wiper of $P_1$ has been set to provide the proper loop gain, it need not be readjusted, unless the inductor type being tested is changed. In practice, measurement of $L$ to a ±0.1 per cent tolerance has been achieved.

Kenneth G. Holmes, Chief Engineer, Magnetic Circuit Elements Inc., Montrose, Calif.

Remote-control time delay needs no turn-off signal

An SCR and unijunction transistor (UJT) can be combined in a remote-control time-delay circuit that requires no turn-off signal. The circuit can handle inductive as well as resistive loads.

The time-delay circuit (see schematic “a”) is turned on by a pulse, remains on for a predetermined period, then shuts itself off. Operation is as follows: The positive input pulse is applied to the gate of the SCR, causing conduction of current through the load to the ground return. Simultaneously capacitors $C_1$ and $C_2$ begin to charge.

When capacitor $C_1$ reaches the emitter peak-point voltage of the UJT, the UJT conducts and discharges capacitor $C_1$ into resistor $R_2$. Since capacitor $C_2$ cannot charge instantaneously, the voltage appearing between ground and the cathode of the SCR is momentarily increased above the supply voltage by an amount almost equal to the peak-point voltage. The SCR becomes reverse-biased long enough to reduce the forward current to less than the holding current and ceases to conduct. Voltage is thus removed from the load.

The circuit was originally developed to light a lamp in an airborne towed target, and so indicate the presence of an interfering signal in a control receiver. Since the interfering signal was present only intermittently, the lamp had to be turned off automatically after a 15-second interval—just long enough to permit observation. This was achieved with an $R_1$ of 680 kΩ and a $C_1$ of 22 μF.

The circuit has been used to initiate and maintain a tone signal for a prescribed time period, and to control a hydraulic valve delivering anti-icing fluid to aircraft windshields. The latter application is the only one in which a primarily inductive load was controlled. The valve solenoid current of 1.0 A at 28 Vdc represented a 28-watt load.

Although the components shown are capable of controlling only an 80-watt load (1.6 A at 50 volts), the circuit is suitable with appropriate changes for regulating more than a kilowatt.

Note that the $R_1 C_1$ time constant must be long enough to permit $C_2$ to charge to the SCR cathode potential, thus setting a minimum time delay. Maximum time delay is limited only by available resistance and capacitance and could conceivably be hours or longer.

In another version, the UJT is replaced by a 4-layer avalanche diode (see schematic “b”). Operation here is virtually the same as in schematic “a”, except that the load capabilities are slightly higher. Current capability is determined by the SCR. The 4-layer diode circuit has been operated with a 7-A load. Increasing the size of capacitor $C_2$ improves the operation of both circuits. The time delay is essentially equal to the product of $R_1 C_1$.

Edward G. Olson, Design Engineer, Naval Air Development Center, Johnsville-Warminster, Pa.

Nuvistor and bipolars form low-noise preamplifier

A nuvistor may be combined with a number of transistor stages to form a low-noise, hybrid preamplifier. This design is especially attractive for very-low-frequency, narrow-band, signal-processing applications.

The use of a nuvistor front end for preamplifiers to be operated at sub-audio frequencies has
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Nuvistor and bipolar form low-noise, hybrid preamplifier. The emitter-coupled feedback loop is used for providing closed-loop gain stability, and higher input impedance and lower output impedance to the open loop.

become popular in power-limited, low-noise, preamplifier applications. Here (see schematic) a hybrid preamplifier was designed to operate at 15 Hz with a source impedance of approximately 300 kΩ.

Because the nuvistor's equivalent noise resistance is significantly below that of a bipolar transistor at these frequencies, it is important for good hybrid operation that—even while the nuvistor is operating in the starved condition—sufficient amplification be provided in the nuvistor stage. This ensures that the noise contribution of the succeeding transistor stage is negligible. From noise considerations, the value of quiescent plate current for T was chosen to be 400 μA. At this value, the amplification factor of the nuvistor is reduced below 35 (its rated value) to 10; the dynamic plate resistance is increased to approximately 10 kΩ—the output impedance of the first stage.

The 2N2484 low-noise, high-beta transistor exhibits minimum noise figure in the range of 5-15 kΩ source resistance and was used to follow the nuvistor stage. To achieve an input impedance that does not load the nuvistor output, and at the same time to retain a good temperature stability factor, bootstrapping or direct coupling may be used. In this direct-coupled configuration, the nuvistor furnishes a stable dc bias voltage to the base of Q1, thereby realizing an excellent dc temperature stability for Q1. The collector current of Q1 was set at 150 μA for optimum noise performance.

The simple, emitter-coupled feedback loop increases the open-loop input impedance and decreases the open-loop output impedance while stabilizing the ac closed-loop gain. Open-loop gain at 15 Hz is 90 dB and closed-loop gain is 40 dB. This yields an excess gain for the loop of 50 dB.

The preamp output circuit consists of a unity-gain, low-output-impedance buffer amplifier which ensures that the feedback network does not load the amplifier. Also, it provides a low impedance source for further processing circuitry.

Gain of the preamp is 40 dB with an equivalent noise resistance of 50 kΩ measured in a 6-Hz bandwidth centered at 15 Hz. Noise bandwidth limiting in the preamp itself is approximately 1.5 kHz. The input impedance is 4 MΩ, and the output impedance, 10 Ω. The gain variation over an operating range of −40 to 60°C is less than 0.1 dB.

George C. Kuipers, Associate Sr. Research Engineer, General Motors Defense Research Laboratories, Santa Barbara, Calif.

VOTE FOR 116

IFD Winner for March 15, 1966
Robert B. Jones, Project Engineer, Continental Device Corp., Hawthorne, Calif.

His idea, "Analog-to-frequency converter has improved linearity, range," has been voted the $50 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.
HIGH GAIN
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SAMPLE SPECIFICATIONS: 2N4250 / 2N3965

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ON READER-SERVICE CARD CIRCLE 46
What do they mean by "an engineer's company"?

Some very successful companies are "sales oriented"—others, equally successful, receive their primary impetus from accounting, legal or business-management directions. Probably because of the highly technical nature of its product, Motorola has always been a company wherein engineering has been the moving force. At any management conference at Motorola, you'll find men think like engineers, and talk like engineers, because so many in the management echelon are engineers.

At Motorola the engineer achieves full professional status—because he is working in an environment where the state of the art has progressed to the point where only an "engineering oriented" management can direct the flow of achievement.

In this dynamic atmosphere, of course, the challenges are great—but equally rewarding for truly qualified engineers. Would you like to talk to us?

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Date of Birth ____________________ Place of Birth ________________ Citizenship __________

Position Desired __________________

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Recent Special Training

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Outstanding Engineering and Administrative Experience

_________________________________________

Professional Societies

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Published Articles

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Minimum Salary Requirements (Optional)

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

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Systems Engineers

Monsanto Company needs system engineers with 3-8 years experience. Background should include circuit and logic design. Knowledge of the application of integrated circuit elements is desirable. The positions are in the area of data acquisition units in computer controlled systems.

Send resume in confidence to:

Manager, Professional Recruiting
Department CL-412
Monsanto
900 North Lindbergh Boulevard
St. Louis, Missouri 63166

An Equal Opportunity Employer

ON CAREER-INQUIRY FORM CIRCLE 902

BENDIX (KANSAS CITY DIV.)

This is the opportune moment to investigate your career potential at Bendix, Kansas City Division. As prime contractor for the AEC, we have enjoyed an enviable, orderly 16-year growth. Now we are entering a unique developmental phase, opening new fields of activity in microminiaturization, microwave and logic circuitry. This situation adds up to a ground-floor opportunity in a well-established corporation noted for advanced engineering. Cooperative, professional atmosphere, plus excellent living conditions. Let us hear from you promptly so we may detail more clearly the many advantages we can offer you.

Please mail résumé at once to:

THE BENDIX CORPORATION, Box 303-H
Kansas City, Missouri 64141

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ELECTRONIC DESIGN

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Can you make major contributions in advancing the Microelectronic Materials Technology?

If your answer is "yes" then you may be interested in current openings at IBM's Thomas J. Watson Research Center. At the present time several select positions are available for Research Engineers and Physicists who can make major contributions in vacuum deposition of insulators and metals and the use of glass and ceramic substrates and techniques for the etching of micro-strip transmission lines.

Qualified applicants should possess a BS, MS or PhD in Electrical Engineering or Physics and a minimum of two years' laboratory experience in materials research, materials engineering and micro-miniature fabrication techniques.

The Thomas J. Watson Research Center at Yorktown Heights, New York, is located in suburban Westchester County, 40 miles north of New York City. Liberal company-paid benefits include relocation expenses.

Please write, outlining your experience and education, to R. L. Meyers, Dept. 555-T3, Thomas J. Watson Research Center, P. O. Box 218, Yorktown Heights, New York 10598. IBM is an equal opportunity employer (M/F).

IBM
FET to replace bulky transformer

**Problem:** Design an analog-gate circuit using microelectronic integrated-circuit techniques to reduce size and weight. Conventional gate circuits use a heavy, bulky transformer in the drive circuit to isolate the gate from the fixed voltages.

**Solution:** A metal-oxide semiconductor field-effect transistor (MOS FET) analog-gate circuit, that adapts well to integrated circuits and provides better system isolation than a transformer.

This analog-gate circuit consists essentially of the MOS FET $Q_2$, and a npn control transistor, $Q_1$. With $Q_1$ in saturation, a conducting channel is formed from the source of $Q_1$ to its drain and the analog gate conducts. With $Q_1$ off, the potential on the gate of $Q_1$ becomes greater than its source or drain potential and the gate is open-circuited.

The FET provides complete isolation of the gate elements, resulting in zero offset voltages.

Because the input and output signals are less than or equal to zero, the body of $Q_1$ is grounded and the source and drain junction leakage is kept in the nanoampere range. Body junctions can withstand voltages up to 25 volts without excessive leakage or breakdown, thus permitting a wide range of input voltages. Crosstalk is minimized by a source-to-drain capacitance of less than 1 pF.

This circuit should be of particular interest in the area of telemetry.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland, 20771. (B65-10284).

**COMMUNICATIONS D&D ENGINEERS**

BSEE or Physics. Several positions, from beginning to senior levels, call for one to ten years' experience in any or all of the following areas: design of varactor multipliers up to 150c; parametric and/or tunnel diode amplifiers for receiver front ends; microelectronics, strip-line techniques, solid state. Your responsibilities will encompass design and development of communications systems involving receivers and/or transmitters at 2, 4, 8 gigacycles, varactor multipliers, micro-miniaturization of microcircuitry, parametric amplifiers.

**SECTION HEAD—ENGINEERING**

BSEE degree. Project Manager for Underwater Instrumentation type of program. Knowledgeable in underwater acoustics, transducer systems, underwater arrays, transducer instrumentation systems (including beacon transponders, acoustic decoys), and marine hardware. Projected use on complex underwater arrays systems for test and calibration, impact location systems and underwater navigation systems.

**DIGITAL COMPUTER SPECIALIST**

BSEE—5 years' hardware experience preferred. An excellent opportunity for an engineer ready to assume technical responsibilities in the design of a Special Purpose Airborne Computer, to solve navigational and coordinate translation problems. Background in design of logic and memory systems as well as experience in programming and organization essential.

**SPACE COMMUNICATIONS ENGINEERS**

BSEE or Physics, MSEE for senior posts. Depending upon positions sought, one to several years' experience in communications theory (solid knowledge of fundamentals), knowledge of communications receivers and modulation equipment, digital hardware, high-power transmitters, antenna components. Ability to design and build to prove your ideas very helpful. Responsibilities will include system analysis, design and development of communication transmitters and receivers, and system studies for space communication equipment and systems. Frequency ranges are from UHF through EHF.

**ELECTRONIC SWITCHING ENGINEER**

BSEE plus 5-10 years' experience in telephone switching systems, message switching systems, and secure communications for both military and commercial applications plus special design and development of electronic solid state switching equipment. Knowledge of and background in at least 3 of the following: electronic switching, logic synthesis, micro-miniaturization, computer orientation and mathematics.

**TECHNICAL SPECIALIST—ACOUSTICIAN**

Familiar with problems of underwater acoustics, effects of environment on acoustic signal transmissions, knowledge of acoustic transmission systems. Minimum of 3 years' experience including underwater acoustics, signal transmission analysis, and acoustic signal processing.

**SPECIALIST OR SR. PROGRAMMER**

(Bachelor's or a Master's degree in Mathematics preferred.)

Develop programs required for computer solution and processing, prepare detailed flow charts. Write required and associated documentation and write appropriate machine language or symbolic language instructions, receives instructions and explanations of the over-all programming objectives of the project and his assignment from his supervisor and is responsible for implementing programs, making octal and symbolic corrections to the operational and/or applicable programs, analyzes and describes problems so that other personnel may locate and correct faults. He will work with well defined problems and concepts under the guidance of Program Analyst and/or as directed by section supervisor.

**PROGRAMMER**

(Bachelor's degree from accredited college or university is preferred; however, two years of college and/or one year of direct applicable experience in programming or computer operation is acceptable.)

Writes and/or participates in the preparation and debugging of machine language or symbolic language instructions and works from detailed flow charts and/or detailed mathematical equations under the guidance of Sr. Programmers and Program Analysts.
If your ideas on communications keep expanding beyond the boundaries of your present job, we’ve got space for you at the labs

Space to develop in — as broadly as you like, and as fast (possibly faster). Because creating progressively more advanced communications systems that incorporate both spacecraft and ground stations is one among many avenues we’re pursuing here in Nutley with something approaching proprietary success.

Take these examples.

We’re developing all the ground-based electronics for COMSAT’s global system’s two 85’ antenna stations in Washington and Hawaii . . . also another in Spain . . . plus two terminals for Apollo support in the Canary Islands. Beyond this we’ve completed a study program covering all the spacecraft communication telemetry & command electronics for a project of exciting magnitude — the first fully global and fully operational communications satellite system.

In addition, under a NASA contract, we are building a complete experimental prototype for a time division multiple access system, to optimize the traffic-handling capabilities of space repeaters. No cinch technically, because absolutely precise synchronization in time is mandatory — despite the fact that each transmission originates from a different point on earth and therefore has a different and varying path length and time constant.

If, with all this vast range of activity you were to suppose that you might get lost, or pigeon-holed, you’d be wrong. For although we have an awesomely big corporation behind us, ours is a closely knit and highly individualized organization. The freedom you’ll have to advance and be recognized professionally is matched only by the spaciousness of the challenges you’ll confront.

So if space is what you’re looking for, and if you have the imagination and flexibility to cope with the explosive demands of high level aerospace technologies, we’d like to know more about you. And we’d like you to know more about us.

Our specific opportunities are listed to the right. Let’s talk about one of them.

For more information, forward your resume in strictest confidence to Mr. W. F. Bieszard, Room 368, ITT Federal Laboratories, 500 Washington Avenue, Nutley, N. J.
complete spectrum of opportunity for creative challenge

At LTV Electrosystems, Inc., talented electronic systems oriented engineers know the excitement of creativity, the satisfaction of personal and professional advancement and contribution in an expanding organization, the flexibility and creative freedom of small product groups. Still they enjoy big company growth and opportunity.

LTV Electrosystems is an organization delivering highly complex new electronic systems to meet defense and space demands of today and the future. Major fields of capability include: space/air/ground electromagnetic reconnaissance and surveillance systems; command and control systems; high-power radar and radio; nuclear detection and surveillance equipment; information processing and display systems; super power equipment; VLF transmitters; commercial radio transmitters; guidance systems; antennas; electronic warfare systems; satellite tracking systems . . . and more.

These vital programs offer exceptional career positions to engineers in the following disciplines: RF SYSTEMS ANALYSIS / RF CIRCUIT DESIGN / DIGITAL CIRCUITS DESIGN / DIGITAL SYSTEMS ANALYSIS / WEAPONS SYSTEMS ANALYSIS / GUIDANCE SYSTEMS / RADAR SYSTEMS / ANTENNA SYSTEMS DESIGN / ELECTRO-MECHANICAL PACKAGING / AIRCRAFT ELECTRICAL INSTALLATION DESIGN / AIRCRAFT STRUCTURES DESIGN / MECHANICAL SYSTEMS / ELECTRO-OPTICS / STRESS ANALYSIS / SCIENTIFIC PROGRAMMING . . . plus others.

For complete information about a career with LTV Electrosystems, Inc., write: Professional Placement, Dept. 166A, P.O. Box 6118, Dallas, Texas 75222. LTV is an equal opportunity employer.

LTV ELECTROSYSTEMS, INC.
A SUBSIDIARY OF LING-TEMCO-VOUGHT, INC
GREENVILLE AND DALLAS, TEXAS

ON CAREER-INQUIRY FORM CIRCLE 905

Electronic Design, June 21, 1966
**Products**

**Epoxy encapsulation** of germanium FET cuts cost, still ensures hermeticity. Page 120

**Display system** compares 128 continuously changing channels simultaneously. Page 180

**Multielectrode quartz wafers** provide precision filtering in micromin package. Page 174

**Also in this section:**

- **Varactor bridge op-amp** goes to dc with big $Z_{in}$ and low noise. . . page 140
- **Ambilogical multiplying** element for hybrid systems. . . . page 178
- **Photoelectric relay system** detects correct frequencies. . . . page 183
Price of germanium FET falls below $1 with use of plastic

Plastic encapsulation of a germanium FET has slashed the volume price to below $1. This planar epitaxial p-channel junction FET is designed for economy applications in the consumer market, particularly in RF mixers and amplifiers. Common-source maximum available gain (MAG) ranges from 8 dB at 500 MHz to 26 dB at 100 MHz.

The package measures 1/4-in. in diameter in a standard TO-18 ten-pin circle configuration. The opaque package insures light insensitivity. The header is a ceramic-glass sandwich with a hermetic seal between it and the leads. The transistor is capable of meeting hermeticity standards of MIL-202C, method 103b. Wrap-around construction prevents separation of the plastic from the header under temperature stress. Operating range extends to 100°C.

Germanium devices have higher room-temperature leakage current than silicon units. But, the high majority-carrier mobility of germanium improves high-frequency FET performance. Transconductance-to-feedback capacitance ratio ($\gamma_{fs}/C_{RSS}$) is increased. Smaller parasitic resistances result in higher input resistance at frequencies above 50 MHz. Common-source forward transfer admittance $[\text{Re}(y_{fs})]$ of the TIXM12 is 6.5 mmho at 100 MHz and feedback capacitance is 3 pF. Common-source forward transfer admittance varies from 1.3 to 8 mmho as the drain current increases from 0.2 to 10 mA. At an ambient temperature of 25°C, a drain current of -5 mA, a drain-to-source voltage of -8 V and a frequency of 100 MHz, common-source input admittance is 0.3 mmho.

Being a FET, the device features low cross-modulation distortion and low noise. Typical noise figure of the TIXM12 at 100 MHz is 2 dB.

Dc characteristics include $BV_{GSS}$ of 20 V min and $I_{GSS}$ ranging from 5 to 25 mA.

P&A: under $1 (over 1000); July. Texas Instruments Inc., 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

25-W npn transistor priced under 40 cents

An encapsulated plastic, npn, silicon mesa power transistor, the B-5000, is priced under $0.40 in high volume. This low-cost transistor is rated at 25 W at $V_{CE}$ of 10 V, collector current of 2.5 A and case temperature of 100°C.

Collector-to-emitter voltage is 35 V min, collector current is 3 A max and base current is 1 A max. $\beta$ ranges from 30 to 250 at 14 V and 0.5 A.

Leads and collector strip are highly conductive silver for soldering ease in mounting. The unit is operable over a -65 to 150°C range.

P&A: $0.99 (1 to 99), $0.75 (100-999), under $0.40 (high volume); stock. Bendix Semiconductor Div., South St., Holmdel, N. J. Phone: (201) 747-5400.

Transistor geometry features inter-digitated construction.
Now, JFD Uniceram® Fixed Capacitors Come
THREE ways

**High Q** Uniceram High Q ceramic fixed capacitors offer a unique combination of small size, exceptional stability and a guaranteed minimum Q of 5000 . . . with up to ten times more capacitance per unit volume than competitive units . . . up to .206 mfd/in³.

**GLASS ENCAPSULATED**—105 models, with capacitance values from 0.5 to 3000 pf, provide the ultimate in High Q, reliability and stability. All models meet applicable requirements of MIL-C-11272B.

**WAFERS**—Uniceram High Q capacitors are also available as unencapsulated wafers with metalized edges. 88 low-cost units, with capacitance values from 0.5 to 3000 pf, offer the same outstanding electrical properties. These wafers are ideally suited for hybrid integrated circuits, can be soldered directly to printed circuit boards or used as discrete components.

**High K ENCAPSULATED**—A High K series of Uniceram ceramic fixed capacitors with up to 1 mfd capacitance is also available. These glass encapsulated units meet applicable requirements of MIL-C-11015C. Volumetric efficiency . . . up to 48 mfd/in³.

**WAFERS**—Uniceram High K capacitors will soon be available as unencapsulated wafers, also.

WRITE FOR CATALOG UNM 65-2
Click, whirrr

All that moves in the world's fastest printer is a motor and a fan.

Monroe Datalog's MC 4000 ultra high speed optical printer offers the unique reliability of only two moving parts. But reliability is only one feature. The MC 4000 records 6000 lines per minute, or any speed less that your application requires. Truly synchronous or asynchronous. Available in numeric or alphanumeric models—both 32 columns wide.

Features: character serial input, bit parallel. 6 microseconds per character data transfer time. Exceptional compactness—10½" x 10½" x 21½". Any 4 or 6 line code with any logic level. All solid state. Cathode ray tube with fiber optics. Permanent copy option available.

And a full year's warranty. Price: $5650 for numeric model; $5850 for alphanumeric model.

For information, contact Monroe Datalog Division of Litton Industries, 343 Sansome St., San Francisco 94104. (415) 397-2813.
Militarized versions of MC 4000 also available.

The Monroe DATALOG MC 4000 is available in any configuration or to any military specifications that your application requires.

For further information, call the Monroe DATALOG Division of Litton Industries, 343 Sansome St., San Francisco 94104. (415) 397-2813.

SEMICONDUCTORS

Contact protector

Connected across an inductive circuit element, series R selenium contact protectors suppress voltage surges from switching and offer protection against arcing. The devices can handle coil voltages from 26 to 250 V and currents from 150 mA to 1.2 A. The protectors are suitable for ac and dc applications and custom epoxy packages and spring clips are available.

Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. Phone: (203) 467-2591.

Circle No. 702

Tuning varactors

Two silicon planar epitaxial tuning varactors for vhf and uhf use are encased in a coaxial or TO-7 package. Any capacitance value from 6 to 26 pF for type MC301 and 26 to 47 pF for MC302 may be specified. Both have a PIV of 40 V and an operating range of -65 to +175°C. They dissipate 500 mW derating at 1.67 mW/°C from 25°C.

P&F: $5 ea. (1000 lots); stock to 30 days. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530.

Circle No. 703

TO-18 silicon photodiode

A silicon photodiode in a TO-18 package is designed to operate with bias conditions required by low cost silicon transistors. Typical reverse dark current at 55°C with -1.0 V is 0.4 µA. Typical short circuit current output at 500 foot candles is 180 µA. Spectral response peak is at 0.85 microns and speed of response is 1 µs.

Price: $2.25 (100 lots). National Semiconductors Ltd., 2150 Ward St., Montreal, Canada. Phone: (514) 744-5507.

Circle No. 704

Silicon rectifiers

Types 1N645 through 1N649 miniature glass rectifiers are packaged in a TO-7 case. At 25°C, peak reverse voltage ranges from -225 V for 1N645 to -600 V for 1N649. Minimum reverse breakdown voltage at -100 µA is available from 275 V to 720 V. Average rectified current at 150°C is 150 mA and max reverse current is available from -15 µA to -25 µA at 150°C.

Nucleonic Products Co. Inc., 3133 E. 12th St., Los Angeles. Phone: (213) 268-3464.

Circle No. 705
Before you freeze that new design...

check with us

If today's electronic know-how had been available to designers fifty years ago, would the phonograph have looked like this?
No!
If tomorrow's know-how were available to you right now, would it affect your next product design?
At Dow Corning it is... and it can!
Dow Corning, the acknowledged leader in silicone research and development for over twenty years, has a history of producing materials to meet unheard of performance requirements... and materials is our only business.

More often than not, the suggestions of our Electronic Products Development Laboratory will spark new concepts, new versatility and capabilities for your product... if you include us in the early stages of your design thinking.

We manufacture high-performance, premium-quality encapsulating rubbers, rigid molding compounds, flexible casting resins and grease-like compounds which meet the most stringent requirements of the electronic industry.

Our Electronic Products Laboratory offers prompt technical assistance in solving your specific problem. Write Dept. 3506, Electronic Materials Department, Dow Corning Corporation, Midland, Michigan 48640. Or phone (517) 636-8940 for more information and the name of the Dow Corning representative in your area.

We're a materials producer exclusively. Let us tailor a material to your need.

Dow Corning® 3110 RTV encapsulant can be readily color coded by mixing in master batch pigments. It is a low viscosity, deep section curing compound that cures at room temperature and is designed for potting, encapsulating and embedding of electronic circuit and components. It flows readily into place and cures to form a tough, resilient solid. (Circle No. 851)

Ready-to-use silicone adhesive encapsulates, seals, bonds. Silastic® 732 RTV rubber is a tough, squeeze-on adhesive/sealant that bonds metal, glass, plastics, rubber and most other materials. It cures at room temperature in 24 hours to a solid rubber... stays flexible from -85 to 500 F. Also recommended as adhesive for Silastic® brand heat shrinkable tubing. (Circle No. 852)

Shrinkable silicone rubber tubing can be the answer where wiring harness and electronic devices or components must be protected. Silastic® brand heat shrinkable tubing simplifies processing—reduces cost—where quick, easy fabrication of a close-fitting insulating covering for splices, leads, or components is required. Shrinks to ½ dia. when heated to 300 F or higher... in length less than 5%. (Circle No. 853)
...and to take the curse out of fluctuating battery voltage in mobile communications, there's the new Amperex 8643...

*with a new, wide-range cathode*
There's a new Amperex cathode in a new Amperex tube, which was specifically designed to handle variations in power supply voltage.

At its high end, this revolutionary, wide-range cathode is immune to high temperatures, and hence, to sublimation; at its low end, it insures adequate talk-power for any emergency!

Now, whether the battery delivers as little as ten volts or as much as sixteen—all other parameters constant—the end result is the same—never less than 90% of full talk-power and no danger of damage to the tube!

The new cathode is being made available for the first time with the introduction of a new Amperex twin tetrode, the 8643, forerunner of a family of wide-range cathode tubes for mobile equipment.

The 8643 was designed for use as an RF power amplifier, oscillator and frequency multiplier up to 175 Mc. It is rated for Push-To-Talk Service, capable of producing 135 watts from less than 4 watts drive as a 175 Mc amplifier under PTTS conditions.

**POWER PERFORMANCE vs. CATHODE VOLTAGE**

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<td>CONVENTIONAL TUBES</td>
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**PUSH-PULL FM AMPLIFIER**

(HEAT SINK OPERATION)

ICAS (175Mc) PTTS (175Mc)

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<tr>
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<td>135.0</td>
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*PUSH-TO-TALK SERVICE, MIN. DUTY CYCLE 1 MIN, OP. 8 MIN, OFF.*

For data on the 8643 and other Amperex twin tetrodes for mobile communications, write: Amperex Electronic Corporation, Tube Division, Hicksville, L. I., New York 11802.

**SEMICONDUCTORS**

**Glass diode pellets**

MIL-S-19500 passivated oxide glass sealed silicon diode pellets are typically 0.05-in. diameter by 0.02-in. thick. Terminations are high-temperature solder tabs. With power heat sinking, the units dissipate 1 W min.

The whiskerless diodes are available as general purpose diodes, logic switches, core drivers, core driver matrix assemblies and zeners.

MicroSemiconductor Corp., 11250 Playa Ct., Culver City, Calif. Phone: (213) 391-8271.

