

December 6, 1965

# ELECTRONIC DESIGN

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Microcircuit technology  
coming next week



1 Gc voltmeter based on random sampling...p 58





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## DESIGNER'S DATEBOOK

DECEMBER							JANUARY						
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(Listings include sponsors and addresses for further information.)

### December

**Welding in Electronics Conference,** (Dec. 8-9, New York) Sponsor: Association of Production & Manufacturing Engineers, W. B. Valentine, 212-269-4339.

**Amer. Assn. for Advancement of Science Annual Meeting** (Dec. 26-31, Berkeley, Calif.) Sponsor: AAAS; Dr. R. L. Taylor, 1515 Mass. Ave., Washington, D. C.

### January

**National Society of Professional Engineers Winter Meeting** (Jan. 5-8, Bal Harbour, Fla.) Sponsor: NSPE; Paul Robbins, NSPE, 2029 K St., N.W., Washington, D. C.

**Soldering Technology Seminar** (Jan. 13-14, Chicago) Sponsor: IITRI; William Dunbar, IITRI, 3241 S. Federal St., Chicago, Ill.

**Annual Reliability Symposium** (Jan. 25-27, San Francisco) Sponsor: IEEE, ASQC; J. W. Thomas, Jr., Vitro Labs, 14000 Georgia Ave., Silver Spring, Md.

**IEEE Winter Power Meeting** (Jan. 30-Feb. 4, New York) Sponsor: IEEE; Edward Day, IEEE, 345 E. 47 St., New York, N. Y.

### February

**Aerospace & Electronic Systems Winter Convention** (Feb. 2-4, Los Angeles) Sponsor: IEEE; Dr. Wm. T. Russell, TRW Space Tech Labs, 1 Space Park, Redondo Beach, Calif.

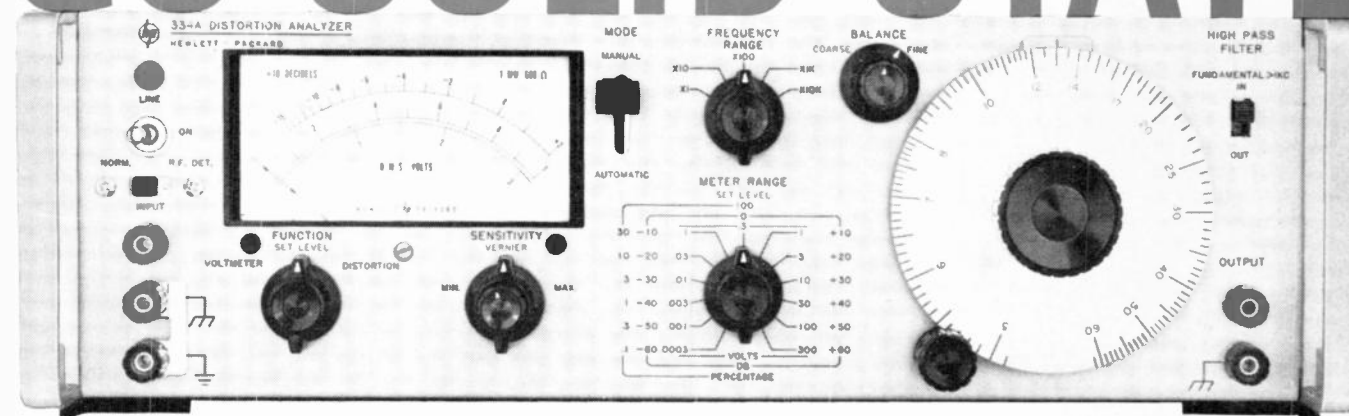
**International Solid-State Circuits Conference** (Feb. 9-11, Philadelphia) Sponsor: IEEE, University of Pennsylvania; Lewis Winner, 152 W. 42 St., New York, N. Y.

### Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service card.

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800	1965 Semiconductor Directory
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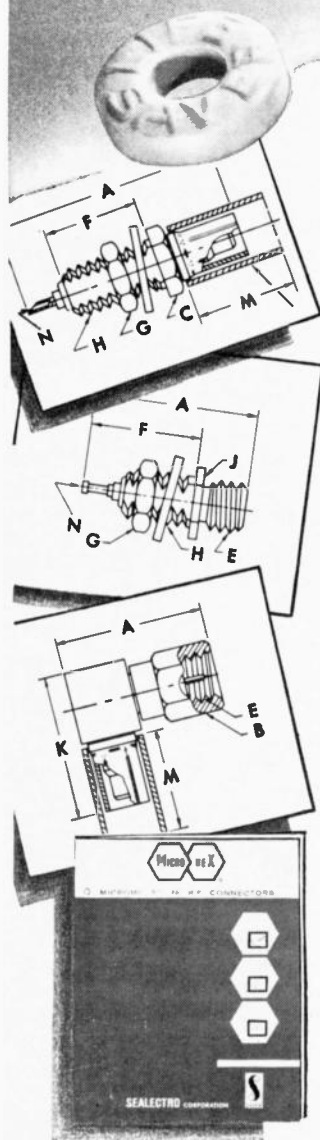
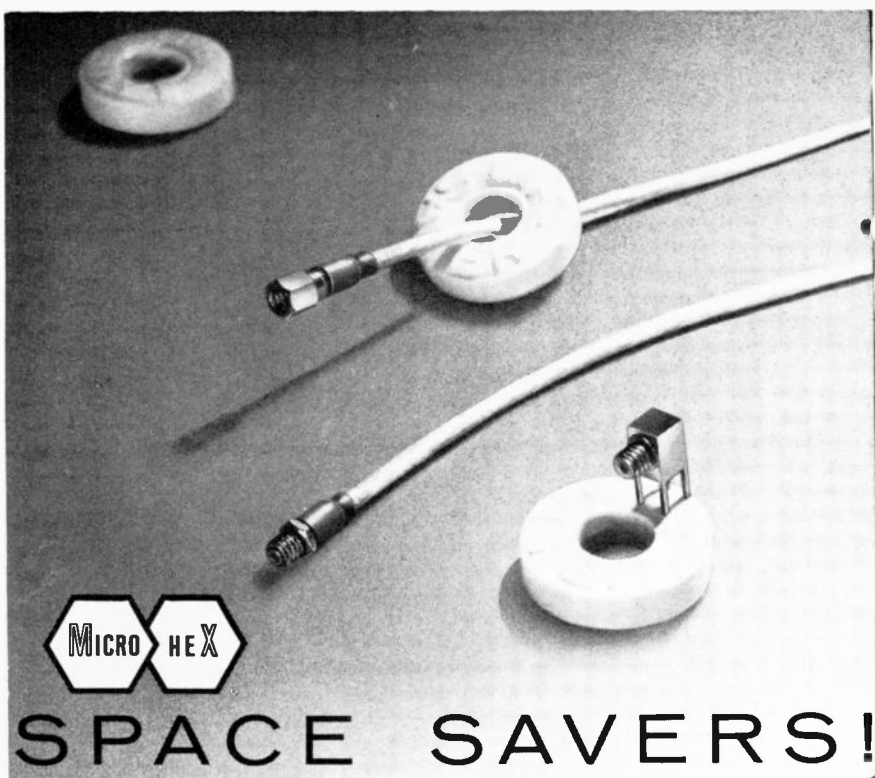
Model	Automatic Fundamental Nulling	High-Pass Filter	AM Detector	Gear Reduction Tuning	Price
331A				V	\$590
332A			V	V	\$620
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# ELECTRONIC DESIGN

CONCEPTS AND IDEAS ESSENTIAL TO DESIGN ACTION • DECEMBER 6, 1965 • VOLUME 13

## COVER

The red waveform represents an RF signal. The white line represents an audio signal developed by sampling the RF at random intervals. At lower left is the new voltmeter at rest. On the move, it determines the rms voltage of any signal from 1 Kc to 1 Gc. See page 58.

## NEWS

### 6 Blackout sheds light on system faults

Power Engineers are scrambling back to their drawing boards to evaluate the findings of the FPC on the North-east blackout. Component unreliability and slowness may point to more electronic devices.

### 12 The wonderful world of the thyristor

Thyristors stole the show at the recent Industrial Static Power Conversion Conference in Philadelphia. Here's a rundown on the wide variety of these devices now available and their many applications.

- 4 News Bulletins
- 10 Computer memory techniques strive to match IC speeds
- 15 Integrated circuits to be installed in underwater beacon
- 16 Washington Report
- 19 Letters

## EDITORIAL

### 18 A new face for ED banishes your pet peeve

The die is cast and you, the readers, have cast it. Beginning with the January 4 issue, ELECTRONIC DESIGN will be in a filable, tear-sheetable 8-1/4x11-inch format. Here are the details of what changes and why.

## TECHNICAL

### 20 SCR gives dc motor synchronous capability

Get synchronous speed control for a dc motor with a commutating SCR in the speed-control feedback loop. The technique is inexpensive and precise.

### 28 Using feedback pairs in integrated circuits

Part 1 of this two-part article analyzes the feedback paths needed for the series-to-shunt pair in integrated-circuit design. Part 2 will cover stability and other feedback pairs.

### 32 Shortcut to logic design of sequential-counters

Is it a strain to work out the logic design of flip-flop gating in sequential counters? You can minimize your efforts by taking advantage of redundancies.

### 36 Radio signals lose more power than you think

Propagation of a radio signal in air can't always be considered as being in free space. These charts give a "ball park" value of the losses the wave encounters.



#### 40 Don't blow your fuse—if you don't have to

Do the fuses in your complex high-power-systems handle the charging currents and transients they're supposed to, yet open in case of failure? If not, here's how you can select a fuse correctly.

#### 44 Find comb-filter frequencies fast

Comb filters are standard tools of telemetry and communications engineers. The tedious and repetitive calculations needed to find the center frequencies of each filter are eliminated with this simple graph.

#### 52 Ideas for Design

- 52 Series-parallel connection produces high-level pulses
- 52 Differentiator-divider analyzes power-line transients
- 54 Locking monostable circuit immune to false triggering
- 55 Out-of-lock detector is digital frequency discriminator

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### CAREERS & MANAGEMENT

#### 46 Can you put your ideas across?

Do people listen when you talk and then act? If not, perhaps you're not understood, the idea isn't well organized or you bore them. Here's a four-point program for stimulating your colleagues and friends to action by means of effective communication.

### NEW PRODUCTS

#### 58 Test Equipment

A new concept in measuring RF voltage—incoherent sampling—is the basis of a wideband voltmeter.

#### 68 Semiconductors

Uhf amplification is provided by an MOS field-effect device rated for operation as high as 450 Mc.

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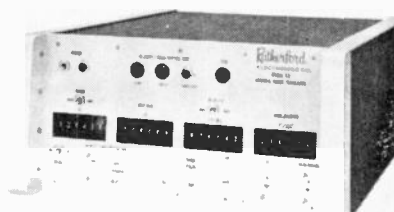
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# NEWS BULLETINS

## MEETINGS

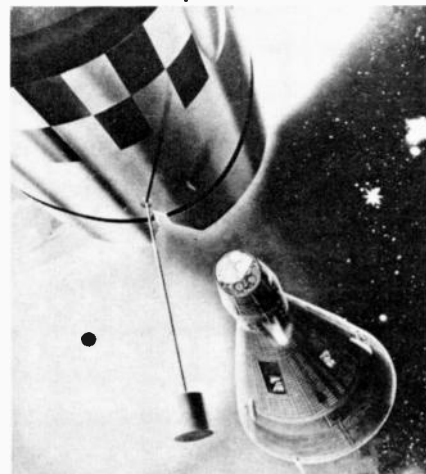
### ME computer memories spotlighted at NEREM

Integrated-circuit array technology may fill the memory void in all-microelectronic computers. At the recent Boston NEREM, the first descriptions of three companies' approaches to this problem were disclosed.

An operating airborne guidance computer containing a 64-word scratchpad memory made up of microelectronic chips was described by R. F. Shively of Litton Industries, Woodland Hills, Calif. The chips include a flip-flop storage element and read/write and sense amplifiers on separate flat-packs. The company predicts quantity-production costs for such a memory to be as low as \$1 per bit.

A 16x16-bit integrated memory array has also been fabricated at Motorola Semiconductor, Inc., Phoenix, Ariz. This memory, as described by J. A. Narud, is a non-destructive-read, word-organized memory with a reported access time of 8 nsec. IC

#### Gemini 6 + 7 ??



—Wide World Photos

A Gemini 6 launch shortly followed by Gemini 7 and then a mating of the two vehicles is expected this week. The strike of McDonnell Aircraft Corp. machinists will hopefully not affect the launches.

memories are limited thus far to scratchpad sizes, but developers see no reason why they can't answer the needs for speed and performance where, they say, ferrite cores and thin-films are falling short.

L. B. Ruthazer of Honeywell EDP, Waltham, Mass., also described a technique for integrated-circuit computer memories.

In another computer circuit area, a pulse-powered digital circuit technique was described by Richard Baker of the Massachusetts Institute of Technology. Power economy can be realized to four orders of magnitude in a typical binary counter that operates in the 5- to 50-Kc range. It involves clocking the power supply similar to the way trigger pulses are generated and disseminated. In addition to conserving power, the technique allows the storing of several bits on a single bistable element by holding the data in capacitors on the flip-flop output.

Pulse-powering thus has significance on the system level of computer organization. Additional design freedom is possible through a relaxation of many traditional low-power requirements, such as premium component performance (low leakage, high current gain at low current, low stray capacitance, etc.), high circuit impedance (a problem with current integrated-circuit technology) and low-tolerance passive components.

J. J. Suran, of General Electric Co.'s Research Lab at Schenectady, N. Y., described a graphical method for switching-circuit analysis which is based on the fundamental properties of a logic network (gain, speed, thresholding, directionality, isolation, reshaping, stability and tolerances). He said that this basic-property approach is necessary as designers consider circuit design on

the logic level rather than on an individual component basis. His technique, based on equations of a charge-control model, allows the evaluation of an integrated-circuit logic block merely by a set of terminal measurements. It can be applied to computer-aided design.

This year's Northeast Electronics Research and Engineering Meeting, held for the first time in the greatly improved facilities of Boston's Prudential Center, was called the most successful yet by NEREM officials. The more than 20,000 attendees represent a sizeable increase over last year.

Proceedings are available from the IEEE Boston Office, 313 Washington St., Newton, Mass.

## CONSUMER

### Results of Polaroid-TI color-TV work expected

Joint research into application of the Land color process to color television picture tubes by Polaroid and Texas Instruments has been rumored to be close to fruition.

Neither company, however, would say anything other than, "The program is still in a preliminary stage." A TI official stated that he expects the eventual results to be "not far from the Land process."

## COMPONENTS

### Expect Japanese radios without IF transformers

The price barrier to using ceramic filters in place of IF transformers in transistor radios has reportedly been broken in Japan.

Used for some time in communications receivers, the ceramic filters require no adjustment, yet are more selective, stable and drift-free than their transformer counterparts. Also, ideally suited for miniature radios, the devices have been expensive, however—around 35¢—compared with 10¢ for transistor-radio-type IF cans.

Murata Mfg. Co. of Osaka will offer tiny IF ceramic filters for 10¢, and they are expected to show up in Japanese transistor sets soon.

The company said that the devices will be offered to the U. S. market

soon and that they are also working to develop them for TV frequencies.

Another ceramic device coming from Japan is a tiny (3/8x1/8-inch) ceramic variable-tuning capacitor. It should begin to show up in both AM and FM portables soon, replacing the standard air-dielectric blade-type capacitor. Costing about twice as much as the cheapest air-dielectric type, the unit will probably be found in higher-priced transistor sets. Two-section AM-FM types are also in pilot production, according to Toko, Inc., near Tokyo.

### Solid-state snoopers due

A third-generation all solid-state snooperscope with a "considerably enhanced" spectral response is reportedly under development.

The infrared snooperscope, still in the laboratory at Electro-Optical Systems, Inc. of Pasadena, Calif., will contain a semiconductor imaging device, not tubes, the researchers said.

### RCA doubles production to enter IC market

The Radio Corp. of America is in the process of doubling its integrated-circuit production facility at Somerville, N. J., to plunge into the lucrative IC market.

Although industry people feel that the company's late arrival and limited output may dull its impact, RCA feels that it has a price/quality edge to offer. The line boasts, for example, a -55° to +125°C temperature range for all linear and most digital models, RCA says. Evaluation quantities of 1-24 units will start at \$1.60 per gate, or \$4.40 for an RF amplifier. (See New Products section, p 100.)

## RESEARCH

### Laser hologram forms images in two colors

Two-color images have been generated from black and white laser holograms.

The two-color pictures were formed at Bell Telephone Labs, Inc., by using two different lasers as the source: a helium-neon laser for the red beam and an argon laser for the blue. The two beams were combined



into a single bluish-pink beam to produce, on a photographic plate, the gray swirling patterns characteristic of a hologram.

The colors were dispersed throughout the gray pattern as layers in the photographic plate. Exposing the hologram to the original red and blue laser beams resulted in a single two-color, three-dimensional picture. By using additional lasers at different frequencies, full color, three-dimensional pictures will be possible, the researchers said.

The use of color in holograms is expected to increase their potential for computer storage applications, since many additional bits of data can be stored in a hologram as different color layers in the photographic emulsion.

## LBJ asks R&D funds for small, state colleges

Based on a recommendation by the House Government Operations Subcommittee, President Johnson has directed that Federal R&D funds be spread around to more small and state-supported colleges.

The subcommittee also found that, although R&D funds have improved higher education, they have also harmed the colleges by diverting scientific manpower from teaching and have concentrated funds in larger colleges, to the detriment of smaller ones.

The group recommended further that the Bureau of the Budget pre-evaluate the effect of proposed R&D programs on teaching manpower.

## PEOPLE

### Dr. Allen Balcom Du Mont television pioneer, dead

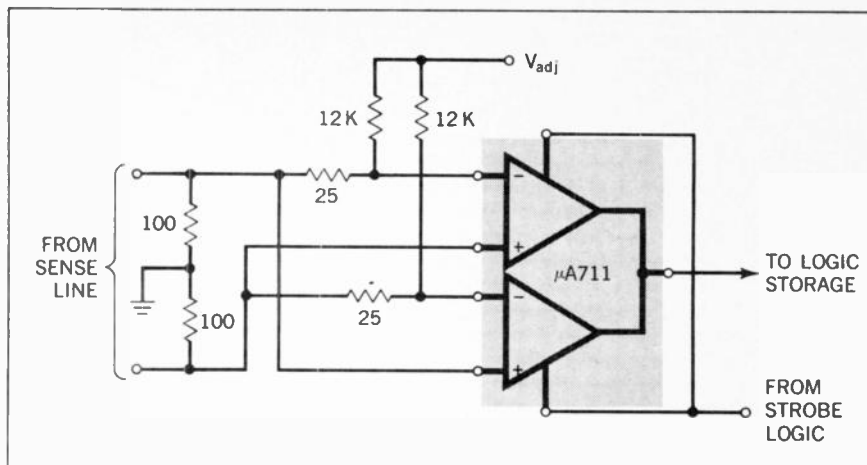
Considered by many as the "father of television," Dr. Allen B. Du Mont died recently at the age of 64.

The founder of the Allen Du Mont Laboratories, Inc., now part of Fairchild Camera & Instrument Corp., Dr. Du Mont was responsible for the development of the practical cathode-ray tube. This led to his sale of the first single-unit oscilloscope and the first all-electronic television receiver, as well as the initiation of the first television network.

### $\mu$ A711 Dual Comparator as a Sense Amplifier

The  $\mu$ A711 is built around an entirely new approach to integrated linear circuits. It eliminates the tolerance problems encountered in designing sense amplifiers for coincident current memories. Using external precision resistors the threshold can be adjusted over a wide range almost independently of integrated circuit characteristics. Excellent threshold stability over the full military temperature range is inherent in this design approach. You can also use the  $\mu$ A711 as a dual sense amplifier for biax memories where the outputs are separated by the strobes.

Other applications include a double-ended limit detector as used in GO/NO-GO test equipment, or a window discriminator for nuclear pulse-height discriminators. Your distributor has the  $\mu$ A711 in stock, or write for complete data sheet and application information. **FAIRCHILD SEMICONDUCTOR**



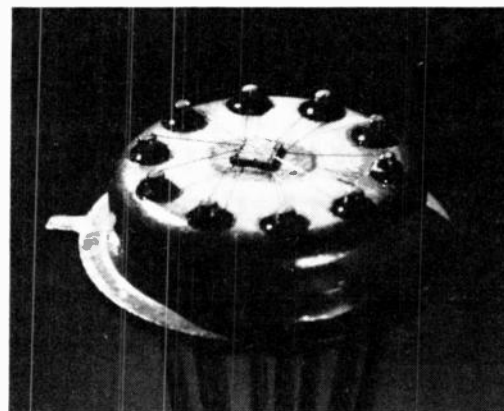
#### $\mu$ A711 Features:

Independent strobing of both channels.  
Outputs can be OR'ed directly.  
Compatible with all popular integrated logic forms.  
Guaranteed over full temperature range (-55°C to 125°C).  
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# FAIRCHILD INTEGRATED SENSE AMPLIFIER





# Blackout sheds light on system faults

The chain of component failures in the Northeast blackout may point to faster, more reliable electronic sensors.

Richard Harnar  
News Editor

When the lights came on again all over the Northeast, hundreds of nervous power engineers went back to their drawing boards.

Their monster system, a maze of some 42 interconnected power stations, had been unexpectedly given a rigorous "systems-effectiveness" test. It failed miserably.

What these engineers will now be discussing is whether electronics can fill the gaps in the system that were exposed by the chain-reaction of component failures. What they have to work with are data, oscillograph recordings and verbal reports from power stations all over the network.

Most of these stations are examples of well-organized, automated—in some cases computer-controlled—

subsystems. Extensive use is made of analog and digital simulation, on-line automatic controls, performance and safety monitoring and computation, and automatic startup and shutdown functions.

There is still a good deal of discussion about this subsystem level, however. As Nathan Cohn, senior vice-president, technical affairs of Leeds & Northrup Co., stated in a recent article, "Widespread differences of opinion currently prevail as to the degree of plant automation that is justifiable or desirable." He quotes a consultant as saying, "A great deal of work remains to make sensors more reliable and to develop systematic methods for flow-charting operations."

On the system level, however, the use of controls and computers is limited. The network itself is informal, and many local companies are

unaware of the total picture, an engineer said.

One of the best examples of power-distribution-system performance has been the very one that collapsed, according to Cohn. The largest of the five networks in the country reaches eastward from the Rockies. One of the three informal groups in this interconnection is CANUS—The Canadian-Northern United States tie of 31 operating utilities that was almost completely blacked out (see map).

## The David that killed Goliath

A review of the Federal Power Commission's preliminary report on the chain of probable events relates: A current-sensing overload relay in a set of six high-tension lines near Queenston, Ontario, tripped without any overload present. Circuit breakers transferred the power from that line to the others, instead of isolating it. This caused overload relays on the other lines to trip and open the circuits.

The power destined for Canada,

therefore, was fed into New York State. Another set of relays should have sensed this reversal, but something went wrong. The resultant power surge cut out several upstate New York generators. Devices that should have isolated these generators didn't.

All of these stations then presented loads instead of sources to other stations further east, including Boston and New York City. This reversal was not sensed and generators, unable to supply the heavy load, shut down.

## Can electronics fill the gap?

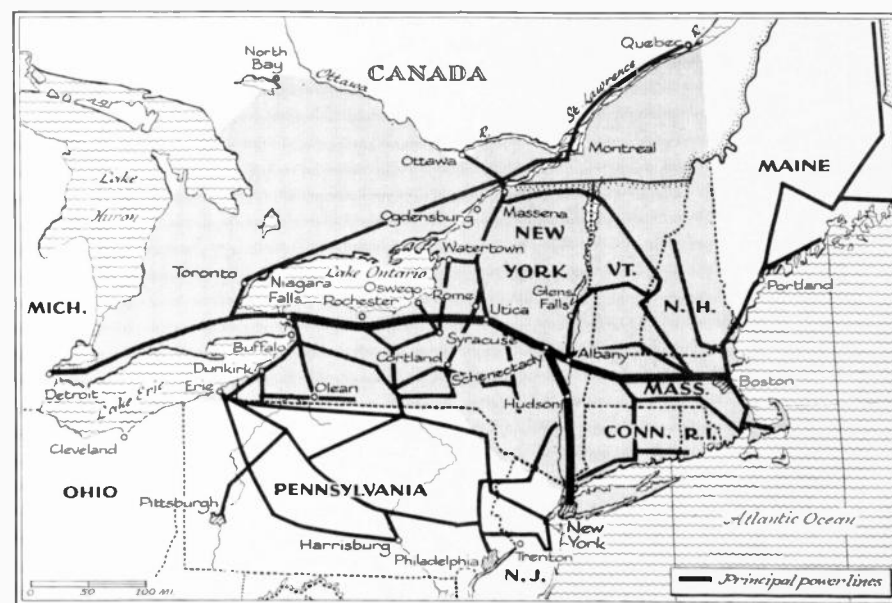
This chain of events points to unreliable, and perhaps too-slow-reacting, sensing devices. When these problems appear in a system, the answer is usually electronic. Can electronics prevent another such blackout? This is the problem the industry will attempt to answer in the next few weeks or months.

A spokesman for the Consolidated Edison Co. of New York City said that the company knows of no automatic device that could meet



Hard-hit in the blackout was New York City, as shown in this north-bound-view of Third Ave. Portions of the city were dark for as long as 15 hours, with the only illumination being provided by cars caught in the massive traffic jams.

—Wide World



The "loose confederation" of some 42 power companies making up the Canadian-Northern United States (CANUS) network was completely knocked out, except for unexplained cutoffs by the Pennsylvania and Maine trunks.

—New York Times



this kind of a "freak and unprecedented electrical disturbance." He added that electronics experts are "uncertain whether even a computer could have sensed what was happening and cut us out of the network in time."

Apparently, any sensing devices that now exist in the system are designed only to prevent damage to generators and cut out only in the event of an overload. Any other situation must be caught and acted upon by a human operator.

William Joyce, manager of systems research for the Diebold Group, management consultants, contends that the total absence of human judgment in such situations would be undesirable. The SAGE North-American defense system leaves the final judgment to a human. But the system lets him know graphically the seriousness of the situation and tells him what he should do to avert catastrophe within a given time limit.

Washington is demanding answers, which may be a long time in coming, and Congress will undoubtedly want an investigation. The integrated nationwide network of power companies recommended by the FPC's 1964 National Power Survey will also be considered in a new light. (See Washington Report, p 16.)

#### Radio engineers innovate

When the lights started to dim, radio-station engineers, traditionally a patch-happy group, hurriedly rigged temporary connections to keep their stations on the air.

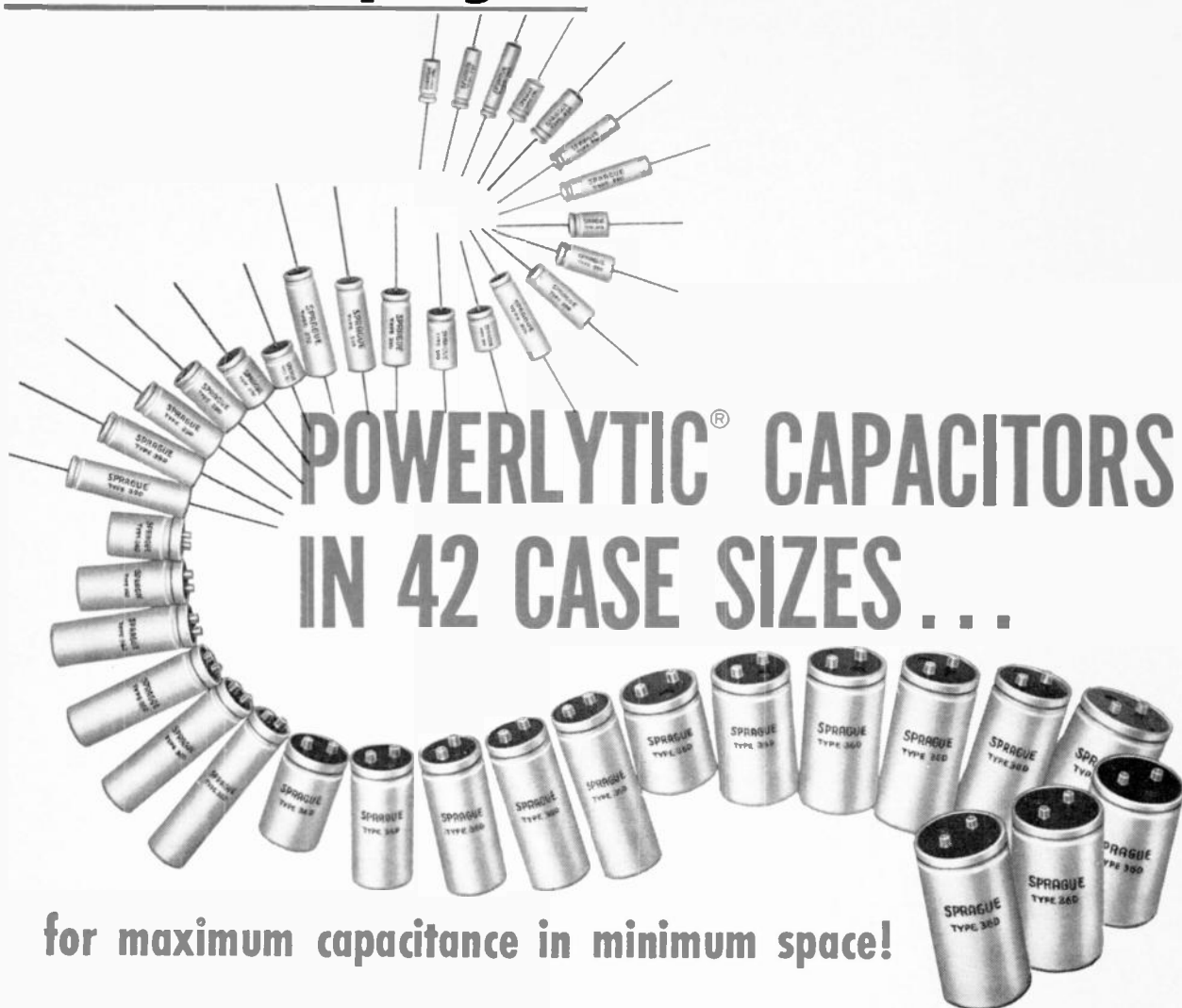
Their main problem was in rigging temporary connections in the dark between studios and transmitters. In many cases, audio signals were stripped into disassembled telephones and calls were placed over regular telephone lines to remote transmitter sites. There, the telephone handset was patched into the modulator.

At radio station WOR in New York City, innovating engineers rigged a portable tape recorder as an audio amplifier. This was clipped into a direct telephone line to their transmitter in New Jersey, which was outside the stricken area. ■ ■

#### Reference

1. Nathan Cohn, "The automatic control of electric power in the United States," *IEEE Spectrum*, November, 1965, p 67.

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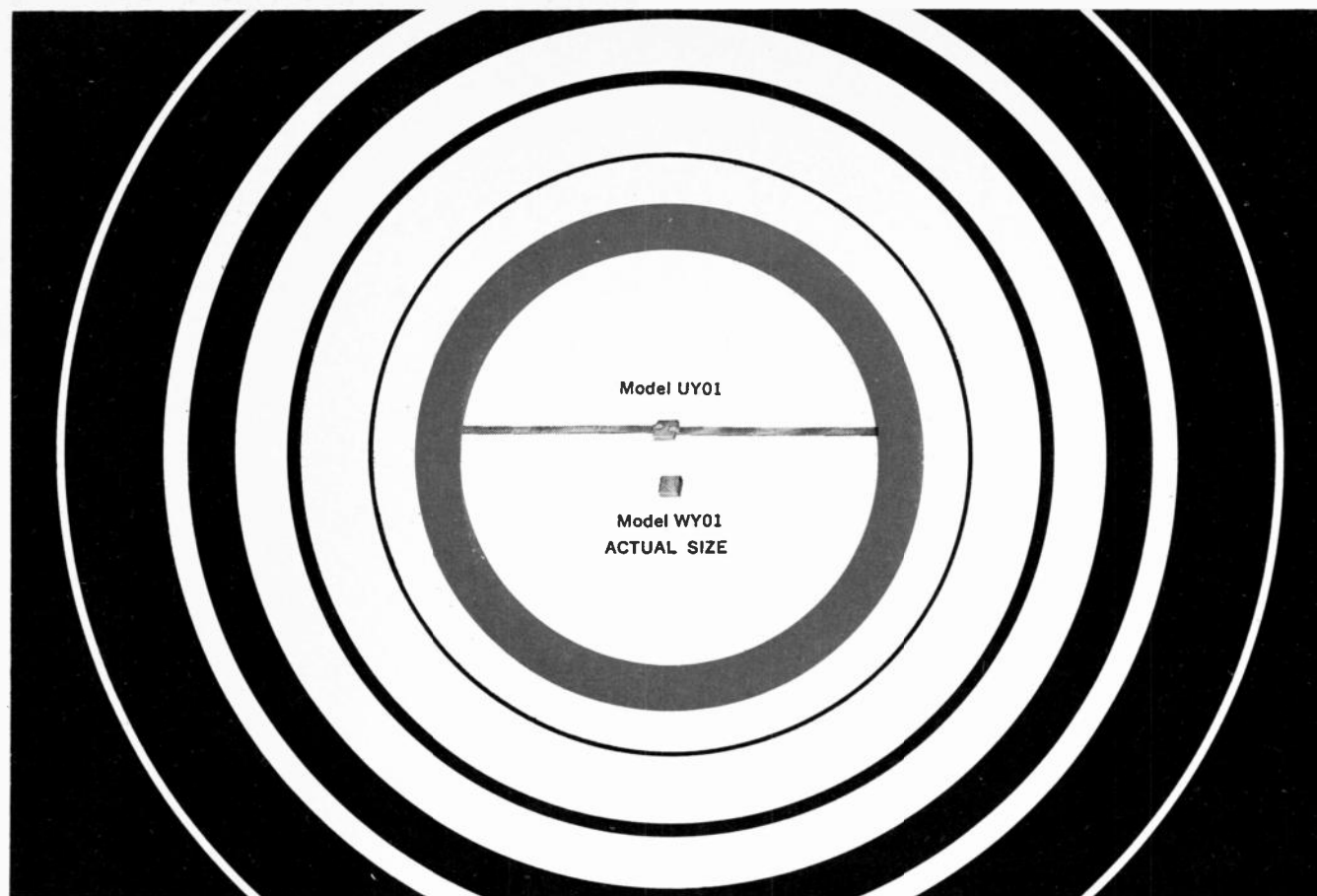
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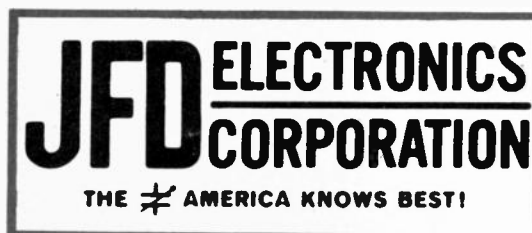
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## NEWS

### Helium-neon laser TV-camera system operating at lab

Protest marchers walk solemnly down the darkened streets of the small town. Suddenly, from a vacant lot along the line of march, a group of men rushes into the street to challenge them. Under cover of darkness, there follows a melee of flying fists and curses.

If only the attackers knew that their faces could be broadcast to TV sets all over the country!

Unlikely? Maybe so today, but distinctly possible in the future of live news coverage. The way seems clear for the development of portable laser-TV systems, based on a feasibility model built by a design group under engineer Marvin J. Fenton at Perkin-Elmer Corp., Stamford, Conn.

### Camera is self-illuminating

Fenton's camera uses a helium-neon gas laser in the visible red. Because it is self-illuminating, it'll work even in complete darkness.

The prototype isn't exactly flashlight size. But there's no reason why it couldn't be a compact unit, according to William F. Matthews, the engineer who did the performance evaluation of the system.

Cost? Although fine grinding is required for the laser optics, it appears that, in quantity, laser-TV cameras could be competitive with orthicon or vidicon types. For one thing, the focusing optics are eliminated since a 1-milliradian laser beam comes to a pretty sharp point at normal TV-image ranges.

Also, since laser beams aren't easily bent, the normal deflection system has been eliminated. Instead, Fenton has used a pair of motor-spun mirror prisms to set up the raster. The line and frame scanning prisms are only a couple of inches in diameter, according to Matthews, and the motor is driven by a 2-Kc solid-state oscillator. The 16-sided line scanner is mounted integral with the motor rotor, and it spins at 60,000 rpm. The 24-sided frame scanner spins at 150 rpm to generate 60 frames a second.



The Perkin-Elmer camera generates two interlaced fields to make up a frame, as in the conventional system. It doesn't include a means of controlling the interlace position, although this could be added if necessary, Matthews said.

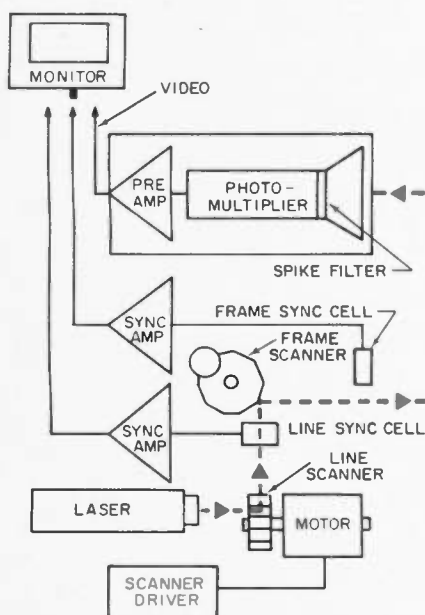
The company has not yet decided if it will pursue the development of laser TV cameras for the commercial market, although it is known to be developing systems for the military. Since Perkin-Elmer's main efforts are in the areas of precision optics and optical instrumentation, it may stick to special-purpose systems, rather than trying to crash the commercial-TV market.

The gas laser's fragile nature is a drawback, but so far this is the only practical type of cw laser.

A more serious drawback is the dark shadows that result from single-source illumination. This might be all right for news reporting, but in the studio, synchronized lasers or mirrors would be needed to provide more satisfactory results.

The demonstrator unit uses a 15-mw output to provide a range of about 30 feet.

A 90-Å spectral filter is used with an 11-stage photomultiplier that has an S-20 photocathode as the pick-up system. The photomultiplier feeds a preamplifier with 26-db gain and 5-Mc bandwidth, which provides a signal suitable for intensity-modulating the cathode-ray tube in a commercial TV monitor. ■ ■



Motor-driven mirror prisms provide line and frame scanning in the Perkin-Elmer laser TV camera.



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- Self-contained 1-kc oscillator and selective null detector. Plug-in modules available for other frequencies. External generator and detector can also be used from 20 c/s to 20 kc/s.
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determinations of D as low as 0.0005 or Q as high as 2000.

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- Internal standards are precision elements: the standard capacitor is a combination silver mica and polystyrene unit with a low temperature coefficient. The wire-wound resistors are similar to those used in GR decade resistance boxes.

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#### Inductance:

0.05 μH to 1100 H in 7 ranges  
(series or parallel)

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Q (series L): 0.5 to 50  
Q (series R): 0.0005 to 1.2 Inductive

D (parallel C): 0.02 to 2  
Q (parallel L): 1 to 2000  
Q (parallel G): 0.0005 to 1.2 Capacitive

**Accuracy (at 1 kc):**  $\pm 0.1\%$  of reading  $\pm 0.005\%$  of full scale except on lowest R and L ranges and highest G and C ranges where it is  $\pm 0.2\%$  of reading  $\pm 0.005\%$  of full scale. D and 1/Q accuracy are  $\pm 0.0005 \pm 5\%$  at kc/s for L and C; Q accuracy  $\pm 0.0005 \pm 2\%$  for R and G. At 10 kc/s L and C accuracy is  $\pm 0.2\%$ ; R and G,  $\pm 0.3\%$

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As for contact pressure, it's over one pound per contact. Together with contaminant-free construction, they easily comply with the minimum current requirements of MIL-R-6106E. Contacts are attached directly to the header terminals to eliminate internal wiring. Not only that, the contacts utilize a "double-break" feature. Arcs are extinguished faster on contact break providing less contact erosion and longer contact life.

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These new units are available in three contact ratings, all meeting the latest revised requirements in the aircraft and aerospace industries. The 9324, is the smallest, lightest, 3-phase, 20 amp AC contactor on the market. The 9123 (MS 27997) is a 25 amp AC or DC unit. The 9124 (MS 27222) will carry a 50 amp AC or DC load. And most important, special mountings are included to make them interchangeable with larger MS "top hat" contactors.

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quite extraordinary**



## NEWS

### Computer memory techniques striving to match IC speeds

Micrologic techniques in computers are pushing memory development, and this year's Fall Joint Computer Conference presented the arguments for ferrite, thin-film and integrated-circuit technologies.

One reason for this, according to Sam Nissim, program chairman, is the increased speed of components in computer systems, which has intensified the imbalance between terminal equipment, memories and central-processing units, with memories forced to bridge the gap.

The latest developments in fixed-access memory elements and system organization covering ferrites and the latest integrated-circuit techniques were discussed at one of five experimental "discuss-only" sessions.

The conference was held November 30-December 2 in Las Vegas.

#### Ferrites still competing

One of the most significant papers described a 375-nsec, 590,000-bit main memory system using 7-mil I.D. ferrite cores developed by IBM, Poughkeepsie, N. Y.

The significances here, according to session chairman Don Meier of National Cash Register Co., Hawthorne, Calif., are that discrete cores can now be operated in the low-nanosecond region and that they are competitive with thin-films in large memories.

The 12-mil O.D. cores are assembled on either side of a single, continuous ground plane. The multi-purpose ground plane serves not only as a return path for the array currents but as a heat-sink. It is temperature-stabilized by running a liquid through it. Geometries were described that, according to the authors, could lead to speeds in the 200-300 nsec range.

Not only are ferrites advancing in terms of memory-core development, but progress is also being made in low-cost organization techniques. This was demonstrated in a paper by Electronic Memories, Inc., Hawthorne, Calif., which described a 900-nsec, 16 Kbit memory using



30-mil ferrite cores organized in a "2-1/2D" three-wire technique. This organization, the authors said, combines the decoding advantages of a three-dimensional organization (coincident-current read/write) with the reduced array-assembly costs of a two-dimensional (linear-select) organization.

#### IC memories coming

The growing impact of integrated circuits in both circuit and storage areas was also emphasized. Though they are not expected to replace large memory units in the foreseeable future, integrated-circuit memories will be increasingly competitive with ferrites in the smaller scratchpad units, according to Meier.

Also under discussion was a 256-word, 72-bit-per-word random-access, integrated-circuit memory developed by Fairchild Semiconductor, Palo Alto, Calif. It has a write/non-destructive-read cycle of 150 nsec, and the entire system's electronic circuits are contained on seven 8x10-inch, two-sided printed-circuit cards.

A new integrated-circuit element, designed for scratchpad memory-storage applications, called SMID (Semiconductor Memory Integrated Device), was covered in a paper by Litton Systems of Woodland Hills, Calif. The element power, per bit, is less than 0.55 mw, and the device can reportedly operate at a cycle time of less than 100 nsec. According to the authors, SMID readout is nondestructive; however, the element is also used in a high-speed alterable-data memory system. They described an integrated-circuit chip that contains nine SMID elements per chip. Total chip size is 40x40 mils. Monolithic-chip drive circuitry has also been fabricated.

In another IBM paper, the design of a prototype 25-nsec tunnel-diode memory containing 64 words of 48 bits each, with address-decoding and data-latching, was described. Information is stored in a TD array interconnected with drive and sense circuits in a configuration to minimize cycle time. Special features, according to the authors, include modularized construction, miniaturized printed-circuit transformer construction, high-speed driving techniques and a rapid regeneration of interrogated information. ■ ■

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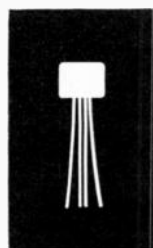
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	<b>2N3932</b>	<b>2N3933</b>	†As measured in noise-test circuit shown in Technical Bulletin for RCA 2N3932 and 2N3933.
NF @ 450 Mc/s	5.0 dB typ.	5.0 dB typ.	
NF @ 60 Mc/s	2.5 dB typ.	3.0 dB max.	
NF @ 200 Mc/s	4.5 dB max.	4.0 dB max.	
• Low Collector-to-Base Time Constant ( $r_b C_C$ ):			
2N3932—8 ps max.	2N3933—6 ps max.		
• High Unneutralized Power Gain ( $G_{pu}$ ):			
2N3932—11.5 dB min., at 200 Mc/s	2N3933—14 dB min., at 200 Mc/s		
• Low Output Capacitance ( $C_{ob}$ ):			
2N3932—0.55 pF max.	2N3933—0.55 pF max.		
• Hermetically Sealed, Isolated Collector with one lead connected to case.			
<b>Maximum Ratings, Absolute-Maximum Values</b>			
	<b>2N3932</b>	<b>2N3933</b>	
$V_{CBO}$ , COLLECTOR-TO-BASE VOLTAGE .....	30	40 max. volts	
$V_{CEO}$ , COLLECTOR-TO-EMITTER VOLTAGE .....	20	30 max. volts	
$V_{EBO}$ , EMITTER-TO-BASE VOLTAGE .....	2.5	2.5 max. volts	
$I_C$ , COLLECTOR CURRENT .....	limited by dissipation		
$P_T$ , TRANSISTOR DISSIPATION at free-air (up to 25°C) .....	175	175 max. mW	
<b>TEMPERATURE RANGE:</b>			
Storage and Operation (Junction) .....	—65 to +175°C		



## The wonderful world of the thyristor

The thyristor family is growing. And so, too, is the range of applications for these versatile semiconductor devices.

Frank Egan  
Technical Editor

If the recently held Industrial Static Power Conversion Conference had been televised, it probably would have been called "The Wonderful World of the Thyristor."

This flexible family of solid-state devices, led by its most popular member, the silicon-controlled rectifier, was the star of the conference. The impression given by many of the papers presented and by the lively audience discussion was that design engineers had better keep abreast of the latest thyristor developments or risk using second-best devices in their equipment. A timely status report on thyristor development was given in a paper by F. W. Gutzwiller of General Electric Co. Much of that report is abstracted here.

Present-day thyristors are shown in the table below. In addition to those types listed, others have been demonstrated and others will undoubtedly be introduced. Each type displays electrical characteristics different from those of the well-known SCR. The newer members of the thyristor family, like the early SCRs, are being introduced for relatively low-power and control applications. Highpower versions of these devices are still expensive to fabricate and will require radical price reductions before they are widely used.

As of now, it looks like price reductions will hinge on major innovations, such as the development of simplified contact techniques and reliable passivation tech-

niques that permit the elimination of hermetic seals in packaging.

### Rapid progress in SCRs

Present SCRs are rated as high as 300-amp continuous average current in a single chip of silicon. With these SCRs and various paralleling schemes, no application appears too large in amperage requirements for today's technology.

In addition to power capability, significant strides have been made

in the development of SCRs for high-frequency applications. Circuit efficiencies of greater than 90% have been demonstrated in SCR inverters operating at 10 Kc. For pulse applications, SCRs are available that can operate over a range of pulse repetition rates from 10 to 25,000 pps, with pulse base widths of from 2 to 1250  $\mu$ sec.

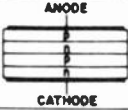


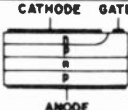





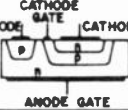


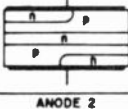

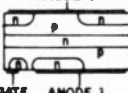

### Four-layer diode similar to SCR

From a construction standpoint, the four-layer diode is the basic member of the thyristor family. It is essentially an SCR without a gate terminal. Close control of the anode breakover characteristic of the four-layer diode is necessary

during manufacture, since this is the characteristic used to trigger the device into conduction.

When triggered by a fast-rising anode voltage, the four-layer diode does not demonstrate the di/dt limitation that is characteristic of the SCR. This is because the high initial anode current is distributed across the anode junction, instead of being concentrated over a small part of the junction, as in the SCR. In fairness to the SCR, it should be pointed out that special SCRs have recently been introduced that can handle rates of current rise up to many hundreds of amperes per microsecond, without requiring artificial delay circuits.

### The rundown on available thyristors

COMMON NAME	I. E. C. NAME	TYPICAL CROSS-SECTION THROUGH PELLET	NO. OF LEADS	CHARACTERISTICS			SCHEMATIC SYMBOL		MAX. RATINGS COMMERCIALY AVAILABLE	MAJOR APPLICATIONS
				QUAD. 1 (ANODE +)	QUAD. 3 (ANODE -)	MAIN TRIGGER MEANS	USAGE	A.S.A.		
FOUR LAYER DIODE	REVERSE BLOCKING DIODE THYRISTOR		2	SWITCHING	BLOCKING	EXCEEDING BREAKOVER VOLTAGE			400 VOLTS 300 A. PEAK PULSE DUTY	TRIGGER FOR SCR'S, OVERVOLTAGE PROTECTION, TIMING DEVICES, PULSE GENERATORS.
SILICON CONTROLLED RECTIFIER (SCR)	REVERSE BLOCKING TRIODE THYRISTOR		3	SWITCHING	BLOCKING	GATE SIGNAL			1500 VOLTS PEAK 300 A. AVG.	STATIC SWITCHES, PHASE CONTROLS, INVERTERS, CHOPPERS, PULSE MODULATORS.
LIGHT ACTIVATED SCR (LASCR)	REVERSE BLOCKING TRIODE THYRISTOR	SAME AS SCR	3	SWITCHING	BLOCKING	GATE SIGNAL OR LIGHT			200 VOLTS PEAK 1.0 A. AVG.	STATIC SWITCHES, POSITION MONITORS, LIMIT SWITCHES, TRIGGER CIRCUITS, PHOTOELECTRIC CONTROLS.
GATE TURN-OFF SWITCH (GTO) OR GATE CONTROLLED SWITCH (GCS)	TURN-OFF THYRISTOR	SAME AS SCR	3	SWITCHING	BLOCKING	GATE SIGNAL TURNS GTO OFF AS WELL AS ON		-	500 VOLTS PEAK 5 AMPS.	LOW POWER INVERTERS, PULSE GENERATORS, DC SWITCHES, CHOPPERS, TRIGGER CIRCUITS.
SILICON CONTROLLED SWITCH (SCS)	REVERSE BLOCKING TETRODE THYRISTOR		4	SWITCHING	BLOCKING	GATE SIGNAL ON EITHER GATE LEAD; SOME GATE TURN-OFF CONTROL			200 VOLTS PEAK 1.0 A. AVG.	INDICATING LAMP DRIVERS, COMPUTER CIRCUITS, COUNTERS, ALARM SYSTEMS, CONTROL CIRCUITS.
BI SWITCH OR SILICON SYMMETRICAL SWITCH (SSS)	BIDIRECTIONAL DIODE THYRISTOR		2	SWITCHING	SWITCHING	EXCEEDING BREAKOVER VOLTAGE OR HIGH dv/dt		-	400 VOLTS PEAK 20 A. RMS	OVERVOLTAGE PROTECTION FOR AC LINES, AC PHASE CONTROL, TRIAC TRIGGERS.
TRIAC	BIDIRECTIONAL TRIODE THYRISTOR		3	SWITCHING	SWITCHING	POSITIVE OR NEGATIVE GATE SIGNAL FOR EITHER POLARITY OF ANODE VOLTAGE; ALSO BY EXCESSIVE ANODE VOLTAGE.		-	400 VOLTS PEAK 20 A. RMS	SWITCHING AND PHASE CONTROL OF AC POWER

### LASCR provides isolation

The light-activated SCR (LASCR), another member of the thyristor family, is, as its name implies, an SCR having a photo-sensitive gate junction. These devices are generally optimized for high triggering sensitivity and therefore operate at relatively low voltages. They are also somewhat sensitive to mistripping at high temperatures and when subjected to fast rates of anode voltage rise. Currently available LASCRs are limited to a lamp current.

An important feature of the LASCR is the isolation it provides between the trigger-signal source and the circuit being controlled. This makes it ideal for use as a static relay or as a gating circuit for other higher power SCRs. LASCRs have been successfully used to trigger high-voltage series strings of SCRs from a single flash source of light.

### GTO good for dc applications

The gate turn-off switch (GTO) adds to the usual SCR properties the ability to be turned off by a negative pulse of gate current. This, of course, makes it highly suitable for applications requiring switching from a dc supply.

In presently available GTOs, over 5 amp of anode current can be turned off with a negative gate pulse of less than 0.5 amp. When inductive load circuits are involved, some means must be provided for dissipating the energy stored in the load at turn-off.

Because of its more complicated structure and the fact that it makes poorer use of the silicon wafer on a current-density basis, the GTO will probably continue to cost more than comparable SCRs.

### Versatility characterizes SCS

What the silicon-controlled switch (SCS) lacks in power capability, it makes up for in versatility. With two gates, one at the cathode and another at the anode, the SCS can be triggered into conduction by either positive or negative pulses.

The device can be turned off like an SCR by anode commutation, or, if properly fabricated, it can be turned off by current pulses at the gates, like the GTO.

SCSs are now available that can

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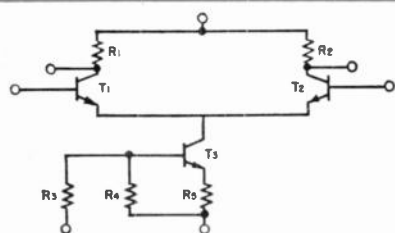


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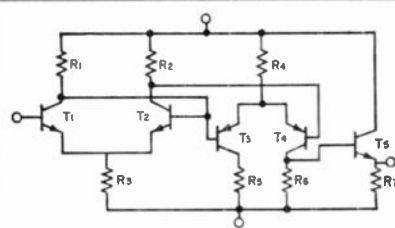
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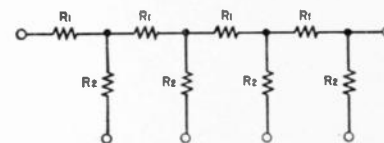
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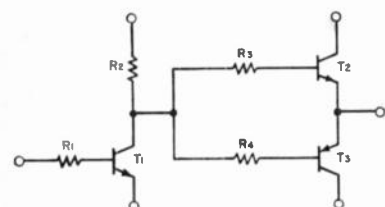
**DIFFERENTIAL AMPLIFIER WITH CURRENT SOURCE**



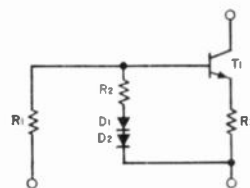
**OPERATIONAL AMPLIFIER**



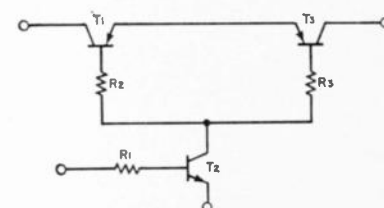
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## NEWS

### Thyristors . . .

control currents of up to 1 amp and block up to 200 volts.

#### SSS is bidirectional

The silicon symmetrical switch (SSS), or bidirectional diode thyristor, exhibits bidirectional switching characteristics in a single semiconductor chip. The device is constructed so that one-half of it represents a four-layer pnpn diode that can be switched by one polarity, while the other half represents a four-layer diode of opposite polarity that can be switched in the other direction.

The SSS is triggered into conduction by exceeding its breakover voltage in either direction. Turn-off is accomplished by a momentary reversal of voltage or the diversion of current.

Present devices are rated as high as 20 amp rms and 400 volts peak. The SSS is particularly useful as an overvoltage shunting device, since it switches into conduction in either direction in less than 1  $\mu$ sec when voltage across it tries to exceed its break-over level.

For an SSS to be useful, its breakover voltage must be well defined within maximum and minimum limits. The resulting complications in manufacture offset its basic low-cost construction.

#### Triac controls ac

The triac, or bidirectional triode thyristor, permits switching of ac current flow under the control of a low-power control gate. Like the SSS, the triac cannot be damaged by voltage transients when properly fabricated. Excessive voltage merely triggers the triac into conduction, allowing the transient energy to be dissipated elsewhere.

Commercially available triacs can handle more than 10 amp rms on 240-volt ac lines. Units with higher ratings are under development. For many applications, the triac now competes economically with SCR pairs and can be expected to improve its cost advantage as production refinements take place.

The Industrial Static Power Conversion Conference, held in Philadelphia November 1-3, was sponsored by the Industrial Power

# NEW MOTOROLA DEVICES GIVE THAT "SOMETHING EXTRA" To Your New Equipment Designs



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If you would like specific details about a particular device mentioned here, write to the Technical Information Center, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

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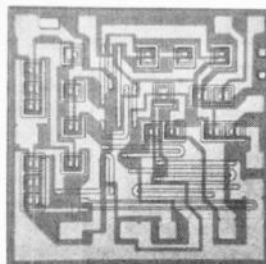
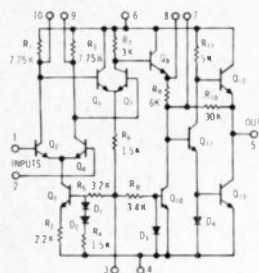
**MEDIUM-POWER**  
(25 watts —  $P_o$ ) 60V and 80V (TO-66)  
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PNP — Types 2N3740-2N3741

**HIGH-POWER**  
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NPN — Types 2N3713-2N3716  
PNP — Types 2N3789-2N3792



New high-performance, low-priced silicon power transistors now offered in complementary specifications to provide a new level of design flexibility.

## HIGH-INPUT-IMPEDANCE MONOLITHIC INTEGRATED CIRCUIT OPERATIONAL AMPLIFIERS



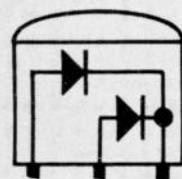
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... priced lower than 2 individual diodes!

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Rectifiers Committee and the Power Semiconductor Committee of the IEEE. Copies of the proceedings can be obtained from the IEEE, 345 E. 47 St., New York. The cost is \$6.50 for members and \$13.00 for nonmembers. ■ ■

## Integrated circuits to be installed in underwater beacon

Integrated circuits will be used extensively in an underwater acoustical beacon soon to be placed 15,000 feet below the ocean's surface.

The acoustical beacon was developed by researchers at the Hudson Laboratories of Columbia University, located near Dobbs Ferry, N. Y. They report it as the first attempt to make widespread use of integrated-circuit components in a unit of underwater equipment. Integrated circuits were chosen because of their long-term reliability and their low power requirements. These are prime concerns, since the unit is designed to remain unattended on the ocean's bottom for periods of up to a year, the researchers said.

A total of 150 integrated-circuit logic blocks are incorporated in the unit. Two standard series of integrated-logic-circuit packages, manufactured by Texas Instruments, are used. Only integrated circuits are used in the unit, except for the transducer drive-electronics portion, which uses discrete transistor circuits. An Augat, Inc., breadboard is used to mount the circuits. No attempt was made to further miniaturize the unit, due to problems in mounting and in bringing in the power leads, it was reported.

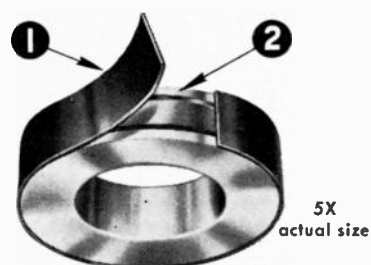
The power for the beacon is supplied by lead-acid storage batteries. To conserve power, all circuits are generally in the OFF condition. A sequence programmer in the unit turns them on at selected intervals to process and transmit data.

However, this power-saving technique also results in severe crosstalk between circuits due to transients during turn-on. Extensive decoupling was required in the equipment to prevent these transients from entering the low-level logic and generating spurious output signals, said Hudson Labs. ■ ■



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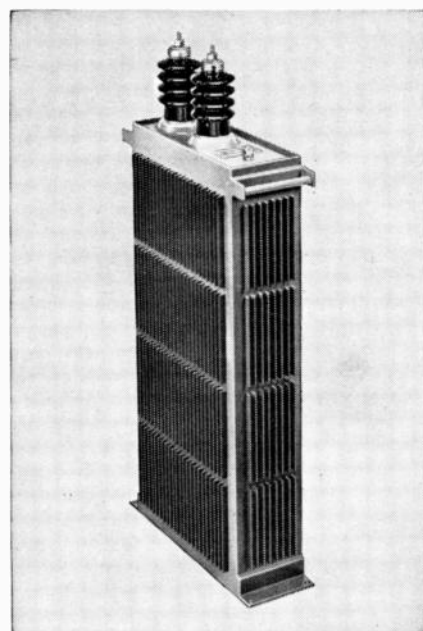
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48PH-104-63

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## WASHINGTON REPORT

S. David Pursglove,  
Washington Editor



### Congress will probe Northeast blackout

Two Congressional investigations of the Northeast power blackout have been planned for next year. Rep. Walter Rogers (D-Tex.), chairman of the Power Subcommittee of the House Commerce Committee, expects to hold hearings just after the first of the year. Sen. Warren G. Magnuson (D-Wash.), chairman of the Senate Commerce Committee, plans to make a "thorough analysis of the event and its causes." He has asked the Administration for all the reports it receives on the subject.

The hearings are expected to fix blame and point the direction to future safeguards. Congressional committee staffers and Federal Power Commission personnel are not attempting to forecast the final conclusions, but they are certain of some early results.

Without doubt, Congress will urge additional spending in several areas. Observers believe that the FPC staff will be beefed up and more field people added. There likely will be increased funds for studies and perhaps new funds for hardware R&D contracting.

At the same time, Congress is expected to seek ways to encourage wider distribution of emergency generators. So far, it has been difficult to persuade businesses to purchase expensive equipment that may never be needed, allocate valuable storage space and maintain the units. Congress could ignore these factors and require ample stand-by equipment at airports and on interstate-transportation systems. However, there will probably be some tax incentive to encourage non-regulated businesses to invest in auxiliary equipment.

Very probably, one consultant to a Congressional committee told ELECTRONIC DESIGN, Congress will make more generators available to Civil Defense and will increase the number, capacity and versatility of stand-by units at Federal installations. The latter aspect may prove especially interesting to electronic designers. Size and portability often work against each other, with the big generator being too far from where it is needed and the portable unit not being large enough to be useful. R&D money—perhaps to be administered through the Office of Emergency Planning, perhaps through the Defense Department—almost surely will be appropriated to reduce the size and increase the versatility of generators.

"A few truck-mounted generators getting around to those

ELECTRONIC DESIGN

office buildings would have been heaven-sent," an assistant to a Senate Commerce Committee member suggested. He expects to see the suggestion put to the committee formally. Federal grants to fire departments and direct purchases for Civil Defense units will probably be suggested. The truck-mounted units would be large enough to operate a skyscraper elevator. They would feature long cables with quickly interchangeable connections that would mate with any commercial elevator system. The generator would be used only long enough to bring stalled elevator cars to the ground floor, then they would move on to the next building.

**Blackout clouds plans for grid expansion.** Federal Power Commission officials admit that the Northeast power blackout has caused a slowdown in FPC's campaign initiated last year to get the electrical-power industry to link together into still-wider grids or even a national network. "We probably could make a good case for our campaign out of the Northeast failure," said one official, "but we're treading softly because there's at least superficially good propaganda against expanded networks in the argument that a wider grid might have meant a wider blackout." Besides, the official pointed out, the FPC is too busy investigating the blackout to do much campaigning.

What was to become a full campaign picked up momentum late last year when the commission published its National Power Survey. It described how "all of our electrical power systems can move from isolated or segmented operations and from existing pools of limited scope to participation in fully coordinated power networks covering broad areas of the country." The survey suggested that "in time, when justified economically, all the systems in the nation may be joined in a single, interconnected network."

Grid-expansion advocates in Congress have hoped that moves in that direction could be encouraged by Federal assistance. It is now likely that any Congressional approval for expansion at Federal expense will be accompanied by demands for safeguards. Before a Congressional committee would accept them as adequate, the safeguards would have to be supported and proved by computer analyses of all possible eventualities and by actual hardware R&D and testing.

In addition to funds for FPC-contracted studies and hardware development, if that course should be chosen, some increase is seen by observers for the Interior Department's programs. Interior has long supported work in power-transmission technology, and its Bonneville Power Administration and the Bureau of Reclamation are now supporting the major U.S. effort in developing long-distance, direct-current transmission.

# **ELECTRONIC INNOVATIONS**

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#### DOWN

#### DOWN

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... especially now that you can specify a 200- or 400-volt TRIAC to do the work of two SCR's. The TRIAC works like back-to-back SCR's with a single gate control.

Not so long ago, when we first introduced the SCR, two of them would have cost you \$290.00 to control a 600-watt load. Not now. Just look at the savings we've brought you since then:

3 volts and 50 ma to be triggered into conduction; what's more it can be triggered by either a-c or d-c current or by short pulses of either polarity.

200- and 400-volt TRIAC's are already performing many high-speed switching functions mechanical devices simply can't. They're reducing manufacturers' component needs in solid state switches, speed control of fans and blowers, static relays, temperature controls with or without feedback, explosion-proof switches and lighting controls. Improved performance at low cost is also possible for manufacturers of heat pumps, humidifiers, room air conditioners, wall and warm air furnaces, business machines, commercial

**COST TO CONTROL A 600-WATT LOAD**

Date	Device	Cost (100-999)
1957	ZJ39A (2 SCR's)	\$290.00
1958	ZJ39L (2 SCR's)	214.00
3/1/59	ZJ39L (2 SCR's)	100.00
7/1/59	C36B (2 SCR's)	79.00
12/8/59	C36B (2 SCR's)	57.00
3/21/60	C10B (2 SCR's)	22.20
6/15/60	C11B (2 SCR's)	20.00
7/28/61	C15B (2 SCR's)	13.00
12/1/61	C15B (2 SCR's)	9.50
1/12/62	C15B (2 SCR's)	8.40
1/25/63	ZJ265B (2 SCR's)	7.80
1/26/64	C22B (2 SCR's)	3.50
2/1/65	SC41B (1 TRIAC)	2.75

### ■ AND COST ISN'T THE ONLY ADVANTAGE OF TRIAC

TRIAC also gives you built-in protection against high-voltage transients. By replacing 2 SCR's, TRIAC reduces the number of components needed in many, many circuits—lowers your component costs while increasing circuit reliability. TRIAC requires only

dishwashers, laundry and dry cleaning units, and commercial cooling equipment.

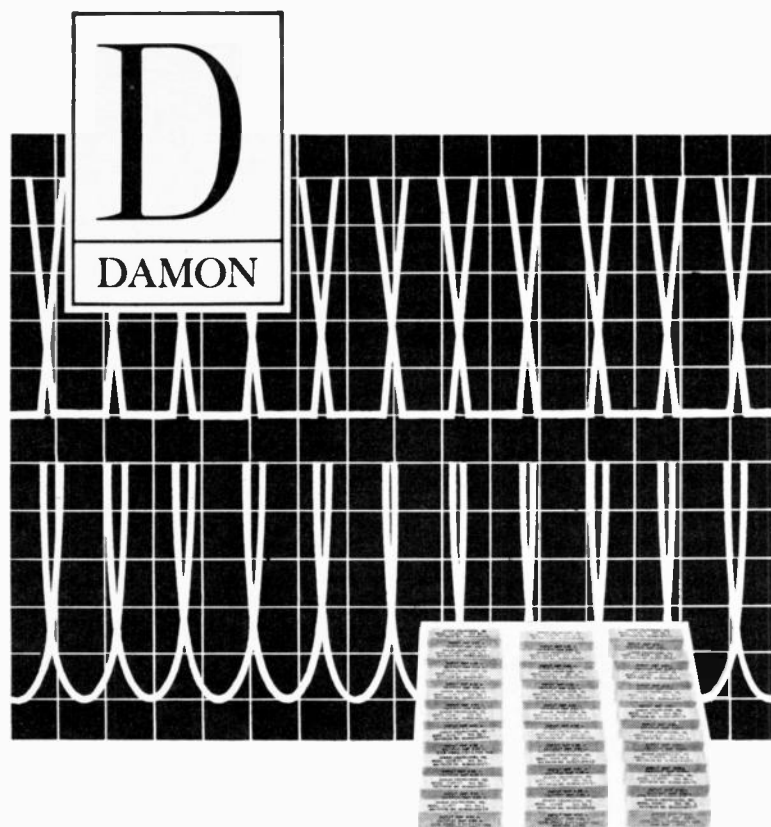
Take advantage of this remarkable price trend now by getting all the facts about GE's 200- and 400-volt TRIAC. Write to Section 220-18 General Electric Company, Schenectady, N.Y. 12305. Export: Electronic Component Sales, IGE Export Division, 159 Madison Ave., New York, N.Y. 10016.

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# Contiguous Comb Crystal Filters

## Multi-Channel Real-Time Signal Detection with Single Channel Driving Power

Contiguous Comb Crystal Filters (Damon's name for a unique new design) permit direct operation of large numbers of adjacent frequency channels from a single low power driver. As there are no padding or isolation losses, drive power requirements are no greater for multi-channel operation than for single channel. Miniaturized Contiguous Comb Crystal Filters with reduced active driving circuitry are now being used in airborne and ground-based Doppler radar systems where small size and high reliability are essential. A wide range of filters is available with Chebyshev, Butterworth or Gaussian characteristics for CW Doppler, FM Doppler, or Pulse Doppler Systems.

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## EDITORIAL

### A new face for ED banishes your pet peeve

"Why do you shackle us with your awkward 11x11-inch magazine size?"

"How can we place your 11-inch deep magazine on an 8-inch shelf?"

"When will you make it convenient for us to clip articles for our files?"

You—our readers—have been directing such questions to us at technical conferences, plant tours, company seminars and just about anywhere ED editors could meet a reader. During this past year, the requests for a change in size have mounted in volume and pitch. With the technology mushrooming at its rapid pace, information filing and retrieval has become a necessity rather than a convenience.

To evaluate reader reaction to a long-pondered switch from our present 11x11-inch size to 8-1/4x11 inches, we surveyed 1000 subscribers; every forty-fourth name on our circulation list was sent a questionnaire. To simply say that the results were staggering would be an understatement. Here's why:

- Of the 1000 questionnaires, 744 were returned with a preference and reasons for the choice indicated. (Hardly anyone wanted to remain silent on this issue.)

- Of the 744 returns, 598 arrived within two weeks of our mailing. (No dilly-dallying here.)

- Voting for the 8-1/4x11-inch format were 91.6%; 6.5% preferred the present 11x11-inch size, and 1.9% indicated there were good reasons for both sizes.

We got the message. Your overwhelming response triggered immediate action. Our editors, artists and a talented art-consultant team have labored (with love) to accomplish a major redesign worthy of your loyalty. The 8-1/4x11-inch format, starting with our first issue in 1966, will provide you with:

- Functional graphics—not art for art's sake—to bring new excitement to our editorial pages.

- Articles arranged for convenient clipping and filing.

- Typeface modifications to promote faster reading.

- Charts, graphs and nomograms designed to make their points most effectively.

- Adjacent articles organized so that clipping one does not damage its neighbor.

Oh yes, one more important detail. To further improve our editorial services to you, we are adding three editors to our team; a San Francisco field editor, an East Coast field editor and an additional New York-based technical editor. We are currently interviewing for these positions. Contact me if you are interested.

In all modesty, we expect you to be delighted with our changes. And remember—it's your publication. Tell us when you find flaws, compliment us when you feel the urge, but, please, keep voicing your thoughts. A publication's success depends on its ability to serve its readers. Without feedback, the system searches.

*Howard Bierman*  
Editor

ELECTRONIC DESIGN

## LETTERS

### Sky spy bird carried alias

Sir:

In your excellent sky spies article of October 11 ["Electronics expands vision of sky spies," p 26], you inadvertently identified the SD-1 drone aircraft [photo, p 28] as manufactured by Bell Aerosystems Co. Although Bell may play a subcontractor role, this bird was designed and is manufactured by the Ventura Division of Northrop Corp., as your text currently indicates on page 30.

**HENRY STILL**

Manager, Public Relations  
Northrop Ventura  
Newbury Park, Calif.

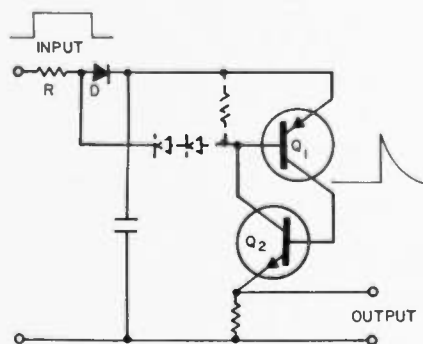
### NASA took hard way to pulse generation

Sir:

The circuit in NASA Tech Briefs [ED, October 11, p 122, "Pulse generator needs no external power"] is much more complex than necessary. The circuit shown below operates the same, except for a two-diode-junction voltage differential, which replaces the four-junction voltage of the published circuit. For a greater differential voltage, place a resistor from the base to the emitter of  $Q_1$  and several diodes in series that conduct from the base of  $Q_1$  to the Junction of  $R$  and  $D$ , as indicated by the dotted lines in the schematic.

**W. J. GODSEY**

Project Engineer  
Hayes International Corp.  
Birmingham, Ala.



December 6, 1965



### The 601 PE... a particular shape for a particular need.

Design with Mylar reliability in the size and shape of a disc! The slim, compact type 601 PE is tailored for printed circuits in military or industrial applications.

In all you will find more than 200 design variations of reliable TRW Capacitors. Round or oval cross-sections. Axial

or radial leads. Dipped, tape-wrapped, or metal enclosed cases. Essentially all these constructions are available in film-foil, in metalized Mylar\* and polycarbonate dielectric.

In a tight spot? There's a TRW Capacitor to help you. Contact TRW Capacitors, Box 1000, Ogallala, Nebraska.

\*Du Pont Trademark

## TRW CAPACITORS

ON READER-SERVICE CARD CIRCLE 13



# Precise speed control, high torque can now be combined in dc motors

A dc motor with the precision-speed attribute of the synchronous motor?—It's easily and inexpensively achieved with a commutating SCR control in the feedback loop.

**I**F YOUR MOTOR application called for a precise-speed characteristic, you would probably settle on the ac synchronous motor. On the other hand, if high-starting and pull-in torques, adjustable speed and battery operation were required, the dc motor would be your choice.

A motor combining all of these virtues would appear to be an engineer's pipedream, because costly, complex auxiliary circuitry would be required. Moreover, this hybrid motor's speed characteristic would be relatively imprecise and its torque would suffer at other than synchronous speeds.

Now, however, thanks to the SCR, the dream can become reality. You can provide a dc motor with true synchronous performance without sacrificing any of its inherent characteristics. This is achieved by commutating the SCR and using it for phase detection in the motor's feedback loop. This SCR speed control merely senses shaft position, changes it to an analog phase signal, and uses the signal to establish the power to be supplied to the motor.

The technique, which is applicable to many types of dc motors, is also inexpensive and highly efficient. The components and configuration vary slightly, dependent on what type of motor is being controlled, but the SCR feedback mechanism is essentially the same for all cases. Moreover, the variety of SCR-type devices available permit the application of the method to various size motors, including the line-voltage operated types.

**E. Keith Howell**, Application Engineer, General Electric Co., Auburn, N. Y. This article was originally prepared for a lecture to be given at the October NEC meeting in Chicago (sponsored by the IEEE).

## Feedback establishes speed control

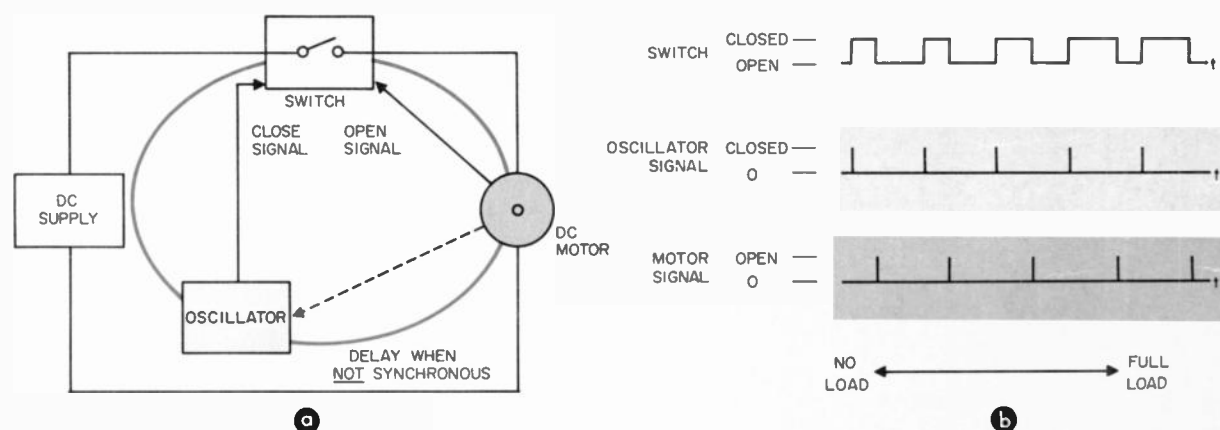
Speed-control systems typically use some form of feedback from the motor in which speed is converted to an analog-current or voltage signal. This signal is compared with a reference and their difference amplified to control the power applied to the motor. Thus, when the motor loading changes, the speed must also change in order to effect a new power level.

