Electronic Design
THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY
VOL. 15 NO. 6
MARCH 15, 1967

Here's an IEEE briefcase filled with news of this year's Big Show. From your desktop, no matter where you are, you can make the trip in the pages of IEEE USA. What's new in materials, plastic transistors or computer-aided design? What will speakers say about tomorrow's cities? The tour begins on p. U81.

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VOL. 15 NO. 6

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MARCH 15, 1967

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., Cleveland, Ohio, and New York, N. Y. Application to mail at controlled postage rates pending at St. Louis, Mo. 61,732 copies this issue.

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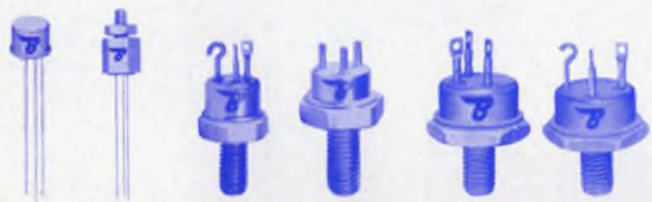
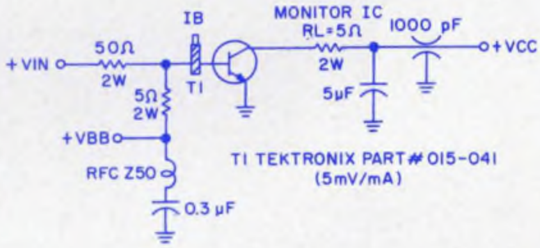
IC	VCEO	hFE	VCE(sat)	PT	SWITCHING TIME t on ns	t off ns	@ IC A	@ ± IB mA
3A	40 to 60V	25 min @ 2A, 10V	0.5V max @ 1A, 0.1A	5W	35	75	1.5	150
5A	40 to 80V	120 min @ 3A, 10V	0.75V max @ 3A, 0.3A		40	300	3.0	300
10A		40 min @ 5A, 10V	1V max @ 5A, 0.5A	25W to 50W				
15A	60 to 100V	15 min @ 10A, 5V	1.5V max @ 15A, 3A	100W	225	600	10	1000
20A		20 min @ 10A, 5V	1.5V max @ 20A, 4A					



TO-5 MT-27 TO-59 TO-60 TO-61

SATURATED SWITCHING TEST CIRCUIT



Maximum Switching Times: td ≤ 25 ns; tr ≤ 200 ns; ts ≤ 300 ns; tf ≤ 300 ns. **Test Conditions:** V_{in} = 70V when generator with 50Ω internal impedance is terminated in a 50Ω load. VBB = −5V; VCC = 55V; IC ≈ 10A; IB_1 ≈ 1A; IB_2 ≈ 1A; tp = 400 ns; f = 720 Hz.

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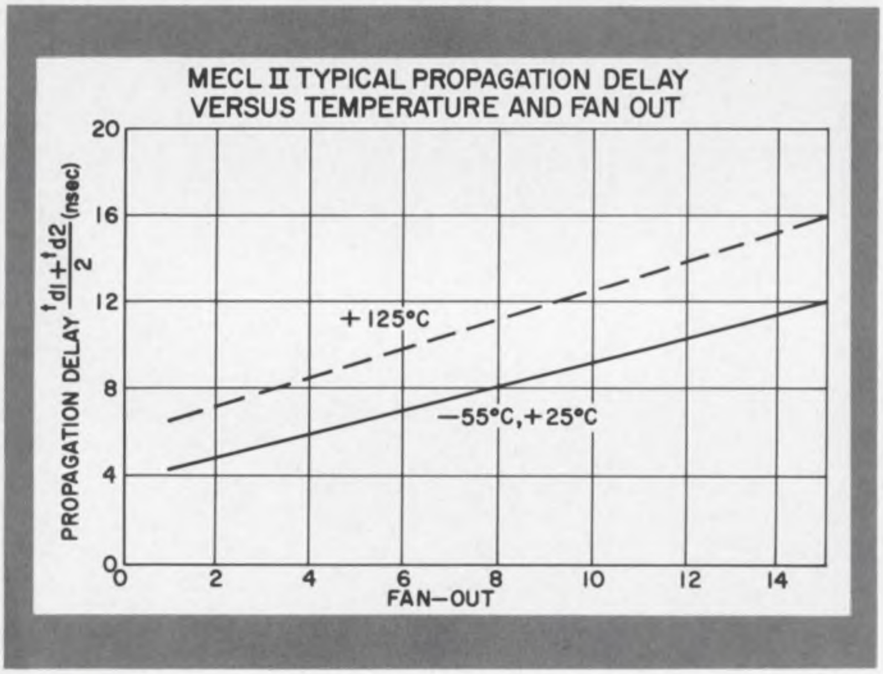
Why aren't all advanced computers designed with current-mode logic?

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



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

Speed

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

Noise Immunity

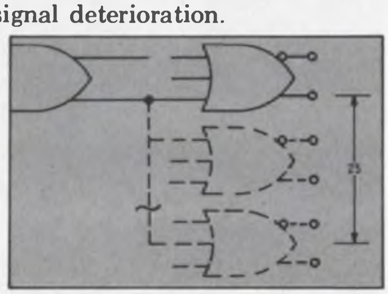
Inherently, current-mode logic is immune to state-changing transients that are integral to all forms of saturated logic. That's because current drain in CML remains constant even during the switching interval whereas with saturated logic any slight difference in transistor characteristics (and there's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

Complementary Outputs

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

High Fan-Out, Fan-In

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



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

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

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

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

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

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

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

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

MECL ≫ MECL II ≫ MECL III

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

And did you know

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

Therefore —

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

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

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

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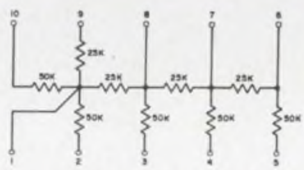
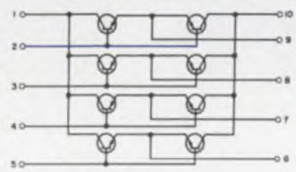
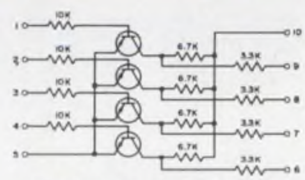


UT-1000 LADDER NETWORK

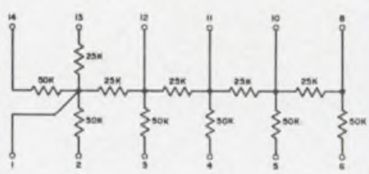


UD-4001 LADDER SWITCH

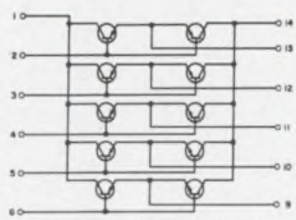


UD-4024 BUFFER AMPLIFIER

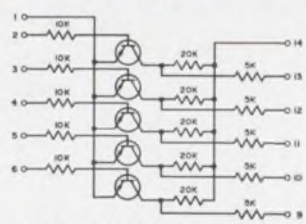
FIVE BIT SERIES



UT-1001 LADDER NETWORK



UD-4036 LADDER SWITCH



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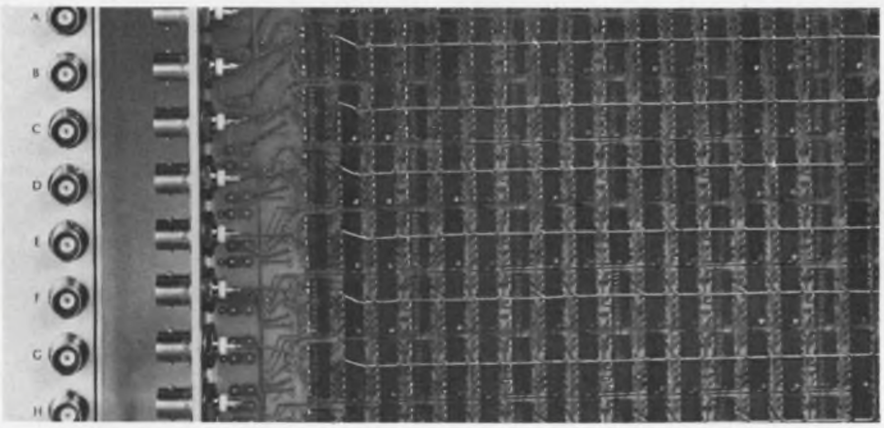
News

Topics of liveliest discussion at Philadelphia's International Solid-State Circuits Conference were transistors as microwave power sources and LSI uses in computer equipment. Page 17



Microcircuitry and computer compatibility are the main trends apparent in the design of physics research equipment. Page 42

Buoys yield data for global weather forecasts. Page 22

Also in this section:

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FAA to test ground aids for supersonic flight

A combined program of the Federal Aviation Agency and the Air Force will determine whether present air-navigation aids, radio communications and ground radar in the United States are adequate to control supersonic traffic. Aircraft at both high and low altitudes will check out the systems in commercial air lanes.

The two-year program will begin in July. The FAA wants to know if present equipment is accurate enough for use in the navigation and control of supersonic aircraft at altitudes ranging between 40,000 and 70,000 feet.

An FAA spokesman said that about 100 transcontinental flights would be made as part of the program. An FAA C-135 jet will fly the routes at less than 40,000 feet, and an Air Force U-2 will fly at about 70,000 feet. Both aircraft will be equipped with the same instruments to check ground navigational aids.

The flights will be made together, to rule out differences due to weather and atmospheric conditions. They will check such navigational aids as VORTAC (Vhf Omnidirectional-Range Tactical Air Navigation) DME (Distance Measuring Equipment) and radar. FAA plans do not include testing of collision-avoidance or other air-to-air electronic systems.

The agency will compare the accuracy of fixes obtained by each test aircraft with fixes obtained by ground radar.

Whenever a new navigational aid is installed in the system or an aid in service receives a major overhaul, it is checked immediately by an aircraft flyover, the FAA spokesman said. However, he added that checks were not usually made from altitudes over 40,000 feet.

The agency wants to know if the accuracy of navigational aids at all altitudes can be checked at the lower altitude. It will try to find out if there is any overlap of signals from stations about 100 miles apart. This overlap would not affect planes flying at less than 40,000 feet, but might be confusing to pilots of high-flying supersonic jets, because the pattern dispersion increases with altitude. So far military pilots who regularly fly at those altitudes have reported no difficulties with present navigational aids. If the correlation of data from the forthcoming tests is not high, the FAA may have to conduct future routine checkouts at higher altitudes.

The FAA's concern with supersonic flight is reflected in its recent announcement of a $44.8 million contract to the Raytheon Co., of Wayland, Mass., for development of a major part of a semiautomatic air-traffic system. Raytheon will build a Computer Display Channel for the agency's National Airspace System, which is intended to improve the capability of the FAA's air-traffic controllers.

The computer display will give the controllers a three-dimensional picture of aircraft in their control areas. Electronically produced alphanumeric tags will represent each aircraft on the radar scope.

U-2 takes the high route, C-135 the low, in FAA navigation aid check

Texas power utility goes fully automatic

Automatic monitoring and control in the electric utility industry will take a giant step forward this summer when work begins on a new energy control center for the Houston Lighting and Power Co.

When completed, early in 1969, the center will control what is billed as the most advanced, fully integrated power system in the world. Two Sigma-5 digital computers from SDS Corp., of Pomona, Calif., will form the center's nucleus. One, called the energy dispatch computer, will govern the loading of the system's nine generating stations to exact optimum operation. It will also provide data for daily load forecasting as well as for scheduling energy interchange with neighboring electric utilities.

The other computer is the systems operation computer. It will control the high-voltage transmission facilities, up to a maximum of 300 distribution substations.

The two computers are coupled by common memory units that permit the transfer of data between them. Should one system fail, the other will automatically take over its functions while still performing its own operations. A small back-up analog computer will take over the essential functions of the two digital computers should both fail.

A variety of displays enables operation of the entire system to be monitored from the control center. The status of any substation can be displayed selectively on a CRT mounted on a control console. Appropriate lines and symbols on the CRT will represent various substation equipment and its status. With a special light-pen the operator can alter operations or conditions at a substation directly from the CRT.

A 20- by 30-foot wall-mounted dynamic display will also be installed in the control center to provide information on the dynamic status of the entire transmission system. An unusual feature of this display will be the use of electroluminescent strips to represent the transmission lines. Loss of power in any line will be indicated by illumination of the corresponding electroluminescent strip.

Prime contractor for the energy control center will be Leeds and Northrup Co. The visual displays and their programing will be handled by Philco-Ford.

Laser system tracks 4000-mph rocket sleds

A laser system that will focus a camera on rocket sleds traveling at Mach 6 has been developed for the U.S. Air Force by Sylvania Electric Products, Inc.

The system, which will be installed 1000 feet from a test track at the Air Force Development Center, Holloman AFB, N. M., will permit scientists to follow and record photographically sleds moving as fast as 4000 mph.

The unit comprises a cw laser, an electronically controlled mirror, and a camera and accessories. Dr. James E. Storer, director of Sylvania's Applied Research Laboratory, explains that the tracker laser's high-intensity beam is aimed at a reflecting surface on the sled. The mirror automatically rotates to keep the laser on target and simultaneously reflects an image of the moving sled into the camera equipment, which records the run.

Once aimed at the sled, the laser tracks the moving vehicle with an accuracy of 25 μrads.

Credit card may replace cash trading before 2000

A "money card," making possible the electronic transfer of money and credit, will be in use for almost all personal transactions within 25 years. Use of such a card, similar to today's credit cards, would drastically reduce the handling of cash and produce fundamental changes in the banking and monetary structure of the U.S. economy.

This was the opinion of 94% of respondents in a recent nationwide survey of top executives of banks, savings and loan associations, insurance companies and large firms.

A commentary on the survey, conducted by Diebold Group, Inc., of New York, described the technology involved in automatic money transfers. It said in part: "The relevant developments include vastly increased information storage capabilities and processing speeds, improved communication links, image storage and transfer devices, and easy man-machine relationships—all at greatly reduced costs."

Diebold has published the more than 2000 responses and their implications in *A Summary Report of the Survey on the Impact of Electronics on Money and Credit.*

Computer data copier speeds distribution

A new, high-speed electrostatic duplicating machine that reproduces continuous computer output can now be housed in the same room as a computer. It uses Triac motor control and solid-state digital logic circuitry for RF suppression.

The copier designed and built by the Xerox Corp., Rochester, N. Y., is specifically made for use alongside computer printout equipment. Directly from continous printer records it automatically reproduces and reduces to page size 40 copies of data a minute. Completed copies are collated and made ready for binding, thus speeding distribution of data.

Continuous computer output is reproduced by high-speed Xerox copier that can be housed alongside the computer.

The Xerox 2400-IV can take 15-by-11-inch continuous fan-fold forms coming from a data-processing printer, and within a half hour turn them into as many as 20 collated sets of 60 pages on regular 11-by-8-1/2-inch paper.

Xerox engineers used solid-state components to eliminate objectionable RF interference. Printed-circuit module boards with discrete components perform the logic functions of control-timing, paper-feeding and copy-collating.

Process transfers color from video tape to film

A process that permits broadcast-quality color films to be made directly from video tape has been announced by Technicolor Corp. of America, of Burbank, Calif.

Joseph E. Bluth, vice president and general manager of Technicolor's Vidtronics Div., said the system combines "the economy and speed of video tape photography with the mass-production savings of color film duplication."

The transfer system basically involves breaking a video tape down into its red, green, and blue images and recording them separately. These images are specially enhanced electronically before processing. Technicolor then registers the separations to produce a quality composite print, integrating the components into a final film.

The process, according to the company, will transfer video tape onto 35-mm, 16-mm, 8-mm and the new Super-8-mm color film.

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ON READER-SERVICE CARD CIRCLE 11

Where LSI will really pack a wallop!

Panel sees a future for those large-scale circuits in impending expansion of time-sharing terminals

Roger Kenneth Field
Microelectronics Editor

The peripheral equipment in a time-sharing computer, said IBM's Paul Low, may contain four times as many circuits as the computer's main frame.

In a smoky room in the basement of Philadelphia's Sheraton Hotel last month, four men from different walks of computing life discussed the future of large-scale integration (LSI). The panel's subject: the peripheral equipment associated with time-sharing computers.

LSI is fraught with many uncertainties. Yet many fascinating speculations filled the air of this informal session. The panelists concluded tentatively that large-scale integration may do much to ease the maintenance and improve the reliability of peripheral equipment but that it won't cut costs significantly.

The first panelist to address the audience, Paul Low, is developing time-sharing terminals at IBM, Fishkill, N. Y.

"The terminals of a time-sharing computer are deceptively important," he said. "Though a fast computer might have 100,000 circuits in its main frame, it could well have four 100-circuit LSI arrays in each of its terminals. If the system were to have 1000 terminals, then these terminals would contain a total of 400,000 circuits."

Low pointed out that since the large-scale arrays in the terminals are fed by a keyboard or graphic display tube, they don't have to be nearly as fast as the main frame logic circuitry. But they do have to be immune to ambient noise and capable of withstanding extreme temperature changes, since the terminals might be located anywhere from the basement of a power generating plant in Brooklyn to a loading dock in Vermont.

Power-supply requirements are an important consideration in the design of both the arrays and the terminals. It would be foolish, Low pointed out, to build a terminal with a $125 keyboard, a few $10 arrays and a $350 power supply; it would be best to use large-scale arrays that didn't require extremely tight voltage regulation.

William Davidow of Hewlett-Packard agreed that the design of the terminals demanded much attention. "One Stanford professor dreams of a time-sharing terminal in every classroom," he noted, "and there are well over a million primary and secondary classrooms in the United States."

There are other problems besides the cost of the terminals. Costs for the use of lines that connect the terminals to the computing center can be considerable, Davidow observed. One professor associated with Project Mac at the Massachusetts Insti-

Users won't buy LSI just to improve terminal reliability, according to RCA's Richard Ahrons.

A terminal in every classroom is the dream of one professor, said William Davidow of Hewlett-Packard.

LSI will buffer, process and code data in the terminal, reported Graham Tyson of Data Products Corp.

tute of Technology, whose broad goal is to develop a community "utility" that would supply computer "power" to customers, reportedly decided to solve a problem on the MIT computer in Cambridge, Mass., while he was traveling in Germany. He dialed the multiple-access computer and in a relatively short time solved the problem. He was startled when the total intercontinental phone charges reportedly amounted to over $2000. One panelist suggested that information transmission was slow and costly because the lines were not designed for digital use but to carry signals in an extremely limited bandwidth, suitable for voice reproduction.

If communication lines for high-speed digital transmission become available, it will be desirable, from the standpoint of costs, to keep them fully loaded with information, noted Graham Tyson of Data Products Corp., Culver City, Calif., a manufacturer of peripheral equipment. "To keep the lines operating at full capacity," he said, "the terminals and print-out devices must buffer the data—store it and compress it before its transmission at high speed, and store it after reception prior to feeding it to electromechanical devices that run at their own [relatively slow] speed. Coding, too, can also be performed in the peripheral gear, which might even have built-in control logic and pre-programed instructions for the main computer."

The big question, Tyson feels, is: Will LSI help the maintenance problem? As the terminals move out of the building that contains the main frame, they move away from the personnel who stand by to service the computer.

"Many of the terminals may be located in pretty inaccesible spots, and it would be better if a secretary could unplug a faulty circuit and slip in a spare," Tyson said. "If she can't, it could take hours for a service man to reach the terminal and get it back into service."

Many potential users wonder if their hopes for LSI will ever come true. "They will!" panelist Gordon Moore assured the audience. His company, Fairchild Semiconductors of Palo Alto, Calif., is already marketing MOS large-scale arrays.

"It'll be hard to build factories fast enough to use up the LSI arrays that will be produced," he predicted. "The big arrays are really a marketing problem. They fall into three categories: relatively few types, such as shift registers and memories, are generally useful; many specialized units will be used extensively in long production runs of popular terminals and print-

User dreams of LSI will come true! Fairchild's Director of Research, Gordon Moore, assured the audience.

outs; and some demand will exist for small runs of specialized circuits. It's this last category that will present a price problem."

Moore agreed that the large-scale arrays in most peripheral equipment did not have to be very fast. "MOS allows a high density of devices and circuits on a chip," he said. "They are more than fast enough to keep up with a mechanical keyboard."

One engineer in the audience rose to ask: "When will they get rid of the antiquated keyboard and develop better interfaces between operator and computer?"

The panel bandied the question about. One panelist pointed out that it was unlikely that $5000 graphic consoles and still more expensive pattern-recognition equipment could be made cheap enough—even with the advent of LSI—to compete with the keyboard. The panel's general feeling was that LSI's main advantage was to increase system reliability.