**Capacitance diodes**

Types 1N5139 to 48 and 1N5139-A to 48A voltage-variable capacitance diodes are designed for RF tuning in the vhf band and above. Reverse leakage current is 20 nA max. Minimum Q is 200 to 350 at 50 MHz and 4 Vdc bias. Tuning ratio is typically 2.9 to 3.4. The "Epicaps" are available in ten types with capacitances of 6.8 to 47 pF at 4 V. Tolerances are 5 and 10%.

Price: $3.90 to $4.30 (over 100). Motorola, P. O. Box 955, Phoenix. Phone: (602) 273-6900.

**Power transistors**

Series MHT 7901 through 7904 transistors are 10-A planar npn devices featuring sustaining voltages from 200 to 300 V. The transistors are offered in a TO-66 package with a power rating of 25 W at 100°C case temperature. I<sub>ebo</sub> is 1 µA max., V<sub>CE/SAT</sub> is 0.5 V max at 5 A and h<sub>fHF</sub> is 50 MHz.

Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

**Fast switching diode**

Fast switching microwave silicon diodes are designed for low loss switch applications at frequencies up to and including Ku band. Model MO 2800A of the 2800 series features a forward switching time of 1.0 ns max, total capacitance of 0.1 pF max, voltage breakdown of 80 V min and dynamic forward impedance of 3 Ω max.

Alpha Industries Inc., 381 Elliott St., Newton Upper Falls, Mass. Phone: (617) 969-6480.
SEMICONDUCTORS

GaAs light transmitter

A vhf visible-light transmitter can be driven up to 165 MHz and pulsed with turn-on and turn-off times of 10 ns. Minimum brightness is 50 foot-lamberts and spectral line width is 400 Å between 6000 and 7000 Å. Power requirement of model A950 is 150 mA at 1.65 V. Applications include optical transmission of vhf sinusoidal and pulsed signals, circuit isolation and light strobe. Both male and female BNC connectors are supplied.

P&A: $55; stock to 10 days. Somerset Radiation Lab. Inc., P. O. Box 201, Edison, Pa. Phone: (215) 348-8889.

Thyristor SCR

Type 254 thyristor silicon-controlled rectifier is rated at 70 A half-wave average (110 A rms) at 50 to 1300 V. This JEDEC-registered device is designed for cycling loads such as inverters, motor controls and primary-controlled power systems. The SCR has a 1600-A surge rating.

P&A: $15.10 to $248 (1 to 100); stock. Westinghouse, Youngwood, Pa. Phone: (412) 925-7272.

Diodes

Glass-passivated silicon mesa devices are packaged in double-plug cases, 0.22-in. long, 0.085-in. in diameter with 0.02-in. lead diameters. Power dissipation up to 200 mW at 25°C can be tolerated. These whiskerless diodes have been designated IN456-IN459, IN461-IN464, and IN482-IN485.

Price: $0.35 to 0.85, (1 to 99), $0.28 to $0.60 (100 to 999) Texas Instruments, 13500 N. Central Expwy., Dallas. Phone: (214) 235-3111.

FET op-amp

Series KM40 FET operational amplifiers feature input impedances up to $10^{11}$ Ω. Current offset is less than 10 pA and voltage offset drift is 3 nV/°C. All units are available with integral power supply.


High-gain transistors

Two new silicon planar epitaxial transistors, the A467 and A473, together make possible an unneutralized, 3-stage TV IF amplifier with an over-all minimum gain of 90 dB. This circuit capability is due to the feedback capacitances of 150 µF and 220 µF respectively. Cut-off frequencies are 350 and 400 MHz and breakdown voltages are 30 and 35 V. Both types are mounted in a standard TO-18 can.

Amperex Electronics Corp., Slatersville, R. I. Phone: (401) 762-9000.

Bridge rectifier

A miniature single-phase bridge silicon rectifier contains double-diffused passivated controlled avalanche junctions in a cold case design. Silver leads are available straight for plug-in or bent for terminal strip mounting. The rectifiers are available with a current of 2 A from 50 to 1200 V PIV.

Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. Phone: (203) 467-2591.

Uhf noise diode

Constructed to match the impedance of a 50-Ω coax line, the TT-1 diode is for use as a hf and uhf noise source. Noise output is a direct function of anode current. Coax construction permits use with tuned or untuned circuits. Maximum anode voltage and current ratings are 300 Vdc and 100 mA. Filament ratings are 3.2 Vac or de and 2.5 mA. Anode dissipation is 30 W max. Frequency range extends to 3 GHz max and dynamic impedance is 16 kΩ min.

Signalite Inc., 1933 Heck Ave., Neptune, N. J. Phone: (201) 775-2490.
Price should be the least of your worries. Right now, several metal film manufacturers (including Dale) are offering MIL-R-10509 RN parts in a price range which is more competitive than ever before. **But price doesn't equalize quality.** Neither does it assure you of the delivery you need. Or the part-to-part homogeneity that can turn a good price into an outstanding one because of the overall savings it makes possible.

You can get these quality, delivery and homogeneity assurances—at a competitive price—by dealing with Dale. Continued expansion utilizing the most advanced automated equipment plus long-established systems of value analysis enable us to be fiercely competitive—without sacrificing quality standards. Standards which enable Dale MF, MFF and MFH resistors to go beyond the Mil. Spec. in meeting your needs.

Don't be bashful about asking us to prove all this. We're continually developing good metal film customers who, at first, were surprised to find we were in the business. As a matter of fact, we'll be pleased to show you that there's still a lot more to a metal film resistor than price. To see what we mean, just take a look on the back of this page.
NEW HOUSED D SERIES opens new design areas for use of precision power metal film resistors

Dale's new D Series are the industry's first housed power film resistors. They combine a heat sink housing already proven by Dale Wirewounds, with a precision power metal film element. The result:

1. As FILM RESISTORS, Dale's D Series offer power/size ratio unmatched by conventional parts (see chart).
2. As HOUSED RESISTORS, Dale's D Series offer higher maximum resistance values and low reactance at high frequencies.

We'll send you complete details on this amazing design flexibility.

D SERIES SPECIFICATIONS

- Resistance Range: 50Ω to 2 Megohms (D5), 30Ω to 2 Megohms (D10), 50Ω to 2.5 Megohms (D15)
- Tolerance: ±0.1%, ±0.25%, ±0.5%, ±1% and ±2%
- Power Rating: D5 4 watts, D10 8 watts (mounted on 4"x6"x.040" aluminum chassis) D15 12 watts (mounted on 5"x7"x.040" aluminum chassis).
- Temperature Coefficient: ±25 and ±50 ppm/°C (−55° to +175°C). Higher T.C.'s on request.

- Maximum Working Voltage: 500V (D5), 600V (D10), 700V (D15)
- Dielectric Strength: 1000 VAC on D5, 1500 VAC on D10 and 2000 VAC on D15
- Construction: Aluminum screw-mount radiator housing with resistance element molded inside for complete environmental protection. Meets all applicable requirements of MIL-R-18546C and MIL-R-10509E.

When specifying metal film resistors look for these features at a competitive price--

**DALE has them!**

LOW NOISE CONSTRUCTION Dale maximum for standard resistance range is 0.10 micro-volt per volt over a decade of frequency, with low and intermediate values below 0.05 micro-volt per volt. Dale uses a unique production method in which a terminating band of low-resistance metal alloy is deposited in the same vacuum as the metal film element. This results in a uniform, OXIDE-FREE, low noise contact area between film, band and press-fit cap.

CONTROLLED TEMPERATURE COEFFICIENT Available in 11 standard T.C. Codes from 0±150 ppm/°C to 0±25 ppm/°C. Close T.C. matching between pairs or sets is also available.

GOOD H.F. CHARACTERISTICS Low reactance is standard and results in excellent stability at high frequencies. For extremely critical applications above 100 megacycles, non-helixied or laterally-adjusted units can be supplied.

SPECIAL CAPABILITIES At your request, Dale can readily supply: ■ Special terminals in any commercial material. ■ Special pre-conditioning (power aging, temperature cycling, etc.). ■ Close tolerance matching in pairs or sets. ■ Resistor networks packaged in various configurations and encapsulants.

MAXIMUM FLEXIBILITY IN ENVIRONMENTAL PROTECTION Three types of specially-developed protective coatings are offered to give maximum flexibility of choice: MFF epoxy coated. Meets electrical and environmental requirements of Char. B, C, D, E; MIL-R-10509E, but is dimensionally smaller. MFH hermetically sealed in ceramic tube. Meets requirement G; MIL-R-10509E. MF transfer molded in epoxy. Meets all requirements of Char. B, C, D, E, F; MIL-R-10509E.

FILM RESISTOR POWER/SIZE COMPARISON

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>D SERIES</th>
<th>2-WATT METAL FILM</th>
<th>5-WATT CARBON FILM</th>
<th>4-WATT TIN OXIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>D5</td>
<td>D10</td>
<td>D15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.343 W X .600 L</td>
<td>.420 W X .750 L</td>
<td>.550 W X 1.062 L</td>
<td></td>
</tr>
<tr>
<td>Power Rating</td>
<td>4 Watts</td>
<td>8 Watts</td>
<td>12 Watts</td>
<td>2 Watts</td>
</tr>
<tr>
<td>Volume</td>
<td>0.064 in.²</td>
<td>0.123 in.²</td>
<td>0.320 in.²</td>
<td>0.242 in.²</td>
</tr>
<tr>
<td>Power Density (25°C)</td>
<td>62.0 w/in.²</td>
<td>65.0 w/in.²</td>
<td>37.5 w/in.²</td>
<td>8.3 w/in.²</td>
</tr>
<tr>
<td>Power Density (125°C)</td>
<td>20.4 w/in.²</td>
<td>21.4 w/in.²</td>
<td>12.4 w/in.²</td>
<td>8.3 w/in.²</td>
</tr>
<tr>
<td>Life Stability (Typical)</td>
<td>.1%</td>
<td>.1%</td>
<td>.1%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Temp. Coefficient</td>
<td>25 or 50 ppm/°C</td>
<td>50 ppm/°C</td>
<td>500 ppm/°C</td>
<td>300 ppm/°C</td>
</tr>
<tr>
<td>Max. Operating Temp.</td>
<td>175°C</td>
<td>175°C</td>
<td>175°C</td>
<td>175°C</td>
</tr>
</tbody>
</table>

*Maximum resistance shift in 1000 hours of operation at rated power.

MFF Epoxy coated.

MFH Hermetically sealed in ceramic tube.

MF Transfer molded in epoxy.

GENERAL SPECIFICATIONS--TYPE MF* MIL-R-10509E

<table>
<thead>
<tr>
<th>DALE TYPE</th>
<th>MIL TYPE</th>
<th>125°C RATING</th>
<th>RESISTANCE RANGE</th>
<th>DIMENSIONS (LxWxH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF-50</td>
<td>RN-50</td>
<td>1/20 watt</td>
<td>0 ohms to 100K ohms</td>
<td>.140x.065</td>
</tr>
<tr>
<td>MF-1/10</td>
<td>RN-55</td>
<td>1/10 watt</td>
<td>0 ohms to 200K ohms</td>
<td>.250x.093</td>
</tr>
<tr>
<td>MF-1/8</td>
<td>RN-60</td>
<td>1/8 watt</td>
<td>10 ohms to 2 Megohm</td>
<td>.460x.140</td>
</tr>
<tr>
<td>MF-1/4</td>
<td>RN-65</td>
<td>1/4 watt</td>
<td>10 ohms to 2 Megohms</td>
<td>.593x.203</td>
</tr>
<tr>
<td>MFS-1/2</td>
<td>RN-70</td>
<td>1/2 watt</td>
<td>10 ohms to 2 Megohms</td>
<td>.750x.250</td>
</tr>
<tr>
<td>MF-1</td>
<td>RN-75</td>
<td>1 watt</td>
<td>10 ohms to 4 Megohms</td>
<td>1.093x.375</td>
</tr>
<tr>
<td>MF-2</td>
<td>NA</td>
<td>2 watts</td>
<td>100 ohms to 10 Megohms</td>
<td>2.188x.375</td>
</tr>
</tbody>
</table>

*Tolerance: ±1% standard; ±.5%, ±.25%, ±.1% available.

ENVIRONMENTAL SPECIFICATIONS*

Dale MF resistors are manufactured to the environmental specifications of MIL-R-10509E. Characteristics D, C or E apply depending on T.C. Code specified at purchase.

<table>
<thead>
<tr>
<th>DALE T.C. CODE</th>
<th>APPLICABLE CHAR. OF MIL-R-10509E</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1 (100 P.P.M./°C)</td>
<td>D</td>
</tr>
<tr>
<td>T-2 (50 P.P.M./°C)</td>
<td>C</td>
</tr>
<tr>
<td>T-9 (25 P.P.M./°C)</td>
<td>E</td>
</tr>
</tbody>
</table>

*Specifications for MFF and MFH are similar, but vary dimensionally.

WRITE FOR CATALOG A giving comprehensive information on Dale's complete Film and Wirewound Resistor line.

DALE ELECTRONICS, INC. 1336 28th Avenue, Columbus, Nebraska
Automatic field tests to NASA specs are made with QC 275 cable tester. Resistance testing is performed with simulated load currents from 40 mA to 1 A. Leakage resistance is measurable to 5000 MΩ with go no-go settings at 50, 100, 150 and 200 MΩ. Total capacity is 75 circuits with adjustable dwell time from 0.5 to 15 s.


Circle No. 319

Model 624 A peak holding charge amplifier with 10-turn potentiometer and 7-step range switch accepts inputs from 50 to 1000 pC. A continuously adjustable automatic reset has periods ranging from 10 to 30 s. Input impedance is 10^11 Ω for calibration and 10^12 Ω in operation. Sensitivity can be adjusted from 0.1 to 100 mV/psi, G or lb.

P&A: $995; stock. Sensonics Inc., P. O. Box 395, Falls Church, Va. Phone: (703) 534-7800.

Circle No. 320

Sine and square wave signals from 20 Hz to 200 kHz are generated by model 636. For the sine wave output, frequency response is flat within ±1.5 dB with accuracy of ±5% and distortion of less than 0.25%. Output is 0 to 10 V rms across a 600 Ω load. For the square wave output, rise time is 0.15 µs. Output is 0 to 10 V p-p into 600 Ω load.

Designatronics Inc., 76 E. Second St., Mineola, N. Y. Phone: (516) 741-7070.

Circle No. 321

This deflection amplifier is a ±40 V driver with regulated power supplies and safety current limiting. The all-silicon unit provides a 12-A change in less than 9 µs with a linearity of 0.02%. Requiring 115 Vac, the amplifier handles from dc to pulses. This unit is compatible with single-ended yokes and needs no synthesizing networks.

Constantine Engineering Labs. Co., 70 Constantine Dr., Mahwah, N. J. Phone: (201) 327-1123.

Circle No. 322

Model 3504A sweep/offset plug-in internally sweeps the manufacturer's 3300A function generator over any decade of its range at rates from 0.01 Hz to 100 kHz. The plug-in also produces outputs which are dc-offset up to ±16 V.

The sweep bandwidth can be adjusted at any value up to a decade. The sweeping voltage is available at an external output to drive an X-Y recorder or a scope. The 3304A also provides sawtooth waves with independent frequency control. Two channels deliver a choice of sine, square, or triangular waves.


Circle No. 323

A portable battery-powered semiconductor analyzer is designed for testing transistors, diodes and low power SCRs. The unit tests semiconductor junctions for low or high impedance and leakage and determines the dc current gain of transistors and the gating function of SCRs. In-circuit shorts and dc current gain may be measured without disconnecting circuit leads.

Short or low impedance junctions and open or high impedance junctions for diodes and transistors are tested on a go no-go basis. Reverse bias leakage is measurable for selectable junction voltages to 30 volts. Diode forward and reverse current characteristics for voltages to 30 volts may be analyzed. Shorts are located in-circuit impedances as low as 3 Ω. Dc current gain scale for npn or pnp transistors extends to 300. The 5-lb unit uses 1.5-V "D" cells.

Dahlberg Electronics Inc., Golden Valley, Minneapolis, Minn. Phone: (612) 545-3722.

Circle No. 324
Resistance bridge

Fixed film or hybrid microcircuit resistors may be continuously monitored as they are adjusted to final value. This resistance trimming bridge automatically halts the trimming process at the programmed “stop” value and performs a high-low-accept check. Typical trimming and testing speed is 1 resistor per second. Final values are selectable from 10 Ω to 10 MΩ and tolerances may be programmed individually from 0 to 11% in 0.1% increments. Over-all accuracy is 0.05%.

Boonton Electronics Corp., Rte. 287 & Smith, Parsippany, N. J. Phone: (201) 887-5110.

Power pulse generator

PM 1355-R power pulser, in conjunction with an existing dc supply, superimposes a pulse onto the lines. Load capability is 100 A max and amplitude is 44 ± 6 V. Frequency is 1 to 10 Hz and pulse width is 7.5 ± 2.5 μs. Rise time is 1 μs max and fall time is 2 μs max.

Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, Calif. Phone: (213) 393-0138.

Gate generator

The GG200 gate generator has 6 outputs including system logic and gate signals and their complements. Delayed positive and negative trigger signals at the end of each cycle permit use as a delay generator. Gating time range is 100 ns to 11 s in 8 overlapping ranges. The cycle may be started and stopped by ±5-to ±50-V pulses as well as logic signals. All outputs drive 50-Ω loads.

EG&G, Inc., 35 Congress St., Salem, Mass. Phone: (617) 745-3200.

DC amplifier

An all-silicon solid state differential dc amplifier features ±300 V common-mode voltage capability and gains from 1 to 2500, with 100 MΩ input impedance. Output is ±10 V- at ±100 mA. Common mode rejection is 160 dB at dc. Switch-selected bandwidth filters have standard values of 10 kHz, 1 kHz, 100 Hz and 10 Hz. Settling time is 100 ms max.

P&A: $745; stock to 45 days.

California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (741) 224-3241.

Capacitance bridge

This capacitance bridge has a range of 1 pF to 1.1 farads and incorporates a 120-Hz generator, detector and adjustable dc polarizing supply. Three-, four- and five-terminal measurements can be made with the type 1617-A bridge. The built-in bias supply has six ranges to 600 V. External bias up to 800 V can be applied. The bridge measures dissipation factors up to 10.


IC tester

A portable test console measures electrical characteristics of all 1- to 14-lead ICs. The unit contains 6 power supplies, four of which are individually front-panel adjusted over 0 to ±15 V. Readout is on the front panel meter or on an external DVM. Accuracy is 1% of full-scale with panel meter, and 0.1% with a DVM. Voltages to 30 V and currents of 1 nA can be measured.

P&A: $985; stock to 3 wks.

Continental Device Corp., Hawthorne, Calif. Phone: (213) 772-4551.
Pulse generator

Model 1010B programmed current pulse generator provides 1-A current pulses with rise times to 10 ns. The unit delivers a serial/parallel train up to 16 steps with a clock rate to 5 MHz. It contains a program generator, up to 6 current drivers, and a power supply. Either polarity with any sync pulse or step repeat function on any step may be programmed.


Circle No. 331

Pre-set digital clock

Model PC-16 miniature digital clock system uses ICs and features dual pre-set knobs for variable time schedule adjustments. Six internal fixed time schedules are also available. Display configurations include seconds, minutes and 12 or 24 hours. BCD or 10-line decimal outputs are available. Bench-top or rack mount models are offered.


Circle No. 332

Ballantine High Voltage AC/DC Calibrator

Model 421A
Price: $650

Portable
0-111 V dc
0-1110 V ac
400 or 1000 Hz, RMS or Peak-to-Peak

May be used with Optional Error Computer

NEW!
Accurately Calibrates to 0.15% Vm's, 'Scopes, Recorders...

Ballantine's new Model 421A is an accurate source of dc or ac voltage that can be set precisely to any value desired up to 111 volts on dc or up to 1110 volts on ac. It's small, rugged, portable... enabling you to check with ease a wide range of instruments without loss of down time. You'll find it useful, too, as an accurate, stable source for measurements of gain or loss, and as a stable source for bridges or strain gauges.

The selected voltage is indicated digitally to four significant figures on each of six decade ranges. The voltage indicated may be dc, or it may be ac at 400 Hz or 1000 Hz, RMS or Peak-to-Peak.

Note, for example, the settings in the photo — 42.35 volts RMS at 1000 Hz output. And with an accuracy that you can be sure is better than 0.15%. The receptacle on the lower right of the instrument is for high voltage outputs from 100 volts to 1110 volts at 400 Hz, RMS or Peak-to-Peak.

The new instrument also features a connection for an optional Model 2421 Error Computer that enables you to read calibration errors directly in percentages, speeding up your calibrations considerably.

In addition to its greater voltage range on ac, the Model 421A has a lower source impedance on ac than the Model 421 it replaces. Line voltage effects on the instrument are negligible. A ±10% line voltage change, for instance, causes less than a 0.05% change in output voltage.

Write for brochure giving many more details

BALLANTINE LABORATORIES INC.
Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR DC AND AC ELECTRONIC VOLTMETERS/AMMETERS-OHMETERS, REGARDLESS OF YOUR REQUIREMENTS. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC LINEAR CONVERTERS, AC/DC CALIBRATORS, WIDE BAND AMPLIFIERS, DIRECT-READING CAPACITANCE METERS, AND A LINE OF LABORATORY VOLTAGE STANDARDS FOR 0 TO 1,000 MHZ.

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 55
PROTECT YOUR INSTRUMENTS WITH AMALCO ALUMINUM CARRYING CASES

Amalco aluminum carrying cases are perfect for carrying instruments safely. Tightly sealed to prevent dust, sprays and dirt to enter, these cases are ruggedly constructed to sustain unusual abuse. The Amalco carrying cases come in eight economical sizes and can be modified to suit your specific needs. Write for descriptive literature and specifications on the Amalco Aluminum Carrying Cases.

DIFFERENTIAL AMPLIFIER

The manufacturer's 530, 540, 550 and 580 scopes will accept the 1A6 plug-in differential amplifier. A constant dc to 2 MHz bandwidth and calibrated deflection factor from 1 mV/cm to 50 V/cm are featured.

Output is the instantaneous difference between signals applied to the + and - inputs. Common-mode rejection ratios of 10,000:1 from dc to 100 kHz (1 mV/cm to 50 mV/cm), and 1000:1 (0.1 V/cm to 50 V/cm) allow cancellation of unwanted signals. Dual inputs allow floating-input measurements between above-ground points. A single control selects the deflection factor and indicates the allowable common-mode signal range from ±15 to ±500 V (combined dc and peak ac).

P&A: $230; July. Tektronix Inc., P.O. Box 500, Beaverton, Oregon. Phone: (503) 644-0161.

HIGH-RANGE WATTMETER

Single- and poly-phase power levels from 1.5 to 60 kW without external current transformers may be measured with this wattmeter. Current ranges are 0 to 10/20/50/100 A rms. A 0 to 50-mVdc output signal, proportional to kilowatts, is available on each power range. Accuracy of this analog signal is ±0.5% full scale. Over-all meter accuracy is ±1% of full scale. The portable wattmeter requires no external power source.

P&A: $890; stock to 4 wks. Scientific Columbus Inc., 1035 W. Third Ave., Columbus, Ohio. Phone: (614) 291-4681.

Circle No. 333

Circle No. 334
Choose our A-MP* Printed Circuit Connectors for their superior performance features. Then, use any one of five ways to terminate the circuit contacts.

You can crimp and snap-in contact and conductor . . . loading only those positions you need.

Solder them.

Weld, if you like.

Wrap, if that’s the way you’ve always done it.

And finally, a new way—clip-on terminations! This is done with our TERMl-POINT* point-to-point wiring devices, which make a reliable, gas-tight connection by merely pushing a spring-clip and wire onto the contact post. You can use any one of a variety of wires—stranded, solid, tinsel, enamel and printed . . . TERMl-POINT devices accept all of them.

No matter which method you choose, you get all these important advantages in our one-piece printed circuit connector:

- finest quality-controlled construction
- gold over nickel plated contacts to prevent oxide creep
- precisely controlled contact pressures for longer contact life and less wear on circuit paths
- alpha-numerical coded housings
- available in 8, 15, 22, 30 and 32 positions

Write today for the full story on the big choice in printed circuit connectors. You’ll get complete information on printed circuit connectors with crimp type contacts or with special post and tab adaptations—plus details on our new TERMl-POINT terminals and tools.

*Trademark of AMP Incorporated

A-MP* products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany
Just 16 oz.
and
humidity proof
shock proof
acceleration proof
temperature proof
noise proof
storage proof...

that's the miniature AGASTAT®
time / delay / relay

All these proofs (meeting MIL specs) mean miniature AGASTAT pneumatic time/delay/relays remain accurate under the most rugged operating conditions.

Environmental hazards can't foul these AGASTAT timers, because they're hermetically sealed.

Tight squeezes don't cramp AGASTAT timers—they measure only 1½” square by about 5” long, weigh only 16 ozs.

Voltage changes, temperature changes or transients can't fool them—their timing action is pneumatically controlled. (Pneumatic timing also means you get instant recycling, with full delay periods regardless of how often the cycle is interrupted before relay “times out.” And because timing is pneumatic, it can even time without electric power!)

Another advantage is an exclusive dial head that lets you make simple, but accurate, linear adjustments over the full timing range of each unit with just a single revolution of the adjustment screw. (Nine timing ranges cover a total span from 0.03 second to 3 minutes.)

AGASTAT timers are available with delay on pull-in or drop-out or both in one unit. You can also choose from a wide selection of mounting and terminal styles. They operate on all popular ac or dc voltages.

Send for our catalog.

AGASTAT® TIMING INSTRUMENTS
ELASTIC STOP NUT CORPORATION OF AMERICA
AGASTAT DIVISION • ELIZABETH, NEW JERSEY
IN CANADA: ESNA LIMITED, 271 PROGRESS AVENUE, SCARBOROUGH, ONTARIO
ON READER-SERVICE CARD CIRCLE 52

TEST EQUIPMENT

Frequency converters

This frequency converter provides a 115-Vac output at 60 Hz ±1% from an input of 105 to 125 V, 380 to 420 Hz at 250 or 500 VA output power. Also standard is a 115-Vac output at 400 Hz ±1% with power levels of 250, 500 or 1000 VA from an input of 105 to 125 Vac 60 Hz ±10%. Regulation is ±2% from no load to full load. The sinusoidal output has a distortion of 3% total rms.

Protran Co. Inc., 7 Commercial St., Hicksville, N. Y. Phone: (516) 931-1880.

Circle No. 335

Dual beam scope

Model D53 dual beam 25 MHz scope has the signal and sweep delays built-in to the main frame eliminating delay lines. Signal delay is 0.25 µs and sweep delay is continuously variable to 50 ms in 2 ranges. The CRT is a split-beam 8.5 kV tube. Plug-ins provide time base and horizontal and vertical amplification. Horizontal deflection of both beams is up to 0.5 µs/cm in 22 calibrated ranges. The unit will trigger on 2 mm of internal display or 0.2 V p-p external.

P&A: $915 (main frame); $80 to $160 (vertical amplifiers); stock to 3 wks. Data Instruments, 7300 Crescent Blvd., Pennsauken, N. J. Phone: (609) 662-3031.

Circle No. 336
Panoramic* UNIVERSAL SPECTRUM ANALYZERS 20 cps to 27.5 Mc

Portable TA-2 and Rack or Bench Mount RTA-5 with 4 Solid State Interchangeable Modules

Make precise, rapid swept band analyses anywhere! Check out and pinpoint troubles in communications signals, sound, vibration, noise and RFI.

The standard—feature-by-feature □ AC/DC or internal battery operation □ Bright, easily read calibrated spectrum displays □ Digital frequency readout of scanned band □ Calibrated linear and 40 db log level scales □ Built-in Xtal markers for self-checking □ Simplified — few controls, many preset for optimum results.

4 solid state plug-in modules feature digital center frequency and sweep width controls □ “Quick-look” overall analysis and highly resolved narrow scans are quickly set up □ Advanced design provides excellent dynamic range, sensitivity, resolution and sweep repeatability.

Choice of analyzer main frames for all modules □ Compact RTA-5 main frame is only 19" wide, 7" high, and 18½" deep — ideal for space saving, rack- or bench-mounting □ Portable, solid-state TA-2 weighs only 40 pounds, complete with module and internal rechargeable battery pack — also operates from almost any AC or DC source.