To obtain a precisely constant speed (synchronous speed), the analog comparison is changed to a phase comparison. With this mode, shaft position is periodically sensed and the power is controlled in accordance with the positional error. This produces the constant-speed characteristic of the conventional synchronous motor.

The block diagram for a basic synchro-

nous-speed-control system is shown in Fig. 1a. To be free from ac supply-frequency effects, the motor uses a dc supply. The motor may have a series, shunt or permanent-magnet field, or may even be some unconventional type. Note the phase relationships between the control elements (Fig. 1b).

Power to the motor is controlled by the periodic closing and opening of the solid-state switch. The average power in the motor is determined by the length of time the switch is closed during each period of operation. Since the losses are confined to the switch, the technique is a very efficient means of controlling dc power. A signal from the oscillator causes the power switch to close. Some time later, a signal from the motor causes the switch to open. Note that the oscillator signal occurs at periodic points in



1. Basic synchronous-speed-control system (a) senses the shaft position and converts it to an analog phase signal. The power applied to the motor is established by the phase error. The switching functions of the system (b) as a function of the loading show the interrelationships between the switch, oscillator and motor, which make up the feedback loop.

time, whereas the motor signal occurs at a periodic point or points in space, corresponding to discrete shaft positions.

### Load level determines phasing

In the normal synchronous mode of operation (Fig. 1b), little power is required to maintain the motor speed at light load. Hence, the turn-off signals occur shortly after the turn-off signals from the oscillator. As the loading is increased, the motor will attempt to lag. This delays the turn-off signal and causes an increase in the applied power. Thus, changes in loading alter the phase relationship between the motor shaft (the source of the turn-off signal) and the oscillator (the turn-on signal source), with the motor speed remaining synchronous with the oscillator. The synchronous speed can be maintained for any load requiring from about 5% to 95% of full applied power.

If the loading is so large that full applied power cannot maintain the synchronous speed, the turn-off signal will occur later than the next consecutive turn-on signal, and the operation will become erratic. To maintain full power at lower speeds, the oscillator signal must thus be delayed until after a turn-off signal occurs. This condition is illustrated in Fig. 2a.

In the case of an over-speed condition (Fig. 2b), normal turn-on and turn-off signal appears before the next consecutive turn-on signal. This may produce operation at twice the synchronous speed. To avoid it, the occurrence of a second turn-off signal in one cycle must delay the oscillator signal such that the next turn-on signal occurs much later than normal (preferably one full cycle later). This action greatly reduces the power to the motor

and permits it to slow down to the synchronous speed.

The basic feedback loop for providing a synchronous operating mode to dc motors has now been established. For the various dc motors about to be discussed, the speed-control circuitry will be tailored to the dictates of each type; thus the oscillator and switch sections will vary somewhat. The delay, or regulating, mechanism will similarly be peculiar to the motor type involved.

### UJT controls series-type motor

A simple circuit for the synchronous control of a series motor is shown in Fig. 3a. A unijunction transistor (UJT)  $Q_1$ , is used in a relaxation-oscillator circuit to produce periodic pulses that trigger the SCR. Because a dc source is employed, the SCR will conduct current through the series field and the armature until it is turned off. At a certain point (or points) in the rotation of the motor shaft, a cam causes switch  $S_2$  to close, thus momentarily by-passing current around the SCR. This action permits the SCR to turn-off (commutate), so that no current flows after switch  $S_2$  opens. Thus, the oscillator (UJT) turns the power on and the motor

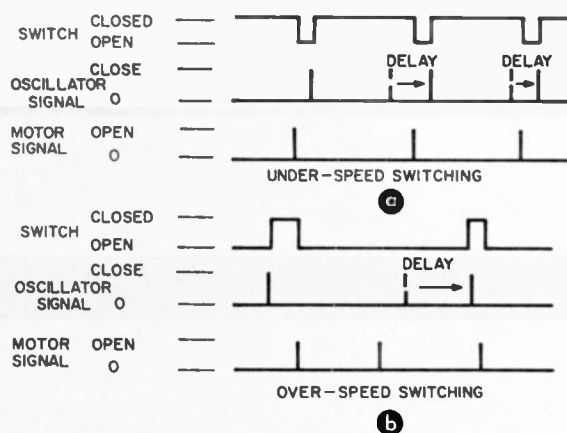
(via  $S_2$ ) turns the power off.

Rectifier  $D_2$  is a "free-wheeling" diode which prevents high voltage from appearing across either the SCR or the switch. It provides a circulating current path for the energy stored in the motor inductance. This diode eliminates most of the arcing normally encountered in the operation of switch  $S_2$ , thus greatly improving its life.

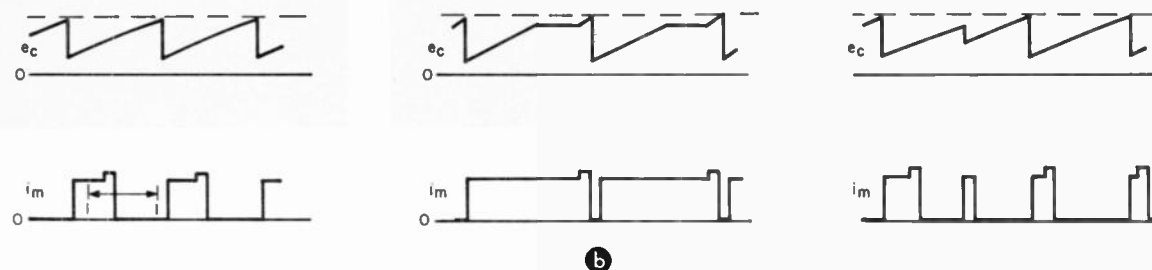
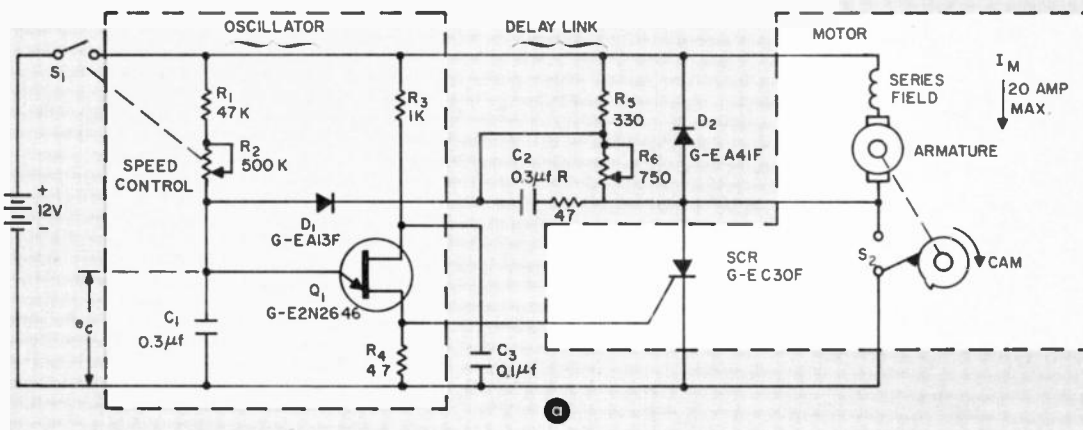
The waveforms of the voltage across capacitor  $C_1$ ,  $e_c$ , and the motor current  $i_m$  appear in Fig. 3b. Under normal operation,  $e_c$  takes the conventional sawtooth waveform of a relaxation oscillator. Motor current starts at the time  $Q_1$  discharges  $C_1$  and ends when  $S_2$  closes and re-opens. Since the voltage drop across the switch is less than that of the SCR, the current is seen to be slightly higher during the time  $S_2$  is closed. The time between turn-on and turn-off of current will naturally depend upon the load.

### Oscillator delay regulates speed

The delaying function required for the under-speed and over-speed conditions is provided by the network composed of  $R_5$ ,  $R_6$ ,  $R_7$ ,  $C_2$  and  $D_1$ . Resistor  $R_6$  is set such that, with the SCR conducting, the voltage at the

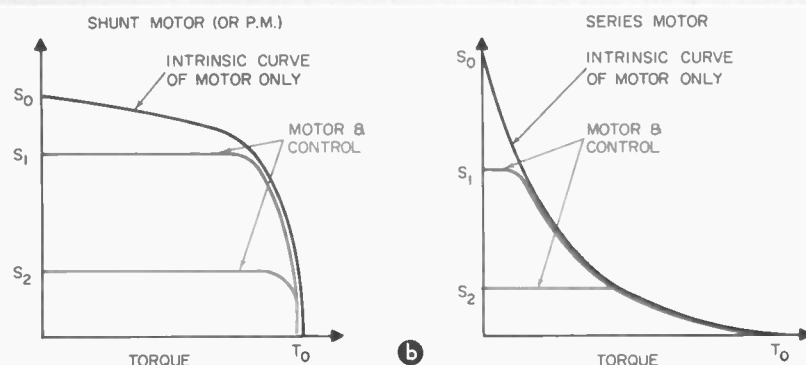
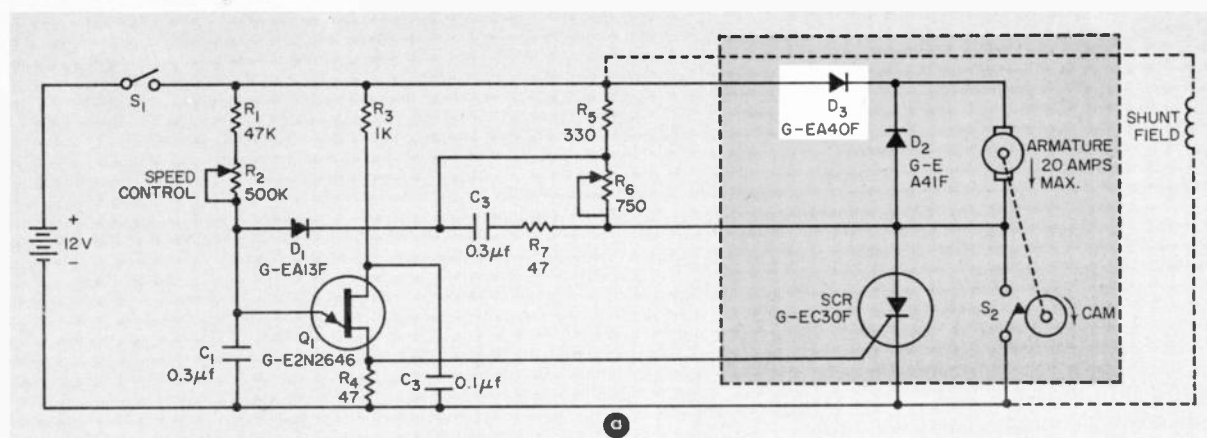


2. Under-speed and over-speed conditions are handled by delaying the oscillator signal so that the proper phase relationships are maintained, as shown in (a) and (b), respectively.

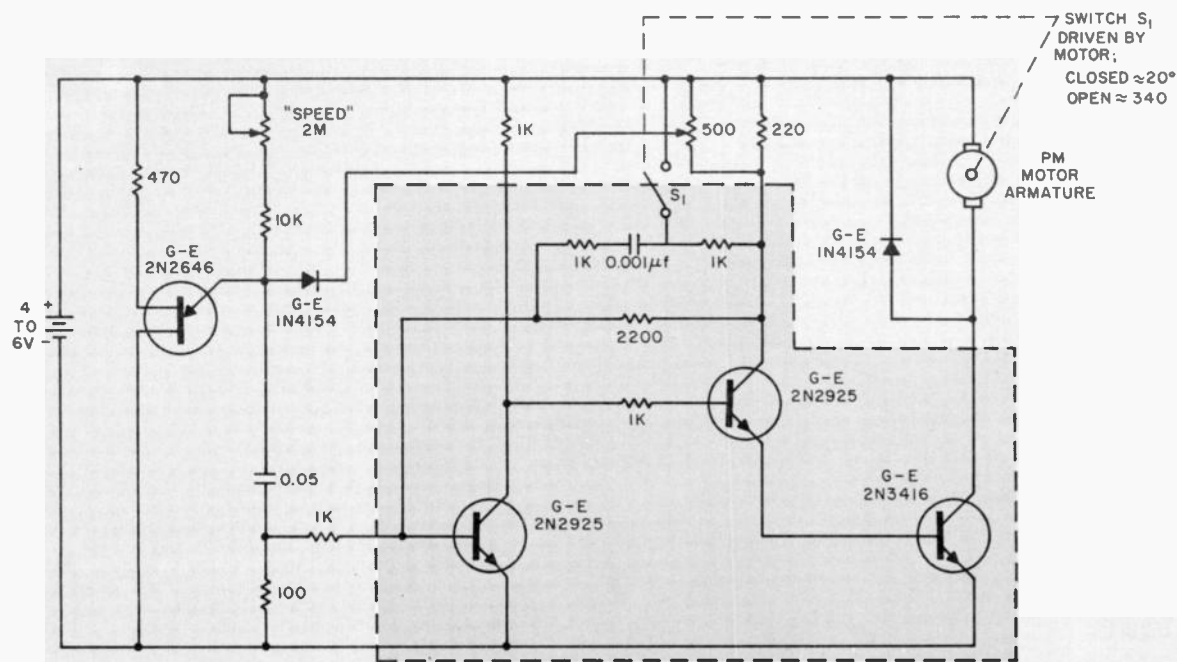


3. For the dc series motor, a UJT relaxation oscillator triggers the SCR, which in turn carries the motor current (a). Operating waveforms (b) show how the UJT capacitor voltage,  $e_c$ , and the motor current,  $i_m$ , vary in accordance with speed. Exhibited are normal operation (left), speed below synchronous (center), and above synchronous (right).





4. Synchronous-speed control for shunt or permanent-magnet motors (a) is similar to that of the series motor. Here, diode  $D_3$  decouples the armature emf from the SCR to maintain the proper delay-link action. Note that the torque-speed curve differs from that of the series motor (b) in that nearly full torque is provided at the lower speeds.



5. Small, battery-operated pm motor requires a simpler synchronous speed control. Its low armature current permits a flip-flop to drive the motor directly.

cathode of  $D_1$  is about 0.6 volts less than the peak-point voltage of  $Q_1$  (shown as a dashed line on the  $e_c$  waveform). If the speed is below synchronous, capacitor voltage  $e_c$  cannot reach the peak point of  $Q_1$  until after  $S_2$  has been opened. In this manner, the oscillator is delayed and produces no turn-on signal until just after  $S_2$  has turned the current off. This action provides about 95% of full power to the motor at any speed below synchronous speed. It makes available the system's high-starting torque characteristic.

In the over-speed condition, the second closure of switch  $S_2$  and the instantaneous-voltage-change property of  $C_2$  cause the cathode of  $D_1$  to momentarily drop to nearly zero voltage. This voltage decrease partially discharges timing capacitor  $C_1$ , thus delaying the next oscillator cycle. The larger the value of  $C_2$  (compared with  $C_1$ ), the more nearly this delay will approach one normal cycle.

The use of a mechanical switch to commute the SCR is primarily responsible for the simplicity and low cost of this control system. An additional cost reduction can be achieved in applications not requiring synchronous speeds by eliminating the RC components of the delay link and by connecting the cathode of  $D_1$  to the SCR anode.

When  $S_2$  opens, the motor's inductive characteristics cause the voltage across it to rise to the sum of the supply voltage plus the 1-volt drop across  $D_2$  in a very short time. For the 12-volt supply, this high  $dv/dt$  will not usually retrigger the SCR into conduction, because the amount of charge moved through the gate junction is very small. However, at higher supply voltages, an RC limiting network may then be required. It would be placed in parallel with the SCR to limit the  $dv/dt$  to a value that permits proper commutation.

#### Rectifier added for shunt motor

The same synchronous control circuit is easily modified for operation with shunt and permanent-magnet (pm) motors. The only change required is the addition of rectifier  $D_3$  (Fig. 4a). It is used to decouple the counter-emf of the armature from the SCR during the latter's OFF condition. This action prevents interference with the delay-link operation. In the OFF state, the voltage across the SCR is the supply voltage, instead of the supply minus the counter-emf. Other than this, the operation of the circuit is identical to that of the series motor-speed control.

The speed-torque curve of the shunt motor is considerably different from that of the

series motor, however (Fig. 4b). In both cases the control system will hold the motor speed in synchronism with the oscillator up to the inherent limit of the motor. Virtually full torque is provided at all lower speeds down to, and including, the locked rotor condition. In the locked rotor case, the system provides full torque, because once the SCR is turned on, it cannot be turned off until the motor turns and operates the commutating switch  $S_2$ .

The length of time that switch  $S_2$  is closed during each revolution of the motor determines the minimum speed and loading that can be used. For example, if the switch is closed for one-twentieth of each revolution, the minimum power that can be applied to the motor is 5%. If the load is such that the motor will run at this power level, then this figure represents the minimum usable speed for that load.

#### Flip-flop drives pm motor

Small, battery-operated permanent-magnet motors may be directly driven by a transistor flip-flop. This is so because these motors, which are used to drive recording instruments, tape-recorders, phonographs, etc., require relatively small armature currents. In the speed-control circuit (Fig. 5), the UJT oscillator drives a flip-flop to energize the motor. When switch  $S_1$  closes, the flip-flop reverses and the motor is turned off. An additional rectifier ( $D_3$  in Fig. 4a) is not needed here, because the delaying signal for the oscillator is derived from the second stage of the flip-flop, rather than from the output.

Since the current through commutating switch  $S_1$  is very low,  $S_1$  may be very small and will only have to bear light actuating forces. At low speeds, it should close several times per revolution of the motor, thus providing multiple current pulses during each revolution. With a fixed oscillator frequency, motor speed can be changed in discrete octave steps by changing the number of switch closures per revolution from 1 to 2 to 4 to 8, and so on. This can be done either mechanically or electrically by changing to appropriate commutating switches.

Note that in the systems discussed thus far, the driver circuitry has been established by the dictates of the load current, but the mechanical turn-off element (the switch) has remained common to all the motors. Only its size changes. When other considerations, such as higher voltages and faster switching speeds come to the fore, a departure from this design procedure must be made. The mechanical element must give way to the

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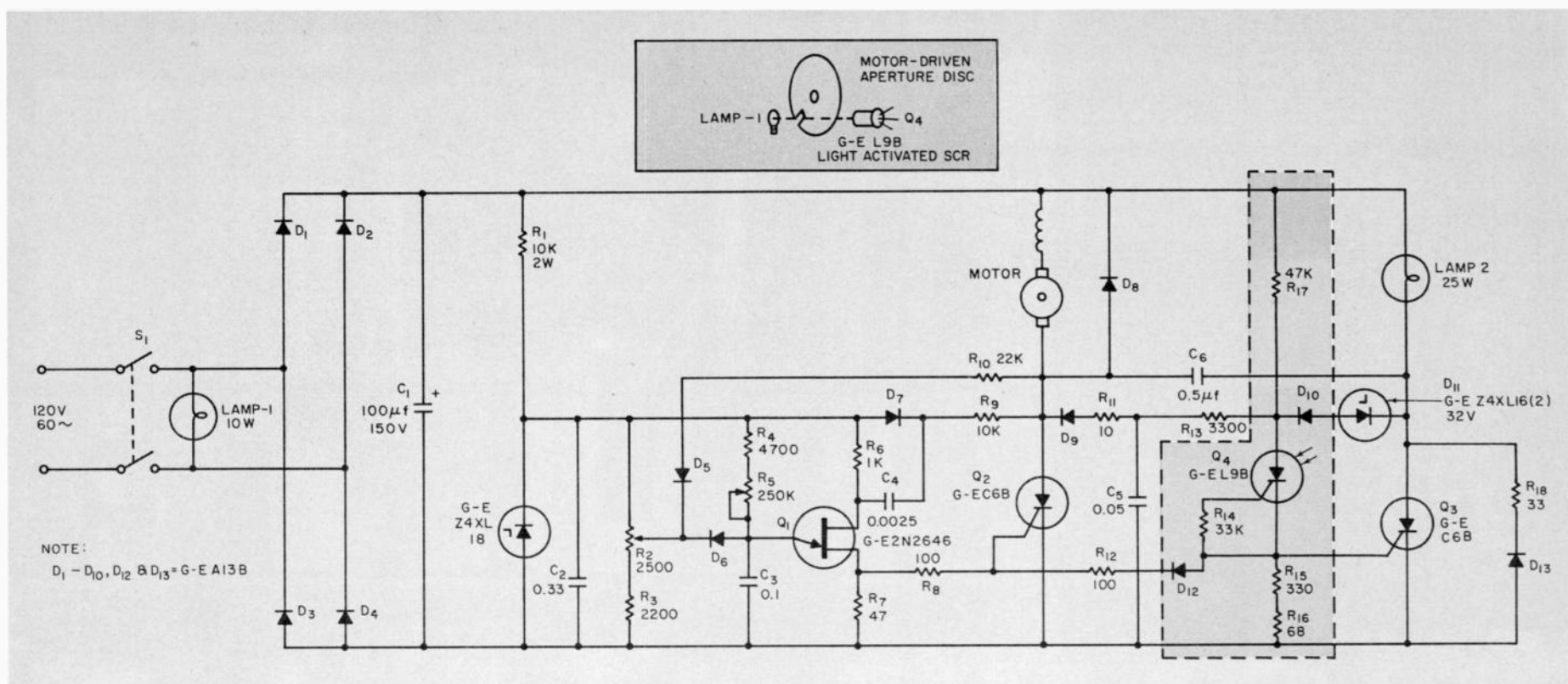
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6. The light-activated SCR (LASCR) replaces the mechanical commutating switch when faster switching speeds are called for. This LASCR-based speed-control system is suitable for higher current, line-voltage-operated series motors.

faster, electronic means of commutation. The electronic components must similarly be modified to handle both high current loads and line voltages (120 vac). A speed-control system for a 1-amp series motor will serve as an example of these more stringent design requirements.

#### LASCR usurps mechanical switch

Rather than use the mechanical commutating switch for a higher voltage (120 volts) series motor, a light beam and aperture disc can provide the turn-off signal (Fig. 6). This approach banks on the use of the light-activated SCR (LASCR) as the commutated element. Circuit operation resembles that of the other systems. The UJT oscillator turns on the main SCR,  $Q_2$ , which is then commutated by an auxiliary SCR,  $Q_3$ , in the classical capacitor-commutated SCR flip-flop connection. The LASCR,  $Q_1$ , is turned on by light when the motor shaft passes a pre-determined position. If the main SCR,  $Q_2$ , is conducting and  $Q_3$  is OFF, current can flow through zener diode  $D_{11}$ , diode  $D_{10}$  and  $Q_4$  to the gate of  $Q_3$ . When  $Q_3$  is turned on by this current, it commutates  $Q_2$  through capacitor  $C_6$ ,  $Q_1$  through diode  $D_9$  and resistors  $R_{11}$  and  $R_{12}$ .

The delaying (lock-out) of the oscillator required for the under-speed and over-speed

conditions, is slightly different from the previous systems. For the under-speed condition, the network  $R_2$ ,  $R_3$ ,  $R_{10}$ ,  $D_5$  and  $D_6$  clamps the voltage across  $C_3$  to a level just below the peak point of the UJT ( $Q_1$ ), while the main SCR is conducting. The result is identical to the under-speed delay achieved and discussed in the previous circuits.

Over-speed lock-out is obtained by having the LASCR trigger  $Q_2$  through  $D_{12}$  and  $R_{12}$ . The turn-on of  $Q_2$  causes the interbase voltage of  $Q_1$  to drop momentarily (via the coupling through  $R_9$  and  $C_1$ ). This potential drop forces  $Q_1$  to discharge  $C_3$ , thus re-initiating the timing cycle of the oscillator. When  $Q_2$  turns on,  $Q_3$  is turned off by capacitor  $C_6$ , but  $Q_1$  is not commutated because of the isolation provided by  $D_{10}$ . Therefore, after the commutation interval, the voltage across  $Q_3$  rises and  $Q_1$  continues to conduct. But the current through  $R_{17}$  is too small to trigger  $Q_3$ . Nevertheless, when the voltage across  $Q_3$  reaches the avalanche voltage of the zener diode,  $D_{11}$ , the current through  $Q_1$  increases and  $Q_3$  is turned on again. This commutates both  $Q_2$  and  $Q_1$ , thus resetting the oscillator and providing a very short pulse of power to the motor.

The essential difference here is the use of light to both eliminate the wear-prone me-

chanical switch and produce no loading on the motor. The system also has a faster response time than the mechanical-switch system, thus permitting a higher oscillator frequency and either higher motor speeds or more cycles of operation per revolution. The use of multiple slots of different lengths provide either mechanical selection of octave steps in speed (by the positioning of the LASCR) or their electrical selection by paralleling several LASCRs mounted at different points on the rotation.

The phase-detector principle used provides a linear output for virtually the full 360 degrees of possible phase error. Its ability to produce full output at any input frequency below the reference frequency and nearly zero output at any input frequency above the reference is unique to speed-control systems. This added function should be useful in automatic frequency control (afc) systems as well as motor-speed control applications.

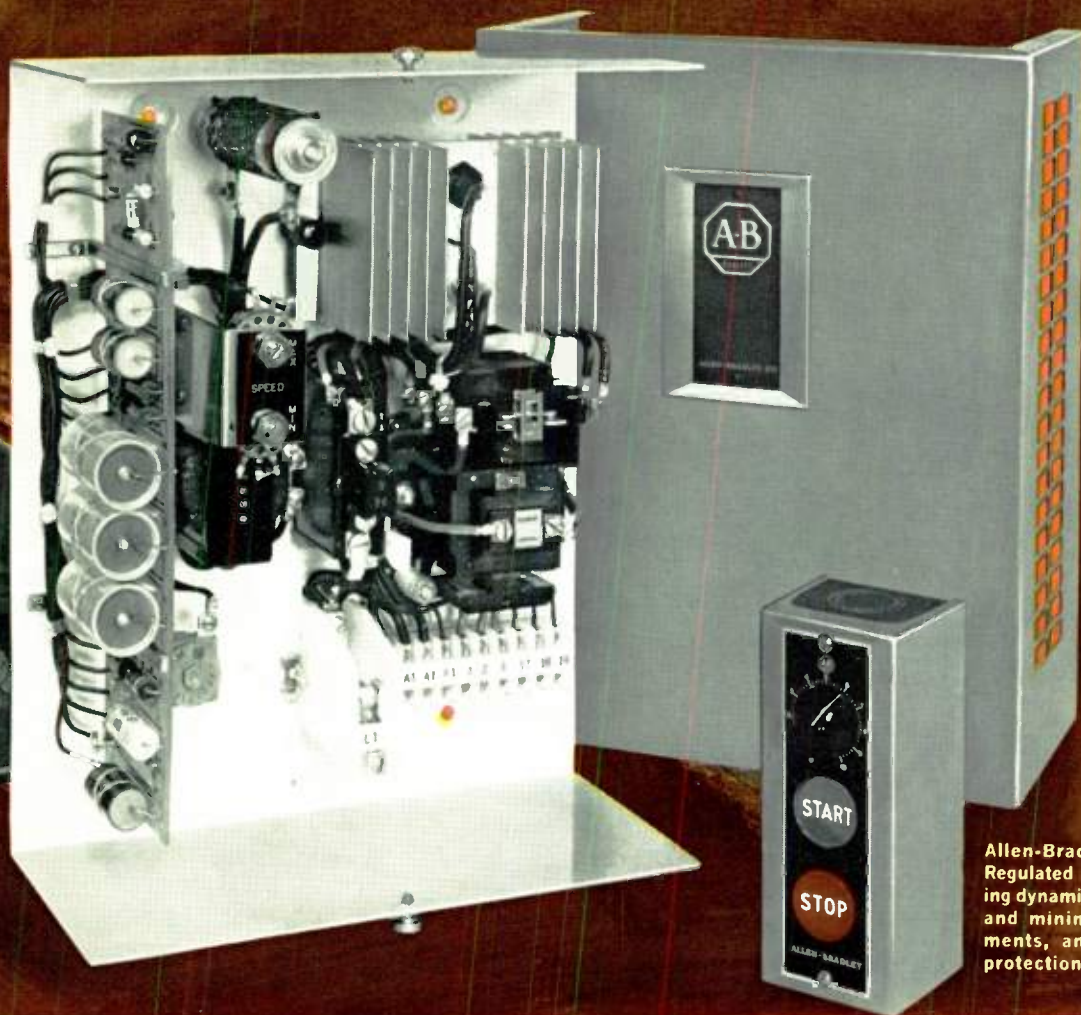
#### Magnetic approach to commutation

Another method for eliminating the mechanical commutating switch would entail the use of a magnetic impulse generator driven by the motor (Fig. 7). The effect is similar to that of capacitor commutation (Fig. 6), except that the energy required for



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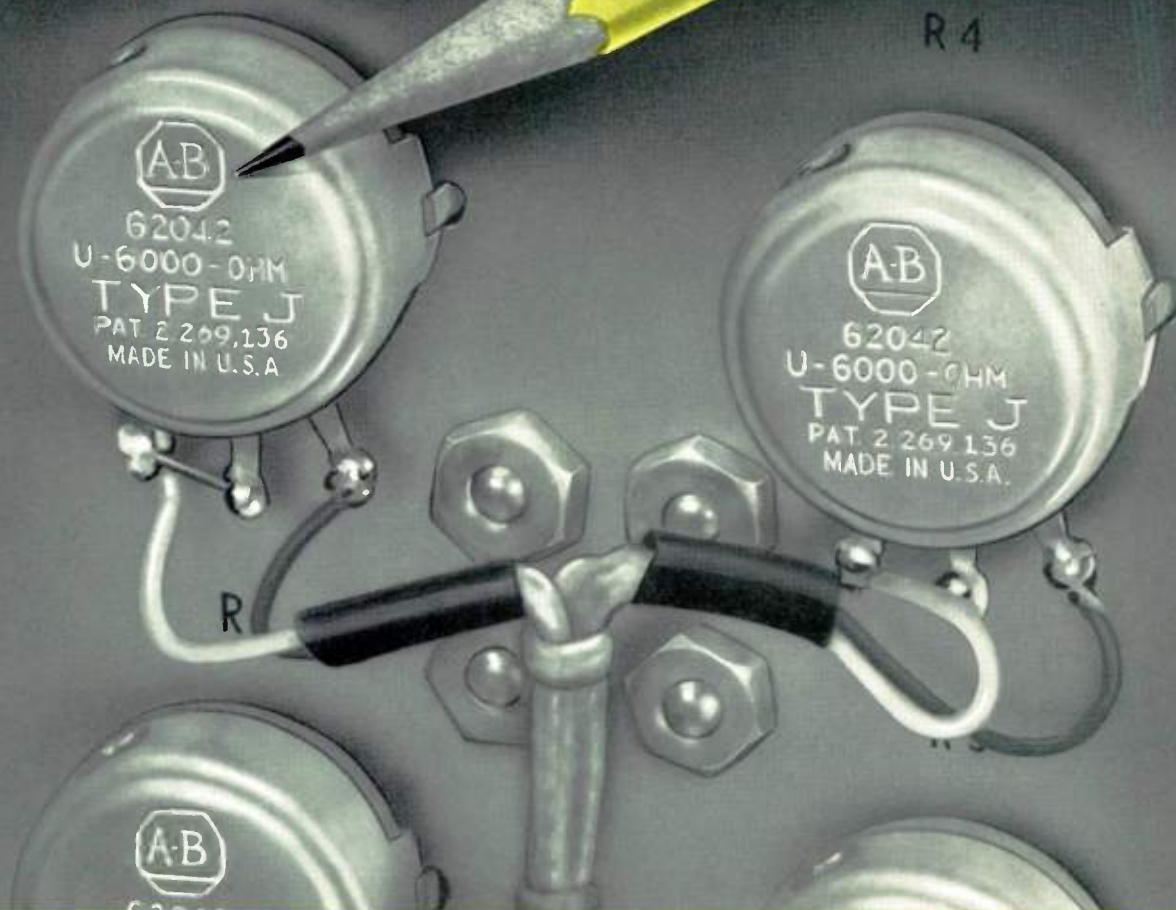
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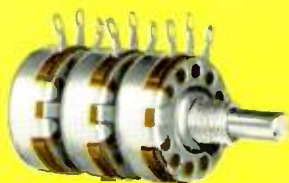
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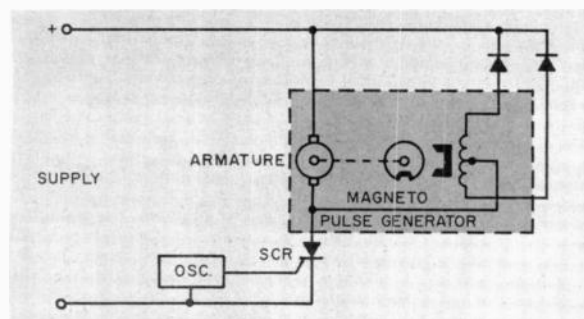
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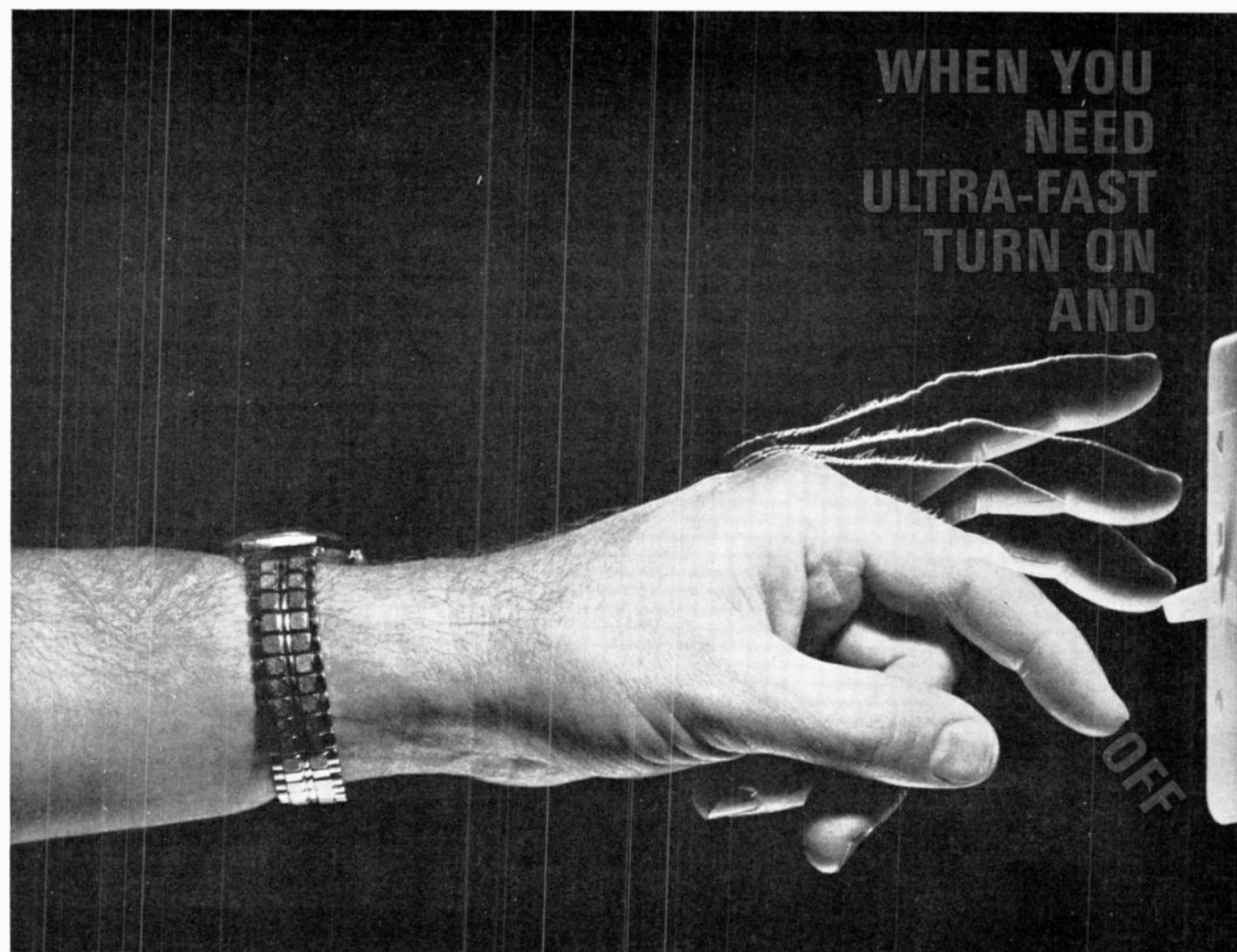
commutation is taken from stored mechanical energy in the rotor rather than from a separate capacitor. The magnetic field for the impulse generator could be derived from a permanent magnet. However, the use of the armature current for this function is preferable, particularly for the higher current motor types.

A brushless dc motor may be given synchronous speed characteristics by using a pm rotor and a wound stator in conjunction with an SCR (or transistor) ring-counter. Commutation would be obtained by either a magnetic impulse or a light signal and its auxiliary commutating SCR or transistor.

#### Multiple motor speed control

Speed control can also be easily fitted into a multiple-motor system. The free-running UJT oscillator of one motor control may be synchronized with that of others. By using this master UJT oscillator, the only additional requirement is for small capacitive couplings between the base-one output of the master UJT and the emitters of the slave UJTs. This direct synchronizing pulse should be small, so as not to interfere with the under- and over-speed lock-out functions. The master oscillator should be run at a frequency slightly higher than the free-running oscillators to obtain the proper slaving. This method produces precisely equal motor speeds, but the phase relationships between the motors will vary with loading and may require additional compensating circuitry. Multiple motor synchronization is useful in many areas, particularly in the strip-processing and recording fields.

All of the speed-control systems mentioned are suitable for applications which require high precision and/or low cost. These include: instrumentation, entertainment systems, automotive motors (not engines), toys, small vehicular drives and small boat drives. ■ ■



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hpa 2302 Min. Max.	35 ma	1 ma	30 v	300 na	1 pf	100 ps	8.70 ea. 5.80 ea.
hpa 2303 Min. Max.	35 ma	1 ma	20 v	500 na	1.2 pf	100 ps	8.00 ea. 5.35 ea.
Test Conditions	$V_F = 1\text{ v}$	$V_F = 0.4\text{ v}$	$I_R = 10\text{ }\mu\text{a}$	$V_R = 15\text{ v}$	$V_R = 0$		

\*These diodes are too fast to measure in conventional circuits utilizing standard reverse recovery time measurements. Therefore, the effective minority carrier lifetime is specified as  $\tau$  instead of  $\tau_{rr}$ . Devices are hermetically sealed in a miniature glass package 0.160" long, 0.070" in diameter, color coded.

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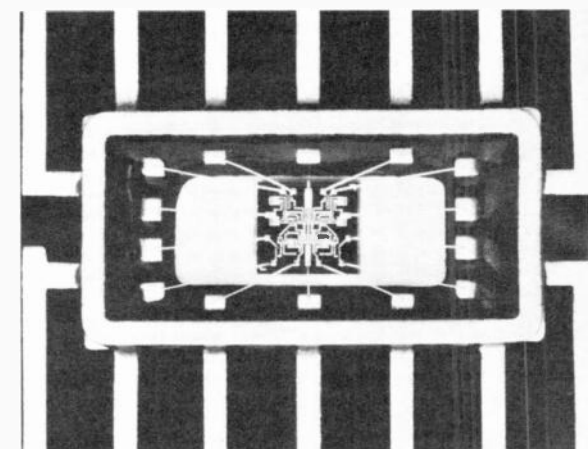


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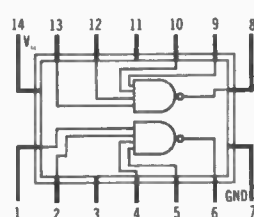
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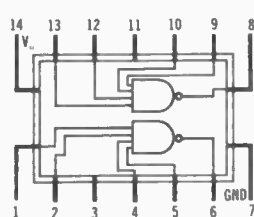


(Above) Package for Series 54 930 T<sup>2</sup>L integrated circuits is same 1/4" by 1/8" TO-84 flat pack with 14 lateral leads as shown in photograph.

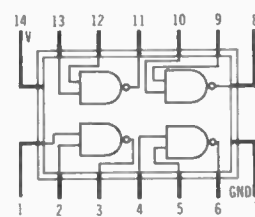
(Left) Chart shows DTL integrated-circuit types with their Series 54 930 T<sup>2</sup>L replacements.



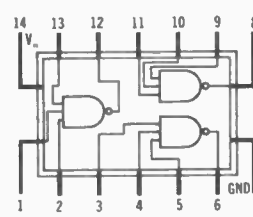
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NAND Gate



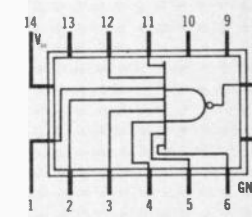
SN54 932  
Dual 4-input  
Buffer



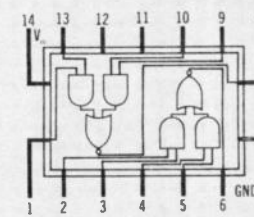
SN54 946  
Quadruple 2-input  
NAND Gate



SN54 962  
Triple 3-input  
NAND Gate



SN54 965  
8-input  
NAND Gate



SN54 966  
Dual EXCLUSIVE-OR  
Gate

These six initial T<sup>2</sup>L circuits in Series 54 930 are identical in every respect with standard Series 54 integrated circuits, except for pin configurations.

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New Series 54 930 T<sup>2</sup>L circuits are

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The new Series 54 930 units are the SN54 930 Dual 4-input NAND Gate, the SN54 932 Dual 4-input Buffer, the SN54 946 Quadruple 2-input NAND

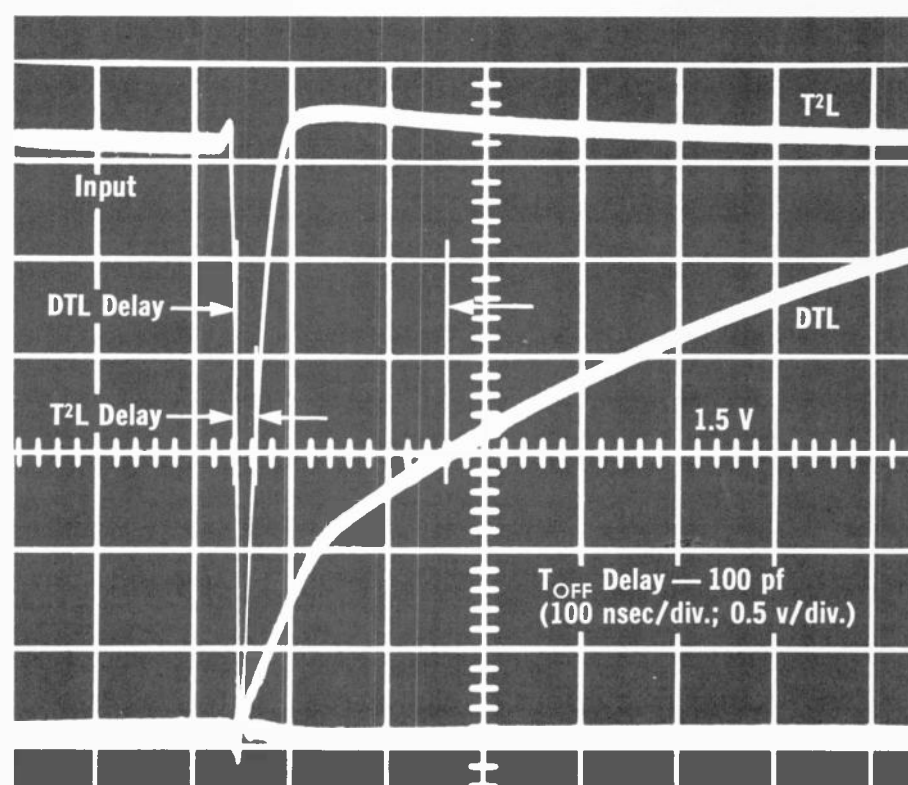
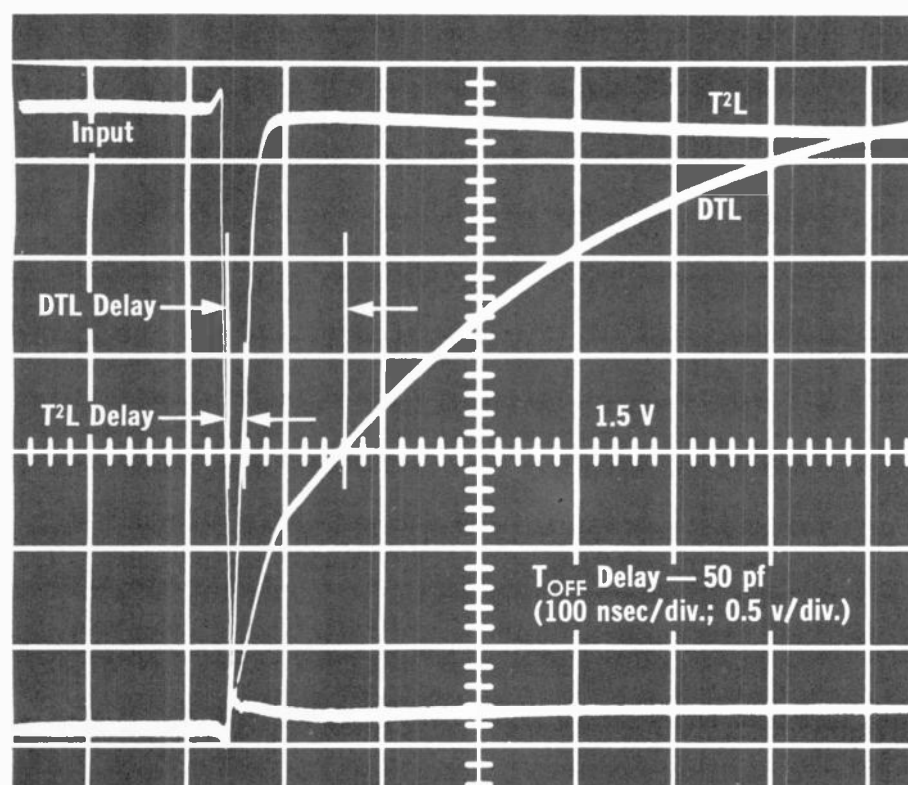
Gate, the SN54 962 Triple 3-input NAND Gate, the SN54 965 8-input NAND Gate, and the SN54 966 Dual EXCLUSIVE-OR Gate. These circuits with DTL-type pin configurations are an expansion of TI's regular Series 54 line. They are identical in every respect with standard Series 54 circuits, except for pin configurations.

Series 54 Transistor-Transistor Logic (T<sup>2</sup>L) fully exploits the inherent capabilities of integrated semiconductor

structures. The multiple-emitter transistor input provides a faster turn-off time than other logic forms, thereby minimizing propagation delay. Because of unique circuit characteristics and exacting process control, propagation delays are almost independent of temperature and loading.

The output stage of the Series 54 circuit provides low line-termination impedance in both logical "0" (12 ohms) and logical "1" (100 ohms) states.

# Your DTL System



(Above) Actual photographs of oscilloscope traces show comparison of speed degradation between 930-series DTL and Series 54 930 T<sup>2</sup>L as capacitance load is increased. Turn-off times for 50-pf and 100-pf loading conditions are shown as measured at the 1.5-volt point.

(Right) Comparison of typical gate characteristics shows that T<sup>2</sup>L offers higher speed, higher fan-out and higher noise margin.

Logic	Propagation Delay (Typical)	Fan-Out	D-c Noise Margin (Guaranteed)
Series 54 930 T <sup>2</sup> L	13 nsec	10	400 mV
930-series DTL	25 nsec	8	350 mV

## Higher Fan-out, Higher Noise Margin

This contributes to low propagation delays and preserves undistorted waveforms even when driving large-capacitance loads. The low line-termination impedance also accounts for low susceptibility to capacitively coupled noise.

Typical noise margin for Series 54 integrated circuits is one volt. Guaranteed worst-case noise margin is 400 millivolts for both logical "1" and logical "0" conditions.

TI's standard ¼" by ½" flat package

(TO-84) is used for all Series 54 circuits. This package — proved by more than 35,000,000 hours of controlled tests and four years of field use — features all-welded construction with hermetic glass-to-metal seals.

Why not try replacing DTL circuits with Series 54 T<sup>2</sup>L in your present system? See for yourself the improvement in performance. For evaluation quantities from stock, contact your local TI Sales Engineer or Distributor.



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## Using feedback pairs in integrated circuits

### Part 1—The series-to-shunt pair

Analyzing feedback paths in integrated circuits can be a complex process. Here is the first part of a two-part article that will give you some techniques to simplify the job.

**F**EEDBACK PAIRS in integrated circuits offer built-in thermal and signal stabilities that make them comparable to single-ended differential-amplifier stages. In addition, they are easy to integrate on a single chip.

The pair combinations possible include:

- Series-to-shunt feedback.
- Shunt-to-series feedback.
- Complementary-structure series-to-shunt feedback.

- Shunt-to-shunt feedback.
- Series-to-series feedback.

Of these five, series-to-shunt feedback (Fig.

1) is the most commonly used and will be discussed in the first part of this article. The second part will cover the other types and their applications.

The closed-loop gain of this circuit in the classical form is:

$$G(s) = \frac{A(s)}{1 - A(s)\beta(s)}, \quad (1)$$

where:

$A(s)$  is the open-loop current or voltage gain and  $\beta(s)$  is the feedback factor.

The product of  $A(s)\beta(s)$  is the return ratio, which can be determined with the expression<sup>1</sup>

$$A\beta = 1 - \frac{\Delta}{\Delta_{REF}}, \quad (2)$$

where  $\Delta$  is the loop or nodal determinant of the circuit, depending upon whether voltage or current gain is to be evaluated.

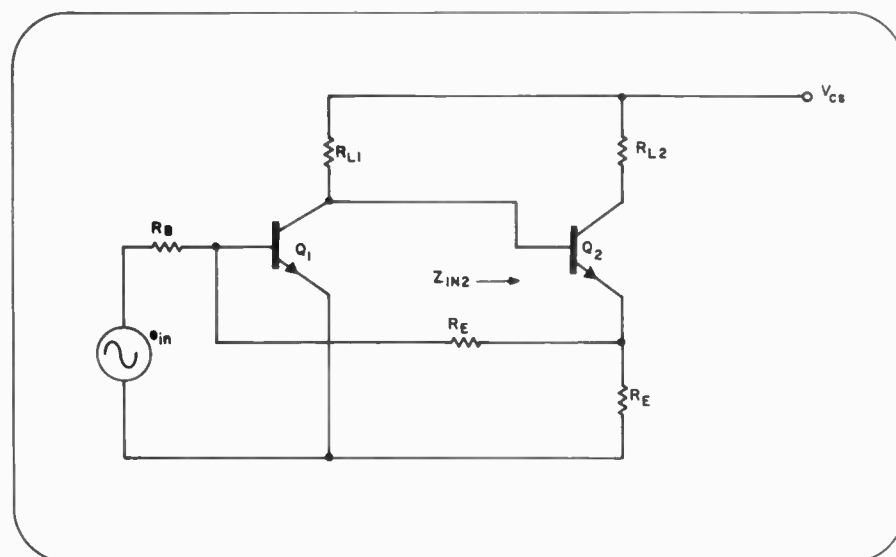
Normally, for shunt feedback at the input, current gain is appropriate; for series feedback, voltage gain is used.  $\Delta_{REF}$  is the determinant with  $\Delta$  in its reference condition, which, when inserted in the  $\Delta$  of the network, makes the forward transmission through the network zero. In many cases, the use of Eq. 2 is cumbersome and involves a lot of calculations. However, the circuit in Fig. 2 can be used to determine  $A(s)\beta(s)$  experimentally.

Here, the feedback path is broken at point A-A', and a network with a driving-point impedance,  $Z_M$ , is connected at a point A'. A unit current applied at point A' will flow through  $Z_M$ . This current is equal to return ratio.

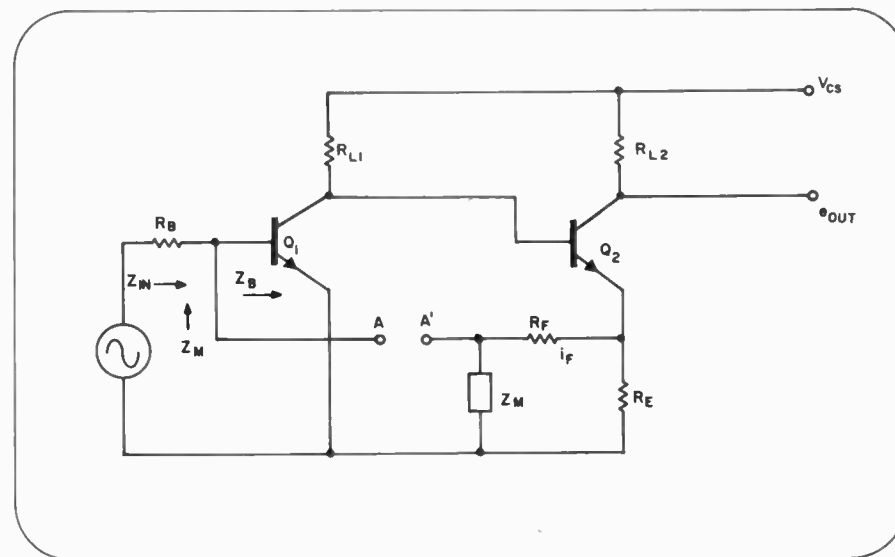
Thus, we can determine the return ratio by measuring the current appearing at the input for a unit current applied at the same point. Since the input and feedback currents

**Vasil Uzunoglu**  
Applied Physics Laboratory\*  
Johns Hopkins University  
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1. Series-to-shunt feedback pair is the type most commonly used in integrated-circuit form.



2. Feedback measurements can be made by breaking the feedback path at points A-A'. With unity current at the input, the current through  $Z_M$  is equal to the return ratio ( $A\beta$ ).  $Z_M$  is equal to  $R_B // Z_B$ .

can not be measured simultaneously at the same point, the circuit in Fig. 2 must be used.

In doing such a measurement, we assume that the forward transmission through  $R_F$  is negligible and that the network does not have any memory. Since return ratio is a complex number, both amplitude and phase must be determined.

At this point we should make the distinction between the three input-impedance levels shown in Fig. 2.  $Z_B$  is the open-loop input impedance,  $Z_{IN}$  is the closed-loop impedance and  $Z_M$  is the input impedance as seen by the feedback current. The last is given as:

$$Z_M = R_B // Z_B. \quad (3)$$

Using the same experimental concept used in determining  $A\beta$ , we can obtain  $Z_M$  analytically. To make such a shunt feedback more effective,  $R_B$  should be much larger than  $Z_{IN}$ . Then the feedback current can be written as:

$$i_F = \frac{i_{e2} R_E}{R_E + R_F}. \quad (4)$$

As  $R_E \ll R_F$ , Eq. 4 can be written in terms of  $\beta(s)$  as:

$$\beta(s) = \frac{R_E}{R_F} \quad (5)$$

and the open-loop current gain  $A(s)$  as:

$$A(s) = \frac{\beta_1 \beta_2 R_{L1}}{R_{L1} + Z_{IN2}} \quad (6)$$

then  $A(s) \beta(s)$  becomes:

$$A(s) \beta(s) = \frac{\beta_1 \beta_2 R_{L1}}{R_{L1} + Z_{IN2}} \cdot \frac{R_E}{R_F}, \quad (7)$$

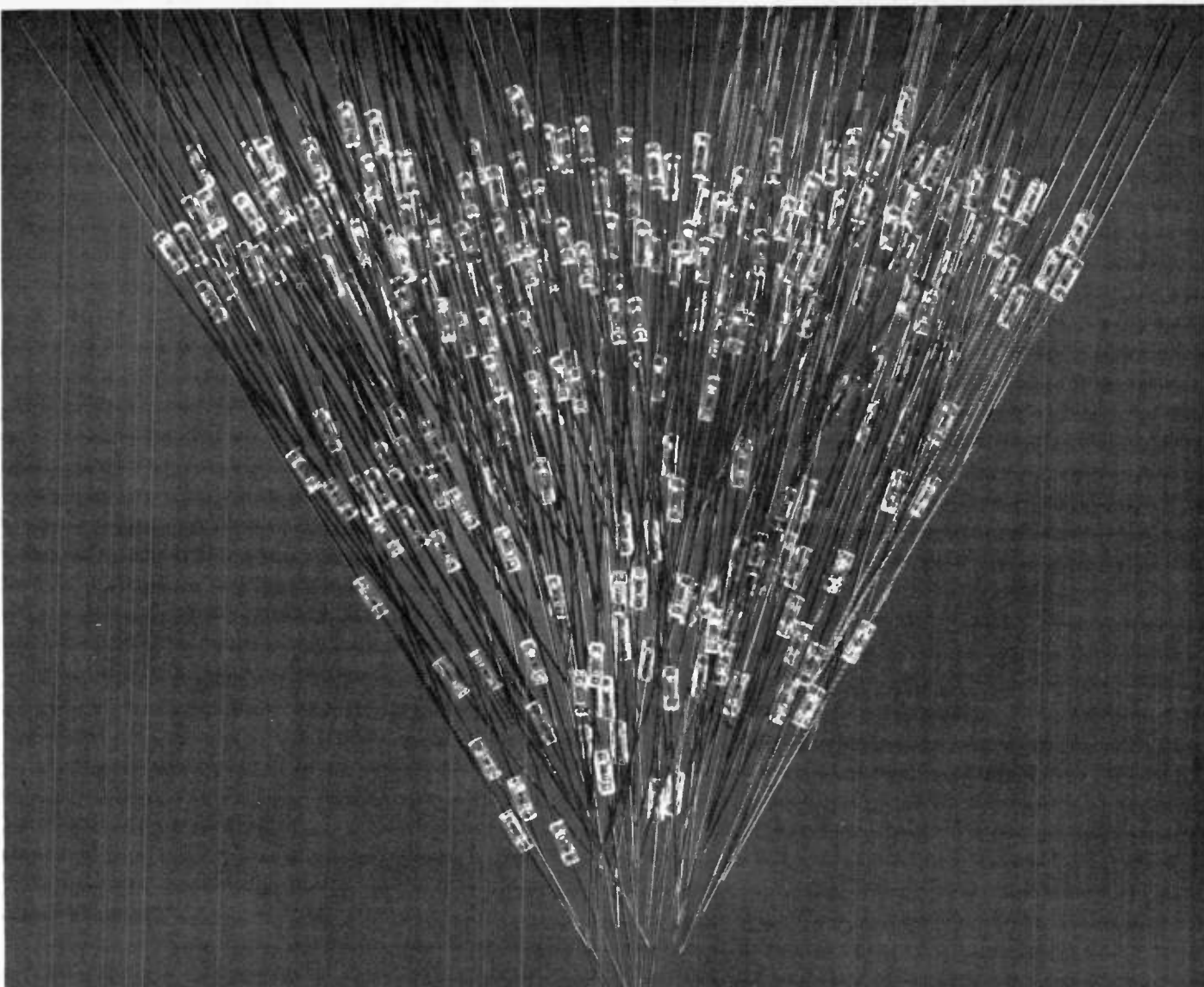
where  $\beta_1$  and  $\beta_2$  are frequency dependent.

Another important characteristic of this feedback pair is its low input impedance due to shunt feedback. The effect of the feedback on impedance can be seen from:<sup>2</sup>

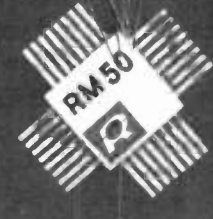
$$Z_{IN} = \frac{Z[1 - A(s) \beta_0]}{[1 - A(s) \beta_\infty]}, \quad (8)$$

where  $Z$  is the driving-point impedance in question, with all active elements eliminated (set equal to zero);  $A(s) \beta_0$  is the return ratio, where the terminals at the driving-point end are shorted together, and  $A(s) \beta_\infty$  is the return ratio when these terminals are left open. Both  $\beta_0$  and  $\beta_\infty$  are frequency dependent.

In a single feedback loop, where only one type of feedback exists, either  $A\beta_0$  or  $A\beta_\infty$  is zero. It is easy to see that for a shunt feedback,  $A\beta_0$  becomes zero, whereas, for a series feedback,  $A\beta_\infty$  becomes zero. For Fig. 2, Eq. 8



# 15




# 15

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can be written as:

$$Z_{IN} = \frac{Z}{1 + A(s)_1 \beta_x} \cdot [1 + A(s)_2 \beta_0], \quad (9)$$

as  $A(s)_1$  and  $A(s)_2$  are minus for both cases.  $[1 + A(s)\beta_x]$  is the shunt-to-series feedback, and  $[1 + A(s)_2\beta_0]$  is the emitter feedback. Eq. 9 reveals that the driving-point impedance is decreased by the existence of this feedback. If it is assumed that  $R_F \gg Z_B$  and  $r_e \ll r'_c + R_{L1} \parallel Z_{IN2}$ , then  $Z$ ,  $\beta_x$ ,  $\beta_0$  and  $A(s)_2$  can be written as:

$$Z = r'_b + r_e \quad (10)$$

$$\beta_x = \frac{R_E}{R_F} \quad (11)$$

$$\beta_0 = \frac{r'_b + r_e}{(r'_b + r_e) r'_c}, \quad (12)$$

$$\text{and } A(s)_2 = -\frac{\alpha r'_c}{r'_b} \quad (13)$$

Note that  $\beta(s)$  in Eq. 5 and  $\beta_x$  in Eq. 11 are the same. This is because we assumed that  $R_B \gg Z_B$  in Eq. 5. This is a necessary condition for this type of feedback to be effective. Using  $A(s)_1$  from Eq. 6, the input impedance is:

$$Z_{IN} = \frac{r'_b r_e}{1 + \frac{\beta_1 \beta_2 R_{L1}}{R_{L1} + Z_{IN2}} \cdot \frac{R_E}{R_F}} \left[ 1 + \frac{\alpha r'_c}{r'_b} \cdot \frac{r'_b r_e}{(r'_b + r_e) r'_c} \right] \quad (14)$$

$R_{L1}$ ,  $R_E$  and  $R_F$  can be of the distributed RC type. At high frequencies, it can be approximated by  $2\sqrt{R}/\sqrt{sC}$ .

Assuming that  $Z_{IN2} \gg R_{L1}$ ,  $\beta_1 \beta_2 R_{L1}/R_F \gg 1$  and that  $r_e r'_c / (r'_b + r_e) r'_c \gg 1$ , we have:

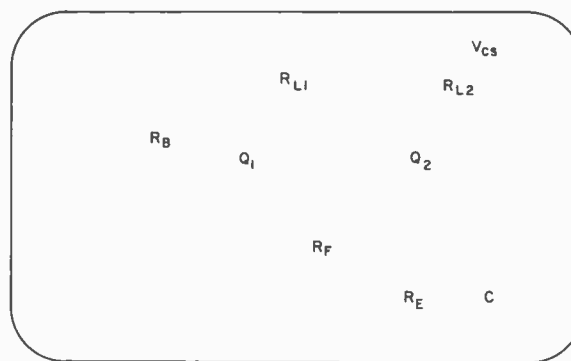
$$Z_{IN} = \frac{R_F r'_e}{R_{L1}} \quad (14b)$$

#### Why use series/shunt.

Some important characteristics of this feedback pair which make it suitable for an integrated circuit are:

- It is direct coupled.
- It has an inherent temperature-stabilization property.
- It has improved bandwidth.
- It is signal stable.

Direct coupling eliminates a capacitor, which is hard to realize on a semiconductor block, and it eliminates the need for separate biasing resistors for the second stage. The direct coupling is also very important in



3. Improved temperature stability can be obtained by using a zener diode either in the base of  $Q_2$  or in series with  $R_E$ .

eliminating any low-frequency attenuation.

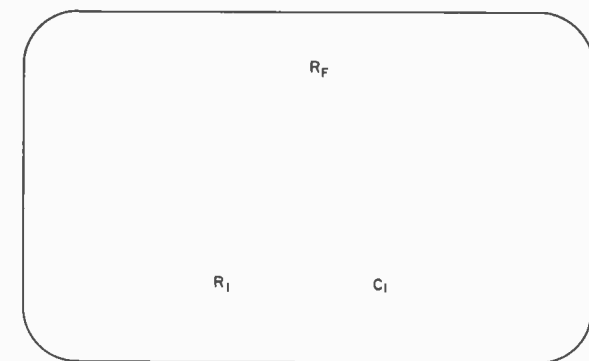
Its temperature stability can be explained as follows. If the temperature goes up,  $I_{C1}$  goes up and  $V_{CE1}$  goes down. Since the rate of decrease of  $V_{BE2}$  is less than that of  $V_{CE1}$ , less current is supplied to the second transistor. This, in turn, means that less  $I_F$  is fed back to  $Q_1$ . As the bias of  $Q_2$  is supplied through the feedback current, this means that the input impedance of  $Q_1$  is increased so that less signal current is fed to  $Q_1$ .

This explanation assumes that all resistors remain undisturbed with variations in temperature. This is not true, of course. Normally the values of resistors go up with an increase in temperature. The percentage of variation is normally less than 0.2%/°C for normal boron-diffused resistors with 300-350 ohms/square resistivity. For thin-film resistors, this value is several orders of magnitude less and can also be negative. Increased temperature stability can be obtained by inserting a zener diode in series with the base of  $Q_2$  or in series with  $R_E$  as shown in Fig. 3. A zener diode with a positive temperature coefficient will further reduce the current flow to the second stage so that less current is applied for biasing  $Q_1$ , if the temperature increases.

Under constant-temperature operation, the zener diode in the emitter leg of  $Q_2$  maintains a constant voltage across  $R_E$  with fewer variations in the amount of feedback.

#### Improving bandwidth

Improved bandwidth for the circuit stems from different factors: the elimination of biasing resistors will improve the frequency response of the amplifier. Since resistors in a microelectronic block are of the distributed RC type, some of them introduce poles in the open-loop gain of the amplifier. In many cases, if low power dissipation is of prime importance, the use of high-value bias resis-



4. Paralleling  $R_F$  with a resistor-capacitor combination improves bandwidth if the phase shift is kept low.

tors will be determining factors of the frequency response, because of the introduction of a pole.

The feedback through  $R_F$  improves the bandwidth. Further improvement in the bandwidth can be achieved by shunting  $R_E$  with a capacitor. This introduces a pole in the return ratio and reduces the feedback as frequency goes up. This is true, of course, as long as the phase shift remains low. Also, if the circuit shown in Fig. 4 is inserted in place of  $R_F$  in Fig. 3, improved bandwidth can be achieved.

This network introduces a pole-zero in the return ratio. By choosing the proper values, it is possible to eliminate an open-loop dominant pole by the zero of the  $\beta(s)$  network. Up to this point, we have assumed that all resistors are of the lumped form. In a practical sense, this is true for thin-film hybrid circuits or oxide-isolated microelectronic blocks. For conventional semiconductor blocks, however, all resistors are of the distributed RC type. A way to keep the RC time constant of the resistors low is to use low-value resistors, which necessitate high power dissipation. This is particularly true in the case of load resistors. The distributed resistors  $R_B$  and  $R_E$ , on the other hand, help in improving the bandwidth. A distributed  $R_B C_B$  at the input of  $Q_1$  has the effect of introducing a pole-zero in the open-loop gain function, the zero of which can be used to eliminate the pole of the stage.

The second part of this article will discuss the elimination of instability in the shunt-to-shunt configuration and investigate the other types of feedback pairs. ■ ■

#### References

1. Vasil Uzunoglu, *Semiconductor Network Analysis and Design* (New York: McGraw-Hill Book Co., 1964), Chap. IV, X.
2. Vasil Uzunoglu, "Double Diffused Transversal Amplifiers," *Proc. IEEE*, April, 1965 (cor.), pp 410-411.



## Microwave Switch Electrically Controlled

The combination of a microwave switch and a microwave circulator permits the switching of two microwave input lines so that there is only a short period of time when both (or neither) of the two is connected to the output line.

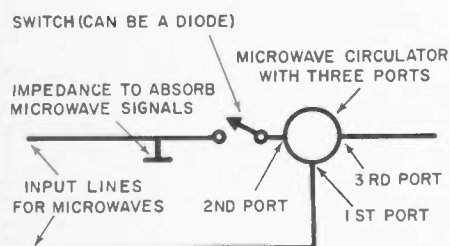
When the switch is closed, signals from the first input line go through the switch into the second port of the circulator and out on the third port to the output line.

An impedance, such as an antenna, is connected to the first input line before it goes to the switch. Hence, if the switch is closed, signals from the second line enter the first port of the circulator, exit through the second port and are absorbed by the termination.

If the switch is open, signals from the first line are blocked; from the second line they enter the first port of the circulator, leave it through the second port and are reflected by the open switch. The reflected signals then will re-enter the second port and finally exit through the third one, to the output line.

The switch is a single-throw, single-pole one, such as a diode that can be switched on or off by a biasing current.

*Brief No. 63-10258, by C. Stelzied & Clauss, Jet Propulsion Lab. (JPL-410) No patent action is contemplated.*



Fast double-throw device is a combination of microwave switch and circulator.



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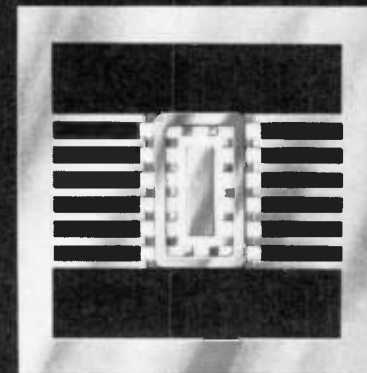
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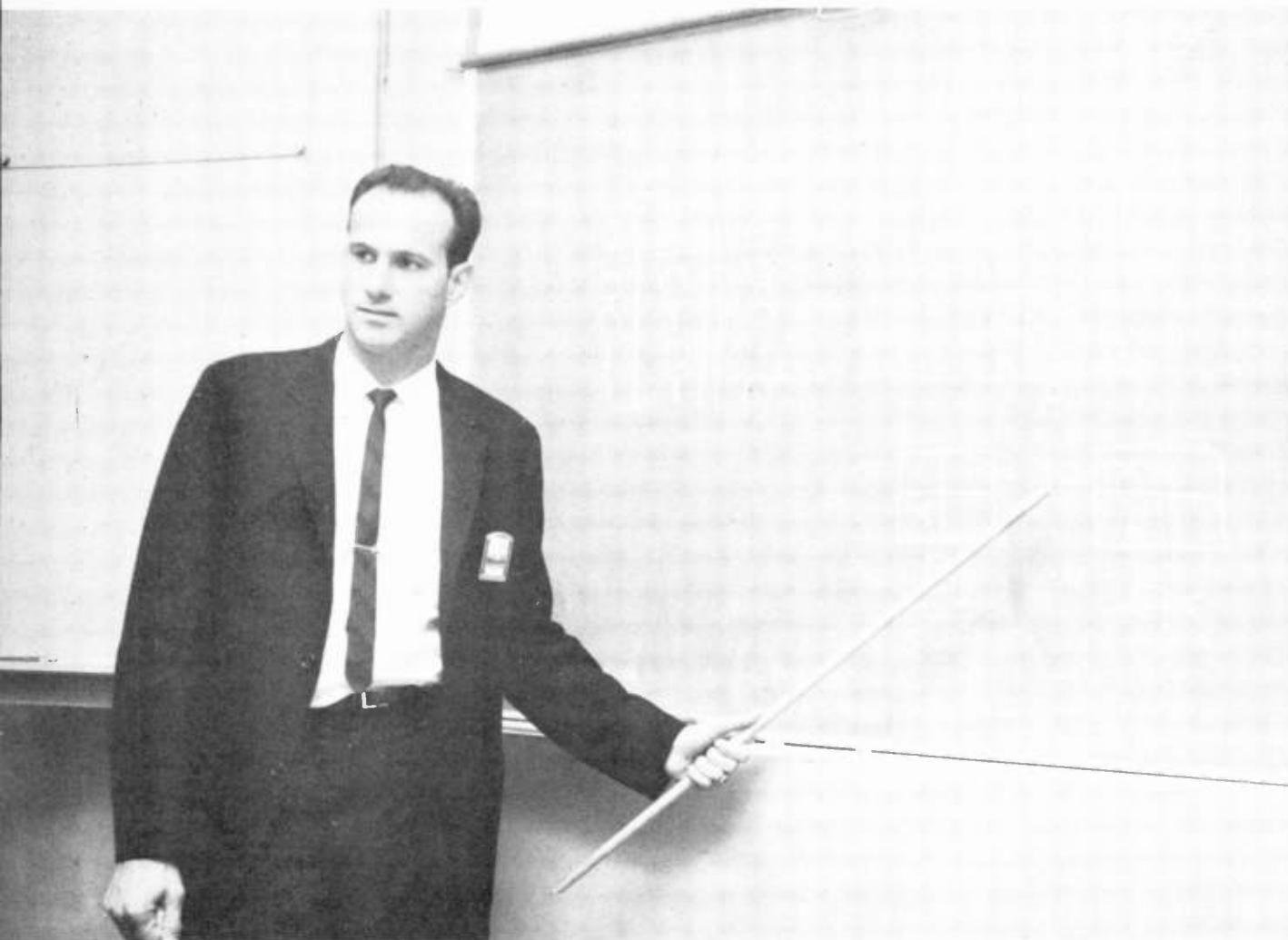


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# Shortcut to logic design of sequential-counter gating

Determining the optimum gating requirements for sequential counters is often a lengthy process. Here's a time-saving method that does the job.



Recognition of redundancies is the key, says author Lucas.

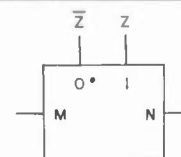
**T**HE TIME REQUIRED for designing the gating associated with sequential counters can be reduced by recognizing certain redundancies in the normal design procedure. A systematic method for accomplishing this will result in a gating configuration that is both logically correct and minimal in terms of the memory elements used.

The steps generally followed in forcing flip-flops to sequentially follow required patterns are:

1. Deriving a sequential-state table for all flip-flops.

## Paul Lucas

Project Engineer  
Hamilton Standard  
Div. of United Aircraft Corp.  
Broad Brook, Conn.



TRUTH TABLE FOR M-N FLIP-FLOP

TIME $t$		TIME $(t+1)$
M	N	Z
0	0	NO CHANGE
0	1	1
1	0	0
1	1	TOGGLE

1. M-N type flip-flop delivers an output at time  $t+1$  that depends on the state of its M and N inputs at time  $t$ .

2. Reducing the table to a Boolean form.
3. Evolving the input equations for the flip-flops in accordance with the type used (R-S, T, J-K, etc).
4. Simplifying these equations while taking into account possible redundancies (unused states).

If the designer makes a one-step transformation of the state table to a Veitch diagram and modifies the results in the same step by the flip-flop truth table, items 2 and 3 may be virtually eliminated, and item 4 simplified. This method can be demonstrated by the example that follows.

A three flip-flop counter will be required to sequentially follow a binary sequence (1, 3, 4, 2, 6, 0, 7) (1, 3, etc.). For the purpose of generalization, the flip-flop will arbitrarily be called an M-N type, having a truth table as shown in Fig. 1. Thus a (0, 0) on the *M* and *N* inputs at time *t* will cause output *Z* to remain in the same state at time *t*+1. A (0, 1) on *M* and *N*, respectively, at time *t* will cause output *Z* to change to the "1" state at time *t*+1. Similarly, (1, 0) forces *Z* to the "0" state at *t*+1, while a (1, 1) will force the flip-flop to change state at *t*+1.

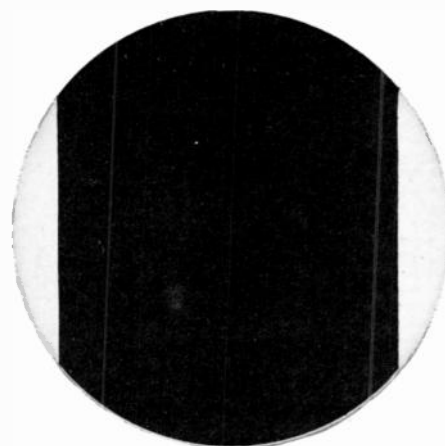
If the three flip-flops of the counter are designated *A*, *B*, and *C*, the state table can be developed. From this, it can be seen that the distribution of the binary counts is as shown in Fig. 2, where the position of each box denotes the flip-flops that must be in the "1" state at that particular count. For each flip-flop a Veitch diagram is then evolved for the *M* and *N* inputs.