At this an RCA representative in the audience, Richard Ahrons, stood up and said that "the reliability of today's integrated circuits is so high, compared with mechanical equipment, that it is pointless to use LSI just for the sake of improving reliability in peripheral equipment."

But Fairchild's Rex Rice, the moderator of the session, suggested that the reliability gains would result from the elimination of pins, connectors and soldered connections rather than from the circuits themselves. ■ ■

Will LSA mode outmode Gunn oscillators?

Transistors are still first as solid-state microwave sources, but new mode in GaAs may close gap

Maria Dekany
Technical Editor

Transistors still lead the way as microwave solid-state power sources, but bulk oscillators and avalanche diodes are closing in.

In coming to this conclusion, a six-member panel on microwave power generation with solid-state devices at the International Solid-State Circuits Conference agreed on the following major points:

- The power and frequency limitations of transistors can be partly alleviated by better heat transfer through the packages and a reduction of the chips' parasitics.
- A new mode of operation, called limited space-charge accumulation, in gallium arsenide may make Gunn oscillators obsolete before they ever hit the market (see Figs. 1 and 2). But the lack of uniform and reliable gallium arsenide is preventing commercial marketing (see "Pace of Gunn-effect research quickens," ED 2, Jan. 18, 1966, p. 17).
- The major drawback of avalanche diodes is noise. Although their output is sufficient, they are too noisy for local oscillators and must be phase-locked, even in Doppler applications.

The six panel members were about evenly divided between transistor and bulk-device advocates. The transistor specialists were Harry Cooke, member, technical staff, Texas Instruments, Inc.; George Luettgenau, assistant plant manager, TRW Semiconductors, Inc.; and Ronald R. Carley, engineering leader, Radio Corp. of America.

The experts on bulk-effect and avalanche devices and on materials were Mark R. Barber, member, technical staff, Bell Telephone Laboratories, Inc.; Daniel G. Dow, manager, microwave semiconductor task force, Varian Associates; and B. Pistoulet, professor, Université de Montpellier, France.

Transistors supply cleanest output

Transistors can now supply fundamental power up to about 6 GHz, said panel member Cooke, and do well with harmonics above this. "Even at much higher frequencies, say, at 16 GHz, transistor-multipliers can yield a few hundred milliwatts' quiet power," he explained, "while the direct outputs of devices like the Gunn oscillator and the avalanche diode are very noisy."

Panelist Carley said that now there are transistors that can deliver 1 to 1.5 watts at 2 GHz with 30% to 40% efficiencies (input power is 300 mW). At 1 GHz, 10-dB gains are available, with output powers around 2.5 watts.

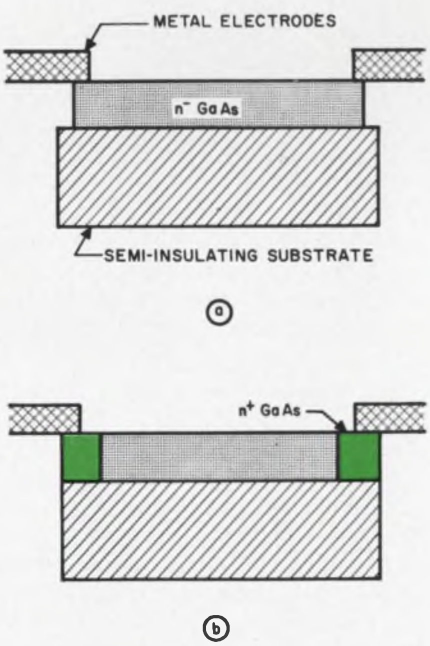
Outlining the limiting factors of transistors, Cooke pointed out the three major problem areas: the chip, the package and the circuit. The chip dictates the intrinsic capabilities of the device. Its parasitics and thermal resistance should be reduced for full realization of these inherent capabilities, he said.

The packaging of microwave transistors requires special care. From the thermal considerations, the ideal package should facilitate heat removal on two sides: through its top and bottom, said Cooke. The transistor specialists on the panel agreed that both stripline and coaxial approaches have their places. The critical factors in the package are the common-lead inductance and the input and output capacitances. Cooke offered a brief rundown of package types for systems engineers (see Fig. 3).

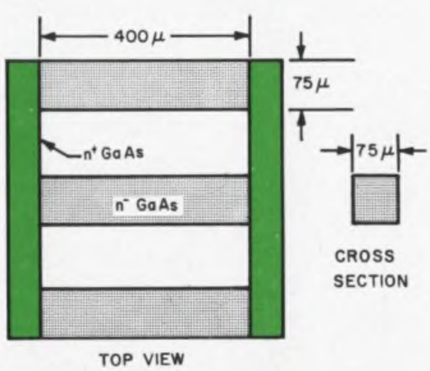
Large coaxial types are usually limited to about 2 GHz, while small coaxial ones have been operated up to about 8 GHz. The lead inductance of the former is about 0.3 nH, and of the latter, 0.08 nH.

Stripline packages come in several versions. For example, a stud-mount type is essentially a stripline package with a stud to remove heat. Its size (about 3/8 of an inch) prevents its use above 2 GHz. In general, the capacitances in the stripline package depend on the frequency. The rub is whether the tuning element should be considered a lumped or a distributed element when the device is inserted in a system.

The latest thing in packages is a



1. **Fringing fields** at the contacts of bulk oscillators, created by conventional mounting techniques (a), are eliminated by the deposition of n^+ type GaAs (b) that serves as a base for the contacts.



2. **Schematic configuration** of a GaAs oscillator shows dimensions for a unit that operates at 1 GHz in the LSA mode. Since in this mode the frequency does not depend on the length of the sample, it is shaped to obtain good heat transfer necessary for cw operation.

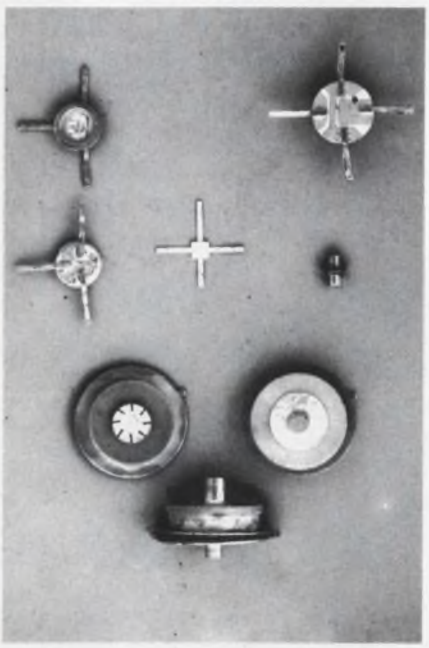
(**microwave power,** *continued*)

chip type. It is a 70-mil square of 20-mil-thick alumina. The transistor is mounted on the metal base and covered with epoxy. Texas Instruments reports operation up to about 6 GHz, with measured common-lead inductances of 0.15 nH.

Limitations due to circuit design usually appear in broad-band applications. The difficulty of matching to large admittances usualy leads to losses and narrow bandwidths. In cases when more than one active device is needed to supply the required power, the complexity of the circuit imposes further restrictions on the bandwidth.

Bulk devices near marketing

Bulk-effect devices can now operate in two modes: Gunn-oscillation, which is a transit-time effect and depends on the length of the sample, and LSA (limited space-charge accumulation), which does not depend on the length of the sample and promises substantial output (see "New technology keys Solid-State Circuits show," ED 5, March 1, 1967, p. 17).



3. **Package types** affect frequency and power range. Both stud-mount stripline (upper right) and large coaxial packages (bottom) work up to about 2 GHz and dissipate about 5 watts. Small coaxial (right center), stripline (left) and pellet (center) types go up to and beyond 6 GHz and dissipate less than a watt.

These devices, even though not yet marketed by U.S. companies, appear to hold great promise as practical microwave power sources. Some of the fundamental problems may soon be solved, as Barber pointed out.

The recently publicized LSA mode of operation strengthens the position of bulk devices at the low end of the microwave spectrum, said Barber. There is no need for very large dimensions, since the operating frequency does not depend on the length of the sample. "If LSA really works, the Gunn-type oscillator will cease to exist," said Harry Cooke.

Contact-mounting difficulties, long plaguing GaAs bulk devices, seem to be near solution, too. Figure 1 shows the approach taken at Bell Laboratories. The trouble with the contacts was the irregular fringing fields created at the point where the metal contacts were attached to the n-type GaAs (Fig. 1a). These fields are eliminated, Barber said, by the deposition of n^+-type GaAs at the ends of the n^--type (Fig. 1b) that serves as base for the contacts.

An L-band bulk oscillator, operating in the LSA mode, illustrates this approach (see Fig. 2). It has three 75-micron-wide and 400-micron long active n^--type strips, deposited on a semi-insulating substrate. The configuration looks very much like a transistor but it is obviously much larger. The comparable dimensions are the bulk oscillator's 75 microns versus about 1 micron for transistors, Barber noted.

The one remaining problem with bulk-effect devices is up to the material scientists: to produce gallium arsenide with the needed homogeneity in quantity. The problem is compounded with operation in the LSA mode; it requires more homogeneous materials than the Gunn oscillator. It will take at least another year for significant improvements to be made, according to Prof. Pistoulet.

English Gunn device for $700

There is only one company, Standard Telephone Laboratories in England, that markets bulk oscillators, Barber commented when questioned about the availability of these devices. The price of an X-band oscillator with a 5-mW output is $700, excluding the cavity. That is $28 extra. Obviously some efforts are still needed to make these devices commercially competitive with transistors and klystrons, the panel agreed.

The capabilities of these new power sources were summed up best by Dow. He uses the product of power and frequency squared (Pf^2) to estimate the possibilities of the Gunn oscillator, the Impatt (impact avalanche and transit-time) diode and the LSA mode. (The complete expression is Pf^2Z, but Z may be assumed to be the same for all three cases.) In pulsed operation (in watts times GHz^2) this product is 400 for the Gunn device, 4000 for the Impatt diode and already 3000 for the LSA mode. Dow believes that ultimately cw operation will follow the same Pf^2 law.

Avalanche diodes received less than an equal share of the limelight during the panel discussion. The fact that they are the simplest solid-state source was briefly pointed out. Mark Barber mentioned some recent results: up to 3 watts pulsed power at 2 GHz is available from prototypes. Commercial devices deliver about 300 mW at the same frequency.

Curiously enough this apparent lack of interest did not extend outside the conference. For example, 16 companies are in the race for a contract to supply avalanche diodes for a Fort Monmouth, N. J., program.

The questions from the floor reflected some of the practical difficulties of the users. For example, a question on how to make good ground connections to the many types of striplines pointed up the lack of standards in striplines. The device designer does not know the thickness of the stripline the engineer will use with the active package. Therefore he cannot make the best-size flanges and the user must improvise. The panel suggested that the user can bring the flanges out and press them down to the stripline, or drill holes into the stripline for ground connection. But the panel agreed that this difficulty may soon be solved with the advent of beam leads (see "Integrated circuits shed their wires," ED 4, Feb. 15, 1967, p. 17). ■ ■

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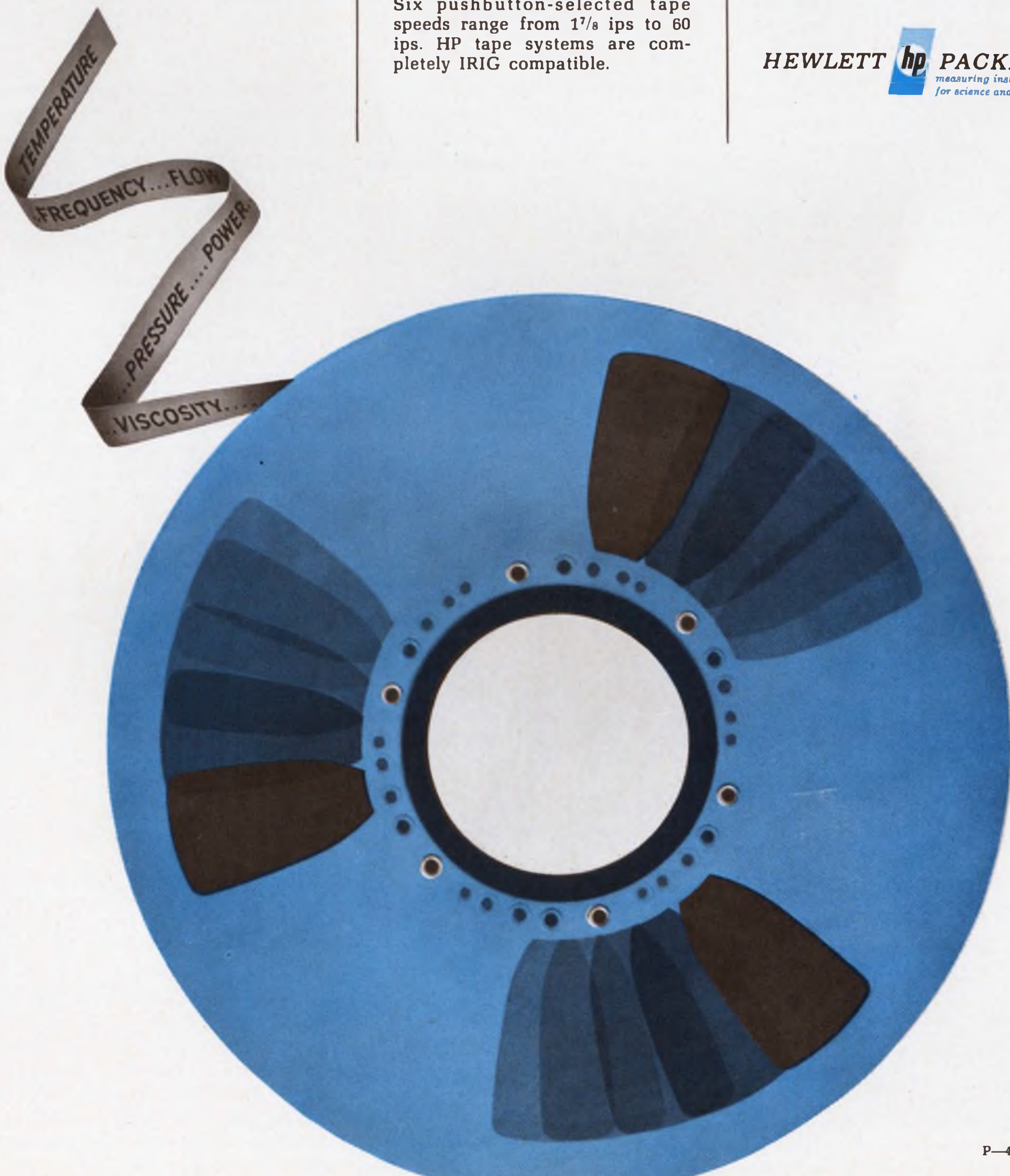

P—450

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THE OUTLOOK FOR LONG-RANGE WEATHER FORECASTING:

Cloudy, probably followed by partial clearing

Many electronic improvements being made, but accurate 2-week predictions still elude scientists

Ron Gechman
West Coast Editor

From Biblical times, when weather worriers scanned the skies for telltale red, to the modern age of satellites, weather forecasters have pursued an elusive goal: long-range accuracy. In the Northern Hemisphere today, weather scientists use daily, besides the U.S. Tiros, Nimbus and Essa satellite systems, some 700 radiosonde balloons, 1000 aircraft and 7000 ships and land observation stations. But the goal of an accurate two-week forecast still escapes them.

The reason, it became clear anew last month at the IEEE Winter Convention on Aerospace and Electronic Systems in Los Angeles, is still basically simple and yet paradoxically complex: scientists still do not know enough about what causes weather. Once the weather is there, they can track it fairly successfully and predict reasonably accurately over a period of 36 hours where it will go.

A sprawling effort is under way in the electronics industry to develop new equipment that will help fill the gaps in knowledge. Among the steps, sources at the Los Angeles convention and elsewhere report, are these:

- The updating of computer equipment.
- Improvements in transmitters.
- The use of rockets to supplement data from radiosonde weather balloons.
- Advances in wind-measuring instruments.
- The use of ocean buoys to relay meteorological information.
- The establishment of automated networks by the military to coordinate data from around the world.

Present techniques limited

The present goal of two-week predictions, according to A. Wiin-Nielsen of the University of Michigan Dept. of Meteorology and Oceanography, stretches current scientific and mathematical techniques to their limits.

Fosdic IV enables the Weather Bureau to retrieve data from microfilm, shown being threaded onto a transport. The recorder is at left. Other racks contain logic, memory, scan control and film-advance circuitry.

One specialist, however, looks to man's ability to overcome the "weather barrier." He is Glenn Cato, manager of atmospheric systems at Electro-Optical Systems, of Pasadena, Calif. He speculates that this country's proposed moon-landing program might lead to experiments that could open the way to weather control from space in 10 years, along with two-week predictions that would be 80 to 90 per cent accurate. Cato feels that after men are landed on the moon, the space vehicle and its service modules could be used for meteorological observations and might prove better suited for the task than unmanned satellites. With weather modification techniques, he looks for six-to-eight-week forecasts of weather in the next half century.

It has been estimated that weather-reporting stations today monitor only 10 to 20 per cent of the earth on a continuing and reliable basis. The areas lacking reporting stations include uninhabited land masses and vast regions of the oceans where much of the world's weather is born.

Nor are present weather satellites the ultimate in data-reporting, according to scientists. The spacecraft are unmanned, and thus restricted by their preselected orbits from following unexpected storm patterns. Moreover their viewing times in each geographic area are limited.

Larger computers needed

But even with shortcomings, the weather satellites relay voluminous quantities of important data. The new technology has opened a need for larger computer systems to assimilate and interpret the deluge of data rapidly, before it is too old to be of value. One Weather Bureau spokesman is reported as saying: "Give me the largest computer you've got. My program is like a cylinder of gas; it will expand to fill it."

Harold Bedient, chief of the Na-

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ON READER-SERVICE CARD CIRCLE 19

(**weather,** *continued*)

tional Meteorological Center's Data Automation Div. in Washington, D. C., sees the problem as twofold: computer systems must be improved to fit the thousands of inputs into a complete weather picture in a hurry and to predict changes in that picture, and the input network itself must be expanded to encompass the entire earth.

The Weather Bureau's most recent updating of equipment has been in a peripheral area. The bureau's Film Optical Sensing Device for Input to Computers (Fosdic), developed by the National Bureau of Standards for use with computers of the National Weather Records Center at Asheville, N. C., has come out in a new version. Designated Fosdic IV, the new machine reads data on past weather conditions from microfilms of punched cards, taken from the center's archives. Fosdic performs logical operations on the data it reads and selects some for recording on magnetic tape, to be used later as inputs to the center's computers. This permits comparisons of past weather conditions with more recently gathered data, so the center can study long-range patterns and improve its prediction services.

The machine reads the microfilms of punched cards at a rate of two million bits a minute, compared with the half-million rate of the earlier machine. The records center is in process of microfilming 400 million punched cards, to take advantage of the greater data density of microfilm and the rapid access achieved by the new Fosdic. Each 100-foot reel of 16-millimeter microfilm can hold the images of up to 12,000 punched cards.

Data are read from the microfilm with the help of a flying-spot scanner. This technique allows examination of only certain areas of each frame, if desired. The punched holes on each photographed card appear as transparent rectangles surrounded by the opaque background of the card stock. A photoelectric cell senses light projected from a CRT beam through the holes. The data are passed from an 80-column storage register serially through a converter for translation from 12-bit logic (Hollerith) to six-bit-plus-parity or, binary coded decimal, whichever is compatible with the next computer operation. The results are then recorded on magnetic tape.

New facsimile equipment

Map-transmission equipment is being updated, too. For years the Weather Bureau has struggled with equipment that, in some cases, is a decade or more old. Early in February, however, a new facsimile data-recording system went into 24-hour operation experimentally at the Weather Bureau center in Suitland, Md. There data from around the world are analyzed and weather maps are drawn up and transmitted to each local weather bureau in the United States. The new setup, a magnetic-tape system made by Consolidated Electrodynamics of Pasadena, Calif., is designed to record, store, convert and transmit meteorological data throughout the entire country. It is being used in conjunction with new recording and scanning units in San Francisco, and it transmits, at higher speeds, maps of more detailed resolution.

With the new transmission and receiving equipment, an 18-by-24-inch weather map that formerly took 15 to 20 minutes to send and record can be processed in about a minute.