Write for brochure, or contact your local Singer Instrumentation representative.
NOW! a NEW Shielded High Q Variable Inductor with exceptional stability!

The NEW Wee V-L

Adjustable Inductance range 0.15µH to 100,000µH in 0.300" by 0.400" molded case with 0.200" grid spacing.

24 HOUR DELIVERY!

The new Wee V-L now offers the design engineer these important advantages: Meets requirements of MIL-C-15305C; unitized epoxy molded construction; 77 stock values; and shielded for minimum coupling.

The Wee V-L is the newest product to join the Nytronics subminiature family of inductors, ceramic capacitors, precision wire wound resistors, thin film resistors and delay lines. Use coupon for engineering data!

Nytronics

Design leaders
STANDARD components to meet CUSTOM requirements

550 Springfield Ave., Berkeley Heights, N. J.

MAIL COUPON TODAY FOR COMPLETE ENGINEERING DATA ON THE NEW WEE V-L

TO: NYTRONICS, INC. Dept. ED
550 Springfield Avenue, Berkeley Heights, N. J.

Please send complete engineering data on the Wee V-L

NAME

TITLE

FIRM

ADDRESS

CITY STATE ZIP

ON READER-SERVICE CARD CIRCLE 53

TEST EQUIPMENT

Time comparator

Model 113 differential time comparator produces a linear full-scale output equivalent to ±5 ns. Frequency differences of 1 part in 10¹³ in approximately 15 minutes to 1 part in 10¹⁰ in 1 s may be determined. Differential switches calibrated in ns, along with a zero set control, eliminate phase-adjusting either input at the start of a measurement. The unit accepts 21 frequencies from 100 kHz to 10 MHz in both inputs. It requires 115 Vac or 22 to 30 Vdc with 100 mA drain at 26 Vdc.

P&A: $980 (single-channel) $1640 (dual channel); stock to 30 days. Parzen Research Inc., 48 Urban Ave., Westbury, N. Y. Phone: (516) 334-4900.

Circle No. 337

Power oscillator

The AC15 power oscillator delivers 15 VA from 0.1 Hz to 20 kHz with less than 0.05% distortion and amplitude stability within 10 ppm. Output voltage ranges from "0" to 160 Vrms. Frequencies are set and read with 4-digit selector switches with moving decimal point plus vernier. Frequency accuracy is 0.1%. Line and load regulation are less than 0.01% and internal resistance is adjustable through zero.

P&A: $1090 to $1600; stock to 30 days. Optimization Inc., 7243 Atoll Ave., North Hollywood, Calif. Phone: (213) 877-0221.

Circle No. 338

ELECTRONIC DESIGN, June 21, 1966
**BIG**: Big performance, big economy.

**small**: 5/8" diameter size.

**200**: CTS Series 200 composition variable resistor for numerous limited space industrial and commercial applications.

**NEW**: New straight and concentric tandems.
New solder lug terminals.

**High Dependability CTS Composition Element**: Proven over the years in all kinds of environments. Over 1 billion elements made; over 300,000,000 now in active service.

**Resistance Range**: 200 ohms through 5 megohms.

**Availability**: 3—6 weeks in quantity. CTS has the industry's largest output of controls.
Vlf receiver

Type 354 receiver tunes 1 to 600 kHz in a single band and receives AM, SSB, CW, MCW and FSK signals. A choice of four IF bandwidths (150 Hz, 1, 2 and 6 kHz), two audio bandwidths (100 Hz to 7 kHz or 825 Hz to 1175 Hz) and four levels of input attenuation (0, -20, -40 and -60 dB) is offered. Image rejection is 70 dB, IF rejection is 60 dB and dynamic range (AGC or manual) is 55 dB. BFO can be adjusted ± 7 kHz and incidental FM is less than 20 Hz peak deviation.

Totally solid state, the 354 weighs 20 lbs. and requires 3-1/2 in. of rack space. It operates from 115 Vac, 50 to 400 Hz, and consumes approximately 4 W. A long steel tape dial is employed for tuning.

P&A: $2000; 60 days. Communication Electronics Inc., 6006 Executive Blvd., Rockville, Md. Phone: (301) 933-2800.

Isolation amplifier

The triple-buffered model 5801 has a self-contained power supply. This unit has 3 independent ± 1 dB amplifiers with a capacitor input of 100 Hz to 5 MHz or transformer input of 100 kHz to 1 MHz. Outputs are at 1 V rms into 50 Ω with an isolation of 60 dB between them. Gain is adjustable over a 2:1 range. The all-silicon circuitry employs tantalytic capacitors.

P&A: $300; 6 wks. RMS Engineering Inc., 486 14th St., N. W., Atlanta. Phone: (404) 873-5257.

Null detector

Model 96016-A tunable null detector has a sensitivity of 1 µV full scale and a range of 25 Hz to 100 kHz. Either a linear or a logarithmic response can be switch-selected. The unit operates from two 6-V internal dry cells. Input impedance is 25 kΩ to 1 MΩ depending on gain control setting and output impedance is 300 Ω in series with 5 pF. Maximum output is 1 Vrms.


Logarithmic amplifier

Five decades (100 dB) of current input are compressed into a logarithmic voltage output. Model 157 chopper-stabilized log amplifier has a dc to 250 kHz frequency range. Full scale output is 5 V at 25 mA and accuracy is ± 2 dB/decade. The amplifier consumes 3 W.


Sine wave analyzer

Combining a sine-wave generator and analyzer, this transfer function analyzer operates from 24 Hz down to 1 cycle/minute. Either of the 2 output channels may be varied through 360°, permitting frequency response to be read off in polar co-ordinates. Readout is in 8 ranges, from 50 mV to 150 V. Generator outputs are 10 V max with output impedance of 10 Ω. Overall accuracy is ±2% in amplitude and ±1° in phase. Modulated signals having a 400-Hz carrier may also be generated and analyzed.

S. Smith & Sons Canada Ltd., 172/76 Baisley Blvd., Jamaica, N. Y. Phone: (212) 528-1900.

Volt-ohm-milliammeter

A transistorized switching circuit protects this portable 500-kHz VOM against accidental burnouts and overloads and eliminates changes in accuracy due to overheating. Sensitivity is 20 kΩ/Vdc and 5 kΩ/Vac and accuracy is ±1-1/2% dc and ±3% ac. The meter has a polarity reversing switch and diode network to protect against transients.

P&A: $895; stock to 30 days. Triplett Electrical Instrument Co., Bluffton, Ohio. Phone: (419) 351-4912.
Industry's enthusiastic acceptance of the type BIP-8211P NIXIE®
tube readout driver and the versatility of its basic design has led
the development of other circuit variations. These compact,
functional modules not only save you design, development, testing
and production costs but also give you the best device for trans­
lating low-level BCD inputs to decimal readout. Modules currently
available from stock include:
• BIP-8211P—accepts 8-line low-level (2V-35V separation) 8-4-2-1
BCD and drives the standard-size rectangular NIXIE tube, type
8422. • BIP-8224P—accepts low-level 4-line, 8-4-2-1 BCD and drives
the standard-size rectangular NIXIE tube, type 8422. • BIP-8227P—
identical to the BIP-8211P except it accepts logic-level separations
as low as 0.7V (from 0 °C to + 85 °C) making it compatible with low-
level, monolithic, integrated circuits. • BIP-8225P—used for com­
puter readout, it drives a NIXIE tube with an integral decimal point
(type B-59956). Type BIP-8225P accepts twelve 4-bit, binary-input
combinations (numerals 0-9, decimal point and blanking) and has
the capability of being electronically dimmed via a separate low­
level control input. • BIP-8222P—drives the type B-59956 NIXIE
tube with integral decimal point from low-level, 8-line, 8-4-2-1 BCD.
Decimal point is independent of BCD input and can either be "on"
or "off" when a numeral is "on". • BIP-8223P—identical to the
BIP-8211P except it operates over the wide temperature range of
-55 °C to + 85 °C.

Other modules which accept other BCD codes as well as decimal
inputs are also available individually or in complete Bezel Assemblies.
They are completely described in a new brochure, Bulletin
1108. For further information contact your Burroughs Stocking
Dealer in your area or Burroughs Corporation in Plainfield, New
Jersey. Dealers names, addresses and phone numbers are listed
for your convenience.

Only Burroughs manufactures NIXIE Tubes
Parametric op-amp achieves pico-level offset, drift and noise

Introduction of the parametric principle (in this case a balanced varactor bridge) to an operational amplifier allows order of magnitude improvements in offset and drift currents and in noise levels. This performance, along with high input impedance and wide common-mode voltage, could answer the needs of bio-medical instrumentation, process controls, electrometry and oceanography. The model 301 parametric op-amp also finds many applications in measurement, control and signal-conditioning.

Although individual improvements in offset, drift or noise performance have been achieved in other devices, the combined performance has apparently never been found in one package thus far. The input impedance of $10^{12} \Omega$ common-mode and $10^{10} \Omega$ differential is matched by FET types. However, the relative instability of FETs prevents those op-amps from achieving the $0.06-pA/^\circ C$ (at $25^\circ C$) drift current of the parametric amplifier. Input offset current ($1-pA$ at $25^\circ C$) is also at least an order of magnitude lower than that of FET types. The low-level ($\approx 30 \mu V$) pump signal of 10 MHz contributes to the input current capabilities.

The low noise figures of the 301 —0.01 pA and $1 \mu V$ p-p at sub-audio frequencies—derive from the balanced varactor bridge input. No active devices or biasing, it is virtually noise-free. "Flicker" (1/f) noise, due to the bias in active-device amplifiers, is eliminated. Johnson noise (random electron motion in resistors) and Schottky noise (junction leakage current) are inherently low. The high power gain of the varactor stage also swamps much of the noise generated in succeeding stages.

The transformer coupling allows a ±300-V common-mode voltage swing. Common-mode rejection ratio of $10^5$:1 is equivalent to that of vacuum-tube electrometers. Sub-millivolt inputs can be resolved even in the presence of a 300-V common-mode input.

Voltage drift is $30 \mu V/^\circ C$ from $-25$ to $85^\circ C$. Bandwidth is 500 kHz and max frequency for the full ±10-V, ±20-mA output is 5 kHz. Open loop dc voltage gain is $10^6$ and slewing rate is 0.3 V/µs.

P&A: $198$; stock to 3 wks. Analog Devices, 221 Fifth St., Cambridge, Mass. Phone: (617) 491-1650.

Varactor bridge has stored charge modulated by input and pump signals and provides 43 dB power gain. Noise-free output of this stage is proportional to the bridge unbalance or input error signal.
Why specify Mallory wet slug tantalum capacitors?

One reason:

☐ proven freedom from catastrophic failure.

Look at these quality control figures:

MTPH tests at rated voltage, 85°C; XT tests at rated voltage, 125°C and 175°C.

<table>
<thead>
<tr>
<th>Type MTPH miniature wet slug</th>
<th>Unit test hours</th>
<th>Catastrophic failures</th>
<th>% failure* /1000 hours</th>
<th>MTBF*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,259,311</td>
<td>1</td>
<td>0.038%</td>
<td>2.7 x 10^6</td>
<td></td>
</tr>
<tr>
<td>Type XT wet slug</td>
<td>8,291,100</td>
<td>6</td>
<td>0.09%</td>
<td>1.1 x 10^6</td>
</tr>
</tbody>
</table>

*60% confidence level

Want more reasons? Mallory Wet Slug Tantalum capacitors have up to five times higher microfarad-volt rating per unit volume than solid electrolytic types ... far lower DC leakage ... and need no voltage derating. We can help by recommending without bias the best type for your application because we make all types—wet slug, solid and foil. Write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.
PRECISION FILM RESISTORS
SAVE WEIGHT AND SPACE
AT NO SACRIFICE IN PERFORMANCE

HIGH STABILITY
HIGH RELIABILITY
LOW TC'S

CONFORMANCE TO MIL-R-10509 AND MIL-R-55182
MICRO-MINIATURIZATION • PERFORMANCE • VARIETY • ECONOMY

AMERICAN COMPONENTS, INC.
8th & Harry Streets, Conshohocken, Pa., Area 215 TA B-5240

ON READER-SERVICE CARD CIRCLE 58

RCL 1/2 "ROTARY SWITCHES
ESTABLISHING A NEW SET OF PERFORMANCE STANDARDS!
• Up to 12 positions per deck with stops.
• As many as 6 poles per deck.
• Shorting and non-shorting poles may be grouped on one deck in any combination.
• All individual deck parts are self-contained, and are permanently molded into place.
• Wiring to switches possible "in the flat".
• Easily assembled and disassembled with WireEasy construction.
“Off-The-Shelf” Delivery

Write for complete engineering information
ELECTRONICS, INC.
General Sales Office: One Hixon Place, Maplewood, New Jersey 07040

ON READER-SERVICE CARD CIRCLE 59

COMPONENTS

Hall multipliers
The HM-3000 series of Hall multipliers consists of temperature-compensated and un-compensated, error voltage-compensated and completely compensated models. The multipliers consist of a Hall element in the gap of a laminated silicon steel core with two identical field coils. An output voltage proportional to the product of the field input current and the Hall input current is produced. The units are epoxy-potted in a hermetically sealed steel case with 9-pin header.
P&A: $44 to $69.50; stock. F. W. Bell Inc., 1356 Norton Ave., Columbus, Ohio. Phone: (614) 294-4906.
Circle No. 347

Panel meter
The "Wide Vue" panel meter with 8-in. scale has ranges from 25 µA to 50 A and 10 mV to 500 V. Standard ranges have taut-band construction while pivot-and-jewel construction is available. Low power consumption and hysteresis and ±2% full-scale accuracy are featured.
Simpson Electric Co., 5200 W. Kinzie St., Chicago. Phone: (312) 379-1121.
Circle No. 348

ELECTRONIC DESIGN, June 21, 1966
FORWARD MARCH TO THE REAR!!!!!!!!

WITH DEUTSCH REAR RELEASE HIGH PERFORMANCE CONNECTORS

Break away from the rank and file! Head for the rear release connectors using uniform standards and tooling to meet the toughest service requirements. The leader in this battalion of total performers is the Deutsch rear release contact system needing one standard crimp tool, one assembly procedure, and one fail-safe, expendable insertion/removal tool. Use this system to march away from logistics problems and simplify field maintenance and repair.

Be prepared! On land, sea, in the air or outer space, there is a squad of Deutsch rear release products to perform beyond the call of duty; environmental series for aerospace, and non-environmental versions for support equipment.

You can bivouac from 3 to 199 conductors in:
- Miniature cylindricals with bayonet, push-pull-quick-disconnect, or thread coupling.
- Subminiature cylindricals with bayonet or push-pull-quick-disconnect coupling.
- Subminiature, high density rectangular types.
- PLUS, solve your terminal, bus and feed-through problems with Terminal Junctions ... the answer to high performance replacement of terminal strips.

Quick-step now, contact your Deutschman for full information about how you can go forward with rear release. Ask for Data File R-1.

ADVANCED SPECIFICATION REAR RELEASE ELECTRICAL CONNECTORS

ELECTRONIC COMPONENTS DIVISION • Municipal Airport • Banning, California

Electronic Design, June 21, 1966
Tilt!

No stoop, stretch, or missed readings with Behlman-Invar's exclusive TILT METERS.

Mount this DC power supply at floor level or above your head—you'll be able to tilt the meters for easy viewing and accurate settings and readings from any operator position!

6 VOLTAGE RANGES: from 0-5 to 0-100 VDC
6 CURRENT RANGES: from 0-6.5 to 0-0.60 AMP

The most power per dollar with silicon reliability... in quarter-rack size. Liberally derated circuit elements. Load regulation: 0.01%, Stability: 10mV/8 hrs. Remote voltage and current programming and sensing. Constant voltage, constant current, with automatic crossover. Provision for external modulation.

Tilt Meter. LIFETIME WARRANTY.

Model LRJR49 thermocouple reference junction provides a precise 150°F reference for up to 12 measurement channels. Designed for 105 to 125 Vac operation, the unit has stability and uniformity of ±0.1°F, channel-to-channel, over an ambient range of 20 to 120°F. Power consumption is 30 W max and warmup time is 15 minutes.

Pace Engineering Co., 13035 Saticoy St., North Hollywood, Calif. Phone: (213) 877-0727.

Circle No. 349

Series 7 ac potentiometers are size 11 20-turn units. Typically, output impedance is 20 Ω and absolute linearity is ±0.01%. Input impedance is 100 kΩ and input voltage is 30 V max, 400 Hz. Output current is 25 mA max. The pots are designed for servo and control systems and meet MIL-specs.

Perkin-Elmer Corp., Main Ave., Norwalk, Conn. Phone: (203) 847-0411.

Circle No. 350

A potentiometer-type pressure transducer with a 0.655-in. diameter has accuracy exceeding 1%. Absolute or gage pressure ranges are 0 to 350 to 0 to 20,000 psi. Resistances are 2, 5, 7.5 and 10 kΩ ±5%. The ac or dc output can be used for telemetry, control or actuating systems without amplification.

Servonic Instruments Inc., 1644 Whittier Ave., Costa Mesa, Calif. Phone: (714) 646-2400.

Circle No. 351

For an energy-storage capacity of 312 J at 25 kV, model ESC-259 parallel-plate capacitors have 0.5 nH self-inductance. Q in excess of 250 at 5 MHz results from the use of impregnated mica-paper as dielectric. Capacitors are available from 500 pF to 10 nF at voltage ratings to 25 kV.

Tobe Deutschmann Laboratories, 550 Turnpike St., Canton, Mass. Phone: (617) 828-3366.

Circle No. 352
The KEMET Golden Z-Series gives you up to three times the capacitance and voltage of standard solid tantalums... cuts space requirements up to 67%. Has gold-flashed lead wires—at standard prices. Two subminiature case sizes, ideal for cordwood modules, printed circuits, and other high density packaging.

Case lengths of 0.250" and 0.375" match standard resistors and diodes... diameters of 0.085" and 0.127" are as much as 67% smaller than other solid tantalums. Other features: excellent stability; very low leakage, dissipation factor, and impedance over a wide range of frequency and temperature. Meets electrical environmental characteristics of MIL specs C-39003 and C-26655B. Available from 0.0047 to 22 microfarads; in 6 to 125 VDC; to operate from -80 to +125°C. Want more details on the new Z-Series solid tantalum capacitors? Get the new KEMET Engineering Bulletin from our sales office or representative nearest you—or mail the coupon.

Regional Sales Offices
Mid-West and South: K. S. Collart, P. O. Box 6087, Cleveland, Ohio 44101. Phone: 216-221-0500.
West Coast: B. G. Bryant, 701 East Whittier Blvd., Whittier, California 90605. Phone: 213-698-8077.

KEMET is a registered trade mark of Union Carbide Corporation.

Clip, fill in name and title, attach to letterhead

Union Carbide Corporation
Linde Division, Dept. ED-63
270 Park Avenue, New York 10017

Please send Engineering Bulletin #6, on KEMET Golden Z-Series Solid Tantalum Capacitors

Name _____________________________

Title _____________________________

ELECTRONICS,v6,11,1966 145
COMPONENTS

Rotary reed switches
A line of magnetic reed rotary switches consists of eight models. They are available with form A or C contacts, or in combination. The rhodium contacts are isolated so that each stack handles up to 12 individual circuits. Models are available handling 1000 V max, 15 A in-rush and 3 A steady.
Circle No. 357

Porcelain capacitors
Radial porcelain capacitors with a ±25 ppm/°C temperature coefficient, 0.2-in. lead spacing and ratings to 200 Vdc are offered. The VY03 line consists of 13 standard values in a 5.1- to 1000-pF range. Dissipation factor is 0.001 at 25°C and 0.002 at 125°C. They operate from -55 to +125°C without voltage derating.
Vitramon Inc., P. O. Box 544, Bridgeport, Conn. Phone: (203) 268-6261.
Circle No. 358

Power resistors
Specifically designed for PC board mounting, series TR radial lead power resistors have a high-temperature silicone coating. Standard temperature coefficient is ±10 ppm/°C. The resistors are available from 1/2 to 10 W in resistance values from 0.5 Ω to 275 kΩ. Temperature range is -65 to +275°C. Units with a rise time of 20 ns are available.
RCL Electronics Inc., One Hixon Pl., Maplewood, N. J. Phone: (201) 763-2820.
Circle No. 359

INTEGRATED LOGIC MODULES

Lowest Prices in the Industry*

- 30 FAN-OUT, ALL SOURCES
- UP TO 4V NOISE REJECTION
- DC TO 5 MC
- 0 TO 70°C

We have solved the Noise Problem

NEW logic and circuit techniques, thoroughly tested for 9 months, have resulted in a minimum fan-out of 30 from all sources, 25% lower prices, and REALISTIC noise immunity from 0.9V to 4V. Delivery from stock. Send for complete and ACCURATE data.

Phone: 213 451-9754

COMPUTER LOGIC CORP.
1528 20th Street • Santa Monica, California

* $11.20 per JK Flip-Flop Unit Load Concept

A COMPLETE FAMILY OF COMPATIBLE TRUE BLUE LOGIC MODULES

ON READER-SERVICE CARD CIRCLE 63
Epoxy bridge rectifier

This epoxy bridge rectifier is a 2-A, full-wave bridge designed for consumer rectifier applications. The devices are available with 200, 400 and 600 V PRV ratings and working voltages of 140, 280 and 420 V rms. Peak one-cycle surge current is 100 A max. All devices have 2000 Vdc minimum circuit-to-case insulation. Controlled and noncontrolled avalanche series are available.

Price: under $1. Varo Inc., 2201 Walnut St., Garland, Tex. Phone: (214) 275-6141.  
Circle No. 360

Voltage programer

A solid-state voltage programer for low-voltage power supplies generates a positive or negative going ramp function. Solid-state circuitry allows for variable ramp rates. The unit can be used with any dc supply with a remote voltage program resistance of 500 to 1000 Ω/V in the range of 0 to 40 V. Overshoot, undershoot and noise problems are eliminated.

Sparton Southwest Inc., P. O. Box 1784, Albuquerque, N. M. Phone: (505) 898-1150. Circle No. 361

Why pay for Oscilloscope capabilities you don’t really need?

There are many situations—production line work, product quality checks, basic laboratory measurements—that require a large number of scopes or employ standard measurements... and where simplicity of operation is essential.

That’s where you need the RCA W0-91B!

Of course the so-called “industrial/laboratory” type scopes will make certain measurements that ours won’t. They may feature triggered sweep, horizontal deflection in microseconds, and other costly refinements. Whenever you need these extras... capability for those extremely precise measurements... spend the money and buy an expensive scope.

Actually, for many very precise research, experimental and lab measurements, we don’t even recommend ours (we use theirs).

But if your requirements call for scopes with characteristics such as the following, the RCA W0-91B is probably your best buy:

• Built-in voltage calibration—large 5-inch screen with VTVM-type voltage scales for fast, simultaneous peak-to-peak measurements and wavseshape display • Flat response (± 1 dB) from 10 cps to 4.5 Mc • 0.018 rms volt per inch maximum sensitivity for use at low signal levels • Continuously adjustable (to 100 kc) sweep oscillator with excellent linearity • Z-axis input for direct modulation of CRT permitting use of timing and calibration markers on trace • Provision for connecting signals directly to the vertical deflection plates of the CRT.

The Optional User Price of the RCA W0-91B is $249.50. It is available locally from your Authorized RCA Test Equipment Distributor. Ask to see it or write for complete specifications to RCA Commercial Engineering, Section F18W-5, Harrison, N.J.
Rotary transformers couple power into rotors without contact, eliminating the number-one cause of early synchro failure. Without brushes, synchro life depends on bearing life alone—normally at least 5 or 6 times average brush life.

Harowe brushless synchros are available for all functions: control and torque transmitters, control transformers, differentials, resolvers. Sizes 5, 8, 10, and 11 are standard; larger sizes available. Use them to boost life expectancy of new systems; upgrade existing systems. Write for complete specs—

Harowe

HAROWE SERVO CONTROLS, INC.
22 Westtown Road
West Chester, Pa. 19380
(215) 692-2700
SERVO, SYNCHRONOUS AND STEPPER MOTORS
MOTOR GENERATORS • SYNCHROS • RESOLVERS
PANCAKE SYNCHROS • GEARHEADS
ON READER-SERVICE CARD CIRCLE 65

A miniature spark gap has a striking voltage of 90 Vdc. It is a radio-active isotope prompted gas-filled surge voltage protector. Current carrying capacity is 5000A for a 10- to 20-μs waveform. Capacitance is 2 pF and insulation resistance under unignited condition is 10^{10} Ω. The protector measures 0.38-inch in diameter and 1/4-inch in length.

Siemens America Inc., 350 Fifth Ave., New York. Phone: (212) 564-7674.

Circle No. 353

This 80-circuit motor-driven sequence cam switch has a 10⁶ cycle life. Up to 80 spdt contacts can be operated at speeds of 1 through 35 cycles/minute. A maximum of 20 notches on each cam can be obtained. Four notched or unnotched cams are maximum for standard unit. The switch is designed for repeat cycle control.

P&A: $9 to $12; stock to 60 days.

Circle No. 354

Standard resistance range of this 0.0015-in.³ resistor is 50 to 200 kΩ. Applications include amplifiers and preamps, wave shaping networks and logic modules. Model 4200 offers a cermet element, an alumina substrate and weldable and solderable leads. Power rating is 70 mW at 100°C, temperature range is -65 to +150°C and resistance tolerances available are 1, 5 or 10%.

Bourns, Inc., 1200 Columbia, Riverside, Calif. Phone: (714) 684-1700.

Circle No. 355

Switching over a pressure range of 30 to 0.04 mmHg (70,000 to 230,000 feet) is accomplished by this high-altitude pressure switch. The switch withstands 20 G vibration, 150 G linear acceleration and has an operating range of -20 to +165 °F. A temperature-controlled thermocouple pressure sensor a constant-voltage source, a dc amplifier and flip-flop switching are used.

MetroPhysics Inc., 331 N. Milpas St., Santa Barbara, Calif. Phone: (805) 965-2526.

Circle No. 356
A family of three perforators is just right when it satisfies about 99 percent of the applications. And these Tally perforators do. Easily the best known perforator on the market today is the wonderfully reliable Tally 420 which operates at 60 characters per second. Some of our customers have operated this perforator up to 500 million cycles without overhaul. Fastest perforator in the family is the Tally P-150, which, as you might guess, operates at 150 characters per second. Rounding out the line is our popular 120 character per second perforator, the P-120. The Tally P-120 and P-150 offer a remarkable degree of sophistication. With the parity option they catch their own mistakes while working at maximum speed. Here’s how it works. Parity contacts in the perforating mechanism allow interrogation during a punching cycle and before the tape is advanced to the next character. If an incorrect parity code is sensed, (1) tape advance is inhibited, (2) the code in error is overpunched with an all-hole delete code, (3) tape is advanced and the same character punched again. Clean accurate tapes are a virtual certainty. All Tally perforators accept paper, plastic, or foil tapes. They feature asynchronous operation so that punch commands can be accepted at any time interval up to maximum speed. Tally perforators handle 5 through 8 channels on any standard tape up to 1 inch without modification. Tally perforators have high quality die blocks and precision honed punch pins individually fitted for long life punching. All models offer integral reeling. All Tally perforators are available in 50/60 Hz, 115/230 vac models. Options include bit echo verification, remote backup, end of tape, low tape, tape motion sensors, and teletypesetter configuration.

Write for more wisdom. Complete data on each and every member of the Tally group of perforated tape equipment is yours for the asking. For your information please address K. Crawford, Tally Corporation, 1310 Mercer Street, Seattle, Washington 98109. Phone: (206) MA 4-0760. TWX: (910) 444-2039. In the U.K. and Europe, address H. Ullyjohn, Tally Europe, Ltd., Radnor House, 1272 London Road, London, S.W. 16, England. Phone POLlards 9199.
ANY ENCLOSURE...

...ANY WEIGHT

From Chassis-Trak you get the broadest range of slide weight capacities and the ideal enclosure for your application. Flexibility...plus uncompromising Chassis-Trak quality...have made Chassis-Trak a part of the package on every major missile project.