#### Procedure for Count 1

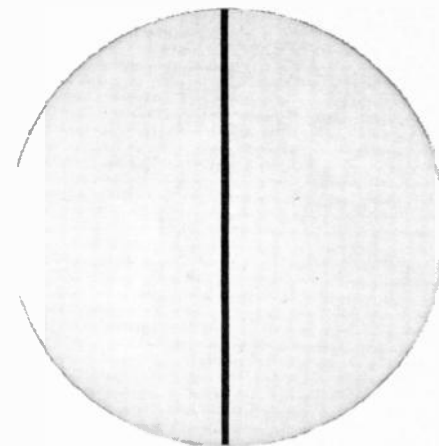
Fig. 3 shows the Veitch diagrams for the *M* and *N* sides of the least significant flip-flop, *C*. The diagrams for *C<sub>M</sub>* and *C<sub>N</sub>* are laid out simultaneously in a step-by-step proce-

		C		C	
		0	1	2	3
		4	5	6	7
		B			
COUNTS	PRESENT STATE			NEXT STATE	
	A	B	C	A	B
1	0	0	1	0	1
3	0	1	1	1	0
4	1	0	0	0	1
2	0	1	0	1	1
6	1	1	0	0	0
0	0	0	0	1	1
7	1	1	1	0	0

2. Distribution of binary counts is evolved into a Veitch-type diagram from the state table.



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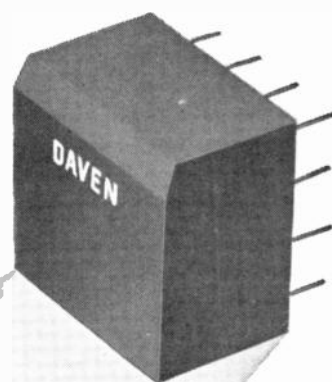


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ture, with each count being modified by the flip-flop truth table. For example, for count 1, the position of which is designated in Fig. 2, flip-flop C is now in a "1" state, and will continue to be "1" in the next state. This can be seen from the state table. Referring then to the truth table, it can be seen that the flip-flop will not change state if a "0" is applied to both inputs. In addition, no matter what the present state, the flip-flop will be forced to a "1" state at time  $t+1$  if a "0" and a "1" are applied to the M and N inputs, respectively.

Either of these situations will satisfy the requirements of flip-flop C for count 1. When both are considered together, it is clear that

		C		C	
		X	0	X	1
A	X	X	X	X	0
	0	X	X	X	0
		$C_M = \bar{A}B$		B	

		C		C	
		1	X	0	X
A	1	0	X	0	X
	0	0	X	0	X
		$C_N = \bar{A}B$		B	

3. Veitch diagram is prepared for each input and shows the state of that input for every count. The Boolean expression for an input is derived from its completed Veitch diagram.

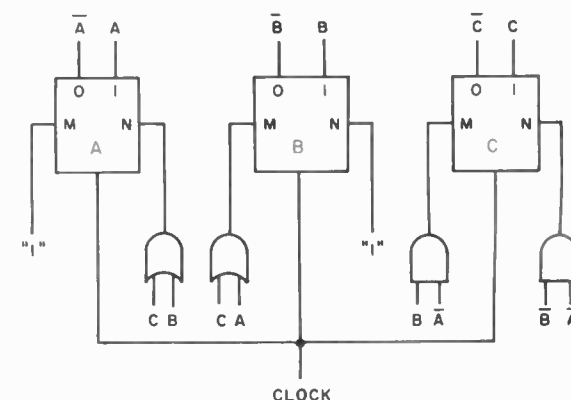
		C		C	
		X	X	0	1
A	X	X	X	1	1
	0	X	X	1	1
		$B_M = A + C$		B	

		C		C	
		1	1	X	X
A	1	1	X	X	X
	0	1	X	X	X
		$B_N = 1$		B	

		C		C	
		X	X	X	X
A	1	1	X	1	1
	0	1	X	1	1
		$A_M = 1$		B	

		C		C	
		1	0	1	1
A	1	X	X	X	X
	0	X	X	X	X
		$A_N = B + C$		B	

4. Counter gating requirements are completely defined once all Veitch diagrams have been plotted and converted to Boolean form.



5. Final gating configuration for the counter consists of two AND and two OR gates.

the  $M$  input must have a "0" on it; however, the  $N$  input may have either a "0" or "1" during the present state to satisfy the requirements. Therefore, for count 1 in Fig. 3, a "0" is placed on the  $M$  side, but since a "0" or "1" will satisfy  $N$ , an  $X$  is placed there indicating a "don't care" condition.

### Procedure for Count 3

The next count to be considered has the value 3. The state table shows that at count 3, flip-flop  $C$  must move from a "1" to a "0" condition. From the truth table, it may be observed that the flip-flop will be forced to "0" under any previous condition if a "1" and "0" are placed on  $M$  and  $N$ , respectively. In addition a "1" on both inputs will force the flip-flop to change states.

Either one of these situations will satisfy the requirements. Once again, a "1" is required on the  $M$  side, but either a "1" or "0" will be correct on the  $N$  side. For count 3, therefore, a "1" is placed on the  $M$  side and a "don't care"  $X$  on the  $N$  side.

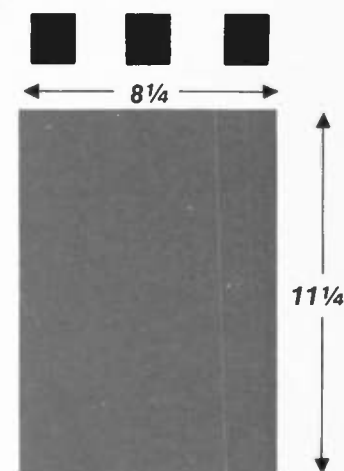
This procedure is also followed for the successive counts (4, 2, 6, 0, 7). Count 5 is not used, and is therefore an  $X$  on both sides. After the Veitch diagrams are completely filled in, they are easily reduced to the simplest forms to represent the equations that will satisfy the counting conditions of the flip-flop. The gating requirements of flip-flops  $A$  and  $B$  are found in exactly the same manner. Fig. 4 shows the completed Veitch diagrams and the equations for  $A$  and  $B$ .

The counter can be checked by verifying that it follows the prescribed counting pattern when gated by the derived Boolean expressions. As an example, the  $B$  flip-flop must change from "0" to "1" at count 1 as the state table shows. From Fig. 4, it can be seen that if either flip-flop  $A$  or  $C$  is in the "1" state, the  $M$  side of flip-flop  $B$  will be a "1." The  $N$  side is always "1." At count 1,  $C$  is in a "1" state; therefore a "1" is present on both sides of flip-flop  $B$ . The truth table shows that a (1, 1) condition forces the flip-flop to change state. From the state table, it can be seen that this is a correct transition.

At the second count (3), flip-flop  $B$  must change back from the "1" to the "0" state. Fig. 4 and the state table show that  $C$  is once again a "1", placing (1,1) on both inputs to flip-flop  $B$ . This forces the flip-flop to change state, which is again correct. A similar quick check of all states for all three toggles can verify the accuracy of the results.

The final configuration of the counter is as shown in Fig. 5. ■ ■

# The shape of things to come



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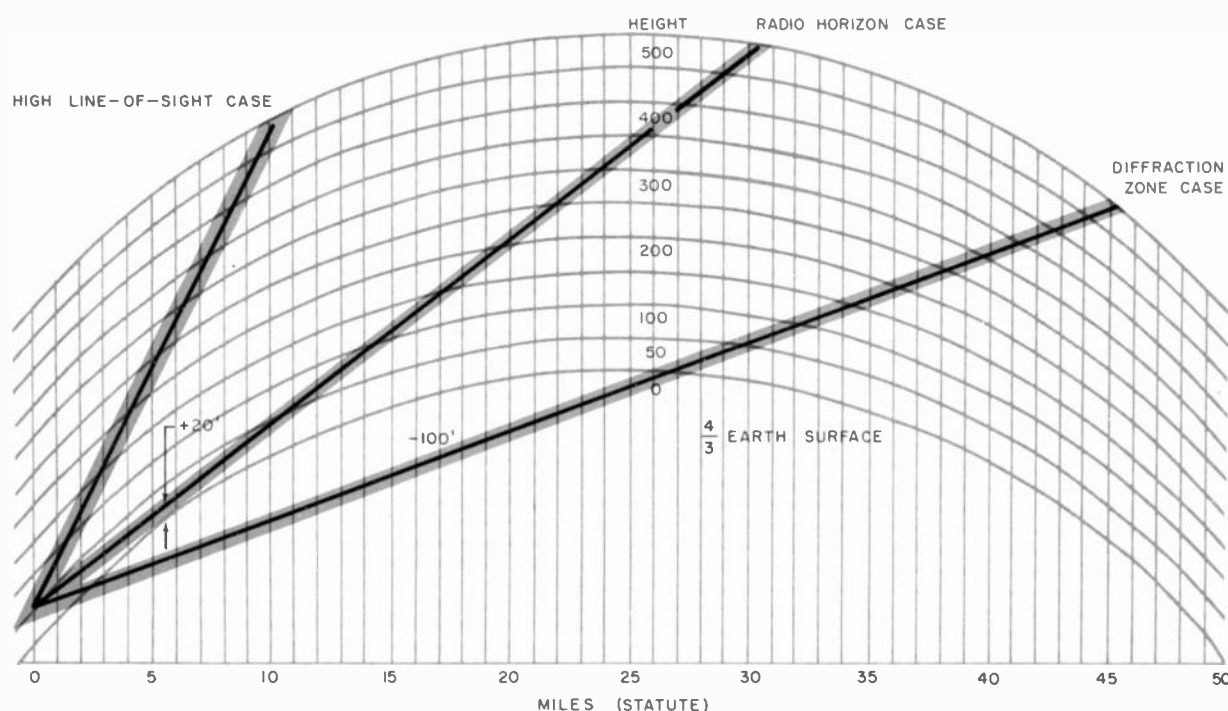


# Radio signals in air lose more power than you think

Transmission in air cannot always be considered as propagation in free space, even if the receiver station is in the line of sight.

**Additional losses resulting from nearness of earth's surface**  
**50' UHF Radar Tower**      **Frequency Gc (over water path)**

Range	Least ray clearance, (ft).	Radius of 1st Fresnel zone (ft)	Clearance as fraction of 1st Fres. radius	1-Way loss in excess of free space	Free space 2-way loss	Total loss (2-way)
10 mi	+50	115	$50/115 = +0.45$	- 4.0 db	$117 \times 2 = 234$	242
30 mi	+20	200	$20/200 = +0.10$	-13.5 db	$127 \times 2 = 254$	281
45 mi	-100	245	$-100/245 = -0.4$	-28 db	$130 \times 2 = 260$	316



1. Chart takes into account the curvature of the earth's surface. The loss suffered by radio waves, traveling near the surface, can be large even if the stations are in the line of sight.

**C**AN YOU ANSWER the question, "When is line-of-sight propagation also free-space propagation?"

Here is a simple technique that gives the answer quickly and helps to find out how much loss is involved in line-of-sight paths, when waves propagate near the earth's surface. Since this technique is intended for the engineer doing preliminary design or proposal work, only chart solutions are given.

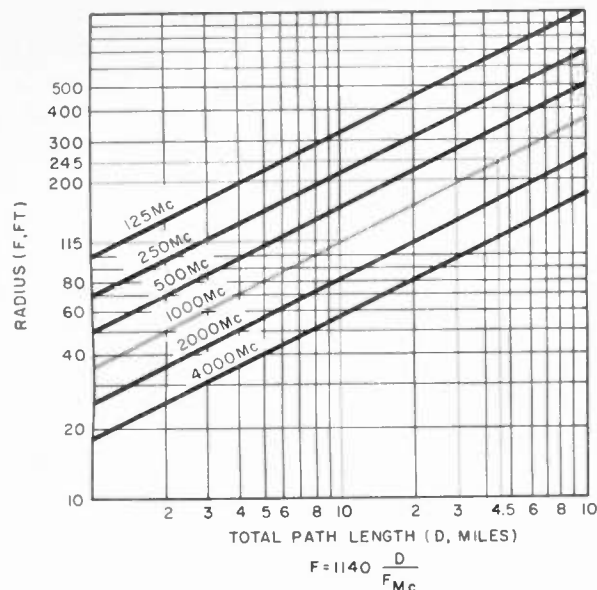
Accurate calculations, justified if much money or other risk hinges upon the amount of the actual path loss, are much more complex, involving many other factors.

The basic understanding one must first absorb in dealing with near-earth propagation is that any wave propagating close to the surface of the earth changes drastically.<sup>1,2,3,4</sup>

Basically, the shortest distance between the wave-ray path and the surface of the earth determines the type of propagation. To determine the distance of the closest approach, a line connecting the two ends of the propagation path is drawn on profile paper, and the point of closest approach is graphically measured from this scaled chart. Typical ray paths are shown in Fig. 1.

For free space propagation, this distance must, at all points, be further away from the surface than six-tenths of the radius of the first Fresnel zone (0.6F).

**Eugene Dusina**  
Professional Engr.  
Melbourne, Fla.



2. **First Fresnel radius** depends on the frequency and on the total path length. For instance, if the path is 30 miles long and the frequency of the signal is 1 Gc, the Fresnel radius will be 200 feet.

This first Fresnel zone is the distance from any spot on the ground within which the reflected wave will have a total distance of one-half wavelength longer to travel than the direct path from antenna to antenna.<sup>1,2,3</sup> This 0.6 F is commonly used with four-thirds earth profile paper to give an average propagation loss. This paper illustrates the fact that the earth looks one-third larger for radio waves, if normal refraction is assumed.

We can take three cases to illustrate the degree of path-loss involved. These examples use an aircraft, flying over water at 500 feet altitude and being observed by uhf radar with an antenna on a 50-foot pedestal:

- An observation of the aircraft at 45 miles will illustrate the losses involved in a non-line-of-sight, or diffraction case.
- An observation at 30 miles will illustrate the losses when propagation is slightly within the line-of-sight.
- An observation at 10 miles will illustrate the losses involved for a path well within line of sight.

The results of the calculations of these examples are shown in the table.

We can start a step-by-step procedure for the 30-mile case by assuming that the radar is operating at a frequency of 1 Gc. Then we:

1. Locate the radar antenna at the zero-mile vertical grid where it crosses the 50-foot altitude circle on the profile chart (Fig. 1).
2. Plot the aircraft location on the 30-mile vertical grid where this crosses the 500-foot altitude circle.
3. Draw a straight line from the radar-

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### CASE HISTORY

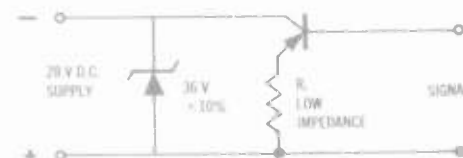
This company has a design engineer--let's call him Bill--who had a problem. Line spikes were causing high base to emitter voltages that were destroying a transistor in the emitter-follower of Bill's solid state amplifier. Transistors with high base to collector voltages were both expensive and difficult to get.

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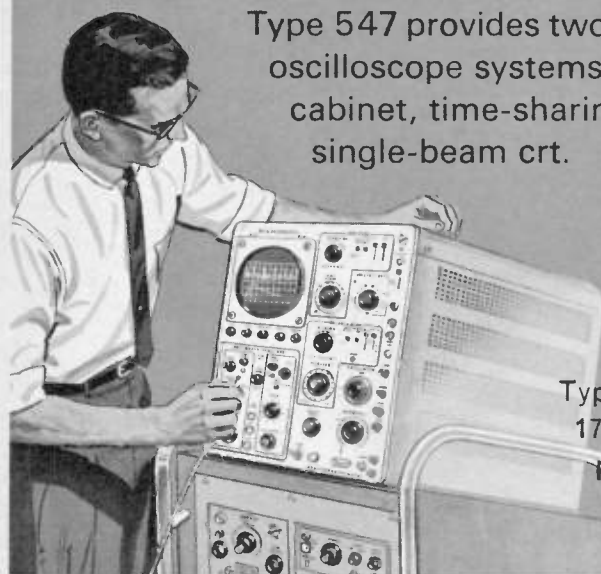
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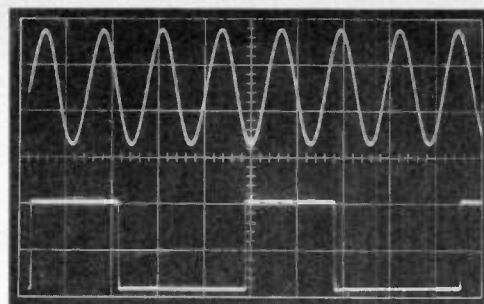
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Single-exposure photograph

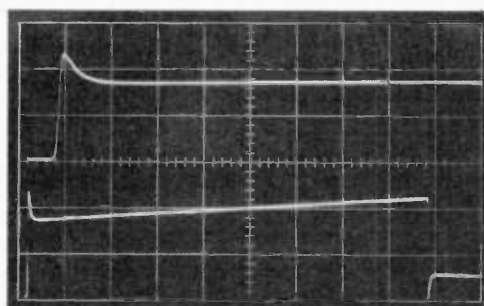
## 2 signals — different sweeps

Upper trace is Channel 1/A sweep, 1  $\mu$ sec/cm. Lower trace is Channel 2/B sweep, 10  $\mu$ sec/cm.

Using same or different sweep rates (and sensitivities) to alternately display different signals provides equivalent dual-scope operation, in many instances.

Triggering internally (normal) permits viewing stable displays of waveforms unrelated in frequency.

Triggering internally (plug-in, Channel 1) permits viewing frequency or phase differences with respect to Channel 1.

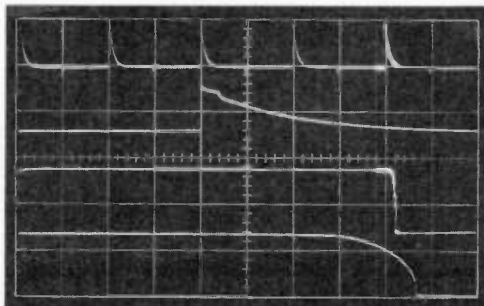


Single-exposure photograph

## same signal — different sweeps

Upper trace is Channel 1/A sweep, 0.1  $\mu$ sec/cm. Lower trace is Channel 1/B sweep, 1  $\mu$ sec/cm.

Using different sweep rates to alternately display the same signal permits close analysis of waveform aberrations in different time domains.



Single-exposure photograph

## 2 signals — portions of each magnified

Trace 1 is Channel 2/B sweep, 10  $\mu$ sec/cm.

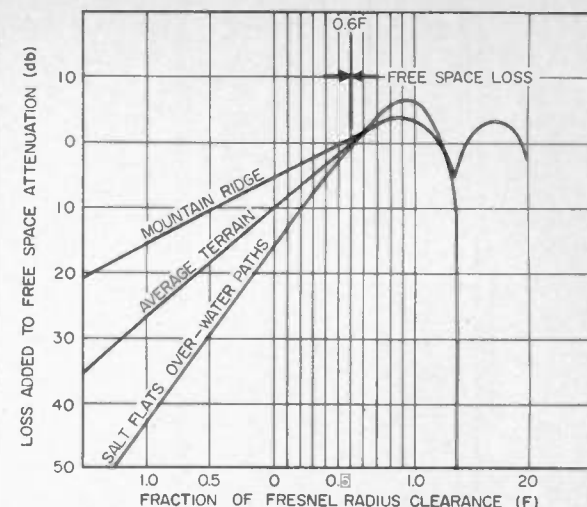
Trace 2 (brightened portion of Trace 1) is Channel 2/A sweep, 0.5  $\mu$ sec/cm.

Trace 3 is Channel 1/B sweep, 10  $\mu$ sec/cm.

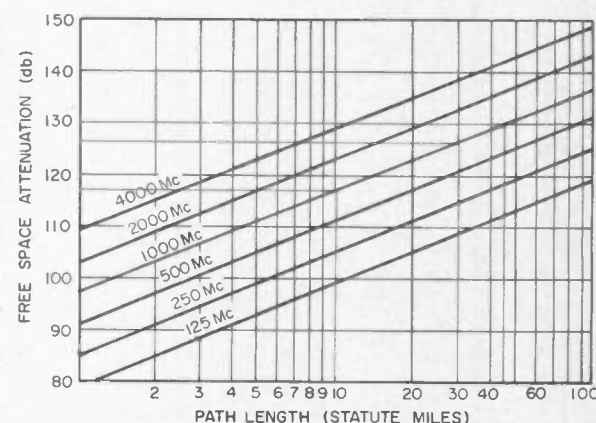
Trace 4 (brightened portion of Trace 3) is Channel 1/A sweep, 0.5  $\mu$ sec/cm.

Using sweep delay technique—plus automatic alternate switching of the time bases—permits displaying both signals with a selected brightened portion and the brightened portions expanded to a full 10 centimeters.

B sweep triggering internally from Channel 1 (plug-in) assures a stable time-related display without using external trigger probe.



**3. Additional attenuation depends on the terrain.** Taking the example of a 30-mile path length, clearance of 20 feet from ground and a Fresnel radius of 200 feet, the additional loss will be -13.5 db over water.



**4. Free-space attenuation increases linearly with distance and with frequency.**

antenna point to the aircraft point.

4. Measure the minimum distance between the straight line drawn, and the surface of the earth; it is 20 feet for this example.

5. Look up the radius of the first Fresnel zone for 1-Gc frequency and 30-miles total distance on Fig. 2. It is 200 feet.

6. Divide the clearance (20 feet) with the first Fresnel-zone radius:  $20/200 = 0.10$ .

This is a plus 0.10, since the 20-foot clearance is above the surface of the earth.

If it were to be below the surface as it is for the 45-mile example, then the ratio would be negative.

7. Look up the extra loss for this +0.10 clearance in Fig. 3 using the curve which pertains to water paths. Its loss is 13.5 db.

8. Look up the path loss for 30 miles of free space at a frequency of 1000 Mc on Fig. 4. It is 127 db.

9. Add this free-space attenuation of 127 db to the extra loss of 13.5 db. The one-way



path loss from the radar to the aircraft is 140.5 db. Doubling this one-way loss gives a two-way radar path loss of 281 db.

From this example, it is clear that, although the aircraft is within radio-line-of-sight, the two-way path-loss is about 27 db greater than for free-space propagation. Thus a sizable error can be involved if the attenuation is not evaluated properly.

The calculations resulting for the 45-mile aircraft-distance results in the values tabulated in the table. Note that the clearance ratio is a negative 0.4 and the one-way loss is 28 db, since the clearance is -100 feet. This negative ratio merely means that the wave must diffract slightly to reach the target. As the diffraction becomes more pronounced, the extra loss sharply increases.

For the 10-mile case, the closest approach of the wave to the surface is at the radar antenna. In this case, the 50-foot height of the antenna is the minimum clearance value, as shown in the table. Whether or not free-space propagation will prevail at this elevation angle depends largely upon whether the antenna illuminates the ground or not.

Narrow-beam antennas will not illuminate the ground, whereas communications antennas normally will.

The amount of loss to be expected at this high elevation angle is somewhat controversial, according to the techniques given in the literature concerning the subject. I personally use free-space loss for estimation purposes whenever the beam clears the ground by more than two beam-widths. If the problem involves a communications antenna with a very wide beamwidth, then a good part of the 4-db loss predicted by this technique will probably be experienced.

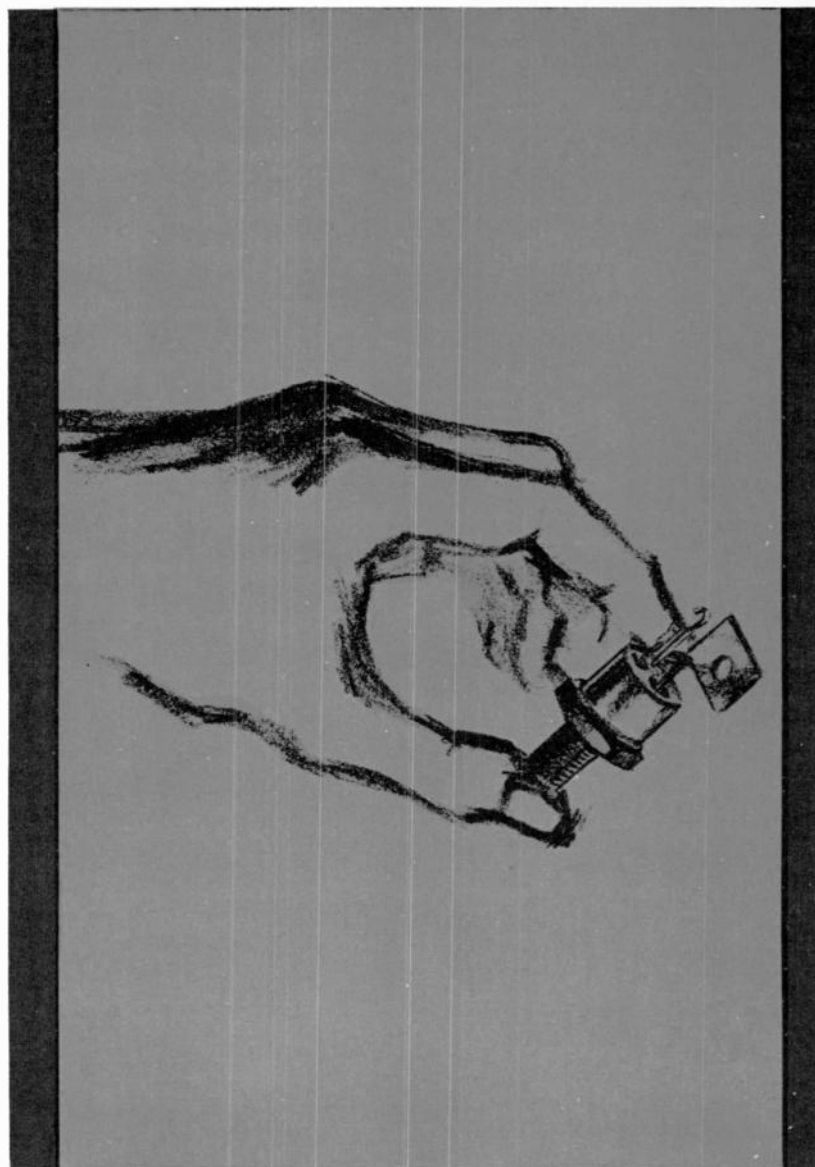
It should be mentioned that the technique of estimating signal losses in this quasi-line-of-sight region is very undeveloped. The loss curve of Fig. 4 gives a fairly good estimate.

For incidental calculations by engineers looking for a "ball park" figure within about 10 db, these charts will place them much closer to the true value than will the improper use of free-space calculations for all paths within line of sight. ■ ■

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1. Kenneth Bullington, "Radio Propagation Fundamentals," *The Bell System Technical Journal*, May, 1957, p 593.
2. *Reference Data for Radio Engineers*, 4th edition, ITT Corp., p 743.
3. "Ground Telecommunications Performance Standards," Part 5, "Tropospheric Systems," *National Bureau of Standards Report 6767*, June, 1961, p 6-19.
4. A. H. Lagrone, "Forecasting TV Service Fields," *Proceedings of the IRE*, June 1960, p 1009.

December 6, 1965



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# Don't blow your fuse

## if you don't have to

Today's high-powered, complex systems can cause designers plenty of trouble—even down to the lowly fuse. Here's how to select a fuse correctly under all conditions.

**P**ICKING A FUSE is ordinarily a snap. But in the realm of complex, high-powered systems, even this seemingly simple task can become complicated, for odd combinations of currents may be encountered in regular system operation. The fuse must be selected to perform its particular protective function, but it must also have a high-enough rating so that an occasional odd combination doesn't burn it out. To arrive at a worst-case condition, the designer must consider:

- Dc currents.
- Rms currents.
- Pulses or pulse-trains.
- Charging transients.

To illustrate an actual situation, an example is shown in Fig. 1. This is a typical circuit in a phased-array radar, with four fuses in the circuit performing widely differing jobs.

The microwave-amplifier tube is protected by fuse 1. Its fast action would prevent the high energy of the capacitor bank from discharging through the tube if an arc were to develop.

The fuse in the charging circuit, fuse 2, has to handle several functions:

- It must pass an initial charging transient when the amplifier module is placed in operation in the array.
- After the warm-up period, it must pass the dc current to the amplifier.
- It must tolerate the ripple in dc current, which makes the rms value of the current

larger than the dc value.

Fuse 3 protects the screen grid from being destroyed if a control-grid-to-screen arc should occur. The distribution system is protected from any trouble in the high-voltage supply by fuse 4.

Hence the current rating for fuses 1 and 3 involve pulse and pulse-train application, whereas fuses 2 and 4 are subjected to charging transients from the initial charging of the capacitor bank and to the normal charging currents, which have dc and ripple components.

In each case, the current has to be calculated. When more than one type of current exists, the highest combined value serves as the basis for evaluation of the fuse. The rating provided by the manufacturer usually needs some modification because of varying environmental conditions.

### Rating good for dc good for rms

The dc current-handling capability of a fuse is determined with a simple formula derived by Preece in 1888:<sup>1</sup>

$$I_d = K_1 D^{1.5}, \quad (1)$$

Where  $I_d$  is the melting (fusing) current for the wire,  $K_1$  is a constant, and  $D$  is the diameter of the wire.  $K_1$  depends upon the wire material and any environmental or atmospheric conditions that will affect the temperature or heat-transfer characteristics of the wire.

The assumptions on which the equation are based are that:

- The wire has a constant temperature throughout its cross-section.

- The heat transfer is directly proportional to the exposed surface of the wire.

- An infinite heat sink is available to accept the heat loss by the wire.

While the first of these assumptions is usually appropriate, the others are often not completely satisfied. Experimental results indicate that the exponent should be reduced to 1.2 or even 1.0 for an enclosed wire.

The thermal time constant for even small (0.001-inch) wire in air is about 40 msec. Therefore, the dc ratings of fuses can be used as rms ratings at power line frequencies and below.

### Will the fuse withstand pulses?

The pulse-current rating of a fuse depends on the size and type of wire in the fuse.

The energy transferred into a unit length of wire during a current pulse is:

$$W_t = i^2 R_1 \Delta t, \quad (2)$$

where:

- $W_t$  = energy in joules,
- $i_1$  = pulse current in amps,
- $R_1$  = resistance per unit length,
- $\Delta t$  = pulse length.

But:

$$R_1 = \frac{r}{D^2}, \quad (3)$$

where  $r$  is the resistivity of the metal and  $D$  is the diameter of the wire.

So:

$$W_t = \frac{i^2 r \Delta t}{D^2} \quad (4)$$

M. Bryan Covington, Principal Engineer  
Frederick G. Schiesser, Asst. Project Engineer  
Bendix Radio Div.  
Baltimore, Md.

The energy required to quickly raise the temperature of the wire per unit length to the fusing point can be expressed as:

$$W_f = dC_p T_f D^2, \quad (5)$$

where:

$W_f$  = required energy per unit length,

$d$  = metal density,

$C_p$  = specific heat,

$T_f$  = melting temperature

When the two energies are equal:

$$\frac{i^2 r \Delta t}{D^2} = dC_p T_f D^2$$

$$i^2 \Delta t = \frac{dC_p T_f}{r} D^4 = K_2 D^4 \quad (6)$$

The constant,  $K_2$  or  $dC_p T_f / r$ , can be calculated if the resistivity, the melting temperature, the specific heat and the density of the fuse wire are known. Both resistivity and specific heat are themselves functions of temperature, and these variations must be accounted for if an attempt is made to calculate  $K_2$ .

Another approach is to experimentally determine  $K_2$  for any specific wire type by measuring the  $i^2 \Delta t$  product for a known wire-diameter.

Once  $K_2$  is determined, then the  $i^2 \Delta t$  rating can be used for pulsed signals if  $\Delta t$  is short compared to the thermal time constant of the fuse, and if the cooling period between pulses is long compared to the thermal time constant.

If either of these conditions is not met, then the signal should be considered a pulse train and the fuse must be evaluated on the basis of other formulas to be discussed later.

#### Safety factors cut back transients

Often a circuit of the type shown in Fig. 2 is used where the fuse must be able to pass the charging surge without opening but still open quickly in case of a capacitor failure.

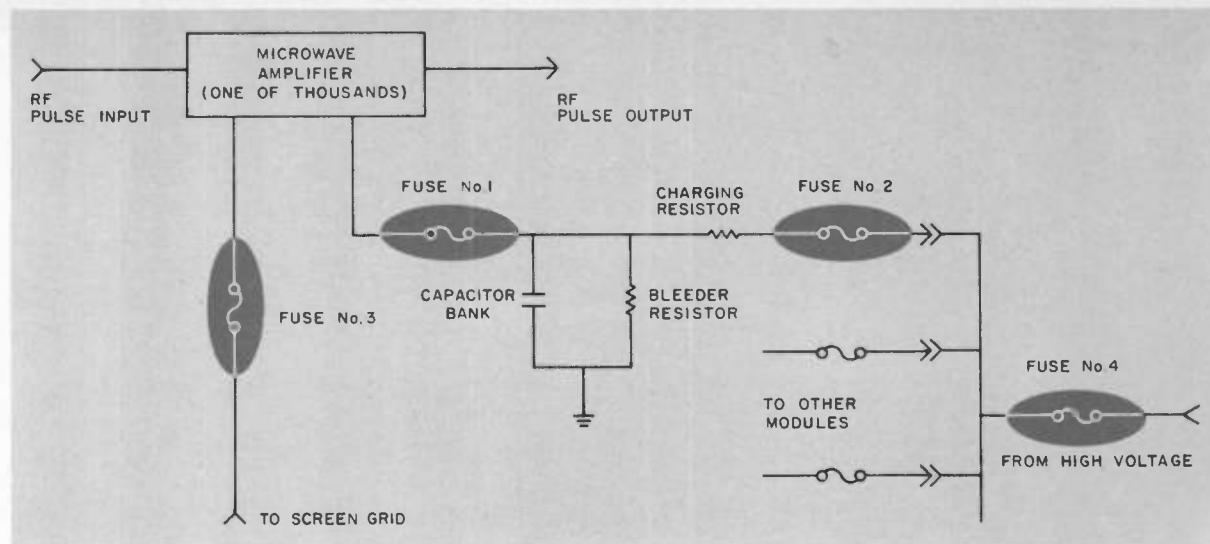
Let's examine the current flow and the energy relationships that permit the fulfillment of both conditions.

For the condition where the fuse should pass the transient charging current, the current in the circuit after the switch closes is:

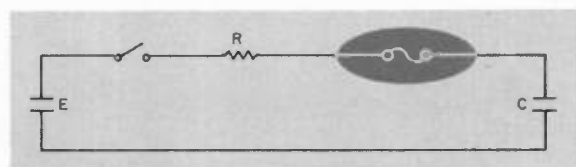
$$i = \frac{E}{R} e^{-t/RC} \quad (7)$$

The energy delivered into each unit length of wire is the integral of  $i^2 R dt$  during the charging cycle:

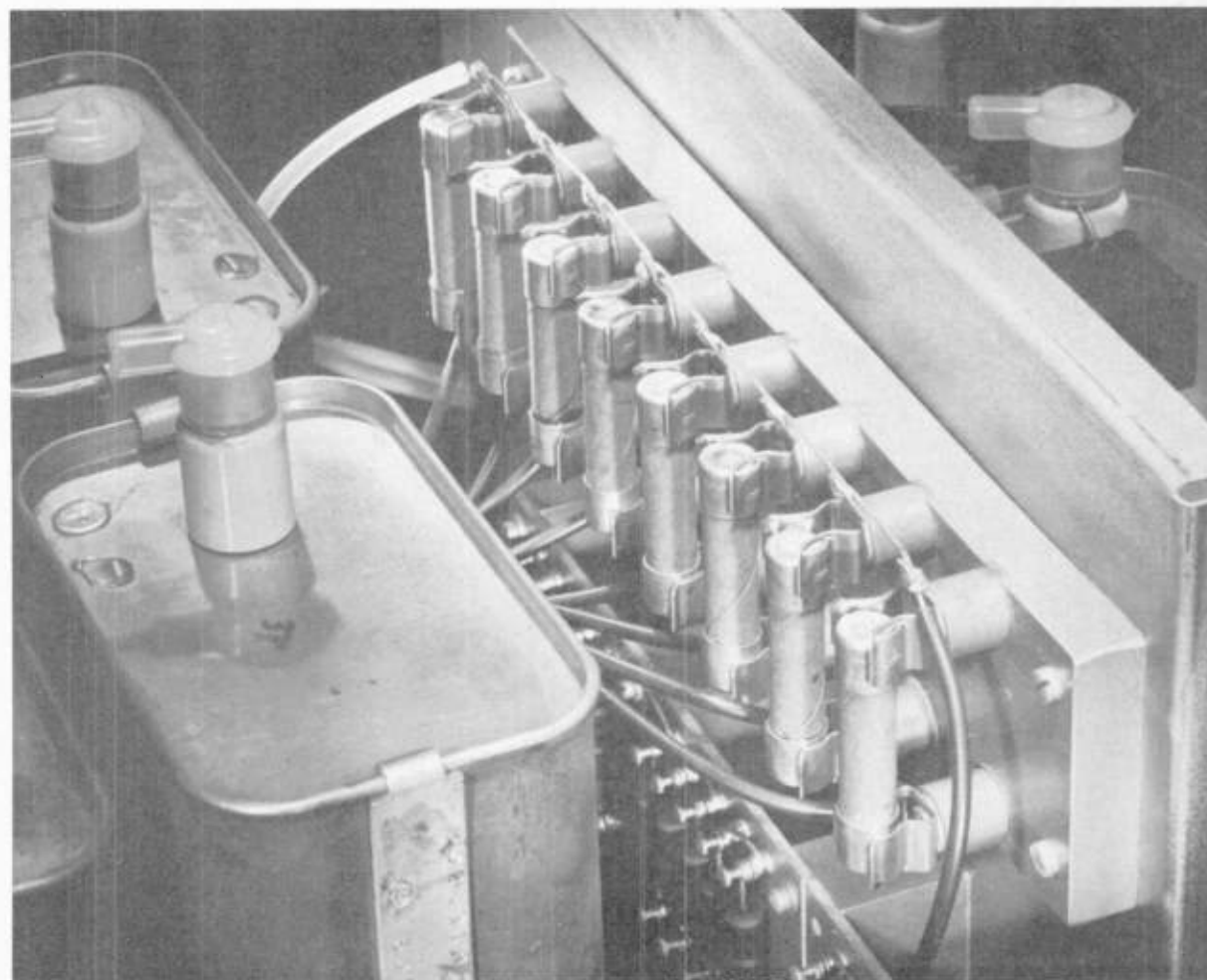
$$W_f(\text{Energy}) = \int_0^\infty i^2 R dt = R \int_0^\infty \left( \frac{E}{R} e^{-t/RC} \right)^2 dt \quad (8)$$



1. Typical circuit illustrates some of the possible current conditions that a fuse has to handle in addition to high voltage. Fuses 2 and 4 are subjected to charging transients and to the normal dc charging currents with ripple. Fuses 1 and 3 carry pulse and pulse-train currents.

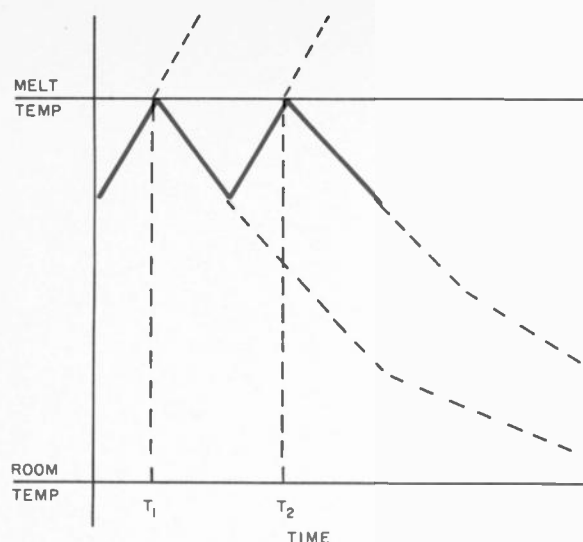


2. Charge-cycle rating is needed in this simple circuit. The fuse must pass the initial charging transient but must open quickly if the capacitor fails.

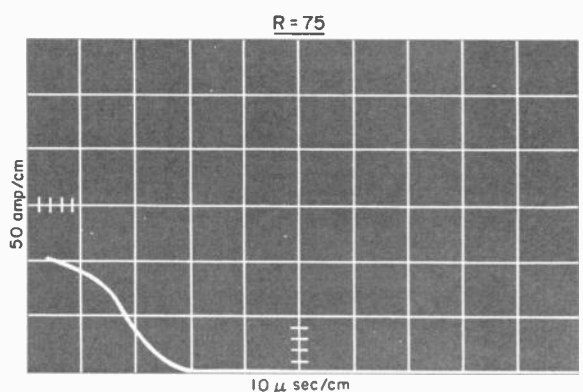
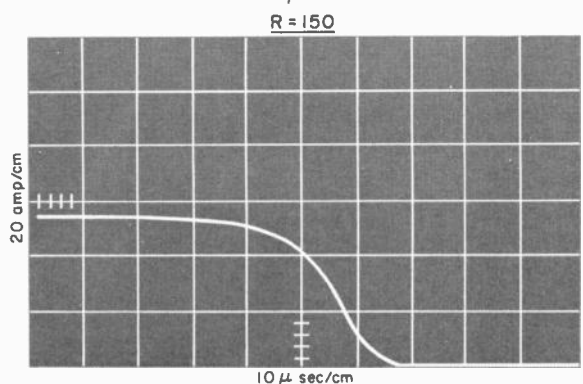
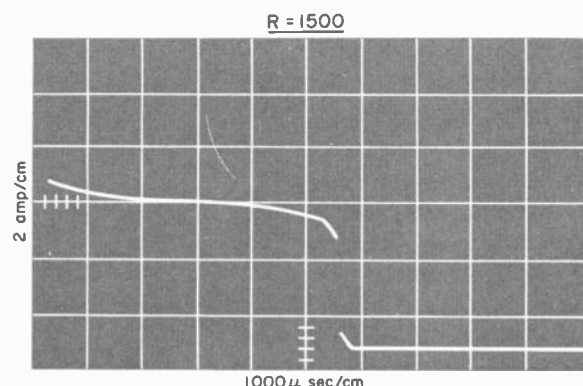


Typical use of fuses is the protection of transmitting tubes in phased arrays.





3. Thermal cycling of a fuse subjected to pulse trains. The period between pulses is not long compared to the thermal time constant of the wire. Note that the fuse operates very near to its melting temperature.



4. Test results with a special, small high-voltage fuse show a dc instantaneous burnout current of about 16 amps at 7.5 Kv. When the current is increased slowly, the fuse will blow at 1.6 amps.

$$W_t = \frac{E^2 CR_1}{2R} = \frac{E^2 Cr}{2RD^2}$$

$$\left(R_1 = \frac{r}{D^2}\right)$$

If a safety factor is included to ensure that the fuse does not blow during normal charging operation, then:

$$\frac{S_1 E^2 Cr}{2RD^2} = dC_p T_f D^2, \quad (9)$$

where  $S_1$  is a safety factor.

The other condition is that the fuse should blow when the capacitor fails. In that case the current will become:

$$I_f = \frac{E}{R}. \quad (10)$$

Another safety factor is needed to ensure that the fuse will blow:

$$I_f = \frac{E}{R} = S_2 K_1 D^{1.5}. \quad (11)$$

Note that this equation is very similar to Eq. 1, except for the safety factor.

The elimination of  $R$  between Eqs. 9 and 11 results in:

$$D^{2.5} = \frac{S_1 S_2 E C K_1 r}{2(dC_p T_f)} = \frac{S_1 S_2 E C K_1}{2K_2}. \quad (12)$$

After calculating  $D$ , resistance  $R$  can be determined easily.

The safety factors,  $S_1$  and  $S_2$ , are necessary to allow for fuse and circuit variations. Typically, a value of 2 might be used for each factor.

Under these conditions:

$$D^{2.5} = \frac{2 C E K_1}{K_2},$$

where  $K_1$  accounts for environmental effects and  $K_2$  for the specific wire and its temperature dependence.

#### Pulse-train: between dc and pulsed

When the pulse length is neither short nor the cooling period long, compared to a thermal time constant, a fuse rating must be developed which will predict the fuse operation under intermediate conditions. The thermal cycle can be represented as in Fig. 3.

The derivation of the necessary formula is rather long and complex. We feel that it is not essential in the application. It is sufficient to say that the analysis is based upon an approach similar to the one detailed above; that is, a consideration of energies during the pulses and between pulses.

The pulse current and the dc current are related by this equation:

$$\frac{I_p^2}{I_{dc}^2} = \frac{1 - \exp\{-K_1^2/[(prf)DK_2]\}}{1 - \exp\{-\delta K_1^2/[(prf)DK_2]\}}, \quad (13)$$

where:

$\delta$  = pulse duty cycle,

$prf$  = pulse repetition frequency,

$K_1$  and  $K_2$  = constants defined above.

#### High voltage needs special design

In many systems, currents are not the only problem. Protection from high voltage is the other major concern, especially in systems where several devices are supplied from the same high voltage source. For instance, in phased-array radars, several thousand transmitter tubes are connected to the same high-voltage source. Each individual tube must be protected by a fast, small and economical high-voltage fuse.

The size of high-voltage fuses increases roughly in proportion to the rated voltage, so devising a small fuse is really a problem in cases like this. The longer length is needed to extinguish the internal arc which always follows the opening of the fuse.

We have worked out a technique that reduces the size considerably. It consists of using exothermic wire in the fuse to effect a rapid gap increase and of potting the wire in an epoxy compound. The epoxy eliminates arcing; hence, there is no high current through the fuse and the equipment is protected.

#### Tests validate formulas

Fuses have been built and tested that have a current rating of up to 1 amp rms and a dc-voltage rating of 10 Kv per inch.

The various constants mentioned here have been determined for one type of wire (Pyrofuze Hi-R from Sigmund Cohn Corp., Mt. Vernon, N. Y.).

$K_1$  is approximately 0.7 in epoxy potting, but experimental results match Eq. 1 better if the exponent is changed to 1.2.

Thus:

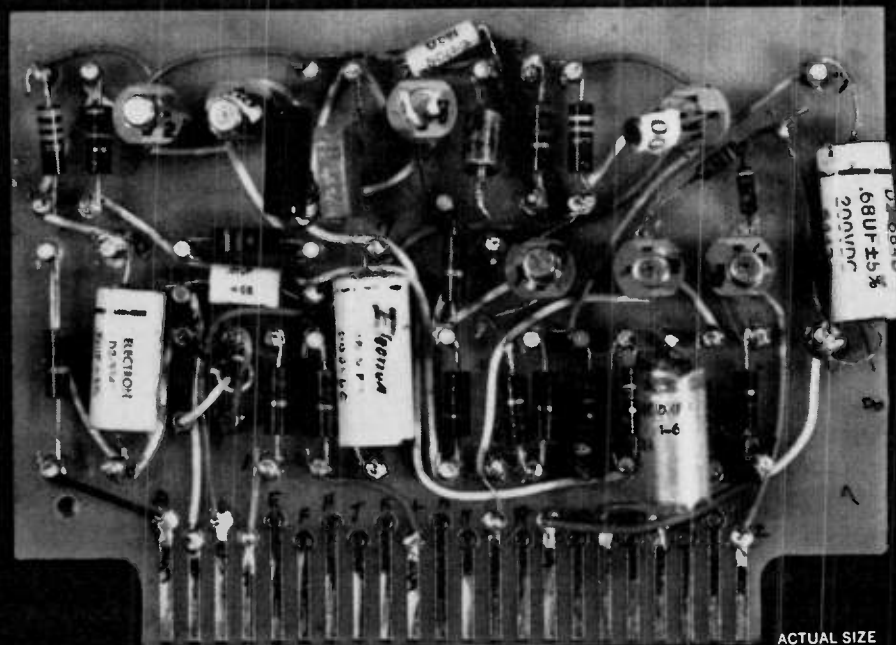
$I_d = 0.7 D^{1.2}$ , where  $D$  is the diameter of the wire in thousandths of an inch.  $K_2$  is approximately 0.005 for single pulses. Therefore, from Eq. 6:

$$I_p^2 \Delta t = 0.005 D^4.$$

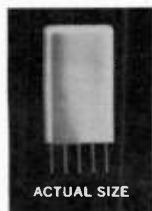
Fig. 4 shows some typical experimental results of dc tests at 7.5 Kv. These fuses were constructed of 2-mil wire and had a dc-burnout current of about 1.6 amps. ■ ■

#### Reference

1. W. H. Preece, "On the Heating Effect of Electric Currents," *Proceedings of the Royal Society*, April, 1884, Dec., 1887, and April, 1888.



What made this DC amplifier circuit obsolete?



## Advanced Microcircuit Packaging

The use of Hamilton Standard microcircuit modules has reduced the size and weight of temperature controls in the Navy's advanced Ling-Temco-Vought A7A light attack aircraft. They function as DC amplifiers in two identical controls for the cabin and pilot's vent suit.

Each module replaces a multi-component  $3\frac{1}{2}$  x

$4\frac{1}{2}$ -inch circuit board, resulting in a 96% weight and volume reduction. Design, production and testing are greatly simplified. Reliability is improved by electron-beam welding of interconnections within the module, and complete hermetic sealing.

Hamilton Standard's design team is experienced in custom circuit packaging and will assist circuit

designers in component selection and circuit layout.

This technology allows flexibility in interconnecting and packaging both uncased integrated circuits and semi-conductors for both digital and linear applications. For complete information, write to Marketing Manager, Electronics Department, Hamilton Standard, Broad Brook, Conn. 06016.

**Hamilton Standard** DIVISION OF UNITED AIRCRAFT CORPORATION

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NO READER-SERVICE CARD CIRCLE 22

December 6, 1965



## Find comb-filter frequencies fast

**T**HE DESIGN of filter arrays, or comb filters, involves time-consuming and repetitive calculations to find the center frequency of each channel or the number of channels needed. This simple nomograph can give the right answers quickly.

Comb filters are used to separate a composite input signal into a number of channels before data processing in telemetry systems and radars.

The spacing between channels may be expressed as a frequency ratio, which depends on the number of channels needed to cover one octave, or  $n$ . In equation form:

$$\frac{f}{f_c} = 2^n, \quad (1)$$

where  $f_c$  is the reference frequency,  $f$  is the unknown frequency of the adjacent channel and  $n$  is any positive or negative real number. For  $n = \pm 1$ ,  $f = 2f_c$ , and  $f = 1/2 f_c$ . These values are the center frequencies of channels, one octave away from the reference frequency.

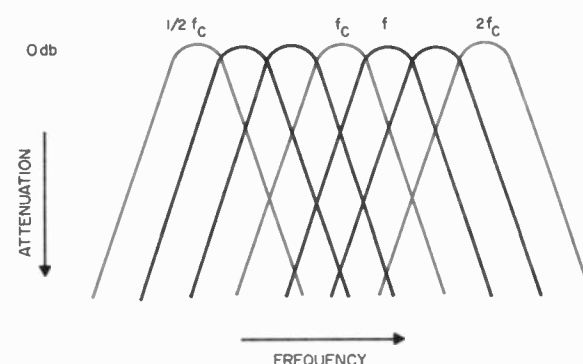
The nomograph evaluates Eq. 1 for positive or negative fractional values of  $n$ . The frequency scales,  $f_c$  and  $f$ , are normalized so that the nomograph can be used for any frequency range by shifting the decimal point. The ratio scale,  $n$ , has a decimal range as well as fractional values.

To use the nomograph, place a straight-edge from the octave fraction or decimal on the  $n$  scale to the reference frequency on the  $f_c$  scale. Read the center frequency of the next channel on the  $f$  scale. Hold the  $n$ -scale value as a pivot point and shift the straight-edge to the same frequency on the  $f_c$  scale as the first answer. Read the next bandpass center frequency on the  $f$  scale. Continue the process until all center frequencies are obtained. For negative  $n$  values, divide the reference frequency by two to obtain the lower octave. After this step, proceed as for

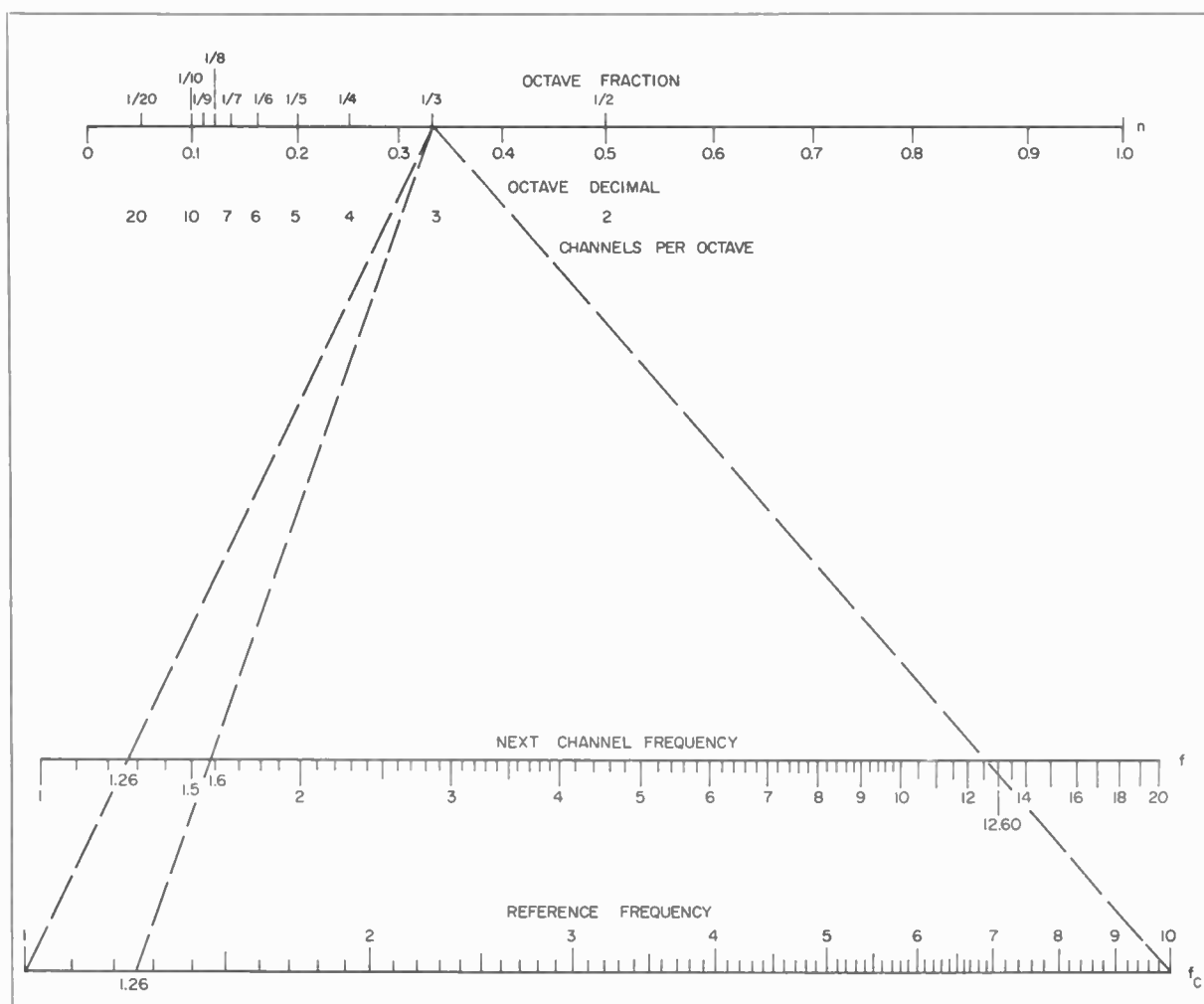
a positive  $n$  value.

**Example:** Calculate the center frequencies for 1/3 octave filters, starting at 100 cps (see illustration).

Set the straight-edge from 1/3 or 0.33 on the  $n$  scale to the one (for 100 cps) on the  $f_c$  scale and read 1.26 on the  $f$  scale; the center frequency of the next channel bandpass filter is 126 cps. Pivot at 1/3 on the  $n$  scale and shift the straight-edge to 126 on the  $f_c$  scale. Read 160 cps on the  $f$  scale. When 1260 cps on the  $f$  scale and 1000 cps on  $f_c$  is reached, shift back to the lower portion of the  $f_c$  scale and continue. ■ ■



Bandpass filter array shown requires three channels to cover one octave. Therefore  $n = 1/3$ .



Joseph F. Sodaro  
T T Electronics, Inc.  
Culver City, Calif.

# Lambda adds 42 new models...

## 2 VDC and up silicon modular power supplies

### ...low-cost overvoltage protection

#### New

42 power supplies designed for integrated circuit and other fixed voltage applications—maximum amps per cu. in. . . . maximum amps per dollar

#### New

Adjustable crowbar type overvoltage protection accessory—\$25

- Designed for continuous operation—no external fuse required
- Temperature coefficient—.05%/°C
- Mounting provisions provided—2-terminal connection

Model	Adj. Volt. Range	Size: H x W x D	Price
LMOV-1	3-8 v	1 1/4" x 3 3/8" x 5/8"	\$25.
LMOV-2	6-20 v	1 1/4" x 3 3/8" x 5/8"	\$25.
LMOV-3	18-70 v	1 1/4" x 3 3/8" x 5/8"	\$25.
For use with all LM Series power supplies			

#### New

Higher ratings with forced air cooling  
Ventilated construction affords substantial increases in rating with small amounts of air flowing over surfaces of power supply.

**Example:** LM 217 is rated at 2.1 amps at 71°C ambient with 200 linear ft./min.; at 60°C ambient with 100 linear ft./min.



### LM Series . . . Data and Features

A-C Input—105-132 VAC  
45-440 CPS

Reg. Line—.05% + 4 MV  
Load—.03% + 3 MV

Ripple—1 MV rms—3 MV  
peak-to-peak

Temp. Coef.—.03%/°C

• Meet Mil. Environment Specs.

RFI—MIL-I-16910

Vibration: MIL-T-4807A

Shock: MIL-E-4907A • Proc 1 & 2

Humidity: MIL-STD-810 • Meth.

507

Temp. Shock: MIL-E-5272C •

(ASG) Proc. 1

Altitude: MIL-E-4970A • (ASG)

Proc. 1

Marking: MIL-STD-130

Quality: MIL-Q-9858

• Convection cooled—no heat sinking or forced air required


• Thermally Protected and Short Circuit Proof—Current Limiting

• Remote Programming

• Mount 3 ways on chassis or in rack

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### Multi-Position-Rated™ and Multi-Current-Rated™ for 40°, 50°, 60° and 71°C Ambients

 <b>Package A</b> 3 3/16" x 3 3/4" x 6 1/2"						
Model	VDC	I MAX. AMPS <sup>1</sup>				Price
		40°C	50°C	60°C	71°C	
LM 201	0-7	0.85	0.75	0.70	0.55	\$ 79
LM 202	0-7	1.7	1.5	1.4	1.1	99
LM 203	0-14	0.45	0.40	0.38	0.28	79
LM 204	0-14	0.90	0.80	0.75	0.55	99
LM 205	0-32	0.25	0.23	0.20	0.15	79
LM 206	0-32	0.50	0.45	0.40	0.30	99
LM 207	0-60	0.13	0.12	0.11	0.08	89
LM 208	0-60	0.25	0.23	0.21	0.16	109


#### RACK ADAPTERS

**LRA 6—5 1/4" Hgt. by 14 1/8" Depth**  
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**LRA 3—5 1/4" Hgt. by 3" Depth**  
Price—\$35.00

**LRA 4—3 1/2" Hgt. by 14 1/8" Depth**  
[for use with chassis slides]  
Price—\$55.00


**LRA 5—3 1/2" Hgt. by 3" Depth**  
Price—\$35.00


 <b>Package B</b> 3 3/16" x 4 15/16" x 6 1/2"						
Model	VDC	I MAX. AMPS <sup>1</sup>				Price
		40°C	50°C	60°C	71°C	
LM 217	8.5-14	2.1	1.9	1.7	1.3	\$119
LM 218	13-23	1.5	1.3	1.2	1.0	119
LM 219	22-32	1.2	1.1	1.0	0.80	119
LM 220	30-60	0.70	0.65	0.60	0.45	129
LM B2	2 ±5%	3.4	3.0	2.3	1.4	119
LM B3	3 ±5%	3.4	3.0	2.3	1.4	119
LM B4	4 ±5%	3.4	3.0	2.3	1.4	119
LM B4P5	4.5±5%	3.3	2.9	2.2	1.4	119
LM B5	5.0±5%	3.3	2.9	2.2	1.4	119
LM B6	6.0±5%	3.2	2.8	2.2	1.3	119
LM B8	8.0±5%	3.0	2.7	2.2	1.3	119
LM B9	9.0±5%	2.7	2.5	2.1	1.3	119
LM B10	10.0±5%	2.6	2.4	2.1	1.3	119
LM B12	12.0±5%	2.4	2.3	2.1	1.3	119
LM B15	15.0±5%	2.1	1.9	1.7	1.2	119
LM B18	18.0±5%	1.8	1.6	1.5	1.2	119

■ All models in grey are new.

<sup>1</sup> Current rating is from zero to 1 max.

Current rating applies over entire output voltage range. Current rating applies for input voltage 105-132 VAC 55-65 cps. For operation at 45-55 cps and 360-440 cps derate current rating 10%.

 <b>Package C</b> 3 3/16" x 4 15/16" x 9 3/8"						
Model	VDC	I MAX. AMPS <sup>1</sup>				Price
		40°C	50°C	60°C	71°C	
LM 225	0-7	4.0	3.6	3.0	2.4	\$139
LM 226	8.5-14	3.3	3.0	2.5	2.0	139
LM 227	13-23	2.3	2.1	1.7	1.4	139
LM 228	22-32	2.0	1.8	1.5	1.2	139
LM 229	30-60	1.1	1.0	0.80	0.60	149
LM C2	2 ±5%	4.9	4.2	3.5	2.4	139
LM C3	3 ±5%	4.9	4.2	3.5	2.4	139
LM C4	4 ±5%	4.9	4.2	3.5	2.4	139
LM C4P5	4.5±5%	4.9	4.2	3.4	2.4	139
LM C5	5 ±5%	4.8	4.1	3.3	2.4	139
LM C6	6 ±5%	4.6	4.0	3.1	2.4	139
LM C8	8 ±5%	4.4	3.8	3.0	2.0	139
LM C9	9 ±5%	4.2	3.6	3.0	2.0	139
LM C10	10 ±5%	4.0	3.5	2.9	2.0	139
LM C12	12 ±5%	3.8	3.3	2.8	2.0	139
LM C15	15 ±5%	3.4	3.2	2.7	1.8	139
LM C18	18 ±5%	3.0	2.8	2.5	1.7	139
LM C20	20 ±5%	2.9	2.7	2.4	1.7	139
LM C24	24 ±5%	2.5	2.4	2.2	1.5	139
LM C28	28 ±5%	2.3	2.1	2.0	1.4	139

 <b>Package D</b> 4 15/16" x 7 3/4" x 9 3/8"						
Model	VDC	I MAX. AMPS <sup>1</sup>				Price
		40°C	50°C	60°C	71°C	
LM 234	0-7	8.3	7.3	6.5	5.5	\$199
LM 235	8.5-14	7.7	6.8	6.0	4.8	199
LM 236	13-23	5.8	5.1	4.5	3.6	209
LM 237	22-32	5.0	4.4	3.9	3.1	219
LM 238	30-60	2.6	2.3	2.0	1.6	239
LM D2	2 ±5%	13.1	11.3	9.2	6.2	199
LM D3	3 ±5%	13.1	11.3	9.2	6.2	199
LM D4	4 ±5%	13.1	11.3	9.2	6.2	199
LM D4P5	4.5±5%	13.1	11.3	9.2	6.2	199
LM D5	5 ±5%	12.6	10.8	9.2	6.1	199
LM D6	6 ±5%	12.4	10.6	8.9	6.0	199
LM D8	8 ±5%	12.2	10.3	8.8	5.9	199
LM D9	9 ±5%	11.3	10.0	8.6	5.7	199
LM D10	10 ±5%	10.8	9.7	8.5	5.7	199
LM D12	12 ±5%	10.0	9.2	8.3	5.7	199
LM D15	15 ±5%	9.0	8.4	7.9	5.3	209
LM D18	18 ±5%	7.9	7.4	6.9	5.0	209
LM D20	20 ±5%	7.4	6.9	6.5	4.9	209
LM D24	24 ±5%	6.7	6.3	5.8	4.8	219
LM D28	28 ±5%	6.0	5.6	5.2	4.7	219



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# Can you put your ideas across?

The most common—often the most important—task we all have is to communicate our ideas to others. It can be done effectively with four keys to persuasion.

**A**S AN ENGINEER, you are constantly trying to convey your ideas to others. Much of your day is spent in explaining, describing, persuading, answering—in other words, trying to put your ideas across to others. The effective use of this skill can mean the difference between success and failure of many a project.

If you learn to put your ideas across effectively, you will:

- Get things done, because others will understand what you want the first time.
- Save time by avoiding errors, misunderstandings and needless backtracking.
- Win cooperation from people by successfully “selling” them on your ideas.
- Become a clearer thinker, because you will be forced to organize your ideas better in order to present them effectively to others.

Here is a simple four-point program for

putting across your ideas . . . every time.

### Know what you want to say

Many people are poor communicators simply because they do not first make an effort to get their ideas clear in their own minds. They have a vague or fuzzy shadow of an idea and then are surprised when they fail to get it across to others.

Fortunately, there is a virtually foolproof way to pretest an idea for clarity: Try writing it out.

There isn't an idea in the world that can't be expressed on paper. If it can't be written out, it isn't a completely developed idea. The very act of finding the appropriate words with which to express the idea compels you to think it through.

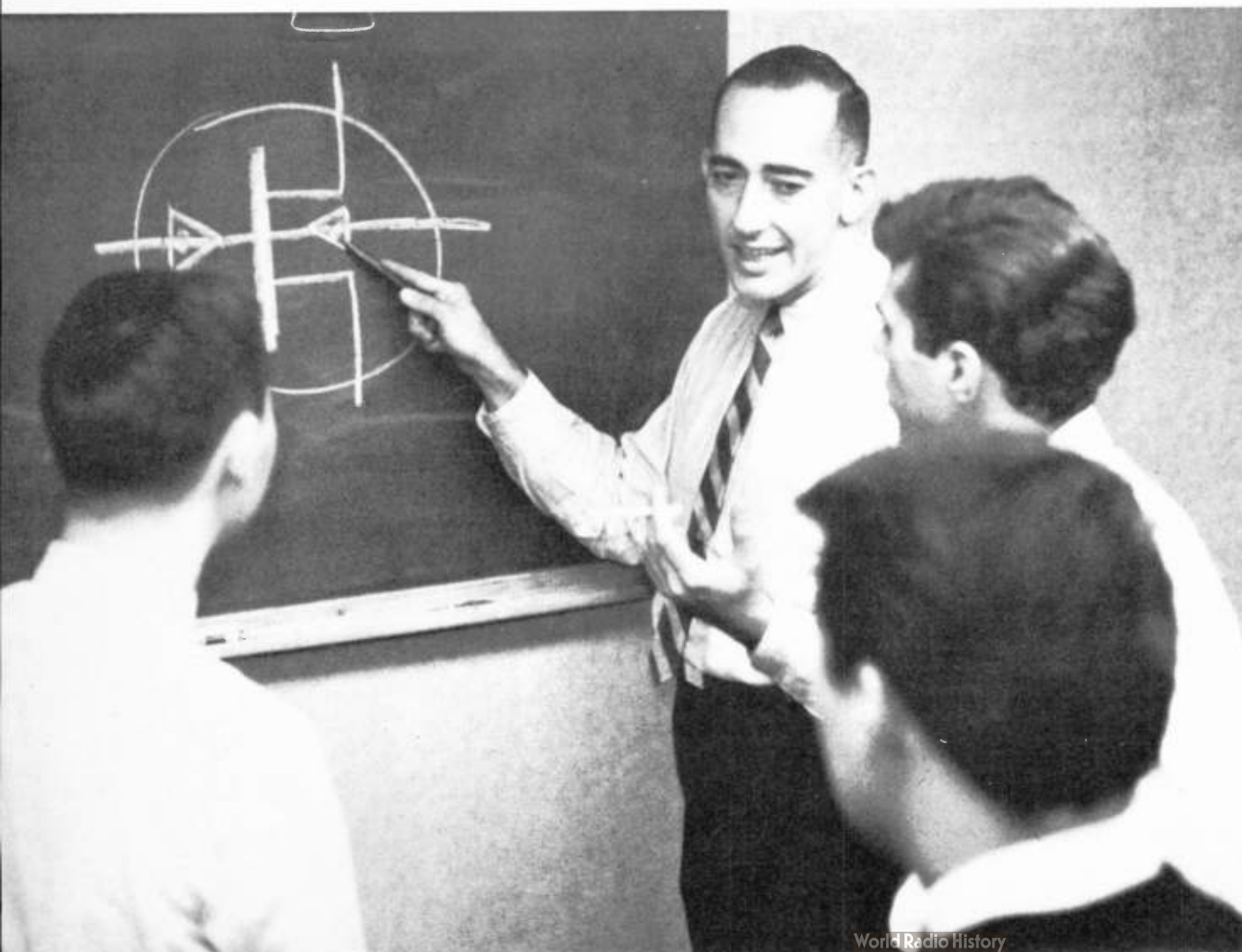
### Know how to say it

Let's say you know what you want to say. Now you want to communicate it. How do you do this without distorting the message?

**Talk the other fellow's language.** Every field from advertising to zoology has developed its own special vocabulary. No matter how we earn our living, we talk a special language on the job. Those with whom we work readily understand what we have to say. But others—even those in the same company—often don't.

Engineers in particular tend to forget this when dealing with people not well versed in their discipline. For example, to tell a mechanical engineer that a circuit requires “fast” diodes might convey the idea that the diodes in the circuit have to be firmly in place. What should be said is that the circuit requires diodes having a very short switching time.

**Ted Pollock**  
Consultant



Unless you know that your audience understands the jargon of your profession, it's best to keep your message simple and in commonly understood terms.

**Be concrete.** It's always easier to visualize specific things than abstractions, and solid facts than vague generalities. Therefore, be specific whenever you have an idea to put across. For example:

Don't say, "In a few weeks." Say, "In three weeks."

Don't say, "Delay can be costly." Say, "Delay will cost us \$520."

Don't say, "I heard that . . ." Say, "Jack Brewster told me."

**Be a showman.** When Joseph E. Levine, the movie mogul, first launched his career with the release of the film *Hercules*, he wanted to impress the public with the fact that he was spending a million dollars to promote it.

Mr. Levine could have issued a publicity release to announce the fact. But he didn't. He could have held a press conference and made the announcement there. But he didn't. Instead, he hosted a formal party for the press at one of New York's finest hotels. There, on a table, protected by armed guards, lay \$1 million in cash, for all to see. The party made headlines, of course—the kind of advertising that mere money could never buy. He got his message across—with a bang.

You will, too, if you take the trouble to dramatize your message. How? By appealing to more than one of your audience's senses. Tell them your idea, by all means, but don't stop there. Demonstrate it. Draw a picture. Show a graph. Point to a model. Dramatize what might occur if the idea isn't accepted.

**Use your voice.** Read the following seven sentences aloud, emphasizing in each case the word indicated. The meanings given by your local inflections are included parenthetically.

I didn't tell John you were stupid. (Someone else told him.)

I *didn't* tell John you were stupid. (I'm keeping the fact a secret.)

I didn't *tell* John you were stupid. (I only hinted at it.)

I didn't tell *John* you were stupid. (I told everyone but John.)

I didn't tell John *you* were stupid. (I said that someone around here was stupid. John must have figured out it was you by himself.)

I didn't tell John you *were* stupid. (I told him you still *are* stupid.)

I didn't tell John you were *stupid*. (I merely voiced my conviction that you weren't very smart.)

Quite a difference in implied meanings,

isn't there? And what is true of this simple sentence is true of almost anything else we say. How we voice our thoughts can make the difference between getting an idea across and disaster.

If your message is intended to whip up enthusiasm, inject enthusiasm into your voice. If you wish to stress the importance of what you are saying, "put italics" under your words. Monotony breeds boredom, so use vocal ups and downs to keep your listener attentive.

### Then highlight the benefits

To a large extent we are all self-centered. That's not a criticism—merely a fact. From time to time, especially in crises, we can overcome this human trait and sacrifice our own interests for others, but most of the time we are inescapably self-oriented. We respond more animatedly to those things that affect our comfort, happiness, safety and finances.

Take advantage of this fact in your communications. Whenever possible, phrase your message in "what's-in-it-for-me" terms, for that is the unspoken question uppermost in your listener's mind. Don't ask a man to accept your idea for what it is: Ask him to accept it for what it will *do* for him.

Want your supervisor to okay a new oscilloscope? Don't describe the operation of a slick new gadget. Do explain how it will eliminate errors, reduce costs, etc.

Want a technician to use his safety equipment? Don't tell him what an injured worker costs the company. Do explain the injuries he may sustain if he continues his neglect.

Take the very next idea you have, and, bearing in mind who your listener will be, express it in terms of the benefits he stands to gain from it.

### But don't oversell

Although a judicious amount of enthusiasm can be contagious and help put your idea across, don't start bragging: "This is the greatest idea you've ever heard."

By overestimating the advantages of your brainstorm, you may inadvertently sour your listener on your notion even before he's heard you out. He may think, "Okay, big shot—I dare you to convince me." There is also the possibility that your idea is not perfect. You'll feel very foolish if, after listening to you, the other fellow immediately points out why it's a downright poor idea.

Further, should your idea prove only moderately successful, it may be considered a flop simply because it did not live up to your fantastic predictions. Any future ideas you

present will find tough sledding.

The word for you is: undersell.

### Anticipate the objections

Ideas are almost always suspect. People dislike having to change their views or actions. They much prefer to let things go along as they have, for the *status quo* is familiar and comfortable.

As the originator of an idea, you automatically become a threat to "things-as-they-are" as well as to the people who are committed to them. Naturally, their reaction to your idea is one of suspicion. Sometimes, this suspicion takes the form of lack of attention to what you are saying. Sometimes, it manifests itself in heated argument. Most often it assumes the guise of objections. Your idea is "impractical" . . . "risky" . . . "harebrained" . . . "It can't possibly work."

Of course, these objections may not necessarily be rationalizations. They may be valid. No matter which, you can largely neutralize them by anticipating them. How? By carefully examining the idea for flaws beforehand.

Does it require too much money? Time? Personnel? Does it depend upon any unproved assumptions? Has something similar to it failed in the past? Is there any good reason why it shouldn't work?

By asking and answering pointed questions like these *before* you make your idea public, you can probe it for weaknesses and modify it accordingly. For example:

"Even though the initial cost will be \$1500 more than we budgeted for such a job, these figures prove that we'll save more in the long run."

"It's the easiest machine of its kind to operate and turns out more copies per minute than any other on the market, even though it is a little larger than most."

"True, we won't see any profit from the new operation for three or four years, but by 1970, when it's in full swing, it will be responsible for 30% of our production and 35% of our profit."

By bringing up the objection to your idea yourself—and disposing of it convincingly—you disarm your listener with reasons for ignoring or discounting the reservations that would normally occur to him.

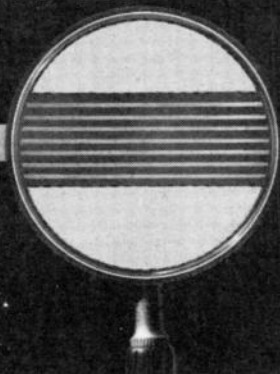
There you have them—four easy rules for communicating effectively: Know what you want to say, know how to say it, then highlight the benefits and anticipate the objections. The next time you are trying to instruct, persuade or sell someone, try these techniques and you will be sure to put your ideas across. ■ ■



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Nortronics has pioneered the development of a new track system to double the storage on 1/4-inch tape. When maximum storage capacity is required—on tape-cartridge or reel-to-reel players—check the new 2-channel, 8-track Nortronics heads! Widely used in automotive and home background music players.

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- Special close fitting mu-metal cases provide outstanding shielding against external magnetic fields.
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- Highly polished all-metal faces, greatly reduce oxide build up.

These new advanced-design heads, available now, are another result of the "engineering-in-depth" policy that has made Nortronics the world's largest manufacturer of laminated tape heads.