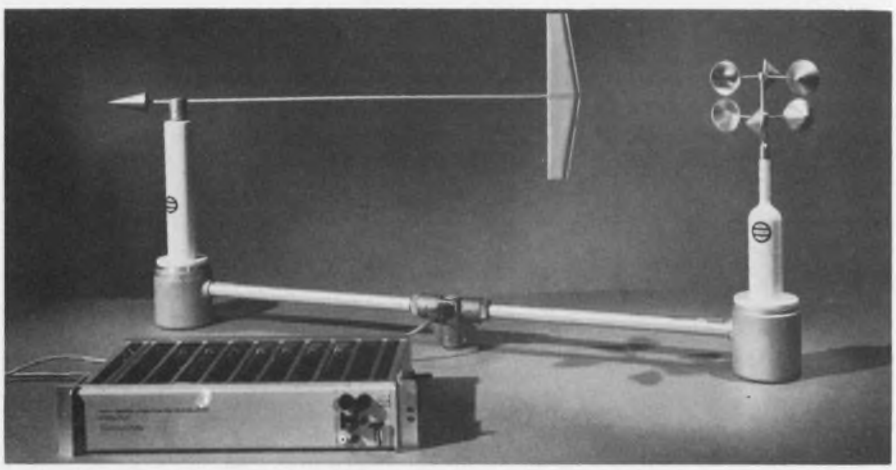
The transmission system uses well-known techniques to improve resolution:

- An input signal processor removes common-mode, or grounding, problems along the lines that might introduce noise.
- An input tracking filter with a narrow bandpass eliminates extraneous signal noise.
- The video information is first stripped from the carrier signal and recorded on tape. A new carrier is then generated from a highly stable oscillator, and it transmits the video information.

Sensing equipment changing

A gradual change in ground-based data-collecting systems is also under way. To the familiar balloon-borne radiosonde system, for example, has been added rocketsonde for collecting both low- and high-altitude data. The Missile Systems Div. of the Atlantic Research Corp., Costa Mesa, Calif., is developing a low-level meteorological sonde system that it calls Metarc. It consists of a solid-state instrumentation package that is lifted to an altitude of 5000 feet by a solid-fuel rocket. The package is ejected at the apogee, and it parachutes back to earth while an on-board transmitter relays data on wind direction and velocity, temperatures (including temperature differentials), humidity, dew point, pressure and density. The system's project engineer, Peter Anello, says it is designed for launching anywhere in the world from either land or sea, manually or automatically by remote control.

For high-altitude data gathering, other rocket systems such as one made by Metro Physics, Inc., of Santa Barbara, Calif., relay meteorological data starting at 200,000 feet. Metro calls its system Met-



Compact Meteorological package built by Atlantic Research Corp. contains a solid-fuel rocket and a self-contained radar tracker. The rocket's instrumentation package is shown alongside the rocket.

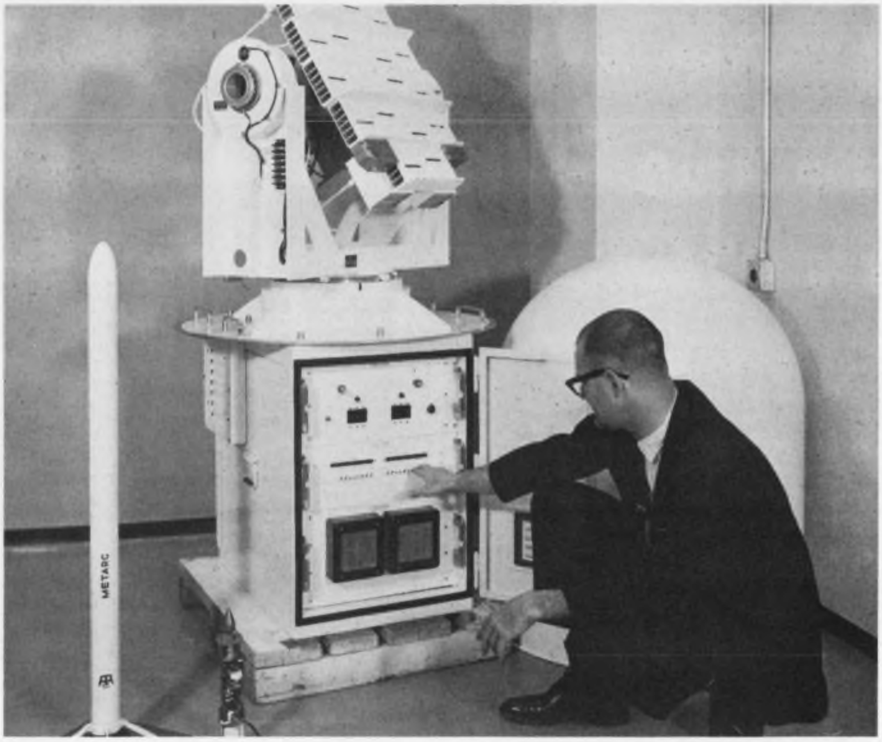
ON READER-SERVICE CARD CIRCLE 20 ➤

(**weather,** *continued*)

rodart. The Air Force Cambridge Research Laboratories has been developing its own systems to measure data in the 400,000-to-600,000-foot range.

Advances in more conventional meteorological equipment have been demonstrated by Beckman & Whitley of San Carlos, Calif. They have eliminated potentiometers and servos from their wind-speed and wind-direction instruments in favor of ac systems that employ capacitive transducers.

In their wind-speed sensor, an air-gap capacitive transducer rotates to produce an AM signal, which is demodulated to provide a sinusoidal output voltage that is proportional to the shaft rotation. The company's wind-direction sensor also employs an air-gap capacitive transducer, to phase-shift a 1-kHz sinusoidal signal proportional to the azimuth of the wind direction. The sensors have totally encapsulated solid-state circuitry and are designed to yield greater accuracy and high reliability with low maintenance.



The latest in wind-sensing devices includes this Beckman & Whitley solid-state ac system, which measures speed and direction.

Weather buoys are launched

Meteorological buoys are being developed by a few companies, too. One buoy, called the Sea Environment Acquisition System, has been developed at Bissett-Berman's San Diego, Calif., plant. It consists of an instrumented subsurface buoy coupled to a surface buoy. The subsurface portion senses such oceanographic parameters as salinity, temperature, current speed and direction, and wave height. The surface buoy gathers meteorological data, such as wind speed and direction, barometric pressure and air temperature. An on-board tape recorder stores sensor input data in binary format until a readout interrogation signal is received from a shore station. The shore station normally reads out sensor data every six hours, but the buoy can be interrogated at any time. One such buoy is installed in the Pacific Missile Range, and the receiving station is at Point Magu, Calif.

General Dynamics has gone into buoy-making on a grand scale. Its Electric Boat Div. in Groton, Conn., is making the hull for a monster buoy, 40 feet in diameter and weighing 50 tons, and its Convair Div. in San Diego, Calif., is instrumenting the buoy. The sensors measure the same basic information that Bissett-Berman's system does plus solar radiation, precipitation and humidity. A propane-driven generator provides power for operating the electrical systems. The buoy is designed to operate unattended for a year.

The monster-buoy data system can receive inputs from as many as 100 sensors. In normal operation the sensors are sampled once an hour, and the data are stored in two memories—a short-term and a long-term one. The short-term memory is used for telemetering data to shore; it reports all of the data collected in 24 hours. (A land-based receiving station interrogates the buoy every six hours to provide an 18-hour overlap in the received information.) The long-term memory stores all data collected in one year of unattended operation.

The data are telemetered in binary bits as a PCM signal on a FSK subcarrier. A single-sideband transmitter is used, with an average power of 100 watts.

General Dynamics is proposing a network of its buoys scattered around all the oceans of the world.

Military systems updated

The military weather services have been updating their equipment also. The Air Weather Service of the Air Force has placed in operation a computer-controlled, automated weather network to speed the flow of world data. The high-speed lines used in the system—some operating at up to 4500 words a minute—channel the data to the Global Weather Central at Offutt Air Force Base in Nebraska. Maj. William Roper of the Air Weather Service told last month's convention that since the system has gone into operation, the number of weather observations available for use within an hour and a half after transmission have increased 45 per cent. Upper-air data available within three hours after observation have increased by 67 per cent, he said.

Although the network has been in service only 18 months, the Air Weather Service has proposed to the Dept. of Defense that the automated setup be expanded and possibly tie in with satellites for the transmission of weather data. ■ ■

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Computerized-crime control in the offing.

Washington Report

S. DAVID PURSGLOVE,
WASHINGTON EDITOR

Crime report gives electronics boost

The real significance of a recent report by the President's Commission on Law Enforcement and Administration of Justice is that Federal money for crime control may be channeled directly to industry, not only through cities and states.

It was predictable that the "Crime Commission" headed by Harvard law professor James Vorenberg should have urged a greater role for electronics in crime control. Computers, rapid communications systems, high-speed information retrieval, "systems-managed" deployment of police forces, new alarms—all have received greater publicity and financial support since the Justice Dept.'s Office of Law Enforcement Assistance was set up less than two years ago. Almost every chapter of the report spelled out in detail the parts that electronics should play.

Now, however, money for development may come straight to the industry. The report stressed the need for a massive program of RDT&E—a term borrowed from Pentagon parlance and meaning research, development, test and evaluation. A member of Vorenberg's staff commented that use of this term showed that the Government was envisioning not merely handing out grants and contracts but also going into crime control in a big way. And this, Washington would approach rather as the Pentagon does a new weapon system, laying out money for hardware and field testing. In fact, the commission itself specifically called for application of the systems approach already tried and proven by the Pentagon. "In other words," the informant said, "these things won't just be scholarly research grants; there are going to have to be some important production contracts after the development."

The report recommended establishment of Federal academies and institutions to guide the application of technology to crime control. Hitherto most of the Government's efforts along these lines have been channeled through the Office of Law Enforcement Assistance, which makes grants to states, metropolitan areas, cities and selected nonprofit organizations. If a hardware manufacturer or R&D firm wants support for a project, it must shop around for a cooperative city or police department that will ask for Federal aid. Now observers believe that contracts may go directly to industry, although the Office of Law Enforcement Assistance declines to comment on the suggestion. But then the office itself may shortly launch its own RDT&E program.

Washington surveys the effect of peace

One of the big unanswered questions facing official Washington is where industry will be if the Vietnam war is settled. For all the studies by the Arms Control and Disarmament Agency, no one knows. Fearing what the effect of peace might be, President Johnson is trying to do something about it in advance. He has handed the job of assessing the impact of peace on present military contractors to Gardner Ackley, chairman of the Council of Economic Advisers. Ackley has to recommend which urban, social, transport and similar massive Federal programs should receive priorities in order to take up the slack.

During the talks between British Prime Minister Harold Wilson and Soviet Premier Aleksei Kosygin at the time of the Tet truce in Vietnam, the Economic Advisers, Commerce Dept. and Treasury Dept. rushed into the formation of peacetime conversion task forces. The nascent Transportation Dept. juggled continually with its plans for highway, high-speed ground transportation and vertical-take-off-and-landing aircraft programs, all of which could expect to receive increased funds if a peace settlement were reached. After months of talking of "peace just around the corner," the White House actually called in small groups of reporters to ask them to play down the theme of an immediate cessation of hostilities because of its adverse effect on the stock market.

The outcome of all the excitement is that Ackley, the director of the Budget Bureau, and the secretaries of Defense, Commerce, the Treasury and Labor are to work out a conversion plan. During the course of the summer the outlines of that plan should become clear in the speeches of agency heads when they describe their future programs. They will begin to refer to what might be done in specific areas if Vietnam's demands were reduced, rather than to the damping effects of that war. Careful listening should reveal priorities that Ackley's group have set up.

The FCC flutters the computer dovecote

Some of the firms asked by the Federal Communications Commission to provide data for the commission's look at the computer business feel that the FCC may be overstepping the authority that Congress gave it to regulate communications. An FCC spokesman says: "We've got plenty of grounds for this study, but if it should ever get down to the short rows, there's always this: The people in the business already have admitted that computers are now talking to other computers. That's communications." Some manufacturers have reservations about such a claim.

As a result of its inquiry, the FCC is caught between two fires. The common carriers want the commission to rule that any computer input or output fed over interstate lines puts that computer into interstate communications. They want the FCC to decide that the common carriers are responsible for all that goes on at either end of their interstate lines. This would give them control over all attachments to their lines and transfer to them from the computer industry a lucrative hardware sales and leasing business that runs to at least $300 million a year. The computer makers and leasers, for their part, are vigorously opposing such a move.

New source of funds for educational TV

A grant of $61,365 to WOUB, an educational TV station run by Ohio University in Athens, Ohio, has set Washington abuzz. The Federal grant for WOUB to expand and improve its mobile services comes in the wake of President Johnson's pledge to extend support for educational television. But what has set the tongues wagging is the source of the grant. Over $38,000 came from the Dept. of Health, Education and Welfare, which is usual enough. But a further $23,000 came from the Commerce Dept.'s Economic Development Administration, and this is unprecedented.

The agency's main concern has been to help small towns and rural communities attract new business by support for the development of craft industries, industrial parks and tourist attractions. It is particularly linked with the Appalachia program. But in future it is going to be thought of also in connection with educational TV. Officials of the administration indicate that more such grants will be made if the television organization seeking funds can show that its activities will raise an area's general educational level and thus help the community to thrive.

WOUB's request had the backing of the Appalachia Regional Commission, which pointed out that the station's programing was seriously hampered because it had only one set of equipment to serve both its mobile unit and its campus broadcasting. The commission was eager for the mobile unit to be free to leave the campus and bring educational television programs to the people of the area. Ohio has 28 counties in the Appalachian region. The commission wants all of them to receive educational television services; at present just half get them.

Medical television service proposed

Dr. James L. Goddard, director of the Food and Drug Administration, is apparently one of the few people who have not forgotten that the Federal Communications Commission has allotted a television band to medical education. He has proposed that a partnership of Federal and private interests should set up a medical television network to keep physicians up to date on the latest developments in their field.

UNION CARBIDE

ELECTRONICS

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March 1967

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ELECTRONICS

PNP TRANSISTORS/Silicon, Epitaxial Planar

ELECTRICAL CHARACTERISTICS

TYPE	Package†	h_{FE} @ 10 μA Min.	h_{FE} @ 10 μA Max.	h_{FE} —55°C 10 μA Min	h_{FE} 10 mA Max.	BV_{CBO} Volt Min.	BV_{EBO} Volt Min.	$V_{CE\,sust}$ Volt Min.	$V_{CE\,sat}$ Volt Max.	$V_{BE\,sat}$ Volt Max.	I_{CBO} nA Max.	C_{OB} pF Max.	NF dB Max.
UC1100	**†TO-46**	**200**	**500**	**30**	**800**	**45**	**6**	**45**	**0.5**	**0.9**	**0.5**	**6**	**2**
2N2604	†TO-46	40	120	10	350	60	6	45	0.5	0.9	10	6	4
2N2605	†TO-46	100	300	20	600	60	6	45	0.5	0.9	10	6	3
2N2605A	†TO-46	150	300	30	600	60	6	45	0.25	0.9	2	6	2

NPN TRANSISTORS/Silicon, Planar

ELECTRICAL CHARACTERISTICS

TYPE	Package†	h_{FE} @ 10 μA Min.	h_{FE} @ 10 μA Max.	h_{FE} —55°C 10 μA Min	h_{FE} 10 mA Max.	BV_{CBO} Volt Min.	BV_{EBO} Volt Min.	$V_{CE\,sust}$ Volt Min.	$V_{CE\,sat}$ Volt Max.	$V_{BE\,sat}$ Volt Max.	I_{CBO} nA Max.	C_{OB} pF Max.	NF dB Max.
UC900	**†TO-18**	**400**	**1000**	**80**	**1200**	**45**	**7**	**45**	**0.5**	**0.9**	**0.25**	**7**	**3**
JAN 2N929	TO-18	40	120	10	350	60	6	45	1	1	10	8	3
2N929	†TO-18	40	120	10	350	60	6	45	1	1	10	8	4
2N929A	†TO-18	40	120	15	350	60	6	45	0.5	0.9	2	6	4
JAN 2N930	TO18	100	300	20	600	60	6	45	1	1	10	8	3
2N930	†TO-18	100	300	20	600	60	6	45	1	1	10	8	3
2N930A	†TO-18	100	300	30	600	60	6	45	0.5	0.9	2	6	3
2N2483	†TO-18	40	120	10	500	60	6	60	0.35	0.7	10	6	3
2N2484	†TO-18	100	500	20	800	60	6	60	0.35	0.7	10	6	3
2N2509	†TO-18	25	—	—	—	125	7	80	1	0.9	5	6	7
2N2510	†TO-18	75	—	25	500	100	7	65	1	0.9	5	6	4
2N2511	†TO-18	120	—	40	750	80	7	50	1	0.9	5	6	4
2N2586	†TO-18	120	360	40	600	60	6	45	0.5	0.9	2	7	2
2N3117	†TO-18	250	500	50	—	60	6	60	0.35	0.7	10	4.5	1

DUAL PNP TRANSISTORS/Silicon, Epitaxial Planar

ELECTRICAL CHARACTERISTICS

TYPE	ΔV_{BE} μV/°C Max.	Package	BV_{CBO} Volt Min.	I_{CBO} Max. nA	h_{FE} match %	$V_{BE\,1\text{-}2}$ mV Max.	h_{FE} @ 10 μA Min.	h_{FE} @ 10 μA Max.	h_{FE} @ 1 mA Min.	f, MHz Min.	NF dB Max.	$V_{CE\,sust}$ Volt Min.	C_{OB} pF Max.
2N2802	10	TO-78	25	10	10	5	15	—	20	60	4	20	8
2N2805	10	TO-78	25	10	10	5	30	—	40	60	4	20	8
2N3347	10	TO-78	60	10	10	5	40	300	60	60	4	45	6
2N3350	10	TO-78	60	10	10	5	100	300	150	60	4	45	6
2N2803	20	TO-78	25	10	20	10	15	—	20	60	4	20	8
2N2806	20	TO-78	25	10	20	10	30	—	40	60	4	20	8
2N3348	20	TO-78	60	10	20	10	40	300	60	60	4	45	6
2N3351	20	TO-78	60	10	20	10	100	300	150	60	4	45	6
2N3349	40	TO-78	60	10	40	20	40	300	60	60	4	45	6
2N3352	40	TO-78	60	10	40	20	100	300	150	60	4	45	6
2N2804	—	TO-78	25	10	—	—	30	—	20	60	4	20	6
2N2807	—	TO-78	25	10	—	—	15	—	40	60	4	20	6

DUAL NPN TRANSISTORS/Silicon, Planar

ELECTRICAL CHARACTERISTICS

TYPE	ΔV_{BE} μV/°C Max.	Package	BV_{CBO} Volts Min.	I_{CBO} nA Max.	h_{FE} match %	$V_{BE1\text{-}2}$ mV Max.	h_{FE} @ 10 μA Min.	h_{FE} @ 10 μA *1 mA Max.	f_t MHz Min.	h_{FE} @ —55°C 10 μA Max.	NF in dB *e_n μV/$\sqrt{\sim}$ Max.	$V_{CE\,sust}$ Min.	C_{OB} pF Max.
2N4042	**3**	**TO-70**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4044	**3**	**TO-78**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4878	**3**	**TO-71**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4099	**5**	**TO-70**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N4100	**5**	**TO-78**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N4879	**5**	**TO-71**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N3680	5	TO-78	60	10	10	3	150	600	60	45	3	50	6
2N2453A	5	TO-78	80	5	10	3	150*	600*	60	40	4	50	4
2N2915A	5	TO-78	45	10	10	1.5	60	240	60	15	4	45	6
2N2916A	5	TO-78	45	10	10	1.5	150	600	60	40	3	60	6
2N2919A	5	TO-78	60	2	10	1.5	60	240	60	15	4	45	6

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE

ELECTRONICS

DUAL NPN TRANSISTORS/Silicon, Planar (Cont.)