Just make sure the slides you order have the Chassis-Trak of Indianapolis, Seal of Quality...your protection against inferior imitations...ask about Vent-Rak cabinets.

A Package for Every Major Missile Project from

525 South Webster Avenue, Indianapolis, Indiana

With Chassis-Trak, you get:
- Ultra-thin slides for standard racks and cabinets
- Choice of tilt, non-tilt, tilt-lock versions in most models
- Poxylube 75 dry-film lubricant
- Choice of solid or roller bearings
- Delivery from stock in standard models

Distributed amplifiers

High-output distributed amplifiers deliver 30 V p-p into 75 Ω or 25 V p-p into 50 Ω. Bandpass ranges are 1 to 30 MHz, 10 to 30 MHz, 50 to 100 MHz or 75 to 125 MHz. Gain is 20 dB min. Other bandpass ranges, gains and characteristics are available.

C-Cor Electronics, Inc., 60 Decibel Rd., State College, Pa. Phone: (814) 238-2461.

Circle No. 362

Adjustable time switch

Timing periods from a few minutes to more than 13 months may be set on this adjustable switch. The unit switches at the end of the timing period with an aggregate error of 1 hour/year. Model 6410 contains a jeweled timepiece driven by a brushless dc motor. The internal battery powers the unit for 10,000 hours. Switch contacts are rated at 1 A resistive and inductive at 28 V.

General Oceanographic Co., P. O. Box 66006, Los Angeles. Phone: (213) 398-8790.

Circle No. 363

COMPONENTS

Components

Electronic Design, June 21, 1966
YES, THIS NEW MINIATURE SWITCH ACTUALLY

BREAKS 7 AMPS AT 125 VAC

CARRIES 15 AMPS AT 125 V

Model 711 is a single-pole, nonshorting selector switch that reaches a new high in compactness. It's a load-break, power switch beyond any doubt, but with a 1½" body diameter, it is smaller than many instrument switches of much lower rating.

How can Ohmite cram such a whopping rating into such a small "package?" Only because the Model 711 reflects 25 years of experience in switches up to 100 amps. It's your guarantee for reliability and long life.

Small: Only 1½" in body diameter; extends 1⅛" behind panel.

Breaks: 7 Amps, 125 VAC (75% power factor) load.

Carries: 15 Amps, AC or DC, 125 volts.

Contacts: Solid-silver-alloy to solid-silver-alloy; 2 to 11 contacts.

Dual-Purpose Terminals: Solder 'em, or push on a ⅛" quick-connect terminal.

Slow-Break, Quick-Make Action: Minimizes sparking and increases contact life with AC. Wiping-action contacts are self cleaning. 30° Indexing.

Superb Construction: Melamine-phenolic body has high insulation rating and resists arc-tracking. Unlike most small switches, thick conductors, not thin springs, carry the current. Stainless steel shaft, ⅛"-32 brass mounting bushing.

Singles and Gangs: Single decks can be supplied enclosed; gangs of two or more decks are enclosed. All mount on ¼" thick maximum panels.

NEED SWITCHES UP TO 100 AMPS? Then write for Catalog 400. It covers nonshorting, power-type switches with load-break ratings from 15 to 100 amperes (2 to 12 taps) and an extensive line of unenclosed types with 2 to 77 taps. Many variations are described along with valuable information on switch selection.

Write for Bulletin 403

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS • SEMICONDUCTOR DIODES • R.F. CHOKES

OHMITE MANUFACTURING COMPANY
3643 Howard Street • Skokie, Illinois 60076
Phone: (312) ORchard 5-2600

ON READER-SERVICE CARD CIRCLE 68
CUT BREADBOARDING TIME . . . . 4 WAYS

New MICRO PLUGBORDS with subminiature connectors. The .042" or .025" dia. holes on .1" or .05" centers allow greater packaging density than possible before with pre-punched boards. Available also without connectors and in copper clad epoxy glass.

Pre-punched PLUGBORDS with Varicon or Vector Edge-Pin contacts ready for your components. Insert Mini-Klip Push-In terminals where needed. JEDEC hole spacing matches transistor leads. "Elico Trademark.

ETCHED CIRCUIT KITS 27X and 27XA provide all materials for making quick, inexpensive etched circuits. New 27XA has time-saving Vectoresist, the "rub-on" transfer resist sheet with lines, circles, ellipses, pads and standard .156" contacts, plus Vectorbord and unpunched copper clad cards and ready-to-use etch bags.

Large and small BREADBOARD KITS with complete hardware systems for faster breadboarding in Lab. or school experiments. Complete with solderless Springclip, solderable push-in terminals, transistor and tube sockets. New Hi Frequency breadboard kit now available.

COMPONENTS

Ni/Cd batteries

Rechargeable “power plant” nickel-cadmium batteries can be repeatedly discharged and recharged. Three basic cell types (button, cylindrical and rectangular) are available in twenty-three capacities from 20 mA-hours to 23 A-hours. Operating voltage is 1.2 V. The hermetically sealed cells are also available in custom configurations.

Bright Star Industries, 600 Getty Ave., Clifton, N. J. Phone: (201) 772-3200.

Circle No. 364

500-G accelerometer

This strain gage accelerometer has a built-in amplifier capable of directly driving magnetic tape or oscillograph recorders. Output of the type 4-290 is amplified by an integral stable differential de amplifier to ±5 Vdc. Acceleration range is ±5 to ±500 G. Operable temperature range is −65 to +250°C, and weight is less than 7 oz. The unit measures acceleration perpendicular to the mounting surface.

P&A: $995; 45 days. CEC, Data Instruments Div., Monrovia, Calif. Phone: (213) 796-981.

Circle No. 365

High-voltage capacitors

Glass-cased capacitors are suitable in high-voltage applications from −55 to +125°C with no voltage derating. The paper-plastic film dielectric, the high dielectric strength of the impregnant, and the thermal glass tubing provide size and weight reductions.

The tubular capacitors provide high resistance to mechanical stresses.

Gudeman Co., 340 W. Huron St., Chicago. Phone: (312) 337-7400.

Circle No. 366

Ratchet counter

The wheels of this subtracting type predetermining ratchet counter may be preset to any figure up to 99,999. In operation, the counter subtracts from the pre-set number to 00,000. At the passage of 00,000 an spdt switch is actuated. Maximum counting speed is 500 strokes/minute. Angle of throw is 36 to 60°. The 5-digit unit is rated at 5 A, 220 Vac.

Landis & Gyr Inc., 45 W. 45th St., New York. Phone: (212) 586-4644.

Circle No. 367
THESE CON AVIONICS POWER SUPPLIES COST $200 LESS THAN THE GOING RATE. WHAT DO YOU TRADE OFF WHEN YOU BUY THEM?

NOTHING.

You certainly don't trade off quality. Our power supplies are guaranteed unconditionally for five years. They have an M.T.B.F. of 35,000 hours, calculated according to Mil Handbook 217. Silicon transistors are used exclusively.

The secret in manufacturing these units for $200 less than the going rate is designing systems power supplies right from the start. (Most other manufacturers just warm over their designs for lab supplies.) So our way, with a lot of value analysis and some new techniques, we're able to pack a lot of value into just 5¼" of panel height.

If you buy systems power supplies it could very well be worth $200 to you to have Con Avionics' data available.

PARTIAL SPECIFICATIONS

INPUT: 105-125 VAC, 47-63 cps
REGULATION: (Line and load combined) ±0.05%
RIPPLE: 1 mv RMS max
RESPONSE TIME: 25 microseconds
TEMPERATURE COEFFICIENT: 0.015% /°C or 18 mv/°C., whichever is higher
TEMPERATURE: 75°C max.
M.T.B.F.: 35,000 hours
GUARANTEE: 5 years, unconditional

The entire voltage range between 0 vdc and 51.0 vdc is covered in 42 models. Currents range from 5.5 amps to 46.0 amps. Wattages from 55 to 816.
60-cycle source?

Stability $\pm 0.2\%$
to a second
per month
$(3 \times 10^{-3} \text{ per 24 Hour})$

Price $60$ up.

Think TRACOR

For further information:
TRACOR, Inc.
General Sales Office
6500 Tracor Lane
Austin, Texas 78721
Phone: 512-926-2800

COMPONENTS

Hybrid dc amplifier

A hybrid microelectronic dc amplifier, TMS 1301, occupies less than 0.1-in.². The amplifier operates from a power supply voltage of $\pm 12 \text{ V}$ and has a minimum dynamic range of $\pm 8 \text{ V}$. Bandwidth is 1 MHz, gain is nominally 1000 and offset at the input is 4 mV. Packaging arrangements are available to special order.


Circle No. 368

2-pin quartz crystal

Two-pin quartz crystal units are offered encased in evacuated glass envelopes. The three styles meet Mil-C-3098. Evacuated glass construction improves frequency tolerances, aging characteristics, long-term reliability and enables operation at up to 150°C. Type 4444 is available in frequencies from 1.6 to 100 MHz and types 4445 and 4446 cover the 5 to 100 MHz band.


Circle No. 369

1-in. vertical attenuator

A new 1-in.-wide vertical or slide attenuator has either 20 or 30 steps in a balanced or unbalanced ladder, T or potentiometer circuit. Impedance ranges are 30 to 600 Ω on ladders or T's and up to 1 MΩ on potentiometers. Standard dB per step is 1.5. All contacts and wipers are solid silver alloy and terminals are located at the upper back end.


Circle No. 370

Sine wave inverter

A 115-Vrms, 400-Hz sine wave inverter is rated at 100 W. The inverter operates from an input of 24 to 30 Vdc. Output power is rated at 100 VA at 50°C or 80 VA at 71°C. The wave shape is sinusoidal with 4% max harmonic distortion at full load.


Circle No. 371
What's the charge?

GLASKYD®
ALKYD

the better molding compound for electrical— electronic products

Here's why GLASKYD glass-reinforced alkyd compounds in continuous rope and cut slug form gain wider acceptance every day:
• excellent dielectric strength
• dimensional stability
• resistance to heat, flame and moisture
• wide choice of colors.

GLASKYD offers economy through new, automated cold plunger molding—with fast cure, short cycles, high production rates. This alkyd also can be molded by compression or transfer techniques.

Widely used in such applications as electrical housings, connectors, coil bobbins and strips, switches and collector rings. GLASKYD also is ideal for arc-less switches, phase barriers, brush holders and tuner strips.

Rope in new markets, new product quality—with GLASKYD.

For details, write:

Cyanamid
American Cyanamid Company, Plastics & Resins Division, Wallingford, Conn.

Sales offices in: Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York
Oakland • Philadelphia • St. Louis • Seattle • Wallingford. Also available in Canada.
What is really important when evaluating crystal frequency standards?

How much can you find out from aging-rate data?

Components

Multi-turn pot

Toroidal inductors

Single-turn pot

Cermet trimming pot

Models 875 and 876 7/8-in. potentiometers are available in 3, 5 and 10 turns, 1/8 or 14-in. shaft, with standard bushing or servo mounting. Resistance range is 25 Ω to 250 kΩ with a linearity tolerance of ±0.25%. These 1-oz pots have a 3-W power rating at 40°C ambient. Life expectancy is 2 × 10⁶ shaft revolutions.

Electro-Techniques, 11301 E. Ocean Ave., La Habra, Calif. Phone (213) 691-0741.

Circle No. 372

Series L toroidal inductors provide 1 to 40,000 mH from 100 Hz to 100 kHz. Inductance is stable to within ±2% from −55 to +85°C. Due to the closed field, magnetic shielding is not required. The units have 5-in. teflon leads. Adjacent stacking results in a minimum of mutual coupling.

Price: $8.08 to $28.54 (1 to 9). Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. Phone: (213) 894-2271.

Circle No. 373

A 7/8-in. bushing mount potentiometer, model 1232, is available in single and multi-cup configurations. Resistance range is 100 Ω to 20 kΩ. Resistance tolerance is ±5% and linearity tolerance is ±0.5%. Life expectancy is 2 × 10⁶ revolutions and power rating is 1.25 W at 40°C. Up to 9 taps and 6 cups can be accommodated.

P&A: $6.75 (over 250); stock. Duncan Electronics Inc., 2865 Fairview Rd., Costa Mesa, Calif. Phone: (714) 545-8261.

Circle No. 374

This trimming potentiometer is a 1/4-in. diameter, single-turn unit with pins spaced on a 0.1-in. grid. Pin length is 3/16-in. Standard resistances available are 10 to 1 MΩ. The cermet element offers a power rating of 0.5 W at 85°C, derating to 0 at 150°C. The 0.75-gram unit is available in continuous rotation or stop configurations.

Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 781-4848.

Circle No. 375

Two reports will be of special help if you want to know the fine points in evaluating a crystal frequency standard.

One is "Selection of a Frequency Standard", Application Report 1266.

The other is a National Bureau of Standards report on a specific oscillator of this type.

Both are yours via the reader-service card in this magazine — or for faster response write directly to:

TRACOR, Inc.
General Sales Offices
6500 Tracor Lane
Austin, Texas 78721
Phone: 512-926-2800

Sulzer Division
© Representatives in principal cities

On Reader-service card circle 71
Small amplifier... Small price ($85)...

Big input impedance

Here is a new operational amplifier from NEXUS that brings you a happy combination of extremely high input impedance; low, low input leakage current; and a very favorable price.

Utilizing field effect transistors in its input, the LFT-1 presents an input impedance of well over a thousand megohms. FET input leakage currents are typically 50 picoamps at 25°C and 1 nanoamp at 85°C.

The LFT-1 costs only $85* in quantities of 1 to 9... substantially less in larger quantities. Delivery is generally within two weeks.

The new FET unit is ideally suited to applications requiring extremely low error currents, such as integrators, sample and hold circuits, and electrometer circuits. The high input impedance and low error currents permit both inverting and non-inverting amplifier configurations, using input and feedback resistors with values of the order of hundreds of megohms.

Send for new data sheet.

---

TYPICAL LFT-1 CHARACTERISTICS
(at 25°C unless otherwise stated)

- Differential input Z @ d-c: $10^{10}$ ohms
- Open loop gain @ d-c (RLL = 10K): $5000$
- Unity gain crossover frequency: $1$ mc
- Input leakage current @ 25°C: 50 picoamps
- Input leakage current @ 85°C: 1 nanoamp
- Output: $10v$ @ $2mA$ (min.)
- Input common mode voltage range: $10v$ (max.)
- $\Delta V_{cm}/AT$ (-25°C to +85°C): $10v$ (max.)
- Supply voltage: $15v$
- Operating temp. range: -25°C to +85°C
- Storage temp. range: -50°C to +100°C
- Case size: 2.02" (l) x 1.14" (w) x 0.62" (h)

---

* Prices F.O.B. Canton, Massachusetts - Prices apply to North America only.
This is a typical sheet from Latronics new catalog on Ceramic and Glass-to-Metal Seals.
SEND for Latronics Catalog 100-266-1.

**Latronics Corporation**
1004 Lloyd Avenue, Latrobe, Pa. 15650 • Phone 412-539-1626 • TWX 412-594-7857

---

**COMPONENTS**

**Ceramic vacuum relay**
Model HC-1 ceramic vacuum relay is capable of switching up to 2.5 kVdc and carrying up to 18 A rms. The spdt unit has a max operating time of 6 ms, a coil resistance of 335 Ω and a coil voltage of 26.5 Vdc. It is evacuated to 10⁻⁸ mm of Hg.
P&A: $59 (1 to 9); stock to 30 days. High Vacuum Electronics Inc., 538 Mission St., South Pasadena, Calif. Phone: (213) 682-3661. *Circle No. 378*

**IF phase shifters**
Variable phase shifters from 1 to 200 MHz incorporate a reactive circuit of lumped parameter devices. Voltage variable capacitors control desired phase shift. Center frequencies of 30, 60 and 70 MHz are offered. All have typical bandwidths of 10% and can be biased to shift 0 to 180° over insertion phase shift. To sweep the full 180° phase variation, 60 V are required. Impedance is 50 Ω at each port, vswr is 1.5 and insertion loss is 1 dB max.
Merrimac Research and Development Inc., 517 Lyons Ave., Irvington, N. J. Phone: (201) 371-1616. *Circle No. 379*
The Hoffman HCD-4 microminiature planar epitaxial passivated diode is designed for computer memory core driver and similar switching applications under 6 nanoseconds.

It features controlled forward conductance, with specified maximum limits on junction capacity and stored charge, to provide devices of uniform reproducible performance.

The conventional method of characterizing the switching speed of a diode by the measurement of the reverse recovery time is not used for fast switching diodes.

Hoffman uses a direct measurement of stored charge of the diode by integrating the reverse current of the diode. The stored charge represents an inherent characteristic of the diode and provides a single, unambiguous figure of merit which has minimal dependence on test conditions or jigs.

Repeatability of storage value measurement to within 5% can be made on direct reading low cost equipment.

For additional information regarding this product, write Hoffman Electronics, Dept. A, El Monte, California.

**MAXIMUM RATINGS**

Power Dissipation: 500 Milliwatts (Derate 3.3mW/°C above 25°C)

Operating Temperature Range: -65°C to +175°C

Storage Temperature Range: -65°C to +200°C

Electrical Specifications: 25°C unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Current (Note 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; = 100 µA</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>430</td>
<td>550</td>
<td>mV</td>
</tr>
<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; = 1 mA</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>540</td>
<td>660</td>
<td>mV</td>
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<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; = 10 mA</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>650</td>
<td>770</td>
<td>mV</td>
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<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; = 100 mA</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>790</td>
<td>890</td>
<td>mV</td>
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<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; = 500 mA</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>960</td>
<td>1350</td>
<td>mV</td>
</tr>
<tr>
<td>Breakdown Voltage</td>
<td>V&lt;sub&gt;B&lt;/sub&gt; = 100 µA</td>
<td>75</td>
<td></td>
<td>Volts</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>V&lt;sub&gt;R&lt;/sub&gt; = 50 Volts, T&lt;sub&gt;1&lt;/sub&gt; = 100°C</td>
<td>I&lt;sub&gt;R&lt;/sub&gt;</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>I&lt;sub&gt;R&lt;/sub&gt; = 20 nA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stored Charge (Note 2)</td>
<td>Q</td>
<td>100</td>
<td></td>
<td>Pico Coulomb</td>
</tr>
<tr>
<td>Capacitance</td>
<td>C&lt;sub&gt;0&lt;/sub&gt; = 5 nF, f = 1 Mc</td>
<td>2.0</td>
<td></td>
<td>pF</td>
</tr>
</tbody>
</table>

Note 1 — Test time at each forward test current 30-40 milliseconds.

Note 2 — Measured on B-Line Electronics Model Q3-3 Stored Charge Meter.

Conditions: Pulse Amplitude = 5 Volts
Pulse Width = 50 nsec.
 Rise Time = 4 nsec.
 Source Impedance = 10 Ohms
Stored charge measurement accuracy ±4% of full scale.

**SEMICONDUCTORS**

Electronic Design, June 21, 1966

ON READER-SERVICE CARD CIRCLE 74
COMPONENTS

Propeller fan performs like blower

The 7-in.² “Tarzan” fan delivers the performance of squirrel-cage blowers. The compact unit is designed for cooling microelectronic modules, PC card chassis for discrete components, computers and communications transmitters. Range of application is 150 to 300 cfm. Axial depth is 4-11/32-in.

Price: $23.50 (1,000 lots). Rotron Mfg. Co., Inc., Hasbrouck Lane, Woodstock, N. Y. Phone: (914) 679-2401.

Circle No. 380

Multi-tap delay line

Featuring a built-in pulse equalization network, a multiple tap delay line is designed for pulse encoders and decoders. The pulse network provides an output amplitude at each tap within ±1 dB on the nominal amplitude at the end of the line. The hermetically sealed unit measures 3-1/8- x 4-1/2- x 1-1/4-in.

P&A: $100; stock to 8 wks. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. Phone: (213) 892-0671.

Circle No. 383

Notch filter

Model APN-60 is an active notch filter which eliminates the 60-Hz frequency without signal distortion. Rejection bandwidth of this filter can be narrowed to 2 Hz without a phase shift in the pass band. Pass band is dc to 25 kHz with a max insertion loss of 0.5 dB. Power required is a regulated ±12 V at 2.5 mA. Input impedance is 1 MΩ.


Circle No. 384

A/D converter card

This analog-to-digital converter card uses integrated circuits. Input range is ±5 V and conversion time is 1 μs/bit max. Output format is 10 parallel binary bit data. Conversion frequencies exceed 100 kHz with internal or remote clock command. Resolution is 10 bits and linearity is 0.05% or 1/2 bit.

P&A: $1200; stock to 60 days. Pastoriza Electronics Inc., 385 Elliot St., Newton Upper Falls, Mass. Phone: (617) 332-2131.

Circle No. 385

X-Y sawtooth generator

Two highly stable and linear gated sawtooth generators are combined to form the SG415. Each is dc coupled, and screwdriver adjustable pots provide a ±50% width adjustment. Nominal sawtooth widths can be specified from 6 ns to 500 ms. Provisions are made for the connection of external timing capacitors.


Circle No. 382

PC reed relays

Mercury-wetted contact and dry reed relays for PC applications measure 3/8-in. high. The units are available in dry reed contact configurations up to 3pst-NO or dpdt and in mercury-wetted contact configurations of spst-NO or dpst-NO. Dry contacts are rated for 10 VA non-inductive loads at up to 250 mA or 100 V max. Mercury-wetted contacts are rated for 28 VA non-inductive loads up to 1 A or 100 V max. Operate time is 1 ms.

Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago. Phone: (312) 282-5500. Circle No. 381

ON READER-SERVICE CARD CIRCLE 246
Now from a new, expanded air variable capacitor line, you can satisfy your capacitor needs in more ways at low cost. From the Johnson line, offering capacitance values up to 1700 pf and peak voltage ratings from 650 to 13,000 volts, you can specify air variables and be assured your design will yield a product that's competitively priced. Johnson air variable capacitors range from sub-miniature types to large units suitable for heavy duty applications. Whatever the use, they provide excellent stability, high Q, uniform capacitance, and exhibit low "hook" in applications involving a square wave form.

For complete capacitor information write on company letterhead for free, detailed Johnson components catalog No. 700.
MACHINED PLATE TRIMMER AND TUNER TYPES - U, UA, UB, U·LC, V, AND W - Available in both printed circuit and chassis mounting types. U types available in differential and butterfly printed circuit mounting types in addition to single section types. V and W capacitors available in single section type only. Maximum capacities of up to 54 pf. Tuners consist of a machined plate trimmer and high Q air wound silver plated inductor, in resonant frequencies of 100 to 750 Mc.

SOLDER PLATE TYPES - Type M: Capacity values to 30 pf. Voltage ratings to 1250 volts peak. Available in single section, differential and butterfly types.
Type S: Capacity values to 100 pf. Voltage ratings to 3000 volts peak. Available in single section, differential and butterfly types.
Type K: Capacity values to 150 pf. Voltage ratings to 3800 volts peak. Available only in single section types. May be furnished in production quantities in full compliance to MIL-C-92A.

SUB-MINIATURE INSULATED TYPES - Designed for printed circuit applications. Operating voltages to 1500 volts RMS . . . 5 amperes current carrying capacity . . . contact resistance less than 2 milliohms. Capacitance between two adjacent jacks less than one pf at 1 Mc. 10 colors available. Test-Point Strip/Handle - rapid-mounting polyamide body contains 12 test points each rated at 5 amps., maximum current capacity. Operating voltage 1500 volts RMS at sea level, 350 volts RMS at 50,000 feet. Contact resistance less than 2 milliohms.

STANDARD INSULATED CONNECTORS - A complete line of connectors molded of tough, low-loss, shock-proof polyamide in 10 colors meeting Fed. Std. 595. Tip, Banana and Dual Banana Plugs; Tip and Banana Jacks; Metal-Clad Tip Jack, Military; Jack and Sleeve; Binding Posts.

RIB-LOC TERMINALS - A new line of miniature, one-piece, insulated terminals with a unique serrated conical design, which resists loosening and turning. Provides an inexpensive approach to convenient press-in type terminals. Six colors conforming to Federal Color Standard No. 595. Terminal styles include single and double turret feed-thrus and stand-offs, .040" dia. tip plug and mating jack for .040 plug.

ULTRA HIGH FREQUENCY SOCKETS - Continuous heat resistance to 500°F, with low loss, glass filled silicone base and heat treated beryllium copper contacts. Low inductance screen bypass capacitor available for VHF and UHF operation.

KEL-F SERIES - Molded of low dielectric loss-factor Kel-F plastic - designed for use with a wide selection of high power transmitting tubes.

STEATITE WAFER TYPES - Available in 4, 5, 6, 7, and 8-pin standard socket types, as well as Super Jumbo 4-pin types. Also giant 5 pin, and 7 pin Septar and VHF Septar Sockets.

SPECIAL PURPOSE TYPES - Includes sockets for special purpose tubes.
Note: For detailed specifications, request Socket Standardization Booklet 536 on your company letterhead.

CHECK Johnson for all your component requirements

Johnson also offers a complete line of heavy-duty RF components for broadcast transmitting, RF heating, antenna phasing and other commercial applications.

Equipment in this line includes fixed and variable inductors, antenna phase sampling loops, isolation filter inductors, feed-thru bowl insulators, static drain chokes, RF contactors and heavy-duty make-before-break switches.

E. F. JOHNSON COMPANY
WASECA, MINNESOTA 56093
COMPONENTS

Active filter

This low-pass active filter offers 60-dB min attenuation from 3 Hz to 100 kHz and handles 5 A dc. It is designed to prevent noise generated by a randomly fluctuating load from being reflected through the power supply and into the distribution system. Typically, a 30-A spike drawn by the load will be attenuated to 3 mA at the power supply. Custom units are available.


Circle No. 386

Band pass filter

A new passive band pass filter is designed to eliminate saturation and third harmonic distortion problems. The output signal is typically phase-adjustable to ±10° (±5° min). Insertion loss is 3 dB.

Model BP41 has center frequencies from 400 to 10,000 Hz with a Q of 4. It provides 58 dB min attenuation for all frequencies greater than three times center frequency.

Guillemin Networks Inc., 170 Brookline Ave., Boston. Phone: (617) 536-5810.

Circle No. 387

Junction compensator

A miniature cold junction compensator for Chromel-Alumel thermocouples eliminates the need for ice baths, boiling water or transitional salts to achieve a constant temperature reference in which to embed the cold junction. With an input of 400 mV into 3.7 kΩ ±1%, the output of the compensator is 11 mV ±3% at 25°C. Tracking ability is within 80 µV from -65 to +125°C.


Circle No. 388

11-crystal oven

Up to 11 plug-in crystals may be installed in the low-power model 900-0153 oven. Power consumption is 6.6 W at turn-on and 1.5 W average at 25°C. Standard operating temperatures are 65, 75 and 85°C. Standard operating voltages are 12 Vdc, 24 Vac or 115 Vac. The ovens are suited for battery-powered mobile communications.

P&A: $22 to $29 (without crystals); stock to 6 wks. CTS Knights Inc., Sandwich, Ill. Phone: (815) 786-2141.

Circle No. 389

Bulova can supply the crystal you need to match your specs!

Many years of supplying crystal control units for the most advanced military and space programs enable Bulova to offer a full line encompassing virtually the entire frequency spectrum — 2 kc to 125 Mc for oscillator and filter applications. We can supply every type of packaging — including koldweld and glass sealed. Our military crystals meet latest MIL-C-30560 specifications. All reasons why you should make Bulova your single source of supply.


Example: Precision SSB Crystals

Frequency: 1 Mc to 5 Mc
Tolerance: ± .0025% from -55°C to +90°C, or to specification
Aging: 3 x 10⁻⁷ per week after one week stabilization at 75°C

KOLDWELD SEALED CRYSTALS — low aging, high reliability, 1 Mc to 125 Mc. Now available in TO-5, HC-6/U and HC-18/U type cans sealed by the koldweld process to eliminate effects of heat and to reduce contamination.

Example: TO-5

Frequency: 15 Mc to 125 Mc
Tolerance: ±.0025% from -55°C to +105°C, or to specification
Aging: 1 x 10⁻⁷ per week after one week stabilization at 75°C

Write or call for specifications on Bulova's complete line of crystals. Address: Dept. ED-17

BULOVA FREQUENCY CONTROL PRODUCTS

ELECTRONICS DIVISION
OF BULOVA WATCH COMPANY, INC.