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ON READER-SERVICE CARD CIRCLE 23

## NASA TECH BRIEFS

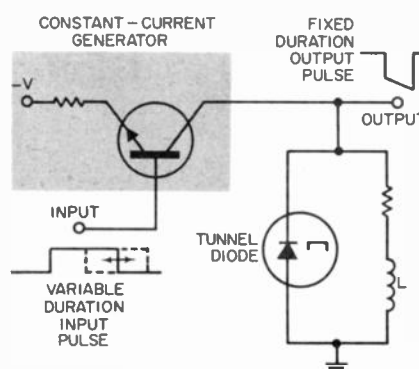


### TD regulates pulse width

**Problem:** Generate an output pulse of fixed duration from an input pulse that ranges from 50 to several hundred nanosec.

**Solution:** A tunnel diode circuit. The diode is in parallel with an inductance and driven by a constant current generator.

The input pulse allows a current to flow through the parallel network. The initial high impedance of the inductor forces the entire current through the tun-



nel diode. This current is greater than the peak current of the diode, causing it to switch to its high-voltage state. The current through the inductor increases with time and the tunnel diode current and voltage decreases. At the valley point of the tunnel diode, the diode will switch to its low-voltage state. Because the inductor now has a low impedance, the output voltage will be zero for the duration of the input pulse.

The pulse-width can be controlled by varying the inductor.

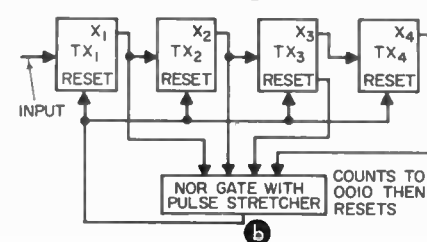
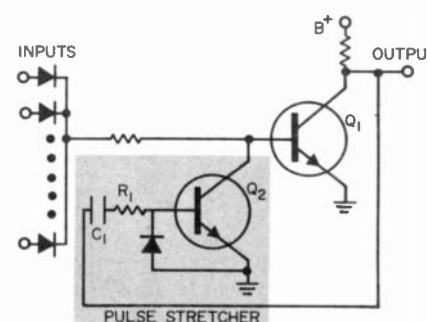
For further information, contact:  
Technology Utilization Officer  
Goddard Space Flight Center  
Greenbelt, Maryland 20771  
Reference: B64-10150

### NOR gate

**Problem:** Provide an output pulse of some predetermined duration.

**Solution:** A pulse-stretcher combined with a NOR gate (a).

With all the inputs at ground, the output is positive. Current



flows through  $C_1$  and  $R_1$  into the base of  $Q_2$ , turning it on until  $C_1$  is charged (approximately 3 times the  $R_1C_1$  time-constant). If the inputs become positive while  $Q_2$  is still conducting,  $Q_1$  will not be affected since its base is being held at ground potential by  $Q_2$ . When  $Q_2$  stops conducting, the inputs regain control of the output.

The binary counter must be reset to zero when a certain preselected count has been reached (b). The NOR gate detects the preselected state and produces a pulse that the pulse stretcher maintains for a period long enough to reset all stages.

For further information, contact:  
Technology Utilization Officer  
Goddard Space Flight Center  
Greenbelt, Maryland 20771  
Reference: B65-10228

## Feedback reduces ADC error

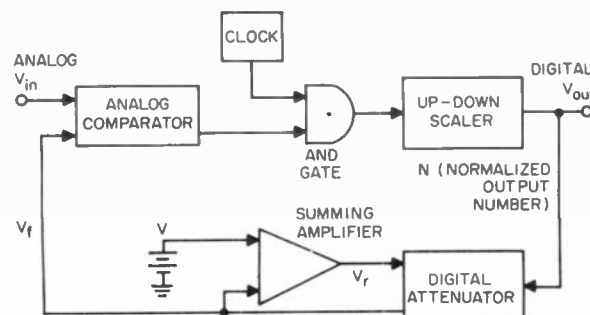
**Problem:** Design a simple, accurate analog-to-digital converter, ADC, that exhibits minimum error characteristics and has no inherent quantization error.

**Solution:** A nonlinear analog-to-digital converter that measures the level of an analog input and continuously adjusts the scale sensitivity of the digital readout to attain an effective increase in accuracy. As the output level decreases the scale sensitivity increases.

An accurate nonlinearity, consisting of the summing amplifier, reference voltage, and digital attenuator, is placed in the conventional feedback path. These elements are capable of a high degree of accuracy.

The analog voltage to be sampled is fed into the analog comparator, which produces an output if there is any difference between  $V_{in}$  and  $V_f$  (the feedback voltage). Any output from the comparator turns the AND gate on and allows the clock signal to be fed to the up-down scaler. The up-down scaler produces the digital output in the form of an output number.

The feedback voltage,  $V_f$ , is proportional to the product of the reference voltage,  $V_r$ ,



and the normalized digital output  $N$ , where  $N$  is the ratio of the output number to the number which represents full scale. The summing amplifier adds the fixed voltage,  $V_r$ , to the feedback voltage and passes the summed voltages,  $V_f$ , to the digital attenuator. The attenuator modifies  $V_f$  by  $N$ , producing a feedback voltage which is a function of itself, a fixed voltage, and the normalized output number.

The error characteristics for this nonlinear digital system are superior to those of linear systems. Error expressed in percent of reading is more nearly constant and extension of scale length is possible.

The system produces attractive error profiles and can be implemented with only one component (a floating power supply or a summing amplifier) added to a conventional analog-to-digital converter.

WHATEVER YOUR NEEDS MAY BE . . .

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Available copper clad or unclad.	Available copper clad or unclad.	Available copper clad or unclad.
Meets MIL-P-18177, type GEE & GEB; MIL-P-13949C, type GE, GB, GF, GH (copper clad).	Meets MIL-P-3115C, type PBE-P (natural color only); MIL-P-13949B, type PP (copper clad).	Meets MIL-P-3115C, type PBE-P (natural color only).
Meets property requirements of NEMA G-10, G-11, FR-4, FR-5.	Meets property requirements of NEMA FR-2.	Meets property requirements of NEMA XXXPC.
Insulation resistance: avg. value 1,000,000 megohms.	Insulation resistance: 500,000 megohms.	Insulation resistance: 500,000 megohms.
Flexural strength $\frac{1}{16}$ " length (flatwise): 75,000 psi.	Flexural strength $\frac{1}{16}$ " length (flatwise): 21,500 psi.	Flexural strength $\frac{1}{16}$ " length (flatwise): 15,000 psi.
Thickness: $\frac{1}{32}$ " to 1"	Thickness: $\frac{1}{32}$ " to 3"	Thickness: 0.015" to $\frac{1}{2}$ ".
Color: off white to light tan.	Color: natural.	Color: natural.
Finish: semi-gloss.	Finish: semi-gloss.	Finish: semi-gloss.
WRITE FOR DATA SHEETS WITH COMPLETE TECHNICAL DETAILS. SPECIFY GRADE.		



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ON READER-SERVICE CARD CIRCLE 28



# NEW

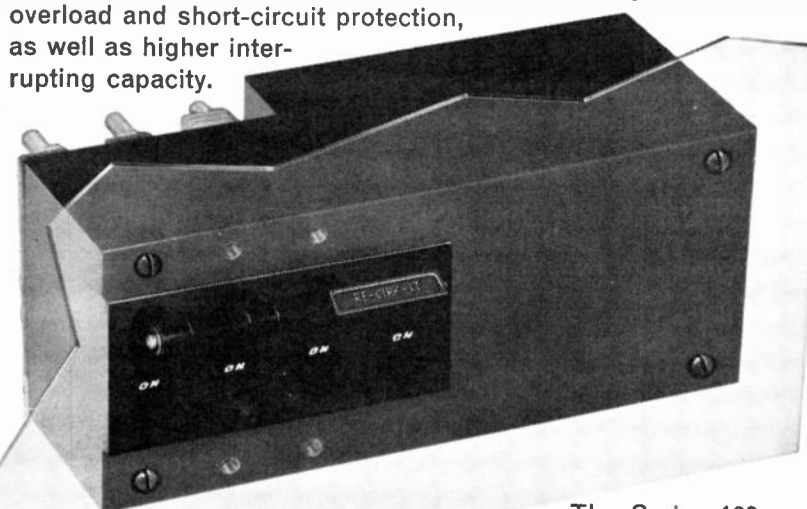
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In some applications, where frequent switching is not required, it might economically replace a contactor. And with the Heinemann remote-operated breaker, you also get built-in overload and short-circuit protection, as well as higher interrupting capacity.



The Series 100 package consists of a one-, two-, or three-pole AM12 Series circuit breaker assembled with an operator module. The operator is powered by a rugged electric-motor drive, which can be controlled by any type of SPDT maintained-contact switch.

The package is compact and easy to install. A three-pole model measures 6" x 2-1/2" x 3-5/16" deep. Panel mounting requires just one cutout, plus four mounting-screw holes. And only the breaker handles and handle boss extend in front of the panel.

The breaker itself is hydraulic-magnetic. It has no thermal tripping elements. Trip points and current-carrying capacity are temperature stable.

We offer the breakers in our remote-operated series with all of Heinemann's special internal circuit arrangements: relay-trip, shunt-trip, auxiliary switch, etc. A variety of control modes is therefore possible.

Bulletin 601 has complete details. Write for a copy.

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Speed Inquiry to Advertiser via Collect Night Letter  
ON READER-SERVICE CARD CIRCLE 29

SA-3033

## NASA TECH BRIEFS



Variation of the fixed voltage,  $V$ , or the value of full scale, produces variations in the error profile.

For further information, contact:  
Technology Utilization Officer  
Ames Research Center  
Moffett Field  
Mountain View, Calif 94035  
Reference: B65-10277

### Foam seals guide window

**Problem:** Devise some means to replace conventional thin dielectric windows in cryogenically cooled waveguides. These windows receive condensation from the atmosphere and require special venting and sealing techniques.

**Solution:** Waveguide windows made from foam plastic and sealed with foamed-in-place plastic.

A 1- to 2-inch section of the waveguide is filled with polystyrene preformed plastic. A 1/16-inch coating of a foaming plastic mixture is applied to the outside end as a seal. As an example of the efficiency of this method, a 2-inch 511U brass waveguide filled with polystyrene plastic and sealed with foamed-in-place plastic has an insertion loss of 0.020 db.

This method would be useful in a radar system employing low-noise input receivers.

Fabrication of this window requires no special tools.

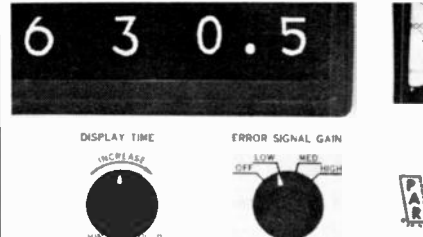
For further information contact:

Technology Utilization Officer  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, California 91103  
Reference: B63-10613

### Staircase waveform from low-power circuit

**Problem:** Generate a staircase waveform of high uniformity, low droop, and fast transition time using low input power and no feedback.

**Solution:** Transferring a charge from an input capacitor to an output capacitor in such a way that the transferred charge is independent of the state of charge of the output capacitor. Equal step increments are thereby achieved without feedback. The design is based on the fact that the collector current of a transistor is proportional to the current flowing in the emitter circuit and



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Price: \$3,950.00 (excluding probe.)  
Write for Bulletin #118.

\*Subject to operating range of actual sensor used.

\*\*Patent Pending

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ON READER-SERVICE CARD CIRCLE 30  
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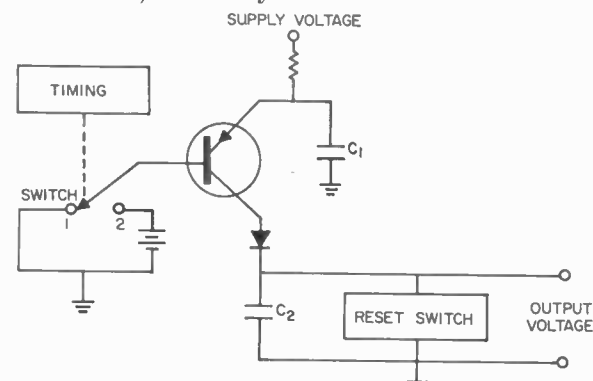
118 Shaw St., Hamilton, Ont. • Phone: JACKSON 9-7151

ON READER-SERVICE CARD CIRCLE 31

December 6, 1965

independent, over a substantial range, of collector voltage.

A capacitor  $C_1$  is added to the emitter circuit of a conventional gating stage as shown in the illustration. The resistor is large enough to make  $C_1$  the sole power source for the transistor. Since the energy stored in  $C_1$  is finite and discrete, the gate will remain open (conducting) during a timing pulse only as long as the emitter voltage remains greater than the base-emitter threshold. This RC circuit is designed, based on the low saturation resistance of the transistor, to decay within the duration of



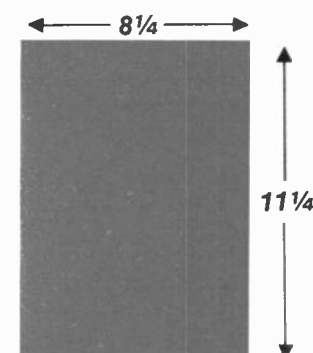
any reasonable timing pulse. The discharge of  $C_1$  results in a pulse of collector current that imposes a discrete charge on the output capacitor,  $C_2$ , and produces a corresponding step in the output voltage. The depletion of the charge on  $C_1$  results in a quiescent cutoff condition in the transistor. This condition continues through the termination of that timing pulse to the point in the following pulse at which  $C_1$  is again discharged. When the switch moves to position 2, the resulting rise in base voltage unclamps the emitter voltage that rises as  $C_1$  charges through the resistor toward the supply voltage. Since steady state is achieved well in advance of the next timing pulse, the amount of charge stored in  $C_1$  will be known and discrete. Thus the discrete increments made in the output voltage are independent of the number of the previous charging pulses and unaffected by variations in timing pulse frequency.

This circuit could be used to advantage in programming physical or biological experiments for display of a family of characteristics simultaneously on a CRT.

For further information, contact:

Technology Utilization Officer  
Goddard Space Flight Center  
Greenbelt, Maryland 20771  
Reference: B64-10007

# Electronic Design leaves the squares behind!



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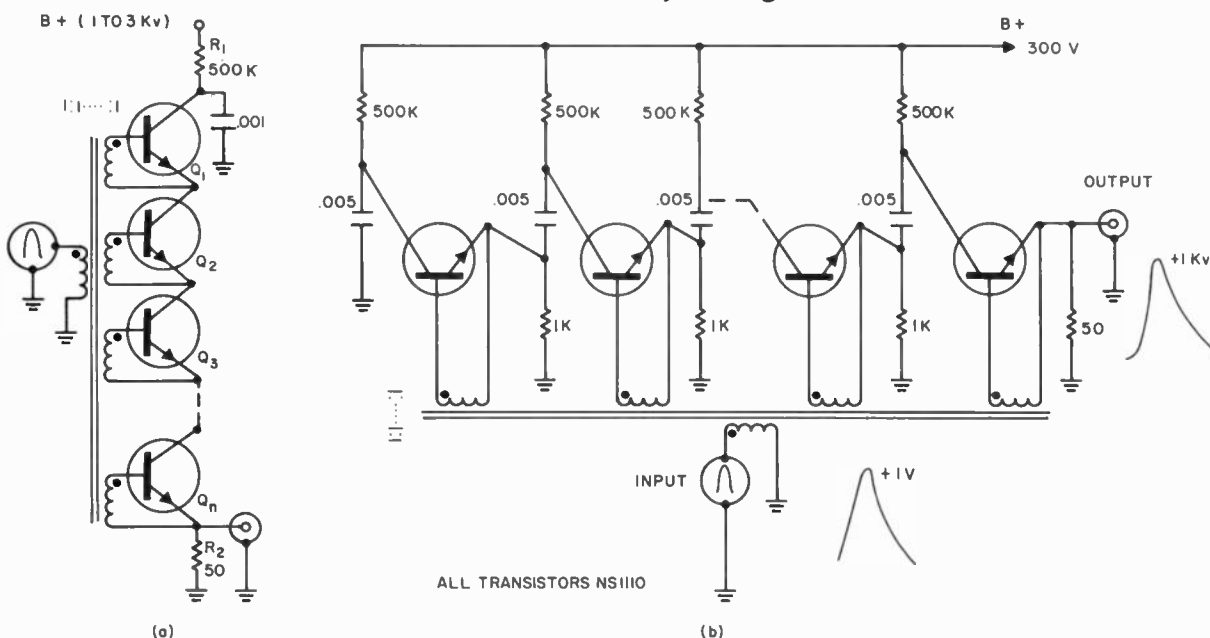
## Series-parallel connection produces high-level pulses

A modification of the standard series configuration of avalanche transistors results in higher yields for high-level-pulse output stages. In addition, the supply voltage level is considerably reduced. This, in turn, permits lower breakdown-voltage-rated transistor units to be used.

Avalanche transistors are conventionally stacked (Fig. 1a) to produce high-level pulses. The circuit requires the current through each transistor to be the same. This restriction aggravates one of the drawbacks of avalanche circuits; namely, low yield (the ratio of usable transistors to the total number procured).

The configuration in Fig. 1b lifts this restriction. Here, all the capacitors are charged in parallel. When the avalanche "switches" close, they discharge in series into the load.

Any number of stages can be added within the limits determined by the relative magnitudes of the load and source impedances.



1. Series-connected avalanche transistor circuit (a) produces a high-level output pulse, but suffers from low yield. A modified configuration (b) features parallel charging and series discharging and permits lower breakdown-voltage units to be used.

Triggering is accomplished by use of a pulse transformer with multiple secondaries, one for each base.

This circuit can produce a 1-Kv pulse across a 50-ohm load with only a 300-volt supply. With careful layout and low-inductance capacitors, the rise-time is 2 nsec. A load consisting of a small capacitance (10 pf or less), is commonly encountered when vacuum tubes or electron beams are to be controlled.

The load can be placed at either end of the circuit, so either polarity output can be achieved. Two circuits, one with a positive output and the other with a negative, can have their outputs mixed at the load. This produces a pulse with well-defined and well-timed rise and fall times.

*E. J. Snyder and A. Whetstone, Design Engineers, Science Accessories Corp., Southport, Conn.*

If this idea is valuable to you, give it a vote by circling Reader-Service number 110.

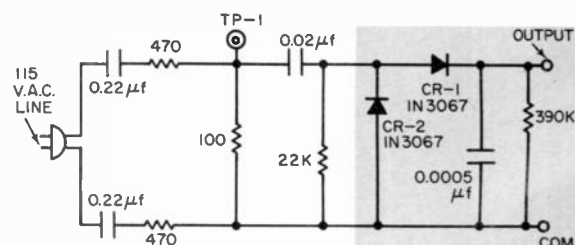
## Differentiator-divider network analyzes power-line transients

Transients and other signals present on power supply lines may be easily viewed on a CRO when a simple, inexpensive analyzing network is used. It uses only resistive, capacitive and diode elements that will even respond to fast, random transients. These transients typically have a very low duty cycle and may occur on either side of the line. Fast non-repetitive pulses provide a very dim oscilloscope trace and usually go undetected when the 60 cps line is applied directly to the CRO terminals.

The circuit (see illustration) is essentially a differentiator followed by a voltage doubler. The 60-cycle component is largely filtered out before the reference point TP-1. The waveform here gives quantitative information on the various amounts of distortion present on the powerline voltage. The diodes act to detect and widen the higher, but very narrow, line transients. Positive transients charge the 0.0005  $\mu$ f capacitor through diode CR<sub>1</sub> directly. Negative pulses charge the .002  $\mu$ f capacitor through diode CR<sub>2</sub> and then transfer this charge to the 0.0005  $\mu$ f capacitor on the back-swing. Since both polarities of pulses must pass through the 0.002  $\mu$ f capacitor, relative pulse amplitudes are not greatly influenced by it.

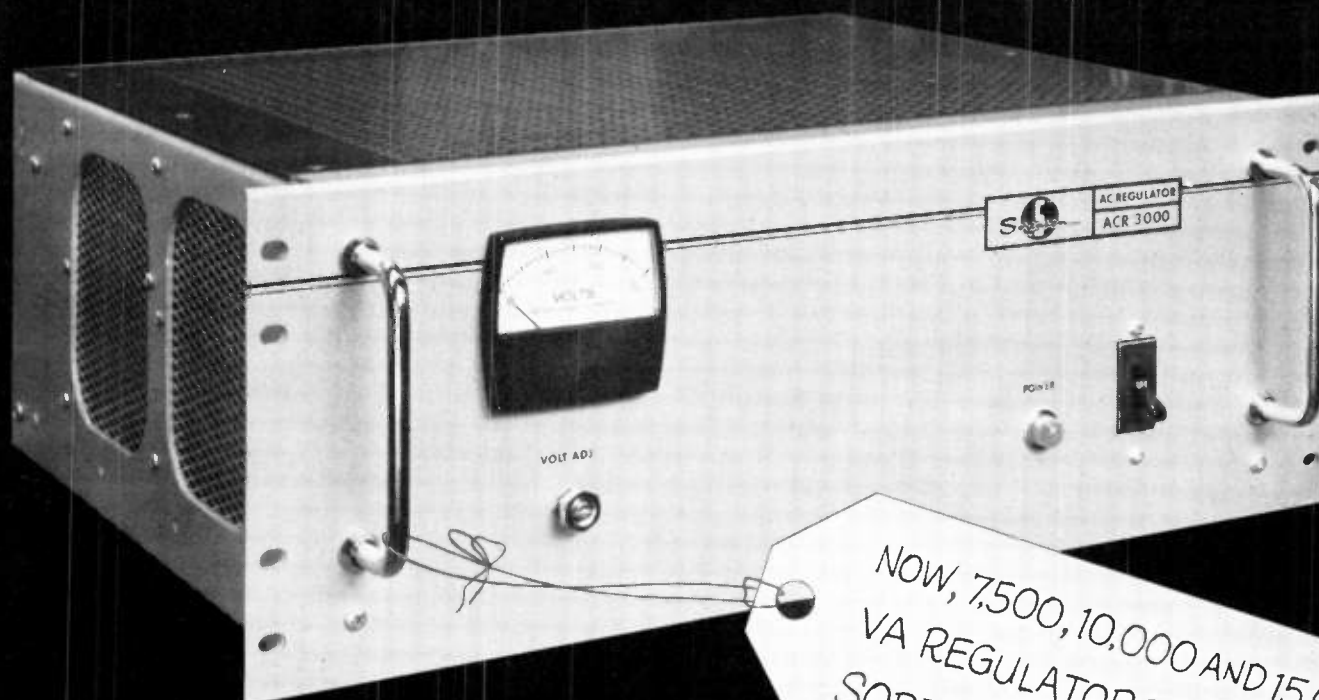
The storage capacitor almost completely charges in 400 nsec or less and holds the charge for 200  $\mu$ sec or more. This provides at least a 500-to-1 widening and brightening of the scope trace produced by a transient. It turns out that many pulses on the line consist of a burst of pulses or oscillations, with individual pulses perhaps only a few nanoseconds wide. The circuit peak-detects a number of these pulses and still provides a wide, readable trace. For this, fast detecting diodes are needed. A voltage divider follows the differentiator to permit the use of low-voltage diodes, thus lowering cost.

In a typical case, with all laboratory equip-



Simple, inexpensive RC-diode network is used to analyze transient waveforms on power lines. The detecting diodes form a voltage doubler, which charges the storage capacitor. This results in wider, brighter pulses on the CRO.

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## ACR ELECTRICAL AND MECHANICAL SPECIFICATIONS

MODEL NUMBER	OUTPUT VA RANGE	REGULATION ACCURACY		EFFICIENCY (FULL VA)	TYPICAL POWER FACTOR	TEMPERATURE		DIMENSIONS (INCHES)				PRICE**
		LINE	LOAD			AMBIENT (°C)	COEFFICIENT (°C)	WIDTH	HEIGHT	DEPTH	RACK HEIGHT	
ACR 500	0-500	$\pm 0.1\%$	$\pm 0.1\%$	88%	75%	0-50	.03%	15*	5	9	5 1/4	\$ 290
ACR 1000	0-1000	$\pm 0.1\%$	$\pm 0.1\%$	90%	75%	0-50	.03%	19	5 1/4	11	5 1/4	340
ACR 2000	0-2000	$\pm 0.1\%$	$\pm 0.1\%$	92%	75%	0-50	.03%	19	5 1/4	15	5 1/4	435
ACR 3000	0-3000	$\pm 0.1\%$	$\pm 0.1\%$	95%	75%	0-50	.03%	19	7	15	7	555
ACR 5000	0-5000	$\pm 0.15\%$	$\pm 0.15\%$	95%	75%	0-50	.03%	19	7	20	7	715
ACR 7500	0-7500	$\pm 0.15\%$	$\pm 0.15\%$	95%	75%	0-50	.03%	19	12 1/2	20	12 1/2	850
ACR 10000	0-10000	$\pm 0.15\%$	$\pm 0.15\%$	95%	75%	0-50	.03%	19	12 1/2	20	12 1/2	1,200
ACR 15000	0-15000	$\pm 0.15\%$	$\pm 0.15\%$	95%	75%	0-50	.03%	19	17 1/2	20	17 1/2	1,500

\* A 19 inch adapter (rack) panel is available.

\*\* Optional Meter \$22.



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ON READER-SERVICE CARD CIRCLE 33

World Radio History



## IDEAS FOR DESIGN

ment except the oscilloscope turned off, random line transients were observed. Some had peak amplitudes of over 50 volts. A brush-type motor powered from a nearby outlet provided large numbers of transients. Switching a nearby inductive load on and off produced up to 150-volt transients.

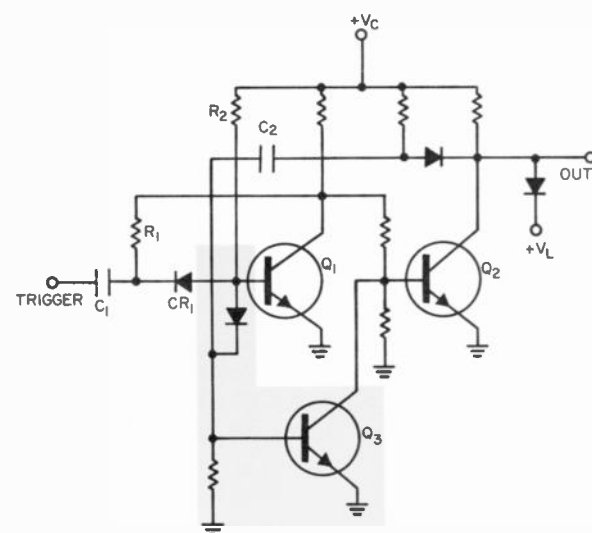
*Peter Lefferts, Chief Engineer, Tia Electric Co., 178 Alexander St., Princeton, N. J.*

If this idea is valuable to you, give it a vote by circling Reader-Service number 111.

### Locking monostable circuit immune to false triggering

When using monostables, care must be taken to ensure that the monostable isn't triggered until the timing capacitor has had sufficient time to fully recharge after a previous cycle of operation. Failure to do this will result in variations in the output pulse-width. The circuit shown is self-protecting in that it locks itself until its cycle of operation is complete. This includes the recharge of the timing capacitor.

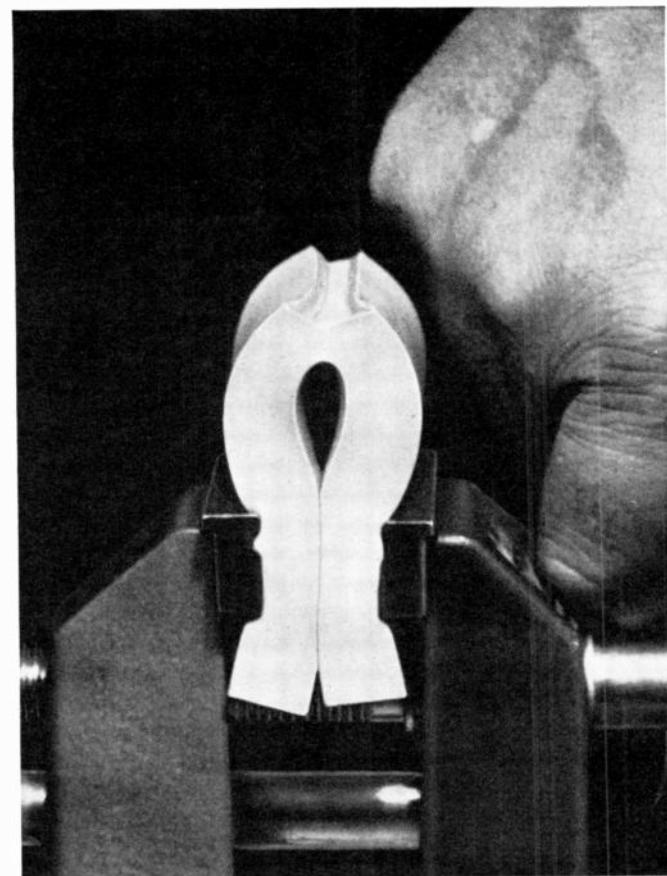
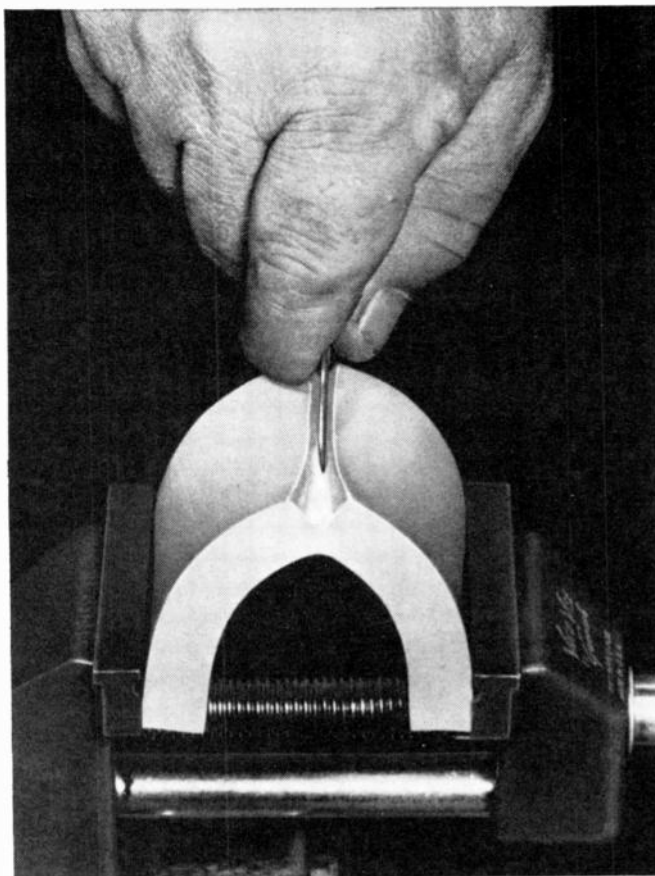
The significant circuit elements are transistors  $Q_1$  and  $Q_2$  that make up the normal multivibrator pair; the "locking" transistor,  $Q_3$ ; an input gate consisting of  $R_1$ ,  $C_1$  and



Locking monostable multivibrator is formed by adding a gating transistor stage,  $Q_3$ , which renders the timing cycle independent of the input trigger. This self-protection quality lasts until the cycle of operation has been completed.



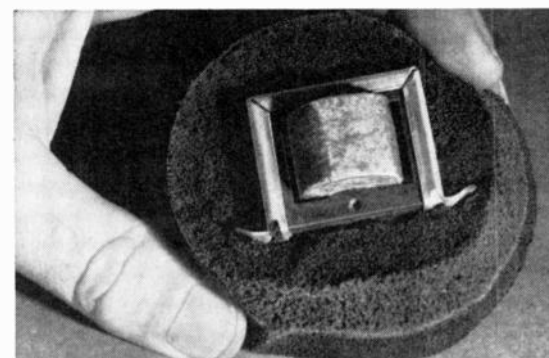
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Mixed with a curing agent, RTV-7 liquid silicone rubber foams and cures on the spot. In 10 minutes flat. Density can be varied to meet specific requirements.



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# Ultra-high strength RTV-630: slash it, flex it double...it never tears

By far the toughest two-part RTV silicone rubber ever developed, General Electric's RTV-630 has a tear strength of 100 psi — die B. *That's more than twice the tear resistance of any other RTV.*

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The overall strength and durability of General Electric's newest RTV are complemented by its superior reversion resistance. By its rapid curing time. And by its outstanding thick section cure capabilities.

## Proven in Plastics Processing and Flexible Mold Applications

Already used for prototypes and in extended runs for plastic parts fabrication, RTV-630 has consistently demonstrated superior performance under rigorous production conditions.

*In thermoforming reinforced plastic parts* for space vehicles, RTV-630 was successfully used as a male punch die. Subjected to 5000 psi at 350°F, it has performed more than *six times longer* than previously used materials without any visible signs of fatigue or deterioration.

*In multi-cavity molding of epoxy parts* for electronic modules, RTV-630 molds lasted *twice as long* as molds made with conventional RTV's.

Now the toughest RTV in existence, RTV-630 also promises to be important in other applications. In potting and encapsulating. Molded functional parts. Pressure bag and matched die molding of reinforced plastics. Conveyor belts. And release coatings.

## 7 common properties of all G-E RTV silicone rubbers

- Extreme temperature resistance.
- Room temperature cures.
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- Strong bonds.
- Excellent dielectric.
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## Ready-to-use RTV-102 cartridge pack speeds production line sealing

No catalyst, no mixing, no priming needed. RTV-102 sealant is ready to go, ready to speed sealing jobs. Provides tough, flexible rubber seals for radio chassis, terminal connectors, other electrical and electronic applications. Ideal for hard-to-reach spots. Sets in minutes. Cures in hours. Won't sag, shrink, crack, harden or peel.

General Electric's new cartridge pack comes with white (RTV-102) and translucent (RTV-108) compounds. In six and 12 ounce sizes for hand or air powered caulking guns.

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Electrical Specialty Co.  
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**WISCONSIN**  
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Milwaukee

For complete information on these newest G-E RTV compounds, ask your nearest distributor as listed, or write to Section L12167, Silicone Products Department, General Electric Company, Waterford, New York.

**GENERAL ELECTRIC**

ON READER-SERVICE CARD CIRCLE 35

$CR_1$ ; and the timing circuit, consisting of  $C_2$  and  $R_2$ .

In the quiescent state,  $Q_2$  and  $Q_3$  are OFF and  $Q_1$  is ON. This allows the input gate to pass a trigger pulse to  $Q_1$ . When triggered,  $Q_1$  turns off, turning  $Q_2$  on. The input gate is then biased off so that no more trigger pulses will be passed to  $Q_1$ . This is the normal multivibrator timing cycle, which ends when  $C_2$  is discharged by  $R_2$  so that  $Q_1$  is turned back on, turning  $Q_2$  off.

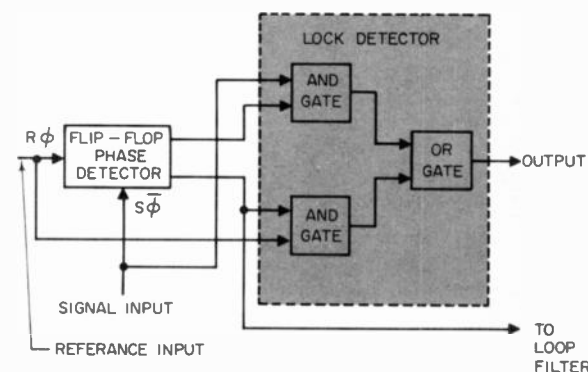
At this point in the cycle, the timing capacitor,  $C_2$ , must be permitted time to fully recharge. This is done by passing the charging current through  $Q_3$  which holds  $Q_2$  off as long as this current is flowing. In this way, even though the input gate may now pass trigger pulses to  $Q_1$ , no multivibrator action will take place until  $C_2$  is charged and  $Q_3$  turns off. The cycle of operation and its timing is now independent of any input trigger timing.

Roy Foerster, staff engineer, The Bunker-Ramo Corp., Canoga Park, Calif.

If this idea is valuable to you, give it a vote by circling Reader-Service number 112.

## Out-of-lock detector performs digital frequency discrimination

An out-of-lock detector can be used to implement a digital frequency discriminator. If the duty cycle of the set and reset pulse trains is low, the detector can give information as to whether a signal is higher or lower than some reference level.



1. Automatic phase-control-loop detector can be used to perform digital frequency discrimination. Output pulses on the  $R\phi$  and  $S\phi$  lines, respectively, indicate when the signal frequency is lower or higher than the reference frequency.



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High attenuation to weight ratio possibilities; can dramatically enhance component performance. The shields stop degradation from unpredictable magnetic fields. When grounded, they also shield electrostatically. Co-Netic and Netic shielding foils are not significantly affected by dropping, vibration or shock, and do not require periodic annealing. Foils are available in thicknesses from .002" in rolls 4", 15", and 19-3/8" wide. Extensively used in experimental evaluation and production line operations for military, commercial and industrial applications

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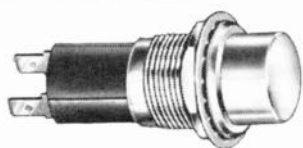
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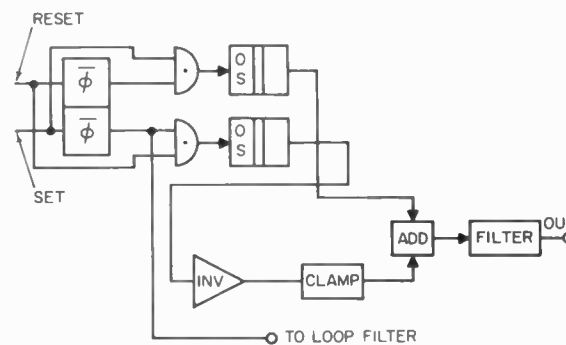
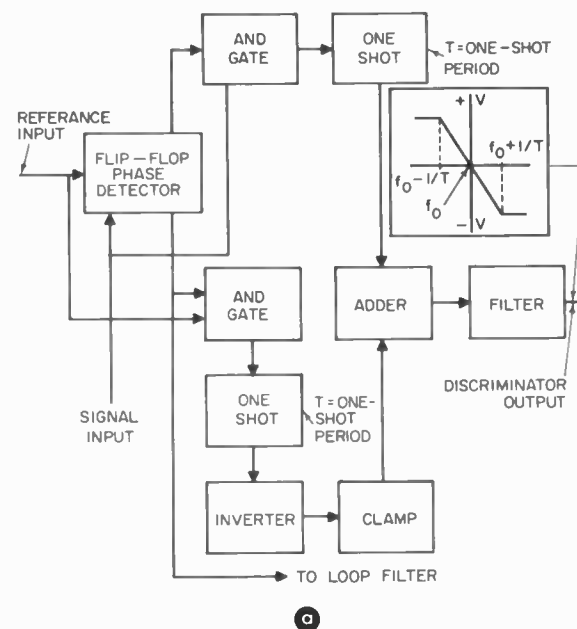
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ON READER-SERVICE CARD CIRCLE 37

## IDEAS FOR DESIGN

Referring to the block diagram of the detector (Fig. 1), an output pulse on the  $R\phi$  line indicates that the signal frequency is lower than the reference frequency. Similarly, an output on the  $S\phi$  line indicates that the signal frequency is higher than the reference frequency. Ahead of the OR gate, this sense information is present. Either  $S\phi$  or  $R\phi$  could be inverted, added to the non-inverted signal and filtered. The output dc voltage would be a function of frequency; however, the sensitivity (volts/cycle/sec) would be very low.

The discriminator can be implemented in a more practical manner by modifying the detector circuit and using the  $S\phi$  and  $R\phi$  signals to trigger one-shot multivibrators.



(See caption on next page.)

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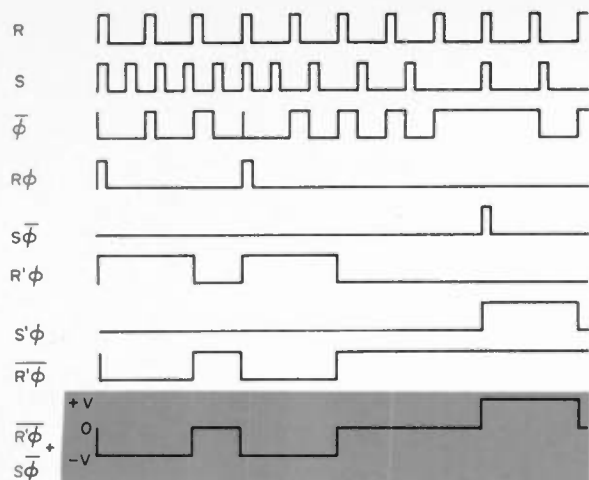
Responsible for customer contact, market planning, and proposal management in areas of Geophysical Measurements & Instrumentation in support of oceanographic, meteorological, and earth sciences programs. Will seek commercial and government markets to promote new business growth. BS in EE or Physics, 3 years related experience. Please send your resume to: Director, Professional Personnel, Dept. 857, Atlantic Research Corporation, Alexandria, Virginia 22314 (Suburb of Washington, D.C.). An equal opportunity employer.

**ATLANTIC  
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ON READER-SERVICE CARD CIRCLE 899

ELECTRONIC DESIGN





2. Digital frequency discriminator circuit (a) features linear, wideband performance, as shown by its characteristics curve. The logic diagram (b) and timing waveforms (c) of the circuit demonstrate the precision of the technique.

These multivibrators would feature controlled pulse-output periods so as to increase the duty factor (see Fig. 2a). One of the multivibrator outputs is then inverted, ac coupled and clamped to provide a negative output pulse. The two outputs are then added and filtered. The result is a linear, wide-bandwidth frequency discriminator, which bears the characteristic shown.

A logic diagram of the operation of the circuit (Fig. 2b) and its associated timing diagram (Fig. 2c) demonstrate the techniques. Note that the outputs from the one-shots could also be used to drive a bipolar-output difference amplifier, thus eliminating the need for the inverter, clamp and adder.

Dan Hill, Data Systems Engineer, Collins Radio Corp., Richardson, Tex.

If this idea is valuable to you, give it a vote by circling Reader-Service number 113.

Submit your Idea for Design describing a new or improved circuit or design technique, the clever use of a new component, or a cost-saving design tip to our Ideas for Design Editor. If your idea is published, you will receive \$20 and become eligible for an additional \$30 (awarded for the Best of Issue Idea) and the grand prize of \$1000 for the Idea of the year.

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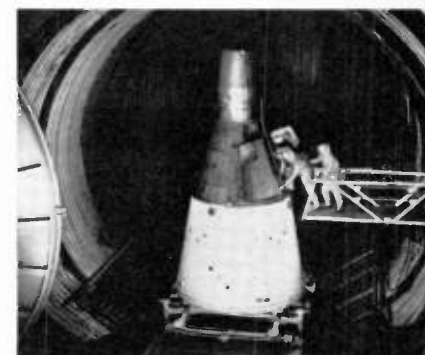
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## TEST EQUIPMENT

# Voltmeter spans 1 Kc to 1 Gc using random sampling

Incoherent sampling, a new concept in voltmeters, could change your concept of what an rf voltmeter should be. For instance, have you ever checked output levels at each stage of a uhf transmitter?

The trouble is that a conventional rf voltmeter is mostly a tuner and detector. If both tuner and detector are good, you can cover a certain frequency range with a degree of assurance, perhaps without interpolation. But you still have to tune carefully and hope that your detector's frequency sensitivity hasn't changed since the last time the voltmeter was aligned.

These inherent limitations are completely avoided in a broadband voltmeter that is similar, in some respects, to a sampling oscilloscope. Presently in production at Hewlett Packard, Loveland, Colorado, the instrument is designated HP 3406.

A frequency capability of 1 Kc to 1 Gc is chief among the 3406 specs. And no tuning is required! Readings are 1 mv to 3 v full-scale in eight ranges, absolute average calibrated in RMS. The meter is also calibrated for simultaneous readings in dbm from -50 to +20. Accuracy is conservatively rated at  $\pm 3\%$  between 10 Kc and 100 Mc, 5% from

100 and 700 Mc, and 8% from 700 Mc to 1 Gc. Full-scale sensitivity is such that a signal as small as 50  $\mu\text{v}$  can be resolved.

Coherent signal sampling techniques, old hat in oscilloscopes, have proven to be too expensive for use in voltmeters, according to Hewlett Packard. The circuitry required to control phase relationships and jitter alone would price such an instrument out of its usual market. A slightly different approach is used in the HP 3406. HP engineers have dubbed their approach *incoherent sampling*, a statistical approach to ac measurement.

As shown in Fig. 1-B, coherent samples taken of a signal can be used to reconstruct a wave-form. The potentials registered at the sampling points will also give an accurate indication of the ac voltage of the signal.

But, since RMS and absolute average voltage are actually statistical representations, the wave-shape is redundant information and the order or phase of the samples is of no importance. If the order of the readings is scrambled, as shown in Fig. 1-C, the statistical average remains unchanged.

Measuring a signal known to be repetitive, then, can be accomplished by taking samples at a comparatively low frequency—the cumulative samples will be a direct statistical function of the original signal. (The only stipulations being that the sampling rate cannot be a harmonic of the measured signals and that enough samples be taken to assure statistical reliability).

For the 1 Kc to 1 Gc bandwidth of the 3406 voltmeter, HP found

sampling at an audio rate to be most convenient. Therefore, the output of the sampling circuit is an audio signal with a frequency equal to the sampling rate and an ac voltage proportional to that of the measured frequency.

Beyond the sampler, the 3406 is basically a narrow-band audio voltmeter. In order to be certain that the sampling frequency is never a harmonic of any rf signal, the sampling frequency of the 3406 is frequency modulated by a triangle-wave. The audio detector is not sensitive to these minor frequency variations.

For added convenience, a pushbutton "push-to-store" feedback loop is provided. This loop allows a reading to be held after the probe is removed from the test point, easing reading in awkward positions.

Two electrical outputs are provided before and after the signal processor. The audio signal tapped off before processing can be used as a check on the processor, or as a feed line for true-RMS, absolute average, peak or other voltmeters.

The voltmeter is supplied with a sampling probe as standard equipment. Other accessories are available to give the basic instrument specialized capabilities. These include: a BNC adapter, a Microdot adapter, a 10:1 divider, a 50 ohm tee, a 50-ohm termination and others.

P&A: \$650.00; approximately 90 days. Hewlett-Packard, Loveland Div., P. O. Box 301, Loveland, Colorado. Phone: (303) 667-5000.

### HP 3406A specifications

**Voltage range:** 1 mv to 3 volts full scale in eight ranges; decibels from -50 to +20 dbm.

**Frequency range:** 1 Kc to 1 Gc; useful sensitivity from 100 cps to beyond 2 Gc.

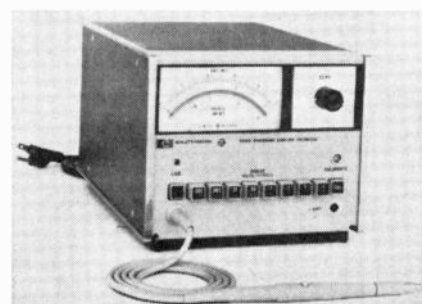
**Full-scale accuracy:**  $\pm 3\%$ , 10 Kc to 100 Mc;  $\pm 5\%$ , 1 Kc to 1 Gc.

**Input impedance:** 100,000 ohms at 100 Kc. Capacity approximately 2 pf. (Input capacity and resistance will depend on accessory tip).

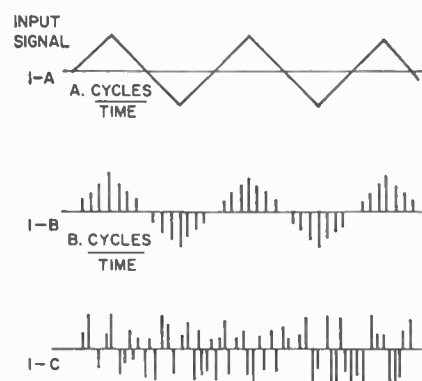
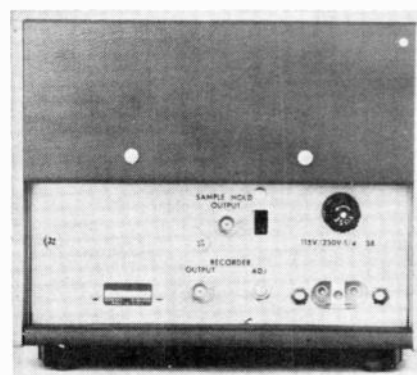
**Dc recorder output:** 1 ma into 1000 ohms at full scale, proportional to meter deflection.

**Sample hold output:** Provides ac signal statistically equivalent to measured signal on ranges 0.01 volt and above.

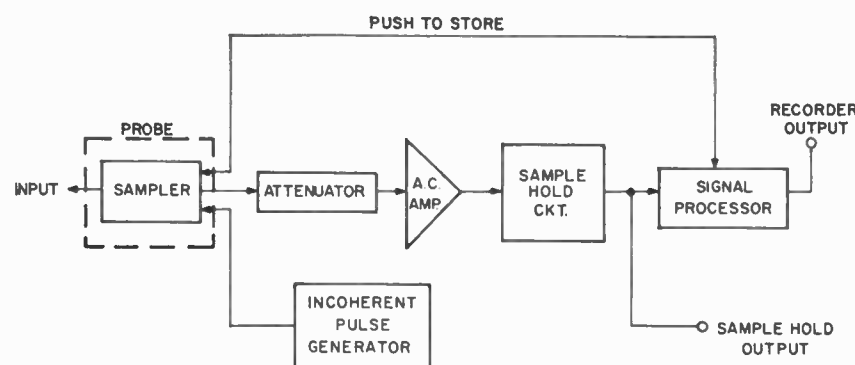
**Accessory furnished:** 11061A isolator tip.



Simple to use, controls are front-panel mounted. Electrical outputs are rear-mounted (as shown right).



Random sampling of a triangular wave provides a "statistical image" of the ac potential regardless of the order of the samples. In the aggregate, 1-B and 1-C are identical.



The new concept in rf voltage measurement amounts to processing an audio signal derived by sampling the rf at random intervals.

Power: 115 or 230 volts  $\pm$  10%, 50 to 1000 cps, approximately 10 w.  
 Dimensions: Standard  $\frac{1}{2}$  module  
 6-1/2-in. high, 8-7/8-in. wide,  
 11-1/2-in. deep (165 x 225 x 292 mm).

Weight: Net 8 lbs.

ON READER-SERVICE CARD CIRCLE 803

## Sweep generator covers audio band

Sweep width of the 610B generator is 20 cps to 20 Kc and sweep speed is variable from 6 to 60 seconds. Output is 2.5 v into 600 ohm with an 80 db attenuation range and a logarithmic sweep characteristic.

Four different sweep modes are generated by this instrument. Internal circuitry is provided to generate a dc control ramp-voltage that programs the oscillator in two automatic sweep modes-continuous and one-shot. In a third mode, the 610B functions as a single range, manually tuned generator. In the fourth, or external mode, the generator is frequency programmed from any external voltage or resistance source such as recorder retransmit pots and function generators.

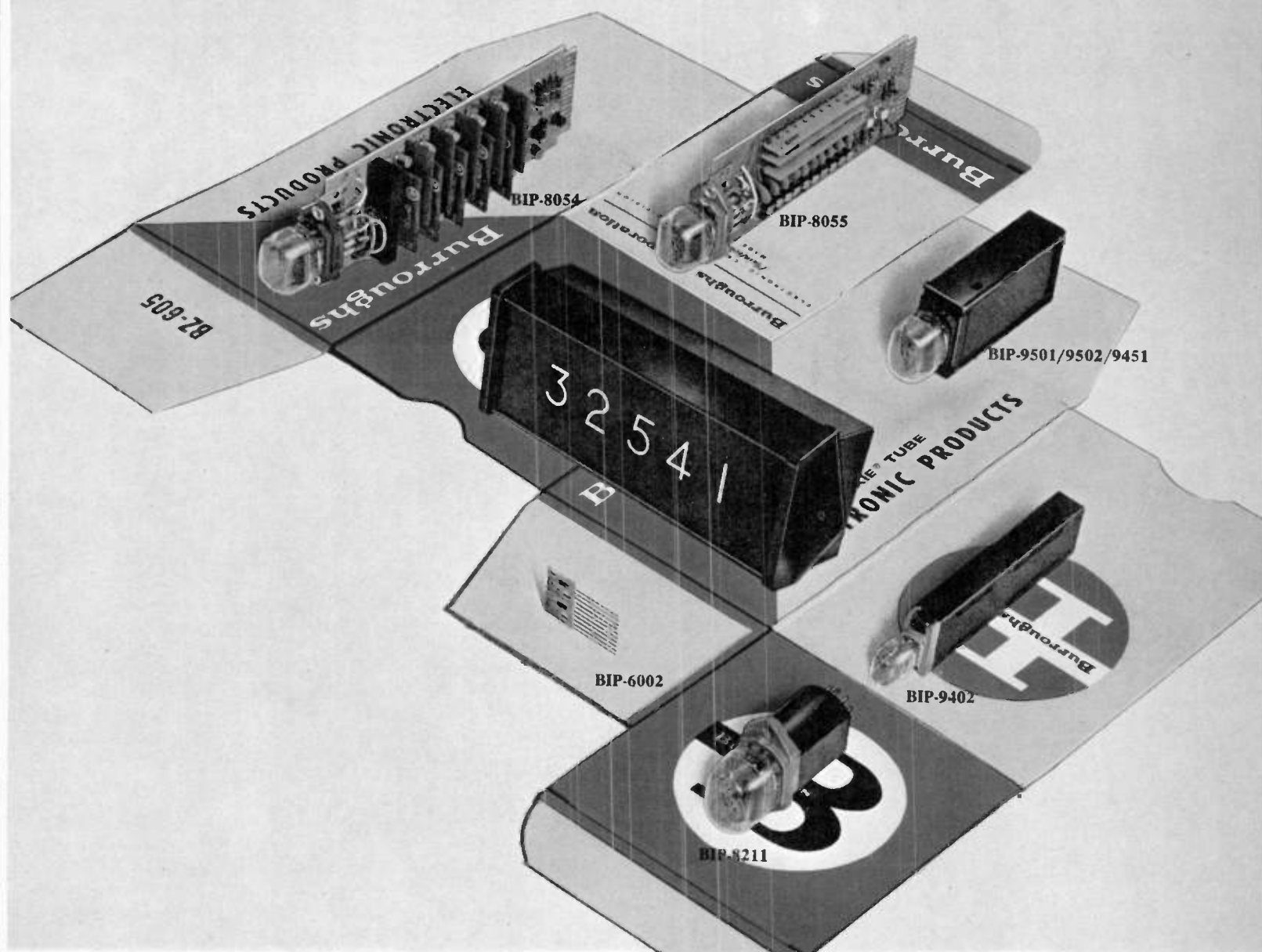
Operating in the three internally generated modes, voltages are also delivered to front-panel binding posts where it can be tapped off for use in plotters and recorders.

P&A: \$1000.00; stock. Waveforms Inc., 333 Sixth Ave., New York, N. Y. Phone: (212) 929-2795.



ON READER-SERVICE CARD CIRCLE 758

ON READER-SERVICE CARD CIRCLE 221 ➤



## When Burroughs wraps up the package, your readout costs you less.

When you buy a NIXIE® tube package, you get a driver module designed with your input requirements in mind plus the finest readout available, at an extremely low cost per function.

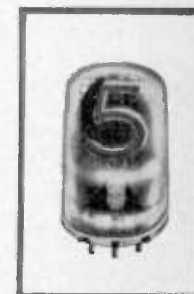
For instance, 1000 lot prices for new driver modules, including rectangular NIXIE tube readout, are as follows:

- BIP-9451, a BCD to decimal decoder with memory in a new hybrid circuit package, \$35.50
- BIP-9501, a 10-bit memory driver module, \$32.50
- BIP-9402, the world's smallest BCD to D decoder with memory, \$49.00.

And these are only the most recent additions to a line which already includes a 150 KC uni-directional counter (BIP-8055), \$50.00 with tube; a 110-KC bi-directional counter (BIP-8054), at \$80.00 with tube, and a wide variety of socket pack drivers and decoder/drivers which range in price from \$28.50 to \$35.50, including readout. All prices apply in 1000 quantities.

Burroughs readout packages save you electrical and mechanical design time, and they are available.

Write for complete information on NIXIE indicator tubes and associated driver modules.



Only Burroughs manufactures NIXIE Tubes.



**Burroughs Corporation**

ELECTRONIC COMPONENTS DIVISION  
 PLAINFIELD, NEW JERSEY



## TEST EQUIPMENT

### Analyzer plug-in

A new spectrum analyzer plug-in, type 74-94A, operates in any 765H series main frame, regardless of the date of manufacture. The new plug-in will analyze any signal or group of signals in the 1 Kc to 2 Mc range.

The 74-94A features a manual scan control that provides frequency accuracy determination to



better than 0.02%. Vertical and horizontal signal outputs are available for driving X-Y pen recorders, DVM's and other oscilloscopes. Incidental jitter and FM are less than 1%. It features a switch selectable choice of a fixed full scan 2 Mc wide dispersion and a continuously adjustable dispersion of 10 Kc to 600 Kc. The resolution is continuously variable over a range of 1 Kc to 8 Kc.

P&A: \$950; 30 days. Fairchild Instrumentation, 750 Bloomfield Ave., Clifton, N. J. Phone: (201) 773-2000.

ON READER-SERVICE CARD CIRCLE 759

### Digital phase meter

Direct readings of phase angles, in four digits, is provided by the type 524A3 phase meter. Accuracy is  $\pm 0.03$  degrees below 40 Kc and, with slightly reduced accuracy, the instrument covers a total range of 20 cps to 500 Kc. Applications include plotting of phase vs frequency of an unknown network.

Ad-Yu Electronics, Inc., 219-259 Terhune Ave., Passaic, N. J. Phone: (201) 472-5622.

ON READER-SERVICE CARD CIRCLE 760

## Two new 40 mw and 20 mw high-speed, billion-operation CLARE Relays

■ These CLARE Type HGSL and HGSM Mercury-Wetted Contact Relays meet the requirements of modern electronic systems.

■ Their complete freedom from contact bounce, isolation between coil and contacts and high speed qualify them as excellent input buffers to solid state circuitry. As output buffers they can be driven by low power logic circuitry with an input to output power gain of up to 5000. Contacts can handle up to 100 va, ac or dc, over billions of operations without derating.

■ As scanner contacts in checkout systems they can stand off a hi-pot voltage of 1000 vac and, at the same time, offer a contact resistance variation of less than 2 milliohms over life for critical resistance measuring circuits. Their lack of contact bounce, high speed and low noise generation commend them for tape transport read-write head switching. In their compact, space-saving packages these relays meet a wide range of design requirements for both printed circuit boards and wired assemblies.

### type HGSM

Module  
for printed  
circuit boards



Relays shown actual size

### type HGSL

Plug-in  
for wired  
Assemblies



### Sensitive

40 mw Single-Side  
Stable  
20 mw Bi-Stable

### High Speed

Nominal operate  
time: 1.0 ms

### Long Life

Billion operations  
minimum at rated  
load

### Contact Advantages

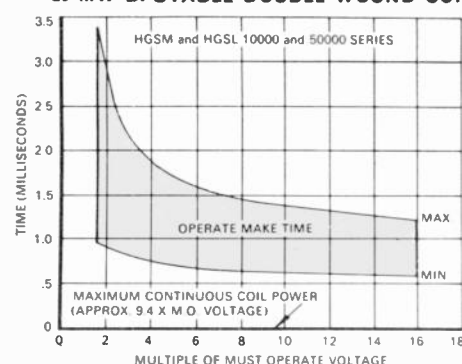
Low and consistent  
contact resistance  
over complete life.

No bounce.

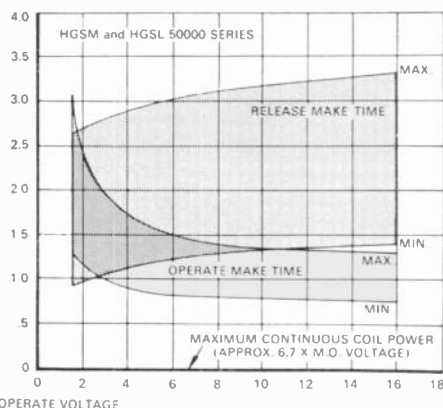
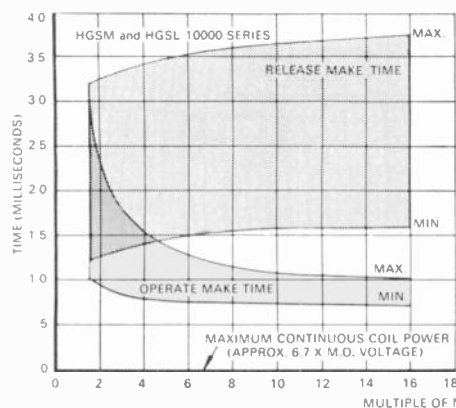
Both form C and form  
D contacts available.

## OPERATE AND RELEASE TIMES

20 MW BI-STABLE DOUBLE WOUND COIL



40 MW SINGLE-SIDE STABLE SINGLE WOUND COIL



ELECTRICAL CHARACTERISTICS	FOR WIRED ASSEMBLIES		FOR PRINTED CIRCUIT BOARDS	
	HGSL		HGSM	
	Series 10000	Series 50000	Series 10000	Series 50000
Contact Arrangement	1 Form D	1 Form C	1 Form D	1 Form C
Sensitivity	40 mw. Single-Side Stable 20 mw. Bi-Stable			
Contact Rating Low Level	0-100 Microamperes 0-300 Millivolts			
Power (with Contact Protection)	2 amperes max. 500 volts max. 100 volt amperes max.			
Contact Circuit Resistance	35 milliohms max. Variation less than $\pm 2$ milliohms from initial value through $20 \times 10^9$ operations (Independent of Current or Voltage)			
Nominal Operating Voltage	Up to 90 vdc			
Nominal Operate Time at Maximum Coil Power	1.0 ms			

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## Sweep/marker generator

The new 1500-B sweep and marker generator, covers a range of 20 cps to 1000 Mc.

The 1500-B offers varied combinations of sweep and marker units for sweeping steep skirts, narrow filters, wide pass bands, video circuits, tv bands, etc. All sweep



heads function as voltage-controlled oscillators over the unit's full range.

Markers include: pulse, RF turn-off, harmonic, cw birdie. Sweep modes cover: 0.2 to 60 cps; log and linear, external input, manual control.

The sweep may be varied continuously from 0.2 to 25 cps; going slowly enough through the pass-band to permit sweep alignment of very high Q circuits; or can be locked to the line for general operation.

Price: \$565. Kay Electric Co., Maple Ave., Pine Brook, N. J. Phone: (201) 227-2000.

ON READER-SERVICE CARD CIRCLE 761

Send for Data Sheet 852 giving complete information on these new miniature, high-speed, sensitive relays. Address C. P. Clare & Co., Group 12A8, 3101 Pratt Boulevard, Chicago, Illinois 60645.



relays and related control components

## Dual channel counter

A new dual channel counter scaler provides direct reading of pulse counts at rates up to 100 Mc without the need for prescaling.

Model 1535 pulse counter provides two independent channels, with separate seven-digit nixie-tube displays, in 3-1/2-in. of panel height. A step-type attenuator and pulse discriminator in each channel provides calibrated triggering and rejection levels from 100 mv to 10 v in seven steps. Each channel has 50-ohm input impedance and will count pulses of 5 nsec, separated by as little as 10 nsec, with an accuracy of 1 count.

Transistor Specialties Inc., Terminal Drive, Plainview, N. Y. Phone: (516) 935-8700.

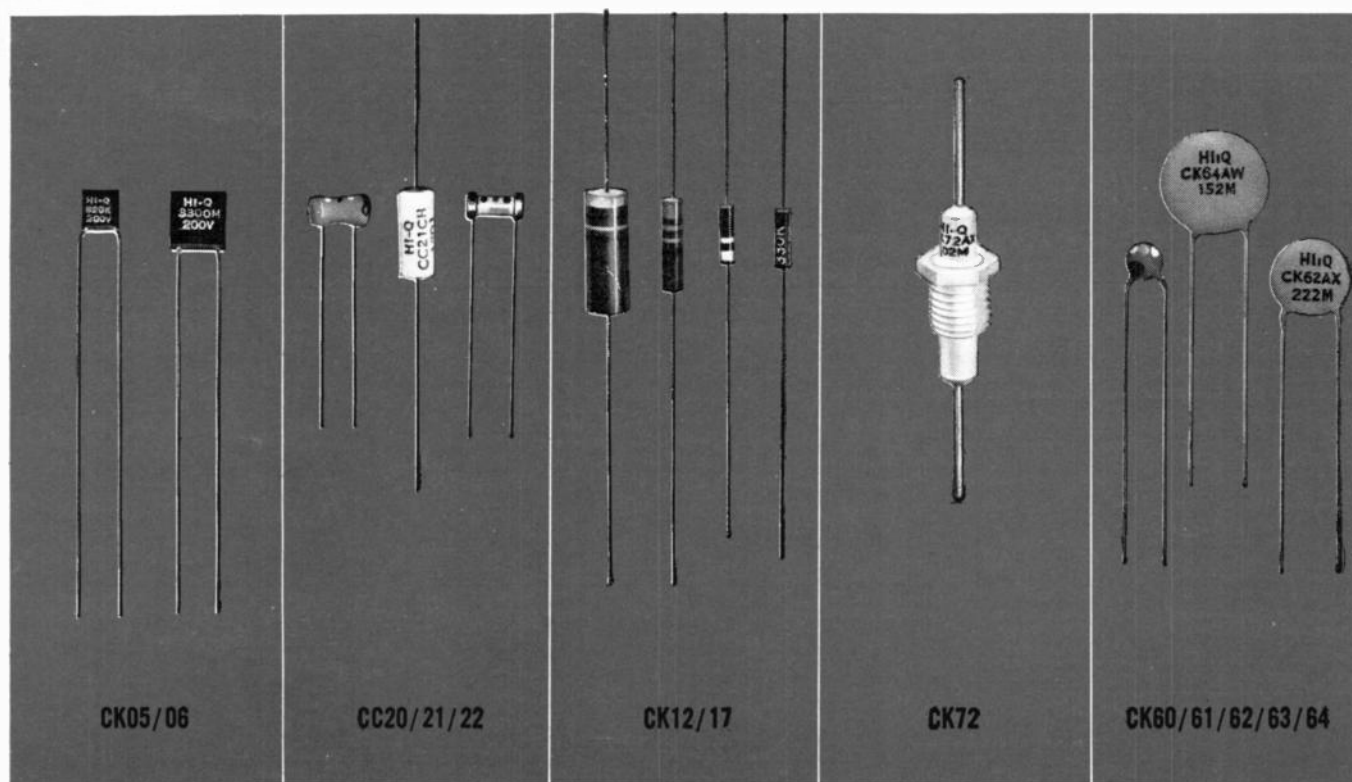
ON READER-SERVICE CARD CIRCLE 762





what ceramic capacitor  
manufacturer can  
meet or exceed  
all these MIL specs?

Hi-Q can!



...and does. Right in step with the increasingly stringent demands of aero/space technology, Hi-Q today provides "one-stop shopping" for all types of Military ceramic capacitors. State-of-the-art temperature compensating, high K, and high reliability ceramic formulations are always available from the company that leads the pack in product advancement. Styles? Whether you need a ceramic high voltage disc, a subminiature radial lead part, a feed thru, a temperature compensating tubular, or a molded high capacitance tubular...you can be sure of getting it from Hi-Q.

And now Hi-Q has developed CERLAM to dramatically increase capacity-to-volume ratios—typified by the CKR12, the CKR13, and the extended range CKR06.

To meet MIL Specs like NPC-200-3, MIL-STD-790, and MIL-Q-9858, Hi-Q has created in-house Reliability and Quality assurance programs that cover everything from design

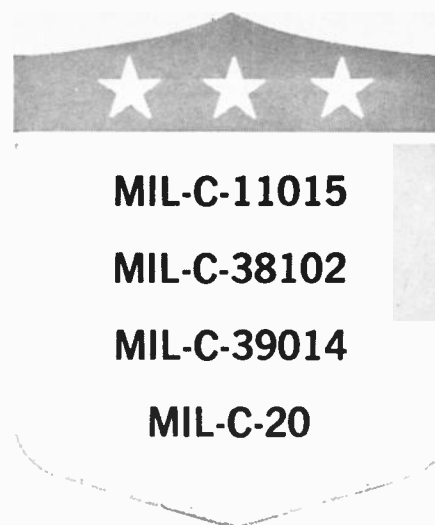
and raw material to the carefully controlled process and inspection that produce the world's finest capacitors. And all this is carried out in outstanding clean room facilities at Myrtle Beach, S. C. and Olean, N. Y.—clean rooms that make it possible to meet the unique demands of HI REL specifications such as MIL-C-38101 and MIL-C-39014.

So if you're looking for a manufacturer that can meet any or all of your requirements for Military ceramic capacitors, call us. We're it:



**AEROVOX**  
CORPORATION  
OLEAN, NEW YORK  
MYRTLE BEACH  
SOUTH CAROLINA

ON READER-SERVICE CARD CIRCLE 40



## TEST EQUIPMENT

### Adapter for VOMs

The Expando adapter is designed to convert multi-tester instruments into expanded scale voltmeters while retaining typical accuracies of 0.5%.

The basis of the adapter is a patented bridge circuit that can withstand overloads of 300%. Ranges



are 20 v up, ac or dc. Testers of the Triplett, Simpson, Weston and Precision VOM lines can be accommodated by the plug-in unit.

P&A: \$25 to \$200, dependent upon range; 3-4 weeks. A&M Instrument-Expando Meters, Community Drive, Long Island City, N. Y. Phone: (212) 276-4343.

ON READER-SERVICE CARD CIRCLE 763

### High-impedance probe

The model 3691 probe amplifier uses a hybrid circuit (nuvistors and transistor) to achieve low noise, high input impedance and low output impedance. With an



overall nominal gain of unity, the model 3691 has a 3 db passband of 10 cps to 200 Mc. The input impedance is 1 Meg, with a 50 ohm output impedance.

C-Cor Electronics, Inc., P.O. Box 824, State College, Pa. Phone: (814) 238-2461.

ON READER-SERVICE CARD CIRCLE 764

## COMPONENTS

### Wideband crystal filter

Used for processing of multi-channel signals, the P119BA crystal filter has a center frequency of 10.7 Mc  $\pm$  1 Kc. Bandwidth at 1 db is 47



Kc min, rising to 100 Kc max at 60 db.

Applications include vhf/uhf receiver systems, FM demodulators, doppler systems, telemetry and commercial communications.

Microsonics, Inc., 60 Winter St., Weymouth, Mass. Phone: (617) 337-4200.

ON READER-SERVICE CARD CIRCLE 765

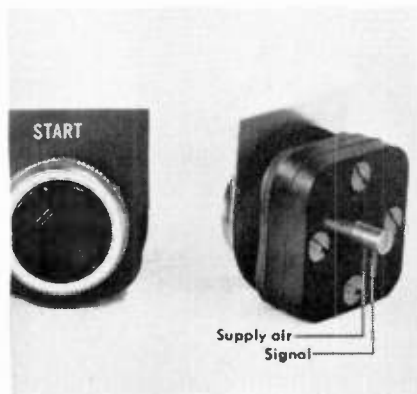
### Fluidic push button

A fluidic push-button switch provides a convenient method of manually supplying input information to a fluidic system. It eliminates the costly transducers and fluidic detectors previously necessary to provide input information.

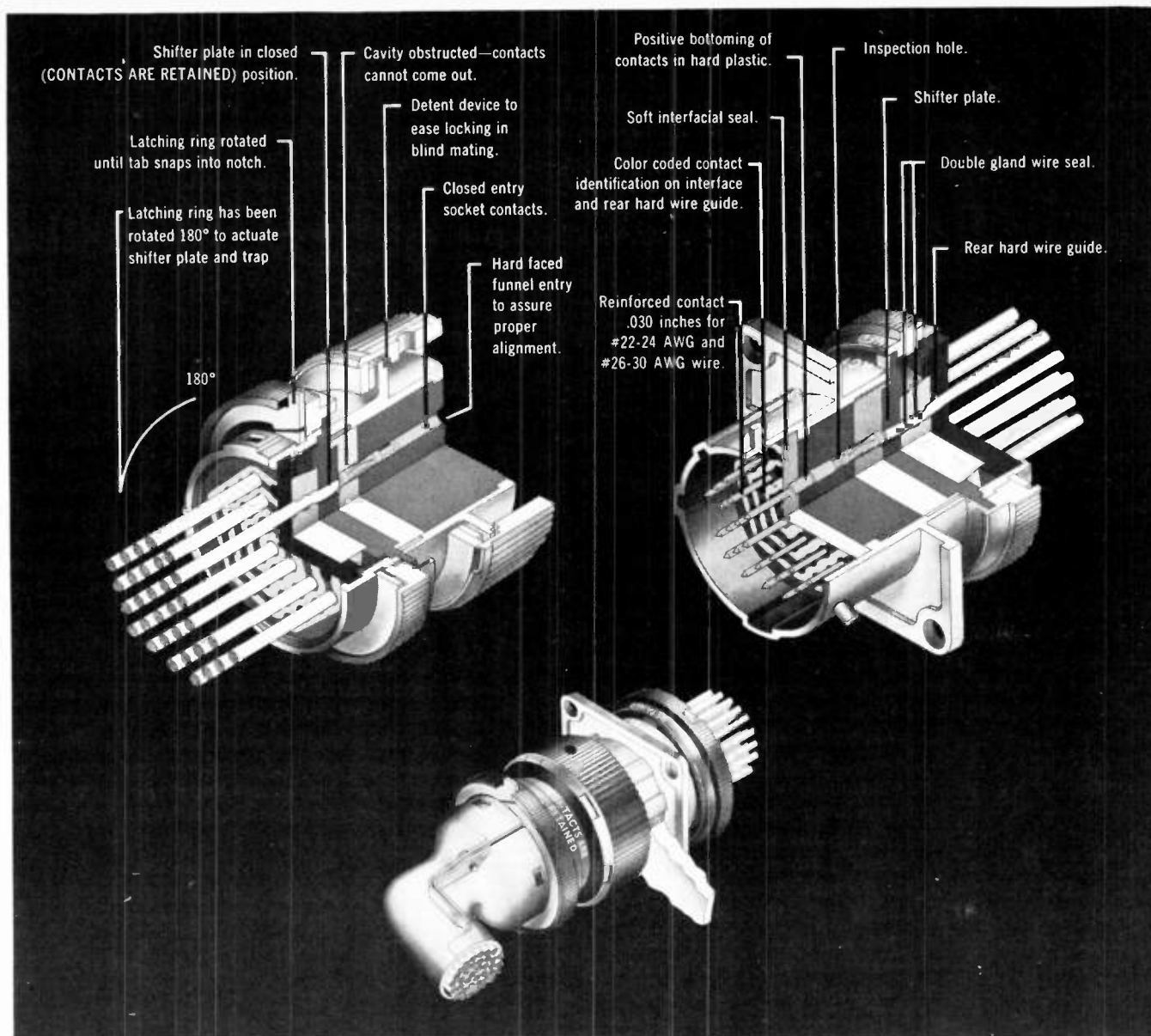
The new switch is the same shape as a standard panel mount electrical push button.

The function of the switch is to provide a manual input signal for a fluidic system.

Basically a back pressure device,



when the switch button is not depressed, supply air bleeds to atmosphere. Pressing the button closes bleed vents forcing the sup-



## This connector begins where others leave off

Take the best subminiature pin and socket connector on the market. Eliminate its inherent failure modes. Give it twice the contact density of other connectors. Then add the very latest innovations in design and materials. This was our objective in developing the new CH-AMP\* Subminiature Circular Connector.

The result shown here is in many ways even more spectacular than the objective. Here is a bayonet-coupled connector with a unique twist-to-lock contact retention mechanism that eliminates the need for retention clips and extraction tools—an environmentally sealed connector designed in a stainless steel housing that provides continuous grounding from mounting flange to cable clamp.

The contacts are a special reinforced spring design with closed entry for probe protection and a four-indent crimp for maximum electrical conductivity. A resilient wafer grips them in the proper position prior to locking. Color-coded interfaces and positive visual checks top off the many precision engineered features that give the CH-AMP Connector a positive GO for all high grade military and industrial applications.

- Meets or exceeds the requirements of MIL-C-26500 and MIL-C-26482
- Available in 85, 58, 37, 26, and 14 contact configurations
- Contact retention force: 2 lbs. unlocked, 15 lbs. locked
- Positive depth-controlled contact insertion
- Moisture-proof, double gland wire seal
- 90° or 180° cable clamp can be applied after connector is wired

Available in five shell configurations for wire sizes AWG 22-30. For full details, write today for the new A-MP\* Subminiature Circular Connector brochure.