ELECTRICAL CHARACTERISTICS

TYPE	ΔV_{BE} μV/°C Max.	Package	BV_{CBO} Volts Min.	I_{CBO} nA Max.	h_{FE} match %	V_{BE1-2} mV Max.	h_{FE} @ 10 μA Min.	*1 mA Max.	f_t MHz Min.	h_{FE} @ −55°C 10 μA Max.	NF in dB *e_n $\mu V/\sqrt{\sim}$ Max.	$V_{CE\ sust}$ Min.	C_{OB} pF Max.
2N2920A	5	TO-78	60	2	10	1.5	150	600	60	40	3	60	6
2N4043	**10**	**TO-70**	**45**	**0.1**	**20**	**5**	**80**	**—**	**150**	**30**	**3**	**45**	**0.8**
2N4045	**10**	**TO-78**	**45**	**0.1**	**20**	**5**	**80**	**—**	**150**	**30**	**3**	**45**	**0.8**
2N4880	**10**	**TO-71**	**45**	**0.1**	**20**	**5**	**80**	**—**	**150**	**30**	**3**	**45**	**0.8**
2N3941	**10**	**TO-78**	**60**	**0.25**	**10**	**3**	**400**	**1200**	**200**	**75**	**0.007***	**45**	**6**
2N3943	**10**	**TO-71**	**60**	**0.25**	**10**	**3**	**400**	**1200**	**200**	**75**	**0.007***	**45**	**6**
2N2453	10	TO-78	60	5	10	3	150*	600*	60	40	7	30	8
2N2639	10	TO-78	45	10	10	5	50	300	—	10	4	45	8
2N2642	10	TO-78	45	10	10	5	100	300	—	20	4	45	8
2N2903A	10	TO-78	60	10	10	5	125*	625*	60	25	7	30	8
2N2915	10	TO-78	45	10	10	5	60	240	60	15	4	45	6
2N2916	10	TO-78	45	10	10	5	150	600	60	30	3	45	6
2N2919	10	TO-78	60	2	10	5	60	240	60	15	4	60	6
2N2920	10	TO-78	60	2	10	5	150	600	60	40	3	60	6
2N2974	10	TO-71	45	10	10	5	60	240	60	15	4	45	6
2N2975	10	TO-71	45	10	10	5	150	600	60	30	3	45	6
2N2978	10	TO-71	60	2	10	5	60	240	60	15	4	60	6
2N2979	10	TO-71	60	2	10	5	150	600	60	40	3	60	6
2N3942	**20**	**TO-78**	**60**	**0.25**	**20**	**10**	**400**	**1200**	**200**	**75**	**0.007***	**45**	**6**
2N3944	**20**	**TO-71**	**60**	**0.25**	**20**	**10**	**400**	**1200**	**200**	**75**	**0.007***	**45**	**6**
2N2640	20	TO-78	45	10	20	10	50	300	—	10	4	45	8
2N2643	20	TO-78	45	10	20	10	100	300	—	20	4	45	8
2N2903	20	TO-78	60	10	20	10	125*	625*	60	25	7	30	8
2N2917	20	TO-78	45	10	20	10	60	240	60	15	4	45	6
2N2918	20	TO-78	45	10	20	10	150	600	60	30	3	45	6
2N2976	20	TO-71	45	10	20	10	60	240	60	15	4	45	6
2N2977	20	TO-71	60	10	20	10	150	600	60	30	3	45	6
2N2641	—	TO-78	45	10	—	—	50	300	—	10	4	45	8
2N2644	—	TO-78	45	10	—	—	100	300	—	20	4	45	8
2N2913	—	TO-78	45	10	—	—	60	240	60	15	4	45	6
2N2914	—	TO-78	45	10	—	—	150	600	60	30	3	45	6
2N2972	—	TO-71	45	10	—	—	60	240	60	15	4	45	6
2N2973	—	TO-71	45	10	—	—	150	600	60	30	3	45	6

MILITARY TRANSISTORS/Silicon, Planar

Type	Military Specifications	Device Type
JAN 2N929	MIL-S-19500/253A	NPN Transistor
JAN 2N930	MIL-S-19500/253A	NPN Transistor
JAN 2N2607	MIL-S-19500/294	P-Channel FET
JAN 2N2608	MIL-S-19500/295	P-Channel FET

FIELD EFFECT TRANSISTORS/Silicon, Epitaxial Planar

General Purpose

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} *BV_{DGO} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	I_{DSS} mA Max.	g_m μMhos Min.	g_m μMhos Max.	V_P Volts Min.	V_P Volts Max.	C_{ISS} pF Max.	C_{RSS} pF Max.	NF in dB *e_n in $\mu V/\sqrt{\sim}$ Max.
2N4416	**N**	**TO-72**	**30**	**0.1**	**5**	**15**	**4500**	**7500**	**—**	**6**	**4**	**0.8**	**2**
2N4417	**N**	**CC-3**	**30**	**0.1**	**5**	**15**	**4500**	**7500**	**—**	**6**	**3.5**	**0.8**	**2**
2N3684	**N**	**†TO-72**	**50**	**0.1**	**2.5**	**7.5**	**2000**	**3000**	**2**	**5**	**4**	**1.2**	***0.15**
2N3685	**N**	**†TO-72**	**50**	**0.1**	**1**	**3.5**	**1500**	**2500**	**1**	**3.5**	**4**	**1.2**	***0.15**
2N3686	**N**	**†TO-72**	**50**	**0.1**	**0.4**	**1.2**	**1000**	**2000**	**0.6**	**2**	**4**	**1.2**	***0.15**
2N3687	**N**	**†TO-72**	**50**	**0.1**	**0.1**	**0.5**	**500**	**1500**	**0.3**	**1.2**	**4**	**1.2**	***0.15**

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE

ELECTRONICS

FIELD EFFECT TRANSISTORS/Silicon, Epitaxial Planar (Cont.)

General Purpose (Cont.)

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} $^*BV_{DGO}$ Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	I_{DSS} mA Max.	g_m μMhos Min.	g_m μMhos Max.	V_P Volts Min.	V_P Volts Max.	C_{ISS} pF Max.	C_{RSS} pF Max.	NF in dB $^*e_n$ in $\mu V/\sqrt{\sim}$ Max.
UC-20	**N**	**†TO-72**	**30**	**0.01**	**0.4**	**2**	**300**		**2**	**5**	**2**		
UC-21	**N**	**†TO-72**	**30**	**0.01**	**0.12**	**0.6**	**200**		**1**	**2.5**	**2**		
UC-22	**N**	**CC-3**	**30**	**0.01**	**0.4**	**2**	**300**		**2**	**5**	**1.3**		
UC-23	**N**	**CC-3**	**30**	**0.01**	**0.12**	**0.6**	**200**		**1**	**2.5**	**1.3**		
UC-200	**N**	**†TO-72**	**50**	**0.1**	**10**	**30**	**6000**			**6**	**7**		**0.5**
UC-210	**N**	**†TO-72**	**50**	**0.1**	**4**	**12**	**4500**			**4**	**7**		**0.5**
UC-220	**N**	**†TO-72**	**50**	**0.1**	**1**	**5**	**3000**			**2.5**	**7**		**0.5**
UC-240	**N**	**†TO-18**	**50**	**0.1**	**1**	**10**	**1200**			**5**	**18**		***0.02**
UC-250	**N**	**TO-18**	**30**	**1**	**50**	**150**	**20000**		**5**	**10**	**25**		
UC-251	**N**	**TO-18**	**30**	**1**	**7.5**	**75**	**12000**		**1**	**6**	**25**		
2N3066	N	TO-18	*50	1	0.8	4	400	1000		10	10		3
2N3067	N	TO-18	*50	1	0.2	1	300	1000		5	10		3
2N3068	N	TO-18	*50	1	0.05	0.25	200	1000		2.5	10		3
2N3069	N	TO-18	*50	1	2	10	1000	2500		10	15		4
2N3070	N	TO-18	*50	1	0.5	2.5	750	2500		5	15		4
2N3071	N	TO-18	*50	1	0.1	0.6	500	2500		2.5	15		4
2N3365	N	TO-18	*40	5	0.8	4	400	2000		12	15		
2N3366	N	TO-18	*40	5	0.2	1	250	1000		7	15		
2N3367	N	TO-18	*40	5	0.05	0.25	100	1000		2.5	15		
2N3368	N	TO-18	*40	5	2	12	1000	4000		12	20		
2N3369	N	TO-18	*40	5	0.5	2.5	600	2500		7	20		
2N3370	N	TO-18	*40	5	0.1	0.6	300	2500		3.5	20		
2N3436	N	TO-72	*50	0.5	3	15	2500	10000		10	18		2
2N3437	N	TO-72	*50	0.5	0.8	4	1500	6000		5	18		2
2N3438	N	TO-72	*50	0.5	0.2	1	800	4500		2.5	18		2
2N3452	N	TO-72	*50	0.1	0.8	4	200	1200		10	6		2
2N3453	N	TO-72	*50	0.1	0.2	1	150	900		5	6		2
2N3454	N	TO-72	*50	0.1	0.05	0.25	100	600		2.5	6		2
2N3455	N	TO-72	*50	0.04	0.8	4	400	1200		10	5		1
2N3456	N	TO-72	*50	0.04	0.2	1	300	900		5	5		1
2N3457	N	TO-72	*50	0.04	0.05	0.25	150	600		2.5	5		1
2N3458	N	TO-18	*50	0.25	3	15	2500	10000		8	18		1
2N3459	N	TO-18	*50	0.25	0.8	4	1500	6000		4	18		1
2N3460	N	TO-18	*50	0.25	0.2	1	800	4500		2	18		1
2N3821	N	†TO-72	50	0.1	1	2.5	1500	4500		4	6	3	*0.2
2N3822	N	†TO-72	50	0.1	0.5	10	3000	6500		6	6	3	*0.2
2N3823	N	†TO-72	30	0.5	4	20	3500	6500		8	6	2	2.5
2N4117	N	TO-72	40	0.01	0.03	0.09	70	210	0.6	1.8	3	1.5	
2N4117A	N	TO-72	40	0.001	0.03	0.09	70	210	0.6	1.8	3	1.5	
2N4118	N	TO-72	40	0.01	0.08	0.24	80	250	1	3	3	1.5	
2N4118A	N	TO-72	40	0.001	0.08	0.24	80	250	1	3	3	1.5	
2N4119	N	TO-72	40	0.01	0.20	0.60	100	330	2	6	3	1.5	
2N4119A	N	TO-72	40	0.001	0.20	0.60	100	330	2	6	3	1.5	
2N4220	N	TO-72	30	0.1	0.5	3	1000	4000		4	6	2	
2N4220A	N	TO-72	30	0.1	0.5	3	1000	4000		4	6	2	2.5
2N4221	N	TO-72	30	0.1	0.2	6	2000	5000		6	6	2	
2N4221A	N	TO-72	30	0.1	0.2	6	2000	5000		6	6	2	2.5
2N4222	N	TO-72	30	0.1	0.5	15	2500	6000		8	6	2	
2N4222A	N	TO-72	30	0.1	0.5	15	2500	6000		8	6	2	2.5
2N4223	N	TO-72	30	0.25	3	18	3000	7000		8	6	2	5
2N4224	N	TO-72	30	0.5	2	20	2000	7500		8	6	2	
2N4338	N	TO-18	50	0.1	0.2	0.6	600	1800	0.3	1	6	2	1
2N4339	N	TO-18	50	0.1	0.5	1.5	800	2400	0.6	1.8	6	2	1

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE

ELECTRONICS

FIELD EFFECT TRANSISTORS (Cont.)

General Purpose (Cont.)

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} *BV_{DGO} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	Max.	g_m µMhos Min.	Max.	V_P Volts Min.	Max.	C_{ISS} pF Max.	C_{RSS} pF Max	NF in dB *e_n in µV/$\sqrt{}$ Max.
2N4340	N	TO-18	50	0.1	1.2	3.6	1300	3000	1	3	6	2	1
2N4341	N	TO-18	50	0.1	3	9	2000	4000	2	6	6	2	1
2N3695	**P**	**†TO-72**	**30**	**0.1**	**1.25**	**3.75**	**1000**	**1750**	**2**	**5**	**5**	**1.2**	***0.2**
2N3696	**P**	**†TO-72**	**30**	**0.1**	**0.5**	**1.5**	**750**	**1250**	**1**	**3.5**	**5**	**1.2**	***0.2**
2N3697	**P**	**†TO-72**	**30**	**0.1**	**0.2**	**0.6**	**500**	**1000**	**0.6**	**2**	**5**	**1.2**	***0.2**
2N3598	**P**	**†TO-72**	**30**	**0.1**	**0.05**	**0.25**	**250**	**750**	**0.3**	**1.2**	**5**	**1.2**	***0.2**
UC-40	**P**	**†TO-72**	**30**	**0.01**	**0.2**	**1**	**150**		**2**	**5**	**2.5**		
UC-41	**P**	**†TO-72**	**30**	**0.01**	**0.06**	**0.3**	**100**		**1**	**2.5**	**2.5**		
UC-42	**P**	**CC-3**	**30**	**0.01**	**0.2**	**1**	**150**		**2**	**5**	**1.4**		
UC-43	**P**	**CC-3**	**30**	**0.01**	**0.06**	**0.3**	**100**		**1**	**2.5**	**1.4**		
UC-400	**P**	**†TO-72**	**30**	**0.1**	**5**	**15**	**3000**			**6**	**8**		**0.5**
UC-410	**P**	**†TO-72**	**30**	**0.1**	**2**	**6**	**2250**			**4**	**8**		**0.5**
UC-420	**P**	**†TO-72**	**30**	**0.1**	**0.5**	**2.5**	**1500**			**2.5**	**8**		**0.5**
UC-450	**P**	**TO-18**	**25**	**0.25**	**25**	**75**	**10000**		**5**	**10**	**25**		
UC-451	**P**	**TO-18**	**25**	**0.25**	**3.75**	**37.5**	**6000**		**1**	**6**	**25**		
2N2386	P	TO-5	*20	10	0.9	9	1000			8	50		2
2N2497	P	TO-5	20	10	1	3	1000	2000		5	32		3
2N2498	P	TO-5	20	10	2	6	1500	3000		6	32		3
2N2499	P	TO-5	20	10	5	15	2000	4000		8	32		4
2N2500	P	TO-5	20	10	1	6	1000	2200		6	32		1
2N2606	P	TO-18	30	1	0.1	0.5	110		1	4	6		3
2N2607	P	TO-18	30	3	0.3	1.5	330		1	4	10		3
JAN2N2607	P	TO-18	30	3	0.3	1.5	330		1	4	10		3
2N2608	P	TO-18	30	10	0.9	4.5	1000		1	4	17		3
JAN2N2608	P	TO-18	30	10	0.9	4.5	1000		1	4	17		3
2N2609	P	TO-18	30	30	2	10	2500		1	4	25		3
2N2841	P	TO-18	30	1	0.025	0.125	60			1.7	6		3
2N2842	P	TO-18	30	3	0.065	0.325	180			1.7	10		3
2N2843	P	TO-18	30	10	0.200	1	540			1.7	17		3
2N2844	P	TO-18	30	30	0.44	2.2	1400			1.7	25		3
2N3329	P	TO-72	20	10	1	3	1000	2000		5	20		3
2N3330	P	TO-72	20	10	2	6	1500	3000		6	20		3
2N3331	P	TO-72	20	10	4	15	2000	4000		8	20		4
2N3332	P	TO-72	20	10	1	6	1000	2200		6	20		1
2N3376	P	TO-72	30	3	0.6	6	800	2300	1	5	5		
2N3573	P	TO-72	25	0.6	0.020	0.100	100	300		2	6	2	*0.15
2N3574	P	TO-72	25	*0.6	0.075	0.375	200	600		2	6	2	*0.15
2N3575	P	TO-72	25	0.6	0.200	1	300	900		4	6	2	*0.15
2N3909	P	TO-72	20	10	0.3	15	1000	5000		8	32	16	

Low Noise

TYPE	Channel	Package	BV_{GSS} *BV_{DGO} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	Max.	g_m µMhos Min.	Max.	V_P Volts Min.	Max.	C_{ISS} pF Max.	C_{RSS} pF Max	NF in dB *e_n in µV/$\sqrt{}$ Max.
2N3684	**N**	**†TO-72**	**50**	**0.1**	**2.5**	**7.5**	**2000**	**3000**	**2**	**5**	**4**	**1.2**	***0.15**
2N3685	**N**	**†TO-72**	**50**	**0.1**	**1**	**3.5**	**1500**	**2500**	**1**	**3.5**	**4**	**1.2**	***0.15**
2N3686	**N**	**†TO-72**	**50**	**0.1**	**0.4**	**1.2**	**1000**	**2000**	**0.6**	**2**	**4**	**1.2**	***0.15**
2N3687	**N**	**†TO-72**	**50**	**0.1**	**0.1**	**0.5**	**500**	**1500**	**0.3**	**1.2**	**4**	**1.2**	***0.15**
UC-240	**N**	**†TO-18**	**50**	**0.1**	**1**	**10**	**1200**			**5**	**18**		***0.02**
2N3695	**P**	**†TO-72**	**30**	**0.1**	**1.25**	**3.75**	**1000**	**1750**	**2**	**5**	**5**	**1.2**	***0.2**
2N3696	**P**	**†TO-72**	**30**	**0.1**	**0.5**	**1.5**	**750**	**1250**	**1**	**3.5**	**5**	**1.2**	***0.2**
2N3697	**P**	**†TO-72**	**30**	**0.1**	**0.2**	**0.6**	**500**	**1000**	**0.6**	**2**	**5**	**1.2**	***0.2**
2N3698	**P**	**†TO-72**	**30**	**0.1**	**0.05**	**0.25**	**250**	**750**	**0.3**	**1.2**	**5**	**1.2**	***0.2**

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE

ELECTRONICS

FIELD EFFECT TRANSISTORS (Cont.)

Amplifiers/DC Through UHF

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	*BV_{GSS} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	I_{DSS} mA Max	y_{fs} μMhos Min.	V_P Volts Max.	C_{ISS} pF Max.	C_{RSS} pF Max.	C_{OS} pF Max.	G_P dB Min.	NF dB Max.
2N4416	**N**	**TO-72**	**30**	**0.1**	**5**	**15**	**4500**	**6**	**4**	**0.8**	**2**	**10 @ 400 MHz**	**4 @ 400 MHz**
2N4417	**N**	**CC-3**	**30**	**0.1**	**5**	**15**	**4500**	**6**	**3**	**0.8**	**1.3**	**10 @ 400 MHz**	**4 @ 400 MHz**
2N3823	N	†TO-72	30	0.5	4	20	3500	8	6	2	—	—	2.5 @ 100 MHz
2N4223	N	†TO-72	30	0.25	3	18	3000	8	6	2	—	10 @ 200 MHz	5 @ 200 MHz
2N4224	N	†TO-72	30	0.5	2	20	2000	8	6	2	—	—	—

Switching

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} Min. Volts	I_{GSS} *I_{DGO} Max. nA	$I_{D\,off}$ Max. nA	I_{DSS} mA Min.	I_{DSS} mA Max.	V_P Max. Volts	C_{ISS} Max. pF	C_{RSS} Max. pF	*R_{on} Max. Ohms	T_{on} nsec	T_{off} nsec
2N3970	**N**	**TO-18**	**40**	**0.25**	**0.25**	**50**	**150**	**10**	**25**	**6**	**30**	**20**	**30**
2N3971	**N**	**TO-18**	**40**	**0.25**	**0.25**	**25**	**75**	**5**	**25**	**6**	**60**	**30**	**60**
2N3972	**N**	**TO-18**	**40**	**0.25**	**0.25**	**5**	**30**	**3**	**25**	**6**	**100**	**80**	**100**
2N4391	**N**	**TO-18**	**40**	**0.1**	**0.1**	**50**	**150**	**10**	**14**	**3.5**	**30**	**15**	**20**
2N4392	**N**	**TO-18**	**40**	**0.1**	**0.1**	**25**	**75**	**5**	**14**	**3.5**	**60**	**15**	**35**
2N4393	**N**	**TO-18**	**40**	**0.1**	**0.1**	**5**	**30**	**3**	**14**	**3.5**	**100**	**15**	**50**
UC155	**N**	**TO-72**	**30**	**0.1**	**0.1**	**10**	**—**	**10**	**4**	**1**	**125**	**—**	**—**
UC155W	**N**	**CC-3**	**30**	**0.1**	**0.1**	**10**	**—**	**10**	**3.5**	**1**	**125**	**—**	**—**
UC201	**N**	**†TO-72**	**50**	**0.1**	**0.1**	**15**	**—**	**8**	**7**	**4**	**125**		
UC250	**N**	**TO-18**	**30**	**1**	**1**	**50**	**150**	**10**	**25**	**6**	**30**		
US251	**N**	**TO-18**	**30**	**1**	**1**	**7.5**	**75**	**6**	**25**	**6**	**75**		
UC401	**P**	**†TO-72**	**30**	**0.1**	**0.1**	**8**		**8**	**8**	**4**	**250**		
UC450	**P**	**TO-18**	**25**	**0.25**	**0.25**	**25**	**75**	**10**	**25**	**6**	**60**		
UC451	**P**	**TO-18**	**25**	**0.25**	**0.25**	**3.75**	**37.5**	**6**	**25**	**6**	**150**		
2N3824	N	†TO-72	50	0.1	0.1			8	6	3	250		
2N4091	N	TO-18	40	0.2	0.2	30	—	10	16	5	30	15	40
2N4092	N	TO-18	40	0.2	0.2	15	—	7	16	5	50	15	60
2N4093	N	TO-18	40	0.2	0.2	8	—	5	16	5	80	20	80

Industrial

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} *BV_{DGO} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	I_{DSS} mA Max.	g_m μMhos Min.	g_m μMhos Max.	R_{on} Ohms Max.	V_P Volts Max.	C_{ISS} pF Max.	C_{RSS} pF Max.	NF dB Max.	Improved replace-ment for
UC701	N	TO-72	40	0.2	0.1	3	150	1500		6	3		4	
UC703	N	TO-72	40	0.5	0.1	10	500	5000	2000	6	6		2	
UC704	N	TO-72	40	0.5	0.2	24	1000	10000	1000	8	8		2	
UC705	N	TO-72	40	1	0.5	50	2000	20000	500	8	12		2	
UC707	N	TO-18	20	2	2.5	250	5000	50000	200	12	30			
UC714	N	TO-72	30	1	2	20	2000	6500	500	8	8	4	2	2N3819
UC750	N	TO-18	30	2	0.05		120			6	6			
UC751	N	TO-18	30	2	0.1		350			6	10			
UC752	N	TO-18	30	6	0.3		1000			6	17			
UC753	N	TO-18	30	10	0.9		2500			6	25			
2N2386	P	TO-5	*20	10	0.9	9	1000			8	50		2	
2N3909	P	TO-72	20	10	0.3	15	1000	5000		8	32	16		
UC801	P	TO-72	25	0.2	0.05	1.5	75	750		6	3		4	
UC803	P	TO-72	25	0.5	0.05	5	250	2500		6	6		2	
UC804	P	TO-72	25	0.5	0.1	12	500	5000	2000	8	8		2	
UC805	P	TO-72	25	1	0.3	25	1000	10000	1000	8	12		2	

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE

ELECTRONICS

FIELD EFFECT TRANSISTORS (Cont.)