61-20 WOODSIDE AVENUE
WOODSIDE, N.Y. 11377, (212) 620-5600

Circle No. 389
NEW! RED SHIELD LINE
of Subminiature Shielded Inductors

- Unsurpassed “Q” to “L” ratio
- Exceptional “L” to size ratio
- High Self-Resonance
- Designed to MIL-C-15305C
- Maximum Coupling—3%—units side by side
- Stock—73 predesigned values
- Non-Flammable Envelope
- Operating Temperature —55° to 125° C.

MICRO-RED

The “Micro-Red” is a shielded inductor that offers the largest inductance range 0.10 to 10,000 µh in its size. “Q” to “L” ratio unsurpassed with excellent distributed capacity. Inductance tolerance ±10% measured per MIL-C-15305C. Stocked in 61 predesigned values.

MINI-RED

The “Mini-Red” offers the highest “Q” to “L” ratio available over inductance range 0.10 to 100,000 µh in a shielded inductor this size. Inductance tolerance ±10% measured per MIL-C-15305C. Stocked in 73 predesigned values.

Data Sheets: Write or Phone

LENOX-FUGLE ELECTRONICS, INC.
475 Watchung Ave., Watchung, New Jersey 07060
Telephone code 201-756-1164-1165
ON READER-SERVICE CARD CIRCLE 76

NEW MICRO-MOTOR

The most excellent characteristics of Mitsumi micro-motor is in its extremely high efficiency. Formerly it has been considered impossible to attain an efficiency of more than 50% for micro-motors with a diameter of 20mm or less. We have, however, succeeded in breaking through this common concept through the adoption of a new system in the magnetic circuit. We serve many types of micro-motors to our customers with automated and quality-controlled mass production.

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Polyvaricon · IFT · Oscillator coil · Antenna coil · Composite coil · Special coil · Micro motor · Synchronous motor · Variable resistor · Trimming potentiometer · FM tuner · TV tuner · Various sockets · CD photo-conductive cell.

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Phone: HA-3-3085, 3086
Main office: 1056, Kondachi, Komae-machi, Kitatama-gun, Tokyo, Japan.
Phone: Tokyo 415-6111/63

ON READER-SERVICE CARD CIRCLE 77

Metal-film trimmers

Low-Ω metal-film trimmers maintain essentially infinite resolution across the entire resistance range. These 1/2-in.² trimmers have a temperature coefficient of 50 ppm/°C and a zero noise level at the trimmed position. A precious metal contact assures low contact resistance. Resistances available are from 50 to 10,000 Ω.

P&A: $5.50; stock to 6 wks. Amphenol, 120 S. Main St., Janesville, Wis. Phone: (608) 754-2211.

Time delay relay

Series 84 single-circuit reset timers are accurate to within 1-1/2% of their total time cycle. They are available with ranges of 4, 15 and 60 s, and 3 and 5 minutes with reset times from 1/3 to 10 s. The timers are fully adjustable over their entire range and are available with or without calibrated dials or a cycle progress indicator. Contact ratings range from 5 to 25 A, 125/250 Vac.

E. W. Bliss Co., 736 Federal St., Davenport, Iowa. Phone: (319) 324-1361.

ON READER-SERVICE CARD CIRCLE 791

ELECTRONIC DESIGN, June 21, 1966
LOW COST 600-volt SCR’s with peak surge currents

12X Irms  30X Irms  16X Irms

2N4101 $1.85*  2N4102 $1.85*  2N4103 $6.00*

for high-voltage supplies • instrumentation • commercial space heaters • ignition systems (auto and boat) • DC power supplies • motor controls

Now available in production quantities...these new all-diffused SCR's are the latest additions to RCA's family of economy devices specifically designed for low cost power-control and power-switching applications. Built-in overload protection further decreases your circuit costs, and standard, easy-to-mount packages are readily adaptable for printed-circuit boards and metal heat sinks. For more information on RCA 2N4101, 2, and 3 and their companion types, as well as copies of Application Notes SMA-38 and SMA-39, write RCA Electronic Components and Devices, Commercial Engineering, Section RG6-3, Harrison, New Jersey.

Also Available Through Your RCA Distributor.

* (Prices in quantities of 1000 and up.)
HEART of missile and radar modulators...

PULSE FORMING NETWORKS

Always look to P.C. when there is no margin for anything but perfect performance. For minimum size plus maximum performance you can rely on P.C. As specialists, we have the training, the skills, and the facilities to produce outstanding examples of pulse forming networks for both standard and "specials" to meet your every requirement. Whatever your need or application, write today for our special bulletin on pulse forming networks; or, send your specifications including: Peak charging voltage, pulse duration, pulse rise time, characteristic impedance, repe rate, max. ripple, temperature range, life, decay or fall time.

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DI B-3735

"Custom Engineered at Production Prices!"

ON READER-SERVICE CARD CIRCLE 78

MIL-C-39012 connector

A type N coaxial connector in field-serviceable and crimp versions meets the new MIL-C-39012. Impedance of the connectors is 40 Ω, voltage rating is 1000 V rms and specified frequency range extends to 10 GHz. The crimp version has max vswr of 1.12 when soldered, 1.26 with 4-indent crimp and 1.35 with hex crimp. The center contact is gold plated, dielectric is Teflon and all other metal parts are silver plated. Operating temperature is 200°C max.

Amphenol, 33 E. Franklin St., Danbury, Conn. Phone: (203) 743-9272.

Circle No. 392

Resonant reed filter

The RF20 contact less resonant reed filter is an audio tone filter (decoder) or a frequency source (encoder) for audio tone generators. With a specified frequency input, the reed generates a predetermined sine wave signal for switching or oscillator frequency control. Frequency range is 80 to 3000 Hz and impedance is 1000 Ω at resonance. The unit requires 0.1 mW.

P&A: $20 (1 to 9); stock to 8 wks. Ledex Inc., College & South Sts., Piqua, Ohio. Phone: (513) 773-8271.

Circle No. 393

ON READER-SERVICE CARD CIRCLE 78

ON READER-SERVICE CARD CIRCLE 79

COMPONENTS
Gyroscope

The FG23 dc free gyroscope with bearing suspension system and dc motor uses less than 8 W. It is electrically caged and uncaged with an indicator circuit. Both gimbals have 360° freedom. Potentiometer pickoffs, voltage regulator and noise filter for 24 to 30-Vdc operation are standard.

Humphrey Inc., 2805 Canon St., San Diego, Calif. Phone: (714) 223-1654.

Circle No. 394

Vhf tee hybrids

The Rf250 series of vhf tee hybrids divides or combines RF power. The hybrids match a 50-Ω source to two 50-Ω loads and may be used to distribute local-oscillator voltage to two mixers, without cross-talk. Tee hybrids may be cascaded to divide power equally to $2^n$ loads. Fifteen models cover from 27 to 968 MHz. Isolation is 20 dB min and insertion loss is 0.25 dB max over a 20% bandwidth.

P&A: $45; 10 days. Rf Dynamics Inc., 51 Harbor Ave., Nashua, N. H. Phone: (603) 822-5854.

Circle No. 395

WE’RE PROLIFERATING!!

We’ve developed an entirely new line of Press-Lite switches and press-to-test indicator lights—including a high quality series of lights and switches that meet industry standards for appearance and performance.

We’re proliferating in the catalog department, too. Write for complete details of the industry’s finest line of neon lamps, indicator lights, illuminated push-button switches and their transistorized or EMI shielded versions. Many options available.
Self-coiling NEG'ATOR® metal readout scales simplify instrument design

The NEG'ATOR, a flat strip of prestressed spring steel, tends to coil at each end and resists uncoiling uniformly over the entire length of the strip.

When used as a printed metal readout scale, both ends are curled on bushings of equal size. Since the opposing forces (coils) are always in balance, the span between is held taut.

With its own built-in recoiling energy, the NEG'ATOR replaces large dial scales, long strips or drum scales, expanding readability while saving space!

Ask for Bulletin 310T containing full details.

HUNTER SPRING
A DIVISION OF AMETEK, INC.
27 SPRING AVENUE, HATFIELD, PENNSYLVANIA 19440

ON READER-SERVICE CARD CIRCLE 81

Components

Accelerometer

The LA45 potentiometer-type accelerometer occupies 3/4-in.² and weighs 1.5 oz. The steel case is hermetically sealed with self-compensating dry-gas damping. A 5000-Ω potentiometer output is provided. The unit is available in full scale ranges from ±2 to ±300 G with accuracies of 1 to 1-1/2%.

Humphrey Inc., 2805 Canon St., San Diego, Calif. Phone: (714) 223-1654.

Circle No. 396

Signal conditioner

Series 10400 signal conditioners meet MIL and NASA specs. They can be used with any standard platinum resistance transducer. With a 24- to 32-V input, they provide an isolated 0 to 5 Vdc over -300 to 2000°F. The 1.5-oz devices are available as NASA or commercially soldered, or NASA welded and are potted and hermetically sealed. Units are available with power consumption of 6-mA and 115-Vac inputs.

P&A: $100 to $1000; stock to 4 wks. Temtech, 2202 S. Wright St., Santa Ana, Calif. Phone: (714) 549-2283.

Circle No. 397
FIELD-EFFECT TRANSISTOR OFFER

The true semiconductor equivalent of a pentode tube...

...voltage controlled, high input Z, now available at experimenter prices!

How the FET works:
The field-effect transistor may be described as a semiconductor resistor whose channel conductance is controlled by one or more applied voltages. That's how the tube behaves—plate current changing with applied grid voltage. Consequently, there is a close resemblance between the output plate characteristic of a pentode tube and the FET's drain voltage/drain current characteristic. The FET's terminals, labeled gate, drain, and source, are analogous to the tube's grid, plate, and cathode. N-channel FETs require the same voltage polarities as the tube, i.e., positive drain voltage and negative bias on the gate. P-channel FETs, on the other hand, use the opposite voltage polarities. For amplifier design, note the transconductance, \( g_{fs} \), since it controls the gain. Impedance matching can be accomplished with a source follower circuit. Voltage gain is almost unity and \( Z_{out} \approx 1/g_{fs} \).

The real advantage of the FET is its high input impedance; cascading stages presents no measurable loading on previous stages. Where the bipolar transistor's input emitter-base circuit is a low impedance, forward-biased diode, the FET offers the same design thinking as the tube. Other advantages: No power wasted on heaters, low power consumption, and solid state reliability. The $1 and $3 packages described below contain a full discussion of FET operation, how they compare with tubes, and complete data on the devices you order.

GET TO WORK WITH FETs FOR AS LITTLE AS $1.00!

Here are the principal parameters (and their tube equivalents) of the two low-priced FETs available from Siliconix.

<table>
<thead>
<tr>
<th>FET Parameter</th>
<th>( I_{ss} )</th>
<th>( V_{c} )</th>
<th>( B V_{dss} )</th>
<th>( g_{m} ) (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube Equivalent Parameter</td>
<td>Zero Bias Plate Current</td>
<td>Grid Cutoff Voltage</td>
<td>Max. Plate Voltage</td>
<td>Minimum Transconductance</td>
</tr>
<tr>
<td>U110</td>
<td>0.1–1.0 ma</td>
<td>1–6 V</td>
<td>20 V</td>
<td>110 ( \mu )mho</td>
</tr>
<tr>
<td>U112</td>
<td>0.5–0.8 ma</td>
<td>1–6 V</td>
<td>20 V</td>
<td>1000 ( \mu )mho</td>
</tr>
</tbody>
</table>

Offer #1—$1.00. A Siliconix U-110 field-effect transistor, data sheet with complete specifications, application notes, and a detailed discussion of FET operations. $1.

Offer #2—$2.00. The U-112 FET, plus all of the circuit and device information noted above. $2.

Clip the coupon and mail today, please send check or money order; no purchase orders, please!

This is a limited offer, for experimenters only, one order to a customer. Offer closes Sept. 30, 1966. NOTE: California residents add 4c, 8c, or 11c sales tax.

ON READER-SERVICE CARD CIRCLE 82
Versatility and simplicity in variable, regulated power supplies

POTENTIOMETERS
TO 10 KV

New Victoreen RX-17 series ceramic potentiometers, when used across a well-regulated high-voltage source, provide reference adjustment with a degree of simplicity never before available to circuit designers.

Long life, resistance stability and panel insulation capability to 20 kV make Victoreen RX-17 series potentiometers ideal for reference adjustment for variable, regulated HV supplies in CRT's, TWT's, Klystrons, GM tubes, proportional counters, etc.

Two RX-17 series are available: One for operation to 5 kV rated at 3 W, the other for 10 kV rated at 5 W. RX-17 series ceramic potentiometers are normally supplied with nominal resistance range of 1 Meg to 5000 Meg, with a linearity of ±2%. Full technical details on request to Applications Engineering Department.

Components Division
THE VICTOREEN INSTRUMENT COMPANY
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104
EUROPEAN SALES OFFICE, GROVE HOUSE, LONDON RD., ILFORD, ESSEX, ENGLAND

Low pass filter

The FLH-600 flat-construction low pass filter is designed for 400-Hz applications. The filter has a source and load of 10 kΩ. Response is within 1 dB from dc to 450 Hz, 3 dB ±1 dB at 600 Hz and at least 40 dB above 800 Hz. Case size is 2-in. square by 1/2-in. high and weight is 2.5 ounces. The hermetically sealed case is shielded to reduce hum.

United Transformer Corp., 150 Varick St., New York. Phone: (212) 255-3500.

Voltage regulator

Model BR-801 is a 0.04-in. 2-gram regulator with an output of 10 to 25 Vdc. The output varies 15 mV with a 10-V input variation. The regulator compares the output voltage to a temperature-compensated zener reference voltage and provides regulating current to a series-regulated transistor at a rate greater than 10 µA/mV of error. It can provide up to 75 mA of load current with a single power transistor and over 1.5 A with a Darlington pair. Operating temperature range is -55 to +85°C. Input is 40 Vdc.

P&A: $35.10 (100 to 499). Bunker-Ramo Corp., 8433 Fallbrook Ave., Canoga Park, Calif. Phone: (213) 346-6000.

Components Division
THE VICTOREEN INSTRUMENT COMPANY
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Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 83
Constant E/1 V/s
Automatic Crossover -
all silicon

Output: 0-10 Volt DC
Load Regulation: 0.01% of 10 mA
Current Range: 0-10 MA RMS
Stability: 0.05% at 60 Hz
Overload Protection: 1250V

Model SWC-40.04 Complete with
- 0-10 Volt DC
- 0-10 MA RMS
- 1250V Overload Protection

N.J.E. Corporation
Electronic Development and Manufacture

Labrick unit.
COMPONENTS

Transformers

Housed in a sealed metal container, type JA transformer provides a 50- to 75-Ω unbalanced impedance match from 0.1 to 250 MHz for the 3-dB down points. It is rated at 5 W, from 1 to 250 MHz.


Circle No. 501

Miniature High Q Air Capacitors

Small Size • High Q • Rugged
High Selectivity • High Sensitivity

- **Size:** .220" dia. 15/32" length
- **Q @ 100 mc:** > 5000
- **Capacitance Range:** 0.4 – 6 pf
- **Non-Magnetic**

New miniature series features high quality materials and workmanship typical of all Johanson Variable Air Capacitors.

Timers

Models 51, 52 and 53 timers have ranges from 100 ns to 300 s. Reset time is less than 25 ms and repeatability is ±2% from -40 to 85°C. The units are mounted on standard 8- and 11-pin octal plugs, and are available as knob-adjustable, screwdriver-adjustable and fixed-time or remote resistor-adjustable models.

Cornell-Dubilier Electronics, 50 Paris St., Newark, N. J. Phone: (201) 624-7500.

Circle No. 502

Relay

The 432 series relay is an spdt relay with a contact rating of 10⁶ operations at 0.5 A. The unit requires 60 mW of operate power and is available in standard coil resistances to 11 kΩ. The 432 is hermetically sealed and welded in a TO-5 type case and meets MIL-R-5757D. The unit is designed for dry circuit applications.

Teledyne Precision Inc., 3155 W. El Segundo Blvd., Hawthorne, Calif. Phone: (203) 679-2206.

Circle No. 503

Feedback wanted

ELECTRONIC DESIGN would like to know how you rate our New Products section. Does it do the job for you? Does every issue contain at least a sampling of products you use? (We try to cover the field from amplifiers to zeners.) Any suggestions for improvements? Please send along your replies on the handy Editorgram card at the back of this issue. It's free.
COHU TV sees everything! may we look for you?

See us at WESCON, Hollywood Park, Booth 111

Engineering Representatives in every major city

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San Diego, California 92112
Phone 714-277-6700
TWX 910-335-1244
PUT THE SWITCH WHERE THE ACTION IS!

WITH SWITCHCRAFT PENDANT SWITCHES FOR REMOTE CONTROL VERSATILITY

Now, an all-new, ultra-versatile line of Pendant ( Cord) Switches for control, indicating, counter and data entry applications without costly relays or custom engineering. A host of never-before-available features give remote switching the kind of reliable action, long life and broad range of functions you'd expect only from console-mounted leaf-spring switches. By all odds, the best looking switches of their type—in a broad range of consumer- or industrial-oriented colors. Choose from momentary non-locking action, locking, push-to-lock/ push-to-release, or locking with remote electrical release...with standard circuitry arrangements from 1-A to 2-C plus 2-A.

CORDMASTER SERIES
Most versatile line ever created. Top or edge button operation; exclusive remote lighting; standard illuminated, or non-illuminated models. Four different functions (including remote release), with choice of 5 different circuits. Lightweight, styled to fit the hand. Accepts cables up to .270 diameter.

CORDETTE SERIES
Standout styling in a momentary-action remote switch with choice of A, B or C contact arrangements. Any length standard 2- to 4-conductor cable can be permanently molded on; or switch supplied with standard phono jack termination for use with any phono-plug equipped cable.

Twin T filter
The 1-in. model NW1778 twin T filter network provides a 60-dB attenuation at 1 kHz or at a customer-specified af. Units operate over a temperature range of -55 to +85°C and maintain a frequency stability of better than ±0.1%. At room temperature, attenuation comes to within ±0.05% of the nominal frequency. The epoxy-encapsulated unit meets MIL-E-5272.
P&A: $60 to $90; stock to 4 wks. General Resistance Inc., 450 Southern Blvd., Bronx, N. Y. Phone: (212) 292-1500.

Circle No. 504

Operational amplifier
Model 10M1 is a dc differential op-amp in a shielded metal case with pins for PC boards. Output current is ±30 mA and output voltage swing is ±10 V. Minimum dc gain is 100,000 into a 330-Ω load. Gain-bandwidth product is 1.5 MHz and full output frequency is 15 kHz. Differential offset drift is less than 25 µV/°C and 0.5 nA/°C.
P&A: $90 (1 to 9); stock. Computer Dynamics Inc., 179 Water St., Torrington, Conn. Phone: (203) 482-7621.

Circle No. 505
New Chairman of the Board cuts costs, creates openings

Look at the specs and you’ll see why so many large users already have turned to the new Weston-Daystrom 501 & 502 5/16" commercial Squaretrim® pots. They save up to 80 per cent of the PC board space formerly required—and no extra cost. Notice the extra dividends:

Convenience 3 different configurations with adjusting screw on top, side or end • Tolerance ±5%
• Adjustability 15 mechanical turns • Slip Clutch eliminates wiper damage, cuts production delays
• Soldered Terminations for better protection against vibration, shock and humidity—no pressure taps • Superior Resolution 0.125% or less • Wide Range 10Ω to 20K • High Power 0.6 watt in still air at 70°C • Wide Temperature Range —55°C to 150°C • Low Temperature Coefficient 70 ppm max. • Low Noise 100 ohms max. ENR • Small Size 5/16" x 5/16" x 5/16"

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

WESTON® prime source for precision... since 1888

ON READER-SERVICE CARD CIRCLE 231
Components

Polycarbonate capacitors
Thin film metallized polycarbonate capacitors are offered in a 100-V series in wrap and fill, epoxy-cased, radial lead and epoxy cased, axial lead configurations. Dissipation factor does not exceed 0.5%. With capacitances ranging from 0.027 to 8 mF, units rated at 1 mF max are referenced to 1 kHz at 25°C. Capacitors rated at more than 1 mF are referenced to 60 Hz. Dielectric strength terminal-to-terminal is 200% of rated dc voltage maintained for one minute. The units are applicable wherever long-term temperature and capacitance stability are required.


Circle No. 506

Quartz wafer filters
The “Uni-Wafer” thin film quartz filter is 60% smaller than standard filters. A 4-resonator, 2-section, cascade lattice filter is contained within a wafer 0.55-in. in diameter and 7 mils thick. Present designs range from filters with 2 resonators per lattice section to complex lattice filters with as many as 6 per section. Tuning from 8 to 100 MHz is accomplished by varying electrode thickness.


Circle No. 507

Operational amplifier
The D-9 operational amplifier has a 50 kHz typical frequency for full output (35 kHz min), and a unity gain bandwidth of 10 MHz min. The device has an output of ±10 V at 5 mA. Gain is 86 dB, offset current is 20 nA, voltage drift is 20 µV/°C and noise is 5 µV rms. The op-amp is packaged in a molded epoxy case and operates from ±15 V supplies.

P&A: $29 (10 to 24); stock. Data Device Corp., 240 Old Country Rd., Hicksville, N. Y. Phone: (516) 433-5330.

Circle No. 508

THE POTTER COMPANY
Pioneering in Imagination Since 1925
7351 North Lawndale Avenue • Skokie, Illinois
ON READER-SERVICE CARD CIRCLE 88
Versatile, Value-priced x-y recorder
...just $895!

**THE MOSELEY 7035A**

This is a high-performance, low-cost solid-state recorder for everyday applications not requiring high dynamic performance. Five fixed calibrated ranges 1 mv/inch to 10 v/inch. High input impedance, floating guarded input, 0.2% accuracy at full scale. Adjustable zero set.

Each axis of the 7035A has an independent servo system with no interaction between channels. Maintenance-free AUTOGRIP* electric paper holddown and electric pen lift are standard. Options available include locks for zero and variable range controls, rear input, and retransmitting potentiometer for X axis.

For general-purpose applications, you can’t beat the Moseley Division 7035A. Ask your Hewlett-Packard field engineer for a demonstration. Or write for complete specifications to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

**HEWLETT PACKARD**

An extra measure of quality

*Trade Mark Pat. pend.
A vacuum relay:

- Carries high rf currents due to large surface area of contacts.
- Smallest size for its power rating.
- Operates faster than other high voltage relays due to small contact separation.
- Will interrupt high dc power.
- Has highest voltage ratings due to vacuum dielectric.
- Has long contact life.
- Low and stable contact resistance from dc through 30 mc.
- Requires no contact maintenance.

Jennings vacuum relays:

- Have the additional benefit of 18 years of constant development effort and manufacturing experience. All Jennings vacuum relays have been field tested and proven successful in countless applications.

consequently:

Jennings vacuum relays are unexcelled for use in high voltage communication systems particularly in aerospace, land, or marine vehicles that cannot tolerate heavy weight and have limited space. Within their size and voltage range they also have no equal for switching dc or pulse forming networks.

Thorough knowledge of the characteristics of vacuum relays is a most useful tool in any electronic engineer's hands. It can easily be obtained by requesting Jennings new vacuum relay catalog No. 103. Jennings Radio Manufacturing Corporation, a subsidiary of International Telephone and Telegraph Corporation, 970 McLaughlin Avenue, San Jose, California 95108.

<table>
<thead>
<tr>
<th>Contact Arrangement</th>
<th>RJ1A</th>
<th>RJ2A</th>
<th>RF10</th>
<th>RB7A</th>
<th>RB1E</th>
<th>RB4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Voltage (Peak KV)</td>
<td>5</td>
<td>18</td>
<td>20</td>
<td>9</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Operate Voltage (Peak KV) (16 mc)</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>3</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Continuous Current Amps RMS (16 mc)</td>
<td>7</td>
<td>15</td>
<td>30</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Interrupt DC Power (KW)</td>
<td>N/A</td>
<td>1</td>
<td>50</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Contact Resistance (Max. ohms)</td>
<td>.010</td>
<td>.012</td>
<td>.012</td>
<td>.020</td>
<td>.012</td>
<td>.010</td>
</tr>
</tbody>
</table>

On Reader-Service Card Circle 121

COMPONENTS

Voltage reference source replaces mV pots

A guaranteed accuracy of ±0.5% of indicated value is featured in this dc reference source. The units cover 10 μV to 0.1 V and have an internal power source. A precision mercury cell and 0.25% resistors yield the high accuracy. Temperature range is 0 to 40°C and output resistance ranges from 0.1 to 100 Ω. The units are short-protected and thermal emf's are minimized. Measurements may be made by substitution or null-balance techniques.

P&A: $39.50; stock. Emcee Electronics Inc., P.O. Box 32, New Castle, Del. Phone: (302) 328-1354.

Circle No. 509

Hard glass headers

Tubulated hard glass headers are fabricated with glasses such as Uranium or Nonex. Pre-beaded versions eliminate glass-to-metal seal problems. All are fully annealed and fire-polished. A variety of sizes and pin configurations are available.

Huggins Laboratories, 999 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 739-9330.

Circle No. 510

Electronic Design, June 21, 1966
For
the
big
programs

... only Norden
can supply advanced
special-purpose
microcircuitry
routinely.

Norden, a qualified supplier to the Minuteman program, is the first manufacturer of integrated circuits to supply dielectrically-isolated units on a routine production basis.

These units are general purpose amplifiers used in the electronic systems of Minuteman missiles by Autonetics Division, North American Aviation. Designed to increase performance and reliability, these unique amplifiers resulted from new manufacturing techniques which isolate active elements on the integrated circuits.

Our leadership in manufacturing is matched by our ability to produce totally new circuitry in a matter of hours—by converting design requirements into hardware with master-dice breadboards. Computer-aided design techniques developed by Norden are another guarantee that new circuitry will match your exact needs for advanced equipment.

For details, write Dept. E, Norden Division, United Aircraft Corp., Norwalk, Conn. 06856, or call (203) 838-4471.

Because of its growing role in the microcircuitry field, Norden has many openings for qualified solid state engineers. Send your resume to Personnel Department, Norden, an equal opportunity employer, M&F.

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DIVISION OF UNITED AIRCRAFT CORPORATION

ON READER-SERVICE CARD CIRCLE 122
examples of MTE IF developments

from thick film

to hybrid

to IF strip

MTE Linear Transponder IF Strip
fo=35 MHz
BW=2.5 MHz
3.8 dB system noise figure
88 dB dynamic range
65 ns delay stability
fast charge, slow discharge AGC
-20°C to +70°C operating temperature

MTE IF-2 Universal
IF Amplifier Microcircuit
A linear IF amplifier stage featuring:
Wide frequency range and outstanding high-frequency stability due to:
- Highly effective integral decoupling and package shielding.
- Cascade configuration for extremely low internal feedback.

Provision for AGC from full gain to insertion loss.

Temperature stability from -55°C to +85°C.

MTE also supplies IF preamplifiers • wide band RF amplifiers • AGC and video amplifiers for all your IF system needs. For further information on these and other products in the leading line of linear high frequency microcircuits, contact MTE Marketing.

COMPONENTS

Hybrid multiplier
for D/A systems

In systems using digital and analog signals, these multiplying digital-to-analog converters (DAC) accept both inputs, multiply the analog value by the digital, and output the product in analog form. The hybrid multiplying elements eliminate much conversion and reconversion by multiplying analogically. Multiplying DAC's at the front end of a data acquisition system allows scaling and "quick-look" before A/D data conversion. The elements in the "Y" series are available with 12- or 15-bit resolution, buffered or double-buffered and with outputs to ±100 V.


Circle No. 511

Accelerometer

Series 500 accelerometers employ a piezoelectric ceramic bimorph bender as the sensing element. Designed for medium frequency applications to 3000 Hz, the disk-like units can be connected directly to a scope or VTVM. A 6-ft cable, 10-ft roll of adhesive transfer tape for mounting, calibration chart and case are included.