\*Trademark of AMP Incorporated



AMP\* products and engineering assistance are available through subsidiary companies in Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

Speed Inquiry to Advertiser via Collect Night Letter  
ON READER-SERVICE CARD CIRCLE 41



# NEW EAGLE RELAYS

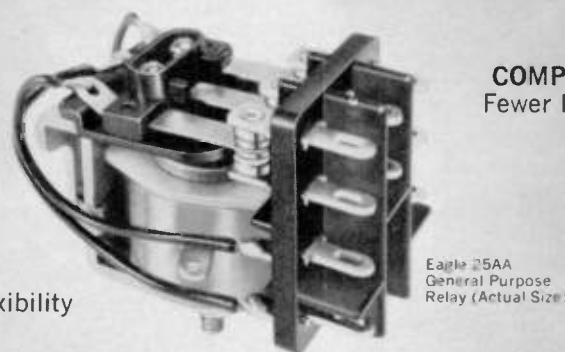
COMPARE  
Better Life Characteristics

COMPARE  
Higher Reliability

COMPARE  
Fewer Parts

COMPARE  
More Design Flexibility

COMPARE  
Lower Pull-in Voltages



Eagle 25AA  
General Purpose  
Relay (Actual Size)

## COMPARE THEM!

New Eagle relays...more than 3,000 types...are the best you can get anywhere. Be crafty. Check the specs and the product. Convince yourself.

**One example:** Gold-plated contacts are *standard* on every general purpose Eagle relay. And on medium power relays, silver cadmium oxide contacts are standard, since they deliver the best possible current-bearing characteristics in this power range.

**Check some more.** Note the sturdy designs...the ratings that exceed all other competitively-priced units...the precise engineering and inventive use of materials. They're all what you'd expect from Eagle—leaders in time/count control devices.

If you've ever dealt with Eagle you'll expect more, and you'll get it. We're talking about unequalled service...service that frankly has never before been available from any relay manufacturer.

**Compare. You'll choose Eagle.**



Part of the "big" picture...more than 3,000 types: plug-in with dust covers; dual latching; hermetically sealed; custom-engineered styles.

Get full details in our new, 16-page color catalog. Send for your free copy to Eagle Signal Division, E. W. Bliss Company, Federal Street, Davenport, Iowa.

**BLISS**  **EAGLE SIGNAL**

A DIVISION OF THE E. W. BLISS COMPANY

Electro-Mechanical, Electronic, Solid State Timing/Counting/Programming Controls ☐ General Purpose, Medium Power Relays

ON READER-SERVICE CARD CIRCLE 42

## COMPONENTS

ply air to back-up and flow out the signal tube. Air consumption is between 1/2 and 1 cubic foot per hour.

P&A: \$8.00; stock. Howie Corp., Fluidic Div., Noble & Jackson Sts., Norristown, Pa. Phone: (215) 279-8190.

ON READER-SERVICE CARD CIRCLE 766

## Automatic integrator

The summatic integrator is capable of automatically converting input signals from 0 to 1 v dc to digital form for a mechanical counter-



printer that operates at 4800 counts per minute. Analyses of gas and liquid chromatography, paper chromatography, spectrometry and other laboratory and process operations can be accomplished in a fraction of the time previously required, according to the manufacturer.

An auto-ranging device attenuates an input signal by a factor of 10 at three decades (1, 10 and 100 mv) for a wide dynamic range. It provides precision of  $\pm 3\%$  on small peaks and  $\pm 0.7\%$  for 20 mv peaks of 10-second duration.

Price: under \$2000. Nester/Faust Mfg. Corp., 2401 Ogletown Rd., Newark, Del. Phone: (201) 368-9146.

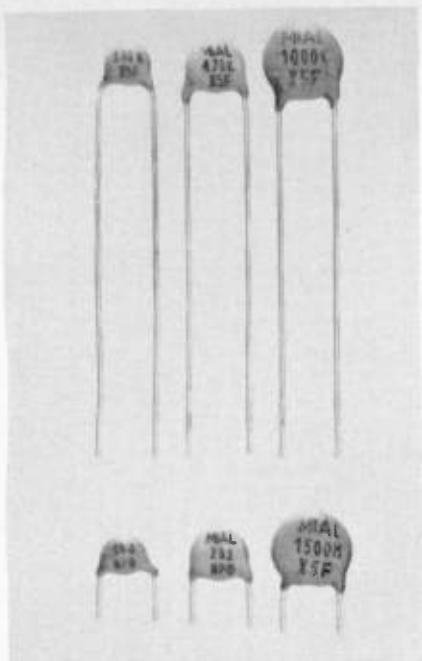
ON READER-SERVICE CARD CIRCLE 767

## Disc capacitors

A series of low cost ceramic disc capacitors features a 0.230-in. maximum diameter unit in each style. The series consists of styles 501, 506 and 511, and all three types are available with long or stub leads for printed circuits. All units, have a 500-volt rating. The capacitance range of the 501 series is up to 33 pf and 68 pf, while the 506 styles have a capacity of up to 1500 pf, and the 511 series, up to 4700 pf.

ELECTRONIC DESIGN





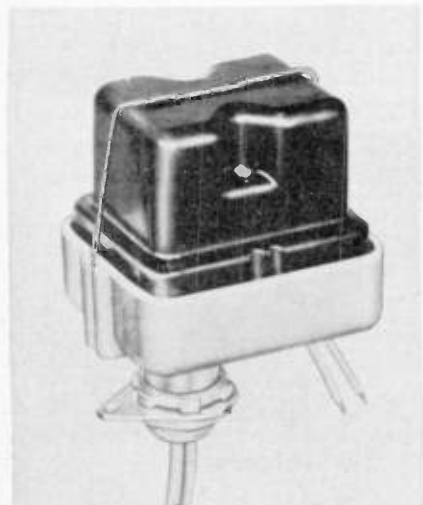
M.I.A.L. U.S.A. Inc., 165 Franklin Ave., Nutley, N. J. Phone: (201) 376-7300.

ON READER-SERVICE CARD CIRCLE 768

### Quick-mounting relay

The totally enclosed Add-A-Relay can be mounted in any half-inch knockout. It has 8-in. color coded lead wires and an aluminum die cast base complete with lock-nuts and position-locking plate to speed installation.

The relay is available SPNO or

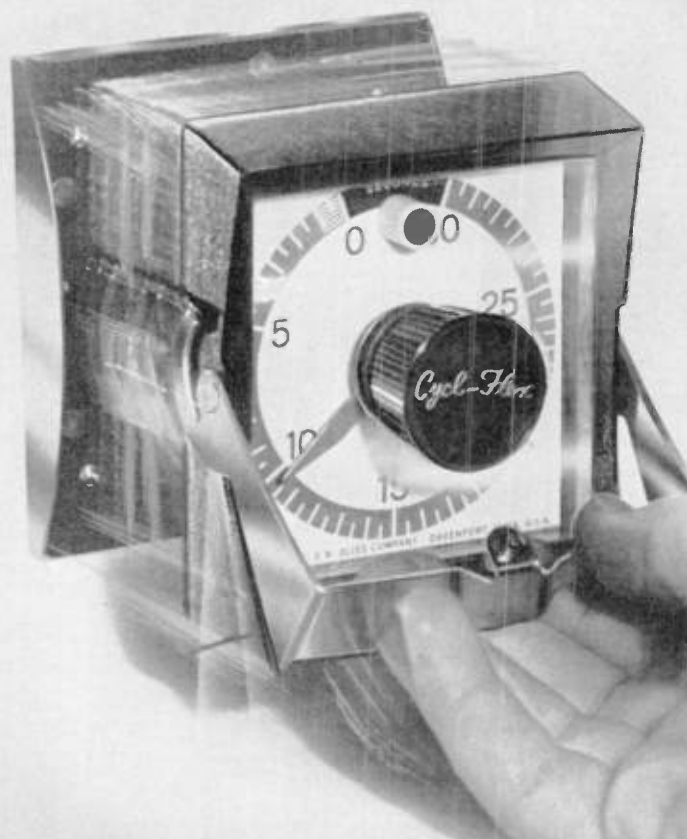


SPNO/SPNC (same polarity) with double break silver alloy contacts rated to 2 HP at 240 v and to 25 amps at 240 v resistive.

Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind. Phone: (219) 743-0311.

ON READER-SERVICE CARD CIRCLE 769

# EAGLE *Cycl-Flex* TIMERS/COUNTERS



## REPLACE THEM IN 5 SECONDS!

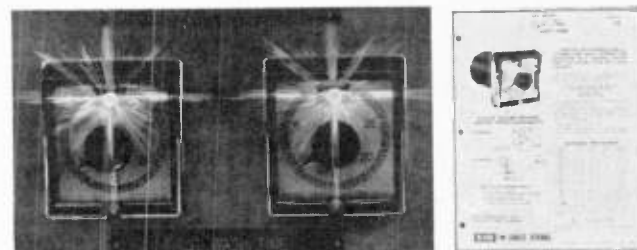
Cut down-time and increase production with Eagle Cycl-Flex time and count controls. You can remove them, check them and replace them in 5 seconds or less...no tools needed!

- Cycl-Flex plug-in timers can be controlled to within 0.5% of the dial range.
- Front-panel mounting makes them easy to install and set.
- Long cycling life—through extensive quality control and life testing programs.
- A synchronous motor and toothed clutch, produced by a special Eagle process, assure totally accurate settings and performance.

Add all these features together. Then add Eagle's special consultation, development and design services...and custom production of all types of units.

Compare. You'll choose Eagle.

Electro-Mechanical, Electronic, Solid State Timing/Counting/Programming Controls ☐ General Purpose, Medium Power Relays



NEW—Now standard on all Cycl-Flex timers, a built-in pilot light, to indicate, even from a distance, that the timer is operating.

For full details on Cycl-Flex timers, write for Bulletin 125, Eagle Signal Division, E. W. Bliss Company, Federal Street, Davenport, Iowa.

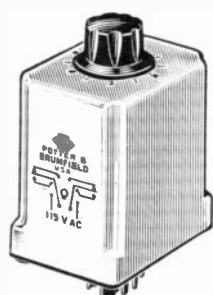
**BLISS**  **EAGLE SIGNAL**

A DIVISION OF THE E. W. BLISS COMPANY

ON READER-SERVICE CARD CIRCLE 43

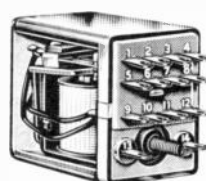


# These P&B relays are immediately available at factory prices from your electronic parts distributor



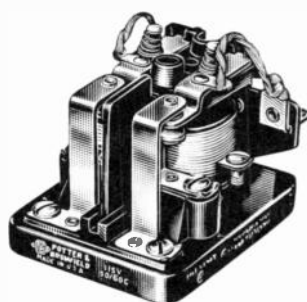
CD-38

**SOLID STATE TIME DELAY**—You get excellent timing characteristics in these knob-adjustable solid state relays. Timing range: 0.6 to 60 seconds. AC or DC models. Internal DPDT relay rated at 10 amperes, 115V AC resistive. For continuous duty over temperature range of  $-40^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ .



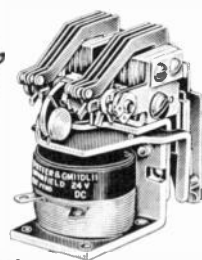
KHP

**COMPACT FOUR-POLE RELAY**—Small, rugged 4PDT relay designed to meet exacting requirements of data processing, computer and process control applications. Rated at 3 amperes at 30V DC or 115V AC resistive. Solder terminals. Special sockets have printed circuit or solder lug terminals. Also available hermetically sealed.



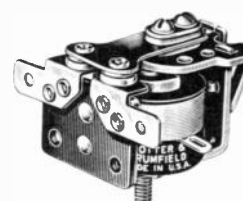
PR

**POPULAR 25 AMPERE POWER RELAY**—Compact, heavy-duty power relay listed by U/L and CSA. Screw terminals and rugged construction suitable for industrial application requiring reliability and long life. AC or DC models.



GM

**VERSATILE IMPULSE/SEQUENCING RELAY**—Unusual single-coil relay can be used to latch, step, count and switch in sequence. Switching occurs during drop-out for greater reliability. AC or DC models. Contacts rated for 3 amperes. Can also be furnished with uni-directional printed circuit boards having 10 or 12 switch positions.



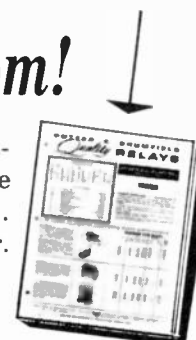
KR3-H

**SMALL RELAY SWITCHES 20 AMPERES**—Three KR3-H relays will fit in space required for most other 20-ampere relays. Mechanical life exceeds one million operations and twin contacts are rated at 20 amperes at 115V AC, 60 cycles resistive or 28V DC, 1 HP 115/230V 60 cycles. Contact terminals will accept  $\frac{1}{4}$ " quick-connects or solder connections. Contact arrangement: SPST-NO-DB.

## ...and there are 60 other types to choose from!

Chances are, you'll save both time and money when you order standard P&B relays from an authorized distributor. You'll get speedy service at factory prices. Your P&B distributor has available more than

60 basic relay types totalling 627 coil voltages and contact arrangements. All are shown in our new Stock Catalog 100 . . . free from your electronic parts distributor. Ask for a personal copy today.



### POTTER & BRUMFIELD

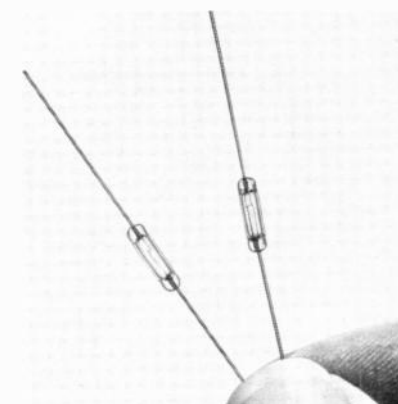
Division of American Machine & Foundry Company, Princeton, Indiana  
Export: AMF International, 261 Madison Avenue, New York, N.Y.

Speed Inquiry to Advertiser via Collect Night Letter  
ON READER-SERVICE CARD CIRCLE 44

## COMPONENTS

### Magnetic reed switch

The MMRR-2, a micro-miniature, single pole, form A reed switch has a glass length of 0.375-in. max., glass diameter of 0.090-in. max., and overall lead length of 2-in., which can be trimmed to overall length of 0.5-in. Actuating time, with normal overdrive, is only 0.5 msec average, including bounce so it can follow up to 300 cps. Resonant frequency of



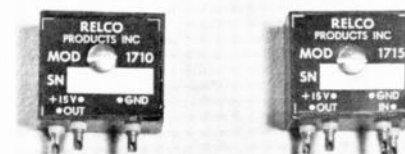
reeds is about 4.5 Kc. The open contact capacitance is approximately 0.25 pf and initial contact resistance is 300 milliohms max. at 150% overdrive. Minimum breakdown voltage is 250 vdc. and contact rating is 10 vdc, 0.010 amp.

Hamlin Inc., Lake & Grove Sts., Lake Mills, Wisc. Phone: (414) Lake Mills 208. TWX: (414) 953-4752.

ON READER-SERVICE CARD CIRCLE 780

### Temperature transducers

A pair of miniature temperature to voltage transducers meet applications in aerospace and control systems. The transducers provide coverage of the  $-50$  to  $\pm 150^{\circ}\text{C}$  range with an accuracy and linearity better than 0.05%. Sensitivities range for 40 to 200 mv/ $^{\circ}\text{C}$ .



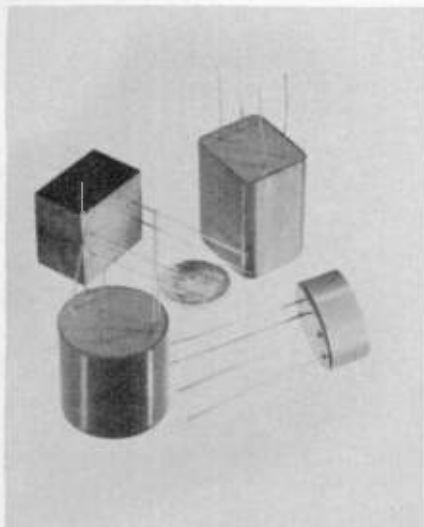
P&A: \$95-\$135; 2-3 weeks. Relco Products, Inc., 5594 E. Jefferson Ave., Denver, Colo. Phone: (303) 756-1143.

ON READER-SERVICE CARD CIRCLE 781

### Dc to dc converter

A series of miniature dc to dc converters include a remote sensing lead, allowing the amplifier to sense the exact voltage at the load. This eliminates loss of regulation due to long feed lines.

The series of units offers output



voltage between 5 and 100 vdc at up to 100 ma with an input voltage of 28 vdc  $\pm 4$  vdc. Line and load regulation is 0.1% or better.

These are solid-state devices incorporating silicon transistors and diodes and 1% metal film resistors in a welded cordwood package.

P&A: \$70 to \$170; 2 to 3 weeks. Electronic Modules, Inc., 2560 East Foothill Blvd., Pasadena, Calif. Phone: (213) 795-4231.

ON READER-SERVICE CARD CIRCLE 782

### Precision dials

A precision dial, knob, and hub are included in Models D-1 and D-2.

Featuring 360 divisions, 0° through 360°, the Model D-2 is only 4 inches in diameter. Model D-1 with 2-1/2 inch diameter has 180 divisions. Accuracy is within 6 minutes-of-arc for both models. They are equally applicable to drive or driven applications.

P&A: \$12; stock. Theta Instrument Corp., Saddle Brook, N. J. Phone: (201) 487-3508. TWX: (201) 488-9452.

ON READER-SERVICE CARD CIRCLE 783

Speed Inquiry to Advertiser  
via Collect Night Letter ➤

ON READER-SERVICE CARD CIRCLE 222 ➤

Here's Lucky Item #13 in the Fluke '65 Pacesetter Line

Accuracy  $\pm 0.0025\%$ . Maximum meter resolution, 0.1 ppm. Fourteen pounds later you have the new solid-state Fluke 885 DC Differential Voltmeter, the first truly portable laboratory standard. Peak-to-peak reference stability is 15 ppm for 60 days. Use the Fluke 885 as an isolation amplifier. Grounded recorder output is so well isolated that a short-circuit at the output produces no voltmeter reading error. Ground loops are completely eliminated when the battery powered Model 885AB is used.

Other Specifications: Range, 0 to 1100 Volts. Null sensitivity, 100 microvolts full scale. Line regulation better than 2 ppm.

No zener oven, less than 30 seconds warm-up time.

Cabinets can be half rack or full rack mounted with optional mounting kits.

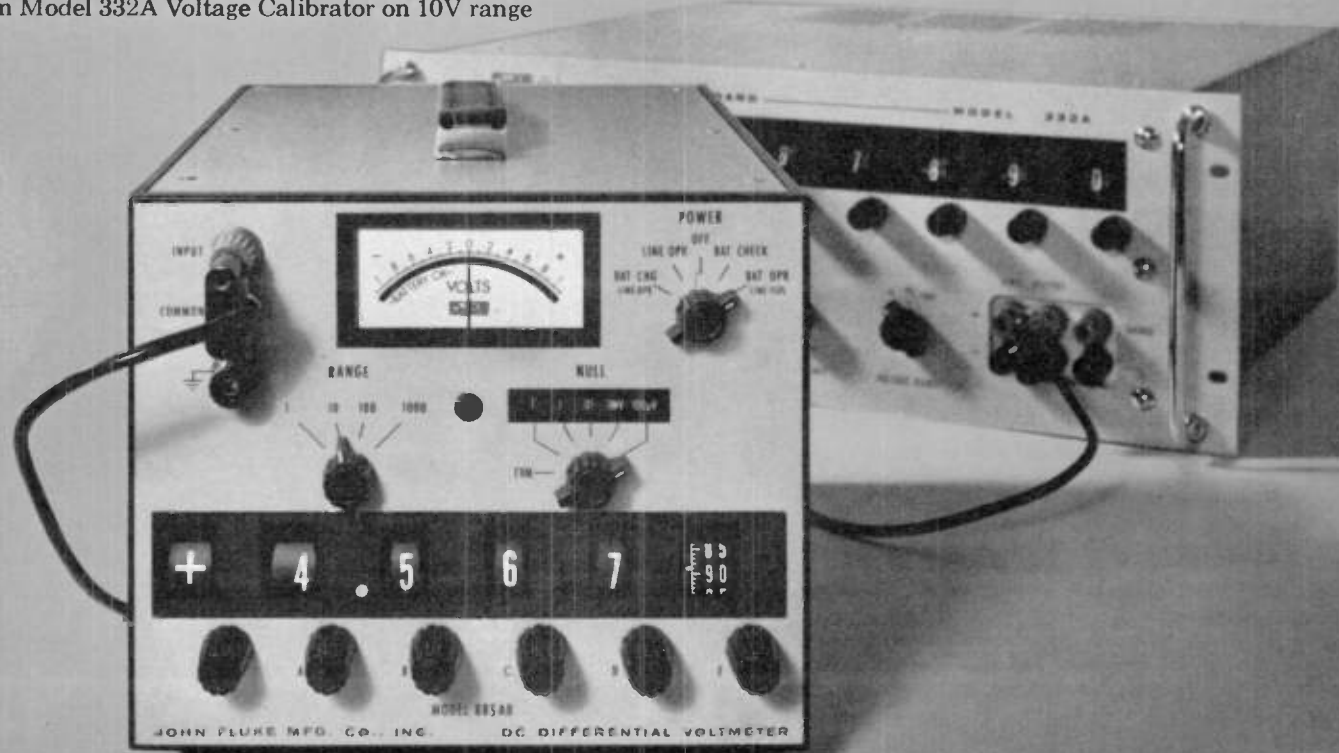
Price of the Model 885A line cord version is \$1,195.

The battery powered Model 885AB is \$1,325.



FLUKE • Box 7428 • Seattle, Washington 98133 • Phone: (206) PR 6-1171 • TWX: (910) 449-2850

Model 885A reading precise voltage  
from Model 332A Voltage Calibrator on 10V range





# VACUUM+ CERAMIC



## JENNINGS TYPE

Operating Voltage (16 mc)  
Test Voltage (60 cycle)  
Continuous Current (16 mc)  
Interrupting Rating  
(dc resistive loads)  
Weight (oz.)

## RF10A

10 KV Peak  
20 KV Peak  
30 Amps RMS  
50 KW  
(up to 5 amps or 10 KV)  
16

## RJ2A

8 KV Peak  
18 KV Peak  
15 Amps RMS  
1 KW  
(up to 1 amp or 1 KV)  
3

## RJ1A

2 KV Peak  
5 KV Peak  
7 Amps RMS  
1

Vacuum plus ceramic adds up to a new line of Jennings vacuum relays that brings you (1) High voltage hot switching capability (2) Highest RF current carrying ratings (3) Shock resistance (4) Small size and light weight (5) Greater reliability (6) Low unchanging contact resistance.

These new relays eliminate the necessity to redesign circuits in order to avoid difficult switching problems. Now small lightweight systems can be designed in the sure knowledge that the new Jennings vacuum relays offer as much as or more reliability and high performance than any other component in the circuit.

The RF10A relay features high power dc interrupting capability up to 50 KW.

The RJ2A and RJ1A are essentially rf relays capable of withstanding high voltage and carrying high rf currents. Even so the RJ2A will interrupt a rather remarkable 1 amp at 1000 volts for many thousands of operations.

Jennings also offers many glass vacuum relays, each designed to provide maximum performance to the particular segment of the electronic field for which they were created.

Our new catalog 102 describing our complete line of vacuum relays is available at your request.

Jennings Radio Manufacturing Corporation — Subsidiary of International Telephone and Telegraph Corporation, 970 McLaughlin Avenue, P.O. Box 1278 San Jose, California 95108.

**ITT Jennings**

ON READER-SERVICE CARD CIRCLE 45

## SEMICONDUCTORS

### MOS FET "quiet" at uhf; 12 db gain with 4 db noise

A new insulated gate field-effect transistor delivers 12 db gain with only 4 db noise while operating at 450 Mc. This N-channel depletion device from KMC Semiconductor Corp., Long Valley, N. J., is designated K1201. It is a companion to the vhf-level K1001, the first commercially available MOS.

The fabrication technique and geometry in the new device is a variant of those used to assure commercial stability and repeatability in the K1001 (see diagram). Increased frequency capability is attained through a simple reduction in physical dimensions. The package has a standard TO-18 outline and is provided with four leads.

Applications are expected to be in such areas as communications equipment for both commercial and military needs.

Other applications include the areas of agc, mixer and modulator circuitry, according to the manufacturer.

Since this transistor is designed primarily as a uhf amplifier, broadband capabilities are also an impor-

tant consideration. At reduced gain useful operation as low as 30 Mc has been reported. But at these levels the older K1001, or a standard hf transistor, is still the best choice. At 225 Mc, around the upper limit of the K1001, gain of the K1201 is about 16 db, the characteristic slope being about 6 db per octave. Like all MOS devices, input impedance is inverse to the operating frequency and must be compensated for.

P&A: \$43; 2-3 weeks. KMC Semiconductor Corp., Parker Rd., RD. 2, Long Valley, N. J. Phone: (201) 876-3811.

#### K1201 specs at 450 Mc

Power gain: 10 db min  
Transconductance: 2500 typical  
Noise: 4.5 db max  
Cross modulation: 1% at 30 mv

$R_{in}$ : 1.2 K

$C_{in}$ : 2.5 pf

$R_{out}$ : 1.9 K

$C_{out}$ : 1.5 pf

$C_{gd}$ : 0.35 pf

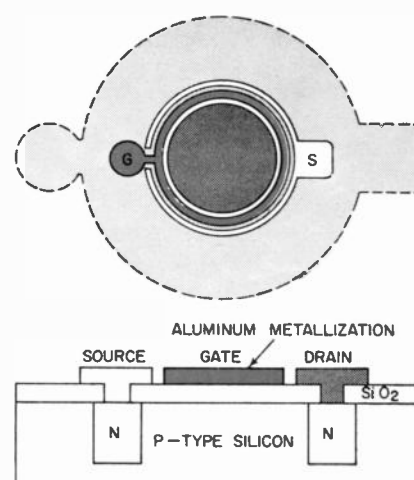
(biased  $V_{ds}$  9.0 v and  $I_{ds}$  3 ma)

### Low-voltage transistors give high vhf gain

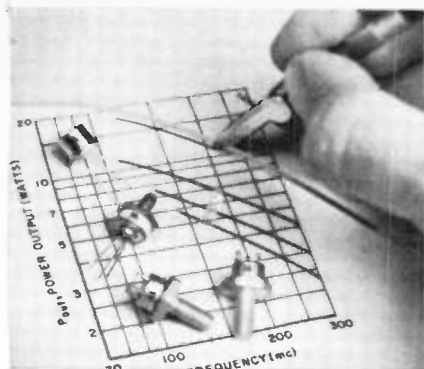
Operating from standard 13.6-v power sources, the 2N3924 through 2N3927 meet large-signal amplifier and driver applications at frequencies from 50 to 300 Mc. The line offers the user a choice of 4, 5, 7, or 12-w outputs at 175 Mc.

Triple-diffusion, rather than epitaxial material, is used to provide a larger safe-operating area in these silicon annular devices. A multiple-emitter configuration gives both large current-carrying capacity and low capacitance.

Package design is matched to the power rating of the individual device. The 4-w 2N3924 is mounted on a standard TO-30 case; the 5-w



Smaller, higher in frequency, the K1200 MOS FET is half the size of its vhf counterpart. A cross-section of the left half of the top drawing shows deposition details.



2N3925 is mounted in the Motorola 102 isolated stud package; and both the 7-w 2N3926 and the 12-w 2N3927 are in the isolated stud TO-60.

Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900.

#### 2N3924-27 specs at 175 Mc

Type	power out	db gain	price
2N3924	4 w	6.0	\$ 5.95
2N3925	7 w	5.4	\$ 9.80
2N3926	5 w	5.8	\$15.95
2N3927	12 w	4.8	\$22.80

ON READER-SERVICE CARD CIRCLE 770

#### Mixer diode operates S-band; 5 db noise

Operating across the L- and S-bands, the C-51 mixer diode is said to provide the lowest noise figure of any available diode for this purpose, 5 db maximum. It is also designed to operate up to 4 Gc with no more than 0.5 db degradation.

Principal specifications include a power-handling rating of 500 mw, a LO power of 5 mw maximum 0.5 mw minimum, and a typical IF impedance of 100 to 300 ohm.

In a typical test set-up, a 2 Gc LO was used to obtain a 30 Mc IF. LO power was the minimum 0.5 mw, load resistance was 100 ohm and signal vswr was 1.2. Resulting noise figure was found to be 1.5 db.

A mixer mount, custom-designed for the C-51 diode is also available. The unit is offered in single and double-ended configurations and can be used with 160 Mc IF amplifiers. Its RF coverage is 1 to 2 Gc.

P&A: \$20 in 1-9 quantities; stock. American Electronic Labs., Box 552, Lansdale, Pa. Phone: (215) 247-0115.

ON READER-SERVICE CARD CIRCLE 771

ON READER-SERVICE CARD CIRCLE 223 ➤

It'll pay you in the long run. You see, Indiana General has the manufacturing equipment and know-how to offer you a better deal on 09, 13, 15, 19, 29, and 40-frame motors. Our engineers have an almost uncanny ability to group motors into family purchases—standardized frame sizes with varying armature and field lengths. Makes for a lot of cost-saving interchangeable parts. And a reason why we can offer motors at such

a surprisingly low price—particularly on large orders. As for quality, Indiana General motors are currently used in many aerospace applications where MIL SPEC precision is essential. Some are tucked into nose cones of missiles as tape recorder drives, others are used as activating devices in missile launchers. But don't overlook the less exotic uses. Our motors are specified for things like reel drives in computers, antenna drives,

or motors to help cool communication equipment. Just give us a chance to quote you. Then, do a job for you. Write to Indiana General Corporation, Electro-Mechanical Division, Oglesby, Illinois, for descriptive literature on our standards. And come fly with us. People like Collins, Admiral, and Grimes already do.

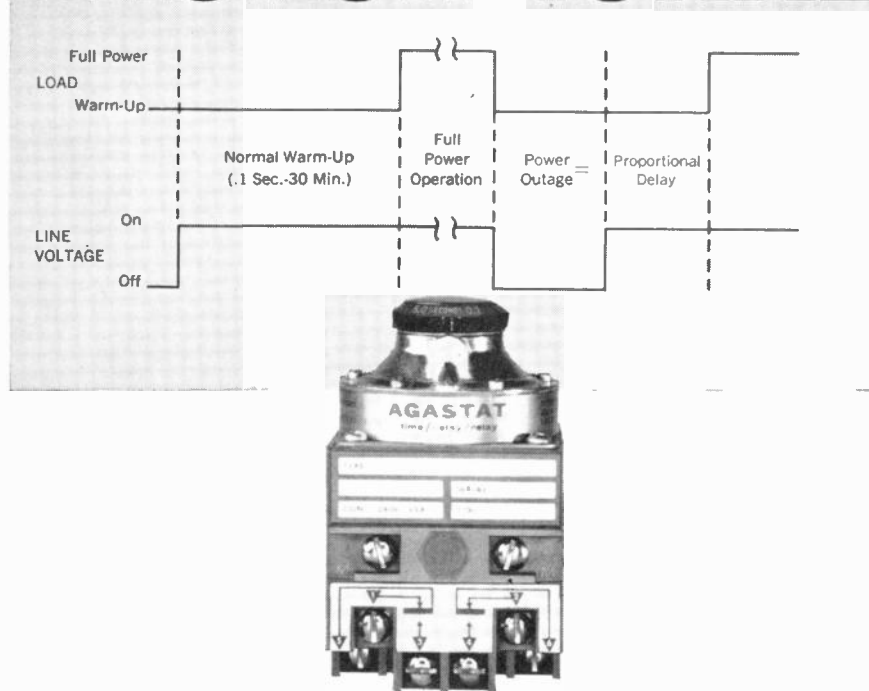
**INDIANA GENERAL** 

## Fly on the economical family plan with Indiana General precision motors





# PROPORTIONAL



The new AGASTAT® Proportional time/delay/relay is the only timing device that offers automatic proportional compensation for time lost during power interruptions.

It is particularly suited for controlling equipment which requires a "warm-up" period at reduced voltage before full power is applied. After full power operation has started, it automatically provides proportionately shorter warm-up periods in the event of brief power interruptions.

In effect, the unit monitors the duration of the outage, and tailors the length

of the subsequent delay to match the "off" time. The equipment is thus returned to service in the shortest possible time, with maximum safety.

This unique model of the 2400 electro-pneumatic Series is available for operation on most popular ac and dc voltages, with time-calibrated adjustment dials in ranges from 0.1 second to 30 minutes. Proportionality (normally 1:1) may be varied on order.

For detailed information, write to the leader in time/delay instrumentation for over 30 years. Department A32-412.

## AGASTAT TIMING INSTRUMENTS

ELASTIC STOP NUT CORPORATION OF AMERICA  
ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

IN CANADA: ESNA LIMITED, 271 PROGRESS AVENUE, SCARBOROUGH, ONTARIO

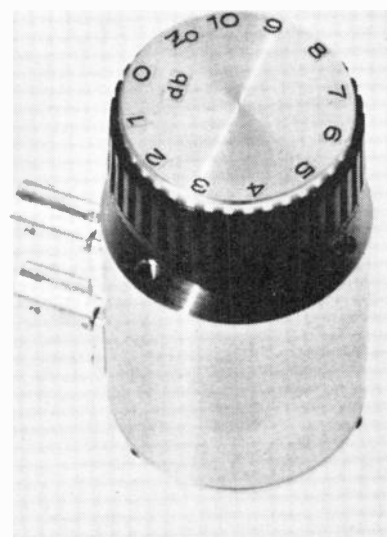
Speed Inquiry to Advertiser via Collect Night Letter

ON READER-SERVICE CARD CIRCLE 46

## MICROWAVES

### Rotary attenuators

The RA-50 and RA-51 miniature rotary attenuators operate in the dc to 2 Gc range. The RA-50 provides 0-10 db attenuation in 1 db steps with an additional step position for a 50-ohm line termination while the



RA-51 provides 0-70 db in 10 db steps.

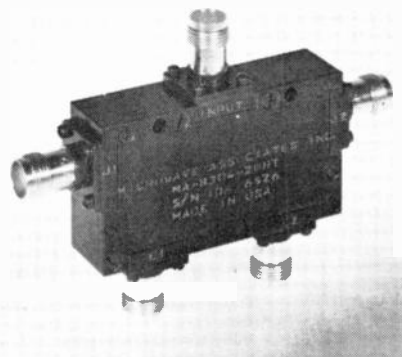
Both attenuators are designed for panel mounting. They use precision film resistor elements and silver contacts throughout. Vswr is less than 1.2:1 at 1 Gc and less than 1.5:1 at 1.5 Gc. Accuracy is  $\pm 0.3$  db at 500 Mc and  $\pm 0.5$  db at 1.5 Gc.

P&A: \$80.00; stock. Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7351.

ON READER-SERVICE CARD CIRCLE 772

### Coax diode switches

Two SPDT coax diode switches for IFF systems handle 5 Kw and 100 w peak-power. The two



models, the MA-8306-2L21N and MA-8305-2L15S, have 200-nano-second switching time. Maximum insertion loss is 0.7 db and 0.5 db, and minimum isolation for both is 25 db. The 5-Kw unit weighs 8 oz.; the 100 w unit 3 oz.

These switches are designed for interrogator sidelobe suppression (ISLS) systems with directional and omni-directional antenna lobbing.

Microwave Associates, Inc., Burlington, Mass. Phone: (617) 272-3000. TWX: (617) 272-1492.

ON READER-SERVICE CARD CIRCLE 773

### Tunable bandpass filters

The new A12400 series of microwave filters feature low loss and high selectivity. They are tunable in octaves or complete waveguide bands between 12 Gc and 40 Gc with 3 db bandwidths ranging as high as 250 Mc.

These devices have individually tunable micrometer adjustments



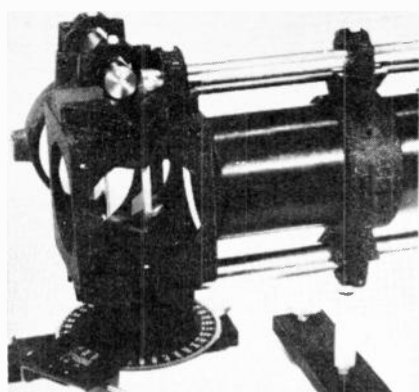
for 2, 3 or 4 sections, calibrated for discrete frequencies over the band of each unit. Maximum insertion loss over the band is 1 db with a maximum vswr of 1.5:1. Bandwidths are constant over the tuning range within 20%.

P&A: about \$2000; 45 days. Frequency Engineering Labs., Farmingdale, N. J. Phone: (201) 938-9221. TWX: (201) 938-2456.

ON READER-SERVICE CARD CIRCLE 774

### Optical system

A set of optical "building blocks" is designed for projects



involving the construction of equipment requiring precisely adjustable beam splitters or folded optical paths, particularly laser systems. Over thirty different modules are available in the set.

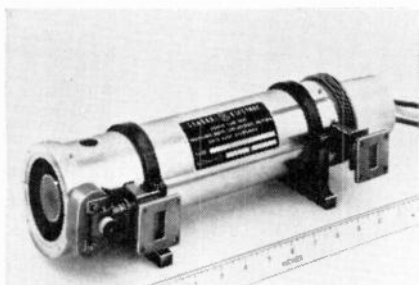
Instruments Unlimited, Inc., 222 Martling Ave., Tarrytown, N. Y. Phone: (914) 631-0573.

ON READER-SERVICE CARD CIRCLE 775

## 10 Kw X-band TWT

A 10-Kw grid-pulsed X-band TWT weighs 14 pounds and measures 15.5-in. long.

The air-cooled type ZM-3280 has a gain of 40 db. Output exceeds 10 Kw from 8.5 to 9.6 Gc. Typical operation is at 22.5 kilovolts and 4.7



amp cathode current. A liquid cooled version, type ZM-3281, is also available.

General Electric Co., Schenectady, N. Y. Phone: (518) 374-2211.

ON READER-SERVICE CARD CIRCLE 776

## Stripline connector

A surface-mounting jack receptacle with performance through 10 Gc features matched impedance.

The new stripline receptacle, designated 50-856-0039, has a vswr of 1.05:1 maximum through 10 Gc when properly loaded. These low loss connectors can be mated with

# BIG = 200 small

**BIG:** Big performance, big economy.

**small:**  $\frac{5}{8}$ " 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.

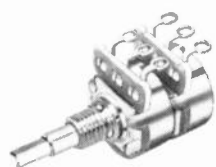
**Resistance Range:** 200 ohms through 5 megohms.

**Availability:** 3-6 weeks in quantity. CTS has the industry's largest output of controls.

### New Constructions



Straight Tandem  
Solder Lug Terminals



Concentric Tandem  
Solder Lug Terminals



Straight Tandem  
P. C. Terminals



Concentric Tandem  
P. C. Terminals

Sample constructions showing Series 200 versatility  
(Many other combinations available.)



Basic 200 Control  
Ear Mounted



Rear Extended Shaft  
Bushing Mounted



ND On-Off Switch  
Bushing Mounted



Q On-Off Switch  
Ear Mounted



Basic 200 Control  
Bushing Mounted



Rear Extended Shaft  
Ear Mounted



Mounted with Shaft  
Perpendicular to  
Panel



ND On-Off Switch  
Shaft Perpendicular  
to Panel



Q On-Off Switch  
Bushing Mounted



Founded 1896

**CTS CORPORATION**  
Elkhart, Indiana

Sales Offices and Representatives conveniently located throughout the world.

### Principal Products

Variable Resistors  
Selector Switches  
Loudspeakers  
Trimming Potentiometers  
Fixed Resistor Micromodules  
& Microelectronic Circuitry  
Crystals, Filters,  
Oscillators & Ovens

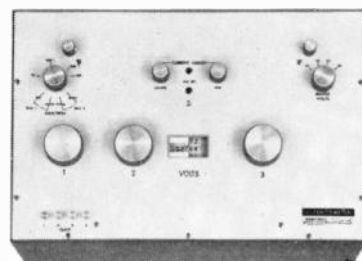
### Subsidiaries

CTS of Asheville, Inc., Skyland, N.C.  
CTS of Berne, Inc., Berne, Indiana  
CTS of Paducah, Inc., Paducah, Ky.  
Chicago Telephone of California, Inc.,  
South Pasadena, Calif.  
CTS of Canada, Ltd., Streetsville, Ontario  
CTS Microelectronics, Inc., Lafayette, Ind.  
CTS Research, Inc., Lafayette, Ind.  
CTS Knights, Inc., Sandwich, Ill.

ON READER-SERVICE CARD CIRCLE 47

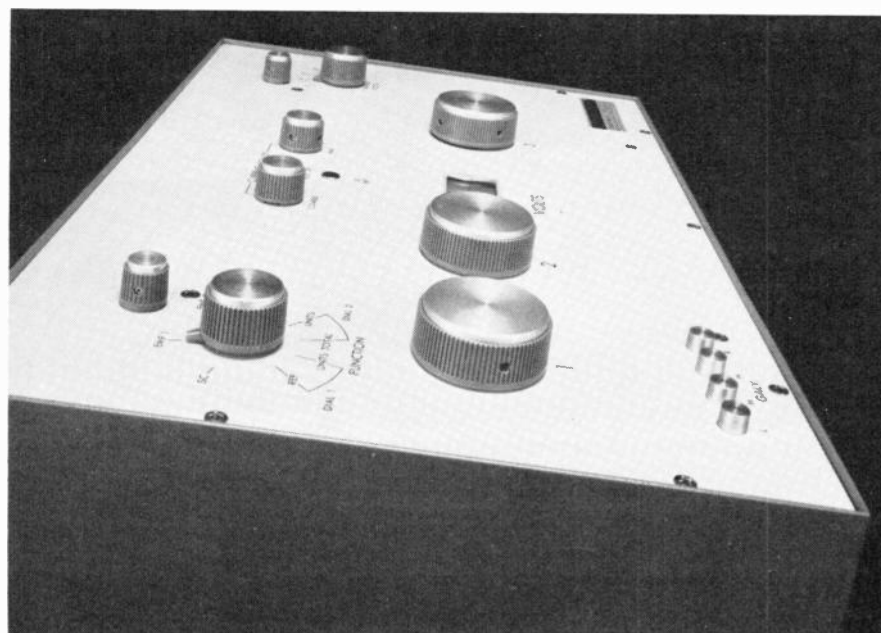


Twice as accurate  
as any potentiometer  
in its price class



Half the price  
of any potentiometer  
in its accuracy class

# Here's the biggest news in potentiometers in 10 years!



It's the all-new Model 2784 Laboratory Potentiometer from Honeywell! We invite you to check specs and prices on all other pots—you'll find that only instruments costing three to four times as much offer the features built into the new 2784. Features such as:

**Extremely High Accuracy**—.002% at the one volt range. Most other pots in the 2784's price range are .01% accurate.

**Wide Range**—From 0 to 11.110 volts, with a resolution of 5 ppm. The 2784 is the first extended range pot from a major manufacturer.

And, its range is direct—no voltage dividers are used.

**Versatile**—Low temperature coefficient design lets you use the 2784 as a laboratory potentiometer or a production calibration instrument.

**Completely Self-Checking**—Another first for instruments in this price range.

**Total Double Guarding**—The 2784 is the first potentiometer in any price class to offer guarding of all measuring system devices.

**Smooth Performance**—Because it uses a non-convoluted slide wire,

you get infinite resolution on the wire... not the bumpy, discontinuous measurements produced by a convoluted slide wire.

**Low Thermal EMF's**—Less than .1 microvolt; residual EMF's are well within the 2784's limits of resolution.

In addition, the new Model 2784 offers recessed terminals; automatic decimal point location; single window in-line readout; printed circuitry; very low temperature coefficient; main dial standardizing; correctable auxiliary output, and dual EMF input.

Call your nearby Honeywell representative or mail this coupon today for complete technical specifications on the new Honeywell Model 2784 Laboratory Potentiometer.

**Carl Boyer**  
Honeywell, Denver Division  
Mail Station 414  
Denver, Colorado 80217

Please send literature on the Model 2784 Potentiometer to:

Name \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

**DATA HANDLING SYSTEMS**  
**Honeywell**

ON READER-SERVICE CARD CIRCLE 48

## MICROWAVES

the manufacturer's type 50-807-3141 which accommodated RG 141/U, RG 142B/U, and other similar cables.

Performance specifications include an operating temperature range from  $-65^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Contact current rating is 1.5 amp dc maximum, and contact voltage drop is 4 mv maximum @ 1 ampere.

Sealelectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

ON READER-SERVICE CARD CIRCLE 777

## Reflex klystrons

A minimum of 1 w is delivered by reflex klystrons in the VA-297 series over a 500-Mc frequency range between 7.5 and 10.7 Gc. RF output



is through a special flange attached to a heat sink on RG-52/U waveguide.

Beam voltage of the VA-297A unit is 750 vdc at current of 74 to 76 ma. Reflector voltage is  $-250$  to  $-500$  vdc under typical operating conditions.

Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

ON READER-SERVICE CARD CIRCLE 778

## Rf coax attenuator

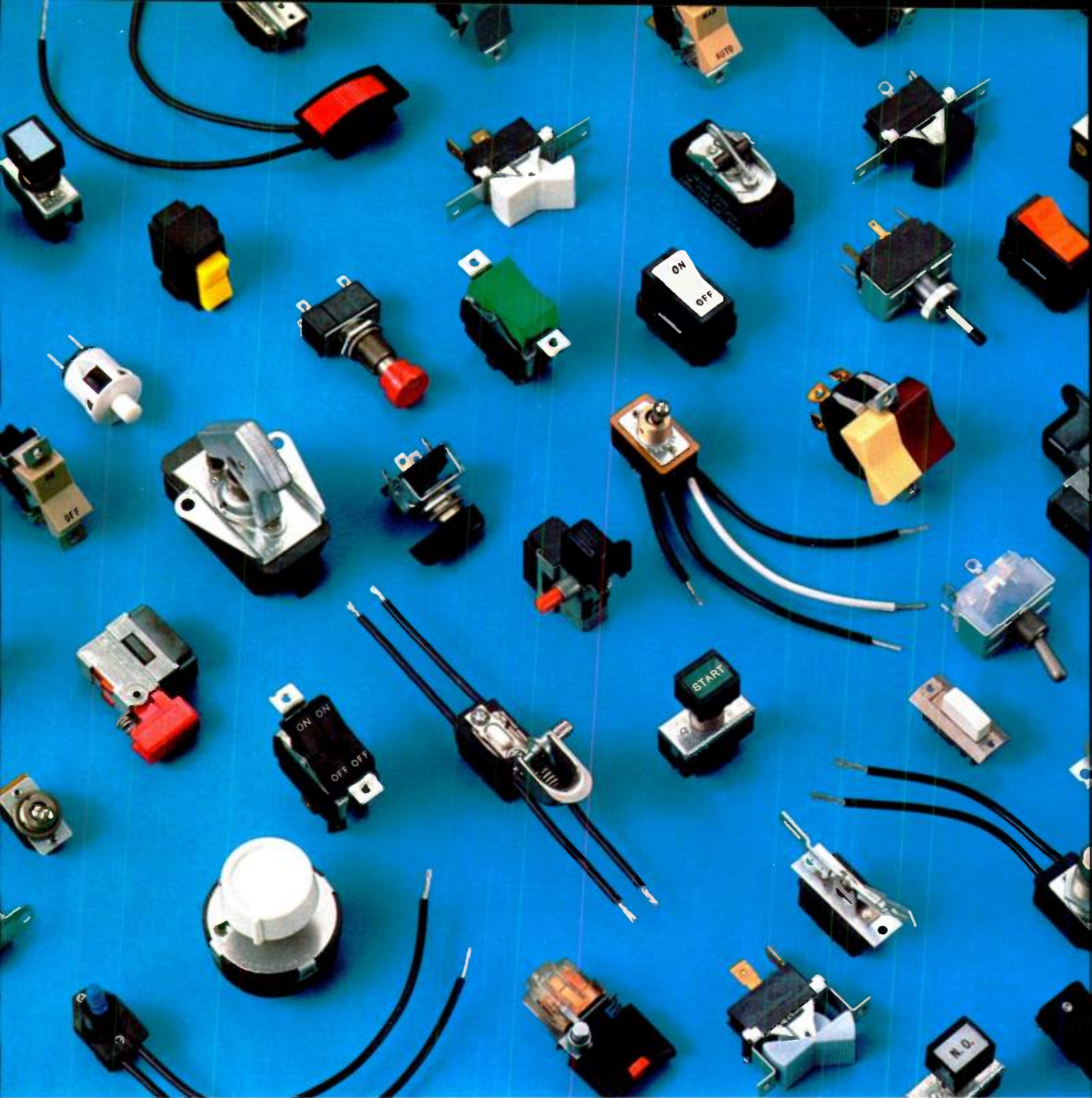
A 2-w average power rating and 1 Kw peak at 5  $\mu\text{sec}$  max pulse width are the leading feature of the 93713 attenuator. Frequency range is dc to 3 Gc with 50 ohm impedance. At values of 10 db and above, vswr is 1.2 max.

Tamar Electronics, Stoddard Electro Systems Div., 2045 W. Rosecrans Ave., Gardena, Calif. Phone: (213) 770-0270.

ON READER-SERVICE CARD CIRCLE 779

ON READER-SERVICE CARD CIRCLE 247 ➤





## All these switches will fail... but only after everything else does!

Everything? Well, that's not overstating it by much.

Because we build a little extra performance into every Cutler-Hammer switch... adding just enough "extra" to make sure our switch is an asset to your product—no matter what your product is.

But there's more to consider when you're

analyzing the Cutler-Hammer "value package."

There's engineering help: if you can't find your switch among the thousands we make... we'll *build* one for you. And fast!

There's coast-to-coast service that includes balanced stocks of standard switches backed by specialized distributors in every major city—supported by 81 sales engineering offices.

How about a 32-page catalog with complete descriptive information, electrical and mechanical details, terminals, mounting variations and ordering data on hundreds of switches? Ask your Cutler-Hammer Distributor. Or write for Publ. LJ-121 to Milwaukee, Wisconsin 53201.



**CUTLER-HAMMER COMMERCIAL SWITCHES** / ENGINEERED FOR VALUE

World Radio History



CUTLER-HAMMER



Daystrom Trimmers are built to take punishment, can easily handle your humidity requirements. The units in the beaker are just a few of the models from industry's broadest line of sub-miniature square trimming potentiometers. They're available with or without stops in commercial as well as military models. For your special designs, they're supplied with humidity proofing which complies with MIL-R-27208A.

The unique resistance element in Daystrom pots is a major factor in their rugged construction and excellent electrical characteristics. This wire-in-the-groove element provides high

resolution, locked-in linearity and low noise. In addition, the units are sealed against sand and dust, are corrosion resistant, and immune to severe vibration and shock.

If humidity is a factor in your designs, you'll want more information on Daystrom pots. Whatever your needs, you'll probably find a standard, off the shelf model in our catalog. See your Weston distributor for your copy, for price lists and evaluation samples.

Weston Instruments, Inc., Archbald, Pennsylvania 18403. Phone: (717) 876-1500. In Canada: Daystrom, Ltd., Cooksville, Ontario.

Only Daystrom's exclusive wire-in-the-groove offers **LOCKED-IN LINEARITY**

#### From Weston's broad trimmer line

**Series 510-00HS Transitrimer TO-5 case.** Slotted adjustment screw. Operation:  $-55$  to  $175^{\circ}\text{C}$ . Range:  $10\Omega$  to  $30\text{k}$ , with or without stops. Rating:  $1.25\text{w}$  @  $50^{\circ}\text{C}$  in still air.



#### Series 313-00HS $\frac{1}{2}$ "

Squaretrim,  $0.187$ " thick, flexible leads. Operation:  $-55$  to  $200^{\circ}\text{C}$ . Range:  $10\Omega$  to  $50\text{k}$ .

Rating:  $1.5\text{w}$  @  $50^{\circ}\text{C}$  in still air. With base pins: Model 318-00HS.



#### Series 210-00HS $\frac{3}{8}$ "

Squaretrim,  $0.150$ " thick, flexible leads. Operation:  $-55$  to  $175^{\circ}\text{C}$ . Range:  $10\Omega$  to  $50\text{k}$ . Rating:  $1.0\text{w}$

@  $50^{\circ}\text{C}$  in still air. With base pins: Model 218-00HS. Side pins: Model 255-00HS.

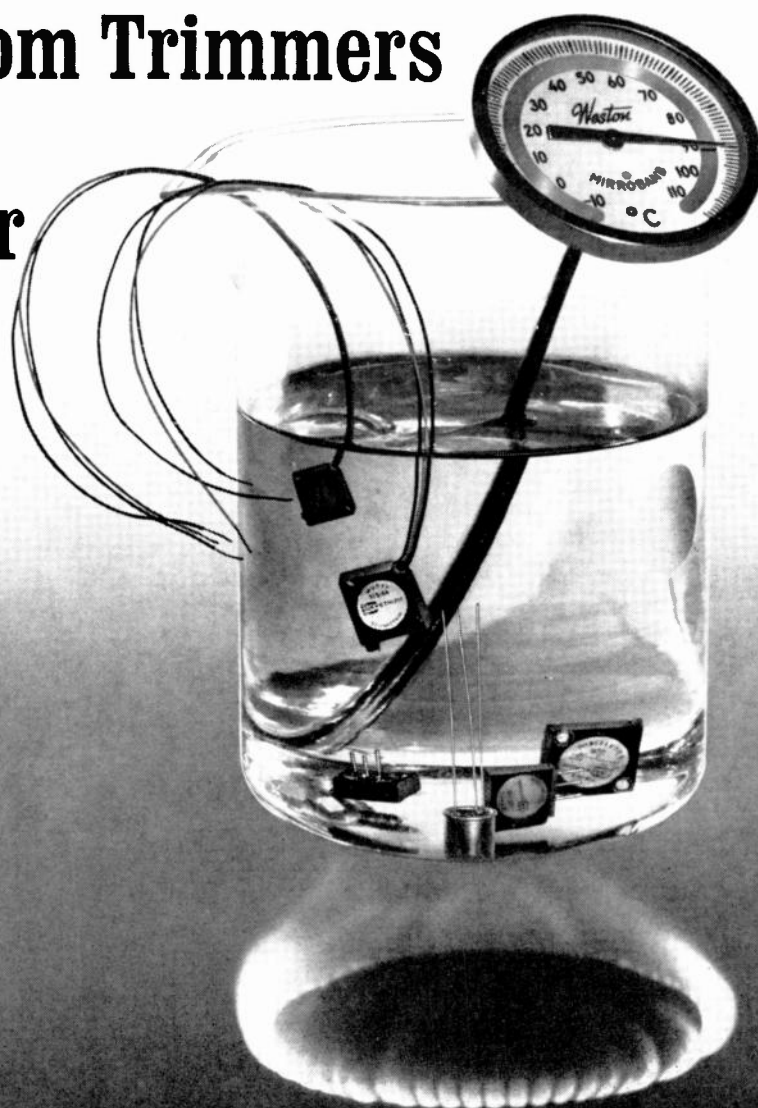
QUALITY BY DESIGN



**WESTON INSTRUMENTS, INC.**

Archbald, Pennsylvania 18403

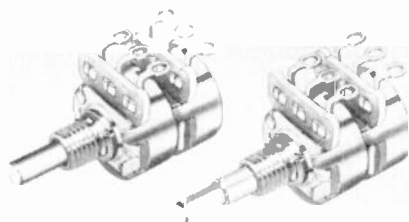
# Daystrom Trimmers are water tight



ON READER-SERVICE CARD CIRCLE 125

## Variable resistor

The 1/4-w, 5/8-in. diameter series 200 variable resistor is available in tandem construction with straight (type 2-200) or concentric (type '2-200) shafts. In addition, newly



designed solder lugs are now available on the complete line of 200 series controls.

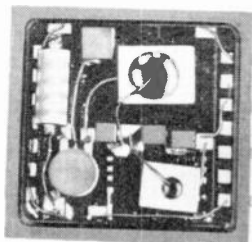
The 200 can be furnished with rear extended or conventional shafts in .125-in. or .156-in. diameters, ear or bushing mounting and various associated switches.

P&A: under 20¢ in quantity for bushing mounted about 16¢ for ear mounted; 3 - 6 weeks. CTS Corp., 1142 W. Beardsley, Elkhart, Ind. Phone: (219) 523-0210. TWX: (219) 522-3121.

ON READER-SERVICE CARD CIRCLE 350

## Hybrid ME preamplifier

A new hybrid microelectronic preamplifier, Model TMS-101 features an input impedance of 4 Meg from 2 Kc to 10 Kc, gain is 20 v/v, output is 500 ohm max, and phase shift is  $\pm 3^\circ$  max. for inputs to 25 mv, and  $\pm 5^\circ$  for inputs from 26



mv to 100 mv. Dimensions of the package are 0.50-in. square by 0.150-in. high.

Solitron Devices Inc., Tappan, N. Y. Phone: (914) 359-5050. TWX: (914) 359-2325.

ON READER-SERVICE CARD CIRCLE 351

# GUDEBROD LACING TAPE CAN SAVE YOU MONEY—



### 1 SPECIAL FINISHES SPEED HARNESSING

Gudebrod has Lacing Tape that almost laces itself—the worker guides it instead of having to fight it. *Work goes fast!*

### 2 BETTER HARNESSES —FEWER REJECTS

Gudebrod Lacing Tape makes proper ties that do not slip. *Saves money on assembly! Saves costly rejects!*

### 3 WORKER SAFETY APPRECIATED

Gudebrod Lacing Tape is easy on the hands, feels good to work with . . . so the work goes better, is faster. *Saves money on harnessing time!*

### 4 GUDEBROD CABLE-LACER *another money saver*

Handle holds bobbin of lacing tape, feeds tape as needed, grips it for knotting. *Speeds harnessing. Has paid for itself in a day. Another money saver.*

Gudebrod Lacing Tape is engineered for the job it has to do—saves money where it counts—in the harness room. More than 200 different tapes in the Gudebrod Line—Write for our Product Data Book!



**GUDEBROD BROS. SILK CO., INC.**

FOUNDED IN 1870

*Electronics Division*



12 SOUTH 12TH STREET, PHILADELPHIA, PENNSYLVANIA 19107

ON READER-SERVICE CARD CIRCLE 49



## COMPONENTS

### Circuit card cage

A 5-1/4 in. cage mounts up to 40 of the manufacturer's Micro Logic cards. Options for solder, wire wrap or taper pin terminations allows complete subassembly and wiring of a removable connector "frame." The basic cage is also available with hinged front panel and provisions for plug-in power supply mounting. A version with retractable slides mounts up to 120 logic cards.

Control Logic, Inc., 3 Stratmore Rd., Natick, Mass. Phone: (617) 655-1170. TWX: (617) 655-0639.

ON READER-SERVICE CARD CIRCLE 352

### Contact adapters

A new device makes possible the addition of manual push button stations where none was originally provided for. Called the TMC series, the units convert sustained spdt contacts of any type to momentary (2 second) ON and OFF operations.

The TMC series can be used with installations controlled by time switches, photocontrols, or other control devices used for automatic ON/OFF programming.

The TMC contacts are wired in series with load contacts of the controlling device. The units have a nominal rating of 12 amp, 277 ac, and are available in 120 v, 240 v, 277 v, and 24 v-50/60 cps.

Tork Time Controls, Inc., Mt. Vernon, N. Y. Phone: (914) 664-3542.

ON READER-SERVICE CARD CIRCLE 353

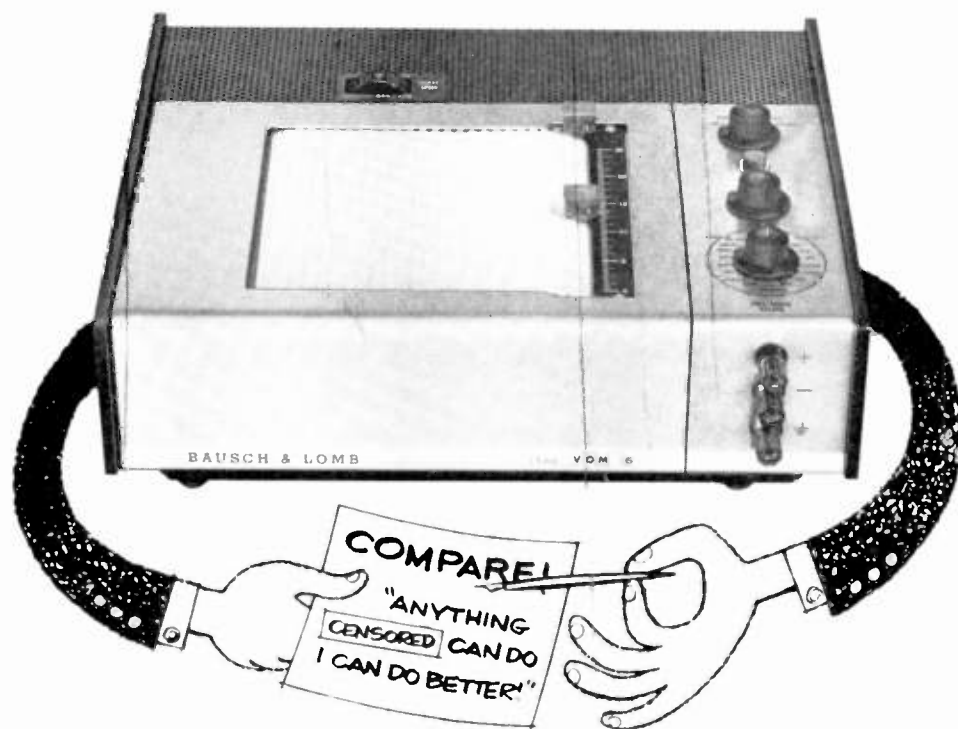
### Binding post/jack

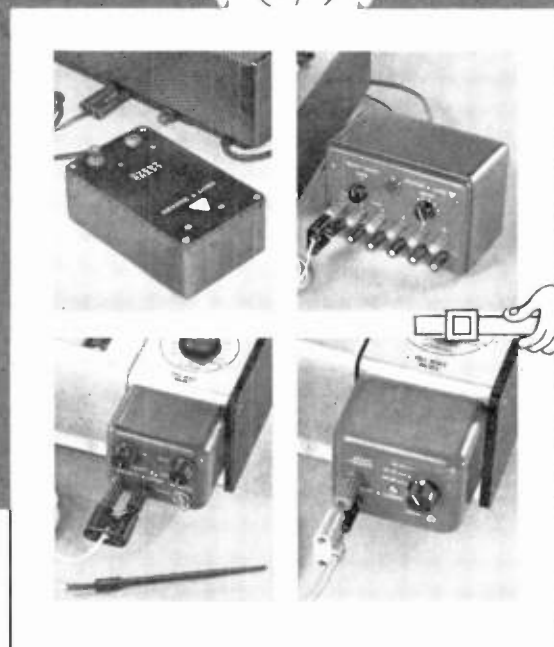
Two binding post and jack assembly combinations are designated part numbers 3284 and 3285. Assembly 32-84 is 1.072-in. in overall length with a .357-in. maximum diameter and is designed to accommodate .040-in. diameter plugs. The 3285 combination is intended for use with .080" plugs and has a 1.484-in. overall length with .500-in. maximum diameter.

The leading feature of these binding posts is that they are designed to accept banana plugs. These posts accommodate meter

*We're into electronics*

**that's why Bausch & Lomb V.O.M.  
ASSURE YOU**





*up to our ears...*

# Recorders outstanding performance!

V.O.M. Recorders are backed by years of experience in engineering the most sophisticated electronic circuitry for a wide variety of precision scientific instruments. An entire division is devoted exclusively to the development and production of electronic products. Result? Outstanding performance and reliability... with exclusive important advantages for you at surprisingly low cost. Like recording multiple inputs... volts, ohms, milliamps... directly, without extra converters. Or the 5 chart speeds, and many more. People who buy them, like them and buy more. The V.O.M. Recorder in use is its own best salesman!

	V.O.M.-5	V.O.M.-6	V.O.M.-7	V.O.M.-8
Voltage range:	10 mv—500 v DC	2.5 mv—125 v DC	0.5 mv—10 v DC	Absorbance / Transmittance Measurement (voltage, current, resistance ranges same as V.O.M.-5)
Current range:	10 $\mu$ a—100 ma	2.5 $\mu$ a—25 ma	1 $\mu$ a—10 ma	
Resistance range:	1 ohm—100 K ohms	0.25 ohms—25 K ohms	1 ohm—100 K ohms	
Prices: (suggested list)	\$595 COMPLETE	\$700 COMPLETE	\$885 COMPLETE	
				\$900 COMPLETE

We also have the capability of designing special recorders... modified to handle whatever applications you wish. For complete information on our standard recorders and the many time-saving accessories available for them, write for Catalog 37-2068. Let us know if you are interested in modification for special needs. Bausch & Lomb, 91524 Bausch Street, Rochester, New York 14602.

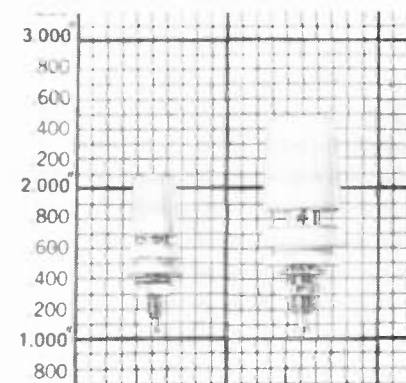
**BAUSCH & LOMB**

ELECTRONICS DIVISION

ON READER-SERVICE CARD CIRCLE 50

December 6, 1965

probes and patch cords directly. Entry is made both axially at the end of the binding post and radially through a side hole. The body acts



as a screwdown binding lock for radial connections.

P&A: \$.60-\$0.77 in quantity; stock. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 876-2800.

ON READER-SERVICE CARD CIRCLE 351

## Dual flip-flop

Product number DFF-S-1 consists of two transistorized flip-flop circuits mounted on a single printed circuit board. As a digital counter stage, it is intended for



use where a low cost component is required to operate below 200 Kc.

The external connections determines whether the module operates in the binary mode (16 counts) or decimal mode (0-9 BCD). Typical specifications include: operating temperature  $-20^{\circ}$  to  $+50^{\circ}$  C; current drain 8.0 ma.

Sparton Corp., Jackson, Mich. Phone: (517) 784-9131. TWX: (517) 787-1966.

ON READER-SERVICE CARD CIRCLE 355

## Amplifier/demodulator

The amplifier-demodulator micro-circuit package, Model TMS-102, uses thin-film techniques. Some of the important characteristics of the circuit include: input





**1 $\mu$ V** RESOLUTION

## MICRO/MILLIVOLT STANDARD\*

EDC's dc Millivolt Standard — with 1 microvolt resolution — is an all-solid-state 5-decade precision source with . . .

**COMPARE  
performance  
..... price**

- **Absolute Accuracy** . . . . .  $\pm 0.01\%$   
(NBS traceability)
- **Outputs (2)** . . . . .  $\begin{cases} 111.110\text{mv} \\ (\mu\text{v steps}) \\ 11.1110\text{v} \\ (100 \mu\text{v steps}) \end{cases}$
- **Stability** . . . . .  $\pm 0.001\%$   
(Short term — 8 hrs)
- **Output current** . . . . . 10 ma
- **Delivery** . . . . . from stock
- **Price** . . . . . \$745

Model MV-100-N a direct reading standard has: automatic recovery . . . short circuit and overload proof . . . warm-up time of 30 sec. Designed as a portable standard for production and laboratory applications, it may be used in: thermocouple simulation; simulation of thermal emf; and in calibration of strip chart recorders, oven controllers, furnace controllers, millivolt meters, strain gauge indicators . . . Weighs only 8 pounds. Traceable certification supplied.

\*Other models to 1000 vdc.

Literature available on request.

**ELECTRONIC  
DEVELOPMENT  
CORPORATION**

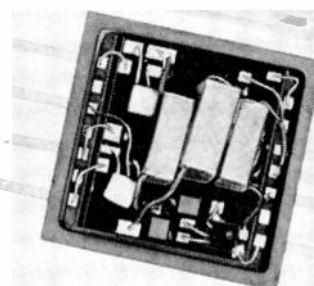


423 WEST BROADWAY • BOSTON, MASS. 02127  
Tel: 617 268-9696

ON READER-SERVICE CARD CIRCLE 51

## COMPONENTS

impedance of  $35K \pm 25\%$ ; gain of 2.6; quadrature rejection ratio of



—26 db; and output noise level of 20 mv rms max.

The package measures only 0.5-in. square by 0.150-in. thick and meets or exceeds the environmental requirements of MIL-E-5272-C and MIL-STD-810-A.

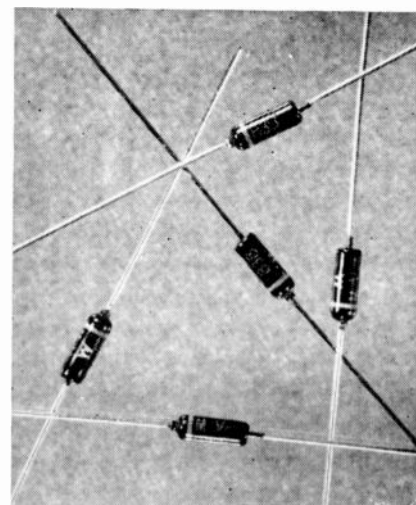
Solitron Devices, Inc., Tappan, N. Y. Phone: (914) 359-5050.  
TWX: (914) 359-2325.

ON READER-SERVICE CARD CIRCLE 356

## Variable capacitors

A series of low-cost voltage-variable capacitors is offered as a replacement for the slower-acting mechanical variable capacitor. Applications cited by the manufacturer include such circuits as VFO, VXO, AFC and FM modulators.

A wide range of capacitor values is available in the new line, ranging from the MV830 with a 4-v capacitance of 15 pf to the MV840 with a



**NEW**



## Smallest Unit Commercially Available

Reeves-Hoffman announces a major breakthrough in oscillator design. Model 52967 is not a laboratory curiosity, but a stable, reliable, rugged, crystal controlled oscillator available now for use in communications and navigation equipment. Designed for printed circuit board mounting, the oscillator is only 0.75 x 1 x 0.562 in. Aging is 3 parts in  $10^6$  per day. The crystal, mounted in a cold-welded holder, is an integral part of the unit. Cost is less than \$50.00 per unit in lots of 100 or more.

**REEVES-HOFFMAN**  
DIVISION OF DCA

400 WEST NORTH STREET, CARLISLE, PENNSYLVANIA 17013

ON READER-SERVICE CARD CIRCLE 52

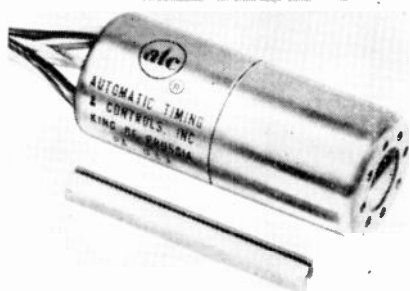
capacitance of 100 pf. All tuning ratios are guaranteed to exceed 2:1.

Price: from \$2.05. Motorola Semiconductor Products, Inc., P.O. Box 955, Phoenix, Arizona. Phone: (602) 273-6900.

ON READER-SERVICE CARD CIRCLE 359

## Differential transformer

A new differential transformer (LVDT) uses a built-in demodulator to give it a dc output. Shielding against strays, quadrature and phase angle considerations, as



well as inability to sum several outputs are said to have been eliminated by this new dc output LVDT.

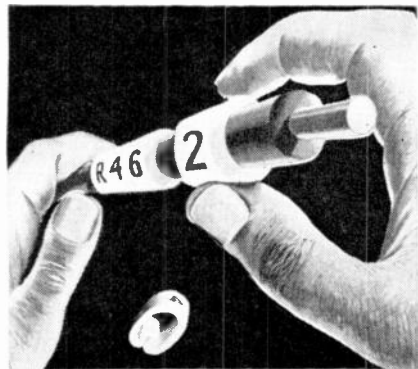
Designated the series 6244 LVDT, the transducer has a 0.1-in. stroke. When excited at rated level (4.2 v rms at 1000 cps), non-linearity is better than 0.1% of full stroke and temperature stability of output voltage is better than 0.1% over the range 0° to 120°F.

Automatic Timing & Controls, Inc., King of Prussia, Pa. Phone: (215) 265-0200.

ON READER-SERVICE CARD CIRCLE 360

## Wire and cable marking

"Z" markers can't peel-off, rub-off, fall-off or unravel according to the manufacturer. Extruded of durable polyvinylchloride (PVC), they will resist abrasion, grease, oils and



ON READER-SERVICE CARD CIRCLE 224 ➤

# Polaroid Land film makes you wait 10 seconds for an oscilloscope picture. The suspense can be unbearable.

We're sorry we can't do anything about that 10-second wait.

But if you can bear up under the strain, you'll get a sharply detailed, high-contrast, trace record.

You can study it, attach it to a report, send it as a test record along with a product shipment, or file it for future reference.

You also get a choice of four films for oscilloscope recording in pack, roll, and 4 x 5 formats.

The standard film has an ASA equivalent rating of 3000. And if you think that's fast, you haven't heard of our special film called Polaroid PolarScope Land film.

With an ASA equivalent rating of 10,000, it's the fastest thing in films. It can actually record a trace too fleeting for the human eye [for instance, a scintillation pulse with a rise time of less than 3 nanoseconds].

Of course, Polaroid Land films are as quick to point out a mistake as they are to point out a success.

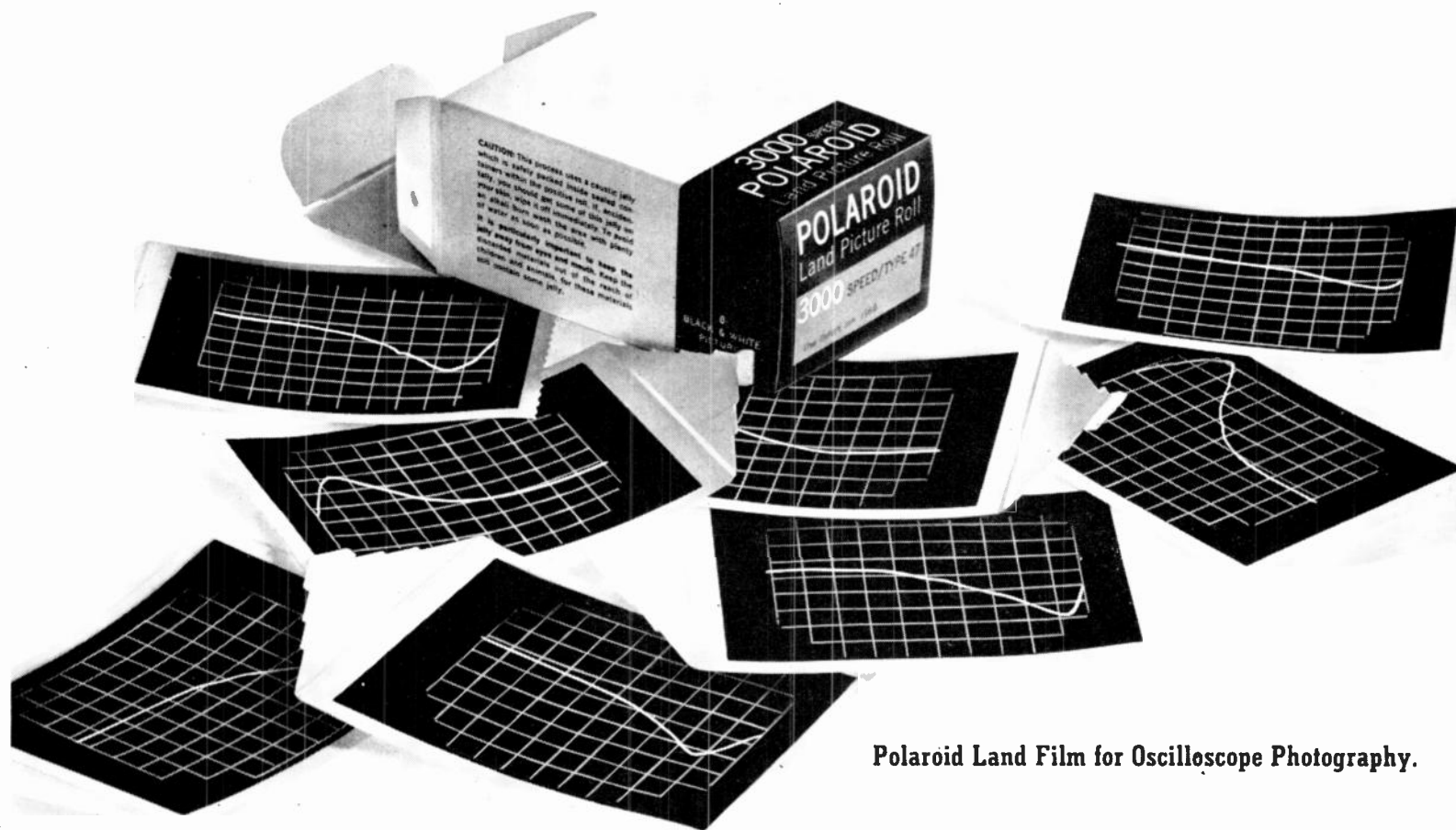
If your trace shows an error, you know it right away. And you never go through the tedium of darkroom procedure only to find out that your blip was a blooper.