Industrial (Cont.)

ELECTRICAL CHARACTERISTICS

TYPE	Channel	Package	BV_{GSS} *BV_{DGO} Volts Min.	I_{GSS} nA Max.	I_{DSS} mA Min.	I_{DSS} mA Max.	g_m μMhos Min.	g_m μMhos Max.	R_{on} Ohms Max.	V_P Volts Max.	C_{ISS} pF Max.	C_{RSS} pF Max.	NF dB Max.	Improved replacement for
UC807	P	TO-18	20	2	1	125	2500	25000	400	12	30			
UC814	P	TO-72	25	2	0.3	15	800	5000	1300	8	16	8	2	2N3820
UC850	P	TO-18	*20	2	0.1	1	110			6	6			U110
UC851	P	TO-18	*20	4	0.9	9	1000			6	17			U112
UC852	P	TO-18	25	2	0.025		60			6	6			U146
UC853	P	TO-18	25	4	0.065		180			6	10			U147
UC854	P	TO-18	25	15	0.2		540			6	17			U148
UC855	P	TO-18	25	50	0.44		1400			6	25			U149

DUAL FIELD EFFECT TRANSISTORS N-CHANNEL

ELECTRICAL CHARACTERISTICS

TYPE	ΔV_{GS} μV/°C Max.	Package	*BV_{GSS} Volts Min.	I_{GSS} pA Max.	I_{DSS} mA Min.	I_{DSS} mA Max.	g_m μMhos Min.	V_{GS1-2} mV Max.	g_m match % Max	I_{DSS} match % Max.	$V_{GS(On)}$ Volts Max.	C_{ISS} pF	NF dB
2N3954	**10**	**CO-71**	**50**	**100**	**0.5**	**5**	**1000**	**5**	**3**	**5**	**4**	**4**	**0.5**
2N3955	**25**	**CO-71**	**50**	**100**	**0.5**	**5**	**1000**	**10**	**5**	**5**	**4**	**4**	**0.5**
2N3956	**50**	**CO-71**	**50**	**100**	**0.5**	**5**	**1000**	**15**	**5**	**5**	**4**	**4**	**0.5**
2N3957	**75**	**CO-71**	**50**	**100**	**0.5**	**5**	**1000**	**20**	**10**	**10**	**4**	**4**	**0.5**
2N3958	**100**	**CO-71**	**50**	**100**	**0.5**	**5**	**1000**	**25**	**15**	**15**	**4**	**4**	**0.5**
UC-2130	**10**	**CO-71**	**50**	**100**	**0.5**	**4.5**	**1000**	**10**	**5**	**5**	**5**	**4**	**0.5**
UC-2132	**20**	**CO-71**	**50**	**100**	**0.5**	**4.5**	**1000**	**20**	**5**	**5**	**5**	**4**	**0.5**
UC-2134	**50**	**CO-71**	**50**	**100**	**0.5**	**4.5**	**1000**	**30**	**10**	**10**	**5**	**4**	**0.5**
UC-2136	**100**	**CO-71**	**50**	**100**	**0.5**	**4.5**	**1000**	**50**	**10**	**10**	**5**	**4**	**0.5**
UC-2138	**200**	**CO-71**	**50**	**100**	**0.5**	**4.5**	**1000**	**100**	**20**	**20**	**5**	**4**	**0.5**
UC-2139		**CO-71**	**30**	**200**	**0.2**	**6**	**750**				**6**	**5**	**2**
UC-2149		**CO-71**	**30**	**200**	**0.5**	**15**	**1000**				**6**	**6**	**2**
2N3921	10	TO-71	50	250	1	10	1500	5	5		2.7	18	2
2N3922	25	TO-71	50	250	1	10	1500	5	5		2.7	18	2
2N3934	10	TO-71	50	100	0.25	1.3	300	5	5		2.7	7	2
2N3935	25	TO-71	50	100	0.25	1.3	300	5	5		2.7	7	2
2N4082	10	TO-71	50	100	0.25	1.3	300	15	5		2.7	7	2
2N4083	25	TO-71	50	100	0.25	1.3	300	15	5		2.7	7	2
2N4084	10	TO-71	50	250	1	10	1500	15	5		2.7	18	2
2N4085	25	TO-71	50	250	1	10	1500	15	5		2.7	18	2

MONOLITHIC DUAL NPN TRANSISTORS/Silicon, Planar

ELECTRICAL CHARACTERISTICS

TYPE	ΔV_{BE} μV/°C Max.	Package	BV_{CBO} Volts Min.	I_{CBO} nA Max.	h_{FE} match %	V_{BE1-2} mV Max	h_{FE} @ 10 μA Min.	h_{FE} *1 mA Max.	f, MHz Min.	h_{FE} @ −55°C 10 μA Max.	NF in dB *e_n μV/√~ Max.	$V_{CE\,sust}$ Min.	C_{OB} pF Max.
2N4042	**3**	**TO-70**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4044	**3**	**TO-78**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4878	**3**	**TO-71**	**60**	**0.1**	**10**	**3**	**200**	**600**	**200**	**75**	**2**	**60**	**0.8**
2N4099	**5**	**TO-70**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N4100	**5**	**TO-78**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N4879	**5**	**TO-71**	**55**	**0.1**	**15**	**5**	**150**	**600**	**150**	**50**	**3**	**55**	**0.8**
2N4043	**10**	**TO-70**	**45**	**0.1**	**20**	**5**	**80**		**150**	**30**	**3**	**45**	**0.8**
2N4045	**10**	**TO-78**	**45**	**0.1**	**20**	**5**	**80**		**150**	**30**	**3**	**45**	**0.8**
2N4880	**10**	**TO-71**	**45**	**0.1**	**20**	**5**	**80**		**150**	**30**	**3**	**45**	**0.8**

† Available in Union Carbide Micro-Package CC-3.

UNION CARBIDE
ELECTRONICS

SILICON SOLID STATE OPERATIONAL AMPLIFIERS

TYPE	MODEL	PKG	SERVICE	Operating Temperature Range Min °C	Operating Temperature Range Max °C	Open Loop DC Voltage Gain Min dB	Open Loop DC Voltage Gain Typ dB	Bandwidth Small Signal Typ MHz	Bandwidth Full Output Typ kHz
INTEGRATED CIRCUIT TYPES	UC4000	TO-101	Any	−55	+125	86	92	2.0	15
	UC4001	TO-101	Any	−55	+125	86	92	2.0	15
	UC4002	TO-101	Any	−55	+125	86	92	2.0	15
GENERAL PURPOSE TYPES	H6000A	A	Military	−55	+125	90	97	4.5	25
	H6000	P							
	H6020C	C	Industrial	−40	+100	86	90	7.0	25
	H6020(5)	P							
	H6010C	C	Commercial	−25	+85	86	90	7.0	25
	H6010(5)	P							
HIGH INPUT IMPEDANCE FET TYPES	H7000A	AF	Military	−55	+125	86	92	2.5	20
	H7000	PF							
	H7020A	AF	Industrial	−40	+100	86	92	3.0	100*
	H7020B	BF							
	H7010A	AF	Commercial	−25	+85	86	92	3.0	100*
	H7010B	BF							
WIDEBAND AND HIGH OUTPUT CURRENT TYPES	H9000A	A	Military	−55	+125	95	100	20	200
	H9020A	A	Industrial	−40	+100	95	100	3.0	35
	H9020B	B							
	H9010A	A	Commercial	−25	+85	95	100	3.0	35
	H9010B	B							
± 20 VOLT OUTPUT TYPES	H7030A	AF	Industrial	−40	+100	90	97	3.0	45
	H7030B	BF							
	H9030A	A	Industrial	−40	+100	100	105	3.0	25
	H9030B	B							
OUTPUT CURRENT BOOSTERS	H6030C	CB	Military	−55	+125	−0.5	−0.2	22.0	—
	H6030	B							
	H6050	PB	Commercial	−40	+100	−1.0	−0.5	15.0	—
DC COMPARATORS (Fast Slew-Rate Operational Ampls., Uncompensated)	H8000A	A	Military	−55	+125	90	97	—	—
	H8020A	AF	Industrial	−40	+100	90	95	—	—
	H8010C	C	Commercial	−25	+85	86	90	—	—

* New improved specification. (1) Adjustable to Zero by ext potentiometer. (2) Input Offset Current doubles approximately every 11°C. (3) Plus output load current. (4) Adjustable to Zero by external rheostat. (5) Also available in "D" PKG upon request. (6) For −55°C < TA < +125°C only. (7) At rated load. (8) Typical value.

UNION CARBIDE

ELECTRONICS

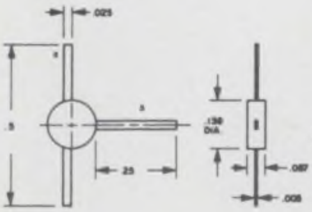
Input Impedance Open Loop Diff	Input Impedance Open Loop CM	Input Voltage Offset	Input Voltage Drift	Input Current Bias	Input Current Offset	Input Current Drift	Input Noise Voltage	Common Mode Voltage Range	Rated DC Output	Rated DC Output	Power Requirements	Power Requirements	Slew Rate	
Typ	Typ	Max	Max	Typ	Max	Max	Max	Min	Min	Min	Nom	Nom	Typ	
MΩ	MΩ	mV	μV/°C	nA	nA	nA/°C	μV RMS	Volts	Volts	mA	Volts	mA[3]	V/μsec	MODEL
3.0	400	Zero[1] / ±5	±10	30	±15	±0.175[6]	0.2[8]	±10	±10	±2.0	±15	±7	1.0	UC4000
3.0	400	Zero[1] / ±10	±20	70	±30	±0.350[6]	0.2[8]	±10	±10	±2.0	±15	±7	1.0	UC4001
3.0	400	Zero[1] / ±15	±40	120	±50	±0.700[6]	0.2[8]	±10	±10	±2.0	±15	±7	1.0	UC4002
10	400	Zero[4]	±10	15	±5.0	±0.1	2.0	±10	±10	±2.0	±15	±3.5	1.6	H6000A / H6000
1.0	500	Zero[4]	±5	80	±25	±0.5	2.0	±10	±10	±3.0	±15	±6.5	1.6	H6020C / H6020
0.25	300	Zero[4]	±10	100	±50	±1.5	5.0	±10	±10	±3.0	±15	±6.5	1.6	H6010C / H6010
10^6	10^6	Zero[1]	±25	.015*	±0.05	[2]	2.0	±10	±10	±2.0	±15	±4.2	1.3	H7000A / H7000
10^6	10^6	Zero[1] / ±1.0[1]	±25	.04	±0.05	[2]	2.0	±5	±10	±2.0	±15	±4.5	6.5*	H7020A / H7020B
10^5	10^5	Zero[1] / ±1.0[1]	±50	.04	±0.1	[2]	5.0	±5	±10	±2.0	±15	±4.5	6.5*	H7010A / H7010B
1.0	300	Zero[4]	±5	75	±25	±0.5	2.0	±10	±10	±30	±15	±4.0	13	H9000A
1.0	300	Zero[4] / ±0.5[1]	±5	80	±25	±0.5	2.0	±10	±10	±30	±15	±4.2	2.2	H9020A / H9020B
0.25	300	Zero[4] / ±0.5[1]	±10	165	±50	±1.5	5.0	±10	±10	±30	±15	±4.2	2.2	H9010A / H9010B
10^6	10^6	Zero[4] / ±1.0[1]	±25	.04	±0.05	[2]	2.0	±15	±20	±2.0	±28	±5.0	5.5*	H7030A / H7030B
0.5	400	Zero[4] / ±0.5[1]	±10	250	±25	±0.5	2.0	±20	±20	±10	±28	±2.5	3.2*	H9030A / H9030B
—	4[7]	±50	—	2.5×10^3	—	—	—	±10	±10	±20	±15	±2.0	100	H6030C / H6030
—	2	±50	—	50×10^3	—	—	—	±10	±10	±100	±15	±6.0	150	H6050
10	400	Zero[4]	±10	10	±5.0	±0.1	—	±10	±10	±2.0	±15	±3.5	10	H8000A
10^6	10^6	Zero[1]	±20	.05	±0.05	[2]	—	±5	±10	±2.0	±15	±4.5	20	H8020A
0.25	300	Zero[4]	±10	100	±50	±1.5	—	±10	±10	±3.0	±15	±6.5	11	H8010C

UNION CARBIDE

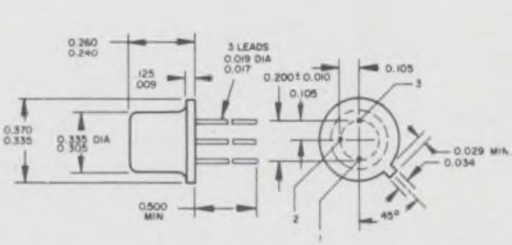
ELECTRONICS

TRANSISTOR PACKAGES

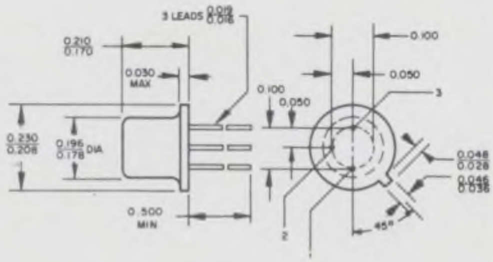
All Dimensions Nominal in Inches Unless Otherwise Noted.



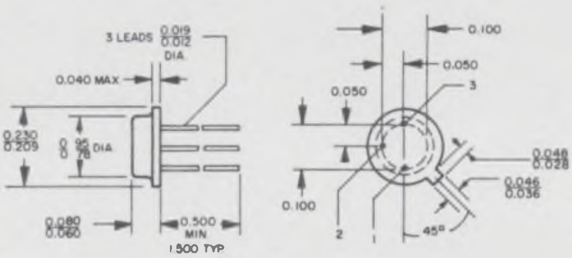
CC-3



TO-5



TO-18



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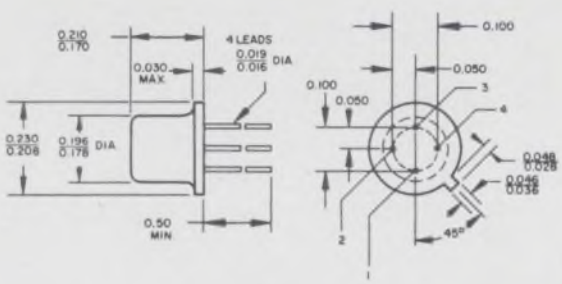
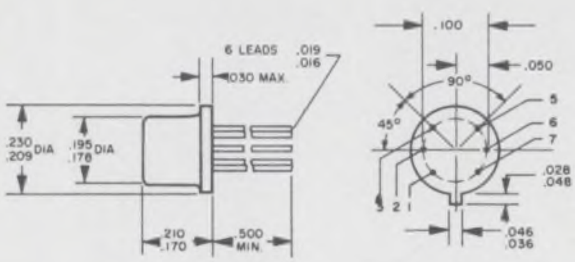
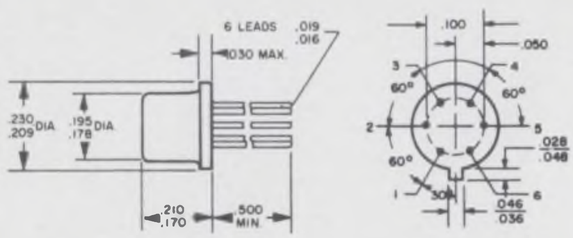


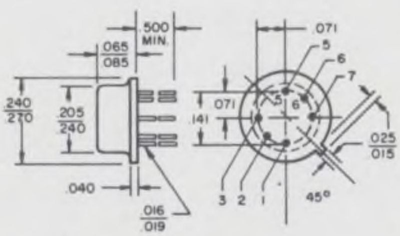
TO-72



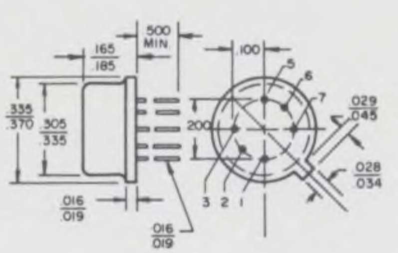
TO-71



CO-71



TO-70



TO-78

NOTE: All base diagrams are bottom view.

DEVICE TYPE	HEADER																											
	T0-5/T0-18/T0-46			T0-72				CC-3			T0-70/T0-78						T0-71						CO-71					
PIN	1	2	3	1	2	3	4	1	2	3	1	2	3	5	6	7	1	2	3	5	6	7	1	2	3	4	5	6
NPN/PNP	E	B	C	—	—	—	—	E	B	C	C	B	E	E	B	C	—	—	—	—	—	—	—	—	—	—	—	—
2N2972-79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	E	B	C	E	B	C	—	—	—	—	—	—
P-CHANNEL	S	G	D	S	G	D	Case	S	D	G	G	D	S	S	D	G	S	D	G	S	D	G	S	D	G	S	D	G
N-CHANNEL	S	D	G	S	D	G	Case	S	D	G	G	D	S	S	D	G	S	D	G	S	D	G	S	D	G	S	D	G
2N4878-80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	B	E	E	B	C	—	—	—	—	—	—

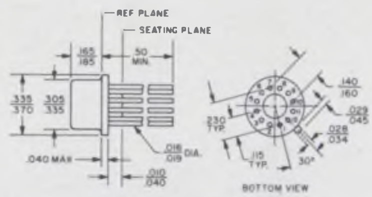
UNION CARBIDE

ELECTRONICS

AMPLIFIER PACKAGES

All Dimensions Nominal in Inches Unless Otherwise Noted.