P&A: $75; stock to 2 wks. Metrix Instrument Co., 8200 Westglen, Houston. Phone: (713) 782-3144.

Circle No. 513

RFI connectors

Stainless steel miniature connectors utilize an RFI shielding component. Within the basic hardware is a stainless steel cone which grounds the braided wire strands to the cable housing to provide conductivity. 360° ground continuity provides minimum leakage and maximum noise suppression in the IF and RF ranges.


Circle No. 514

Operational amplifier

With a 20-μV/°C voltage drift and a 1.5-nA/°C current drift at each input, this low-cost dc differential op amp operates over -25 to 85°C. Offset current is 150 nA and coupling is 20 μV and 2 nA max for each percent change in supply voltage. Model 105 has an open loop gain of 30,000, input impedance of 50 MΩ common-mode and 150 kΩ differential. Input noise is 4 μV rms from dc to 10 kHz. Output is ±10 V at ±10 mA.


Circle No. 514
Relay shipments rescheduled again?
Next time call Leach!

One week delivery. That’s a promise. At least on standard units. Even our new series K for example. Here’s a 10 amp 4PDT polarized relay offering maximum capabilities for the most severe aircraft, missile and aerospace applications. And we have built up an inventory to cover your requirements.

The series K holds size and weight to an absolute minimum without sacrificing operating characteristics. It will withstand 100g shock, 30g, 70 to 3000 cps vibration, meets Mil-R-6106E and has a temperature range of -70° to +125°C. Operate and release time is less than 15 milliseconds including bounce. Yet it measures only 1.000” x 1.015” x 1.015” and weighs less than 2.5 ounces.

If you need one? A dozen, a hundred? Even a thousand? Then call us today. You’ll have them. Right on time.

Leach Corporation, Relay Division, 5015 Avalon Boulevard, Los Angeles, California 90003
Phone (Area code 213) 232-8221
Export: Leach International S.A.
Choice of three – Portable 444, Ruggedized 414 or 1000-speed 447

The Model 444 precision, 6 channel, wide-band recording oscillograph features big performance in a small package. Superior optics and a low-heat tungsten light source means less DC power, less cost, less weight. • The Model 414 is designed to perform under adverse conditions of humidity, shock, vibration and acceleration; provides 14 channels of data in a small, light-weight package.

• The Model 447's highly precise electronic drive permits selection of any 12 of a possible 1000 speeds (.1''/sec to 100''/sec). The 447 also features Automatic Record Length based on time and Continuously Variable Remote Speed Control. (These three are just part of the line — our Model 409 is a standard in the industry for airborne recording, for example.) • Write to us indicating your areas of interest. We will send you complete specifications.

Photoelectric relay senses frequencies

A modulated-light photoelectric relay unit is unaffected by all forms of ambient or artificial light other than that emanating from the correct source. The system has a transistorized oscillator which controls a projector lamp so that its output oscillates at a set frequency. The receiver, which has a 1-MHz response time, detects the oscillation and the amplifier's tuned circuit operates the relay. If the beam is interrupted or if the frequency is changed, the relay provides a warning or performs a control function. The equipment operates at up to 100 ft using a light beam or up to 1000 ft with an IR beam. The plug-in covered relay has 2 sets of change-over contacts rated at 5 A, 25 Vac resistive.


Circle No. 515

Transient recorder

Single transient events or intervals of continuous analog data are accepted by this recorder/reproducer. Input signals of sub-millisecond to minutes are sampled and stored. Model 848 reproduces 256 sequential data points in time. 1024 or 40-96 additional points may be added. Reproduce mode is non-destructive, so that the stored signal may be regenerated continuously as a repetitive waveform.

P&A: $2880; 30 days. Evans Associates, P.O. Box 5055, Berkeley, Calif. Phone: (415) 653-2616.

Circle No. 516

Current drivers

An improvement in overload protection is offered by these positive (type 2603) or negative (2503) current drivers. Outputs are 0.1 to 1.6 A and can be equalized with front-panel trimmers. They remain equal despite variations up to 15% in main amplitude control.

Overload protection uses a current limiting source to drive the output transistors. Limits selected prevent the transistors from over-dissipating.

Digital Equipment Corp., 146 Main St., Maynard, Mass. Phone: (617) 897-8821.

Circle No. 517

Recorders

A family of console graphic recorders with 4 to 10 crossover channels has a 10-in. span on all channels. Each channel may be operated fully floating or with grounded input. The potentiometric servo balance system is all silicon solid-state. The units have 6-speed pushbutton chart drive and are zero settable anywhere on full scale.

P&A: $2750 to $7150; stock to 60 days. Argonaut Associates, P.O. Box 273, Beaverton, Ore. Phone: (503) 292-3149.

Circle No. 518
Let SOLA custom-build your “tough spec” power supplies...

No specs are too tough for SOLA design engineers. Proof? SOLA has custom-designed power supplies for the most sophisticated applications. Electron probe microanalysis equipment, nucleonic liquid gages for supersonic aircraft, precipitators, CRT devices, for instance.

The SOLA power supply used in liquid gages, for example, contains 120 parts, four etched circuit boards, yet measures only 1.86” in diameter, and .9” high. What's more, it provides regulation of ±0.25% for all conditions of line, load, and temperature. It operates in a temperature range of -55°C to 72°C, at thirty times the pull of gravity.

This is one of the many “tough spec” custom power supplies SOLA has engineered over the years. Whatever your requirements might be... extreme temperatures, tight regulation, low ripple, compactness, stability... remember, SOLA can custom-build your power supplies in OEM quantities. And at a price that’s realistic.

Try us. We haven't been stumped yet. Send us your specifications, or a description of the end result required.

Write Sola Electric, Division of Sola Basic Industries, 1717 Busse Road, Elk Grove Village, Illinois 60007. Or call (312) 439-2800.

SOLA ELECTRIC
DIVISION OF SOLA BASIC INDUSTRIES

MINIATURE POWER SUPPLIES
120 parts, 1.86” dia., .9” h.

50KV TRANSISTORIZED
POWER SUPPLIES
The increased acceptance and use of aci Signaflo Systems is partially a result of this unique aci advancement, "Spread-Pitch", for interconnection adaptability and versatility. It is another reason for aci's leadership and ability to solve interconnection problems.

aci has developed a manufacturing technique, "Spread-Pitch", which can change the pitch dimension of conductors wherever required. Thus, narrow pitch dimension cable can be used on aci Signaflo Systems and yet match hardware contact with various dimensions for interconnection simplicity without loss of any inherent characteristics, such as flexibility, strength, low total cost, weight and space savings.

Core memories
Models RF-1, -2 and -3 expandable core memories offer a word access time of 600 ns. The family has 512 to 16,384 words in 4- to 36-bit lengths for a 2048 to 588,824-bit total capacity. PC board assemblies, ICs and silicon semiconductors are used. Full-cycle timing is 1.8 µs and half cycle is 1 µs. Input power required is 300 W + 10 W/bit.
Price: $2600 to $42,000. Ampex Corp., 401 Broadway, Redwood City, Calif. Phone: (415) 367-2011. Circle No. 519

Sampling recorder
A 2-channel sampling recorder has a sampling rate of 3 kHz/channel. Type 1520-A recorder has a bank of 101 fixed stylus which produce plots on electrosensitive paper. Paper speed can be set up to 10 ips. Vertical rise times as short as 300 µs can be determined from the chart. Calibrated voltage ranges are 1 to 500 V (linear) and 20 and 50 dB (log) full-scale. The recorder prints its own coordinates as well as voltage and time scales. Overall accuracy is ±1%.
FM discriminator
A tunable FM discriminator provides ±1% center frequency accuracy and 0.1% linearity. Model 4140 accommodates all telemetry subcarriers from 100 Hz to 1.5 MHz. A rotary switch selects the deviation ratio: ±7.5, 15, 30 or 40%. Output filter cut-off frequency is switch-selectable, the 3-dB point being adjustable from 1 Hz to 300 KHz. Roll-off characteristics available are 42, 36 or 18 dB/octave.

Electro-Mechanical Research Inc., P. O. Box 3041, Sarasota, Fla. Phone: (813) 955-8153.

Circle No. 521

Display system
Model 650 display system simultaneously displays changing information from up to 128 data channels in bar-graph form on a 17-in. CRT. The system can hold data on as many as 256 channels in an internal core memory. Data channels which would normally require 128 separate meters are displayed on a single scope with the relative magnitude of each channel instantly visible. Calibration circuits automatically generate calibration markers at intervals of 25% full-scale. A front panel switch permits checking the calibration values stored in memory against an internal standard.

Telemetrics, 2830 S. Fairview St., Santa Ana, Calif. Phone: (714) 546-4500.

Circle No. 522
Whatever your temperature control requirements...AC or DC, aerospace or industry...some combination of our family of components will solve it. UCC systems provide any of the following features to match your needs:

- On/off Control
- Proportional Control
- Adjustable Differential
- Power Ramp Warmup
- Exact Set-point Control
- Set-point Stability
- Fail/safe Performance
- Solid State Control

“Control” is our middle name. Call or write for details on UCC capability.

**Drum synchronization**

Model DS12 synchronization system provides speed/phase and indexing control of a magnetic storage drum. An unlimited number of drums may be synchronized with a time displacement error between drums of less than 200 ns. The system couples drums using an external reference frequency which becomes the clock frequency for the computer or display system.


Circle No. 523

**2-channel recorder**

A two-channel wide chart servo recorder has 1/8-s full scale response in each of the side-by-side 4-1/2-in. channels. Source impedance is 100 kΩ and off-balance input impedance is 50 kΩ. Any calibrated span from 1 to 100 mV full scale can be measured without changing range cards or internal connections. Zero is continuously adjustable from 0 to ±100 mV.

Esterline Angus Instrument Co. Inc., P.O. Box 24000, Indianapolis. Phone: (317) 244-7611.

Circle No. 524

**Tracking receivers**

Telemetry and tracking receivers (AM, FM or PM) cover all standard IRIG and NASA frequencies from 105 to 2300 MHz. There are 4 phase-lock modes of operation. Plug-in IF filter units from 2 kHz through 3.3 MHz are available. Phase-lock loop bandwidths down to 10 Hz are standard. The receivers have been used at signal levels below -140 dBm.


Circle No. 525

**Surveillance system**

An automated spectrum surveillance system covers 20 Hz to 1 GHz. The system consists of the manufacturer's interference analyzers, programmer, X-Y plotter and rackmount scope. Model FSS-250 enables programming of any portion of the range and plotting of the spectrum profile. Each of the 16 bands of the system may be analyzed.

Price: about $25,000. Fairchild Camera and Instrument Corp., 88 Church St., Amsterdam, N. Y. Phone: (518) 843-2600.

Circle No. 526
An Eight-Second Review.

8 COE makes timers and time delay relays.
7 With rugged solid state circuitry.
6 repeatability of ±2%.
5 25 millisecond reset time, maximum.
4 200 millisecond to 300 second range.
3 high volumetric efficiency.
2 design flexibility and
1 long, dependable life built right in.
0 standard stock ratings available.

If you like the subject, do some research with the CDE field engineer or authorized distributor in your area. He will gladly discuss your application requirements at no obligation.
On-line storage system

A buffer tape/read search system in conjunction with the manufacturer's 4096-channel multiparameter analyzer combines the data acquisition rate of a magnetic core memory with the storage capacity of magnetic tape. In addition to providing memory-buffered on-line storage of related-address data, the ND-160BT/RS system enables rapid tape readout of arithmetic data in the memory.

Nuclear Data Inc., P.O. Box 451, Palatine, Ill. Phone: (312) 529-4600.

Circle No. 527

Digital recorder

Model R34 digital magnetic tape recorder records up to 250,000 characters at 130/s on a 1/2-in., 7-track cartridge. It uses 6 bits for data and 1 for parity or synchronism. The recorder requires ±6 V at 200 mA. Input logic levels are 0 to 0.5 V for "0" and 4 to 6 V for "1." MTBF is 2000 hours with 1-ppm max bit loss through the write/read sequence.


Circle No. 528
HELIPO T
CUTS THE SIZE
OF ITS 10-TURN POT

but there’s not
a spec of difference

It's true... Helipot actually cut the length of its \( \frac{3}{8} \) diameter 10-turn in half. No hocus pocus. The new Model 7266 is \( \frac{3}{4} \) long... the shortest 10-turn \( \frac{3}{8} \) diameter precision potentiometer you can buy. Yet its precision performance is unscathed, and the wirewound resistance element is actually longer than that of its predecessor. It is a precision pot in every respect. Resolution is better, the total resistance range is still 10 ohms to 125K, with \( \pm 0.2\% \) linearity as good as ever.

How much was the price raised? Not a penny — it's priced at $10 for 1—9 pieces and well below $8 in quantity. (And you get two for the size of one.) Complete product information is available now from your local Helipot sales office.

Beckman Instruments, Inc.
HELIPO T DIVISION
FULLERTON, CALIFORNIA • 92634

INTERNATIONAL SUBSIDIARIES: GENEVA; MUNICH; GLENROTHES, SCOTLAND; TOKYO; PARIS; CAPETOWN; LONDON

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 132
Microwave Isolators

Low bilateral vswr and length reductions up to 25% are featured in a series of full bandwidth waveguide isolators. Typical is the model covering 5.85 to 8.2 GHz. Isolation is 30 dB min, insertion loss is 1.0 dB max, bilateral vswr is 1.1 max and length is 5 in. Minimum front-to-back ratios of 30 are maintained over each band. Twelve models cover 3.95 to 18 GHz.

E&M Laboratories, 7419 Greenbush Avenue, North Hollywood, Calif. Phone: (213) 875-1484.

Cutoff attenuator

A variable cutoff attenuator, type 198-519, has 150 dB of variable energy decay in the 2 to 4 GHz band. Variation in dB is essentially a linear function of shaft angle except at low attenuation. The unit has an insertion loss of 17 dB, a cutoff frequency of 13.83 GHz, type N connectors, a rack and pinion drive and an attenuation resetability exceeding 1 dB.

PRD Electronics Inc., 1200 Prospect Ave., Westbury, N. Y. Phone: (516) 334-7810.

Coax switch

A dpdt RF coaxial switch, model SW-20, covers dc to 2 GHz. Characteristic impedance is 50 Ω, and insertion loss is 0.05 dB at 1 GHz and 0.1 dB at 2 GHz. Vswr is less than 1.1 and isolation exceeds 80 dB at 1 GHz.

P&A: $55; stock. Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7352.

Feedback wanted

Electronic Design would like to know how you rate our New Products section. Does it do the job for you? Does every issue contain at least a sampling of products you use? (We try to cover the field from amplifiers to zeners.) Any suggestions for improvements? Please send along your replies on the handy Editorgram card at the back of this issue. It's free.

Oscillators

A series of high-power oscillators are electronically or manually tunable over any 200 MHz range between 2.8 and 4.2 GHz. Nominal input power required is -28 Vdc at 150 mA. Power output is 50 mW min.

Three ranges are available: 3.0 to 3.2 GHz, 3.5 to 3.7 GHz and 4.0 to 4.2 GHz.

Trak Microwave Corp., 4726 Kennedy, Tampa, Fla. Phone: (813) 877-8341.
REMEMBER
FOUR NEW LOW-COST PNP/NPN TRANSISTORS
AND YOU CAN FORGET 35 OTHER TYPES!

Here are four, new low-cost UNIBLOC® plastic transistors that offer such broad performance versatility and complete specifications that you can use them to replace some 35 other current types.

For general purpose switching and amplifier service covering all commercial/industrial applications in the 10 to 100 mA range and from audio to 100 MHz frequency range, these four Motorola types, the NPN 2N4123 and 2N4124 and the PNP 2N4125 and 2N4126, cover practically all your application requirements!

THESE — 2N4123, 2N4124, 2N4125 and 2N4126 replace all these —

2N2711 2N3393 2N3845A
2N2712 2N3394 2N3854
2N2713 2N3395 2N3855A
2N2714 2N3396 2N3855
2N2715 2N3397 2N3855A
2N2716 2N3398 2N3856
2N2921 2N3721 2N3856A
2N2922 2N3723 2N3858
2N2924 2N3843A 2N3859
2N2925 2N3843 2N3859
2N2926 2N3844 2N3860
2N3390 2N3844A 2N3900
2N3392 2N3845 2N3901

As with all Motorola plastic transistors, you get the added assurance of rugged Unibloc transistor construction — the solid, single-piece, pressure-molded package that offers unusual physical strength for internal leads and connections, plus improved heat transfer characteristics.

One other point, they have Motorola's patented "annular" device structure which assures you maximum reliability and stability.

Your local Motorola district office or franchised distributor have units available for immediate evaluation. For complete technical details, write: Technical Information Center, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

ON READER-SERVICE CARD CIRCLE 108

HIGH SPEED LOW-COST NPN LOGIC SWITCHES CHARACTERIZED ON "DESIGNERS" DATA SHEET

A pair of new low-cost NPN plastic Unibloc transistors have been characterized with limit curves which are directly applicable to "worst case" saturated switching circuit designs — giving sufficient information to permit the design engineer, in most cases, to design entirely from the data sheet alone!

The devices (types 2N4264 & 65) are specified in a Motorola Designers Data Sheet* at both 10 mA and 100 mA levels and feature a very low storage time of 20 nsec. Although they offer the economy of plastic devices (prices range from $.40 to $.45 in 100 quantities), the units offer performance matching that of other higher-priced units. For example:

<table>
<thead>
<tr>
<th></th>
<th>2N4264</th>
<th>2N4265</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVcsc (@ 1 mA)</td>
<td>15 V</td>
<td>12 V</td>
</tr>
<tr>
<td>hfe min (@ 10 mA)</td>
<td>40 100</td>
<td></td>
</tr>
<tr>
<td>fT min (@ 10 mA)</td>
<td>300 MHz</td>
<td>300 MHz</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>4 pf</td>
<td>4 pf</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>8 pf</td>
<td>8 pf</td>
</tr>
<tr>
<td>Turn-On (@ 10 mA)</td>
<td>25 nsec</td>
<td>25 nsec</td>
</tr>
<tr>
<td>Turn-Off (@ 10 mA)</td>
<td>35 nsec</td>
<td>35 nsec</td>
</tr>
</tbody>
</table>

In addition, the rugged, high-pressure, single-piece molded-plastic encapsulation of Unibloc devices provides a uniform, dense and solid package, free of voids (and leaks). Also, they feature Motorola's exclusive "annular" device structure for optimum reliability.

For more information on these high-performance, fully-specified, low-cost devices, circle the reader service number below.

ON READER-SERVICE CARD CIRCLE 109

*Trademark of Motorola Inc.
Can you get high-speed complementary transistor design in IC’s—without compromise?

Look at Philco’s hybrids.

Suppose you want your circuit design to take full advantage of complementary transistor techniques—with low standby power requirements, high speed, the ability to drive high currents and high capacitive reactance loads. Yet you’d like the advantages of integrated circuitry, miniaturization, reliability and cost reduction.

This is where our hybrid microcircuits can help. The CTL flip-flop microcircuit shown above, for example, has a stage propagation delay of less than 5 nsec at 100 ma. It is easily fabricated at minimum cost by hybrid techniques—requiring no compromises in achieving simultaneous NPN and PNP action.

In addition, our hybrid techniques permit the simple construction of complementary linear IC’s, RF/IF amplifiers with center frequencies in excess of 100 MHz, and FET input operational amplifiers. Of course, the same advantages of high power capability and moderate cost still apply.

The examples above indicate only one or two problem areas that yield to the hybrid approach. High power and voltage requirements can also be easily met in hybrid IC’s. A call to your local representative or to Philco’s Marketing Department, Spring City, Pa. (215-948-8400), will bring you further information—and an invitation to submit discrete circuit plans for a quick quote on hybridization costs!

SOLID-STATE PRODUCTS OPERATION

Variable attenuator

Model 3704-10B is a continuously variable coax attenuator which will withstand up to 100 W average and 10,000 W peak. Frequency range if 1350 to 1450 MHz and attenuation range is 0 to 10 dB min. Insertion loss is 0.6 dB max and vswr is 1.5 max. Attenuation vs frequency is flat to within ±0.25 dB. The 5-in. diameter unit uses type N female connectors.
P&A: about $500; stock to 8 wks. Arra Inc., 27 Bond St., Westbury, N. Y. Phone: (516) 334-8770.

Circle No. 535

Flat coax coupler

Highly directional and physically compact coaxial couplers are designed to provide maximally flat coupling over full octave frequency ranges. Frequency variation is 0.2 dB/octave and directivity is 25 dB min.

The completely potted unit measures 4 x 5.6 in. The 3-terminal devices are available with 10-, 20- and 30-dB coupling values. All are calibrated at five frequencies.
P&A: $180 and $190; stock to 6 wks. Microlab/FX, Livingston, N. J. Phone: (201) 992-7700.

Circle No. 536
Our gyros are tops

This one can be rewound and rearmed without removing its cover

We build all our gyros to be tops in quality and reliability. Important developments in vertical, free and directional gyros for drone, missile and aircraft applications are continually being developed by Electronic Specialty Co. in Portland, Oregon.

One of our newest gyros is the stored energy type NF 6010B, designed and produced by ES for a classified torpedo program. Used to provide a course reference, it was designed with emphasis on reliability and minimum size.

This state-of-the-art gyro has a unique rewinding feature: the gyro can be rewound and rearmed without removing the cover. This is accomplished by rotating the cover a quarter turn to expose the winding mechanism, then winding about twelve turns with a standard Allen wrench. The cover is then returned to its original position. When the process is completed a switch closes; this can be used in system readout to provide a “wound and caged” indication. This “permanent” cover further insures reliability because the mechanism remains cleaner and is not subject to inadvertent change in adjustment.

Energy is supplied from a spring motor to bring the gyro up to running speed in less than 60 milliseconds. The gyro rotor is maintained at running speed by an A.C. induction type sustaining motor.

The unit has free gyro drift of 1 degree per minute maximum. It operates with 360° of freedom on both inner and outer gimbals, and provides potentiometer pick-off from the outer gimbal. Pick-off on both gimbals can also be provided. The gyro weighs 1.5 pounds and is approximately 2.5 inches in diameter and 3.5 inches long.

If you visit the Northwest, you are invited to inspect our new, ultra-clean modern facility in Portland, Oregon. It has the finest equipment available for the design and production of gyros and relays. For a complete description of our Portland capabilities and detailed information and specifications of the NF 6010B write for a data sheet.
MICROWAVES

7 mm termination
Type RMA terminations are used from dc to 18 GHz as coax standards and terminations for 4-terminal measurements in 7 mm systems. Vswr is 1.0 to 1.01 up to 12 GHz and 1.05 at 18 GHz. The inner conductor is partly a deposited-carbon resistor and is spring-loaded at the end in the outer conductor. The unit does not use a coaxial support or a spring cap.
P&A: $115; stock to 30 days. Rohde & Schwarz, 111 Lexington Ave., Passaic, N. J. Phone: (201) 773-8010.

Transistor amplifier
Up to ±12 V at 20 mA can be handled by this lightweight transistor amplifier. Center frequency is 1.3 GHz, bandwidth is 300 MHz and noise figure is 4.0 dB max. Input signal 1-dB compression level equals −25 dBm. Gain is 15 dB and input-output impedance is 50Ω. Connectors are standard coaxial.
International Microwave Corp., River Rd., Cos Cob, Conn. Phone: (203) 661-6277.

Sweep oscillator
A compact sweeper, model 5000, has self-contained power supplies for operating any of 4 plug-in oscillators covering a range of 0.25 to 2.4 GHz. A calibrated frequency vernier, direct phase lock connection and a narrow spectrum free of spurious responses are featured. Internal PIN leveling is provided using an external RF detector. The instrument employs semiconductor oscillator circuits.
P&A: $1490, $1250 to 1590 (plug-ins); stock to 60 days. Kruse-Storke Electronics, 790 Hemmeter Lane, Mountain View, Calif. Phone: (415) 967-2299.

Coax terminations
Series LP-1 coaxial terminations operate from dc to 1.3 GHz with vswr less than 1.05 and to 4 GHz with vswr less than 1.15. Power dissipation is 1 W. Series MP-1 operates from dc to 1.3 GHz with vswr less than 1.1 and to 2 GHz with vswr less than 1.2. Power dissipation is 25 W. Both have 50Ω impedance and male or female type N connectors.
P&A: $12 (LP-1), $25 (MP-1); stock. Radiation Devices Co., P.O. Box 8450, Baltimore, Md.

TR-switch
The MA-3801 TR-switch covers 3.29 to 36.0 GHz and operates at peak power of 10 kW max. It combines a gas TR tube and a solid-state switch. Maximum insertion loss is 1.5 dB, spike leakage is 0.02 ergs/pulse and flat leakage is 40 mW. Recovery time is 2 μs. It is designed for use in the receive channel of ferrite duplexer circuits.

RF coaxial connectors
Radio frequency coaxial connectors for edge feed from strip circuitry operate from dc to 18 GHz. In 50-Ω circuits, typical vswr is 1.25. Model MOE-1 mates with male OSM connectors. It is intended for use with lines of 1/8-in. dielectric with 1/16-in. metal backing top and bottom.
P&A: $5 (1 to 4); stock. Varian Associates, Akron St., Copiague, N. Y. Phone: (516) 264-2200.
WHAT'S NEW IN
Constant Voltage Power Supplies?

...NEW LOW PRICES

- CONSTANT VOLTAGE
- AUTOMATIC E/I CROSSOVER
- SOLID-STATE, SCR INPUT
- REMOTE SENSING
- PROGRAMMABLE
- MHOREGRAMMABLE®

MODEL PV-36 VOLTS - 15 AMPS

MODEL PV-60 VOLTS - 15 AMPS

The same high quality for which Electronic Measurements' Constant Voltage Power Supplies have been noted, is now available at NEW, LOW prices. Merger of the Electronic Measurements Company and The Rowan Controller Company has increased purchasing power, expanded productivity and integrated high quality components. The savings are being passed along despite today's trend of rising prices. Same high quality — lower price!!
WHAT'S NEW IN
Half-Rack Power Supplies?

NEW LOW PRICES

- CONSTANT VOLTAGE
- AUTOMATIC E/I CROSSOVER
- ALL SOLID STATE
- PROGRAMMABLE
- COMPACT HALF-RACK DESIGN
- PORTABLE MODEL AVAILABLE

The same high quality for which Electronic Measurements' Half-Rack Power Supplies have been noted, is now available at NEW, LOW prices. Merger of the Electronic Measurements Company and The Rowan Controller Company has increased purchasing power, expanded productivity and integrated high quality components. The savings are being passed along despite today's trend of rising prices. Same high quality — lower price!!
New Sorensen Modular Power Supplies

The new Sorensen QSA Series offers the only modular power supply line in the 0 to 35 volt range that combines ±.005% regulation line and load, 20 µs. response time, 71°C operating temperatures, 300 µV ripple—all at prices below other lines having lesser performance specifications. Sorensen's QSA Series modules are ideal for OEM, lab or system applications. They can be used as bench models (mounted in any position) or mounted in combinations of 3 or 4 in an optional 19" (3½'' high) rack adapter. Other design features include: Load current vs. temperature, 110% @ 40°C—100% @ 50°C—85% @ 60°C—66% @ 71°C • Temperature coefficient 0.01%/°C • Stability 0.025%/8 hrs. • Models QSA10-1.4, QSA10-2.2 and QSA10-3.7 permit operation of up to 20 units in series; other units permit operation of 2 units in series; All models permit operation of 4 units in parallel • No turn-on/turn-off overshoots • Remote sensing • Remote programming • Ripple voltage peak to peak 3mV. All Sorensen power sources conform to proposed NEMA standards. For additional QSA Series details or for data on other standard/custom DC power supplies, AC line regulators or frequency changers, call your local Sorensen representative, or write: Raytheon Company, Sorensen Operation, Richards Avenue, Norwalk, Conn. Tel: 203-838-6571, TWX: 710-468-2940.