To use these films on your scope, you need a camera with a Polaroid Land Camera Back. Most manufacturers have them. Such as: Analab, Beattie-Coleman, BNK Associates, Fairchild, EG&G, General Atomics, Hewlett-Packard, and Tektronix.

You can get complete details by writing to one of these manufacturers or to Polaroid Corporation, Sales Department, Cambridge, Massachusetts 02139.

By the way, if 10 seconds fray your nerves, just imagine what it was like when Polaroid Land film made you wait 60 seconds to see your trace.

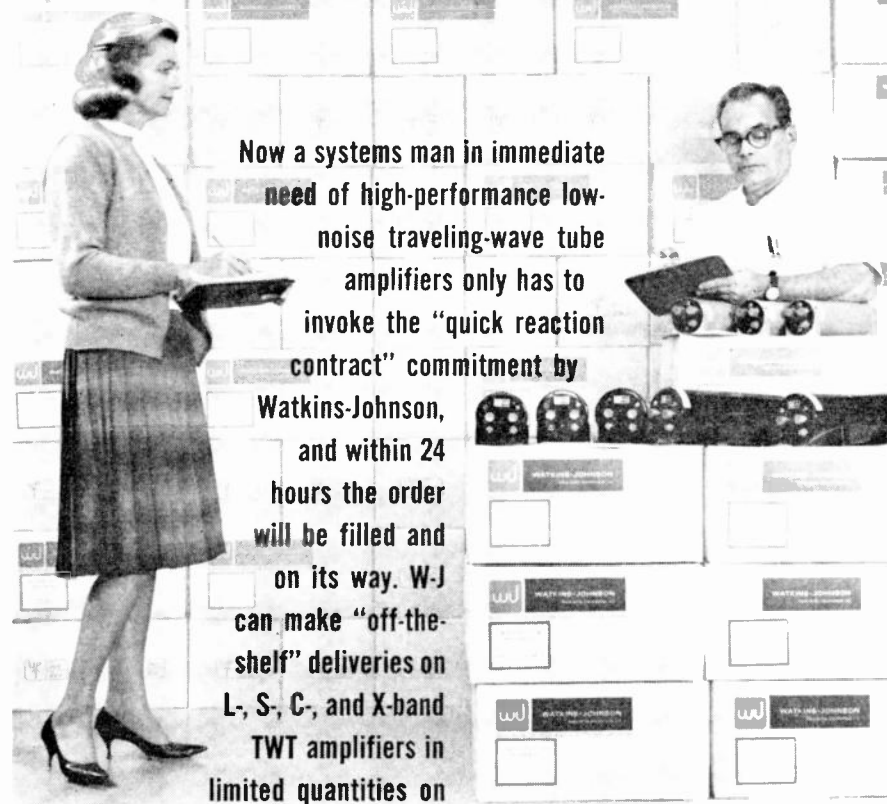
"Polaroid" and "PolaScope"®



Polaroid Land Film for Oscilloscope Photography.



# a QRC Capability



Now a systems man in immediate need of high-performance low-noise traveling-wave tube amplifiers only has to invoke the "quick reaction contract" commitment by Watkins-Johnson, and within 24 hours the order will be filled and on its way. W-J can make "off-the-shelf" deliveries on L-, S-, C-, and X-band TWT amplifiers in limited quantities on short notice—TWX with purchase order number, shipping and billing addresses. All the normal W-J guarantees apply.

We are ready when you are, with the following:

Type	Frequency Range	Maximum Noise Figure
WJ-268	1.0-2.0 GHz	5.0 dB
WJ-269	2.0-4.0 GHz	5.5 dB
WJ-271	4.0-8.0 GHz	6.5 dB
WJ-276	8.0-12.0 GHz	8.5 dB

Information in more detail available from representative in your area, or from Applications Engineering.



3333 HILLVIEW AVENUE  
STANFORD INDUSTRIAL PARK  
PALO ALTO, CALIFORNIA 94304

ON READER-SERVICE CARD CIRCLE 53

## COMPONENTS

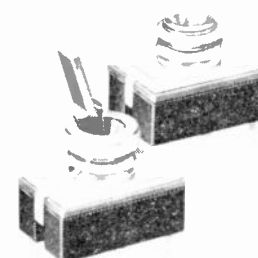
chemicals. The marker is a one-piece, flexible sleeve with an accordion-type pleated back. The pleat easily expands to accommodate a range of wire and cable sizes and then contracts for positive gripping action. Twelve sizes fit a range of wires and cables with outside diameters from .045" to .460".

Price: \$6.00-\$10.25. Electrovert Inc., 240 Madison Ave., New York, N. Y. Phone: (212) 683-7191.

ON READER-SERVICE CARD CIRCLE 361

## Snap-slide switches

A snap-slide action (as illustrated below) is said to provide highly reliable, self-wiping action in a



high-capacity toggle switch. The switches, Series 84000, are rated for ac at 5 amp at 125 v and 2 amp at 250 v. Dc ratings are 4 amp at 125 v and 1 amp at 250 v. They are offered in all configurations, SPST



through SPDT with three types of contact materials: silver-plated bronze, silver alloy and gold-plated.

Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford, Conn. Phone: (203) 249-8471.

ON READER-SERVICE CARD CIRCLE 362

## Plugs and jacks

Gold-plated right-angle and straight semi-rigid cable plugs and jacks feature a collet clamp mating method.

The 50-ohm connectors mate with standard "N" type jacks and plugs and may be used with any 0.325

When You  
Think of a  
Wire Source for  
"Specials"  
... Think of  
**Columbia Wire  
and Supply Co.**

Columbia Wire can assure the finest service for special wire requirements. We are constantly producing products for the production lines of consumer and military oriented manufacturers. This includes braiding and shielding • harnesses • marked and numbered leads • extension cords and cables • cut leads with terminals • assemblies • automatic terminal attaching • wire stripping • power cord sets.

For fast delivery on stock items, Columbia stocks millions of feet of many products — including: air conditioner cable ■ automotive cable ■ coaxial cable ■ hi-temp wire ■ hi-voltage wire ■ hook-up wire ■ inter-com wire ■ juke box speaker cable ■ microphone cable ■ shielded cable ■ shielding-braided copper ■ shielded multi-conductor cable ■ speaker cable ■ television wire and cable ■ test lead wire ■ tinned copper-solid ■ U/L service cord ■ Teflon ■ mil-spec hook-up ■ mil-spec cables ■ heater cord breather tube cable.

For your next wire need, standard or special, ask Columbia... your order will be given prompt and careful attention.

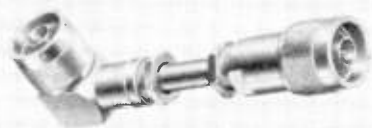
Write for Catalog 111



**Columbia**  
**WIRE & SUPPLY CO.**  
2850 IRVING PARK ROAD  
CHICAGO 18, ILLINOIS

ON READER-SERVICE CARD CIRCLE 54

ELECTRONIC DESIGN



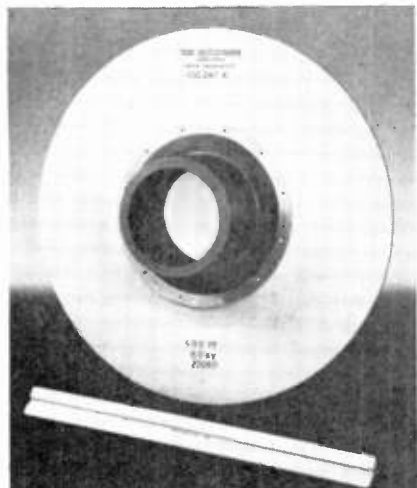
semi-rigid cable. The plugs feature a vswr of 1.10:1 maximum through 6 Gc. Operating temperature ranges from  $-65^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

ON READER-SERVICE CARD CIRCLE 363

## Storage capacitors

A new series of high-voltage energy-storage capacitors has self-inductance of only one nh at any energy-rating up to 500 joules and Q of more than 250 at 5 Mc. Voltage ratings range from 10 Kv to 50 Kv.



Capacitance ratings are from 250 pf to .5  $\mu\text{f}$ . These units can also be constructed to operate at high repetition rates. The photo shows a 500 pf 50 Kv unit.

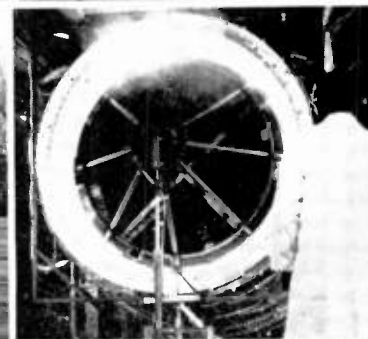
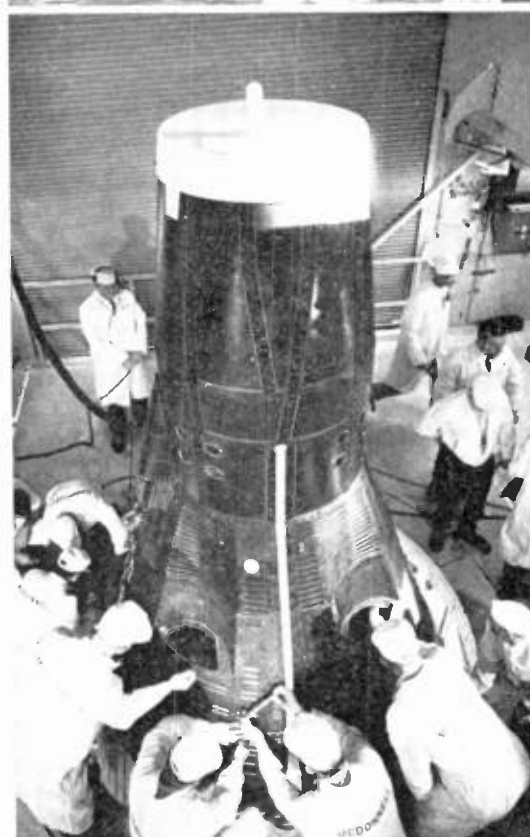
Tobe Deutschmann Labs., 2391 Washington St., Canton, Mass. Phone: (617) 828-3366.

ON READER-SERVICE CARD CIRCLE 364

## Pulse transformer

A new series of low-cost pulse transformers is said to be particularly suited to transistor and computer circuitry applications. Called the hC-Tran, all units are designed on a miniature ferrite toroid.

Windings are arranged to give the lowest leakage with the view



## MEET "MAC"

If you think growing room is at a premium, look to McDonnell where there's no ceiling on professional growth. McDonnell's many more active programs in-house—in *spacecraft, aircraft, missiles, electronics, precise time reference systems, and automation* have kicked the lid off. ■ The McDonnell Team enjoys group insurance (McDonnell pays 90%); retirement income (McDonnell pays  $\frac{2}{3}$ ); patent compensation; 8 paid holidays; educational assistance (up to full sponsorship and reduced work weeks); professional recognition; beautiful communities and natural vacationlands. ■ To arrange an interview appointment in your area of interest, please send your résumé with the completed coupon. *We will answer every inquiry.*

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Long-term positions are immediately available for the following specializations:

- Aircraft Structural Design Engineers
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- Industrial Engineers
- Stress Analysts
- Loads, Weights Engineers
- Plant Design Engineers
- Facilities Engineers
- Specifications Engineers
- Engineering Psychologists
- Flight Test Engineers
- Aerospace Ground Equipment Designers
- Chemical Engineers
- Systems Analysts
- Scientific Programmers
- Electronic Equipment Engineers

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Attn: W. R. Wardle, Engineering Employment Office, Dept. R-126  
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Home Address \_\_\_\_\_  
City & State \_\_\_\_\_  
Phone \_\_\_\_\_  
Present Position \_\_\_\_\_  
Degree \_\_\_\_\_

ON READER-SERVICE CARD CIRCLE 898



# INSPIRATIONAL THOUGHTS FOR THE TECHNICALLY INCLINED

## ITTSY BITS

Why the baby talk? We're bubbling with happiness over our latest baby. It's the fifth generation of a native-born family, and although the smallest, it is undoubtedly the best today by virtue of its breeding. This latest offspring is the new Size 11 Shaft Encoder we have named ADAC. Now ADAC, like its ancestors, is characterized by engraved drums which are interconnected by high-speed, anti-backlash, continuous gearing and by special brushes which interrogate and read out the drum position on the run or at rest.



At this point we can almost hear you say, "So what's new about that?" It's an all-around better baby! First of all, the ADAC is a high-speed device designed to run at 200 rpm input shaft speed. It can be interrogated on a bit-by-bit basis in 1 millisecond while on the run. Even more important, it packs a lot of bits into a tiny package—for example, in a can only 1.062" in diameter and 2.355" long, you can buy a count of 16,384 bits ( $2^{14}$ ). We have also included all the advantages of V scan (U scan optional) for unambiguous binary outputs and

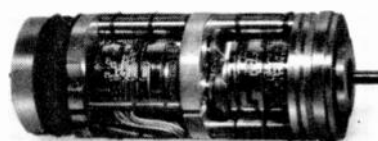
have incorporated all necessary diode logic as well.

ADAC units are available as binary encoders covering the range of  $2^8$  through  $2^{14}$ . We also have BCD encoders in decimal counts to 99999 and angular counts to 359.9°. A  $2^{10}$  gray code device is also available.

To give you a better idea of the new encoder's breeding, we think these statistics will prove helpful.

### TYPE SIZE 11 UNITS

CHARACTERISTIC	BINARY	BCD
Voltage/Current Interrogation	28vdc/20ma Pulsed or continuous	28vdc 20ma Serial
Readout	On run and static	
Output	Parallel	Parallel digit, serial between digits
Time Sharing	Isolation diodes are standard to permit time sharing	
Counts per revolution	126 or 256	100
Starting Torque	0.20 in. oz.	0.20 in. oz.
Accuracy	1 bit for any given input shaft angle	
Life	5,000,000 revolutions at 300 rpm (min)	



### SUMMARY OF OTHER FEATURES

- Solid gold alloy drums and brushes
- In-line brush geometry
- Continuous precision gearing
- Flush conducting and non-conducting drum surface
- Steel shafts and precision bearings
- Standard Size 11 mounting
- Isolation diodes for positive and negative logic included.

The proud parents are anxious to send you a brand new brochure celebrating the event, so let us know who you are and where we can find you.

ON READER-SERVICE CARD CIRCLE 55

## INERTIA

Sometimes it takes a sharp push to get things going. We say we're working against inertia. At other times we pull and haul to get things "off the dime" overcoming a kind of viscous unwillingness. But inertia and viscosity can be real advantages instead of irritants. There are times, for example, when a tach generator (we make them, too) can be replaced by a viscous or inertial damped servo motor. There's been a lot written on the subject, and we're not going to discuss the obvious advantages of these devices except for the following summary and an invitation to write for more details.

### TYPICAL DAMPED SERVOMOTOR CHARACTERISTICS

TYPE—VISCOS		
SIZE	8	8
Part Number	CMO 0180 450	CMO 1302 450
Stall Torque	0.26 in. oz.	0.31
No-Load Speed	5190 rpm	6200
Rotor Moment of Inertia	0.69 gm cm <sup>2</sup>	0.48
Theoretical Accel at Stall	28,600 rad sec <sup>-2</sup>	48,500
Time Constant	0.0531 sec	0.0119
Fly Wheel Damping	—	196 dyne-cm-sec
Fly Wheel Inertia	—	4.6 gm cm <sup>2</sup>
Weight	2.0 oz	2.6

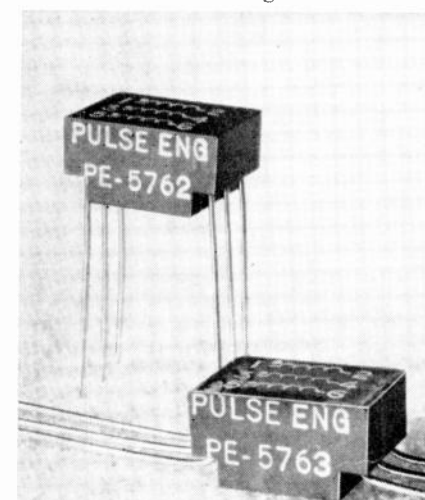
	TYPE—INERTIAL		
SIZE	11	15	18
Part Number	CRO 1300 660	T1310-41B	R1320-2B
Stall Torque	0.60	1.45	2.25
No-Load Speed	6000	4500	4500
Rotor Moment of Inertia	1.45	5.48	6.25
Theoretical Accel at Stall	30,700	18,700	26,000
Time Constant	0.022	0.0255	0.0185
Fly Wheel Damping	100	750	750
Fly Wheel Inertia	10	100	100
Weight	6.0	12.0	18

**KEARFOTT DIVISION**  
**GENERAL**  
**PRECISION INC.**

**AEROSPACE GROUP**  
 Little Falls, New Jersey

## COMPONENTS

that most transistor and core memory applications will call for current or current gain. Primary inductance values range from 10 to



2000  $\mu$ h and turns ratios from 1:1:1 to 4:2:1.

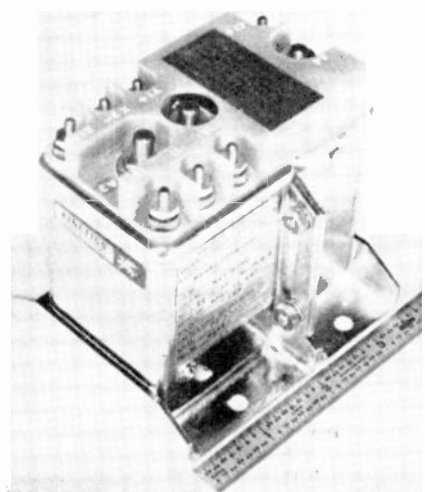
P&A: \$6.50; stock. Pulse Engineering Inc., 560 Robert Ave., Santa Clara, Calif. Phone: (408) 248-6040. TWX: (408) 287-6570.

ON READER-SERVICE CARD CIRCLE 365

## Motor-driven switch

The M945 power control switch is a motor-driven unit whose single-pole, single-throw pin-and-socket contacts are rated at 75 amps at 28 vdc. Voltage drop is 50 millivolts, transfer time is 85 milliseconds and minimum guaranteed life of 20,000 cycles.

Built-in, sensor circuitry consumes only 1/3 watt, provides automatic circuit interruption in the



FOR SWITCHCRAFT, INC. INSERT  
 ON READER-SERVICE CARD CIRCLE 248

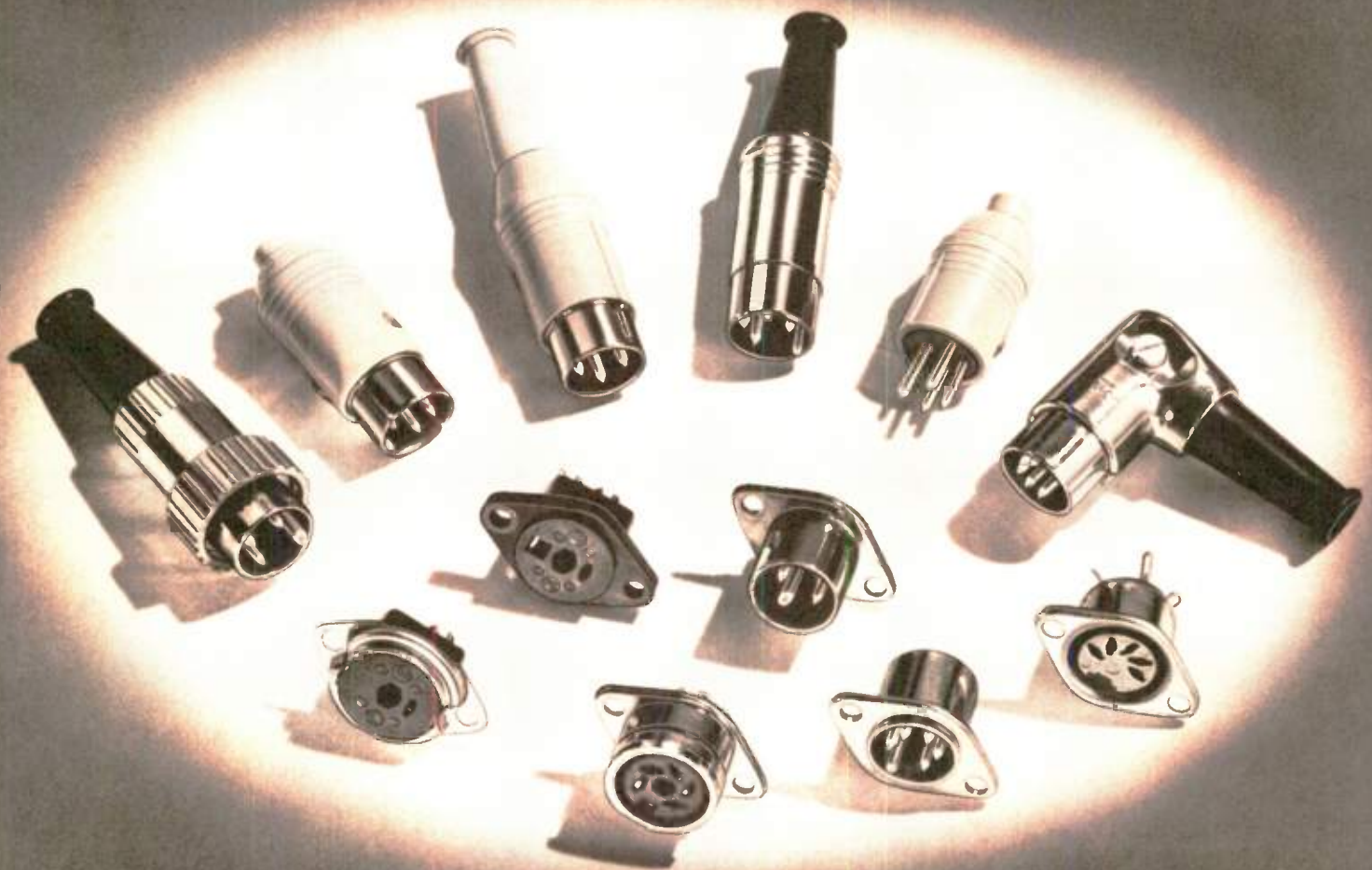
engineering specification

CATALOG NO. C-503  
SWITCHCRAFT/PREH  
audio connectors

Switchcraft/Preh Plugs .....	Pages 3, 4
Switchcraft/Preh Receptacles .....	Pages 5, 6
Switchcraft/Preh Control and Switching Receptacles and Plugs .....	Pages 6, 7
Mating Chart .....	Page 8

available at all leading Electronic & Radio Parts Distributors

**SWITCHCRAFT**  
INC.



**NEW FROM SWITCHCRAFT!**

A COMPLETE LINE OF QUALITY-BUILT,  
MINIATURE MULTI-PIN CONNECTORS!

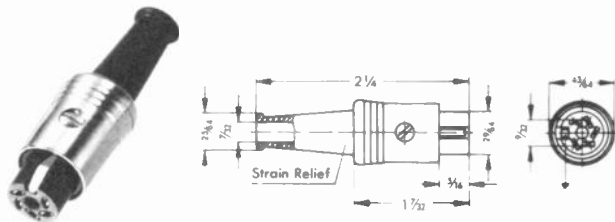
TEAR THIS COMPLETE CATALOG OUT AND KEEP IT FOR READY REFERENCE.

World Radio History





## STRAIGHT CORD PLUG with Extended Socket

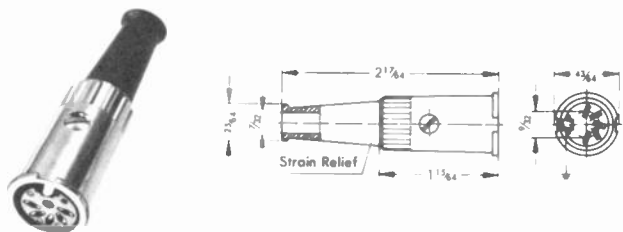


Type 14FL5F—typical

Miniature female plug with extended socket and short metal shell. Flexible rubber strain relief. Socket with "Ground Contact" designed to mate with bayonet type receptacles such as Part No. 61JD5M.

Part No.	Description	Contact Arrangement	U.S.A. List Price
07FL3F	3 contacts at 180°	B	\$1.60
11FL4F	4 contacts at 210°	D	1.70
14FL5F	5 contacts at 240°	E	1.80

## STRAIGHT CORD PLUG with Lock Flange

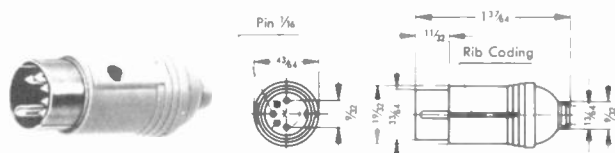


Type 06EL5F—typical

Miniature, female plug with "Ground Contact". Lock flange designed to accept 30° locking. Insert screw firmly holds insert assembly in shell. Flexible black strain relief with 7/32" diameter cable entry. Heavy duty cable clamp.

Part No.	Description	Contact Arrangement	U.S.A. List Price
06EL3F	3 contacts at 180°	B	\$1.65
06EL5F	5 contacts at 180°	F	1.85
10EL4F	4 contacts at 210°	D	1.75
13EL5F	5 contacts at 240°	E	1.85

## STRAIGHT CORD PLUG with Snap-Lock Plastic Shell

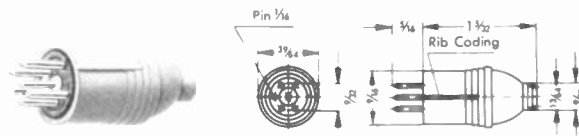


Type 05LK5M—typical

Miniature male plug with short snap-lock plastic shell and shielded barrel. Can be used in place of die cast metal plugs in less critical applications. The two piece metal barrel which surrounds the pin insert provides an electrical shield. The short plastic shell snaps over and locks on the barrel's metal lock-tab. Provides a rugged assembly. All purpose cable clamp. Standard color is gray, other colors available on special order only.

Part No.	Description	Pin Arrangement	U.S.A. List Price
05LK3M	3 pins at 180°	2	\$0.90
05LK5M	5 pins at 180°	5	1.10
09LK4M	4 pins at 210°	3	1.00
12LK5M	5 pins at 240°	4	1.10

## STRAIGHT CORD PLUG with Short Plastic Shell

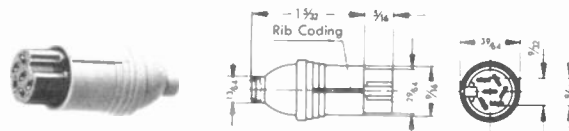


Type 12QK6M—typical

Miniature male plug with short insulated plastic shell. No ground connection. Insert pin assembly snaps in shell to make up complete plug. Quick and easy cable attachments. Simply feed cable through plastic shell and cable clamp ring, solder wires to terminals. Crimp ring around cable and retract. Snap pin insert into shell. Standard color gray, other colors available on special order.

Part No.	Description	Pin Arrangement	U.S.A. List Price
05QK3M	3 pins at 180°	2	\$0.60
05QK5M	5 pins at 180°	5	.80
09QK4M	4 pins at 210°	3	.70
12QK5M	5 pins at 240°	4	.80
12QK6M	6 pins at 240°	6	.90

## STRAIGHT CORD PLUG with Extended Socket

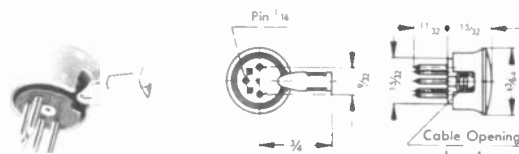


Type 14QK6F—typical

Miniature female plug with extended socket and insulated, short plastic shell. No "Ground Contact". Designed to mate with recessed shell (57JD3M) or extended shell (57KD3M) type receptacles. Tubular cable clamp. Part No. 08QK3F features two extra blanks in insert to mate with plug (5 pins at 180°) where application requires versatility and flexibility. Standard color gray, other colors available on special order.

Part No.	Description	Contact Arrangement	U.S.A. List Price
07QK3F	3 contacts at 180°	B	\$0.60
07QK5F	5 contacts at 180°	F	.80
08QK3F	3 contacts at 180° 2 extra blanks	C	.60
11QK4F	4 contacts at 210°	D	.70
14QK5F	5 contacts at 240°	E	.80
14QK6F	6 contacts at 240°	G	.90

## RIGHT ANGLE CORD PLUG with Insulated Plastic Shell



Type 05UK5M—typical

Subminiature right angle cord plug with integral cable clamp and insulated plastic shell. Shell easily snaps-on for quick disassembly and assembly of plug. Normally used for internal circuit connectors. Recommended for use in applications requiring infrequent disconnections. Standard color gray, other colors available on special order.

Part No.	Description	Pin Arrangement	U.S.A. List Price
05UK3M	3 pins at 180°	2	\$0.60
05UK5M	5 pins at 180°	5	.80

## SCHEMATIC CIRCUITS



1



2



3



4



5

## AUDIO CONNECTORS

Switchcraft/Preh is the name given to this high-quality family of versatile miniature audio connectors. A family that includes male and female plugs and receptacles from 2 to 7 contacts, eye-catching bright nickel-plated shells, colorful plastic snap-on shells. All are precision manufactured.

Switchcraft/Preh family of plugs and receptacles are unique among fine audio connectors for their internal switching. In all, there are thirteen different receptacles that provide some form

of switching.

Designed for audio circuitry, they are also ideal for use in test equipment, instruments, computers, cameras, control devices and many other types of low level circuits.

Switchcraft/Preh connectors have been field tested and proved over many years in a wide variety of critical applications, they are in fact among the best selling, high quality, low-cost connectors in many areas of the world.

## SWITCHCRAFT/PREH DESIGN FEATURES:

### GROUNDING AND SHIELDING PROVISIONS

A positioning "Ground Key-Rib" or "Ground Contact"—electrically integral with the connector shell—is provided in each plug and receptacle (except those with plastic shells or housings) to quickly ground or shield the connector shell. Where the two halves of a connector are plugged together the ground or shield circuit is automatically engaged through the "Ground Key-Rib" to the "Ground Contact".



Any contact circuit can be readily grounded to the shell of a plug or receptacle by a jumper/wire between the selected contact and the "Ground Key-Rib" and/or "Ground Contact" terminal.

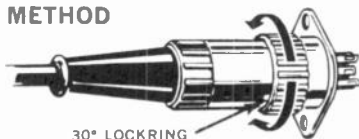
### BUILT-IN SWITCHING

Unique internal switching built-in to many of the receptacles provides single closed or up to double break switch circuitry in addition to the mating of the contact circuits. Control switching is also available in a complete line of connectors which are discussed below.

### CONTROL AND SWITCHING CONNECTORS

Switchcraft/Preh offers a complete line of plugs and receptacles for monaural and/or stereo speaker switching and other low level audio applications. Many of the receptacles offer flexible switching possibilities when the mating plug is turned 180°. The plugs feature a large, flat center pin for greater reliability. All plugs include a plastic, insulated shell which "snaps" on and off for quick and easy cable installation.

### COUPLING METHOD



Switchcraft/Preh connectors use a contact friction or locking means of coupling mating plugs and receptacles. The unique 30° twist locking quickly and efficiently couples the two halves of a connector even under such operating environments as shock and vibration.

### INSERT DIELECTRIC

A molded phenolic with high dielectric strength is used in all inserts to effectively reduce noise resulting from mechanical interference. The insulation material holds each contact in a fixed position so that all circuits are properly connected, both mechanically and electrically.

### CONTACT PINS AND SPRINGS

All control and switching and metal flanged receptacles have silver plated contact fork shaped springs. In addition, all metal flanged receptacles and metal shell plugs have a silver plated "Ground Contact" with a solder terminal riveted to the flange of the receptacle or to the center terminal of the plug. This "Ground Contact" spring makes contact with the nickel-plated "Ground Key-Rib" barrel of the mating plug, as described under "Grounding and Shielding Provisions". All male plugs feature silver-plated pins.

\* Preh is a trademark of Preh Electromechanical Works, Bavaria, Germany

### 8-POSITION RIGHT ANGLE PLUG



An exclusive feature of the Switchcraft/Preh family of connectors is the singular 8-position barrel of the right angle plug. This feature enables you to position the cable entree at any one of eight different angles. This gives you great latitude in the design and housing of small, compact electronic equipment.

### SNAP-LOCK PLASTIC SHELLS



An insulated plastic shell which "snaps" on and locks to a metal barrel of a plug is available in various pin arrangements from 3 to 7 contacts. These attractive plastic shells provide fast and simple disassembly and reassembly of the plugs. The snap-lock feature securely holds the plastic shell to the metal plug barrel.

### POLARIZATION

Switchcraft/Preh connectors are so designed that it is virtually impossible to mate them incorrectly. The polarization is accomplished through contact arrangement and a "Ground Key-Rib" which is provided on all metal barrel plugs.

### RUGGED CONSTRUCTION

Thick die cast-zinc shells, bright nickel-plated, have been designed to take a maximum of punishment.

### HEAVY-DUTY CABLE CLAMP

Provides a secure lock on most standard size cables.

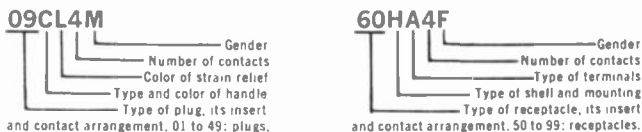
### MOUNTING

A variety of mounting methods is available on Switchcraft/Preh receptacles—such as flush, extended, printed circuit board, screw and rivet types. Plugs are available in straight cord and 90° angle, metal or plastic shells.

### CABLE ENTRIES

The high quality flexible plastic bushings used on the Switchcraft/Preh plugs provide a strong strain relief. Standard strain relief cable entry is 1/4"; a smaller size of 1/8" is available on special order. Standard color of rubber bushing used on nickel-plated plugs is black, other colors available on special order.

### NOMENCLATURE BREAKOUT



### MATERIAL SPECIFICATIONS

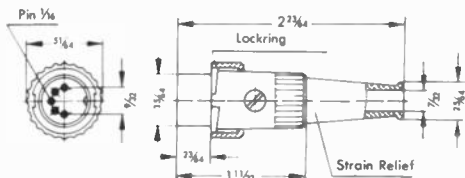
Shell: Diecast zinc alloy, bright nickel plated finish.  
 Receptacle Mounting Flange: Steel.  
 Receptacle Body: Molded phenolic.  
 Insert Material: Molded phenolic.  
 Socket Contacts: Silver-plated.  
 Pin Contacts: Silver-plated.  
 Cable Relief Bushing: Soft plastic.  
 Standard Distributor Package—5





# PLUGS

## STRAIGHT CORD PLUG with 30° Lock Ring

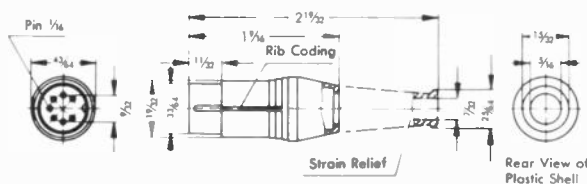


Type 05CL5M—typical

Miniature, male plug with "Ground Key-Rib". Unique 30° turn locking securely fastens two halves of connector. Mates with lock flange female connectors and receptacles. Insert screw firmly holds insert assembly in shell and also retains locking on shell. Flexible black strain relief with 1/2" diameter cable entry. Heavy duty clamp.

Part No.	Description	Pin Arrangement	U.S.A. List Price
03CL2M	2 pins with insulated switch actuator.	1	\$1.75
05CL3M	3 pins at 180°	2	1.75
05CL5M	5 pins at 180°	5	1.95
09CL4M	4 pins at 210°	3	1.85
12CL5M	5 pins at 240°	4	1.95

## STRAIGHT CORD PLUG with Shielded Barrel

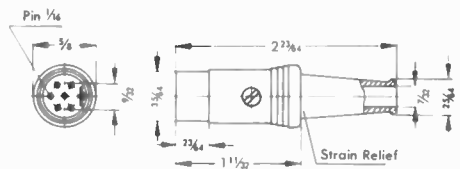


Type 15GM7M—typical

Miniature, male cord plug with shielded barrel and insulated snap-lock plastic shell. The two piece metal barrel surrounds the pin insert to form an electrical shield. The entire insert assembly is held together by snapping the insulated plastic shell over the assembly. The barrel's special metal tab locks the shell in place. Standard color of plastic shell is gray; other colors such as beige are available on special order. All-purpose cable clamp.

Part No.	Description	Pin Arrangement	U.S.A. List Price
05GM3M	3 pins at 180° Gray shell and strain relief.	2	\$1.10
05GM5M	5 pins at 180° Gray shell and strain relief.	5	1.30
09GM4M	4 pins at 210° Gray shell and strain relief.	3	1.20
12GM5M	5 pins at 240° Gray shell and strain relief.	4	1.30
12HN5M	5 pins at 240° Beige shell and strain relief.	4	1.30
15GM7M	7 pins at 270° Gray shell and strain relief.	7	1.50

## STRAIGHT CORD PLUG with Extended Barrel

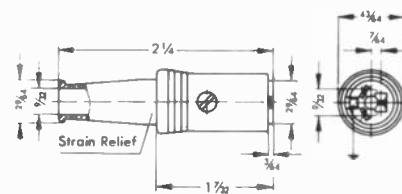


Type 12BL6M—typical

Miniature, male plug with "Ground Key-Rib". Nickel plated diecast handle. Contact friction coupling. Flexible black strain relief. Heavy duty cable clamp.

Part No.	Description	Pin Arrangement	U.S.A. List Price
03BL2M	2 pins with insulated switch actuator.	1	\$1.65
05BL3M	3 pins at 180°	2	1.65
05BL5M	5 pins at 180°	5	1.85
09BL4M	4 pins at 210°	3	1.75
12BL5M	5 pins at 240°	4	1.85
12BL6M	6 pins at 240°	6	1.95

## STRAIGHT CORD PLUG with Flush Socket Insert

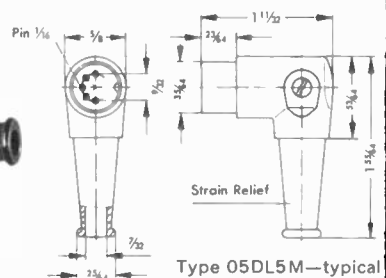


Type 04AL2F—typical

Miniature female plug with "Ground Contact". Diecast metal shell nickel plated. Two contact plug. Part No. 04AL2F includes a break circuit switch (1-B) which is opened by engaging the insulated switch actuator of the mating plug or receptacle. Flexible black strain relief.

Part No.	Description	Contact Arrangement	U.S.A. List Price
04AL2F	2 contacts with closed-circuit switch. (Schematic #4)	A	\$1.65
06AL3F	3 contacts at 180°	B	1.65
06AL5F	5 contacts at 180°	F	1.85
10AL4F	4 contacts at 210°	D	1.75
13AL5F	5 contacts at 240°	E	1.85
13AL6F	6 contacts at 240°	G	1.95

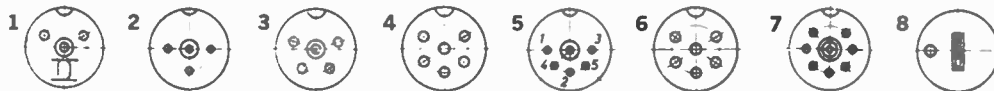
## RIGHT ANGLE CORD PLUG with 8 Position Barrel



Type 05DL5M—typical

Miniature right angle chassis hugging, male plug with flexible black rubber strain relief. Unique 8-position barrel gives you a choice of any one of eight different cable entree angles. Ideal for use with miniaturized electronic equipment.

Part No.	Description	Pin Arrangement	U.S.A. List Price
03DL2M	2 pins with insulated switch actuator.	1	\$2.00
05DL3M	3 pins at 180°	2	2.00
05DL5M	5 pins at 180°	5	2.20
09DL4M	4 pins at 210°	3	2.10
12DL5M	5 pins at 240°	4	2.20

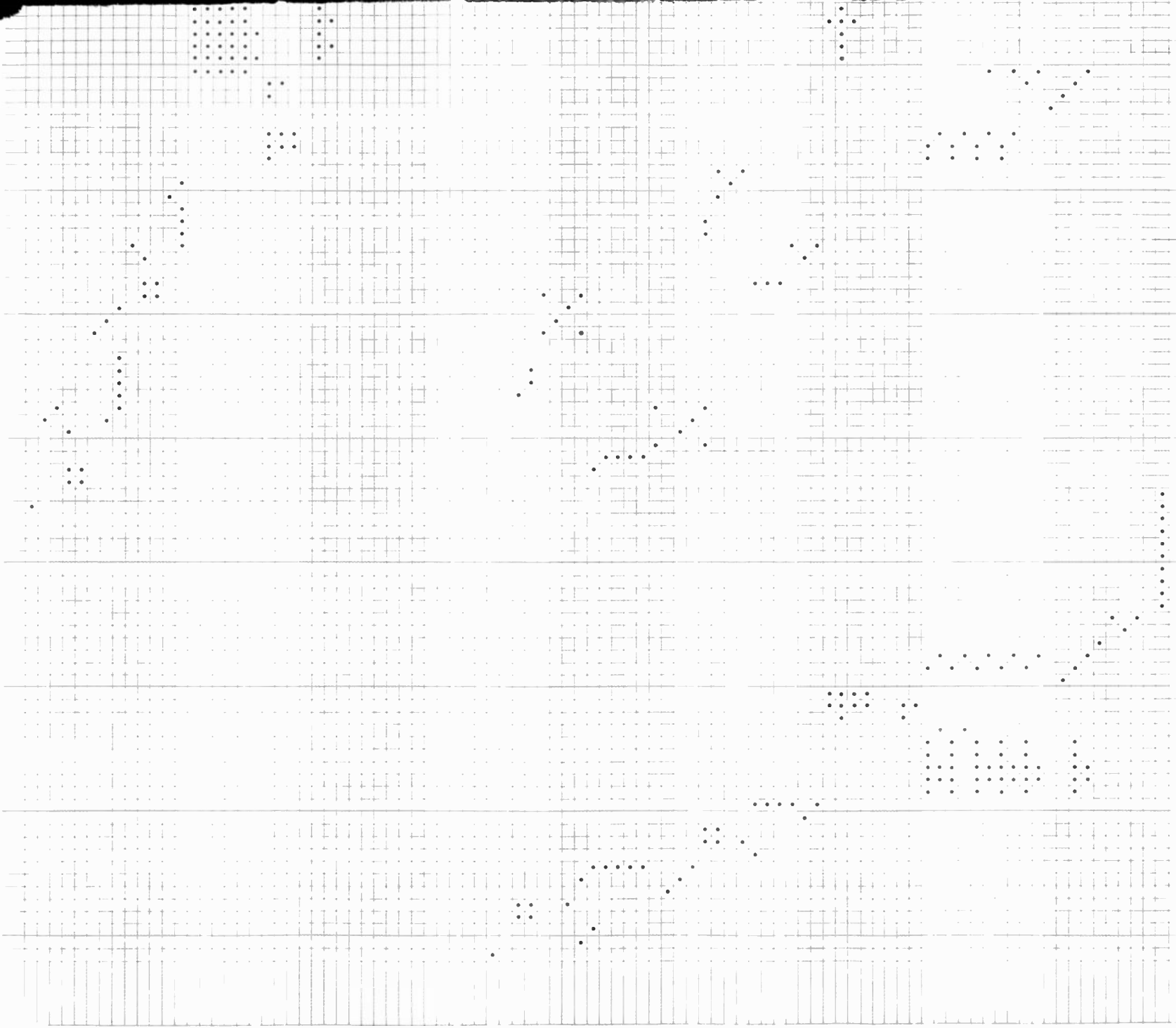


# CONNECTOR MATING CHART

## PLUGS

## RECEPTACLES

05LK5M  
05QK3M  
05QK5M  
05UK3M  
05UK5M  
06AL3F  
06AL5F  
06EL3F  
06EL5F  
07FL3F  
07QK3F  
07QK5F  
08QK3F  
09BL4M  
09CL4M  
09DL4M  
09GM4M  
09LK4M  
09QK4M  
10AL4F  
10EL4F  
11FL4F  
11QK4F  
12BL5M  
12BL6M  
12CL5M  
12DL5M  
12GM5M  
12HN5M  
12LK5M  
12QK5M  
12QK6M  
13AL5F  
13AL6F  
13EL5F  
14FL5F  
14QK5F  
14QK6F  
15GM7M  
51DA2F  
52BA2F  
52CA2F  
52DA2F  
53BA2F  
53CA2F  
53DA2F  
54BA2F  
54CA2F  
54DA2F  
55GA2F  
55HA2F  
56KD2M  
57GA3F  
57GB5F  
57HA3F  
57JD3M  
57KD3M  
57LD5M  
57LA3F  
57NC5F  
58CB3F  
58NC3F  
59GB5F  
59GB5F  
60GA4F  
60HA4F  
60JD4M  
60KD4M  
60LA4F  
61GA5F  
61GA6F  
61HA5F  
61JD5M  
61KD5M  
61LA5F  
61LA6F  
62GB7F



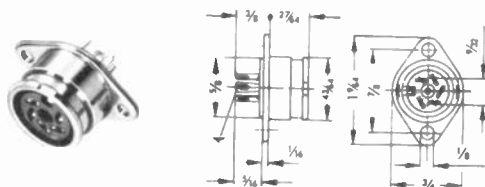
**SWITCHCRAFT**<sup>®</sup>

GENERAL OFFICE AND PLANT  
5555 NORTH ELSTON AVENUE, CHICAGO, ILLINOIS 60630  
AREA CODE 312 — TEL: 744-1515 — TWX 312/265-1314



# RECEPTACLES

## RECEPTACLE for Lockring Plug



Type 61HA5F—typical

Female receptacle with "Ground Contact". Chassis or panel mount. Diecast bayonet extension shell with mounting flange. Mates with all locking plugs, such as Part No. 12CL5M. Part No. 55HA2F includes closed-circuit switch (1-B). All receptacles have straight solder terminals.

Part No.	Description	Contact Arrangement	U.S.A. List Price
55HA2F	2 contacts with closed-circuit switch. (Schematic #4)	A	\$1.00
57HA3F	3 contacts at 180°	B	1.00
60HA4F	4 contacts at 210°	D	1.10
61HA5F	5 contacts at 240°	E	1.20

## RECEPTACLE for Chassis or Panel Mounting

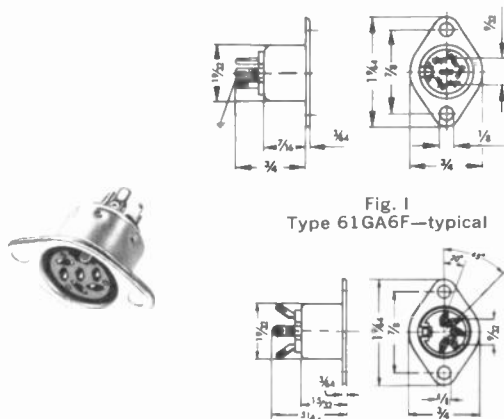


Fig. I  
Type 61GA6F—typical

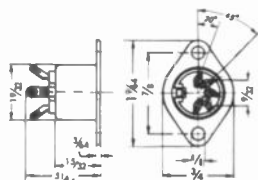
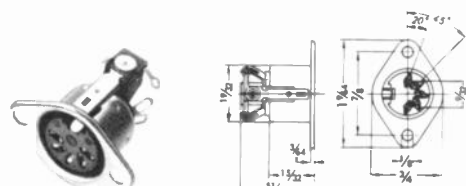


Fig. II  
Type 57GB5F—typical

Drawn metal recessed shell with mounting flange and "Ground Contact". Available with straight or flared solder terminals. See drawings above. Part No. 55GA2F includes a break contact switch circuit (1-B), which is actuated by an insulated pin of the mating plug, such as Part No. 03BL2M. Part No. 58GB3F features two extra blanks in insert for proper mating with (5 pins at 180°) plug where applications may require greater connector flexibility.

Part No.	Fig. No.	Description	Contact Arrangement	U.S.A. List Price
55GA2F	I	2 contacts plus closed-circuit switch. (Schematic #4)	A	\$0.70
57GA3F	I	3 contacts at 180°	B	.70
57GB5F	II	5 contacts at 180°	F	.90
58GB3F	II	3 contacts at 180° 2 extra blanks	C	.75
60GA4F	I	4 contacts at 210°	D	.80
61GA5F	I	5 contacts at 240°	E	.90
61GA6F	I	6 contacts at 240°	G	1.00
62GB7F	II	7 contacts at 270°	H	1.10

## RECEPTACLE with Closed Circuit Switch

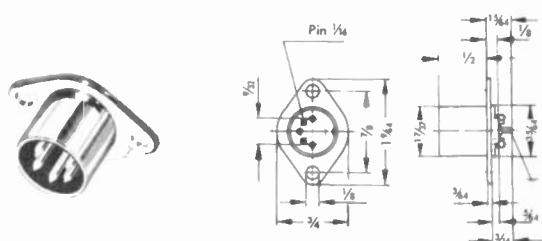


Type 59GB5F—typical

Unique 3 and 5 contact receptacles include a 1-B (closed-circuit) switch which is mounted to drawn metal shell. Switch is actuated by the shell of the mating plug. Receptacles also provide complete shielding through the "Ground Contact". Flared solder terminals.

Part No.	Description	Contact Arrangement	U.S.A. List Price
59GB3F	3 contacts at 180° plus closed-circuit switch. (Schematic #5)	B	\$1.30
59GB5F	5 contacts at 180° plus closed-circuit switch. (Schematic #5)	F	1.50

## RECEPTACLE with Extended Shell

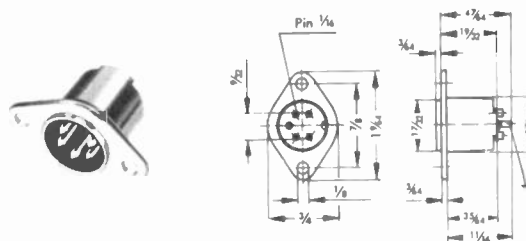


Type 61KD5M—typical

Male receptacle, 2 to 5 pins, with "Ground Key-Rib". Diecast extended shell and flange for chassis or panel mounting. Turret terminals.

Part No.	Description	Pin Arrangement	U.S.A. List Price
56KD2M	2 pins with insulated switch actuator.	1	\$1.00
57KD3M	3 pins at 180°	2	1.00
57KD5M	5 pins at 180°	5	1.20
60KD4M	4 pins at 210°	3	1.10
61KD5M	5 pins at 240°	4	1.20

## RECEPTACLE for Recessed Mounting



Type 61JD5M—typical

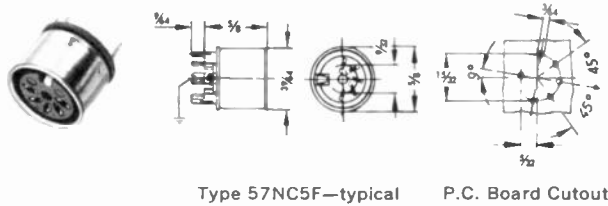
Male receptacle, 3 to 5 pins, with "Ground Key-Rib". Diecast metal shell and mounting flange. Turret type terminals for easy soldering.

Part No.	Description	Pin Arrangement	U.S.A. List Price
57JD3M	3 pins at 180°	2	\$1.00
60JD4M	4 pins at 210°	3	1.10
61JD5M	5 pins at 240°	4	1.20





## RECEPTACLE for Printed Circuit Board Mounting



Type 57NC5F—typical P.C. Board Cutout

Mounts direct to printed circuit boards. Special P.C. type terminals "snap-in" precut boards. See drawing. Tubular metal shell with "Ground Contact". Part No. 58NC3F mates with either 3 pin or 5 pin (at 180°) plugs because of its 2 extra blanks in the contact insert.

Part No.	Description	Contact Arrangement	U.S.A. List Price
57NC5F	5 contacts at 180°	F	\$0.80
58NC3F	3 contacts at 180° 2 extra blanks	C	.60

## SCHEMATIC CIRCUITS



1



2



3



4



5

## CONTROL and SWITCHING RECEPTACLES

Originally designed for connecting a remote speaker to existing equipment, or for stereo applications, these singular receptacles are also ideal for use in many types of electronic test and measurement equipment.

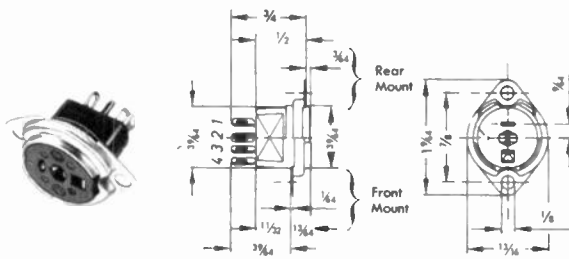
When inserting mating plug, Part No. 01QK2M, contact is made to terminal Nos. 1 and 2. The receptacle's built-in closed-circuit switch is not actuated. Plug can then be turned 180°, without a polarity change, and re-inserted in receptacle to open switch and make contact to

terminal No. 2. This convertible feature is available in receptacle Nos. 51DA2F, 52BA2F, 52CA2F and 52DA2F.

Control and switching receptacles are offered in several different mounting and housing types, such as: metal flange for screw mount, metal rivet mounting flange and an insulated molded type. See drawings and listings below.

Each receptacle includes an elongated center contact for positive polarization. The silver-plated fork shaped contacts are reinforced with an additional steel spring for long dependable life.

## RECEPTACLE with Metal Mounting Flange

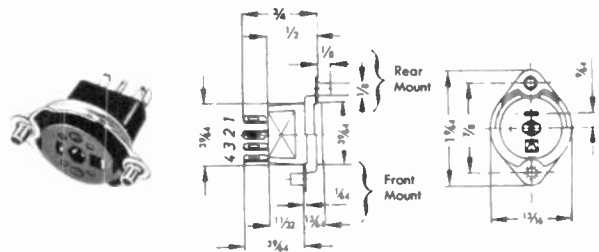


Type 52DA2F—typical

Female receptacles with molded body and metal flange for screw mounting to chassis or panel. No "Ground Contact". Metal flange for front of panel mounting furnished as standard. Flange for rear of panel mounting available on special order. Refer to above dimensional drawing.

Part No.	Description	Contact Arrangement	U.S.A. List Price
52DA2F	2 contacts (Schematic #2) with closed-circuit switch. Convertible.	J	\$0.65
53DA2F	2 contacts.	K	.55
54DA2F	2 contacts (Schematic #3) with closed-circuit switch. Not convertible.	L	.60

## RECEPTACLE with Metal Rivet Mounting Flange



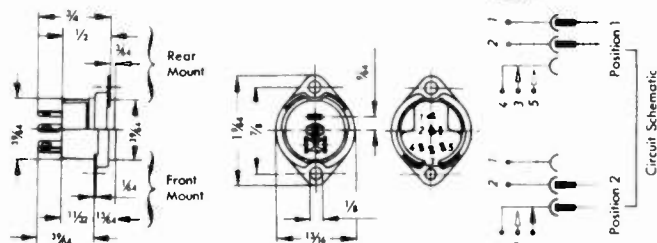
Type 52BA2F—typical

Unique female receptacle with metal flange for rear of panel rivet mounting. Front of panel rivet mounting flange is also available on special order. Molded plastic body, no "Ground Contact".

Part No.	Description	Contact Arrangement	U.S.A. List Price
52BA2F	2 contacts (Schematic #2) with closed-circuit switch. Convertible.	J	\$0.70
53BA2F	2 contacts.	K	.60
54BA2F	2 contacts (Schematic #3) with closed-circuit switch. Not convertible.	L	.65



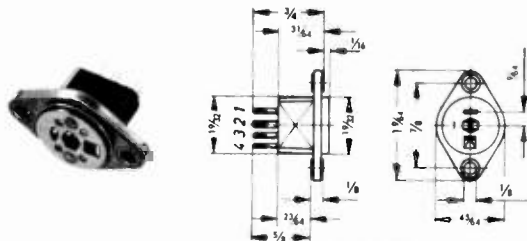




Type 51DA2F—typical

Part No.	Description	Contact Arrangement	U.S.A. List Price
51DA2F	2 contacts (Schematic #1) with make-break circuit. Convertible.	M	\$0.80

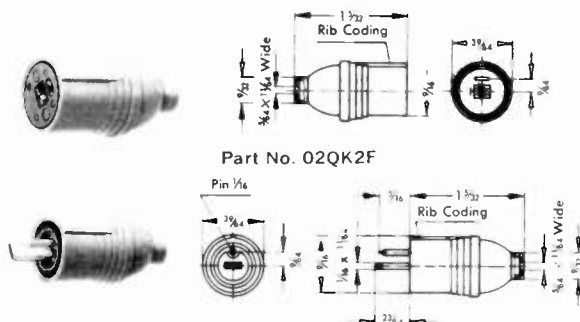
### RECEPTACLE with Insulated Plastic Body



Type 52CA2F—typical

Part No.	Description	Contact Arrangement	U.S.A. List Price
52CA2F	2 contacts (Schematic #2) with closed-circuit switch. Convertible.	J	\$0.60
53CA2F	2 contacts	K	.50
54CA2F	2 contacts (Schematic #3) with closed-circuit switch. Not convertible.	L	.55

## CONTROL and SWITCHING PLUGS with Snap-On Plastic Shells



Part No. 02QK2F

Part No. 01OK2M

Part No.	Description	Pin/Contact Arrangement	U.S.A. List Price
01QK2M	Male plug, 2 contacts	8	\$0.40
02QK2F	Female plug, 2 contacts.	K	.50

# CONNECTOR MATING CHART

This Switchcraft/Preh mating chart gives you the recommended plug and receptacle mating part numbers. To assure proper selection of connectors always refer to this chart.



# PLUGS

## RECEPTACLES

[illegible]

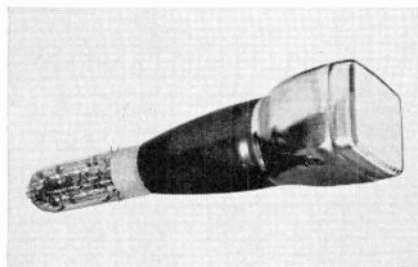
event of either an overload or a reverse current. Overload protection is provided by a special magnetic sensor which measures the current through the switch and causes transfer whenever the overload exceeds limits for a pre-determined period.

Kinetics Corp., 410 So. Cedros Ave., Solana Beach, Calif. Phone: (714) 755-1181.

ON READER-SERVICE CARD CIRCLE 366

## Dual trace CRT

A rectangular face dual-trace instrument cathode ray tube uses a mesh p.d.a. This high brightness tube, the 1300P series, incorporates auxiliary electrodes for independent

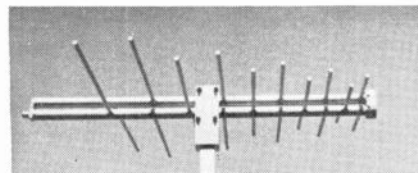


astigmatism correction on each beam and separate beam equalising and blanking plates. The sopt size is 0.35 mm shrunk raster for a current of 5  $\mu$ a per beam.

The M-O Valve Co., Ltd., Brook Green Works, London W.6, England. Phone: Riverside 3431.

ON READER-SERVICE CARD CIRCLE 367

## Log-periodic antennas



Model 301-301A log-periodic antennas offer field tested performance in the 200-400 Mc range. They are fully ruggedized and capable of performance under the most severe environmental conditions.

A Leading feature of the Model 301A is that the entire unit can be quickly disassembled for transportation. A special mount prevents the antenna from twisting in high winds.

P&A: \$275; 20-30 days. Translab Inc., 4754 Federal Blvd., San Diego, Calif. Phone: (714) 263-1876.

ON READER-SERVICE CARD CIRCLE 368

FOR SWITCHCRAFT, INC. INSERT

ON READER-SERVICE CARD CIRCLE 248

# QUALITY, VARIETY SERVICE

...that's the story of "Ohmitran" v. t.<sup>®</sup> variable transformers



From Ohmite's tiny, exclusive, 1-amp VT1 to the husky VT20, a full range of single-unit ratings to 25 amps is available.



**SATISFY** yourself . . . eliminate irritating variable transformer difficulties with Ohmite's famed reliability and long service life. In any piece of equipment, an Ohmite component indicates that there has been no compromise with quality.

**MEET** virtually all your requirements from Ohmite's big selection. Single units start with a tiny (and exclusive) 1-amp model, extend through heavy-output models of 25 amps. For single and/or ganged models,

voltage inputs begin below 40 volts, run to 480 volts. There are assemblies for 3-phase applications, too, plus models in stationary or portable cases—with meters if you like. Most are stocked for fast delivery.

**EASE** engineering headaches by taking advantage of Ohmite's ready-to-ship stock of standard units, or willing advice and service on units for special applications. Bone up on the broad aspects of Ohmite's complete variable transformer service by requesting *Catalog 500*.

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • RELAYS  
TAP SWITCHES • TANTALUM CAPACITORS • SEMICONDUCTOR DIODES • R.F. CHOKES

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MANUFACTURING COMPANY  
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Phone: (312) ORchard 5-2600

ON READER-SERVICE CARD CIRCLE 56





# Now you can have the fastest, most flexible logic modules ever made.

(But you'll have to pay less for them.)

Who knows more about monolithic integrated circuitry than SDS?

Nobody. We were the first to announce an integrated-circuit computer, and we were the first manufacturer making deliveries.

Everything we've learned about the state of the art in integrated circuitry has gone into our new line of logic modules.

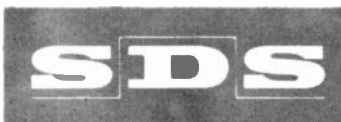
To tease you a little: SDS modules have unique monolithic flip flops with true trailing-edge triggering. They have both inverting and non-inverting logic at the same price. They have fully buffered AND/OR gates, alone or in conjunction with NAND/NOR gates. A variety of gating structures, and 52-pin connectors, give such flexibility that you'll need far fewer cards for each function. Delay times as short as 18 nanoseconds per stage.

Cost? For quality and performance, the lowest in the industry.

We'll be glad to give you the rest of the details the moment you show some interest. Just write or call.

## Scientific Data Systems

1649 Seventeenth Street, Santa Monica, California  
U.S. sales offices in New York, Boston, Washington, Philadelphia, Pittsburgh, Huntsville, Orlando, Chicago, Houston, Dallas, Albuquerque, Denver, Seattle, San Francisco, St. Louis, Detroit.



ON READER-SERVICE CARD CIRCLE 57

## COMPONENTS

### Time delay relay

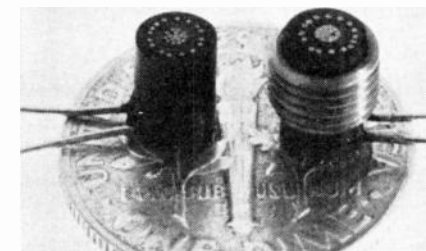
For heavy industrial applications, a 5-amp capacity at 115 vac is provided by the Model HD200 time delay relay. Delay time is 2 to 300 seconds. Rated life of the octal plug-in component is 500,000 operations.

P&A: \$3.00-\$4.50; 2 weeks. Thermal Controls, Inc. 75 Rutgers St., Belleville, N. J. Phone: (201) 759-7474.

ON READER-SERVICE CARD CIRCLE 369

### Sub-miniature transducers

Type P/16/150S inductive transducers are described as the smallest non-contact displacement transducers currently available. Length is 0.185-in. and diameter is 0.16-in. Weight is only 0.15 gms.



With associated electronics, the transducers measure over a range of 0.010-in. with a resolution of up to 0.0001-in. They will detect vibration and displacement from dc to 25 Kc.

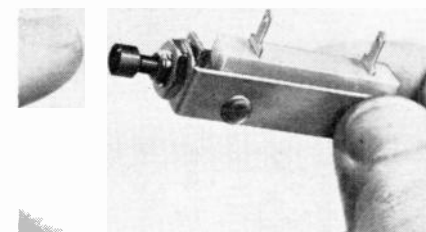
Associated Engineering Ltd., Cawston, Rugby, Warwickshire, England. Phone: Rugby 6111.

ON READER-SERVICE CARD CIRCLE 370

### Reed pushbutton

The Seal-X switch uses a permanent magnet to actuate a reed capsule.

A Spdt, from A switch, it can be used for virtually any pushbutton.



ton control application. The designer has a choice of either normally closed or normally open configurations.

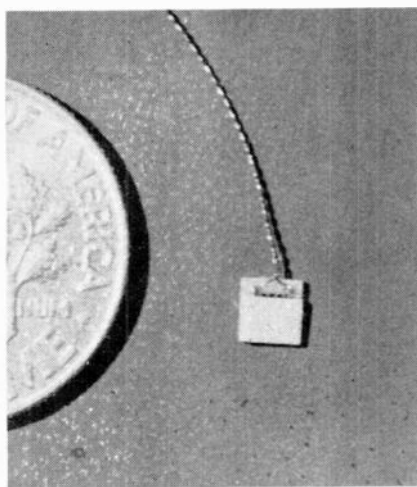
Contacts are gold alloy and open switch capacitance is 0.2 pf max. Operating speed is up to 100 cps. Switching voltage is up to 150 v with power carrying capacity up to 10 VA in dc operation and 12 VA in ac circuits. Terminals accept Amp miniature Faston terminals or may use solder connections.

P&A: from \$1.55 to \$2.70 in quantity; stock. James Electronics Inc., 4050 N. Rockwell St., Chicago, Ill. Phone: (312) 463-6500. TWX: (312) 222-0745.

ON READER-SERVICE CARD CIRCLE 371

## Flux-sensitive resistors

The applied magnetic field varies the absolute resistance of two new circuit elements, the MRI-100 and MRI-500. They can be used with



either permanent or electromagnetic fields in a variety of applications.

Type MRI-100 has a nominal resistance of 100 ohm, increasing by a factor of 7 to 10 under a flux of 10 Kilogauss. Type MRI-500, with a base resistance of 500 ohm increases 13 to 18 times under 10 kilogauss. Change is square-law to 3 kilogauss and linear through 10.

American Aerospace Controls, 129 Verdi St., Farmingdale, N. Y. Phone: (516) 694-5100.

ON READER-SERVICE CARD CIRCLE 372

## Photomultiplier tube

Built entirely of ceramic and metal, the C70144 photomultiplier is a 10-stage venetian-blind head-on type with a 2-in. aluminum-oxide window. The tube is designed

ON READER-SERVICE CARD CIRCLE 229 ➤

# Miniature SCR delivers 7 amps (rms)






**RCA's low cost 40378 and 40379 SCR's combine high forward current capability and a low-profile package... ideal for compact mounting in appliance and tool handles.**

Now you can fit SCR control into tighter spaces, update your present product without extensive case modifications and add stepless control without adding bulk to your new designs—with new, low-profile RCA 40378 and 40379.

Rated for standard 120 volt and 240 volt AC line operation, the new RCA 40378 and 40379 are economical for volume use in products such as tools, appliances, light dimmers and portable electric heaters.

Add the new-product sales appeal of variable speed and adjustable torque control, stepless heat or brightness regulation, by specifying from RCA's broad family of SCR's in space-saver packages. For information or application assistance on low cost SCR's, call your

local RCA Representative. For technical data and a copy of SMA 38, "Application of RCA SCR's to Speed Control of Universal Motors," write RCA Electronic Components and Devices, Commercial Engineering, Section RG 12-1 Harrison, New Jersey 07029.

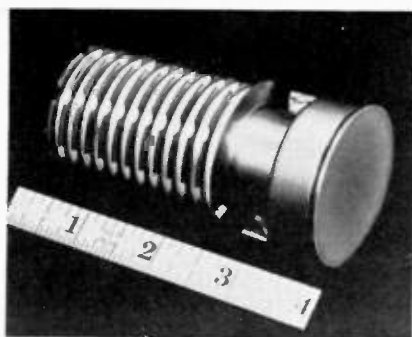
	T0-8	T0-66	New "Low Profile"		
					
	2N3528	2N3228	40378	40379	
Standard AC Supply	120	120	120	240	Volts
V <sub>RRM</sub> (rep)	200	200	200	400	Volts
I <sub>FSM</sub> (surge)	60	60	80	80	Amperes
I <sub>FRMS</sub>	2 @ 25°C	5 @ 75°C	7 @ 60°C	7 @ 60°C	Amperes

AVAILABLE THROUGH YOUR RCA DISTRIBUTOR



**The Most Trusted Name in Electronics**





to withstand the shock and radiation environments of aerospace use.

A similar type, the C31009, provides similar features with a 3-in. diameter. In both, pulse-height-resolution is typically of the order of 7% for Cs<sup>137</sup> and a sodium-iodide crystal.

RCA Industrial Tube and Semiconductor Div., 415 S. Fifth, Harrison, N. J. Phone: (201) 485-3900. TWX: (201) 621-7846.

ON READER-SERVICE CARD CIRCLE 373

### Dpdt vacuum relay

A dpdt, high voltage vacuum relay, Model H-18, capable of switching up to 10 Kvdc in air, and carrying up to 10 amps.

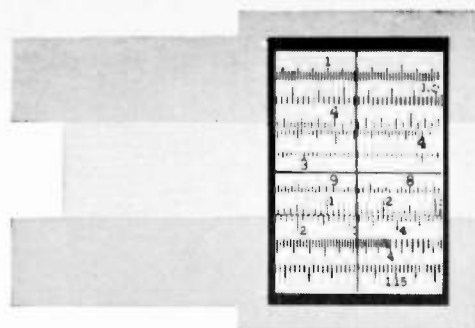
The relay has a maximum operating time of 15 msec. Standard coil



resistance is 265 ohm, and coil voltage is 26.5 vdc. It can also be supplied with 115 vdc coil. The H-18 will withstand vibration to 10 g's at 11 milliseconds.

P&A: about \$135.00; 20-35 days. High Vacuum Electronics, Inc., 538 Mission St., South Pasadena, Calif. Phone: (213) 682-2149. TWX: (213) 449-2552.

ON READER-SERVICE CARD CIRCLE 374



## MTA molded electrolytics outperform many metal case capacitors



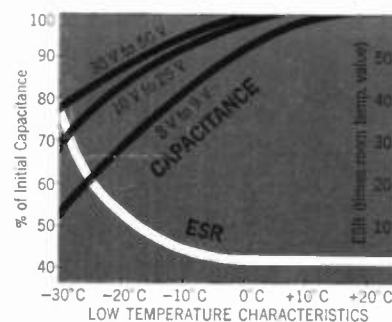
The MTA is a different kind of aluminum electrolytic. Its plastic case is molded in one piece around the capacitor element. Its price is exceptionally attractive. And its performance and quality beat cardboard and plastic case miniatures, and even many metal case models. It's already being used by leading manufacturers of entertainment and commercial electronic equipment. Here are some results of evaluation testing done recently.

Low temperature stability is good for a miniature aluminum capacitor. Capacity retention, even at -30°C,

is more than ample for most uses.

High temperature tests at 65°C and at 85°C, show that DC leakage, dissipation factor and capacitance stability are comparable with much higher priced units. DC leakage of polar models is less than 0.03 microamperes per mfd-volt.

Long-term reliability tests indicate that the MTA may set a new standard of value in its class. At 85°C, there hasn't been a single failure of any kind in 1 million piece-hours of life test. At 65°C, there has been only one failure in 2½ million piece-hours.



CIRCLE 105 ON READER SERVICE CARD

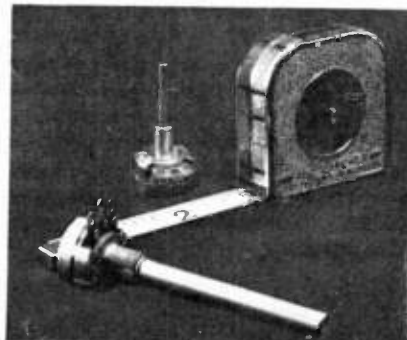
## Miniature 5-Watt Control

Only ¾" in diameter, this Mallory wire-wound control is rated 5 watts at 35°C ambient... can be derated linearly to zero watts at 105°C.

Resistance range is 1 to 25,000 ohms for non-linear tapers. Non-linear tapers can be supplied on order, with resistance range depending on taper.

Two styles are available: VW, with ⅜" bushing and ¼" shaft; and SC, with ¼" bushing and ⅛" shaft. Can also be supplied in military types as QVW and QSC. Special mounting

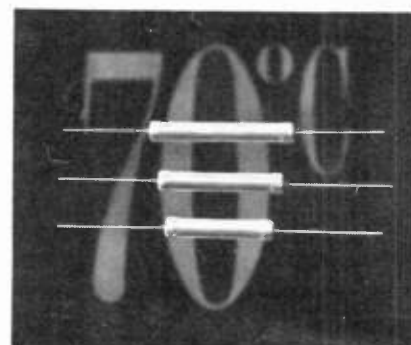
arrangements can be provided to your specifications.



CIRCLE 106 ON READER SERVICE CARD

# MALLORY

## MOL Film Resistors rated full wattage at 70°C

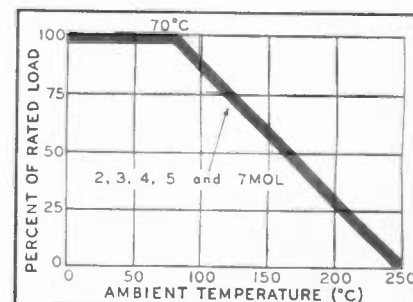


We are now rating MOL metal oxide film resistors for full wattage at 70°C ambient. Even at this new higher temperature, these resistors maintain the superior stability which has made them the choice of all major television manufacturers.

In a typical load-life test at 70°C, 125% of rated load was applied on a cycle of 15 minutes on and 15 minutes off. After 200 hours, resistance change of 7-watt MOL resistors averaged less than 5%.

The MOL line has superior stability on all counts. Temperature coefficient is only ±250 PPM/°C. Humidity tests at 95% R.H. for 100 hours at no load showed less than 0.04% change in resistance.

A wide range of resistance values is available in 2, 3, 4, 5 and 7 watt sizes.



CIRCLE 107 ON READER SERVICE CARD

# DESIGNER'S FILE

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

## "Zero defects" program produces high-reliability Certified Mercury Cells



One of many inspection operations on the Mallory Certified Cell line.

For battery applications where maximum reliability is required, such as implanted heart pacemakers, we are producing Certified Mercury Cells in a special, completely separate manufacturing facility. The Certified Cell line, unique in battery manufacturing, uses the most advanced methods of screening and quality control to assure "zero defects" output. Of the many thousands of cells produced on this line, there has not yet been a single report of premature failure. As a result of the Certified Cell program, the mean life of cells used in heart pacers has been increased by about 50%.

All manufacturing operations are performed by trained technicians. Every component... anode and

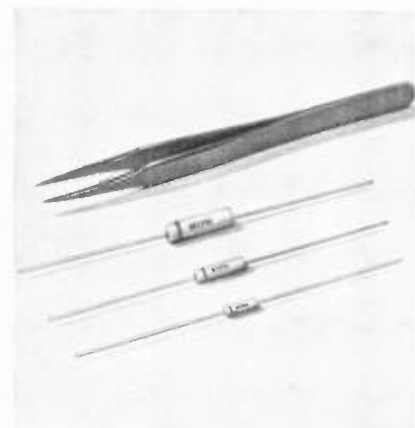
cathode pellets, containers, seals... is individually tested and pre-selected and only those which come within tight limits of optimum specification values are used. Fall-outs are discarded and not re-worked.

Complete physical and electrical tests are made on each cell during and after assembly. Complete test data are kept in permanent record for each production lot. Each shipment is individually certified to have been produced to the highest level of quality that is possible under the present state of the art.

A broad range of Mallory Mercury Cells can be supplied under the Certified Cell program.

CIRCLE 109 ON READER SERVICE CARD

Speed Inquiry to Advertiser via Collect Night Letter  
ON READER-SERVICE CARD CIRCLE 105 THRU 109



### MTPH tantalum capacitors record zero failures in 3,700,000 test hours

Quality control and long term testing of MTPH miniature wet slug tantalum capacitors shows a reliability level amply high for the most demanding applications. In 3.1 million piece-hours of testing at rated voltage at 85°C, there have been zero failures, either catastrophic or DC leakage degradation.