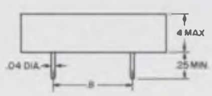
INTEGRATED CIRCUIT TYPES



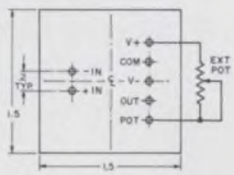
(1) COMMON
(2) NEGATIVE SUPPLY
(3) OUTPUT COMPENSATION
(4) INTERNAL CONNECTION
(5) OUTPUT
(6) POSITIVE SUPPLY
(7) BALANCE POTENTIOMETER
(8) INPUT COMPENSATION
(9) INPUT (INVERTING)
(10) INPUT (NON-INVERTING)
(11) INPUT COMPENSATION
(12) BALANCE POTENTIOMETER

TOP VIEW

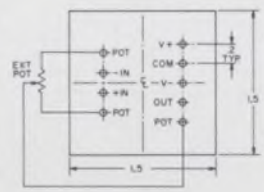
SIDE VIEWS	BIPOLAR TRANSISTOR TYPES	FIELD EFFECT TRANSISTOR TYPES	BOOSTERS



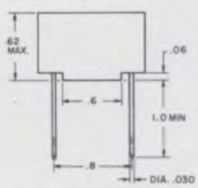
"A" PACKAGE



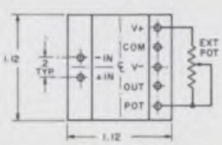
"A" BASE



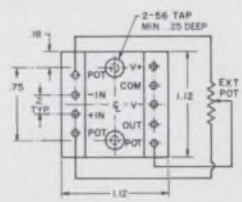
"AF" BASE



"P" PACKAGE



"P" BASE



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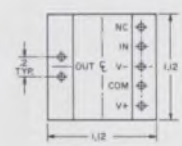
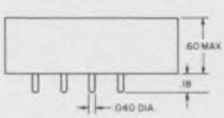


"PB" BASE



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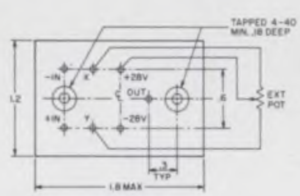
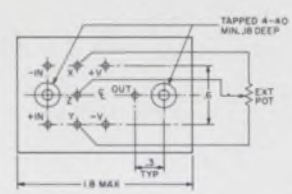


"B" BASE



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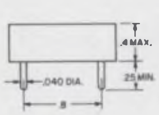
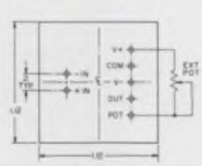
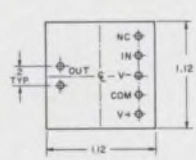


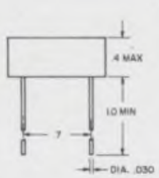
"C" PACKAGE



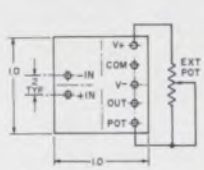
"C" BASE



"CB" BASE

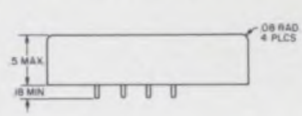


"D" PACKAGE

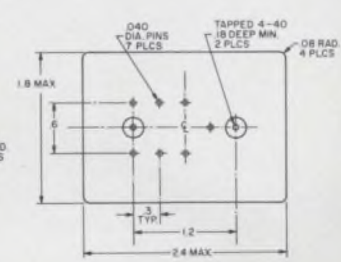


"D" BASE

CHOPPER-STABILIZED TYPE



BL PACKAGE



BL BASE

NOTE: All base diagrams are bottom view.

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Temperature sensor has high stability

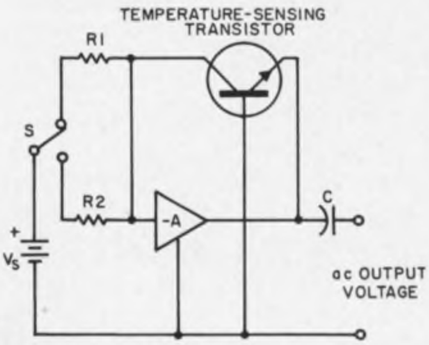
Attempts to use semiconductor diodes and transistors as temperature sensors have often been unsuccessful because of difficulties in obtaining measurement reproducibility and stability.

An ac-junction thermometer was described at the Solid-State Circuits Conference (see p. 17) in which improved performance was achieved by operating a transistor with ac to eliminate the contribution of saturation current in the device output.

According to D. W. Bargen of Electro-Optical Systems, Inc., Pasadena, Calif., the transistor sensor is operated in such a way that the effects of recombination-generation currents and surface leakage are eliminated. As a result, stability of $\pm 0.1°$F and interchangeability of $\pm 1.0°$F, or better, may be obtained with transistors as temperature sensors, even though the transistor parameters vary by $\pm 50\%$, Bargen said.

As shown in the illustration, a high-gain amplifier leads to low output impedance and essentially short-circuit operation of the collector base junction. Placing the transistor sensor in the amplifier feedback loop enables the collector current to be changed by switching between two fixed resistors. The emitter base voltage can then be read out as the dependent variable.

If the gain of the amplifier is high and the input current is negligible, the output of the circuit is: $\Delta V_{BE} = V_{out} = T(k/8) \ln R1/R2$. ■ ■



Transistor temperature transducer circuit eliminates the effects of recombination-generation current and surface leakages.


COUNT
DISPLAY TIME
DC RANGE
FUNCTION
TIME BASE
FILTER
INPUT
POWER
SAMPLING RATE
VOLTS
CHASSIS
OHMS
OVERLOAD
RATIO
VOLTS
OHMS
VOLTS
OHMS
FUNCTION
RANGE

Army strengthens U.S. computer defenses against bombers

While most public discussion about defense against air attack centers on antimissile-missile systems, the U. S. Army is quietly strengthening its potential to down any enemy bombers that might try to hit key cities. It is replacing its 10-year-old Missile Master system with a faster, more advanced electronic setup—Missile Mentor.

The new system employs high-speed, general-purpose computers and display consoles to give air defense commanders more data than they have ever had to make battle decisions, according to the Hughes Aircraft Co. of Fullerton, Calif., manufacturer of Missile Mentor.

The new system is housed in two vans that operate as a single command post. One van contains the display consoles and displays for defensive missile batteries, and the other houses the computer and a radar processor.

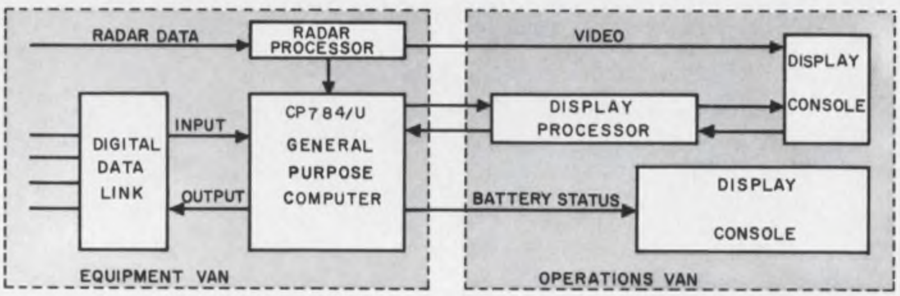
The general-purpose computer, built by Hughes, contains four core memories, each containing 8192 words of 18 bits each; eight buffered input-output channels, and 24 index registers. Parallel, synchronous operation is employed, with a 2.2-MHz clock rate.

Input to the system is from local radar installations or from other air defense systems, such as SAGE or BUIC. If desired, a remotely located third van, containing a computer and display consoles, can be used with a remote radar station to enlarge defensive radar coverage.

Missile Mentor provides high-speed command and control facilities to coordinate the firing of the Army's Nike Hercules and Hawk surface-to-air missiles. Display and processing equipment in the vans provide surveillance, tracking, threat evaluation, battery-status monitoring, weapons assignment and damage-assessment data.

Missile Mentor systems are reported in operation in the air-defense areas of San Francisco, Los Angeles, Chicago-Milwaukee, Washington-Baltimore, Pittsburgh, New York-Philadelphia and Detroit-Cleveland. Sites at Boston and Miami are expected to be operational soon. ■ ■

Display console of Missile Mentor uses symbols and alphanumeric characters to identify targets.



Missile Mentor block diagram, showing the data flow between the two vans that house the system.

Compact, 3-W undersea nuclear generator makes bow

A small, self-contained three-watt nuclear generator for undersea use was unveiled by the Martin Marietta Corp. at the Offshore Exploration Conference in Long Beach, Calif.

The cylindrical unit, 30 inches high and 24 inches in diameter, operates at depths down to 3000 feet, and with modifications down to 15,000 feet. Two similar units generate 25 and 50 watts, respectively.

All three models, which contain no moving parts, are fueled with strontium 90. They generate power by converting the decay heat of the isotope fuel through a series of thermoelectric elements.

N. E. Felt, Jr., Martin Marietta's general manager of nuclear programs, says: "We can now offer long-lived electrical power from 3 to 50 W using single units, and we can meet higher power requirements by using more than one unit."

One of the three-watt units has been sold to the U.S. Navy for evaluation testing at the Naval Civil Engineering Laboratory, Point Hueneme, Calif. A 25-watt generator is already operating in the Bering Strait supplying electricity to a Navy oceanographic measuring station off the coast of Alaska.

Typical uses on land and at sea include offshore drilling equipment, navigation aids, and seismological and weather stations. ■ ■

Submersible nuclear generator, fueled with strontium 90, produces 3 watts.

The DVM's:

Fairchild 7200:

A full 5-digit meter made for precision measurements in the laboratory or on the production line. It operates to a high standard of accuracy, with 10μV resolution, and excellent short and long term stability. The principle of operation is based on a new concept where high accuracy and long term stability are achieved by a digital time base memory (Pat. Pend.). The basic unit provides DC voltage measurements, DC ratio measurements, and counting functions to 1MHz. Optional plug-in cards or modules provide AC measurement, frequency measurement, resistance measurement, and other capabilities. Basic unit price is $3500.00.

Fairchild 7100A:

A full 4-digit meter with extensive capabilities for laboratory and production line measurements. The 7100A measures voltage, resistance and ratio, with AC capabilities optionally available in a plug-in unit. It features guarded construction, 10μV resolution, 0.01% performance, and excellent stability. Price is $2075.00.

Fairchild 7000:

A small, half-rack size, portable, medium price 4-digit meter, the 7000 features 0.01% accuracy. The basic unit provides DC voltage measurements, with provisions for adding AC voltage, resistance and current measurements as well as autoranging and BCD output. The front panel of the instrument controls all measurement functions, so that capabilities may be added simply by plugging in a circuit board. Basic unit price is $1150.00.

Fairchild 7050:

This low-cost, accurate, 3-digit instrument is intended primarily as a replacement for analog-type meters and panel indicators in such applications as production testing, general testing, quality assurance, servicing and the like. Basic features include DC volts and resistance, full scale readout of 1500, input impedance greater than 1000 megohms, floating input, and readout storage (non-blinking display). Price is $299.00

Where to get them: For immediate assistance or for the name and address of the representative in your area, contact any of these Fairchild Instrumentation Field Sales Offices:

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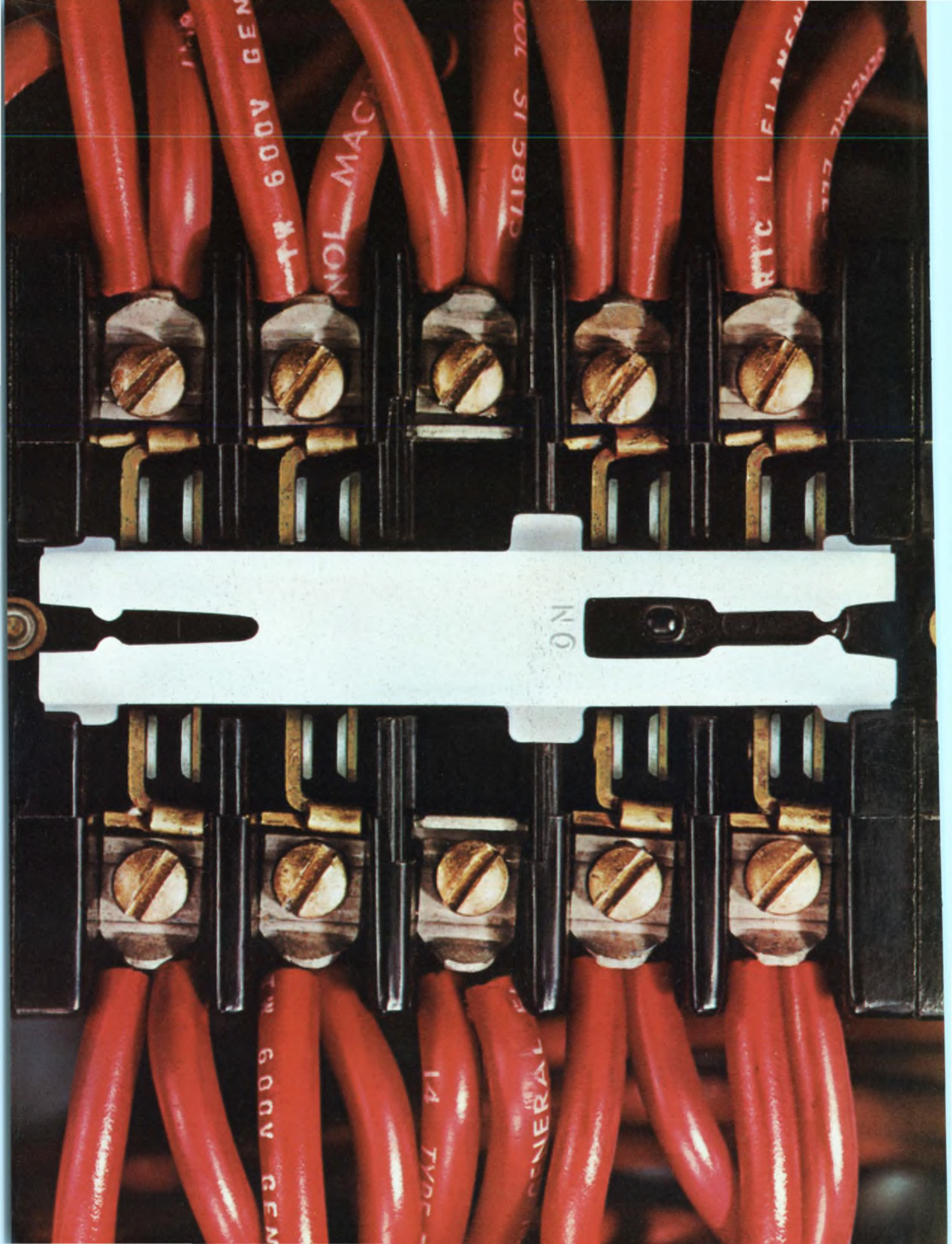
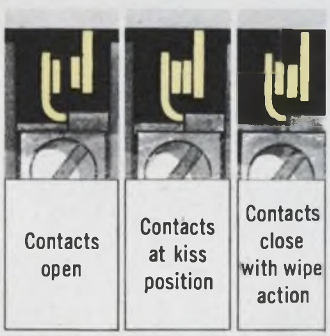
ON READER-SERVICE CARD CIRCLE 26



You can't clean your relay contacts after every cycle...

so we do it for you.

Or, more accurately, our contacts do. They clean themselves. Every time they open and close.



Here's how: As the contacts open and close with high tip pressure, they provide a scrubbing action that keeps the points clean—assures positive make and break for greater contact fidelity. Even after millions of operations. And under all kinds of operating conditions.

Every G-E 300-volt relay has these self-cleaning contact tips . . . a good tip to remember. Here are more:

G.E.'s open design of the contact structure exhausts dust particles. While, vertical contact tips further reduce dust accumulation. Result: cleaner tips, more positive action.

G-E 300-volt relays are available in 2-, 4-, 6-, 8-, 10- and 12-pole forms. Including latched, time-delay and d-c forms.

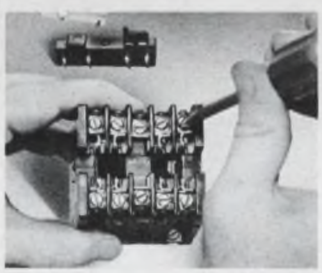
Need more poles? It's a snap. A unique building block design enables you to add them as the need arises. Quickly, easily.

2- & 4-pole adders available

Use 2-pole adders to continue an in-line relay approach without changing coils or disturbing wiring of existing relays.

Or, install 4-pole adders on the front of existing 4-pole relays. They snap right into place. Just the thing for saving panel space. Plus, the sides of the relay act as a wiring trough . . . more space saved.

And, 4-pole adders can be converted from normally open to normally closed. Quickly, without extra parts.



All G-E 300-volt relays are completely front accessible. Change the coil and convert the contacts without removing the relay.

A specialized installation? No problem. A complete line of accessories is available.

Want to know more? Your G-E Sales Engineer or Control Distributor is the one to see. Just ask him for your free copy of "The General Electric Relay Selection/Application Guide."

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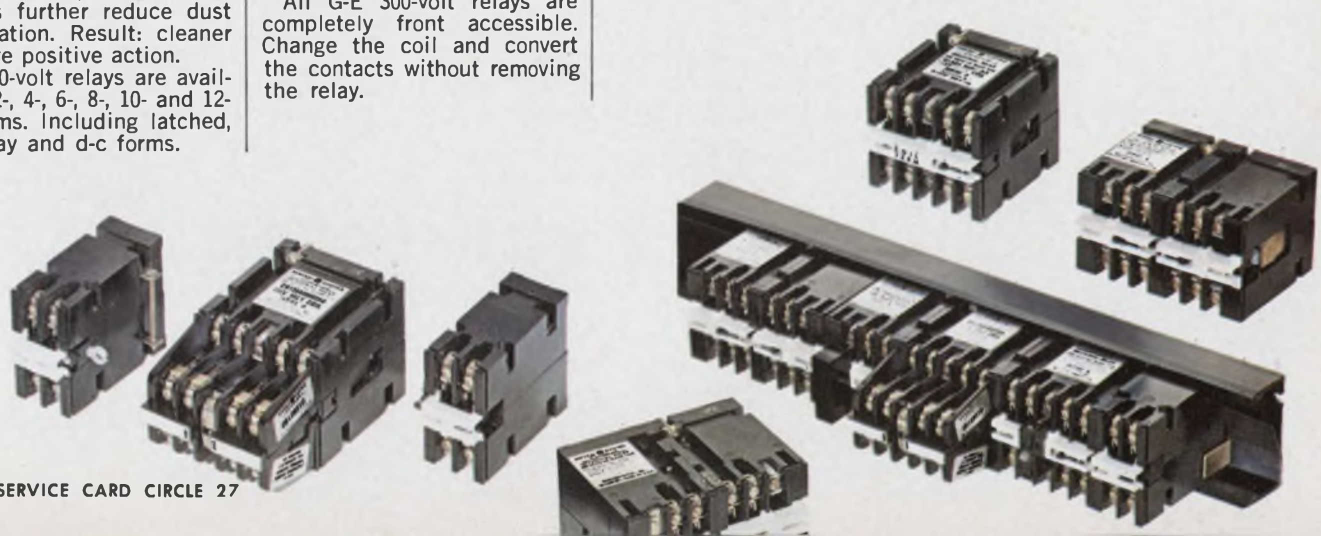

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For detailed descriptions of one or both of these timers, get our CA Series Bulletin 322 and our HG Series Bulletin 320. Write Eagle Signal Division, E. W. Bliss Company, 736 Federal Street, Davenport, Iowa 52808; or call (319) 324-1361.

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ON READER-SERVICE CARD CIRCLE 29

Computers, ICs to help physicists probe nature

Designers are busy modifying research instruments to take advantage of new advances in electronics

Robert Haavind
Managing Editor

Designers of instrumentation for physics research are heading rapidly into an era of microcircuitry and computer compatibility.

For years clever design has been necessary to cope with the nanoseconds, random events and angstroms that make up the world probed by the physicists. Some of these design techniques have found their way into other areas of electronics, such as high-speed computer circuits. A sampling of the design techniques used in recent instrumentation illustrates some of the latest trends. Of many new designs being developed, the following ones will serve to indicate the general directions:

- A microcircuit multiscaler suitable for eight count channels at rates up to 50 MHz.
- A 20-MHz scaler using miniature Nixie readouts, and containing a computer-addressable register, now under development.
- An active-filter amplifier used in counting instrumentation.
- An integrating-type signal averager for picking signals out of noise.

Tight microcircuit packaging

Tight packaging of fast microcircuits leads to a compact 8-channel, 50-MHz multiscaler, designed by Carl Radmer of LeCroy Research Systems Corp.

The present package, an AEC-1 module, has signal wiring printed on the back of a circuit board, and supply buses on top of the microcircuit side (see photo). Multilayer boards may be used in future designs.

The model 150 multiscaler, shown in the photo, can collect counts in eight channels providing 24 parallel bit outputs suitable for computer interface. This unit sells for $1950. A model 151 twelve-bit unit handles four channels and sells for $750 to $1090, depending on input and readout options.

Miniature Nixie tube readouts are provided in a scaler under development by Hamner Electronics, Inc., Princeton, N. J. This scaler, the model NS-20, will include a computer-addressable register. Thus, with proper interface circuitry, a computer can program the operation of a number of scalers. This unit will handle 20-MHz rates. Here again integrated circuits are used, this time as Nixie drivers, to keep the package compact. Total count capacity for the 7-digit scaler is 10^7. Inputs of ± 0.2 volt or ± 2 volts can be accepted. The price will be under $1500.

This scaler, which is scheduled to be marketed in the next couple of months, will be the start of a computer-addressable line of instrumentation available from Hamner.