<table>
<thead>
<tr>
<th>MODELS (RANGES)</th>
<th>SIZES (IN.)</th>
<th>PRICES (U.S. List)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSA10-1.4 (0-10V, 1.4A)</td>
<td>7 x 3-5/16 x 3-7/8</td>
<td>$89</td>
</tr>
<tr>
<td>QSA12-1.4 (8-14V, 1.4A)</td>
<td></td>
<td></td>
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<tr>
<td>QSA18-1.1 (14-22V, 1.1A)</td>
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<tr>
<td>QSA28-.7 (22-35V, .7A)</td>
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</tr>
<tr>
<td>QSA10-2.2 (0-10V, 2.2A)</td>
<td>7 x 3-5/16 x 5-1/8</td>
<td>$109</td>
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<tr>
<td>QSA12-2.2 (8-14V, 2.2A)</td>
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<tr>
<td>QSA18-2.0 (14-22V, 2.0A)</td>
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</tr>
<tr>
<td>QSA28-1.3 (22-35V, 1.3A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSA10-3.7 (0-10V, 3.7A)</td>
<td>10 x 3-5/16 x 5-1/8</td>
<td>$129</td>
</tr>
<tr>
<td>QSA12-3.7 (8-14V, 3.7A)</td>
<td></td>
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<tr>
<td>QSA18-3.0 (14-22V, 3.0A)</td>
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<td></td>
</tr>
<tr>
<td>QSA28-2.0 (22-35V, 2.0A)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sorensen represented in California by Ward-Davis Assoc., 770 S. Arroyo Parkway, Pasadena, Phone 213-684-2640; 3921 E. Bayshore, Palo Alto, Phone 415-968-7116; 5492 Pickett Street, San Diego. Phone 714-291-4611.
Mix these signal, power and coax leads in any combination.

Burndy Trim Trio Connectors—available in many shapes—accept three contact styles, all crimp-removable, for signal and power leads #16 thru #24, twisted pair #24 and #26, and subminiature coaxial cables.

Changing conductors is fast and simple, whether for lower voltage drop or better shielding or mechanical reasons. This makes Trim Trio Connectors ideal for breadboard and prototype work as well as production. For large production runs you can take advantage of the economies offered by the automatic Burndy Hlyematic™ with a crimp rate of up to 3000 contacts per hour.

Get more details on how you can take advantage of the Burndy Trim Trio System—THE ACCEPTED METHOD OF INTER-MIXING CONTACTS.
One simple, rugged design adds reliability to all three rectilinear Mil wirewound styles

RT-10, RT-11, RT-12 — Dale meets all three with a single design. You benefit from this simplification through increased reliability, faster delivery, better price. Call us today!

1. **ALL-MOLDED HOUSING** design eliminates seal problems. Meets MIL-STD-202 and MIL-R-27208A.
2. **RUGGED COLLECTOR SYSTEM** assures you of noise levels well below mil requirements.
3. **FULL LENGTH WINDING** allows increased power handling capability. Permits use of large diameter thermocoective mandrel which eliminates "hot spots" by acting as high mass heat sink.
4. **1-PIECE WIPER ASSEMBLY** of precious metal insures setting stability under all environmental conditions.
5. **STAINLESS STEEL ADJUSTMENT SCREW** has metal-to-metal clutching — prevents over-travel damage.
6. **CONSTANT LEAD SCREW SEAL** is assured by shaft-retaining spring which maintains unvarying pressure against high temperature silicone rubber "O" ring.

**DALE MIL-R-27208A MODELS**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT-10</td>
<td>Model 691 P.C. Pin&lt;br&gt;Model 697 Flex. Leads</td>
</tr>
<tr>
<td>RT-11</td>
<td>Model 1287 P.C. Pin&lt;br&gt;Model 1288 Flex. Leads</td>
</tr>
<tr>
<td>RT-12</td>
<td>Model 1680 P.C. Pin&lt;br&gt;Model 1697 Flex. Leads</td>
</tr>
<tr>
<td>RT-22</td>
<td>5000 Series — 1/4&quot; square-trim models meet RT-22, made with same basic design considerations shown here</td>
</tr>
</tbody>
</table>

WRITE FOR CATALOG B — containing specifications on 57 Dale T-Pots including many special models.
ROUGH WITH A REASON

Unique GVB finish cuts core winding costs

GVB encased cores mean fewer production delays because GVB does much more than seal the core box against potting material. Its matte finish provides a resilient, non-slip base for winding, and the tough epoxy skin prevents the wire from cutting through to the core box. Guaranteed not to fail, even when wound with heavy #6 wire, GVB surface also eliminates abraded wire problems. No prior taping of the core is required, so another winding operation is wiped out.

Magnetics doubles the normal guarantee on core box finishes by expressing it in this unique way: The guaranteed voltage breakdown (GVB) finish seals the box and is capable of withstandng at least 1,000 volts at 60 cycles between a bare winding and the aluminum case. Quality control monitors the application and curing of GVB to assure dimensional and voltage breakdown fidelity. Performance characteristics are maintained between -65 and 200 degrees C.

To reduce production costs on your winding operations, try Magnetics' tape wound cores with GVB. Eight material types, in a wide range of sizes from 0.375" to 4.0" inside diameter, are stocked for immediate delivery. More information? Write Magnetics Inc., Dept. ED-27, Butler, Pa.
Coaxial switch

Life of the "Type-E" coax switch is claimed to be $10^6$ operations with 60 dB isolation across 0 to 11 GHz. VSWR is less than 1.4 at 11 GHz and less than 1.2 at 5 GHz. Insertion loss is less than 0.3 dB from 0 to 11 GHz. The MIL-spec switch is motor-actuated and available in SPdt to SP6t, DPDT and transfer models.

Transco Products Inc., 4241 Glencoe Ave., Venice, Calif. Phone: (213) 391-7291.

Circle No. 251

Waveguide termination

The MSP-11 is a 9-in. termination designed for the 3 to 4 GHz band. VSWR is less than 1.08 from 3 to 4 GHz. The load is supplied with round or rectangular flanges and in bronze or aluminum waveguide. The unit may be used at peak powers to 1 mW and average powers up to 500 W. Fin temperature without fan cooling with 500-W dissipation is approximately 400°F.

P&A: $350; stock to 60 days. Metcom Inc., 76 Lafayette St., Salem, Mass. Phone: (617) 744-5958.

Circle No. 252

Turret attenuator

Model RA-54 turret attenuator covers 0 to 50 dB in 1-dB steps and digitally displays. Dual independently adjustable rotors provide 0 to 40-dB attenuation in 10-dB steps and 0 to 10 dB in 1-dB steps. Accuracy exceeds ±0.5 dB at 500 MHz, ±1 dB at 1000 MHz and ±1.5 dB at 1500 MHz. VSWR is 1.25 max and insertion loss is 0.3 dB max at 1000 MHz. Connectors are BNC, TNC or type N.

P&A: $165; stock to 3 wks. Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7352.

Circle No. 253

Waveguide circulator

Waveguide circulator model HC-8169 has 3 ports and covers 8.2 to 12.4 GHz. Isolation over the full bandwidth is 20 dB min, insertion loss is 0.3 dB max, and VSWR is 1.20 max. Power ratings are 10 kw peak and 20 W average. Custom models with insertion loss of 0.1 dB and VSWR of 1.05 are available.

P&A: $245; 30 days. Huggins Labs., Inc., 999 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 736-9992.

Circle No. 254
SOLID STATE NOISE GENERATORS

Model 602A 5 cps to 5 mc, 3 Ranges $290
Model 603A 5cps to 5 mc, 3 Ranges $495
Model 610A 5 cps to 5 mc, 8 Ranges $1,175
Series 624 (Fixed frequency) 5 cps to 500 kc $1,175
Model 610A 5 cps to 5 me, 8 Ranges $1,175
Model 603A 5cps to 5 me, 3 Ranges $495
Model 311A Two outputs DC to 40 cps . . $1,995
Model 312A Two outputs DC to 120 cps and 10 cps to 20 kc . . $2,495
Model 321A DC to 120 cps . . $2,095
Model 331A 10 cps to 20 kc . . $1,275

ENCAPSULATED NOISE SOURCE MODULES

Series 1602, 1603, and 1606 $144 to $389
Various frequency ranges and output flatness available. Size: 4⅜"x6⅝"x1". Write for details.

NOISE GENERATOR CARDS

Series 3602, 3603, and 3606 $144 to $389
Various frequency ranges and output flatness available. Size: 4⅜"x6⅝"x1". Write for details.

VACUUM TUBE NOISE GENERATORS

Model 301A DC to 40 cps . . $1,995
Model 311A Two outputs DC to 40 cps and 10 cps to 20 kc . . $2,395
Model 312A Two outputs DC to 120 cps and 10 cps to 20 kc . . $2,495
Model 321A DC to 120 cps . . $2,095
Model 331A 10 cps to 20 kc . . $1,275

Model 3602A

Model 312A

MATERIALS

Resistive paste

A line of ceramic resistive pastes for silk screen applications has typical temperature coefficients of less than ±150 ppm/°C on high alumina substrates. The glaze coatings are designed for fixed and variable resistor fabrication, either as discrete components or in thick film networks or microelectronic circuits. They are available in standard sheet resistivities in the decade ranges from 10 to 20,000 ω/square. The pastes are fired at a peak temperature of 750°C for 10 minutes. Screens of 200 to 325 mesh are suitable for depositing films 0.5 to 1.0 mils thick.


Circle No. 255

Epoxy molding powder

"Ecomold HT-50" is an epoxy compression molding powder that can be molded at pressures below 100 psi. The powder produces molded items with densities as low as 40 lb/ft³. Heat distortion temperature is above 500°F. Two components are supplied and the blended material has a shelf life of a month at room temperature. Cure time in the mold is typically 3 minutes at 320°F. Physical properties can be improved by an "out of mold" post-cure for 20 minutes at 320°F.


Circle No. 256

Gold plating solution

"Pure gold SG-10" is processed from hyper-pure gold compounds and is well buffered. This solution deposits 99.99% pure gold. The plate has a center cubic structure and Rockwell hardness of 24. Contact resistance is in the mΩ range. Optical properties afford reflectivity greater than 90% in the IR region. Uses are in contacts and terminals, tube base pins, switches, printed circuits and waveguides.

P&A: $20 (pint), $30 (quart), $80 (gallon); stock. Transene Co. Inc., 121 Conant St., Danvers, Mass. Phone: (617) 774-4272.

Circle No. 257

Polyurethane coating

"Conathane 1158" is supplied as two low viscosity components that develop thixotropism about 8 minutes after mixing. The coating is then suitable for application to PC assemblies by conventional screen processing techniques. The cured coating has a dielectric constant of 4.28 and a dissipation factor of 0.028 at 1 MHz. Dielectric strength is 7.0 kV/mil. It resists short time exposure to a solder bath at 560°F and continuous exposure to 180°F.


Circle No. 258

Resistor paste

Designed for use in thick film or hybrid microelectronic circuitry, four "Firon" resistor materials have sheet resistances of approximately 300 Ω, 1 kΩ, 3 kΩ and 10 Ω/square mil. The pastes are silk-screen applied, and, when fired, fuse to the substrate, providing an integrated resistor substrate. Resistors made from these pastes have a temperature coefficient of less than ±150 ppm/°C when measured from +55°C to -150°C. "Firon" resis­ tors show excellent moisture stabil­ ity and no significant resistance change during dip soldering or high-temperature exposure.

Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, N. Y. Phone: (914) 698-8434.

Circle No. 259

Diallyl phthalate resin

Diallyl phthalate molding powders are available as an insulating resin. Type 1F19 is a one-can sys­ tem for coating, sealing, dip-encap­ sulating and laminating of wire wound resistors, coils, transistor chips, capacitors, diodes, transformers and motor windings. The resin is stable over a wide temper­ ature range and will withstand dip or wave soldering. It can be dipped, brushed or sprayed and is tack-free for handling in 30 minutes.

Columbia Technical Corp., 24-30 Brooklyn-Queens Expwy. West, Woodside, N. Y. Phone: (212) 952-0800.

Circle No. 260
"HM" Subminiature switches are available in many variations—can be used in a greater variety of applications requiring electrical or mechanical stability under abrupt changes in severe environmental conditions.

A few of the many assemblies and actuators available for a wide variety of operating requirements are shown above.

This is a true hermetically-sealed switch—sealed metal-to-metal, metal-to-glass. It assures reliable, consistent operation over long periods of time at temperatures of −300°F to +250°F and −300°F to +500°F, even with sudden changes in atmospheric pressure. Meets corrosion-resistant requirements of MIL-S-6743. Electrical rating: 3 amps. ind., 5 amps. res., 28 vdc.

Qualified switch engineers located in Branch Offices. Call (see Yellow Pages) or write for Data Sheet 192.
Quality and economy in servo motors and motor-tachs depend on the manufacturer's experience

...and CEDAR has it!

When it comes to sizes 8, 10 and 11 servo motors and motor-tachometers both with and without gear heads, Cedar is the leader, currently building at a higher rate than any other manufacturer in the country.

Because Cedar's volume is big and production techniques have been perfected and standardized, you are assured of the most economical price available. At the same time, the reliability testing and quality assurance programs built up on these units through years of experience guarantee you the finest quality and dependability.

When you need a servo motor or motor-tach, remember that the most advanced designs built with the most modern production techniques come from Cedar. Write or call us for complete information. You'll be glad you did.

CEDAR CONTROL DATA
ENGINEERING DIVISION CORPORATION
5806 W. 36th St., Minneapolis, Minn. 55416 Phone (612) 929-1681

MATERIALS

Superconductive tape

A strong and highly flexible superconducting tape is fabricated of a 0.5-in. wide ribbon of niobium/tin (Nb,Sn) foil laminated between 2 layers of 1 mil thick tinned copper. Niobium/tin permits operation at 18°K and 200 kgauss. The material suffers no reduction in its current-carrying ability at a bending diameter as small as 0.2-in. and a tensile load up to 20,000 psi.

General Electric Co., One River Rd., Schenectady, N. Y. Phone: (518) 374-221.

RF gaskets

A new RF gasket, "Porcupine Metalastic," consists of a critically expanded sheet of monel metal impregnated with a silicone elastomer. A large number of contact points per square inch results in high attenuation at low pressure. The material is available in bulk and as finished gaskets 0.03-in. thick, 8-in. wide and 0.02-in. thick, 10-in. wide. Other sizes and elastomers are available.

Metex Corp., Walnut Ave., Clark, N. J. Phone: (201) 381-7272.

Glossary of FHP Motor Terms FREE!

Know the difference between a splash-proof motor and a waterproof motor? Between pull-in torque and pull-out torque? This glossary has clear, concise definitions for these and nearly 100 more terms applying to fractional horsepower motors; helps you and fellow staff members talk the same language. Covers motor classes, enclosure types and general engineering terms. It's free...just ask for the Motor Dictionary.

BODINE ELECTRIC CO. 2528 W. Bradley Pl., Chicago, Illinois 60618

Electronic Design, June 21, 1966
Dielectric

"Z-tron G" dielectric is a thermoplastic of electrical grade polyphenylene oxide for use in strip-line circuitry and microwave PC design. The material combines the high strength, rigidity, and thermal and dimensional stability of thermosets with the low electrical loss characteristics of thermoplastic olefins.

A low linear coefficient of thermal expansion prevents thermally induced stresses, rupture of copper cladding or loss of bond from -270 to 375°F. Volume resistivity is 10^17 ohm-cm, dielectric constant at 60 Hz to 3 GHz is 2.55 and dissipation factor at 3 GHz is 0.0011. Copper cladding is bonded to the substrate without the use of an adhesive. The material is available copper-clad or un-clad, in sheets up to 16 x 24-in. and in thicknesses of 0.0625 to 0.25-in. at a tolerance of ±0.001-in.

Polymer Corp., 2140 Fairmont Ave., Reading, Pa. Phone: (215) 376-5791.

Circle No. 263

Silicon tetrachloride

Ultra high-purity silicon tetrachloride is now available for high specification epitaxial deposition of silicon films on wafer substrates. The chemical is used in IC and semiconductor manufacture. Demands for tight control and high layer resistivity are met with a 100 Ω/cm minimum resistivity. The material is available in pyrex, teflon and stainless steel containers.

Apogee Chemical, Inc., DeCarlo Ave., Richmond, Calif. Phone: (415) 233-4684.

Circle No. 264

Epoxy compounds

These new epoxy molding compounds have been developed to meet forthcoming MIL-specs. Epoxy X-7074 will withstand 500°F for 100 hours with a 4% weight loss. The glass-fiber reinforced, resin compound is available in black.

U.S. Polymeric Inc., P. O. Box 2187, Santa Ana, Calif. Phone: (714) 549-1101.

Circle No. 265

ELECTRONIC DESIGN, June 21, 1966

NEW LOW DRIFT, FET CHOPPER STABILIZED
OPERATIONAL AMPLIFIER

MODEL 1538A from BURR-BROWN

This new, general purpose Burr-Brown operational amplifier features an FET chopper for maximum stability in addition to excellent noise and bandwidth specifications. The small 0.6" x 1.8" x 2.4" epoxy module makes it especially suited for high density, high performance applications. It is immediately available from your local Burr-Brown representative's JET-STOCK for same day shipment. Single unit price is $175, only $157.50 in quantities of 10-24.

TYPICAL APPLICATIONS
The model 1538A Operational Amplifier is ideal for use in:
- analog computers
- A to D converters
- navigation systems
- any system where stability is a prerequisite.

It provides low integrator errors over a long integration time and a wide temperature range.

E drift = ±0.5 µV/°C (typical)
I drift = ±1 pA/°C (typical)

E offset = ±15 µV, (at 25°C) rms (dc -10 kHz)
I offset = ±30 pA (at 25°C)

Bandwidth -15 MHz
Slew rate -30 V/µs
Rated Output - ±10 V at 20 mA
Also available with 20 V output

HIGHLIGHT SPECIFICATIONS
from -25°C to +85°C

E offset = ±30 pA (at 25°C)
I drift = ±1 pA/°C (typical)
E offset = ±15 µV (at 25°C)

Input Noise = 6 µV, rms (dc -10 kHz)
= 10 µV, peak (dc -10 kHz)

For complete technical information including detailed Specification Sheet, Short-Form Catalog covering all products and prices, use this publication's reader service card, call your nearest Burr-Brown Representative, or contact Burr-Brown direct.

FOR COMPLETE TECHNICAL INFORMATION including detailed Specification Sheet, Short-Form Catalog covering all products and prices, use this publication's reader service card, call your nearest Burr-Brown Representative, or contact Burr-Brown direct.

Speed inquiry to Advertiser via Collect Night Letter ON READER-SERVICE CARD CIRCLE 139
Why the most readable readouts have a new lens system.

We've just designed a totally new lens system for our miniature rear-projection readouts, the Series 120 and the Series 220 (front plug-in model). Since we already had the most readable readouts made—even with the old lens system—why all the effort?

Frankly, the most important thing we (or any other readout manufacturer) have to sell is readability. That's why we keep on working to make the best just a little bit better. This time it really paid off. Our new lens system delivers a significant increase in character sharpness and a 50% increase in brightness!

First we squared our circular lenses. That gives us greater usable lens area for a twofold effect: the new larger lenses collect more light; magnification required is reduced. Both factors increase brightness and sharpness.

Second, we split the old single condenser lens and made a lens-film-lens sandwich. The old lens refracted light rays toward the projection lens before the rays passed through the film. Of necessity, the lens had steep curvature which limited the usable size of film. The new split-lens condenser refracts light in two stages: before it passes through film and after. By comparison, the new lenses are practically flat, permitting use of larger film and reducing aberration associated with thick lenses. The effect builds up: larger film means Jess magnification which in turn means greater brightness and sharpness.

So that's why the most readable readouts have their new lens system. Frankly, this new lens system may not seem earthshaking to you, unless you happen to be using readouts. In any case, send us your inquiry. We'll give you the reading on readability!
Now you can quick-connect two wires to each socket terminal of the Class E relay

Here's new design flexibility—more than you've ever seen in plug-in Class E relays. The bottom view of our new ETP terminal* shows why.

For each terminal, the mating socket provides two taper pin receptacles. This is an AE exclusive, and it can double circuit capability: two wires on each contact terminal!

Connecting these wires is quick and easy. Just insert a taper pin—and get a connection that's even more secure than with conventional terminals.

And every time you make a circuit change, the connection is as good as the first one.

You can prewire the mating socket and later insert a standard Class E taper-tab relay. Add a plastic snap-on dust cover, and you've got a complete Series ETP assembly.

Sound interesting? Get some helpful details. Write for AE's Product News on the ETP socket.

Widest Mounting Choice
Besides this new ETP (taper pin) and the EIN (integral socket) versions, Class E relays are available with conventional solder, taper tabs, or wrapped-wire terminals, or pins for plug mounting. This is the widest selection of Class E relay connections in the industry—another good reason to check Automatic Electric for all your relay needs. Write the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164. *Patent applied for

AUTOMATIC ELECTRIC

GEN
ERAL TELEPHONE & ELECTRONICS GT&E

Electronic Design, June 21, 1966
**Send in your ORIGINAL test application (for Simpson's famous 260 VOM) NOT ALREADY described in our new book, "1001 Uses For The 260® . . ." You can get a copy from your Electronic Distributor; list price, $1.00. He also has entry rules. Contest ends Dec. 31, 1966.**

**Grand Prize:** One week at the famous Tropicana in Las Vegas.

**Other Prizes:** Goof-proof VOMs and Diode Meter Protectors.

**SIMPSON ELECTRIC COMPANY, 5202 W. Kinzie, Chicago, Ill. 60644**

---

**rotary & linear ACTUATORS custom tailored**

Because Globe is the largest manufacturer of precision miniature a.c. and d.c. motors and compatible stock gear trains, we can design and deliver an actuator to meet your requirement in a short time. Gain the lead time advantages of Globe’s thoroughly proven modular design and large inventory. A refined design can be adapted to your needs for rotary torque to 1000 in. lbs., including all necessary take-off and control elements such as limit switches, potentiometers, etc. No matter what your special requirements may be, a Globe linear actuator will combine maximum thrust in the smallest possible package. Our application specialists will recommend the optimum unit. We routinely handle actuators that must meet MIL specs, specified reliability, high shock and vibration. Request Bulletin A-1 from Globe Industries, Inc., 2275 Stanley Ave., Dayton 4, Ohio.

**GLOBE**

---

**Ultrasonic bonder**

Model WU-600 wire bonder ultrasonically bonds aluminum, gold and other soft metals from 0.0005- to 0.005-in. The bonding cycle and the wire are completely controlled. The bond at the die leaves no pigtail. The ultrasonic generator has two power and time settings allowing an alternate bond schedule at die and terminal. A selector switch permits automatic indexing at the end of each cycle for 12, 10, 8 and 6-pin headers and most transistors.

Axion Corp., 6 Commerce Park, Danbury, Conn. Phone: (203) 743-9281.

**Circle No. 270**

---

**Soldering pencil**

Model R soldering pencil with temperature-sensor grounded tip and temperature control and indication unit maintains a pre-set temperature at the soldering point. Temperature control is infinitely variable from 350 to 1000°F with calibration accuracy of ±2%. Power capacity is 50 W for a rapid response to loss of tip temperature.


**Circle No. 271**
sampling made simple

with your existing Type 530, 540, 550, or 580 Series Oscilloscopes

Here's a new dc-1 GHz sampling unit with operation practically as simple as conventional plug-ins—as you can see by the front panel of the sampling plug-in. You need no pretriggers or external delay lines—the 1S1 unit has internal triggering with a built-in delay line.

Many other features add to the capabilities and operating ease of the Type 1S1, such as:
- A tunnel-diode trigger circuit that insures stable triggering through 1 GHz
- A single control to select the sweep rate and magnify the display up to X100 when desired
- Direct readout of the sweep rate even when magnified
- A dc-offset control that permits observation of millivolt signals in the presence of up to ±1 volt input levels
- Less than 1 mV noise in the display, with a smoothing control for further reduction
- Output signals available at the front panel for driving chart recorders—and for powering an auxiliary time domain reflectometer pulser unit.

**BASIC CHARACTERISTICS**

- **RISETIME**: 0.35 ns
- **SENSITIVITY**: from 2 mV/cm through 200 mV/cm, in 7 steps
- **DYNAMIC RANGE**: ±2 V
- **SAFE OVERLOAD**: ±5 V
- **DC OFFSET RANGE**: greater than ±1 V
- **Sweep Rates**: from 100 ps/cm to 50 µs/cm
- **Vertical Output**: 200 mV per displayed cm through 10 k
- **Horizontal Output**: 1 V per displayed cm through 10 k

**Type 1S1 Sampling Plug-In Unit** $1100

**Type 281 TDR Pulser Unit** $95

*U.S. Sales Prices, f.o.b. Beaverton, Oregon

*used with Type 81 Plug-In Adapter.

For a demonstration, call your Tektronix field engineer.

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Tektronix, Inc.

Electronic Design, June 21, 1966
INSULTITE
heat-shrinkable tubing

Meets or exceeds MIL-I-23053
(WEPS) rev. A.
Recognized by U.L., Inc.

first of the INSULRAD
family of irradiated
polyolefins from E.C.C.

Now there's an important new source of
heat-shrinkable tubing—INSULTITE from
Electronized Chemicals Corporation.
INSULTITE meets competitive heat-
shrinkable tubing requirements spec for
spec—outperforms other shrinkables in
volume resistivity, longitudinal change,
water absorption, and resistance to
solvents.

INSULTITE is the answer wherever skin-
tight packaging or encapsulating covers
are needed. Apply heat: INSULTITE
molds itself around smooth or irregular
shapes to form a tight protective jacket.

Hugle Industries, 587 N. Mathilda Ave., Sunnyvale, Calif. Phone: (408) 738-1700.

Circle No. 272

Epitaxial reactor

An epitaxial reactor, model
HIER, for the growth of silicon or
germanium layers, has a capacity
for 25 1-in. wafers, with a growth
factor of 1.2 micron/minute. Features
include solenoid valves for ex-
act duplication of optimum settings,
timing control, and lines, valves and
fittings of teflon, glass, stainless
steel and monel.

Hugle Industries, 587 N. Mathilda Ave., Sunnyvale, Calif. Phone: (408) 738-1700.

Circle No. 272

Soldering system

This 3-probe soldering system,
model 3080, allows single-schedule
soldering of multi-layer and other
PC boards with variable heat sink
masses. Soldering heat is created by
passing ac current between two
tungsten electrodes on the first pack
lead. The third probe, a small ther-
mosouple, senses interface tempera-
ture.

Development Associates Controls, 123 W. Padre, Santa Barbara, Calif. Phone: (805) 963-3708.

Circle No. 273

Die tester

A tester for "flip-chip" semi-con-
ductors offers positive contact dur-
ing testing through the "pad con-
tact" method. The chip is lifted
with a vacuum pickup and placed
face down onto flexible pads. After
testing, the instrument selects the
proper sorting bin and counts the
tested devices automatically.
P&A: $2500; stock to 4 wks.
Hughes Aircraft Co., Centinela Ave., & Teale St., Culver City, Calif. Phone: (213) 391-0711.

Circle No. 274

Relay tester

Model RT-6000 relay tester is de-
signed to facilitate inspection and
adjustment of electromagnetic re-
lays. The unit uses a crystal-con-
trolled pulse generator as a timing
reference and a high-speed count-
er, gated by the test relay, as the
time interval indicator. Power to
the relay coil is controlled by a
momentary or latching contact on
the panel. Time interval of the de-
sired relay action is read directly on
a 3-digit Nixie display covering 0.1
ms to 999 s.

Front-panel adjustments allow
the measurement of the time from
application of coil power to the clos-
ing of a normally-open contact, time
between two successive contacts or
between opening of a normally
closed to closing of a normally open.
The instrument accommodates any
voltage rating with coil currents to
2 A. Paper tape printout facilities
are optional.

Price: about $1000. Astrosonics
Inc., 190 Michael Dr., Syosset, N. Y.
Phone: (516) 921-2037.

Circle No. 275

ELECTRONIZED
CHEMICALS
CORPORATION
a subsidiary of
HIGH VOLTAGE ENGINEERING
See us at NEP/CON '66, Booth 702,
New York Coliseum, June 21–23.
ON READER-SERVICE CARD CIRCLE 145

PRODUCTION EQUIPMENT

Epitaxial reactor

Relay tester
We need skilled production workers with at least six hands.