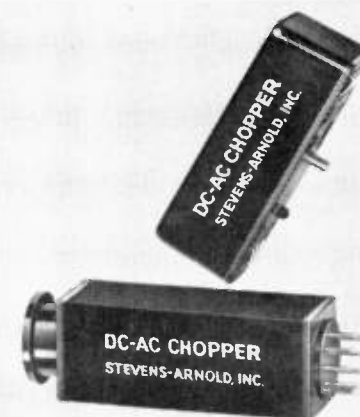
These capacitors are manufactured in the same "white room" facilities that we use for producing a similar line for Minuteman II for Autonetics Division of North American Aviation. Reliability programs under Minuteman specifications have been in continuous operation at this facility for over two years.

The MTPH has considerably higher rating per unit volume than other wet slug, solid or foil tantalum capacitors. Maximum C-V product ranges up to 170,000 mfd-volts per cubic inch. Its small case size makes it applicable for use with thin films and integrated circuits. Ratings are from 450 mfd, 6 volts to 6.8 mfd, 50 volts; case sizes are 0.115" dia. by 0.400", 0.145" dia. by 0.590", and 0.225" dia. by 0.775".

CIRCLE 108 ON READER SERVICE CARD

### 0-120 cps choppers

The series 1050 choppers are rated 0-120 cps. They are available in 9-pin or spring-contact types with either ac or dc drive. All use the same low-noise electro-mechanical



design (rated 1  $\mu$ v rms across 100 K).

Specs include a drive voltage of 6.3 v, a resistance of 270 ohm and an impedance of 285 ohm at 60 cps.

P&A: \$21.95 to \$26.70 in quantity; stock. Stevens-Arnold Inc., 7 Elkins St., South Boston, Mass. Phone: (617) 268-1170.

ON READER-SERVICE CARD CIRCLE 375

### Illuminated pushbuttons

A line of illuminated switches, Marcoswitch Press-Lites show, at a glance, exactly which circuits are activated.

These switches are rated at 5 amp or 15 amp and offer a number of options—SPDT or DPDT, alternate or momentary action; accommodate incandescent or neon lamps.



Snap action provides high current handling capacity with very low contact bounce. Service life is a minimum of 25,000 operating cycles at rated current load.

Price: from \$2.50 to \$6.00. Oak Electro/Netics Corp., Marco-Oak Industries Div., 207 South Helena, Anaheim, Calif. Phone: (714) 535-6037. TWX: (714) 776-6111.

ON READER-SERVICE CARD CIRCLE 376

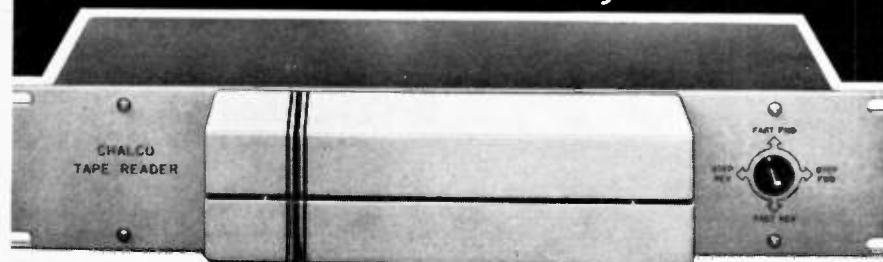


# CHALCO

## photo-electric tape reader

**\$400<sup>00</sup>\***

- 500 characters/second
- 3½" high
- One week delivery



\*Basic unidirectional module. Amplifiers and other options available at extra cost.



Send for literature

**CHALCO ENGINEERING CORP.**

Mfrs. of tape readers and D.C. power supplies

15126 S. BROADWAY, GARDENA, CALIFORNIA • FA 1-0121 (213)

ON READER-SERVICE CARD CIRCLE 60

## telephone quality components

There is no higher standard for switching components. Specify famous Stromberg-Carlson . . . known to telephony since 1894.

**RELAYS:** Types A, B, BB, C and E. All standard spring combinations are available. Send for Bulletin T-5000R3.

**KEYS:** Broad selection of push-button, cam and twist types. Send for Bulletin T-5002R2.

**HANDSETS:** High-efficiency instruments; standard or with switch assemblies. Send for Bulletin T-5017R.

Full-line data on request.

**STROMBERG-CARLSON  
CORPORATION**

116 Carlson Road • Rochester, N.Y. 14603



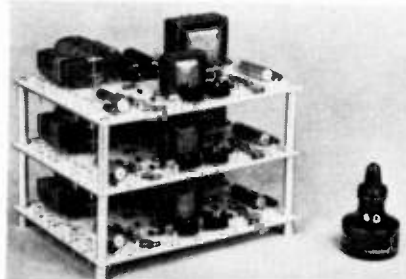
ON READER-SERVICE CARD CIRCLE 61

## COMPONENTS

### SCR gate drives

The Silicontrol Series VS6532 and VS6732 SCR gate drivers are stacked open-card assemblies suited for SCR firing in 3-phase ac or dc power control. They require no biasing or pulse preset and the load and control circuits are fully isolated for fail-safe operation.

Both have a 17-v open-circuit gate pulse and a 1.8 amp short-circuit gate current with a 1 to 2 usec



pulse rise time. Series VS6432 produces one gate pulse per cycle per phase while VS6732 produces two isolated gate pulses per card for a total of six gate pulses per cycle.

Sprague Electric Co., 347 Marshall St., North Adams, Mass.

ON READER-SERVICE CARD CIRCLE 377

### Photomultiplier tube

The S-20 photomultiplier, type 9558B, has a two inch diameter end-window tube with 11 venetian blind dynodes and highly stable CsSb secondary emitting surfaces. Gain is in excess of  $3 \times 10^6$  and dark current typically of the order of 2 nanoamps. The 9558B, with Pyrex window, covers the region between 3,000 and 8,500 angstroms. The similar 9558Q, which is made with a spectrasil window, covers the



range 1,650 to 8,500 angstroms. Select grade tubes of both types can be had for very difficult applications.

Whittaker Corp., 80 Express St., Plainview, N.Y. Phone: (516) 433-5900.

ON READER-SERVICE CARD CIRCLE 378

**Immediate  
career  
opportunities  
for engineers  
with  
imagination!**

EMR's continuing program of planned growth in Company-sponsored activity includes these vital study areas: Digital Data Transmission, Ground and Airborne PCM, and FM/FM Telemetry. Urgent requirements exist for the following:

- Computer Design Specialist
- Technical Writers
- Reliability Engineers
- Quality Control Engineers
- Logic Design Engineers
- Senior RF Engineer
- Product Development Engineers
- Circuit Design Engineers
- Electronic Systems Engineers
- Application Engineers
- Electronic Packaging Engineers

To investigate these opportunities in more detail, send your resume in confidence to: J. B. Appledorn, Professional Staffing.

**Electro-Mechanical  
Research, Inc.**

P.O. Box 3041, Sarasota, Florida



an equal opportunity employer

ON READER-SERVICE CARD CIRCLE 897

ELECTRONIC DESIGN



# ULTRA-COMPACT 4 CRYSTAL FILTERS for 4.0 to 7.5 MEG. RANGE\*

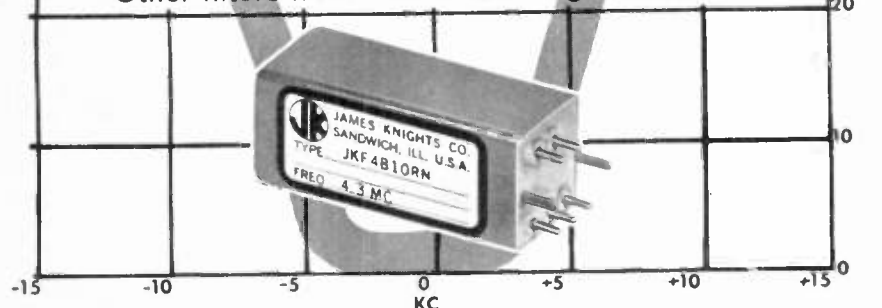
Sharpens band pass of IF's in AM receivers.

Good shape factor and low insertion loss.

Only 5/8" square x 1 17/32" high.

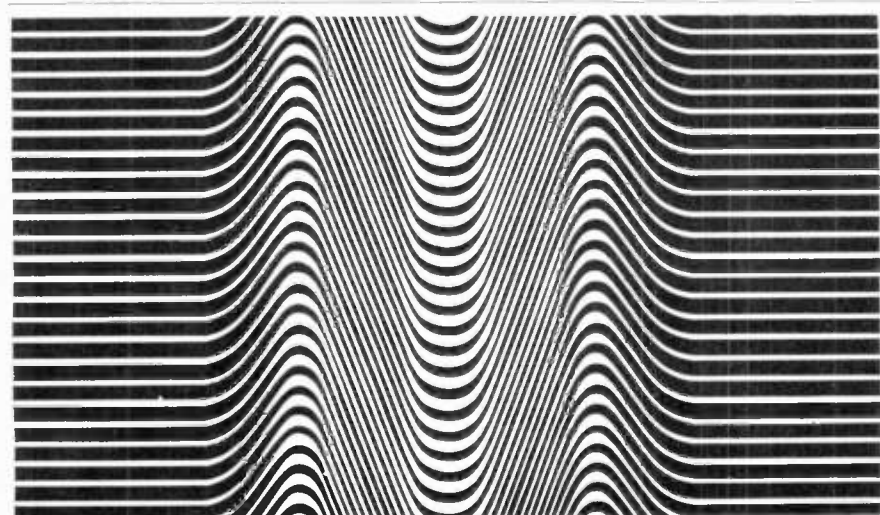
Temperature range: -30°C to +65°C.

\*Other filters from 1 kc to 100 meg. available.



**CTS KNIGHTS, INC.**  
(Formerly the James Knights Company)  
**SANDWICH, ILLINOIS**

a subsidiary of CTS Corporation, Elkhart, Indiana  
ON READER-SERVICE CARD CIRCLE 62



## optimizing the art... in magnetostrictive delay lines

**LFE STANDARDS** • Designed for commercial and military applications □ Delays from 5 to 10,000 μsec □ Frequencies 300 Kc to 2 Mc □ Delay Drift due to temperature less than 1 PPM/C □ Compatible standard input and output circuitry available.

**CUSTOM DESIGNED** • For special commercial and exotic military applications □ Fixed, tapped, adjustable and variable □ Frequencies to 5 MC RZ and 10 MC NRZ □ Delay Systems to 100,000 μsec incorporating amplifiers and related interface circuitry.

To Optimize your design, OPT LFE



**LFE ELECTRONICS**

A Division of Laboratory For Electronics, Inc.  
WALTHAM, MASSACHUSETTS 02154

Delay Lines • Filters • Transformers • Amplifiers, and Associated Electronics  
Microwave Measurement & Signal Generation Equipment

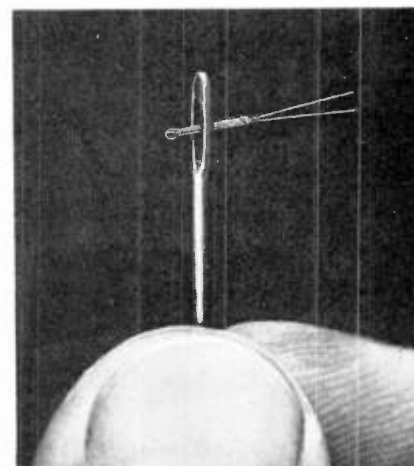
ON READER-SERVICE CARD CIRCLE 63

December 6, 1965

## Thermistor probe

A glass thermistor probe, measuring only 0.03-in. in diameter and a little over 1/4-in. in length, features time constant on the order of 25 msec in moving water.

The new "submini-probe" unit consists of a miniature thermistor bead sealed in the tip of a shock-resistant, thin-wall glass tube, with corrosion-resistant platinum-iridium leads. The new probes are



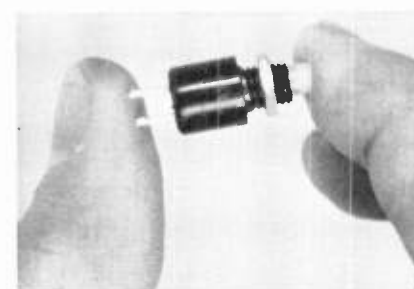
available in nominal resistances of 500 ohms to 300 K, and used at temperature up to 300°C.

Fenwal Electronics, Inc., 63 Fountain, Framingham, Mass.  
Phone: (617) 875-1351. TWX: (617) 872-1087.

ON READER-SERVICE CARD CIRCLE 379

## Pushbutton switch

The series 301 snap-action switch is rated 1 amp resistive and meets the requirements of MIL-STD-242F and MIL-S-8805. Housing diameter is 3/8-in. to mount with a 1/4-32 hex nut. Life cycle test at 35 cpm, making and breaking the rated load of 1 amp, is said to have passed one million operations. The switch is available in illuminated or non-illuminated types.



Pendar, Inc., P.O. Box 1014,  
Coeur d'Alene, Idaho. Phone: (208) 773-7311.

ON READER-SERVICE CARD CIRCLE 380

everything  
**HALL EFFECT**  
from  
**F.W. BELL**

## COMPLETE LINE OF "HALL-PAK" HALL EFFECT DEVICES

- Model BH200: General Purpose Transverse
- Model BH202: Small Axial
- Model BH204: Midget Axial
- Model BH206: High-Sensitivity, Low-Cost Transverse
- Model BH208: Ultra Midget Axial
- Model BH700: Low Cost Transverse
- Model BH701: High Linearity Transverse
- Model BH702: Ferrite Imbedded

These and many other Hall Effect Devices are available as a result of F.W. Bell's advanced research and development programs. Bell devices of high reliability and accuracy are used today for magnetic field measurement, magnet inspection, and in magnetic circuits, transducers and multipliers. If you have a special application problem, look to Bell for assistance in solving it.

**F.W. BELL INC.**

1356 Norton Avenue  
Columbus, Ohio, 43212  
Phone (614) 294-4906  
TWX 614-759-0193

ON READER-SERVICE CARD CIRCLE 64



## Mallory Film Resistors



**...fast on delivery  
tops in performance**

We can ship orders for standard values of Mallory MOL metal oxide film resistors with reasonably short lead time requirements. Special values or tolerances may take a little longer. Reason: our automated production has been expanded in step with fast-growing demand for these high-stability, low-priced resistors. Five sizes are now in production: 2, 3, 4, 5 and 7 watts, in a broad range of resistance values.

And we do mean high stability. Resistance change on 10,000 hour load-life test is less than 5%, after 1000 hours at 95% humidity, average resistance change is  $\pm 0.7\%$ . Temperature coefficient is  $\pm 250$  ppm/ $^{\circ}\text{C}$ .

Want to see how fast . . . and how well . . . we can deliver? Write or call Mallory Controls Company, a division of P. R. Mallory & Co. Inc., Frankfort, Indiana 46041

**MALLORY**

ON READER-SERVICE CARD CIRCLE 65

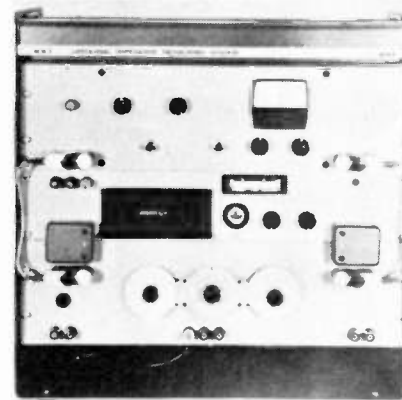
## TEST EQUIPMENT

(continued from p 62)

### Impedance bridge

The Model 292 universal impedance measuring system provides for precise measurements of resistance, conductance, capacitance and inductance. For capacitors and inductors, it also measures the dissipation factor (D) and storage factor (Q).

The modern design permits a conservative accuracy rating of



$\pm 0.01\%$  for inductance and capacitance and  $\pm 0.05\%$  for resistance and conductance. Comparative five-figure measurements can be made using the 120, 005 divisions of dial resolution provided by the Dekadial decade dials.

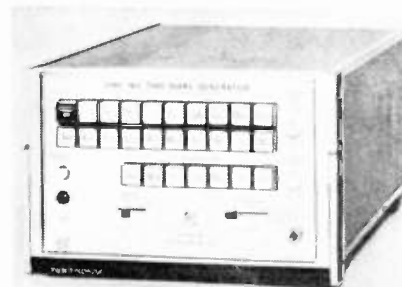
The system features the Model 290A impedance bridge; the Model 803 dc generator-detector, and the Model 860A ac generator-detector.

P&A: \$1285 (complete); stock-30 days. Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, Oregon. Phone: (503) 646-4141.

ON READER-SERVICE CARD CIRCLE 381

### Time-mark generator

Featuring a 500-Mc output, the type 184 provides 16 marker intervals, 5 sine-wave frequencies, and 7 trigger-pulse intervals. All but the 2-nsec and 5-nsec sine waves



are selected by pushbuttons. Markers up to 2 decades apart may be stacked by pushing the desired buttons simultaneously. Triggers are time-coincident with the corresponding markers.

The type 184 is transistorized, plus 6 nuvistors, and is frequency controlled by a temperature-stabilized 10-Mc crystal oscillator. Long-term stability is 3 ppm/24 hours.

Positive-going markers are provided from 100 nsec to 5 sec in 1-5-10 sequence, 1-v minimum amplitude into 50 ohms. Marker amplifier output provides positive or negative going markers with 14 intervals of 1  $\mu\text{sec}$  to 5 sec in 1-5-10 sequence, 25-v minimum amplitude into 1K.

P&A: \$675; 60 days. Tektronix, Inc., P.O. Box 500, Beaverton, Oregon. Phone: (503) 644-0161.

ON READER-SERVICE CARD CIRCLE 382

### Panoramic plug-ins

Covering two frequency bands, four new plug-in modules are designed to extend the capability of standard Tektronix scopes. The plug-ins are the MPR U/TA and MPR U/TB for use over the 500-Mc



to 5-Gc band and the MPR X/TA and PMRX/TB for use in the 2- to 12-Gc band. Models with an A suffix mate with the Tektronix 560 scopes while B-suffix models mate the letter-series instruments.

For use with other types of scopes, a separate modular power supply is available.

P&A: \$1750; stock-2 weeks. Microwave Physics Corp., 420 Kirby St., Garland, Tex. Phone: (214) 276-7189.

ON READER-SERVICE CARD CIRCLE 383

ELECTRONIC DESIGN

## Frequency comparator

The frequency comparator Model 091 accepts 21 commonly used frequencies between 100 Kc and 10 Mc in both input channels. It can compare 231 pairs of frequencies. Following error multiplication, the frequency difference can be



indicated in terms of parts in  $10^{10}$ ,  $10^9$ ,  $10^8$ ,  $10^7$ , or  $10^6$  on conventional digital frequency or period counters.

The equipment requires either  $115 \pm 10\%$  v, 50-400 cps, single phase, or +22 to +30 vdc, negative ground. Both ac line and dc battery connections can be made at the same time, and the instrument will automatically transfer to the battery during failure or low voltage of the ac line.

P&A: \$2,350.00; 30 days. Parzen Research Inc., 48 Urban Ave., Westbury, N. Y. Phone: (516) 334-3900.

ON READER-SERVICE CARD CIRCLE 384

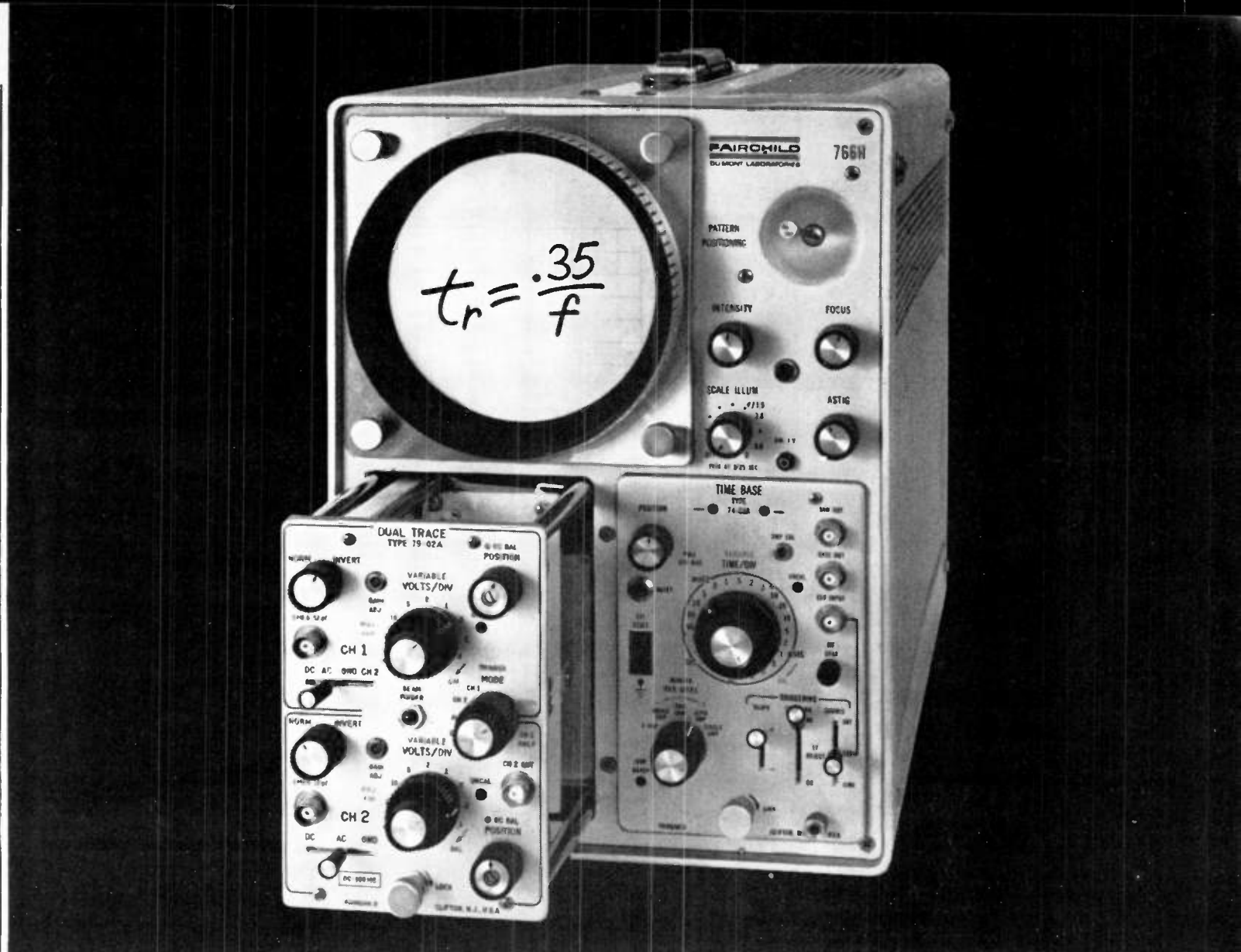
## Megohmmeter

Megohmmeter M-6 is designed for direct reading of resistances from 0.5 to 10 million Meg.

The unit features a 1-Meg output terminal of 50, 100, 250 and 500 volts, a guard terminal and a



ON READER-SERVICE CARD CIRCLE 225 ➤



## You can get a rise out of a Fairchild scope faster than anybody's

In 3.5 ns, to be precise. That's the risetime of Fairchild's Series 765H scopes fitted with the Type 79-02A plug-in. And if  $t_r = 3.5 \text{ ns}$ ,  $t = 100 \text{ mc}$ . Thus, whether you look at it in terms of speed or bandwidth, the 765H Series is the highest performance, real-time general purpose scope available.

But compare some other features too: dual trace capability with the 79-02A plug-in... 10 mv/cm sensitivity (or cascade the preamplifiers by flipping a switch and get a 50 mc single trace at 1 mv/cm)... trigger selection from composite signal or Channel 2 only... built-in 230 ns delay line.



Also consider the advantages in reliability and compactness of Fairchild's all solid-state circuitry... of advance design that incorporates all amplifier circuitry in the plug-in. These and other features of the Series 765H with its family of plug-ins give you the precision and versatility demanded in so many applications today.

\*Technological Obsolescence

Price of the dual trace 79-02A plug-in is \$1,200, and the entire 100 mc scope with  $5 \mu\text{s/cm}$  sweep is only \$2,265. Call your Fairchild Field Engineer today for a demonstration at your convenience, or for complete specifications write Fairchild Instrumentation, 750 Bloomfield Ave., Clifton, N.J.

**FAIRCHILD**  
INSTRUMENTATION  
A DIVISION OF FAIRCHILD CAMERA  
AND INSTRUMENT CORPORATION





## Last year weeds grew here.

It seems our telemetry pros never have a chance to get used to the scenery on the range. It changes too fast. Next year the skyline will be even more dramatic. It's never been any other way.

What better method of keeping on top of the technology?

Take Tel-4, for example. In order to pick up heartbeats from astronauts on their way to the moon (among other exotic space mission requirements), this advanced telemetry system now being installed incorporates bandwidth and gain characteristics unexcelled in the free world. Its computer controlled switching system will hook all equipment together in 20 seconds, and will be capable of changing from one mission to another in a matter of minutes. Completely automatic, its self-calibrating features will do in 240 seconds the task it would take humans a week to accomplish.

Other current modernization projects in the telemetry area alone include building in advanced capabilities to handle more data generated by more sophisticated space missions...providing more real-time readout for manned missions...receiving all modulations...shifting from very high frequency to ultra high frequency...providing more accuracy and reliability.

If you'd like to benefit from these dramatic and sweeping technological changes, you are invited to write to Manager, Professional Employment, Dept. 000



## GUIDED MISSILES RANGE DIVISION

PAN AMERICAN WORLD AIRWAYS, INC.  
750 S. ORLANDO AVENUE, COCOA BEACH, FLORIDA  
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ON READER-SERVICE CARD CIRCLE 895

## TEST EQUIPMENT

grounded binding post ground link for grounded and ungrounded operation. A 6-position meter multiplier switch is on the front panel.

Ranges are from 1 to 10 million Meg at 500 v, 0.5 to 5 million Meg at 250 v, 2 to 2 million Meg at 100 v, and 1 to 1 million Meg at 50 v.

The megohmmeter is in a metal carrying case measuring 6 x 7 x 12-in.

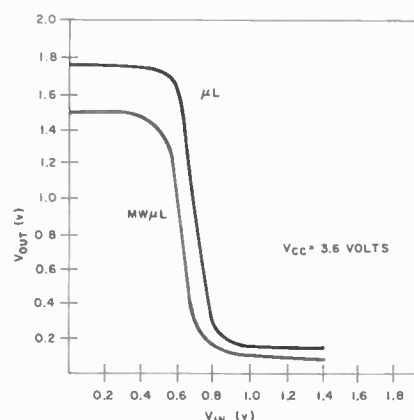
P&A: \$210; stock. Hipotronics, Inc., Brewster, N. Y. Phone: (914) 225-4075.

ON READER-SERVICE CARD CIRCLE 385

## Thermocouple test board

A low-cost pin type program board offers an economical method of testing up to 50 thermocouples.

Similar to the manufacturer's 10 x 10 proto-kit, the new SBX-104 features bussed upper and individual lower gold-plated contacts. A spe-



cial jumper plug is used to connect pairs of lines for each thermocouple. The board permits the use of five recorders with a ten thermocouple capacity per recorder.

Sealectro Corp., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

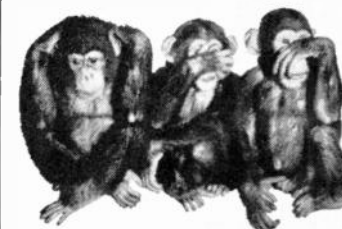
ON READER-SERVICE CARD CIRCLE 386

## Temperature probes

A new variable resistance immersion probe incorporates an integral amplifier to produce a standardized 0 to 5 vdc output.

Using the resistance variation of pure platinum wire with temperature, the unit will measure temperatures from  $-100^{\circ}\text{F}$  to  $+250^{\circ}\text{F}$

# Mind your own business



Protecting your employees' health: **your business.**

As a boss. As a **human being.**

Protecting them against America's No. 2 killer: cancer.

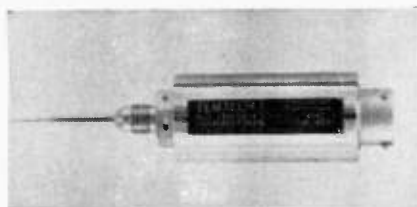
We can help. With a free comprehensive employee educational program: films, speakers, exhibits, leaflets, posters—all designed to help save lives.

Call your local ACS Unit and give us the go-ahead.

You're the boss.

american  
cancer  
society

ELECTRONIC DESIGN



at an accuracy of  $\pm 0.25\%$  of full scale over the complete range. The time constant is 0.25 second. Designated the 10654, the unit can withstand corrosive liquids and gases and operates from a 28-vdc source.

Temtech, 2202 South Wright St., Santa Ana, Calif. Phone: (714) 549-2283. TWX: (910) 595-1521.

ON READER-SERVICE CARD CIRCLE 387

## Electronic galvanometer

The Model 56A offers a voltage capability from 1  $\mu$ v to 100 v, and a current capability from 0.1 pa to 10  $\mu$ a. 160 db of sensitivity control is provided in 8 ranges and input impedance is 10 Meg on all ranges.

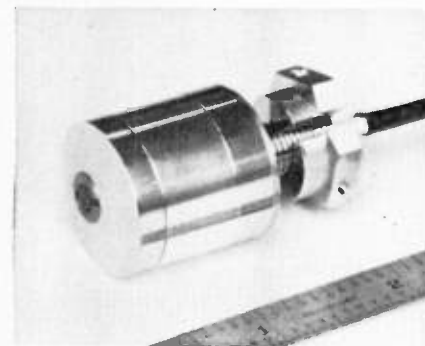
Price: \$450-\$475. Boonton Electronics Corp., Parsippany, N. J. Phone: (201) 887-5110.

ON READER-SERVICE CARD CIRCLE 388

## Acoustic microphone

A variable impedance microphone gives high-intensity, near field acoustic measurements.

The microphone will operate accurately in high transient heat fluxes of 20 BTU/ft<sup>2</sup>/sec, intense nuclear radiation, extreme electromagnetic pulses and high-g shock

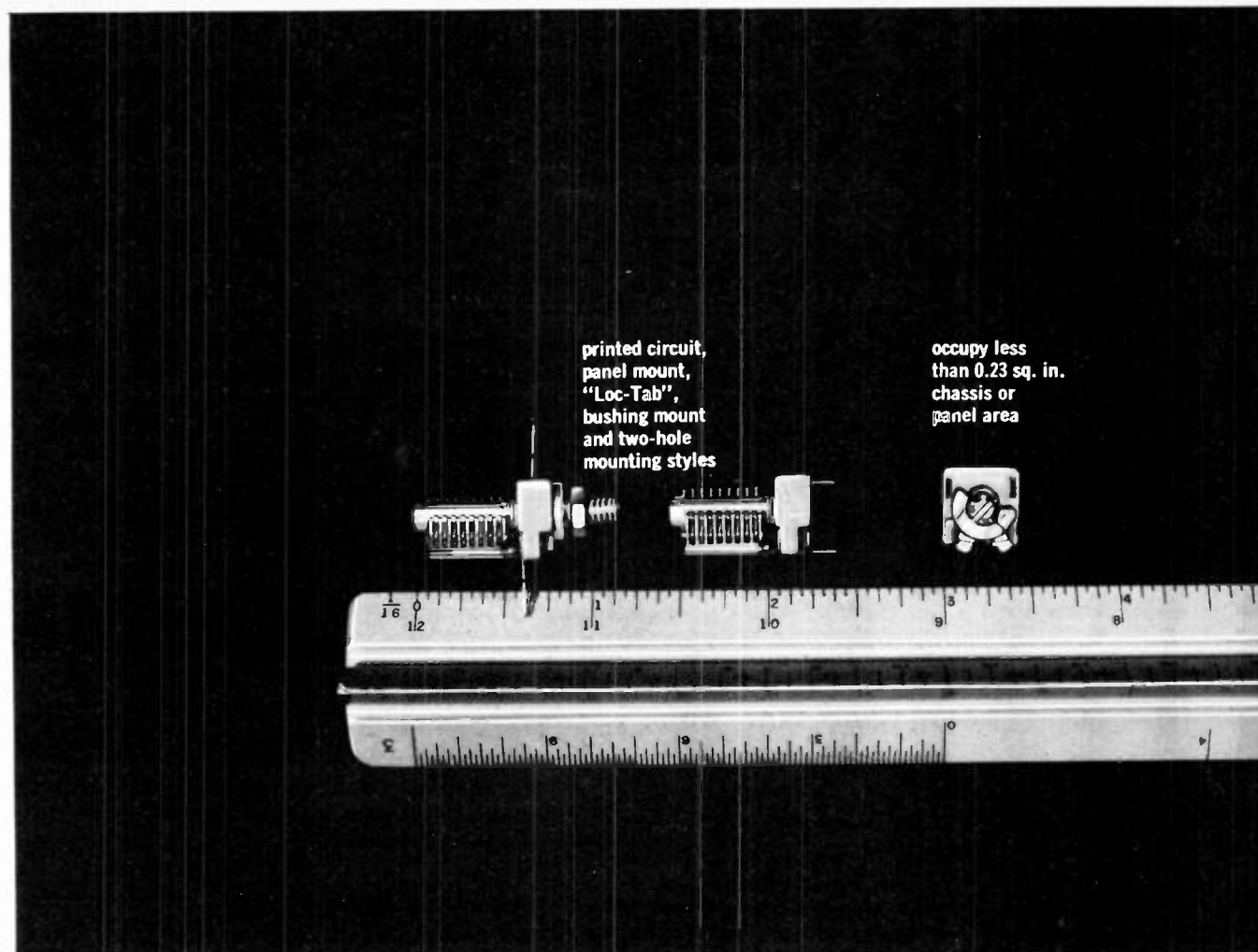


and vibration levels. It can be installed directly in rocket engine exhaust plumes. Noise level measurement ranges are 110-190 db SPL, with a frequency response flat  $\pm 2$  db from dc through 10 Kc.

Kaman Nuclear, 1700 Garden of the Gods Rd., Colorado Springs, Colo. Phone: (303) 473-5880.

ON READER-SERVICE CARD CIRCLE 389

December 6, 1965



## THESE TINY AIR VARIABLES SOLVE BIG DESIGN PROBLEMS!

Cut costs—improve performance—and save valuable space with these tiny sub-miniature air variable capacitors! "U" requires less than 0.2 square inch for chassis or panel mounting . . . types "UA" and "UB" require less than 0.23 square inch! Unique precision design with stators and rotors machined from one piece of solid brass, provides outstanding mechanical stability and uniformity. High "Q"—greater than 1500 at 1 Mc. High torque-to-mass ratio—2½ to 10 inch-ounces. Exceptionally low temperature coefficient—plus  $45 \pm 15$  PPM/°C. Provides absolute freedom from moisture entrapment found in trimmer capacitors of the enclosed or solid dielectric type. All metal parts silver-plated. Ceramic is Grade L-423 steatite, or better. Exceptionally uniform delta C and voltage characteristics. Choice of wide, double-pierced or printed circuit style terminals. Single-section models available in "Loc-Tab"; 2-Hole; Printed Circuit; and #10-32 Bushing Mount Types—Differential and Butterfly models available in Printed Circuit Types.

**TYPE "V" MINIATURES**—Slightly larger than the Type "U" series, the "V" miniatures offer all of the design, construction and performance features of the "U"s plus higher capacity with little increase in mounting area requirement. Available in Single Section types for printed circuit or panel mounting.



**"U-LC" TUNERS**—Combines precision machined Type "U" capacitor with air-wound, silver-plated inductor. Offers low cost, compact tuneable L-C circuit with excellent "Q" and temperature stability!



**DETAILED CATALOG AVAILABLE**—In addition to the variable capacitors described above, Johnson also manufactures other electronic components. For complete specifications and current prices, write for Components Catalog 984.



**E. F. JOHNSON COMPANY**

3332 TENTH AVE. S.W. • WASECA, MINNESOTA 56093

ON READER-SERVICE CARD CIRCLE 66



## Tunnel diode amplifiers— a note on gain, bandwidth, cubic inches and the state of the art

Putting one parameter next to the other — what's happened in the TDA field? Let's try it with our new P704 C-band amplifier: *Frequency Range:* 4.5 to 5.5 Gc ... *Bandwidth:* 1 Gc ( $\pm 1$  db gain variation) ... *Gain:* 20 db ... *Max Noise:* 5 db (or 4.0 db with GaSb diode) ... *Volume:* 15 cu. in. ... *Weight:* 11 oz.



In gain-bandwidth considerations this represents, we believe, the present capability of the state of the art.

Like all our tunnel diode amplifiers, the P704 is offered with germanium diodes — for greatest resistance to burnout and maximum dynamic range — or with gallium-antimonide diodes for lowest noise figures.

What about other bands? Well, the P702 X-band amplifier, for example, offers excellent electrical performance for the size and weight involved: *Frequency Range:* 8.2 to 9.0 Gc ... *Gain:*  $16 \pm 1$  db ... *Max Noise:* 5.5 db (or 4.5 db with GaSb diode) ... *Volume:* 27 cu. in. ... *Weight:* 16 oz.

Reliability? We start ahead of the game here, because we use our own ultra-reliable microwave tunnel diodes and are in a position to specify completely the diode characteristics. This also permits us to offer a *quick* reaction to your custom-design requirements. Try us.

For detailed information and technical help, call, write or wire Russ Wright, or at least circle the Reader Service Card. (Phone: 215-855-4681.)

### SOLID-STATE PRODUCTS OPERATION

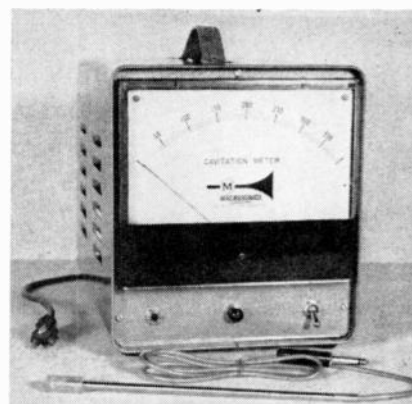
**PHILCO**  
A SUBSIDIARY OF Ford Motor Company  
LANSDALE DIVISION • LANSDALE PA  
In Canada, Don Mills Road, Don Mills, Ontario, Canada

Speed Inquiry to Advertiser via Collect Night Letter  
ON READER-SERVICE CARD CIRCLE 67

## Test Equipment

### Cavitation meter

The cavitation meter (Model CVM-3a) gives an instantaneous indication of the true amount of energy released during the cavitation of liquid media. The outstanding characteristics of this meter



are: response time less than 1 second; frequency range to 600 Kc; analog dc output; light (9 lbs.) weight. Each meter is calibrated with the carbon tetrachloride decomposition technique.

Macronsonics Corp., 1001 Roosevelt Ave., Carteret, N. J. Phone: (201) 541-4131.

ON READER-SERVICE CARD CIRCLE 390

### Laboratory kit

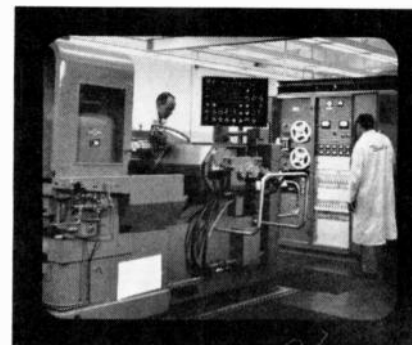
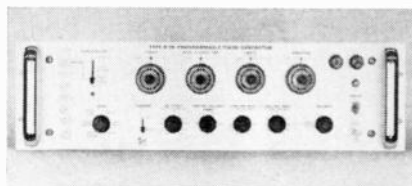
A laboratory kit of precision, standard coaxial mismatches contains two reference terminations rated at 1.03 vswr maximum, and a set of ten fixed standard mismatches ranging from 1.10 to 2.0 vswr. Vswr variation is less than  $\pm 0.03$  across the frequency range of 0 to 4000 Mc.

Meca Electronics, Inc., P.O. Box 645, Dover, N. J. Phone: (201) 625-0661.

ON READER-SERVICE CARD CIRCLE 391

### Pulse generator

Applications where a variety of pulse amplitudes, polarities, shapes in rapid sequence are required are met by the Type R116 generator.



To electronic engineers with a sense of timing:

**BENDIX IS ON THE MOVE!**

(KANSAS CITY DIV.)

This is a highly opportune moment to send us your résumé. Bendix, prime contractor for the AEC, has enjoyed an enviable, orderly expansion for 16 years, but right now we are entering a unique developmental phase which opens new fields of activity in microminiaturization, microwave and logic circuitry. This situation adds up to a ground-floor opportunity in an already well-established engineering corporation. Let us hear from you promptly so we may spell out more clearly the many professional advantages we can offer you.

Please mail résumé to:

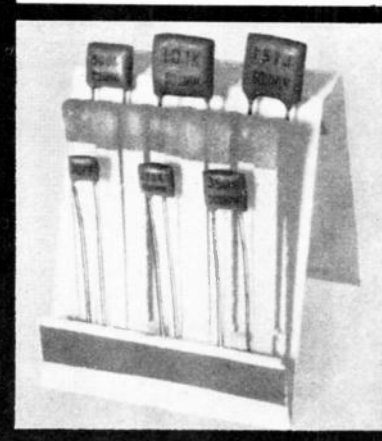
MR. E. C. MCGURREN  
Tech. Personnel Rep.  
BENDIX CORPORATION  
Box 303-CF  
Kansas City, Mo. 64141



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ON READER-SERVICE CARD CIRCLE 68

Cut costs with world's smallest, uniquely produced Silvered Mica Capacitors



### SOSHIN FMCON

- Smaller than and comparable in price to ceramic capacitors
- Excellent capacitance temperature characteristics

FMCON (500 WV) Temperature range: $-30^{\circ}\text{C} \sim +85^{\circ}$						
Type	Size (mm)		Lead $\phi$	Maximum Capacitance (PF)	T.C.	
	Area	Thickness (Max.)				
FM05	5 x 5	5.0	0.3	10	D	
FM06	6 x 6	5.0	0.4	25	D	
FM07	7 x 7	5.0	0.4	43	D	
FM08	8 x 8	5.0	0.4	75	E	
FM09	9 x 9	5.0	0.5	110	F	
FM10	10 x 10	5.0	0.5	150	F	

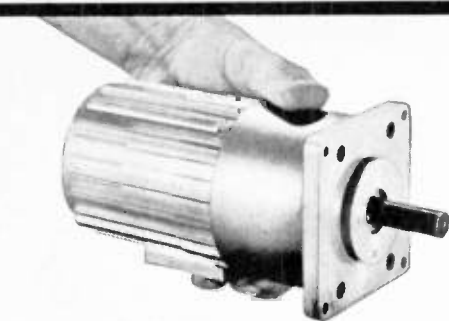
Various other types are also available.

**SOSHIN**  
ELECTRIC CO., LTD.

2-4, Magome-machi, Nishi 4-chome, Ohta-ku, Tokyo, Japan. Cables: SOSHINCAPACITOR TOKYO

ON READER-SERVICE CARD CIRCLE 69

ELECTRONIC DESIGN



## COMMERCIAL PLANETARY GEARMOTOR

to 200 lb. in. continuous duty  
to 600 lb. in. intermittent duty

You've never seen a higher torque, more compact gearmotor! Globe high quality planetary gearing for commercial and industrial applications gives highest torque-to-size ratio at lowest torque-to-dollar cost.

Type CLC gearmotors are available 115 and 230 v.a.c.; 50 or 60 cps; 1, 2 or 3 phase; 2, 4 or 6 pole. 1/75 to 1/20 hp. D.C. units available. 6 to 115 v.d.c. Eleven standard gear ratios from 12:1 to 1800:1. Others on special order. 3½" dia., 9" max. length. Request Bulletin 4474.

**GLOBE**

Globe Industries, Inc., 2275 Stanley Ave.,  
Dayton, Ohio 45404, U.S.A., Tel.: 513 222-3741

ON READER-SERVICE CARD CIRCLE 70



Z82R10  
82 Volts  $\pm 1V$

## VOLTAGE REFERENCE AND REGULATOR TUBES Tolerance $\pm 1$ Volt



Z100R12  
100 Volts  $\pm 1V$

### GENERAL SPECIFICATIONS

TUBE NUMBER	Z82R10	Z100R12
Maximum DC Breakdown Voltage (in dark or light)	115	150
Average	105	140
Reference Voltage (DC)	82 $\pm 1$	100 $\pm 1$
Measured at	2.0 ma.	3.0 ma.
Voltage Regulation — limits for less than 1 volt variation	0.3 to 10.0 ma.	0.6 to 12.0 ma.
Temperature Coefficient (typical)	-2 mv/°C	-9 mv/°C
Maximum Operating Current	14.0 ma.	14.0 ma.
Minimum Operating Current as shunt regulator	0.3 ma.	0.7 ma.
in parallel with capacitor	0.7 ma.	1.8 ma.
Life Expectancy (Hours)	30,000	30,000
Typical Variation at 250 Hours	Less than 0.3%	Less than 0.6%

Used in oscilloscope calibrators, digital voltmeters, regulated power supplies, and dc amplifiers. Provide the advantages of close regulating voltage control, low temperature coefficient, miniature size, low price and high reliability.

The Single Source for  
All Glow Lamps **Signalite INCORPORATED**

NEPTUNE, NEW JERSEY AREA CODE 201-775-2490 TWX 201-775-2255

ON READER-SERVICE CARD CIRCLE 71

December 6, 1965

The instrument provides amplitudes as high as 10 volts in either polarity.

Calibrated and programmable parameters include trigger source, period, delay or burst time, width, amplitude, mode, de-offset, rise, fall and polarity.

Complete programing capability requires 21 bits and 7 analog lines.

P&A: \$11,550; 60 days. Tektronix, Inc., P.O. Box 500, Beaverton, Ore. Phone: (503) 644-0161.

ON READER-SERVICE CARD CIRCLE 392

## Dc voltage system

The Model 1045A voltage measuring system provides direct-reading measurement of dc voltage from 1,111.1110 volts full scale to 11.111110 volts full scale on three ranges. Seven decade dials provide 1  $\mu$ v resolution on the lowest range.

The system combines a direct-reading potentiometer, a direct-reading standard cell comparator, a guarded voltbox and two independent null detectors. The self-calibrating feature of the system permits an accuracy rating of ( $\pm 5$ ppm + 1 microvolt) of reading for most settings.

P&A: \$4,200.00; 30 days. Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, Oregon. Phone: (503) 646-414.

ON READER-SERVICE CARD CIRCLE 393

## Temperature controller

Digital indication and temperature control is provided by the Model 4164. Solid-state control circuitry takes its input from a platinum resistance thermometer. The digital



readout is of the servo-type. Capabilities include control of oil baths to within 0.1°F.

Winsco Instruments & Controls Co., 1533 26th St., Santa Monica, Calif. Phone: (213) 451-5646.

ON READER-SERVICE CARD CIRCLE 394

# from NYTRONICS

## HIGH RELIABILITY CERAMIC CAPACITORS

*Over 300,000 in Stock!*

- ★ 24 Hour delivery.
- ★ 93 standard values from 5.6 pf. to 2.5 mfd.
- ★ Meets MIL-C-11015 requirements.
- ★ Subminiature components.
- ★ Rugged, epoxy-encapsulated.
- ★ Highest reliability and performance.

**MIL-CAP** in CK05 and CK06 case styles are 0.200" and 0.300" square by 0.100" thickness; capacitance range — CK05, 47 pf to 1,000 pf; CK06, 1,200 pf to 10,000 pf — both  $\pm 10\%$  and  $\pm 20\%$  capacitance tolerance; capacitance change  $\pm 15\%$  maximum over temperature range of  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$ . Working voltage 200 VDC, insulation resistance 100,000 megohms at  $25^\circ\text{C}$ , 1,000 megohms at  $150^\circ\text{C}$ . Dissipation factor  $2\frac{1}{2}\%$  maximum at 1 kc.

**HY-CAP** offers capacitance range 0.01 mfd. to 2.5 mfd. with maximum capacitance change of  $\pm 12\%$  over temperature range of  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ . Case size range from 0.225" to 0.800" width, 0.175" to 0.550" height and 0.110" to 0.375" thickness; working voltage 100 VDC; dissipation factor  $2\frac{1}{2}\%$  maximum at  $25^\circ\text{C}$ .

**DECI-CAP** has greatest capacitance range available in cordwood envelope. Molded 0.100" diameter by 0.250" long; capacitance range 5.6 pf to 27,000 pf; capacitance tolerances  $\pm 10\%$ ; capacitance change  $\pm 7\frac{1}{2}\%$  from 5.6 pf to 470 pf and  $15\%$  maximum from 560 pf to 27,000 pf over temperature range of  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ ; working voltages 200 VDC from 5.6 pf to 470 pf and 100 VDC from 560 pf to 27,000 pf; insulation resistance 20,000 megohms minimum and dissipation factor  $2\frac{1}{2}\%$  maximum at  $25^\circ\text{C}$ .

For Complete Engineering Data Write Dept. ED or Phone (201) 464-9300

## NYTRONICS

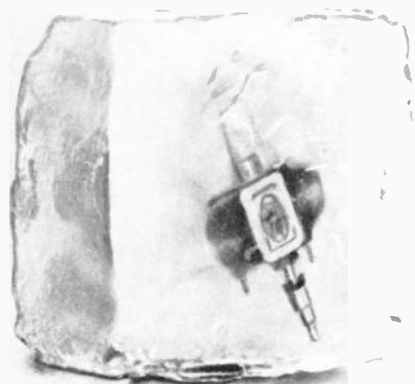
550 Springfield Ave., Berkeley Heights, N. J.

Design Leaders — STANDARD Components to Meet CUSTOM Requirements

ON READER-SERVICE CARD CIRCLE 72



taking  
the  
heat  
off



Keeping the temperature of sensitive electronic circuits constant while the ambient temperature wanders all over the lot, helps take the heat off design engineers. And that's the job Eastern refrigeration-type cooling systems do best.

These refrigeration units are the vapor-cycle, closed-system type. Years of tough testing in actual operation prove they sail through government military "specs" with flying colors. The rugged heart of these systems is a semi-hermetically sealed compressor, piston type, — powered by a 400 cycle motor.



Send for  
Series C Bulletin.



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BRANCH OFFICES: Topsfield, Mass., Lyndhurst, N. J., Wilmington, Del., Chicago, Ill., Torrance, Calif. IN CANADA: ENTERPRISE AGENCIES, INC., Montreal, Quebec

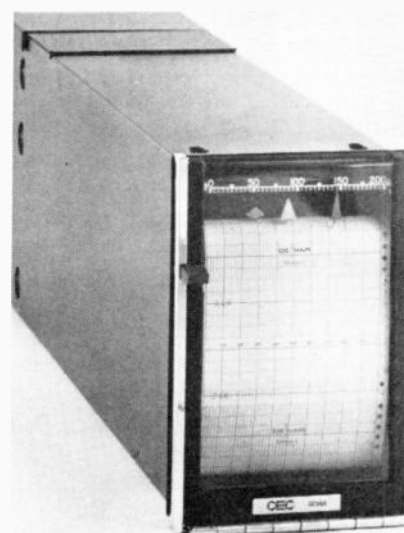
ON READER-SERVICE CARD CIRCLE 73

## SYSTEMS

### Strip chart recorder

The type 18-301A recorder is available with function module channels to accommodate standard 1 to 50 volt dc inputs or milliamp dc inputs in ranges of 1 to 5, 4 to 20, or 10 to 50 ma. Also, function modules can be installed to accept special inputs such as dc millivolts and frequency or computed inputs from function module computer systems.

One-, two-, or three-pen models of the recorder are offered, with all



pens providing simultaneous full-scale rectilinear writing on a four-inch chart. The recorder case is capable of housing a power supply and function modules to compute a complete BTU, ratio, or similar equation.

Price: from \$250. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Phone: (213) 796-9381. TWX: (213) 577-0067.

ON READER-SERVICE CARD CIRCLE 395

### Synchro transmitter

A solid-state synchro transmitter, Model 650 without moving parts will drive up to 3 size 15 synchro receivers. Functional accuracy is up to six minutes. Output is 3-wire 11.8 v 400 cps line to line.

Two dc voltages proportional to the sine and cosine of the desired angle will drive the synchro transmitter. Alternately, operation from dc voltage, 0 to plus and minus 10

## Two electrifying reasons for coming home with us to Paris:

### 1. The Electronic Components Exhibit. 2. Paris.

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THE WORLD'S LARGEST AIRLINE  
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ON READER-SERVICE CARD CIRCLE 74

ELECTRONIC DESIGN



volts proportional to angles from 0 to 360 degrees, is provided through the manufacturer's solid-state sine-cosine generator, Model 670.

Power required is 40V dc unregulated with 1 amp transient capability and 26V 400 cps reference.

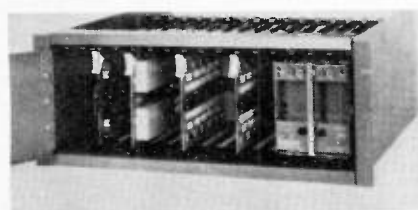
P&A: from \$200 in quantity: 4 to 6 weeks, prototypes. Transmag-netics Inc., 134-08 36th Rd., Flushing, N. Y. Phone: (212) 539-2750. TWX: (212) 539-2653.

ON READER-SERVICE CARD CIRCLE 396

## Analog elements

The Model 510 dual-channel operational amplifier is guaranteed for less than 25  $\mu$ v/day drift, maximum noise of 500  $\mu$ v, and  $\pm 100$  v at 20 ma output. The 502 multiplier, of the same family, offers a maximum error of 50 mv for both inputs within the range of  $\pm 100$  volts.

The Model 530 sine-cosine generator performs trigonometric functions with a maximum static error



of 25 mv. A compatible reference and power supply with cabinet holding up to 12 cards is designed for easy construction of special purpose systems.

Zeltex, Inc., 2350 Willow Pass Rd., Concord, Calif. Phone: (415) 686-6660.

ON READER-SERVICE CARD CIRCLE 397

## Portable X-ray unit

A new portable X-ray unit, the Baltograph 300/2, is capable of penetrating steel up to 2-1/2-in. thick using lead screens and 4-in. thick with calcium tungstate screens.

The Baltograph 300/2 is rated at 300 Kv, 3 Ma. with self-rectified circuitry, and duty cycle can be extended through use of an optional water cooling jacket allowing high production, continual radiography. Unit weight is 149 pounds.

Balteau Electric Corp., 10-14 Meadow St., Stamford, Conn. Phone: (203) 324-6118.

ON READER-SERVICE CARD CIRCLE 398

ON READER-SERVICE CARD CIRCLE 226 ➤

# Progress Report

of special interest for thin film

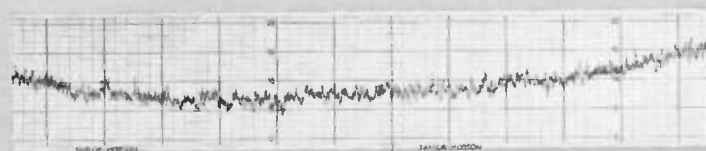
ALSiBASE®

## CERAMIC SUBSTRATES

with

"AS FIRED" SURFACE SMOOTHNESS of 6 to 8 Microinches CLA

**"AS FIRED" SURFACES.** An "as fired" working surface as smooth as 6 to 8 microinches CLA is being regularly produced in ALSiBase substrates of ALSiMag 772, a 99 1/2 % alumina ceramic composition. The "as fired" surface is suited for many resistive patterns in thin film circuitry.



Surface smoothness is measured on our Talysurf equipment. Above: Tape of ALSiMag 772 with "as fired" surface smoothness of 6 microinches CLA at 10,000 amplifications.

**BERYLLIA\* CERAMIC SUBSTRATES.** Beryllia ceramics are excellent electrical insulators. They conduct heat about as well as aluminum does. These characteristics suit beryllia substrates to applications where heat must be dissipated rapidly. American Lava Corporation has developed and refined a dense 99.5% beryllium oxide material with "as fired" surface of 15 microinches CLA or better on the working side. This material, ALSiMag 754, is finding an increasing number of applications. It requires special precautions in handling and is justified where other materials will not meet design requirements.

**MEASUREMENTS OF COORDINATES.** An increasing number of ceramic substrates require accurate placement of a number of holes. American Lava has precision equipment which produces a printed tape showing the x-y coordinates of the holes. This equipment is

used to inspect set-ups before production and to inspect the final product to assure compliance with exacting specifications.

Typical coordinate measuring machine tape. Decimal is two places to the right.

SEQUENCE NUMBER	X	Y
001	007252	
002	008500	002498
003	009754	003752
004	010004	003746
005	012496	003998
006	012498	005250
007	012498	005250

**STOCKED SIZES.** Prototypes to your specifications can be supplied. Preferred sizes of substrates are stocked "as fired" in a thickness of .025". In ALSiMag 614 and ALSiMag 772 alumina, present sizes are 1/2"x3/4", 1"x1", 1"x2", 2"x2". In ALSiMag 754 beryllia, 1"x1". ALSiMag 614, a 96% alumina ceramic with ALSiMag 743 glaze can be supplied in a thickness of .030" in sizes 1/2"x3/4", 1"x1", 1"x2", 2"x2".

Let your own practical tests on prototypes or stock items give you the answer.

\* It should be noticed that special precautions are necessary to insure safe handling of beryllium oxide ceramics.

# American Lava Corporation

3M COMPANY

A SUBSIDIARY OF

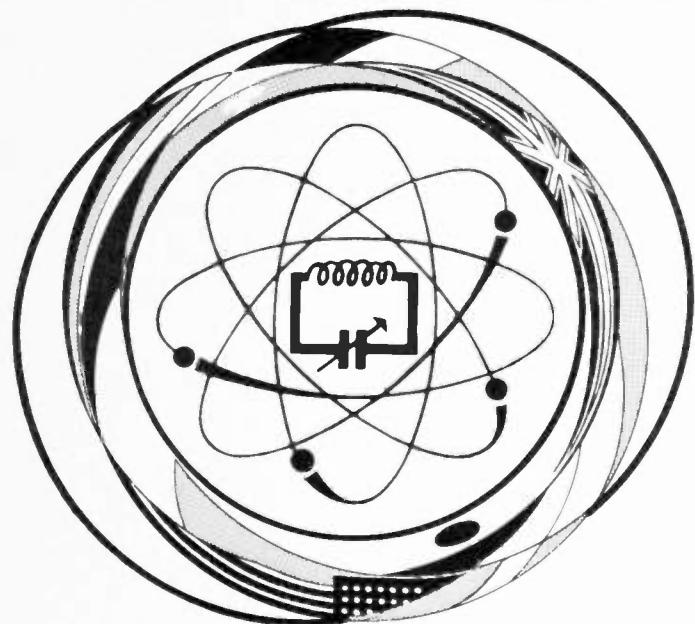
PHONE 615 265-3411, CHATTANOOGA, TENN. 37405

For service, contact American Lava representatives in Offices of Minnesota Mining and Manufacturing Co. in these cities (see your local telephone directory): Birmingham, Michigan • Boston: Needham Heights, Mass. • Chicago: Bedford Park, Illinois • Cleveland, Ohio • Laurens, S. C. • Los Angeles, Calif. • Minneapolis, Minn. • Metropolitan New York: Ridgefield, N. J. • Up-State New York: Phelps, N. Y. • Philadelphia, Penn. • Dallas, Texas • Roanoke, Va. • South San Francisco, Calif. All export except Canada: Minnesota Mining and Manufacturing Co., International Division, 700 Grand Ave., Ridgefield, N. J.

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YEAR  
OF  
CERAMIC  
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from February 3 to 8, 1966  
in Paris, gateway to Versailles**



**the first world confrontation of the year  
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# ELECTRONIC COMPONENTS

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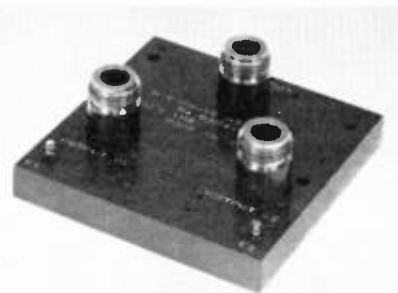
**SALON INTERNATIONAL DES COMPOSANTS ELECTRONIQUES**

ON READER-SERVICE CARD CIRCLE 75

## MICROWAVES

### Transmission-line diode

A SPDT strip transmission line diode switch is designed for X-band operation. The MA-8304-2X1S can operate in any 500 Mc band be-



tween 7 and 12 Gc. Peak power is 25 watts with 10 nanosecond switching time.

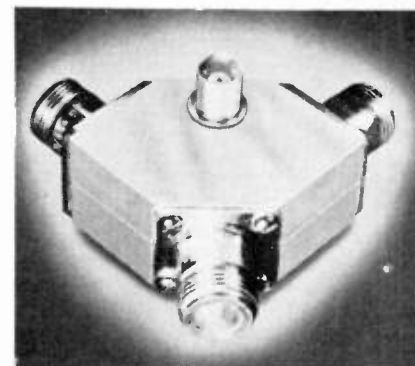
Maximum insertion loss is 1 db with minimum isolation of 20 db. The unit weighs less than three ounces and measures 1-3/4 x 1-3/4 x 5/8-in.

Microwave Associates, Inc., Burlington, Mass. Phone: (617) 272-3000. TWX: (617) 272-1492.

ON READER-SERVICE CARD CIRCLE 702

### Spdt coaxial switches

Model MSK diode coaxial switch and model MRSK Reed switch are designed for low loss, high speed remote control and transfer of signals over a broad frequency range.



The Spdt diode switch covers the range of 5 to 900 Mc and the SPDT reed switch covers dc-2 Gc. They are packaged in an aluminum housing.

P&A: \$105.00 and \$115.00; one week. Teltronics, Inc., 24 Main St., Nashua, N. H. Phone: (603) 882-6242.

ON READER-SERVICE CARD CIRCLE 703

## We have a way with wire

(any way you want it)

For example. Let's take a spool of wire. We can straighten it and cut it. (Diameters from .004 to .125, in lengths from .020" to 12 feet). And form it into shapes of all kinds. Or coil it. Head it in sizes as fine as .008". Upset it even in multiples as fine as .009". Or flatten it wherever you want. Pierce it to specs. Swage it in many ways. Or chamfer one end or both ends—make a full radius on .025". And even give you any combination you may want.

Our range is from fine of .004" to heavy .125". Parts shown are subject to type of wire and temper. Send us your drawings and specs for an estimate. No obligation. And if you need small metal stampings, we do that too.

### ART WIRE AND STAMPING CO.

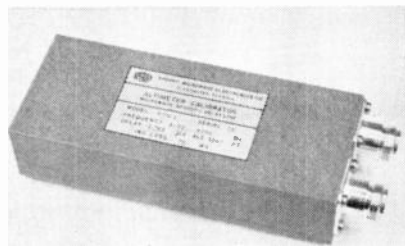
17 Boyden Place, Newark 2, N. J.  
ON READER-SERVICE CARD CIRCLE 76

ELECTRONIC DESIGN

## Altimeter calibrator

The D71C5 altimeter calibrator can be installed in existing radar altimeters without modification of the radar. The unit permits in-flight checking and continuous performance monitoring in altimeters where the size and weight of conventional delay lines allowed only preflight checks.

The calibrator consists of a microwave acoustic delay line having



a delay non-dispersive with frequency and temperature. Covering the 4.1 - 4.5 Gc band, the D71C5 provides a delay time of 2.782 microseconds  $\pm 1\%$ , corresponding to an altitude of 1367 feet, with a nominal insertion loss of 96 db. Spurious outputs and direct signal leak-

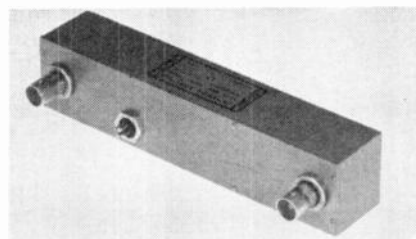
age are suppressed in excess of 30 db below the desired output signal.

Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. Phone: (813) 855-3311.

ON READER-SERVICE CARD CIRCLE 704

## Vhf amplifiers

Two broadband vhf amplifiers operate over the vhf television band. Model TAV-70 covers 40-100 Mc with a noise figure of 2.7 db,



and Model TAV-195 covers 160-230 Mc with a noise figure of 3.5 db. The amplifiers, which are completely solid-state, have 30 db minimum gain and have a 75 ohm matched output.

International Microwave Corp., River Rd., Cos Cob, Conn. Phone: (203) 661-6277.

ON READER-SERVICE CARD CIRCLE 705

**YOKES      FOCUS COILS      DRIVERS**

# DEFLECTION YOKES

Highest resolution

Rotating

The best Deflection Yoke for your display is the one that meets your total system requirements, at the lowest cost, delivered on time. For most displays you can select that best yoke directly from the CELCO Display Engineering Manual.

Which CRT? — What Resolution? — Drive Circuitry? — Shielding? — Recovery Time? — Environment? — Measurement? — WE KNOW! Call for free Engineering Consultation. When other sources fail, we produce workable solutions.

Write for our Yoke Brochure

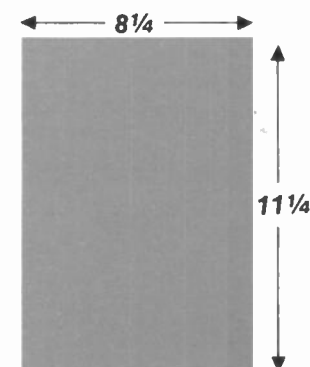
**Constantine Engineering Laboratories Co**

TEL. 201-327-1123      MAHWAH, N. J.      TWX 201-327-1435

ON READER-SERVICE CARD CIRCLE 77

$$E/D: 1/4/66 = 8.25 \times 11.25$$

## Formula for Your Convenience



*In response to readers' preferences, ELECTRONIC DESIGN is changing its size. Look for ELECTRONIC DESIGN in standard 8 1/4 x 11 1/4 format, starting with the January 4, 1966 issue. You'll find the new size easier to file, easier to tearsheet, easier to carry with you.*

**Electronic Design**



## IC logic family

The T Series of logic modules use monolithic integrated circuits as flip-flops, buffers and inverters. This, according to the manufacturer, brings fully buffered AND/OR gates into the price range of inverting NAND/NOR components. This also permits three levels of logic to be performed with a single level of amplification.

The series includes buffered AND gates, buffered AND/OR gates, decoders, buffer amplifier matrix, inverter matrix, NAND gates, NOR gates and other configurations.

Propagation delay in buffered AND/OR or NAND/NOR configuration is typically 18 nsec, 30 nsec worst-case. Flip-flop delay is 40 nsec typical and 70 nsec worst-case. Fan-out is 14.

A complete set of mounting cases, power supplies, module testers and auxiliary hardware is also available.

Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif. Phone (213) 871-0960.

ON READER-SERVICE CARD CIRCLE 706

## IC series

The IB-1 and IB-1A are two additions to the manufacturer's Abacus I-series of monolithic integrated-circuit modules.

The IB-1 provides the gating required to form one decade of a BCD up/down counter. The IB-1A provides the gating required for 4 bits of a binary up/down counter. Both modules are designed for use with the IF-6 module, which contains 6 J-K flip-flops.

Counters of arbitrary lengths can be formed by the selection of appropriate numbers of IF-6 modules and IB-1 or IB-1A modules.

Each of the modules is based on monolithic integrated-circuits and operates at speeds up to 5 Mc. Each measures 2 x 3-in. and uses a single supply voltage. Peripheral circuits such as Schmitt triggers, lamp drivers and interfaces round out the line.

Whittaker Corp., 9229 Sunset Blvd., Los Angeles, Calif. Phone: (213) 274-0771.

ON READER-SERVICE CARD CIRCLE 707

## FIRST PRIZE:

*win 2 round-trip  
New York*

- ▶ All Electronic Design subscribers are
- ▶ Over 100 other valuable prizes!
- ▶ Guess the top ten ads in Electronic Design's

# Electronic Design's 1966

## SEPARATE CONTEST FOR MANUFACTURERS AND ADVERTISING AGENCIES

Not forgotten in "the Top Ten" contest, advertisers and their agencies may also enter. In addition to prizes of a **flight to Paris, color TV, and electronic timepiece**, the top 10 ads, and the winning advertiser's ad (if run in *FOCUS '66*) will be re-run in the March 29th issue. Watch for the special "Top Ten" contest rules and entry blanks appearing January 4, 1966.



### 2ND PRIZE HOFFMAN COLOR TV CONSOLE

Hoffman 23" console, featuring 26,000 volts of picture tube power... 4" x 6" front-firing speaker... easy vision camera control for sharp color movies and positive, black and white picture shading... InstaVision on-off control... 32" x 29" x 19 1/2" cabinet. (Retail value: \$600.00.)



### 3RD TO 8TH PRIZES BULOVA ACCUTRON® ELECTRONIC TIMEPIECES

The "Spaceview" is an ideal timepiece for electronics engineers. Its clear-view dial reveals transistorized electronic circuit and tuning fork assembly. The tuning fork, advertising symbol and unique frequency standard of Accutron® timepieces, is the reason Bulova guarantees an in-use, on-the-wrist accuracy of within 60 seconds a month. (Retail value: \$150.00.)



### PLUS 100 ADDITIONAL PRIZES 400 IDEAS FOR DESIGN

Innovations, techniques, guidelines of design, the "best" to come across the desks of *Electronic Design* editors, are featured in this useful volume. The selections feature outstanding ideas that have appeared in recent years in this popular department of the magazine. This attractively bound, hard-cover edition will be given to 100 winners. (Retail value: \$8.50.)

watch for entry blanks in the January 4th issue of

# *tickets between and PARIS*

VIA AIR FRANCE

eligible!

January 4th, "FOCUS '66" issue.

## "Top Ten" contest

### HERE'S ALL YOU HAVE TO DO TO ENTER:

Rate the ads appearing in the *FOCUS '66* issue of *Electronic Design* (January 4). Select the "Top Ten"... the ads that, in your opinion, will be best remembered by readers. Your choices will be measured against the 10 ads ranking highest in the "Recall-Seen" category of Reader Recall—*Electronic Design's* scientific method of measuring readership. In making your predictions, be sure to consider your 53,000 fellow engineers' interest in the subject matter of the ads, their effectiveness, impact, and attention-getting values.

Entry blanks and complete contest rules will appear in the January 4th issue. Don't miss this opportunity to win one of the many valuable prizes shown at left. The first prize winner will receive round-trip tickets for two, between New York and Paris via Air France!

## Electronic Design

### Operational amplifier

A monolithic operational amplifier, the  $\mu A709$  is designed for use as a general purpose amplifier in dc servo systems, high impedance analog computers, low level instrumentation applications, and for the generation of special linear and nonlinear functions.

The new circuit uses non-Darlington input to achieve low offset, and to minimize thermal drift.

It features a voltage gain of 45,-



000; an output swing of  $\pm 14$  v; and an input voltage common mode range of  $\pm 10$  v. Other features include an offset voltage of 1 millivolt; power consumption of 80 milliwatts, and thermal drift of  $3 \mu V/^{\circ}C$ . Temperature range is  $-55^{\circ}$  to  $+125^{\circ}C$ .

P&A: \$50-\$75; stock. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530.

ON READER-SERVICE CARD CIRCLE 708

### Video amplifier

A new, low-cost integrated video amplifier, type E13-511, features high stability from  $-55^{\circ}C$  to  $+125^{\circ}C$ . Type E13-511 amplifies from dc to over 50 Mc ( $-3db$ ) with an essentially flat gain characteristic to 40 Mc. Key specifications include voltage gain of 24 db, gain variation ( $-55^{\circ}C$  to  $+125^{\circ}C$ ) of  $\pm 0.3$  db, limits of gain variation (dc to 10 Mc) of  $\pm 0.5$  db, and dynamic range of 7.0 volts.

P&A: \$12 (1-99); stock. Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. Phone: (415) 968-9241. TWX: (415) 969-9112.

ON READER-SERVICE CARD CIRCLE 709



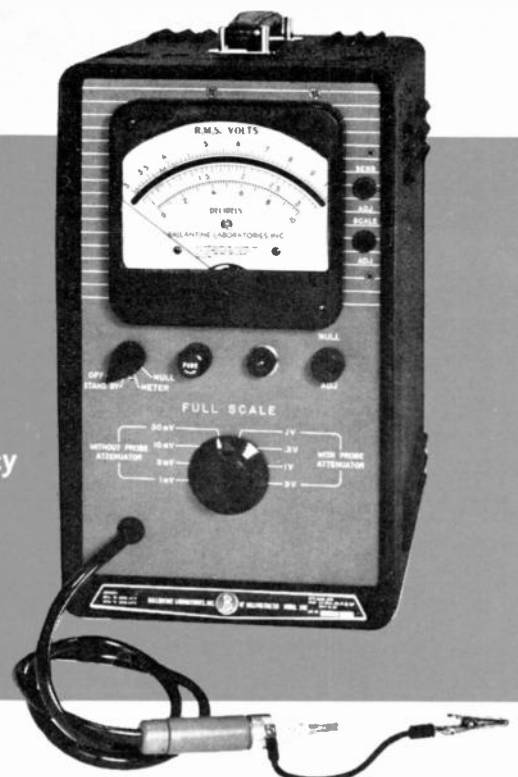
# Ballantine Sensitive True-RMS RF Millivoltmeter

## Model 340

Price: \$760  
(with all accessories\*)

Measures True-Rms  
regardless  
of Waveform  
and Voltage

High, Uniform Accuracy  
and Resolution over  
entire 5-inch scale



## Measures 300 $\mu$ V to 3 V from 0.1 Mc to 1,000 Mc

Ballantine's Model 340 is a sensitive, wideband, rms-responding voltmeter with a basic accuracy of better than 4%. Its 5-inch voltage scales spread out the readings logarithmically. Thus you can make measurements to the same high resolution and accuracy at the bottom of the scale as you can at full scale.

Outstanding is the Model 340's rms-response to distorted sine wave voltages, regardless of their levels. This is most important at high frequencies since all known calibrating standards are based on rms-responding devices.

### SPECIFICATIONS

Voltage Range..... 300 $\mu$ V to 3 V	Crest Factor.... 100 to 3 depending on voltage range
Frequency Range..... 0.1 Mc to >1,000 Mc; calibrated to 700 Mc	Scales.... Two logarithmic voltage scales, 0.95 to 3.3 and 3.0 to 10.6. One decibel scale, 0 to 10
Indication..... True-RMS on all ranges, all voltages	Mean Square DC Output 0.1 V to 1.0 V dc. Internal resistance 20 kilohms. (For connection to recorder.)
Accuracy.... % of Reading	
0.1 Mc — 100 Mc, 4%;	
100 Mc — 700 Mc, 10%;	
above 700 Mc as sensitive indicator	

\*Accessories include a probe tip for in-circuit measurements, an adapter for connection to N or BNC, a T adapter for connection to a 50 ohm line, and a 40 db attenuator

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**BALLANTINE LABORATORIES INC.**  
Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR DC AND AC ELECTRONIC VOLTMETERS/AMMETERS OHMMETERS, 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 78

## MICROELECTRONICS

### RCA integrateds bow

With the introduction of 17 integrated circuits and the announcement of six more still in the planning stage, RCA has formally entered the growing IC market. The new devices include both digital and analog types.

The digital types are five ECCSL (emitter coupled current-steered logic) circuits and three DTLs (diode transistor logic). The ECCSL line includes two families with propagation delays of 6 and 3.6 nsec.

Linear types include nine amplifiers: three for operation at 100 Mc, one each for 20 Kc, 650 Kc, 11 Mc, and 16 Mc, as well as two operational amps at 300 Kc.

Four digital and two linear circuits will be added to these lines in the first quarter of 1966.

Prices for the digital circuits start at \$1.60 per gate in evaluation quantities. Linear devices are priced from \$4.40.

Radio Corp. of America, Electronic Components and Devices, Harrison, N. J. Phone: (201) 485-3900. TWX: (201) 621-7846.

ON READER-SERVICE CARD CIRCLE 710

### ICs for industry

A new family of linear integrated circuits are designed specifically for applications in industrial environments.

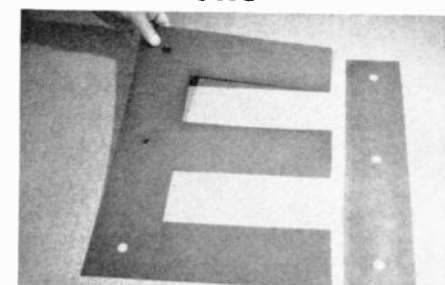
Designated series 72, the new family of monolithic silicon circuits initially includes the SN723 general-purpose differential amplifier and the SN724 general-purpose operational amplifier. Operating temperature range of the SN723 and SN724 is 0° to +70°C.

Both SN723 and SN724 operate from  $\pm 12$  v but can be operated from  $\pm 6$  v or from single-polarity supplies if ac coupled unit.