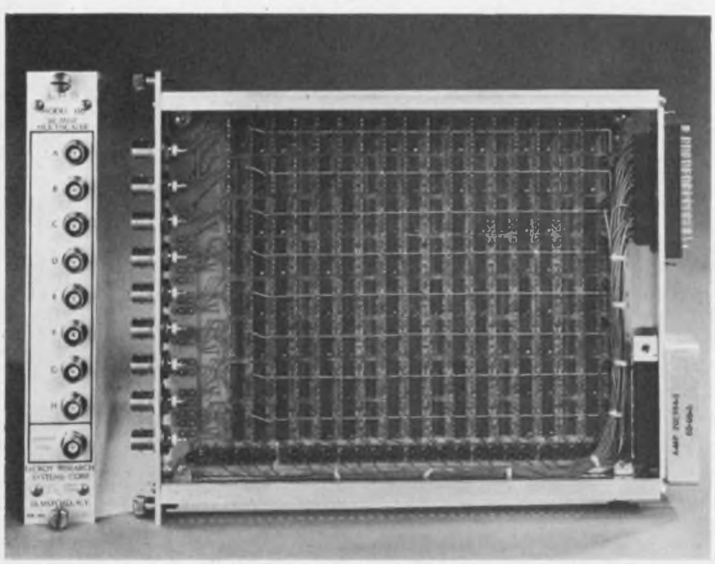
Pole-zero cancellation

The active-filter amplifier design includes a pole-zero cancellation technique to eliminate the long exponential tail on differentiated pulses. Essential details of the design are presented in the box (page 46). This amplifier is used for counting outputs of semiconductor detectors, scintillation counters or gas ionization chambers. It is important to eliminate the undershoot when making such measurements for two main reasons. First, high overloads may occasionally occur and thus saturate the amplifier long enough to miss subsequent counts. Second, "pile-up" may occur. That is, subsequent pulses may start somewhere along the overshoot rather than at the baseline after the exponential has decayed. If this happens sequentially, it can cause considerable errors.

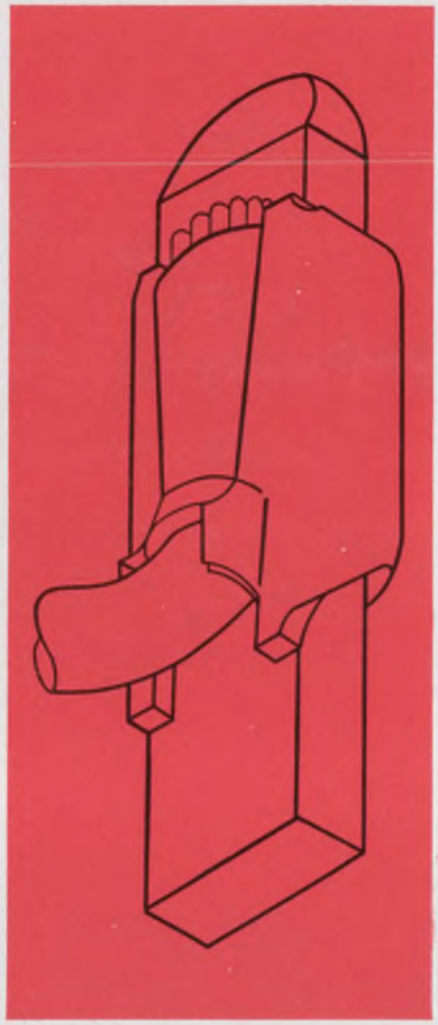
Active filtering is used to eliminate the need for inductors. This results in simple networks which could be easily translated into microcircuit form in later designs.

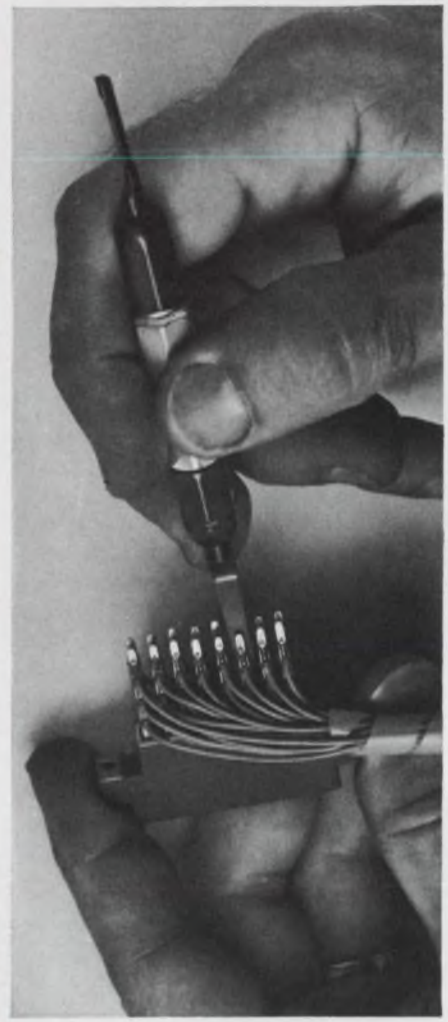
This particular amplifier, the model 435, includes two integrated-circuit amplifying stages after the differential input preamplifier,

(continued on p. 46)



Both these scalers use integrated circuits. The 8-channel multiscaler (left) designed by LeCroy Research Systems Corp. operates to 500 MHz. Wires across the tops of the microcircuits are bus lines. The scaler at right with 7-digit Nixie readout is under development at Hamner Electronics. It includes an addressable register for computer compatibility.



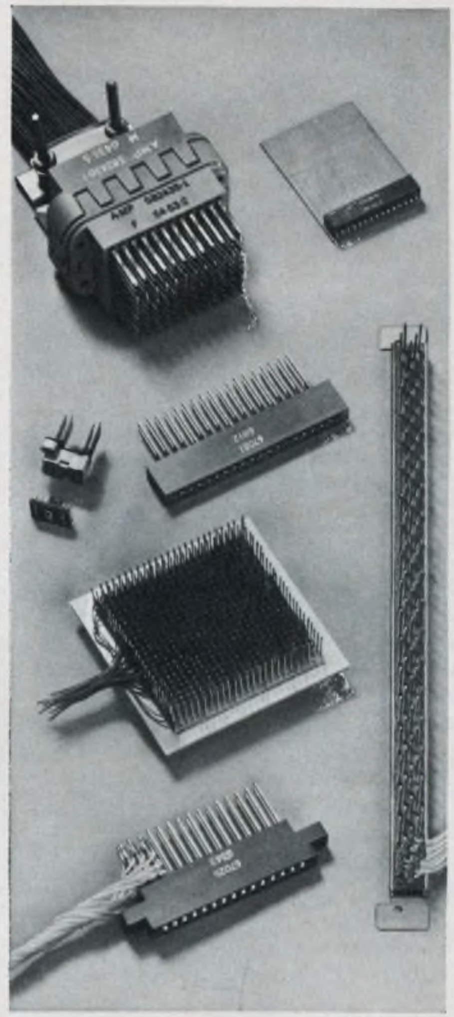


Some pointed facts about wiring

1. Ours is the only point-to-point wiring technique designed for both solid and stranded wire, bulk or pre-cut, and other types, such as enamel insulated wire. Production flexibility is further enhanced by the variety of TERMI-POINT tools which range from lightweight pneumatic and hand application devices to fully automated high-speed equipment. Since head-on insertion, not wrapping or twisting, is utilized in our technique, these tools require a minimum of working space, permitting grid densities to .100" . . . even tighter in future generation products!

2. TERMI-POINT wiring devices are fully compatible with other production methods . . . although our plated chamfered post was designed specifically for TERMI-POINT clips. These posts are available in several sizes, including the new miniature .022" x .036" rectangular post. Mating TERMI-POINT clips are applied over the mandrel and onto the post in a manner which "irons" the wire. Clips are made of fine grain phosphor bronze and incorporate integral springs. The combination of the ironed wire and the integral spring produces a gas-tight connection—without nicking either post or wire!

3. TERMI-POINT clip terminations are the easiest to service of any production wired devices. Individual connections may be tested non-destructively in the field using simple hand tools, without damage to the post involved or adjacent posts. Unlike wrapped connections that require a dozen or more steps to replace, the bottom TERMI-POINT clip on a 3-high post can be removed with a quick twist of the extraction tool. Upper clips slide into position on the post, and the new connection is applied on top. Posts can be used many times without deterioration.



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ON READER-SERVICE CARD CIRCLE 31

(physics, ***continued*****)**

which uses a pair of 2N3638s. The output stage is also not integrated, since to feed 100 ohms at about 10 volts requires an output current of 100 mA, a little too husky for today's ICs. The differential inputs are important in physics laboratories where lots of equipment is often humming away during an experiment. One cable carries the signal and the second acts as a dummy. This cuts common-mode noise by a factor of 200.

This amplifier, like most other equipment in this field, is designed according to AEC-recommended NIM (Nuclear Instrument Module) specifications. Design was handled by Thomas Emmen, Ortec chief engineer.

Signal averagers are another type of instrument coming into wide use in physics research and also the medical field. Fabri-tek, Inc.'s Instrument Div. in Madison, Wis., is moving into this field with new microcircuit designs. The basic idea of such instruments is to sample a

Pole-zero cancellation and active filtering

Pole-zero cancellation is a technique to eliminate the undershoot from the waveform $e_1(t)$ in Fig. 1a. This pulse is obtained by putting the output of a preamplifier, $e_0(t)$, through a differentiator (R_1C_1). The result, obtained by use of Laplace transforms, is:

$$e_1(t) = E_o e^{-t/T_o} \times G_1(t),$$

$$e_1(s) = E_o\left[\frac{1}{s + (1/T_0)}\right] \times \left[\frac{s}{s + (1/R_1C_1)}\right],$$

$$e_1(t) = \left[E_o/(T_o - T_1)\right] \times \left[T_0 e^{-t/T_1} - T_1 e^{-t/T_o}\right];$$

where $T_1 = R_1C_1$.

If the network of Fig. 1b is used instead, the undershoot is eliminated if the potentiometer ratio, K, is set correctly. This can be seen from the following expressions:

$$e_2(t) = E_o e^{-t/T_o} \times G_2(t),$$

$$e_2(s) = E_o\left[\frac{1}{s + (1/T_0)}\right] \times \left[\frac{s + (K/R_2C_1)}{s + (1/R_pC_1)}\right];$$

where $R_p = R_1R_2/(R_1 + R_2)$. Thus, the condition for pole-zero cancellation is:

$$s + 1/T_0 = s + K/R_2C_1.$$

If this condition is met, the expression reduces to:

$$e_2(s) = E_o\left[\frac{1}{s + (1/R_pC_1)}\right],$$

$$e_2(t) = E_o e^{-t/R_pC_1}.$$

Thus a single exponential with no undershoot results. A screw adjustment in the side of the amplifier sets the potentiometer to determine the value of K between 0 and 1.

The amplifier also contains two integrated-circuit amplifier stages and an active filter. Active filtering is used to provide a waveshape that approaches a theoretical optimum for best signal-to-noise ratio. Such a point occurs, for a FET, when gate current and drain thermal noise are equal. The ideal waveform is a cusp (Fig. 2a) where:

$$e^{-t/RC},\ t > 0;$$
$$e^{t/RC},\ t < 0.$$

This could be simulated with a gaussian curve represented by the following transfer function:

$$\left[\frac{1}{s + (1/RC)}\right]\left\{\frac{1}{[s + (1/RC)]^n}\right\}$$

where $n \to \infty$.

A gaussian approximation for $n = 2$ is shown in Fig. 2b. The first term of this function can be provided by an RC high-pass filter like the one of Fig. 1a. The circuit of Fig. 3 could provide this term if $K = 1$. However, an improved waveform, Fig. 2c, can

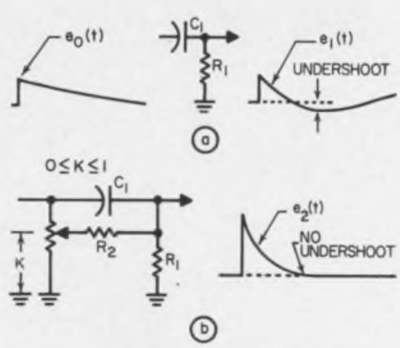

Fig. 1. **Waveforms show results** without pole-zero cancellation (a) and with it (b).

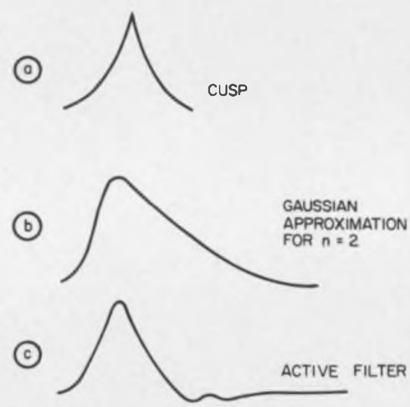

Fig. 2. **Waveforms illustrate active filter concept.**

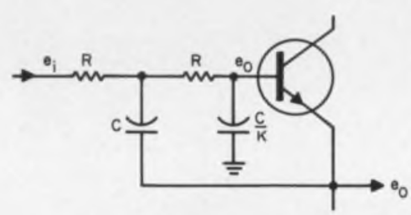

Fig. 3. **Active filter circuit.**

be achieved if a value of $K = 4$ is used. The transfer function for this network is:

$$\frac{e_o}{e_i} = \frac{4/R^2C^2}{[s+(1+j\sqrt{3}/RC)] \times [s+(1-j\sqrt{3}/RC)]}$$

This can be combined with a differentiating (high-pass filter) stage to produce the waveform of Fig. 2c, represented by the following function:

$$\left(\frac{4}{R^2C^2}\right)\left[\frac{s}{s + (1/RC)}\right] \times \left[\frac{1}{s + (1 - j\sqrt{3}/RC)}\right] \times \left[\frac{1}{s + (1 + j\sqrt{3}/RC)}\right].$$

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(physics, ***continued*****)**

voltage repeatedly at a number—typically 512 or 1024—of sampling times. An average value for each of the sampling time slots is built up. Since any noise superimposed on a periodic signal is just as likely to be positive as negative, the stored average values will eventually be almost noise-free.

An ideal averaging system of this type would do an integration over the total time of each sampling interval, and produce the average value for that interval. In Fabri-Tek's design (models FT-1051 and FT-1052 averagers), integration takes place over 97% of the sampling interval to produce an average value. The "growing" waveform that results from the averaging process is shown on a CRT. Digital output is also possible. One circuit board used in the averagers mounts 53 microcircuits.

Fabri-tek is now working with Federal Scientific Corp., New York, to apply the averaging process to a wave analyzer, thus giving a frequency-averaged signal analogous to the time-averaged signal being produced by the present instrument. ■ ■

Helping hands tested

Mechanical hands could ease the task of astronauts clothed in bulky pressure suits or working in hostile space environments. Master-slave manipulators would enable the spacemen to repair spaceborne nuclear reactors, turn on tiny switches or even adjust dials. The experimenter above is performing a series of NASA tests with a pair of such manipulators at the Argonne National Laboratory.

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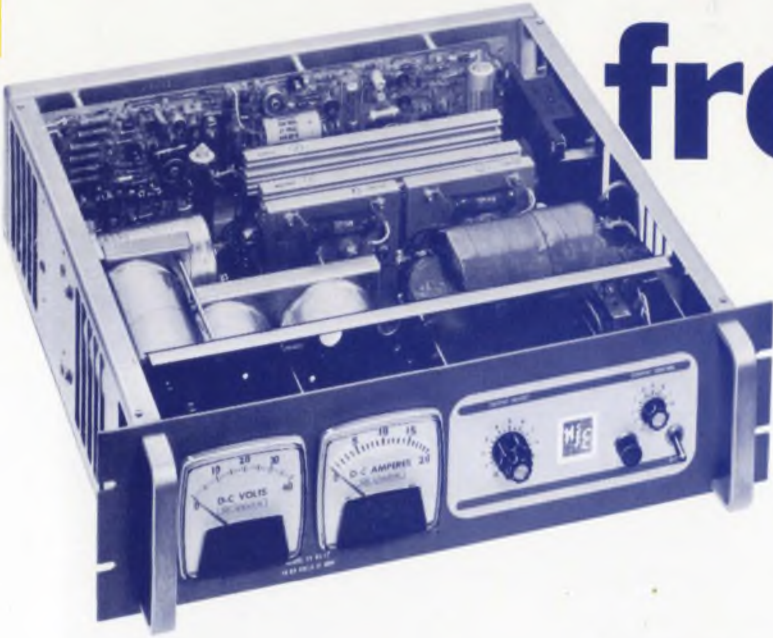

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10-36	0-30	SY-36-30	105-125	55-65	1	±0.01%	±0.01%	7" x 19" x 16⅝"	105	$625
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*Prices above are for unmetered models. For metered models, add suffix "M" to model designation, and $20 to the price shown.

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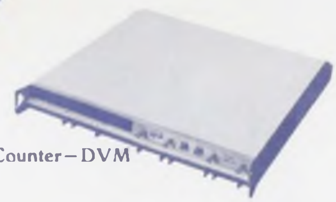
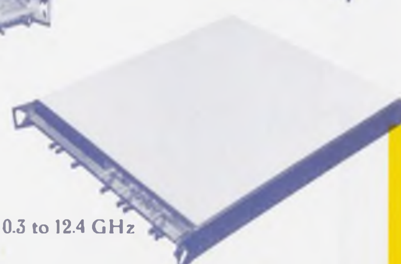


Counter — DVM

5 MHz frequency counter



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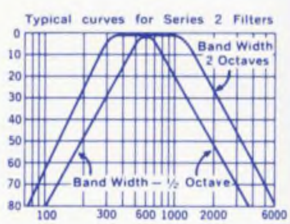

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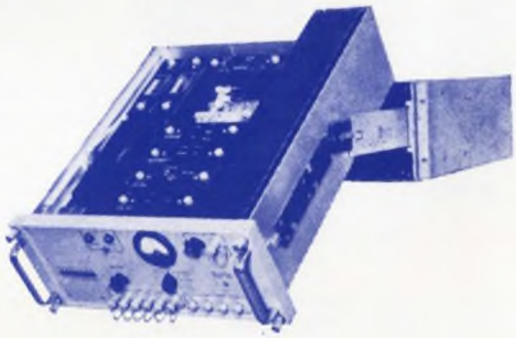

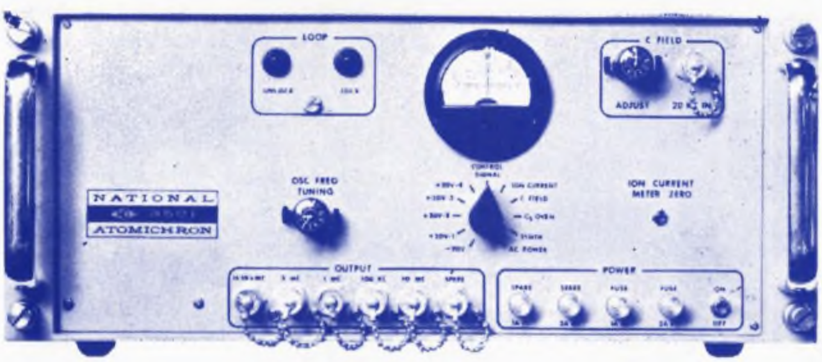

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Cold-cathode operated over 6000 hours

A new type of cold-cathode, called a transverse-field semiconductor emitter, has now been operating successfully for more than 6000 hours.

The principle of the emitter has been known for years but first experimental results were announced only at last year's IEEE Tube Conference in New York City. Efforts to make the devices practical, however, have been hampered by major production difficulties.

The cathode is still considered a laboratory device and its future applications are not yet clear. However, according to Robert Dore and Don Geppert of SRI's Solid-State Research Div., it could eventually be used in conjunction with a photoconductor in a heat-sensing or infrared-imaging device. They also foresee its use in high-power microwave tubes, because the cathode can be pulsed on and off rapidly at low voltages.

The principle of the emitter, somewhat simplified, is that two electrical conductors are separated by a very thin gap—about 0.1 mils—and the gap is bridged by a thin film of semiconductor material. When a voltage is applied across the conductors, electrons will be drawn from one conductor to the opposite conductor, accelerating through the semiconductor and picking up energy in the process. Some of these "hot" electrons have sufficient energy to escape into the vacuum and are then drawn to the anode as in an ordinary vacuum tube.