How come? Because the increasing demand for our series 900 relays keeps our hands full to meet the production load.

Our real problem (if you can call it that) is that engineers know value when they see it. They've found that this 98c relay gives them longer trouble-free performance and greater reliability than they can find in relays costing much more. The reason is in the exclusive design with molded switches, keyed and locked lifters, encapsulated coil and greatly reduced number of parts.

Maybe we could step up productivity by relaxing quality control and inspection just a little. But you know Guardian better than that.

So if you know any girls with six hands, send them around. In the meantime, if you need 900's in quantities to 199, see your franchised Guardian distributor. If you need them in larger quantities direct from factory production, order now. We'll just ask our two-handed girls to work a little harder.

Series 900 relay,
10 amp. resistive load DPDT.
Size 2-11/16 x 1-11/16 x 1-29/32
UL listed.
**POWER EQUIPMENT**

**Constant voltage supply**

Model 100-2 constant voltage supplies replace dry cell batteries, standard cells and standardizing mechanisms in self-balancing potentiometric type chart recorders. Ratings are 10, 6, 5, 3 and 1 mA with a 1.03-Vdc output. Voltage line regulation is ±0.0016% over 94 to 140 Vac. Isolation is 6 mVac rms across a 1 MΩ resistor from output to ground.

P&A: $54.50 (1 to 9); stock to 2 wks. Dynage Inc., Hartford, Conn. Phone: (203) 249-5654.

*Circle No. 276*

**High voltage supply**

Model 240A has an output voltage from 0 to ±1200 Vdc, front-panel selectable in calibrated 1-V steps. A pot permits interpolation with better than 5-mV resolution. Output current is 10 mA max. Line and load regulation are both ±0.005% ±2 mV. Accuracy is ±1% of the dial setting for all outputs. Ripple and noise are 1 mV rms max.

P&A: $345; stock to 30 days. Keithley Instruments, 12415 Euclid Ave., Cleveland. Phone: (216) 795-2666.

*Circle No. 277*

**Klystron supply**

Model CP-2055V klystron power supply has a continuously variable beam voltage of −250 to −800 Vdc at 0 to 100 mA. Ambient range is 0 to 50°C with stability of 0.02%/°C. Reflector output is 0 to −800 Vdc with respect to negative beam output at 0 to 0.5 mA. Filament output is 5.7 to 7 Vdc at 0 to 2 A. The modulator produces a −5 to −150 V square wave at 250 to 2500 Hz or a sawtooth at 50 to 500 Hz. Ripple is 1 mV beam, 0.5 mV reflector and 2 mV filament.


*Circle No. 278*

---

**NO TOOLS . . . EASY HAND INSTALLATION**

**SELF-LOCKING, PERMANENT**

Just one component — molded of tough, flexible nylon — forms a secure, permanent harness. Easy to use without tools: just place around wires ... slip end through buckle ... pull taut ... trim. It's virtually indestructible! Three sizes for bundle diameters up to 2¼". Write for a free sample today.

**CABLE TIE**

*Electrovert Inc.*

86 Hartford Ave., Mount Vernon, N. Y. 10553

Burbank, California  •  Milwaukee, Wisconsin

**OTHER ELECTROVERT PRODUCTS:** Cradleclip, Strapping, Spireband, Markers, Grommet Strip, Wavesoldering Systems. Sold Coast-to-Coast through Authorized Distributors.

**HEART FUND**

Give...so more will live

ON READER-SERVICE CARD CIRCLE 146

Electronic Design, June 21, 1966
Modulated source

Model CH-50 is a modulated 5-A dc power source with an adjustable 18 to 37-V output. The source offers five modulation modes: random noise, square wave, transient, voltage spikes and external input. Random noise modulation from 10 Hz to 100 kHz is provided by an internal white noise generator. Square wave modulation from dc to 10 kHz is internal squaring of an external sine wave input. Modulation amplitude for the two modes is adjustable from 0 to 10 V p-p.

Transient modulation mode offers 20-ms pulses of +15 or -30 V. Spikes of 80 V and 10 ms duration may be superimposed on the dc output. External modulation source may be sine, square, or any waveform whose harmonic content does not require frequency response in excess of 150 kHz. Output impedance is adjustable from 0.1 to 16 Ω and regulation is 0.5%. Power required is 600 W max at 117 Vac.

Chrysler Corp., Space Div., 1312 N. Meridian St., Huntsville, Ala. Phone: (205) 837-6100.

Circle No. 376

Ac-dc modules

The PC-80 series of silicon-regulated ac-dc power modules requires little or no heat-sinking. The series offers regulation accuracy of ±0.05% against line and load at base temperature ratings to 80°C. Outputs ranging from 4.1 to 152 Vdc at up to 60 W are offered as standard. The modules meet MIL environmental specifications.

Technipower Inc., 18 Marshall St., Norwalk, Conn. Phone: (203) 866-9244.

Circle No. 377

Bausch & Lomb V.O.M. Recorders assure you outstanding performance

1. Directly measure and record d-c voltage, current and resistance
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4. 17 different input ranges
5. Zener diode reference supply
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Bausch & Lomb V.O.M. Recorders are available in a variety of models with different full scale sensitivity. We have a wide range of accessories that make our recorders equal to just about any task required. For your special needs, we have the capability of designing customized recorders . . . modified to handle whatever applications you have in mind. Let us hear about your recorder requirements. Write for Catalog 37-2068. Better yet, ask for a personal demonstration. Bausch & Lomb, 91530 Bausch Street, Rochester, New York 14602.
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For Low Cost Frequency Control

Use TUNING FORK OSCILLATORS
For Low Cost Frequency Control

New Inexpensive Model G
Frequency—from below 1 CPS to 30 KC with choice of accuracy for each of five temperature ranges. Standardized construction allows excellent delivery of prototypes or production runs. Many special features are available. Long-term stability—2-year guarantee.
Prices start at $35.00. Send for complete information.

Other style cases available, including models for printed circuit use.

Catalogued in EEM VS MF

POWER EQUIPMENT

Dual supply

Model 506 power supply has a dual output of ±12 to ±24 Vdc at 150 mA for each channel. The unit features current limiting, short circuit protection and convection cooling over an operating range of -20 to 70°C. Line regulation is 0.03% and load regulation is 0.15%. The supply requires 105 to 130 Vac at 45 to 440 Hz.

Circle No. 279

The SMC-1 stepper motor control functions as a push-button pulse generator, a translator and a power supply to control one or more stepper motors over a speed range of 144,000 to 1. Output rates are 10, 20, 40, 100, 200 and 400 steps per second, minute or hour. The unit is programmable and delivers 2 A to drive 12 to 14-V center-tapped or bifilar motors.
P&A: $750; 45 days. Houston Instrument Corp., 4950 Terminal Ave., Bellaire, Tex. Phone: (713) 667-9307.

Circle No. 280

A continuously variable output of 200 to 1800 Vdc in two ranges at 0 to 10 mA is designed to power photomultiplier tubes. Line regulation of model PM-1K-01A is ±0.001% for a 10% change and load regulation is 0.001% from no-load to full load. Ripple is 2 mV p-p and stability is 0.01%/hour. Output voltage and current are monitored by a pair of 2%-accuracy front panel meters.

Circle No. 281

Power inverter

A solid-state transistor power inverter is designated Gemini 50-128. The device converts conventional 12 V storage battery current to a filtered 117 Vac. Rated capacity of this power inverter is 450 to 500 W. The unit is housed in a heavy-gage copper clad case with carrying handle.

Circle No. 282
Check your lacing tape requirements here

THEN GET THE RIGHT TAPE FROM GUDEBROD!

Perhaps you are regularly using Gudebrod Gudelace 18, the standard, wax impregnated nylon tape that’s known round-the-world for its non-slip knotting (meets MIL-T-713A specs, too). You are doing well then—with the finest tape and saving money on harnesses, too!

But when you are making gear for tropic or arctic use, if you are involved with outer space or special industrial applications—come to Gudebrod. Here is your one best source for lacing tape information. Ask for a copy of our Product Data Book describing the more than 200 different tapes in our regular stock. In it you’ll probably find the tape that fits your requirements—but if you don’t, inquire about having one made to your particular specifications.

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Electronics Division
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Area Code 215, WA 2-1122

ON READER-SERVICE CARD CIRCLE 152
Series 3000 ac line conditioner offers complete isolation from power lines. With response time of 50 µs max, input/output isolation of 10 dB, output distortion of 0.25% max and regulation of ±0.05%, the units provide 2-1/2 kVA transient-free ac power. Models are available to operate at 47 to 53, 57 to 63 and 380 to 420 Hz.


Circle No. 283

A fully programable, amplifier-type power supply has an output voltage of 0 to 3000 V. Programing voltage is +85 V. Line regulation is 0.001%, load regulation is 0.0007% and ripple is 5 mV rms. Model V-302 is available as a rack-mount or in a remote version. Input is 105 to 125 Vac.

Price: $700 (rack), $800 (remote). Gyra Electronics Corp., P.O. Box 184, La Grange, Ill. Phone: (312) 354-4644.

Circle No. 284


Littelfuse
Des Plaines, Illinois

Circle No. 153

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**Adapter**

This off-the-shelf adapter/control unit converts solid-state power supplies to laboratory dc sources. A front-panel control adjusts output voltage over its full range. Plug-in power supplies are available with voltage outputs from 0 to 400 Vdc and current outputs from 0 to 25 A. All have automatic short and overload protection.

Price: $14.95. Power/Mate Corp., 163 Clay St., Hackensack, N. J. Phone: (201) 343-6294.

Circle No. 285
What marking job can we help you do better?

These are only a few of hundreds of marking jobs you can do more efficiently and more economically with Markem machines. So why waste time improvising and experimenting?

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.
MINIATURE TEST ACCESSORIES 1/3 smaller...

1/2" SPACING for the new generation of miniaturized test equipment

Pomona created a complete line of 1/2-inch spaced Banana plugs, jacks, cable assemblies, patch cords, adapters, and binding posts to meet the industry's continuing demand for miniaturization.

Banana plug springs formed of one piece Beryllium copper (per QQ-C-533), heat treated for long service life and low contact resistance. Tough, molded thermoplastic bodies provide maximum strength and insulation. Available in a wide selection of colors.

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Lists over 230 molded test accessories, all designed to meet rigid industrial and military specifications—and built by the quality leader...

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Telephone (714) 623-3463

ELECTRONIC DESIGN, June 21, 1966

MICROELECTRONICS

Semi-conductor package

The "LID" (leadless inverted device) is a microminiature semiconductor package that can be mounted on substrates by mass production jiggling techniques. Initially, a family of high-speed switches and a family of high-gain amplifiers are offered. The all-ceramic "LID" measures 0.075 x 0.045 x 0.032 in. It has four contact legs and is coated with metallized solderable gold. Any number can be mounted simultaneously and bonded to the substrate by low-temperature soldering.

Amperex Electronic Corp., Slatersville, R. I. Phone: (401) 762-9000.

Programable logic

Programable digital logic cards can be converted to meet different circuit requirements. Boardboard designs may be altered by changing "program cap strip" connection points. The strip allows rapid addition or contraction of logic functions. A single card can provide two 5-input NAND gates, one 10-input NAND gate or one 8- and one 2-input NAND gates. Programing also permits optional collector loads and different switching speeds.

P&A: $17.25 to $31.50; stock to 30 days. IBM Corp., 1000 Westchester Ave., White Plains, N. Y. Phone: (914) 696-1900.

Ferrite memories

A monolithic ferrite memory stack with diode selection matrix has a full-cycle time of 500 to 600 ns. The 2-in.² stacks contain 512 or 1,024 words with 32 bits/word for a max storage capacity of 32,768 bits. The devices are also available in plane form. The MF-2100 is a 64-word by 64-bit memory while the -2101 is a 64-word by 32-bit memory.

Wafers contained in these units are a "batch-processed" ferrite device eliminating core-stringing and hand-wiring. The ferrite material is fired into a solid monolithic wafer 1-in.² by 5x10⁻³-in. thick. Each wafer contains 4096 theoretical cores with 5-mil effective diameters. They are interconnected through 16 selection matrices of 128 diodes each.

Price: $420 (MF-2100), $305 (-2101) (1 to 24). RCA, Components and Devices, Harrison, N. J. Phone: (201) 485-3900.
Call your local Weston Distributor for additional information. He stocks the complete Weston line, has what you need, and is primed for fast delivery!

New VOM sits up so you can sit down

Put an end to the stoop and squint routine—use the VOM that gives you real legibility with 5½° scale and refractive plastic scale overlay for parallax-free readings. New Weston Model 80 VOM permits you to reverse polarity even under load, provides a single switch for controlling functions and range, and gives you both fuses and diode overload protection. Matching family of multi-function test instruments also available.

ACCURACY: 1% dc, 1.5% ac. DC Volts: 0.25v to 5Kv in ten steps @ 20k ohms/volt. AC Volts: 2.5v to 5Kv in seven steps @ 5K ohms/volt. DC Current: 50µa to 10 amps in six steps. Five Ohmmeter Ranges: 2K to 20 meg full scale; 20 to 200K center scale. DB Scale: -10 to +10 db.

Ask for the portable Model 80, or the convenient rack-mounted version, MODEL 80R, for 19" relay rack panel installation.

Contact your Weston Distributor, or Weston Instruments, Inc., Newark Division, Newark, N.J. 07114

WESTON® prime source for precision... since 1888
D/A microcircuits

D/A microcircuits in hermetically sealed TO-90 and TO-91 flat packs allow up to 12-bit operation with less than 1/2-bit error. The series consists of ladder switch, ladder network and buffer. The family utilizes the combination of thin-film tantalum nitride resistors, nickel-chromium resistors and active planar devices.


Feedback wanted

Electronic Design would like to know how you rate our New Products section. Does it do the job for you? Does every issue contain at least a sampling of products you use? (We try to cover the field from amplifiers to zeners.) Any suggestions for improvements? Please send along your replies on the handy Editorgram card at the back of this issue. It's free.

Transistor chips

A line of 15 pnp and npn silicon transistor chips is offered for hybrid circuit applications. The chips are gold-plated on the collector surface for mounting. They are also available pre-mounted on gold-plated Kovar tabs 0.05 in. square and 0.006-in. thick.

Price: $.55 to $1.65 (100 to 999).

Raytheon Co., 141 Spring, Lexington, Mass. Phone: (617) 862-6600. Circle No. 292

Multivibrator

A direct-coupled, high-drive, one-shot DTL monostable multivibrator provides complementary output pulses adjustable by the addition of external discrete passive components. The SW728 multivibrator is a monolithic epitaxial silicon IC with a dc noise margin exceeding 700 mV and a power drain of 50 mW. Pulse input is 20 ns min and fan-out is typically 20. Supply voltage is 8 V (continuous) and 12 V (pulsed).

Microcircuits Inc., 730 E. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-9200. Circle No. 293

Breadboard sockets

Series 030 breadboards are available with 10, 20 or 30 sockets to accept dual in-line ICs for aging, testing or circuit development. Busses may be connected to individual sockets with turret lugs or spring-loaded pin jacks. The sockets accept 14 or 16 round, octagonal or flat leads. Body dielectric is Teflon for operation from -65 to 200°C. Interlead capacitance is 0.1 pF for opposite terminals and 0.26 pF for adjacent terminals. The boards may be interconnected for more complex configurations.

Barnes Development Co., 213 W. Baltimore, Lansdowne, Pa. Phone: (215) 622-1525. Circle No. 294

GOOD FORTUNE AND PROSPERITY
AWAIT ENGINEER ORDERING E-T POTS

E-T 7½" 10-turn precision pots:
- cost $4.50 or less, in production quantities
- meet or exceed existing, accepted specifications
- resistance range from 25 to 250,000 ohms
- linearity tolerance ± 0.25% (special to ± 0.05%)
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Unique, self-healing units that remain in circuit during voltage surges with little or no loss of electrical properties. Use the M2W's where size and weight are limiting factors and long life and dependability are required. The units utilize metalized Mylar Dielectric with film wrap and custom formulated epoxy resin end fill. Available in round and flat styles.

*Du Pont Trademark for Polyester Film

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ON READER-SERVICE CARD CIRCLE 158
Information and the design engineer:

This definitive work fully examines this major system of information storage and retrieval

DIGITAL MAGNETIC TAPE RECORDING:
PRINCIPLES AND COMPUTER APPLICATIONS
Bernard B. Bycer

Design engineers have a dual interest in the storage and retrieval of information: they must be able to rapidly obtain and interpret large amounts of information for use in their own design work, and they are involved in the design of the systems which perform this function. Both of these interests are served in this comprehensive book by an eminent authority. The extent of the possibilities of the system is fully developed, so that the engineer may make fuller and more specific use of it; every operational aspect is covered in detail, providing a design guidebook for creation of the systems themselves, or for their inclusion in larger systems.

CONTENTS
Magnetic Tape Recording • The Digital Magnetic Tape Transport • Digital Magnetic Heads • Principles of Digital Magnetic Recording • Coding Digital Magnetic Tape • Digital Magnetic Tape • The Organization of Data on Magnetic Tape • The Digital Tape Station • Computer Applications • Recent Developments and Applications
• Appendices: Tape Reservoir Length, Demagnetization, Tape Access Time

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2 Gives useful and practical information on all design aspects

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John S. Murphy. An easy-to-follow, rapid means of mastering the fundamentals of digital computers. Fully illustrated for reinforcement. 416 pages, clothbound, #0073, $9.50

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Electronic Design, June 21, 1966
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Send for new full-line catalog

MICHIGAN MAGNETICS, INC.
VERMONTVILLE, MICHIGAN
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Design Aids

Selector slide rule

A product selector for filters, inductors and delay lines is offered in the form of a circular slide rule. With the dial turned to the product desired, complete specifications are read through the cut-out window. The rear of the rule details parts numbers and case styles, and presents various filter and inductor graphs. Stanford Applied Engineering.

Circle No. 295

Film and tape chart

A cross reference chart of relevant parameters for all currently available high-temperature and pressure-sensitive tapes and films is offered. The chart covers Teflon and related products and lists 73 types of tapes and films complete with specifications and sources. On the reverse side is an engineering and application guide. Technical Fluorocarbons Engineering Inc.

Circle No. 296

Delay line memories

A file folder doubles as a design guide to specifying magnetostrictive delay line memories. With the aid of schematics, operating principles and associated circuitry are detailed. Fourteen practical notes considering parameters of interest for delay lines and associated circuitry complete the two-color folder. Deltime.

Circle No. 297
Test applications

A 90-page, paper-backed book details "1001 Uses" for the manufacturer's volt-ohm-milliammeter. Each test application is explained in text as well as by schematic or circuit diagrams. Tables, charts and formulas are included.

A section, "Other Measurements," covers tests of frequency, transistors and diodes, capacity, $\mu$V attenuation, batteries and field strength.

Available for $1.00 from Simpson Electric Co., 5200 W. Kinzie St., Chicago.

Veto efficiency

Successful anti-coincidence or veto operation of a coincidence or AND circuit requires nearly 100% efficiency in the veto channel. Available discriminator/trigger circuits are unsatisfactory as none provide better than 50% efficiency.

This 4-page application note shows how a dual limiter module may be used to assure that the efficiency of the veto channel is limited only by the detector and the bandwidth of the limiting and veto circuits. Schematics, oscillograms and equations aid in the discussion. EG & G, Inc. 

Circle No. 298

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COMPARE THESE SPECS AGAINST COMPETITIVE EQUIVALENTS (IF YOU CAN FIND ANY!)

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<table>
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<td>Resistance Range</td>
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<td>Linearity</td>
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<td>Power Rating</td>
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<td>Operating Temperature</td>
<td>$-55^\circ$ C to $+125^\circ$ C</td>
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Prices start at less than $9.00 in 100 quantities, and yet these quality pots meet or exceed many military environmental specifications. For full information, send for a data sheet.

Spectrol Electronics Corporation, 17070 E. Gale Ave., City of Industry, Calif. 91745

...YOU'VE JUST FOUND THEM!

A standard $\frac{3}{8}$-inch shaft $\frac{1}{8}$-32 thread bushing mount, a popular $\frac{3}{4}$-inch shaft $\frac{1}{8}$-32 thread bushing mount, and a unique low-cost serve mount—all with rear terminals!

Speed Inquiry to Advertiser via Collect Night Letter ON READER-SERVICE CARD CIRCLE 163
Motor tach generators

Motor tach generators from size 5 to size 23 are fully described in a 28-page booklet. Data on such related devices as integrating ac/ac mechanical filters, dc tachometers, ac motor/dc tach combinations, integrating tach generators and specialized motor generators are given. A "Definitions and Applications" section contains functional schematic and block diagrams, together with equations relating to major performance characteristics. General Precision Inc., Kearfott Products Div.  

Circle No. 299

Silicon rectifier guide

Complete electrical replacements for a broad range of silicon rectifiers are outlined in a new replacement guide. The guide facilitates replacement of more than 1200 competitive rectifier types, both JEDEC and house numbers. A selection guide, cross-reference charts, current/temperature derating curves and dimensional drawings are provided. Motorola Semiconductor Products, Inc.  

Circle No. 302

Contacts

Innovations in contact materials and value analysis in contact applications are detailed in bulletin PEP-2. Analyzed are considerations such as combining properties of springiness, strength and conductivity into one system, heat sinks and scrap and space control. Charts and drawings illustrate techniques such as overlay, top-lay, stripe, temper top-lay and edgelay. Texas Instruments, Metals & Controls Div.  

Circle No. 303

Wavesoldering

An 8-page brochure describes and illustrates automated soldering systems available to meet PC requirements. Details as wave characteristics, operating temperatures, applications and physical specifications are included for each wavesoldering machine and various fluxing, preheating, cleaning and drying units. The brochure also explains the principle of wavesoldering and hot-dip tinning. Electrovert, Inc.  

Circle No. 304

Rectifier handbook

A 216-page silicon rectifier handbook provides information needed for effective selection and application of silicon rectifiers. For the experienced and the newcomer to the power control field all phases of the rectifier art are covered. Circuits for single and multi-phase systems as well as rectifier voltage multipliers and circuits for regulation, arc suppression and other specialized applications are described and analyzed. Areas of overvoltage and overcurrent protection and thermal design are discussed.  

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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. 6½" disc with capacity of 1 million bits. Customized airborne memories available with capacity up to 50 million bits.

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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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Dual output power supplies are housed in one case 3-5/16" x 4-5/32" x 4-11/16" high. Identical or different output voltages from 1.5 to 75 are available in 1 volt increments for each of the DC outputs. The graph below furnishes maximum current corresponding to output voltage. Select the two outputs needed and telephone Acopian for all the details — plus guaranteed 3-day shipment after receipt of your order.

TYPICAL SPECIFICATIONS
Input Voltage: 105 to 125 VAC
Line Regulation: ± 0.5 to ± 0.05% (depending on model)
Load Regulation: ± 1.0 to ± 0.05% (depending on model)
Ripple: 5 to 1 mv (depending on model)
No additional external heat sinking required.

Write for Acopian's 16-page catalog and price list to: Acopian Corp., Easton, Penna., or call collect (215) 258-5441.

NEW LITERATURE

Frequency control
A comprehensive review of frequency control and timing instrumentation, components and systems is offered. Frequency standards, phase comparators, distribution amplifiers, digital clocks, crystal oscillators, proportionally controlled ovens and crystal controlled linear discriminators are described. The 4-page brochure includes photographs, specifications and descriptions. Frequency Electronics Inc.

Amplifier selection
"Selecting a Differential Amplifier" discusses the wide range of differential amplifiers and the difference existent between common-mode rejection methods and rejection level capabilities. Parameters discussed include constancy of common-mode rejection with gain, common-mode slewing and overload characteristics, floating versus grounded-source conditions and input attenuation design. Dynamics Instrumentation Co.

Drum programmer
The 12-page technical bulletin 200 provides detailed information on the concept, application, construction, and specifications of a stepping drum programmer. End-point program control is explained and typical applications are graphically described. The solutions of program-control problems are compared using this programmer and other types of systems. Options, special circuits, and programming accessories are included. Tenor Co.

Resistance tests

Timing controls
A 4-page illustrated product file on automatic timing controls is offered. The folder includes complete specifications and dimensions on time delay relays, interval timers, cycle timers, running time meters, percentage timers, reset timers, time switches and program clocks. Zenith Controls Inc.

Terminal blocks
Engineering data and specification charts on a 300-V, miniature sectional terminal block line, are featured in the 30-page catalog G-104. A fold-out page containing tables 310-12 and -13 of the NEC for terminal block current ratings is included. Buchanan Electrical Products Corp.

Components catalog
A 120-page components catalog covers a line of precision and trimming potentiometers and counting dials. Electrical, mechanical and environmental characteristics are completely specified. Each pot is shown in a cut-away form to depict important product features. Amphenol.

Relays
The Proceedings of the 14th National Relay Conference, April 27, 1966, are offered. The volume contains 25 technical papers, covering areas ranging from contact geometries, materials and reliability to packaging.

Available for $5 from Mr. James V. Roughan, National Association of Relay Manufacturers, P.O. Box 7765, Phoenix, Ariz.

ON READER-SERVICE CARD CIRCLE 165
Magnetrons

This bulletin outlines breakthroughs in protecting voltage-tunable magnetrons against RF interference. The 4-page brochure discusses how the shielding reduces susceptibility to degaussing. Also described are advantages including modulation rates as high as 20,000 MHz/µs, electronic linear tuning, and a relatively flat power variation across wide bands. General Electric, Electronic Components Div.

Circle No. 313

Stepping motors

A new 12-page design booklet aids in the use of stepping motors in precision positioning systems. Criteria for open- versus closed-loop systems for direct digital positioning are examined. Theory, cost and reliability are discussed and illustrated with sample applications. A table lists the specifications of most motors available today. Icon Corp.

Circle No. 314

Bellows couplings

A 2-page engineering bulletin describes a complete line of bellows couplings. Couplings for synchros, pots, shaft encoders and other rotary devices are covered. Theta Instrument Corp.

Circle No. 315

Digital printer

Bulletin 2045 describes a 63-character alphanumeric strip printer used for computer interrogation and monitoring. Specifications cover all pertinent electrical and mechanical parameters. Franklin Electronics, Inc.

Circle No. 316

OPEN A NEW WORLD IN PROGRAMMING

SEALECTOBOARD

offering unlimited versatility in programming, switching, and circuit control without patchcords or jumpers. Selecto-board has a unit that can perform virtually any programming function with one to four contact decks, bussed contacts, shorting, skip, and component holding pins, and countless hole, contact and mounting configurations.

If your application calls for a fast, highly reliable, program-at-a-glance programming system, contact Sealec. Our Applications Engineers are experts at solving programming problems.

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ON READER-SERVICE CARD CIRCLE 166

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Sealec Ltd., Portsmouth, Hants, England

ON READER-SERVICE CARD CIRCLE 166
NEW LITERATURE

Core memories

Core memories for industrial and computer applications are described in this 4-page brochure. Complete specifications are included. Rese Engineering Inc.

Circle No. 317

RF power measurement

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**Electronic Design, June 21, 1966**
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ON READER-SERVICE CARD CIRCLE 183
how to cool hot black boxes

in the Vigilante

Five liquid cooling systems for avionics in every bomber!

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ON READER-SERVICE CARD CIRCLE 169

Designer’s Datebook

June 21-23
Conference on Precision Electromagnetic Measurements (Boulder, Colo.) Sponsor: Institute for Basic Standards; John Cronland, University of Colorado, 328 University Memorial Center, Boulder, Colo.

June 27-29
2nd Annual Conference & Exhibit on “Exploiting the Ocean” (Wash., D.C.) Sponsor: Dr. James H. Wakelin Jr., Scientific Engineering Institute, Waltham, Mass.

July 6-9
Annual Meeting of the National Society of Professional Engineers (Minneapolis, Minnesota) Sponsor: National Society of Professional Engineers; Kenneth E. Trombley, 2029 K St., N.W., Washington, D.C.

July 11-13

July 11-14

July 18-20

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Microelectronics Symposium (St. Louis, Mo.) Sponsor: IEEE; Dr. John W. Butterey, McDonnell Aircraft Corp., P. O. Box 516, St. Louis, Mo.

Electronic Design, June 21, 1966
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