P&A: \$11.00 (SN724) and \$18.75 (SN723) at the 250-unit level; stock. Texas Instruments Inc., 13500 N. Central Expwy, Dallas, Texas. Phone: (214) 235-3111. TWX: (214) 231-1492.

ON READER-SERVICE CARD CIRCLE 790

## For Design Latitude... Specify T&S Engineered Laminations



T&S Giant Lamination, 3.60 three phase type.



This  $\frac{3}{8}$ " single phase lamination is the smallest standard manufactured by Thomas and Skinner.

When it comes to transformer laminations, T&S offers the widest range of standard sizes in the industry today. Designed within scrapless dimensions, T&S Laminations provide most efficient use of core material... avoid special die costs... permit use of standard mounting hardware. Write for descriptive literature on the T&S Laminations that suit your need...

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WIDE WINDOW LAMINATIONS... For high frequency applications. Bulletin L513

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3 ( ) LAMINATIONS... A T&S development. Bulletin L514

Mr. Magnetician, symbol of over 60 years T&S experience in the field of magnetics.



### CERTIFICATION OF MAGNETIC QUALITY

Thomas and Skinner is the first manufacturer to provide certification of magnetic quality with each lamination shipment. All T&S laminations are tested and certified under ASTM A-346-58 specification. The T&S material certifications provide volt amperes per pound, core loss and material lot number. The material lot number identifies and serves as a control on each lot. The material certification is forwarded with the invoice and a duplicate copy is forwarded with the packing slip covering the shipment. Our quality control system conforms to MIL-19858.

**Thomas & Skinner, Inc.**



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PHONE 317-WA 3-2501

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ELECTRONIC DESIGN

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## NEW COMPONENT PART CONCEPTS

Unusual opportunities now exist in the field of component development and performance analysis, due to a conceptual approach developed by our Research and Development Laboratories. These positions demand the ability to perform laboratory evaluation on existing components and prepare a critical analysis of their performance. Where the state of the art is a limiting factor, new approaches must be proposed and development work initiated to provide the required component performance.

In the process of developing new approaches to the solution of component problems, papers must be prepared which will be used as the basis for proposals.

Well equipped laboratories are provided in which the applicant can employ the latest techniques in development and instrumentation to assist in the exploitation of his ideas.

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Please airmail your resume to:

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Head of Employment  
Hughes Aerospace Divisions  
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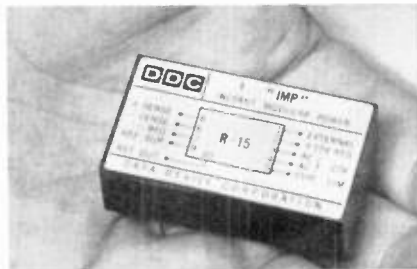
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## Modular supply

Called the "Imp" (for instant modular power), and measuring only 5/8" high x 1.2" x 2.1", the R-15 provides 25 ma of highly regulated power at 15 v for microcircuit and discrete component power requirements.

The "Imp" features regulation



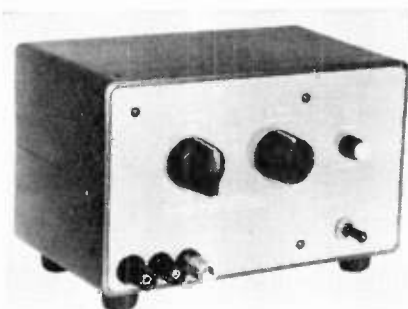
of 0.01% line or load, temperature coefficient of 0.05%/°C, and long-term drift of less than 1 mv over 8 hours for an operating temperature range of -25°C to +85°C.

P&A: \$63-\$65; stock to 10 days.  
Data Device Corp., 240 Old Country Rd., Hicksville, N. Y. Phone: (516) 433-5330.

ON READER-SERVICE CARD CIRCLE 710

## Variable dc source

A variable power supply and three power-limiting resistor switches to match the output load constitute the Model 820 power source for bridges, potentiometers and other dc instruments. The entire assembly is mounted on a



guard chassis in order to maintain at least  $10^{14}$  ohms between the high terminal and ground.

The output power is continuously variable to a maximum of 1 w into a matched load. Full scale output voltages are 2 v, 20 v, and 200 v. The input voltage requirement is 117 vac, 50 to 400 cps.

P&A: \$145.00; stock. Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141.

ON READER-SERVICE CARD CIRCLE 713

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FREE AIR  
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## ERA SILICON MAGITRAN®

### VARIABLE HIGH-CURRENT POWER SUPPLIES

- All-Silicon Design
- Low Cost for all Systems Applications
- Long Term Stability Less Than 8 MV
- Current Ranges up to 25 Amps
- Continuously Adjustable 0 to 36 VDC
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- Closely Regulated
- Low Ripple Content
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- No Fuses or Circuit Breakers to Reset
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- Ungrounded Outputs
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- Functional Design—Easily Serviceable
- Minimum Size and Weight
- Front and Rear Terminals
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- Removable Panel Mounts
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- Extended Warranty

#### GENERAL SPECIFICATIONS

Input Voltage Range: 105-125 VAC  
Input Frequency Range: 50-400 cps  
Regulation Line:  $\pm 0.01\%$  or 5 mv  
Regulation Load: 0.05% or 8 mv  
Long Term Stability: Less than 8 mv, constant line, load and temperature  
Ripple: Less than 1 mv, RMS  
Transient Response: Less than 50  $\mu$ sec  
Operating Temperature: -20°C to +65°C  
Temperature Coefficient: 0.01%/°C or 3 mv  
Automatic Overload Recovery

Short Circuit Protection with automatic recovery  
Remote Sensing  
Parallel and Series Operation  
Vernier Voltage Control  
Output Terminals (Ungrounded): Location, front and rear  
Reverse Voltage Protection  
Cooling: Convection  
Metering: Separate Current and Voltage Meters

#### STANDARD MODELS

Model	Voltage	Current	Price
SL36-2M	0-36 VDC	0-2 amps	\$235.00
SL36-2/2M	0-36 VDC Dual	0-2 amps Dual	465.00
SL36-4M	0-36 VDC	0-4 amps	290.00
SL36-8M	0-36 VDC	0-8 amps	355.00
SL36-12M	0-36 VDC	0-12 amps	455.00
SL36-25M	0-36 VDC	0-25 amps	650.00



For complete information write for Catalog Supplement #133a.

**ELECTRONIC RESEARCH ASSOCIATES, INC.**

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ON READER-SERVICE CARD CIRCLE 80



## Can an engineer flunk Fortran and still find happiness?

**Happiness is**  
finding a digital computer with a simple keyboard,  
whose language is algebra.

**Happiness is**  
having 48 to 88 individually addressable storage registers  
plus 5 separate registers for arithmetic manipulations,  
480 steps of program memory,  
and/or 18 optional prewired programs of 48 steps each,  
right in your own department.

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not spending a million dollars for a digital computer,  
or \$50,000, or \$20,000, or even \$10,000.

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getting 8 to 9 significant digit accuracy  
with a 2 digit power of ten exponent,  
automatic decimal placement,  
paper tape readout,  
100 column number capacity.

**Happiness is**  
getting intelligent accessories,  
like a paper tape punch and reader,  
or a page printer.

**Happiness is**  
a Mathatron 8-48 plus the new  
Auxiliary Program Storage.

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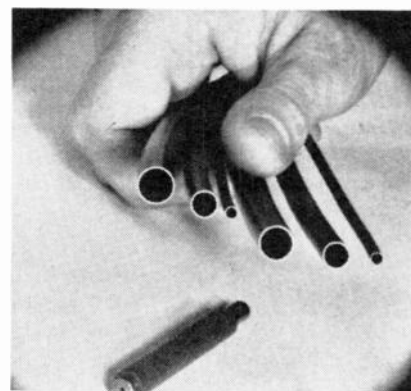
ON READER-SERVICE CARD CIRCLE 81

## MATERIALS

### Thin-wall tubing

A filled-TFE formulation, Rulon TW, is used to extrude thin-wall tubing with inside diameters from 0.050 to 1.5-in. and thicknesses down to 0.015-in.

The new material is said to be 500 times more resistant to wear than unfilled-TFE (polytetrafluoroethylene) paste extrusions while



providing the same low friction (0.04 to 0.2) and broad temperature tolerance  $-400^{\circ}$  to  $+500^{\circ}\text{F}$ .

Rulon TW can be heat-shrunk on rolls, shafts and pins. It can be used with or without lubricant.

Dixon Corp., Metacom Ave., Bristol, R. I. Phone: (401) 253-7500. TWX: (401) 253-5940.

ON READER-SERVICE CARD CIRCLE 714

### Ceramic material

Hypalox E-37 Tr has a density approaching that of sapphire. Applications include microwave and infrared systems where thermal conductivity and chemical inertness are required. Composed of  $\text{Al}_2\text{O}_3$ , E-37 Tr has a dielectric strength of over 15 Kv/mm and is stable up to  $1800^{\circ}\text{C}$ .

American Feldmuehle Corp., P. O. Box 2160, Glenbrook, Conn. Phone: (203) 325-1511. TWX: (203) 096-5913.

ON READER-SERVICE CARD CIRCLE 715

### Fluorosilicone adhesive

A ready-to-use fuel resistant fluorosilicone rubber adhesive bonds fluorosilicone rubber parts to a variety of other materials or to fluorosilicone rubber itself.

The new material, Silastic 142 fluorosilicone adhesive, is highly re-

# 100 db

## Logarithmic Converter



Model TP 662

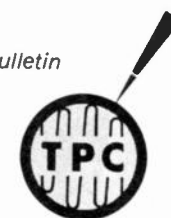
# \$890\*

\*  
BASIC UNIT  
DC INPUT

Plug in for

1 cps — 200 KC... \$105.00  
2 KC — 400 KC... 97.00

Write for Bulletin



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ON READER-SERVICE CARD CIRCLE 82  
ELECTRONIC DESIGN

## AIRBORNE RADAR SYSTEMS ENGINEERS

Our Aeronautical Systems Division has several openings for Airborne Radar Systems Engineers who are familiar with fire control systems and the associated AGE and maintenance testing, and who have experience defining test equipment requirements, or are familiar with development/integration testing.

The assignments will involve the analysis and definition of customer requirements related to the maintenance and check-out of prime aero equipment, the functional design of AGE and/or the supervision of laboratory test activities. An accredited degree in E.E. and a minimum of three years of applicable, professional experience are required.

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Please airmail your resume to:

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11940 W. Jefferson Blvd.  
Culver City 8, California

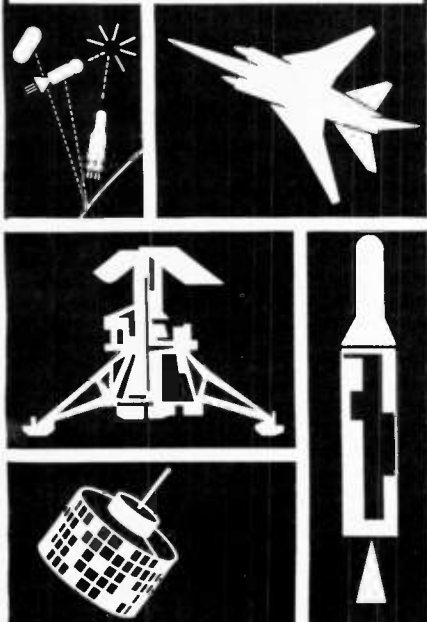
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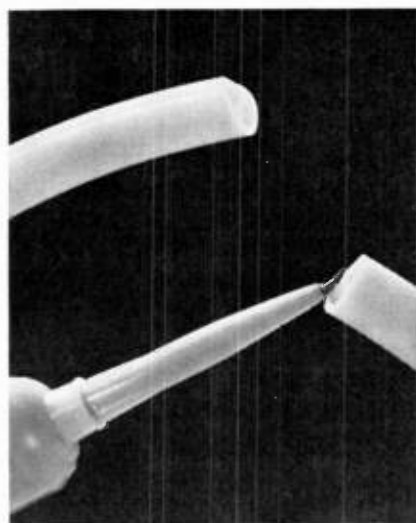
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sistant to most fuels, oils, and solvents, as well as to weathering, ozone, and moisture. It stays flexible at temperatures from  $-70^{\circ}$  to  $+500^{\circ}\text{F}$ .

Physical properties of the adhesive include an ultimate elongation



of 500%, tensile strength of 550 psi, and peel strength of 100 pounds per inch width.

Price: \$22.50 per 8-ounce polyethylene cartridge, in lots of 144.

Dow Corning, Midland, Mich.  
Phone: (517) 636-8507.

ON READER-SERVICE CARD CIRCLE 716

## Expitaxial GaAs.P<sub>(1-x)</sub>

A new epitaxial process now produces highly pure single-crystal gallium phosphide, gallium arsenide and gallium arsenide-phosphide. The materials are said to be particularly valuable in light-emitting diode work.

The new process produces individual epitaxial layers of each material in thicknesses from 2 micron to 0.025-in. Multiple layers are produced as combinations of the various materials or of various dopings.

Crystals and slices are produced to specifications on a two week basis.

Texas Instruments, 13500 N. Central Pkwy., Dallas, Texas.  
Phone: (214) 235-3111. TWX: (214) 231-1492.

ON READER-SERVICE CARD CIRCLE 717

## Porous metal/ceramic

A wide range of porous metal and ceramic structures are available with pore sizes ranging from below

## RELIABILITY



*Ultra high speed  
Monroe DATALOG®  
MC 4000 Printer  
delivers*

**6000 lines  
per minute!**

That's 100 lines per second, synchronous or any speed less than 100 lines per second that your application might require. The MC 4000 is truly synchronous or asynchronous.

A non-impact printer. Completely silent. Absolute reliability.

It's available in a numeric model (15 characters in each column) or in an alphanumeric model (43 to 64 characters in each column). Both models are 32 columns wide and have the same 6000 lines per minute printing speed.

Look at these MC 4000 features: Character serial input, bit parallel. Data transfer time of 50 microseconds (no buffers required). Only two moving parts—the paper feed stepping motor and the fan. Compact: 10½" high, 10½" wide. Rack mount available. All solid state with cathode ray tube through fiber optics.

Any 4 line code for the numeric model; any 6 line code for the alphanumeric model. Any logic level.

Price, just \$5650 for the numeric, \$5850 for the alphanumeric model.

Reliable. Silent. Ultra high speed. Synchronous or asynchronous.

And, like all Monroe DATALOG printers, the MC 4000 is covered by a full year's warranty with on-site maintenance.

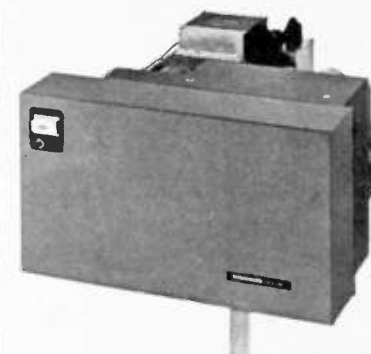
For additional information, specification sheets or a demonstration, write or call Monroe DATALOG Division of Litton Industries, 343 Sansome, San Francisco. (415) 397-2813.

**MONROE DATALOG** 

A DIVISION OF LITTON INDUSTRIES

ON READER-SERVICE CARD CIRCLE 83

## RELIABILITY



**MONROE DATALOG®  
HIGH SPEED PRINTERS  
AT NEW LOW PRICES!**

Check the new low prices on these two printers:

The MC 10-40, which prints 1040 lines per minute and has 4, 8, 12 or 16 columns of printing with 15 characters (0 through 9 plus 5 symbols) in each column. Prints legibly, reliably.

The MC 13-80, which prints 1380 lines per minute and delivers 4, 8, 12 or 16 columns of printing with 10 characters (0 through 9) in each column. Prints legibly, reliably.

Both are priced at:

4 column capacity	\$1790
8 column capacity	1890
12 column capacity	1980
16 column capacity	2480

Quantity discounts are available—and the cost of any unit is \$100 less than quoted above if it is to be used only with 3M Action paper.

Both models have parallel input, accept any 4 line code, any logic level, flat pack or roll record, and have low audible noise level. (No extra charge for any of these.) Options include high order zero suppression or high speed (250 microseconds transfer time) buffer registers.

Both models have cam driven hammers and clear, legible printouts. Neither model has hot and cold, sometimes running, solenoids. Both models have reliability.

The MC 10-40 and MC 13-80 are both covered by a one year warranty which includes parts and on-site maintenance.

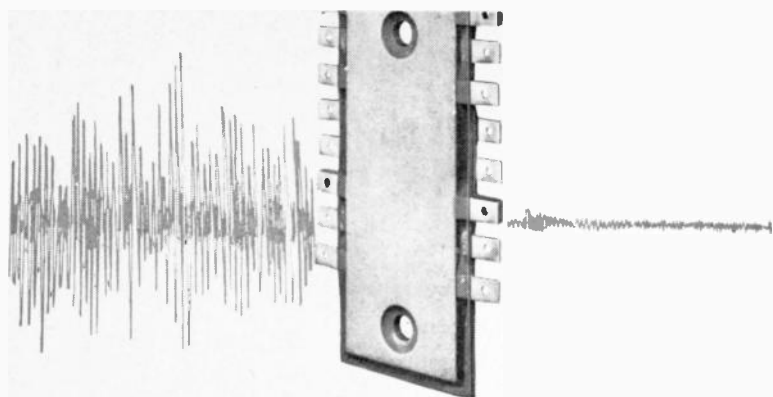
For a published price schedule and specifications, write or call Monroe DATALOG Division of Litton Industries, 343 Sansome, San Francisco. (415) 397-2813.

**MONROE DATALOG** 

A DIVISION OF LITTON INDUSTRIES

ON READER-SERVICE CARD CIRCLE 84





## Laminated Bus Bars For Noise Reduction



Flat bus conductors laminated with Eldre's thin, rugged insulation will reduce electrical noises which cause havoc in high speed, solid state equipment. Lower the inductance and control the capacitance of your vital power distribution lines. Ground shields are interleaved with the voltage-carrying conductors so that effective shielding can be adequately provided. The terminations of each conductor, as shown, are for soldering but other types can be incorporated into the bus design. This compact and completely molded bus can replace a bulky harness and repetitive wiring.

Increase the reliability of your circuit with a bus system and obtain efficiency.



COMPONENTS INC. • 1239 UNIVERSITY AVENUE • ROCHESTER, N. Y. 14607

ON READER-SERVICE CARD CIRCLE 85



**LIGHT  
TO FIGHT  
BY...**

*Portable military shelters require a very special kind of interior lighting.*

**WE MAKE THIS KIND.**

*Literature on request*



**BRUCE INDUSTRIES, INC.** 1528 West 178th Street, Gardena, California

ON READER-SERVICE CARD CIRCLE 86

## MATERIALS

1 micron to beyond 2000 microns and in pore volumes from 10% to 97%.

Inventoried porous materials are simple block shapes up to 1-in. x 5-in. x 5-in. in the most popular materials, such as nickel, tungsten, alumina and zirconia. The more popular materials produced as porous structures have been the refractory metals and ceramics, though other materials—such as lead, copper, bronze, monel, 316 stainless steel, iron, nickel, fused silica, spodumene, titanates etc.—have been produced.

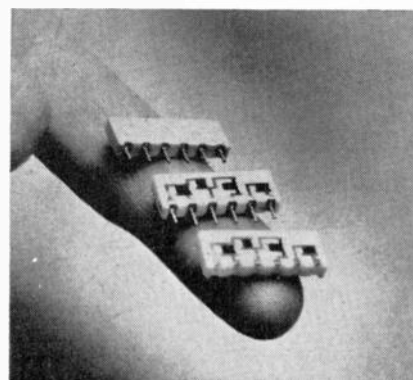
Astro Met Associates Inc., 503 Glendale-Milford Rd., Cincinnati, Ohio. Phone: (513) 772-1242.

ON READER-SERVICE CARD CIRCLE 718

## Insulating coatings

A varnish based on Dapon diallyl phthalate resin offers a high degree of protection against arcing and shorting. In photo, bottom module is untreated; unit in center has received initial transparent coating of varnish; module at top has received a second, pigmented coating of the material. (CTS Corp. resistor and capacitor modules shown).

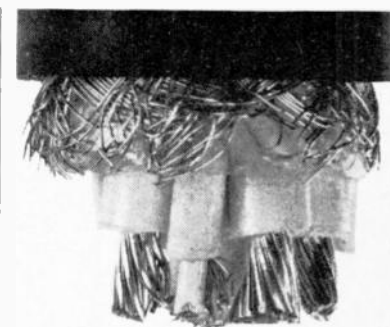
The coatings withstand 500 vac and each is cured to a three-dimensional polymer at temperatures exceeding 160°C. Coatings consist of



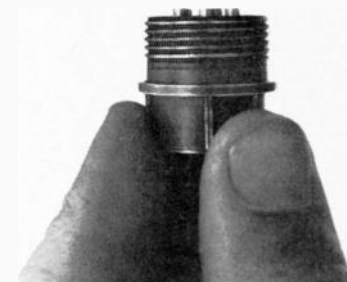
both diallyl phthalate prepolymer (Dapon) and monomer in a solvent solution. They are supplied for coating, sealing, and dip encapsulating uses.

FMC Corp., Organic Chemicals Div., 33 Third Ave., New York, N. Y. Phone: (212) 687-7400.

ON READER-SERVICE CARD CIRCLE 719

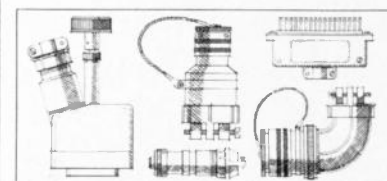


# how?



**With Glenair adapters,  
backshells and elbows...  
compatibility is easy.**

Adapt any size cable to your connector; combine strain relief, RFI and environmental protection. Glenair also provides bulkhead seals, shorting caps, protective covers, cable & wire accessories and special tools. Choose from over 90,000 different parts and assemblies. If these standard items cannot solve your problem, Glenair will quickly design special hardware for you, modify connectors or provide integral connector and rear hardware assemblies. Cable connector compatibility is Glenair's technical specialty. Send the coupon for full details on fast, complete Glenair service and products.



**GLENNAIR, INC.**  
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Glendale, Calif. 91201  
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Send data on Glenair service and products

Name

Title

Company

Address

Phone No.

ON READER-SERVICE CARD CIRCLE 87

ELECTRONIC DESIGN



## SIDE-LOOKING RADAR SYSTEMS ANALYSTS

New programs at HUGHES are generating opportunities for Systems Analysts experienced in high-resolution data gathering, data transfer and data processing systems. Openings exist for Systems Engineers, Mathematicians and Physicists qualified in synthetic array radars, optical, and other data collection systems (IR, Electro-Optical, SIGINT and others). Assignments include:

**Senior Systems Scientist** with 20 years' electronic systems experience—at least 10 years relevant to side-looking radar systems. Applicants will be considered for important program management responsibilities. M. S. or Ph. D. degree required.

**Senior Systems Analysts** with 10 years' electronic systems experience—at least 5 years relevant to high-resolution systems pre-design and evaluation. Applicants will be considered for assignments in concept formulation; single and multi-sensor applications; data transmission, processing and interpretation; systems integration and performance evaluation. M. S. or Ph. D. required.

**Systems Analysts** with 5 years' experience in: detection of signals in noise, optimum filter theory, non-linear signal processing, information theory, MTI and doppler systems analysis. B. S. or M. S. required.

Please airmail your resume to:

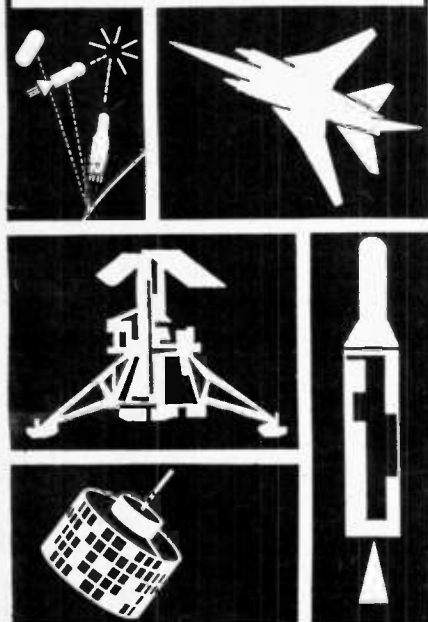
**MR. ROBERT A. MARTIN**  
Head of Employment  
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11940 W. Jefferson Blvd.  
Culver City 9, California

Creating a new world with electronics

**HUGHES**

HUGHES AIRCRAFT COMPANY  
AEROSPACE DIVISIONS

U. S. CITIZENSHIP REQUIRED  
An equal opportunity employer.



## Structural polypropylene

A modified polypropylene, Olefil, is offered in both medium and high impact formulations. It is said to retain the chemical resistance and low moisture absorption of conventional polypropylene while providing better toughness and rigidity.

Prices range \$0.28-\$0.30 per lb. Avisun Corp., 21 S. 12th St., Philadelphia, Pa. Phone: (412) 568-5520.

ON READER-SERVICE CARD CIRCLE 720

## Beryllium copper alloy

A free-machining beryllium copper alloy, Berylco 33-25, is said to machine in less than 40% of the time required by conventional Alloy 25. The material is available in rod form for use with automatic screw machines.

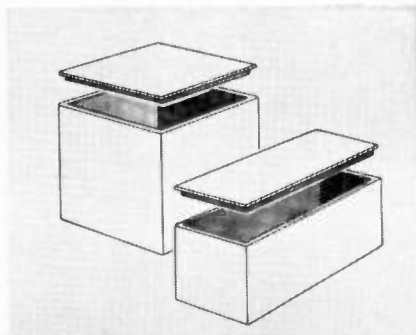
Beryllium Corp., P. O. Box 1462, Reading, Pa. Phone: (215) 929-0781. TWX: (215) 390-5583.

ON READER-SERVICE CARD CIRCLE 721

## Potting forms/headers

No tooling costs are required to make matching fiberglass laminated epoxy header plates to fit a line of standard glass epoxy potting forms. The class F epoxy is of fiberglass laminated construction.

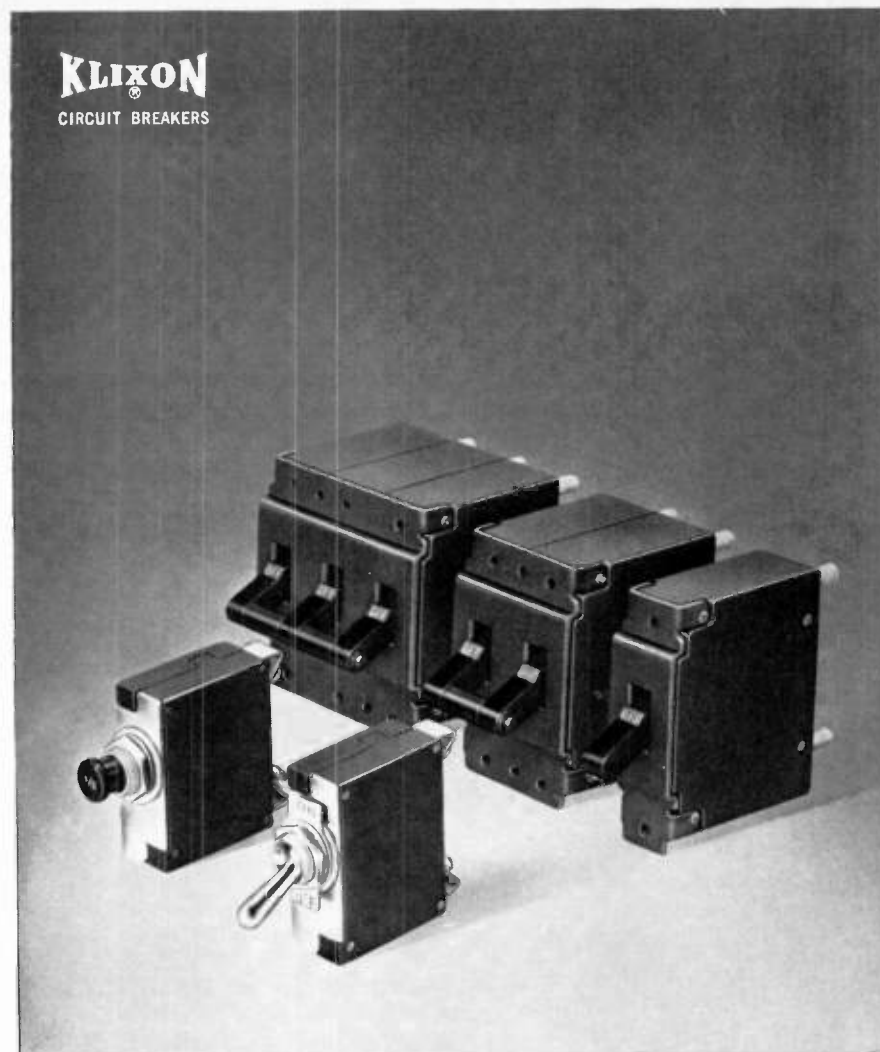
Glass epoxy tubes—black or natural green—are made in 18"



lengths on any of 1200 sizes of mandrels. The tubes, in .030 in. thickness, are then cut to specific lengths. Header plates are made to fit the open end of the tubes and a shoulder cut is made on all four sides of the header.

Stevens Tubing Corp., 128 North Park St., East Orange, N. J. Phone: (201) 672-2140.

ON READER-SERVICE CARD CIRCLE 722



## When magnetic circuit breakers are needed for high-reliability protection

### ...TI DELIVERS!

**Name your specifications!** Ratings from 0.050 to 50 amp. 2, 3 or 4 terminals. Internal circuits for series, shunt, calibrating tap or relay trip. Remote indication or control. Toggle or push-pull actuation. One, two or three poles. 20% lower voltage drop. 50% higher rupture capacity. All these options are included among the 202 standard types of KLIXON® brand Magnetic Circuit Breakers. All available for off-the-shelf delivery from stock.

**Bulletin CIRB-1** contains complete technical information on TI magnetic circuit breakers. Write for your free copy today.

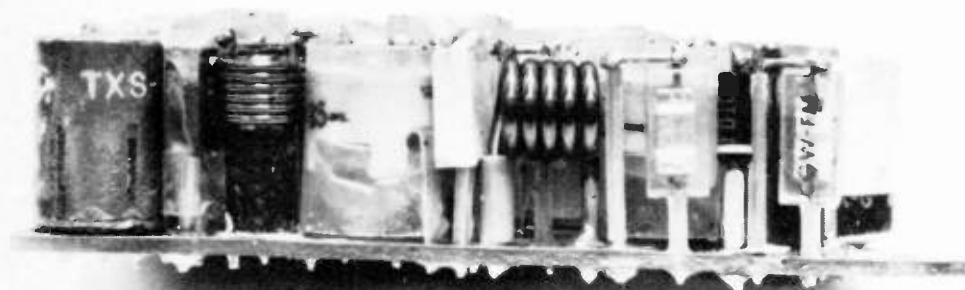


**METALS & CONTROLS INC.**  
5112 FOREST ST., ATTLEBORO, MASS.  
A CORPORATE DIVISION OF  
**TEXAS INSTRUMENTS**  
INCORPORATED

ON READER-SERVICE CARD CIRCLE 88



*who runs most editorial on  
packaging and production?*



Illustrated above: A packaged transceiver unit employing techniques that combine the ruggedness of an embedded cordwood unit with repairability. The unit, having a density of 35 components per cubic inch, was designed by Ryan Electronics. It appeared in a Special Report on Packaging in the July 5, 1965 issue of **ELECTRONIC DESIGN**.

Last year, **ELECTRONIC DESIGN** carried 266.5 editorial pages on packaging and production . . . 71.8 more pages than *three* other electronics publications combined.

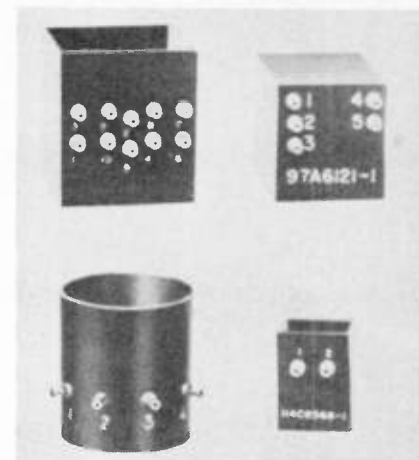
**MOST EDITORIAL ON PACKAGING AND PRODUCTION—  
ANOTHER REASON WHY ELECTRONIC DESIGN IS THE  
INDUSTRY'S BEST READ MAGAZINE.**

**ELECTRONIC  
DESIGN**

a HAYDEN publication  
850 Third Avenue • New York, N.Y. 10022

## MATERIALS

### Encapsulation cups



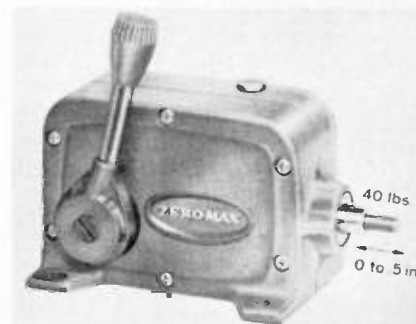
Over 30 new sizes have been added to the standard EC encapsulation cup line. The cups have continuous heat resistance to 450°F, a compression strength of 30,000 psi and a dielectric strength of 400 v/mil.

Electronic Production Development Inc., 11965 South Prairie Ave., Hawthorne, Calif. Phone: (213) 772-4185.

ON READER-SERVICE CARD CIRCLE 723

### Linear actuator

A variable length linear actuating device meets fractional horsepower control applications. Called the "Multi-Stroke" model UNO, the unit converts a rotating input motion to a stroking, or reciprocating



output. It is adjustable from zero to 0.5 inch by simply moving the control handle. Stroke frequency remains constant at 1:1 ration with input speed, and it can produce up to 40 pounds of force. A 1/8-hp, split phase or capacitor type motor is sufficient drive.

Zero-Max Co., 2871 Harriet Ave. So., Minneapolis, Minn. Phone: (612) 827-5521.

ON READER-SERVICE CARD CIRCLE 724

**ELECTRONIC DESIGN**

# DESIGN AIDS

## Materials guide

"A Selection Guide to Electronic Materials" provides three pages of selection tables for such materials as coatings, potting and encapsulating media, coolants and lubricants. The information is grouped: mechanical, electrical and physical.

Dow Corning Electronic Products.

ON READER-SERVICE CARD CIRCLE 725

## Indicator selector

A 12-page design guide, GED 5289, is offered as an aid in the selection of pushbutton and indicating lights. The guide is divided into two sections with pushbuttons and indicating lights receiving separate attentions.

General Electric General Purpose Controls.

ON READER-SERVICE CARD CIRCLE 726

## Capacitor handbook

The job of selecting the right capacitor for a particular application can be made easier using the information provided by the 33-page booklet, "Which Capacitor." Prepared by F. L. Johnson of Marshall Industries, Capacitor Div., the booklet discusses the various capacitor types in light of a variety of specifications. The material includes testing and reliability factors as well as specifications charts and formulas. Marshall Industries.

ON READER-SERVICE CARD CIRCLE 727

## Resistor calculator

Instant calculation of resistor styles is said to be possible with the Resisto-Dial. The circular slide-rule gives a selection based on the requirements of a particular application. It also calculates failure rate based on unit hours at given confidence levels and other operations involved in resistor selection.

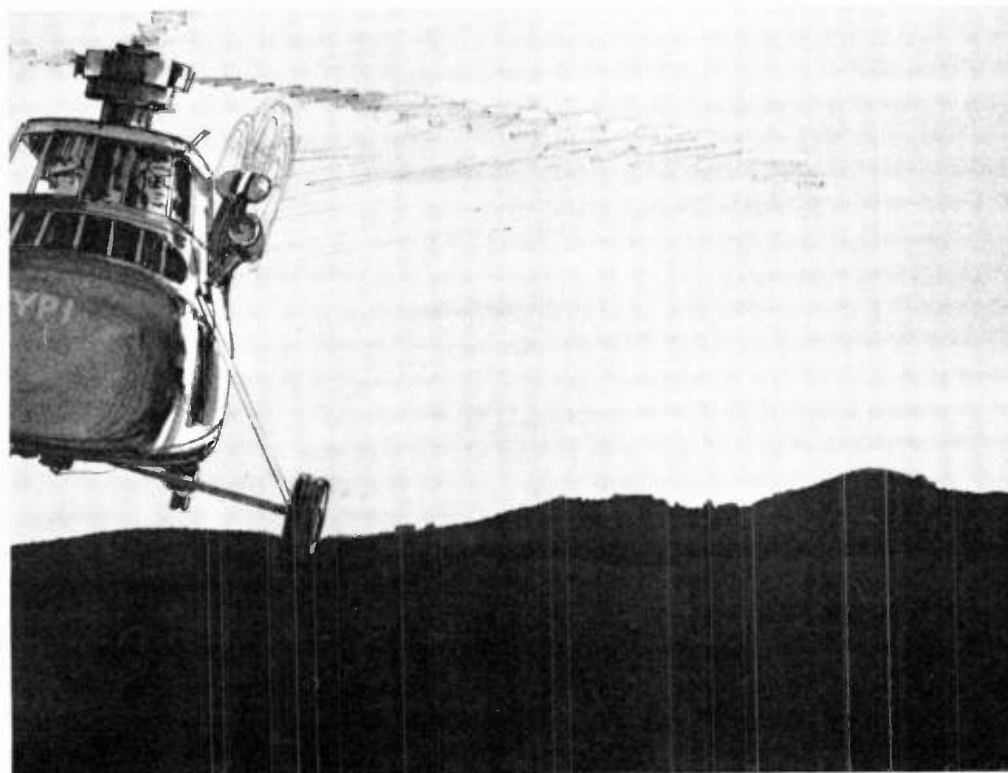
Daven Division of Thomas A. Edison Industries.

ON READER-SERVICE CARD CIRCLE 728

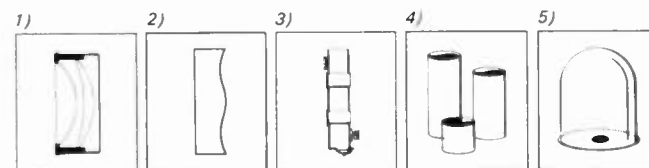
ON READER-SERVICE CARD CIRCLE 227 ➤

## Objective:

**To pierce the night  
and spot the enemy  
with a compact  
surveillance  
system.**

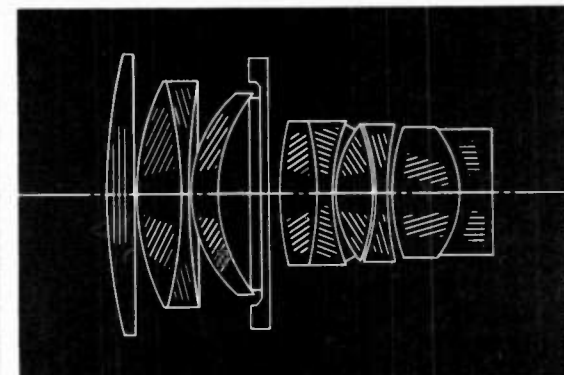


Passive observation of terrain, under the cover of darkness, is essential for up-to-date intelligence. To accomplish this task, airborne systems further require minimum weight and space characteristics. Combining its recent innovations in fiber optics and optical design, American Optical produced the compact but powerful 136 Hytar lens system. Speed:  $f/0.8$  (adjustable to  $f/16$  for daytime



**Achieved by another  
American Optical development:**

**Wide-angle  
reconnaissance  
lens system  
smaller than  
a bread box.**



operation); range: 7 ft. to infinity; field angle:  $40^\circ$ . The 8-lb., shock-resistant package can be tucked neatly into the underbelly of a helicopter or mounted in any tactical orientation.

Let American Optical contribute to the solution of your problem. For 132 years we have been advancing optical technology. Our capabilities include materials research, instrument development and production, and systems integration. For help with your optical problem, consult the leader in optics. Write American Optical Company, Space-Defense Division, Dept. 500, Southbridge, Massachusetts 01551.

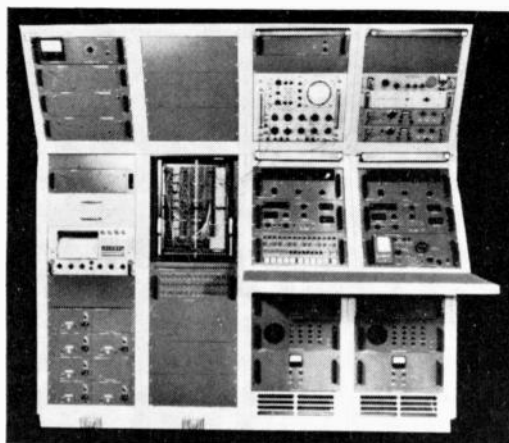
Investigate these other AO products: 1) Custom Optics, 2) Aspheric Lens, 3) Sights, 4) Laser Glass, 5) Thin Film Coatings



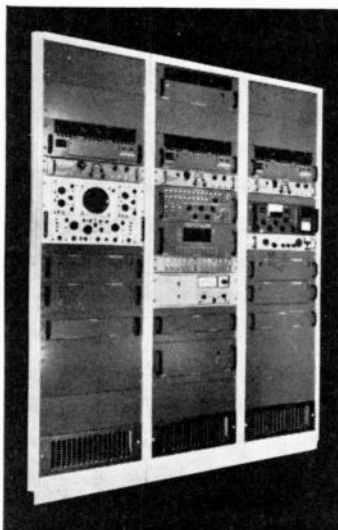
**AMERICAN OPTICAL COMPANY**

SPACE-DEFENSE DIVISION—SOUTHBRIDGE, MASSACHUSETTS

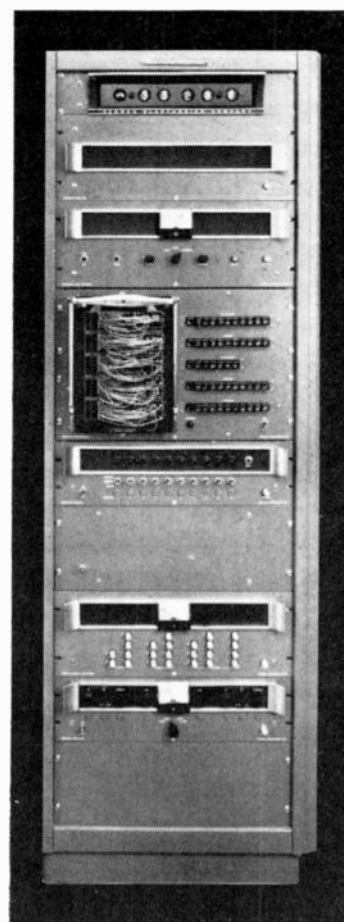




U. S. Navy  
(AUTC)  
Master Timing  
System



NASA  
Mississippi  
Test Facility  
(MTF) Master  
Timing System



NASA Wallops Island  
Terminal Time Systems

# Hyperion

## the name for Precision Time Indexing and Automatic Search Equipment and Systems

Hyperion's Timing Equipments are being used on many major Range Facilities including NASA, Mississippi Test Facility (MTF), U. S. Navy Underwater Range (AUTC), NASA, Wallops Island, etc.

Hyperion's Technical Staff represents 100-man years of technical experience in the field of Precision Timing and a broad background in the field of Ultra-Stable Oscillators, Automatic Time Synchronization with LORAN-C, VLF, and WWV Time Transmission Equipment, Precision Time Equipment includes Precision Time Code Generators and Countdown Clocks, and Fully Automatic Tape Search Equipments for Ground and Airborne environments.

Write or call Hyperion for your precision range time indexing and search requirements

# Hyperion

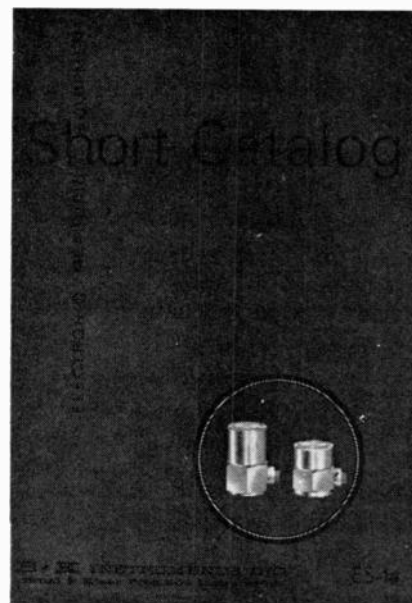
INDUSTRIES CORPORATION

• DIGITAL PRODUCTS DIVISION

134 COOLIDGE AVENUE, WATERTOWN, MASSACHUSETTS 02172  
TWX: 617-924-9272 TEL: 617-WA6-0140

ON READER-SERVICE CARD CIRCLE 90

## NEW LITERATURE



### Measurement devices

A line of dynamic measurement instrumentation is described in 28-page catalogue ES-14. The models are primarily ac voltage-measuring devices, used for measurement, analysis and recording of AM and FM signals in such areas as acoustics, data analysis, noise control, fatigue and vibration, R&D and strain. B&K Instruments.

ON READER-SERVICE CARD CIRCLE 729



### Solenoids/steppers

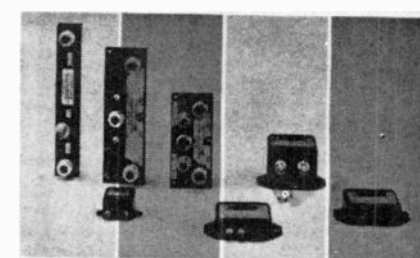
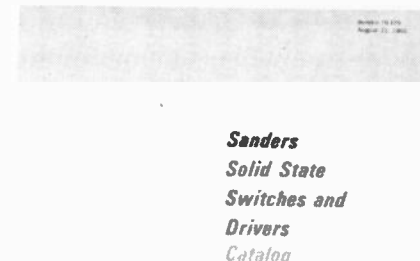
Catalogs GA and 5-32 are respectively 27 and 34 pages in length and are devoted to various types of solenoids and steppers. Both include descriptions, specifications, design features and selection guides to aid in ordering the proper unit for different applications. Guardian Electric Mfg. Co.

ON READER-SERVICE CARD CIRCLE 730

### Semiconductor diffusant

A series of technical bulletins describe solvents, buffers and diffusants for semiconductor technology. Properties, price and instructions for application are included. Transene Co.

ON READER-SERVICE CARD CIRCLE 731



### Switch/driver catalog

Twenty-one models of solid-state switches and drivers are described in Bulletin TG-176. Included is a switch-selector chart containing pertinent operating data. It also gives detailed descriptions, typical curves, dimension drawings and specifications. Sanders Associates, Inc.

ON READER-SERVICE CARD CIRCLE 732

### Control components

A series of spec sheets gives applications for components in the area of measurement and control. Illustrations are included. Schaevitz Engineering.

ON READER-SERVICE CARD CIRCLE 733

### Test equipment manual

A 28-page catalog gives applications for the instruments listed and descriptions of the various types. Test instruments for resistors, diodes, transistors and zener diodes are included, as are specialized uses and capabilities. Teradyne.

ON READER-SERVICE CARD CIRCLE 734

## Digital modules

SP-191, a 16-page digital-module catalog supplement, provides general descriptions, detailed specifications, and logic and application diagrams on 12 types of germanium digital modules. Some of the units described are half-adders, subtractors, comparators and parity generators. Reed relays and silicon switches are also detailed. Raytheon.

ON READER-SERVICE CARD CIRCLE 735

## Printed circuit design

A guide to printed circuit design includes material on preparation of artwork, location and alignment of holes, physical characteristics, conductors, plated conductors, solderability, selective area soldering and printed circuit board markings. Reference table gives dimension tolerances for all printed circuit board parts. Lockheed Aircraft Corp.

ON READER-SERVICE CARD CIRCLE 736



## Semiconductor catalog

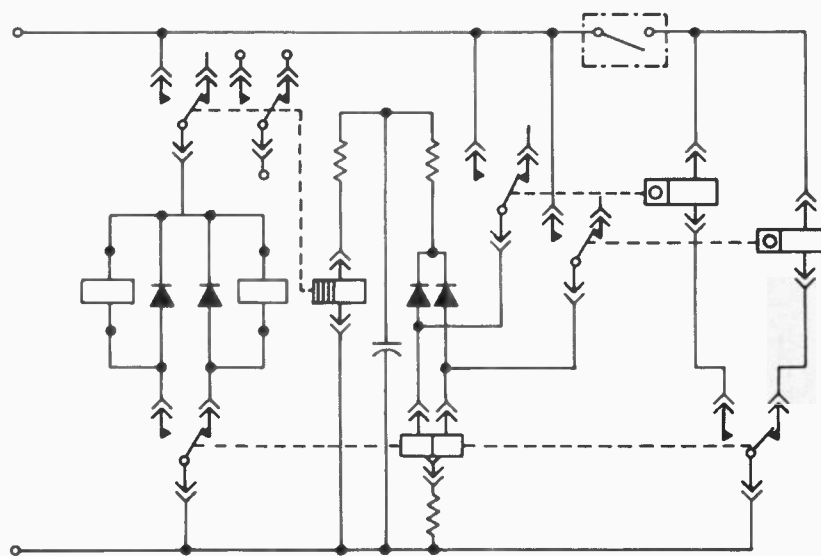
1966 catalog lists power transistors, rectifiers, zener-, reference-, and 4-layer diodes, gate-controlled switches, unijunction transistors, circuit assemblies and military-type devices. Dimensional drawings and photos accompany product descriptions. Cramer Electronics.

ON READER-SERVICE CARD CIRCLE 737

December 6, 1965



# HECON QUALITY COUNTS



## Complete Line of High Performance Electro-Magnetic Counters

Hecon counters do more than count. They are highly reliable control devices that exercise control by counting. Our exclusive building block design permits many system variations and applications. Used as an individual control instrument, or as part of a control system, Hecon counters can solve your control problems.

For reliable, low cost digital control systems, only Hecon offers a complete line of high performance electro-magnetic counters featuring closed loop design.

**F 043 Totalizing Counter** — Modular 6 digit plug-in unit, with either manual or electrical reset — speeds up to 60 counts per second — life in excess of 200 million operations.

**FA 043 Predetermining Counter** — Modular 6 digit plug-in unit, with manual, electrical or automatic reset, for speeds up to 35 counts per second — life in excess of 200 million operations.

**FR 967 Single Decade Counter** — Features electrical readout, transfer and reset, (optional push button preset available). Unique system of rolling ball contacts on flush rhodium plated circuit boards — escapement operation for fast and accurate pick-up — speeds up to 50 counts per second — life in excess of 200 million operations.

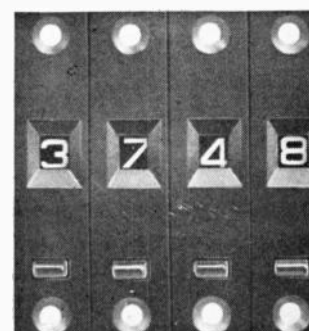
Hecon engineers can help you solve your counting and control problems with Hecon high performance counters — reliably and economically. Write or call today for full information on these and other Hecon counters.



F 043



FA 043



FR 967

# HECON

**HENGSTLER NUMERICS, INC., 318-320 Bergen Boulevard, Palisades Park, N.J. 07650**

ON READER-SERVICE CARD CIRCLE 91





## ARNOLD/TOROIDAL COIL WINDER

*sets up quickly...easy to operate...  
takes wide range of wire sizes*

### SPECIFICATIONS:

- Min. finished hole size: .18 in.
- Max. finished toroid O.D.: 4.0 in.
- Winding speed: 1500 turns/min.
- Wire range: AWG 44 to AWG 26
- Dual, self-checking turns counting system
- Loading (wire length) counter
- Core range: 9/32" I.D. to 4" O.D. to 1 1/2" high

### LABORATORY USE

- Change wire and core size in 45 sec.

### PRODUCTION USE

- 1500 turns per minute
- Insert core and load in 20 sec.

**\$890.00** includes all rings, counters and accessories



immediate delivery, literature on request

**ARNOLD MAGNETICS CORP.**

6050 W. Jefferson Blvd., Los Angeles, Calif. 90016  
(213) 870-6284

ON READER-SERVICE CARD CIRCLE 92

Mount either end in 1.578" hole with servo clamps.



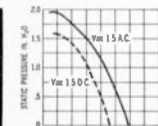
VAX-1.5-AC



VAX-1.5-DC

## MICROCIRCUIT BLOWERS

Globe Type VAX-1.5 A.C. and D.C. blowers weigh only 4 and 5 oz. respectively, yet put out 19 and 22 cfm at 0" H<sub>2</sub>O. These compact units are ideally suited for semiconductor and integrated circuit cooling. Housing and blade are precision cast aluminum designed to meet MIL-specs for environmental protection. Variations can be built for life exceeding 1000 hours, low noise levels, or other special characteristics. Request Bul. VX-15. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, U.S.A., 45404. Tel. 513 222-3741



**VAX-1.5-AC** 115 v.a.c., 400 cps, 190 MA, .25 MFD phasing capacitor, 22,000 rpm, life at 125°C 1000 hrs. 1 1/4" dia. x 1 1/2" long.

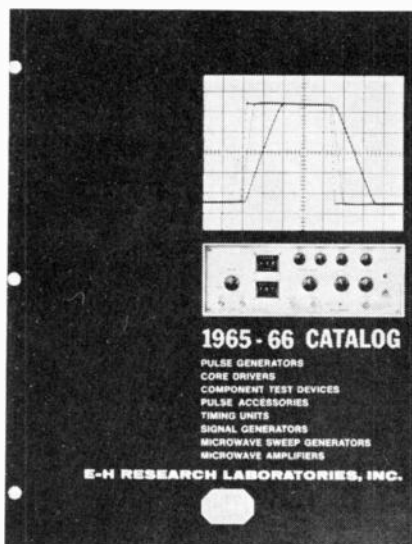
**VAX-1.5-DC** 50 v.d.c., 350 MA, 20,000 rpm, 1 1/4" dia. x 1 1/4" long.

ON READER-SERVICE CARD CIRCLE 93

## NEW LITERATURE

### Tube manual

A 652-page manual, ET1901 (revised edition), covers the characteristics of 2200 tubes. Data are included on special-purpose cathode-ray tubes, semiconductor diodes and rectifiers, special-purpose receiving tubes, photo-conductors and some transmitting tubes. Other reference material includes a picture-tube interchangeability guide, diode replacement guide, European/American receiving-tube replacement guide and R/C-coupled amplifier data. Available for \$3.00 from Sylvania Electric Products, 1100 Main St., Buffalo, N. Y.



### 1965-66 catalog

A tabulated summary of sweep generators introduces this 27-page catalog. Specs and illustrations are given, covering pulse-, signal-, and microwave sweep generators, core drivers, component test devices, pulse accessories, timing units and microwave amplifiers. E-H Research Laboratories.

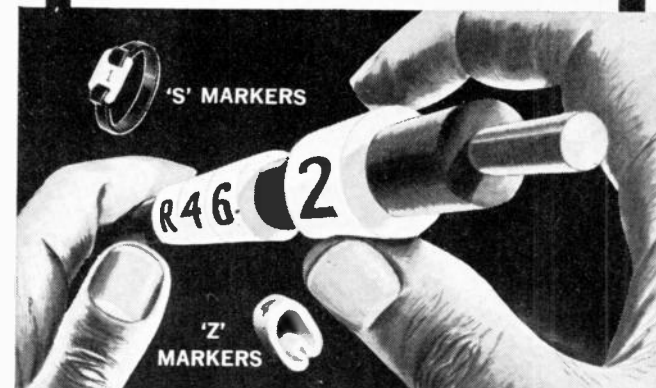
ON READER-SERVICE CARD CIRCLE 738

### Transmission data

Bulletin 202A contains detailed technical data on Specon mechanical differential wide speed range transmissions. Photos, drawings and tables are included. Fairchild Hiller Corp.

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ON READER-SERVICE CARD CIRCLE 97

December 6, 1965

## OEM price list

Texas Instruments' OEM Price List #6510, effective October 1, 1965, supersedes all other price lists. Listings include integrated circuits, diodes and rectifiers, controlled rectifiers, resistors, sensors, capacitors, transistors, light sensors, field effects, tetrodes and unijunctions.

A complete list of standard part numbers is included in this 21-page booklet. Texas Instruments Inc.

ON READER-SERVICE CARD CIRCLE 740

## Data processing

The 1965 catalog of data processing reference books includes information on a systems encyclopedia, data processing yearbook and monthly news letter and information services. American Data Processing.

ON READER-SERVICE CARD CIRCLE 741

## Regulator catalog

Technical data and application information is provided in an illustrated catalog of Stratos, Kendall and Gouvernaire air regulators. The high-precision, high-capacity line includes basic precision regulators, computing relays, back pressure regulators, vacuum regulators, reversing relays and pressure/electric switches. Fairchild Hiller Corp.

ON READER-SERVICE CARD CIRCLE 742

## Semiconductor Devices

Specifications for power transistors, power rectifiers, military semiconductors and ignistors are listed in a 13-page booklet. Also included are semiconductor outlines and their dimensions. Bendix Semiconductor Division.

ON READER-SERVICE CARD CIRCLE 743

## Rectifier listing

A partial listing of the company's line of zener diodes and rectifier products is given in a 6-page folder. Dimensional drawings and photos accompany the tables. Diodes Inc.

ON READER-SERVICE CARD CIRCLE 744

## PROBLEM:

How To Reduce Linear Circuits  
To Microelectronic Packages?

## PROBLEM:

How To Lower Costs Of Procuring  
Present Microelectronic Packages?

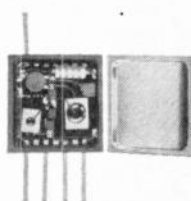
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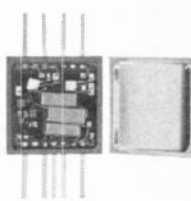
From micro chips to micro modules, Soliton has full capabilities for production of linear microelectronic packages. Soliton can convert your linear circuit to a microelectronic package and produce it in small or large quantities. Or we can economically produce packages that are presently being supplied to you.

Three Examples of Linear Module Designs  
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- Gain: 20 volts/volt
- Output Impedance: 500 ohms maximum
- Phase Shift:  $\pm 3^\circ$  for inputs to 25 mV
- $\pm 5^\circ$  for inputs from 26 to 100 mV
- Size: 0.5" square x 0.150" high



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- Input Impedance: 35,000 ohms  $\pm 25\%$
- Gain: 2.6 volts DC/volt RMS
- Quadrature Rejection Ratio:  $-26$  db
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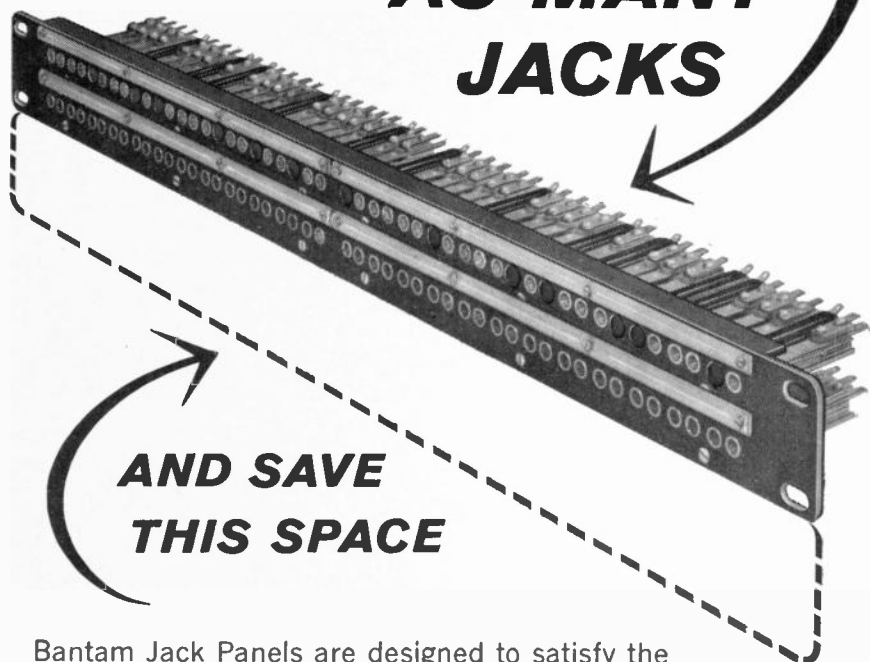
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## APPLICATION NOTES

### Low-cost audio amp for line operation

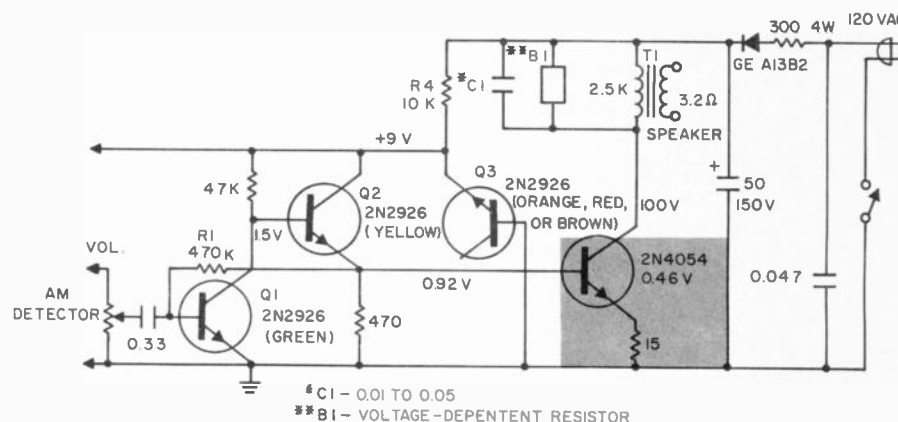
Based on the new 2N4054 plastic-capped transistor, a new circuit design delivers one watt of audio power to a speaker with less than 10% total harmonic distortion at 1 Kc and about 3 mv of input signal. The circuit, shown above, is described in detail in the single-sheet applications note, 92.1.

According to the designer, Dwight V. Jones of General Elec-

tric, the key to low-cost performance is direct coupling (no electrolytic capacitors). The availability of low-cost transistors allows a profitable trade-off between electrolytics and active components in this situation.

General Electric Semiconductor Products.

ON READER-SERVICE CARD CIRCLE 745



### Function modules

Seven bulletins are available on measurement computation applications for function modules. They are: AE/1000 on mass gas flow totalizer; AE/1001 on BTU liquid flow; AE/1002 on heat transfer rate; AE/1003 on rate of process change; AE/1004 on chromatograph peak ratio computer; AE/1005 on statistics computer, and AE/1006 on chromatography per cent total carbon computer.

Consolidated Electrodynamics Corp.

ON READER-SERVICE CARD CIRCLE 746

### Percussive welding

Application Note AB-0165 shows Percussive Welder PW 200 in two operations—butt-welding and core plane wire terminal welding. Low-cost methods for lengthening and repairing component leads are illustrated.

IBM Industrial Products Div.

ON READER-SERVICE CARD CIRCLE 747

### Shock synthesis/analysis

An electrodynamics shaker shock synthesis and analysis system is described in a 10-page booklet. Authors D. D. Arnold and Theodore Bogart describe the capabilities of the SSA-100 and PRM-100 systems used in conjunction with standard shock testing machines and shakers.

LTV Ling Altec, Inc.

ON READER-SERVICE CARD CIRCLE 748

### Parallax error

The problem of parallax error in oscilloscope photography prompted the publication of application note #104 by George Rakonit of Fairchild's Scientific Instrument Department. This form of error is usual in the standard oscilloscope since the trace and the calibrating scale are on separate planes.

Note #104 provides a means of estimating the magnitude of error caused by parallax and offers several means of minimizing the error.

Fairchild Instrumentation.

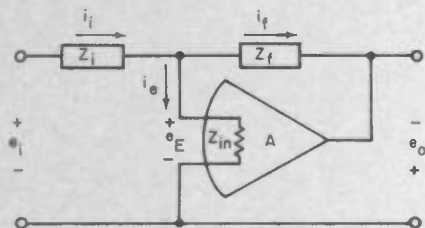
ON READER-SERVICE CARD CIRCLE 749



## Operational amplifiers

A 24-page technical note details the principles of operational amplifier operation and the analysis of errors in their applications.

The note, written by Ray Stata of Analog Devices, progresses from



the most basic theory to comprehensive design data for a wide variety of applications. The material is illustrated and provided with tables and formula derivations where needed.

Analog Devices, Inc.

ON READER-SERVICE CARD CIRCLE 750

## TV color processing

Chromatron TV tubes using semiconductor circuits are described in a 12-page technical paper incorporating an appendix. Conversion of the NTSC signal to the chromatron drive signals is illustrated, as are most of the processes involved. Performance data are given in chart form.

Fairchild Semiconductor.

ON READER-SERVICE CARD CIRCLE 751

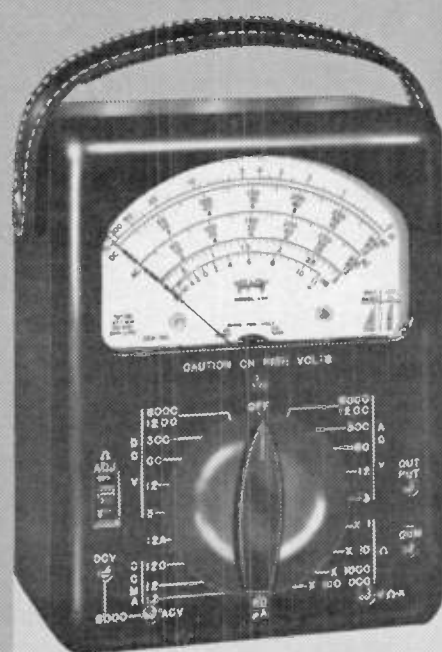
## Phase meter selection

A technical article by Dr. Y. P. Yu of Ad-Yu Electronics describes a process by which a choice can be made among the wide range of available phase meters. The text details the pertinent differences between the various types of meters and relates them to laboratory needs.

The article is reprinted from ELECTRONIC DESIGN's May 3 Test Equipment Reference Issue. A compilation of phase-meter specifications and manufacturer's index from that issue is also contained in the reprint. Ad-Yu Electronics.

ON READER-SERVICE CARD CIRCLE 752

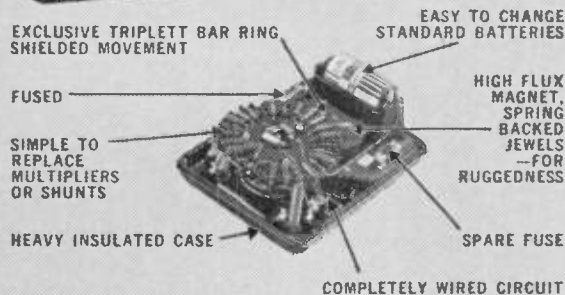
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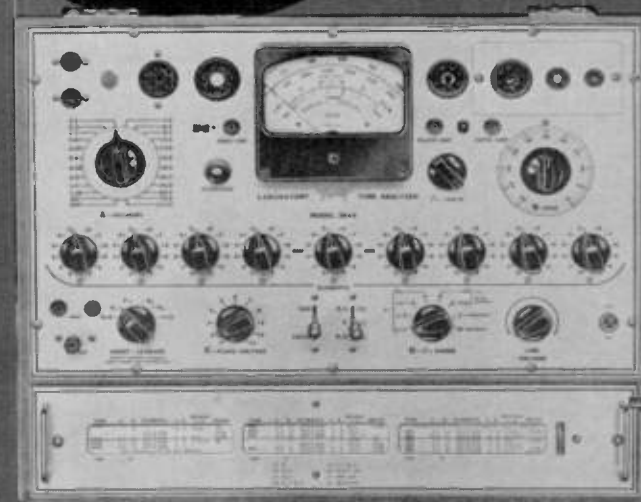
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## APPLICATION NOTES

### FM tuner

MOS-FET devices and integrated circuits, as applied to FM tuners, are described in an 8-page technical paper. Performance, power supply and the devices used are discussed and illustrated with schematic drawings and performance data charts. An appendix explains the design of the 10.7 Mc IF amplifier.

Fairchild Semiconductor.

ON READER-SERVICE CARD CIRCLE 753

### Integrated choppers

Applications for the manufacturer's Inch and  $\mu$ Chopper line are provided in the four-page application note #101. The material is presented in schematic form with brief comments on each circuit.

National Semiconductor Corp.

ON READER-SERVICE CARD CIRCLE 754

### Envelope decay plots

The use of the manufacturer's type 524A3 digital phase meter for plotting envelope decay curves is covered by a two-page applications bulletin. The process described can be used to plot envelope decay characteristics of an unknown network from 210 Kc up into microwave levels.

Ad-Yu Electronics, Inc.

ON READER-SERVICE CARD CIRCLE 755

### Transistor biasing

Four ways of simplifying biasing circuits using BCY42 and BCY43 transistors are described in Application Note MK/187. Tolerance chart, viation table and current ratios are listed.

STC Semiconductor Div.

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### Servo stability

"Techniques for Achieving Servo System Stability," a five-page booklet, describes six techniques to control the amount of time required for a system to attain and maintain a stable state. The material is divided into a brief discussion of the problem, a description of the six techniques and an analysis of the techniques. Tables, formulas and typical block diagrams are included.

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ELECTRONIC DESIGN



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### Kistler Instrument Corporation

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Clarence, N. Y. 14031

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### Flexible Waveguide



This new 12 page catalog contains detailed engineering data on Airtron's complete line of flexible and twistable waveguide in sizes from WR-2100 (350 mc) to WR-28 (40 gc). Also included are gaskets and RF seals for UG and EIA flanges in this same range. Application information and design data are supplied for use in systems design.

### Airtron Division

Litton Industries  
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### The Multireed Relay



This highly explicit pamphlet provides full technical data on Thermosen's Multireed Relay. The Multireed Type A has 4 to 8 contact groups controlled by a single coil; Type B has up to 3 independent DPDT relays; and Type C has up to 5 SPDT relays. True Form C switching and individual contact adjustment make this unit adaptable in a wide variety of applications. For further information write:

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plug-in to measure above 400 Mc. Speaking of plug-ins... the 616A comes well equipped! Slip in a frequency converter or other special CMC frequency extender plug-ins, and your frequency measurements can soar to 1,000 Mc, 3,000 Mc, and even a phenomenal 12 gigacycles! Or, with our time interval plug-ins, measure time from .1  $\mu$ sec. to 1 sec., or 1  $\mu$ sec. to 10 sec.

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3	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192
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701	711	721	731	741	751	761	771	781	791	801	811	821	831	841	851	861	871	881	891
702	712	722	732	742	752	762	772	782	792	802	812	822	832	842	852	862	872	882	892
703	713	723	733	743	753	763	773	783	793	803	813	823	833	843	853	863	873	883	893
704	714	724	734	744	754	764	774	784	794	804	814	824	834	844	854	864	874	884	894
705	715	725	735	745	755	765	775	785	795	805	815	825	835	845	855	865	875	885	895
706	716	726	736	746	756	766	776	786	796	806	816	826	836	846	856	866	876	886	896
707	717	727	737	747	757	767	777	787	797	807	817	827	837	847	857	867	877	887	897
708	718	728	738	748	758	768	778	788	798	808	818	828	838	848	858	868	878	888	898
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Product: \_\_\_\_\_

December 6, 1965 Issue

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Company \_\_\_\_\_  
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World Radio History



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Company \_\_\_\_\_

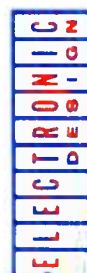
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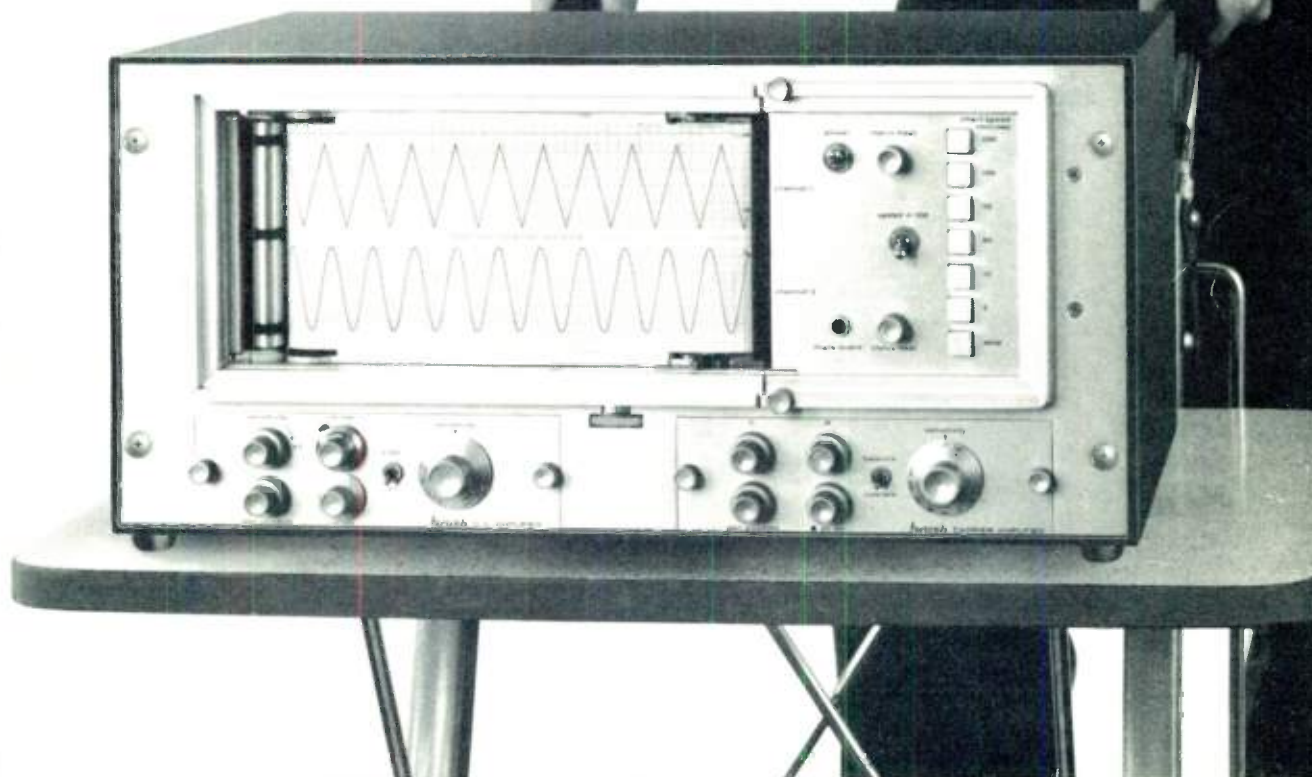
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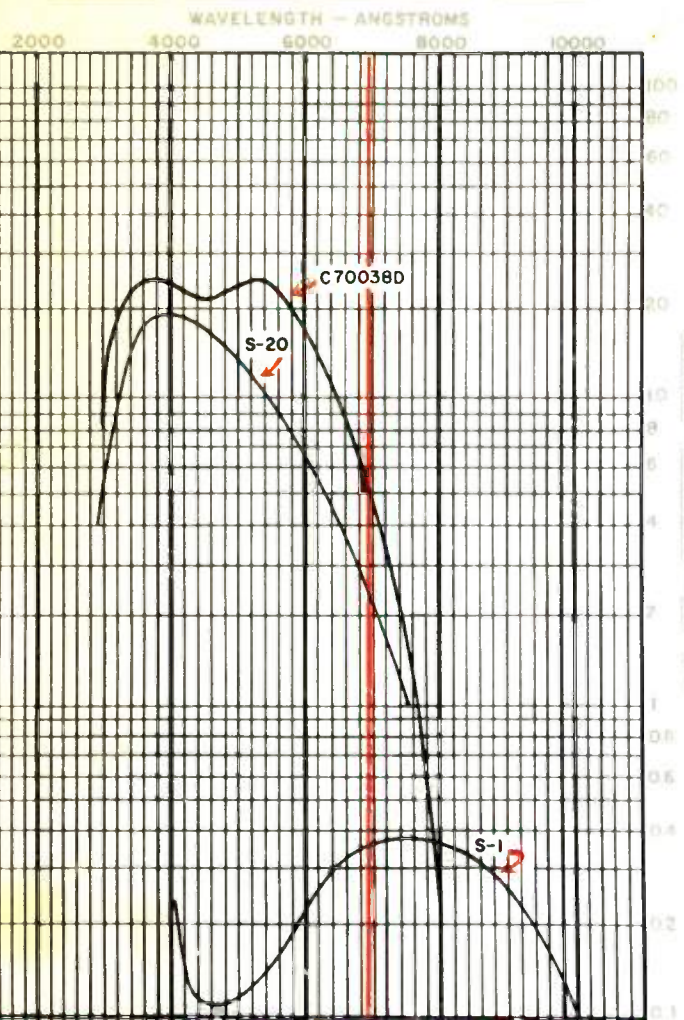
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