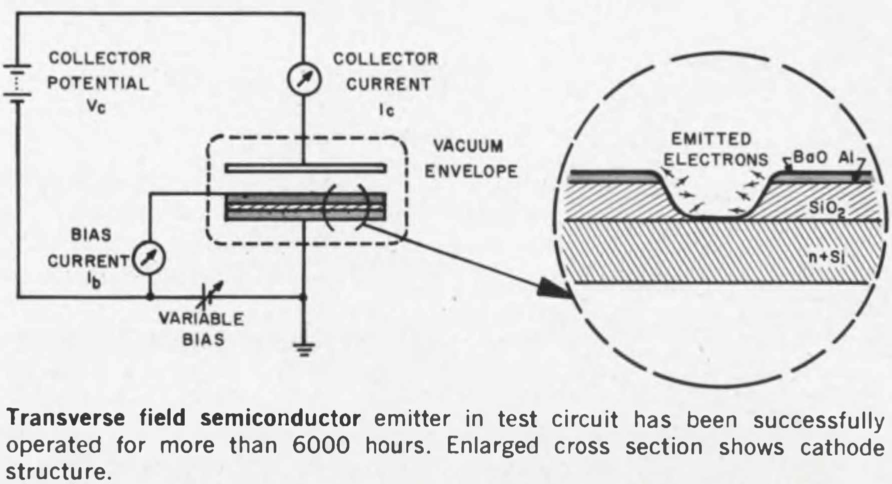
As shown in the illustration, one conductor side of the sandwich is a narrow slice of pure n-type silicon, the surface of which has been oxidized to a controlled thickness of about 1 micron. This layer of silicon dioxide is exposed to aluminum vapor in an evaporator, to form the top conducting layer of the "sandwich." This "sandwich" is broken into segments, exposing the edge of the "sandwich." A layer of semiconductor, barium oxide, is evaporated onto the segment, which is supported on a gold-plated base.

The result is two conducting layers separated by about 1 micron of insulator, but with a semiconducting layer bridging the one-micron gap all around the edge of the segment.

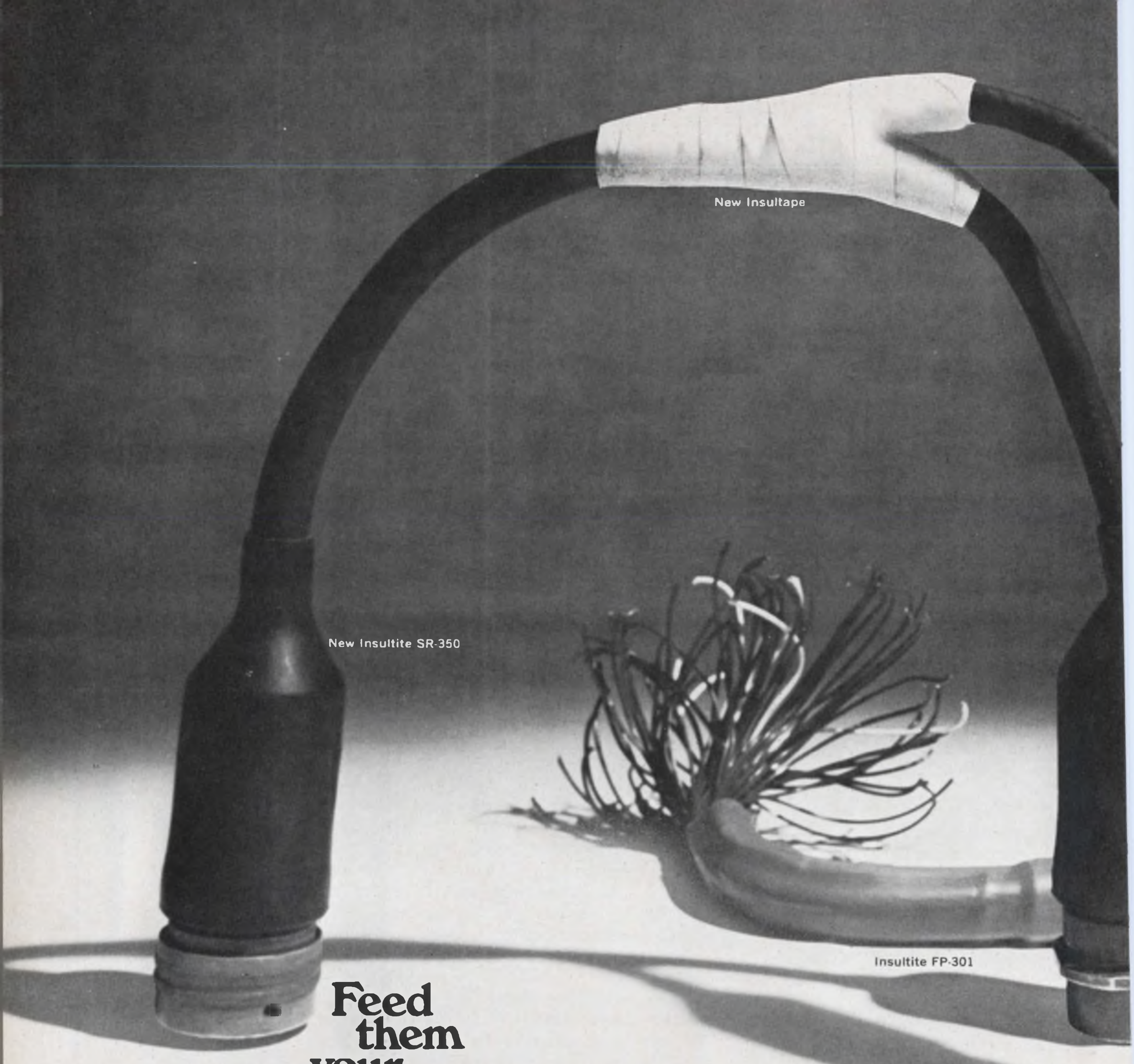
When a 50- to 100-volt dc potential is applied across the two conductors, electrons flow from the edge of the silicon through the barium oxide film.

Dore noted that a major hindrance to making a practical emitter has been the difficulty in defining the narrow gap between the two conductors. With IC technology, this is no longer a problem, he said.

Their laboratory device has an emitter current density of 10 mA/m², but this, according to Dore, could be increased to as much as 100 mA per square centimeter. ■ ■



Transverse field semiconductor emitter in test circuit has been successfully operated for more than 6000 hours. Enlarged cross section shows cathode structure.



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ON READER-SERVICE CARD CIRCLE 36

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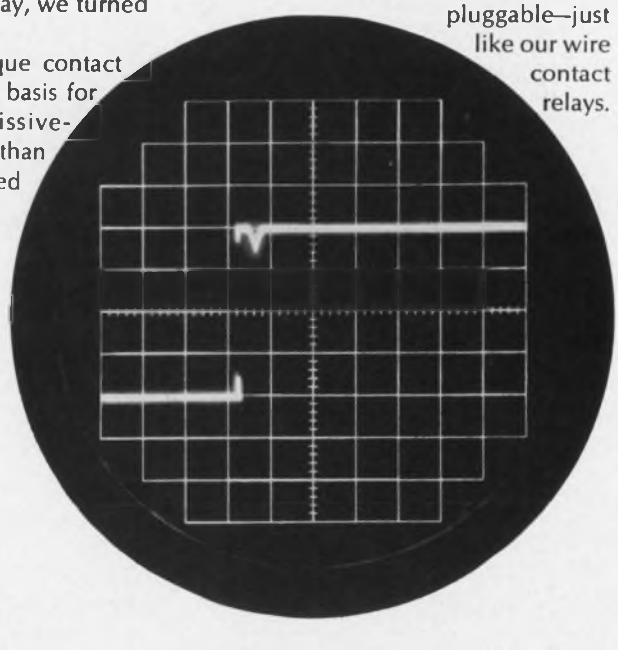


Typical bounce characteristics of the IBM permissive-make relay appear at the right. Time base is 20 microseconds per centimeter-amplitude base is 0.5 volts per centimeter.

Picturephone to use silicon image sensor

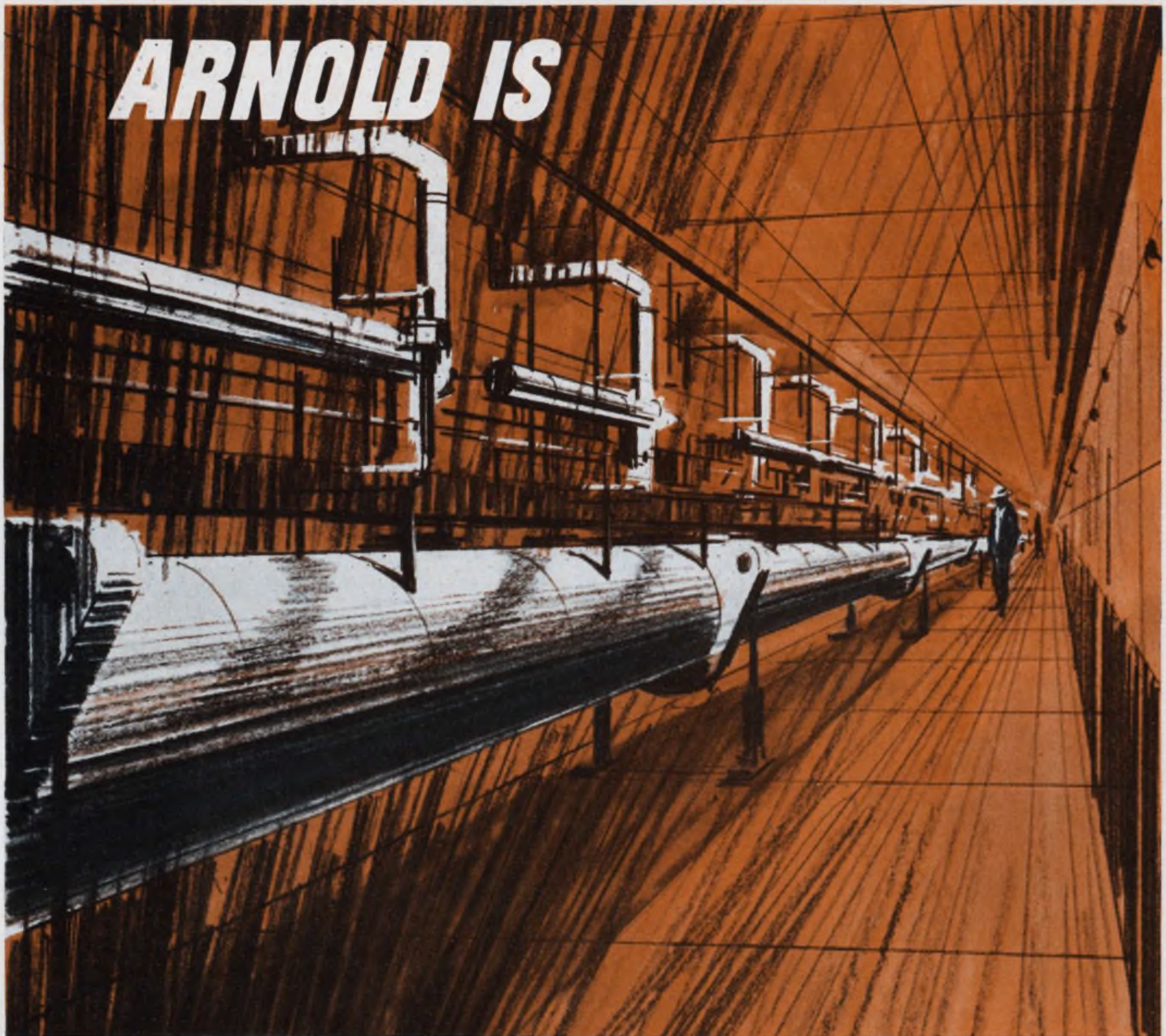
A silicon optical sensor, which is many times more sensitive to light and lasts several times longer than a conventional vidicon, will convert light images into electrical signals in the Picturephone, the Bell System's video telephone. It is to be called the Dactron. The unit is seven inches long and one inch in diameter.

The sensor's working surface is a square of n-type silicon with a side that measures 0.8 in. An image, focused by a lens, falls on its matrix of 540 by 540 boron diffused p-type circles, each eight microns in diameter. The circles, spaced 20 microns apart, are scanned four at a time by an electron gun. Gold squares cover each p-type circle.

Although both the vidicon and the plumbicon use electron beams for scanning, neither uses a semiconductor for the photosensitive surface. They use antimony sulfide and lead oxide, respectively. The sil-

(continued on p. 60)

New television tube—called a Dactron—is held by M. H. Crowell of Bell Telephone Laboratories. It may be used in future models of the utility's Picturephone visual telephone.



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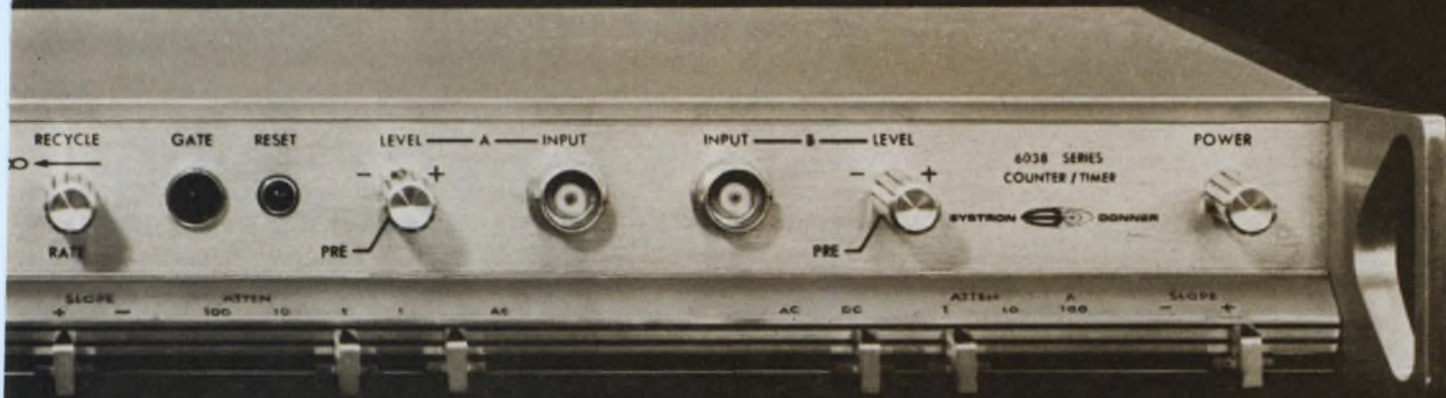

Champion space saver. Nothing could be less demanding of rack space – only 1¾ inches required. When there is "no room left," a Thin Line counter may save the day.

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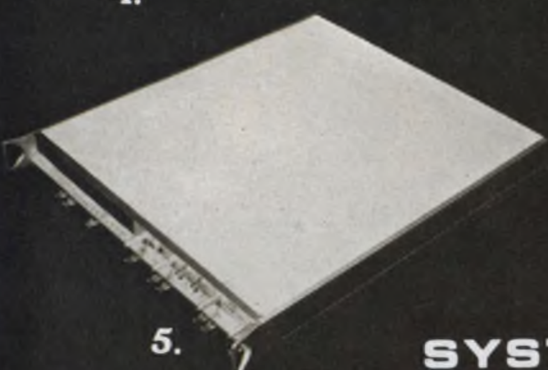

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SYSTRON DONNER

EIMAC has advanced power amplifiers for low power UHF-TV transmitters

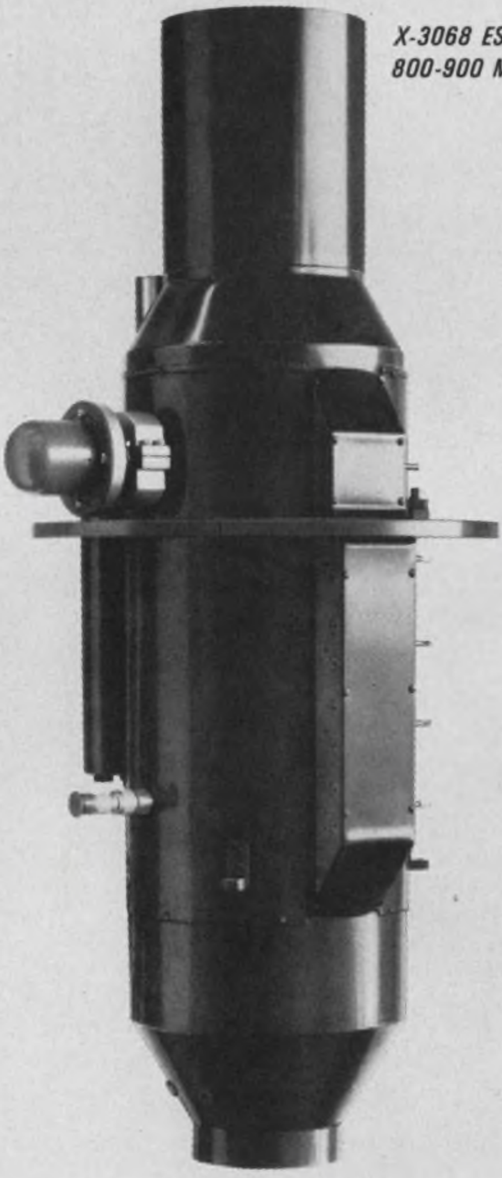
These power amplifier tubes are electrostatically focused klystrons (ESFK). They need no magnets. Our entire ESFK family offers you the best power-to-weight ratio of any power amplifiers. That means when you use one of our new ESFK's in your next design, your UHF-TV transmitter will be smaller—and easier to maintain. And since these tubes are air-cooled, they need less heat dissipation equipment, so your transmitter is less expensive to operate.

One example: the X-3068 amplifier. Note its 35 db gain with 36% beam power efficiency. At UHF frequencies, power outputs between 1 and 3 kilowatts are available.

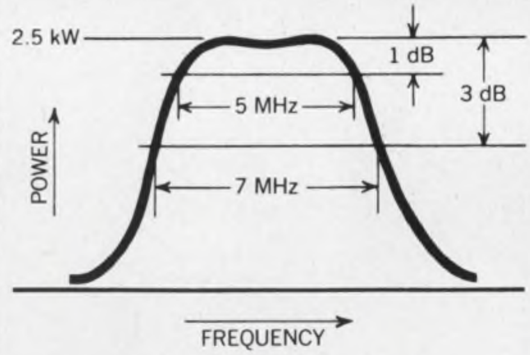
For S-band transmitter designs, check our X-3065. It offers 500 watts output yet weighs only 5 pounds and measures just 6 inches. And provides 30 to 40 db gain with efficiency between 35% and 45%; heat-sink or air-cooled.

We have spent more than ten years in advanced materials research, ceramic-to-metal technology, and beam focusing studies. To make an advanced power amplifier, it takes experience. You can count the number of experienced ESFK manufacturers on one finger.

EIMAC
Division of Varian
San Carlos, California 94070



X-3068 ESFK
800-900 MHz



RF OUTPUT POWER vs. FREQUENCY.
CAVITIES TUNED FOR BANDWIDTH.

DRIVING POWER	2 W
OUTPUT POWER	2.5 kW
GAIN	31 dB
1 dB BANDWIDTH	5 MHz
3 dB BANDWIDTH	7 MHz

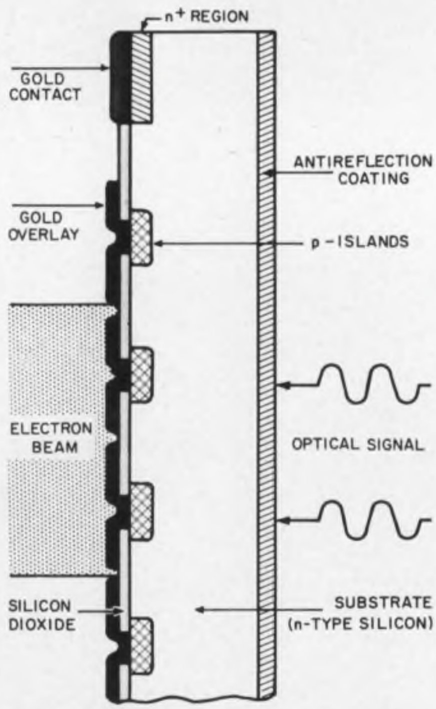
ON READER-SERVICE CARD CIRCLE 42

(**optical sensor,** *cont'd from p. 54*)

icon diode matrix, according to scientists at Bell Telephone Laboratories, is free from raster and image burn-in. Image burn-in occurs when a vidicon is focused on a very bright object such as the sun or a lighted bulb; the camera continues to transmit the image of the bright object for many seconds after the object has actually left its field of view. Raster burn-in is damage to the photosensitive surface caused by the scanning electron beam. The surface, under the intermittent bombardment of fast moving electrons, changes chemical structure and becomes insensitive.

The Dactron represents a viable intermediate image sensor between the bulky electron-beam scanning tubes and the beamless solid-state image sensors.

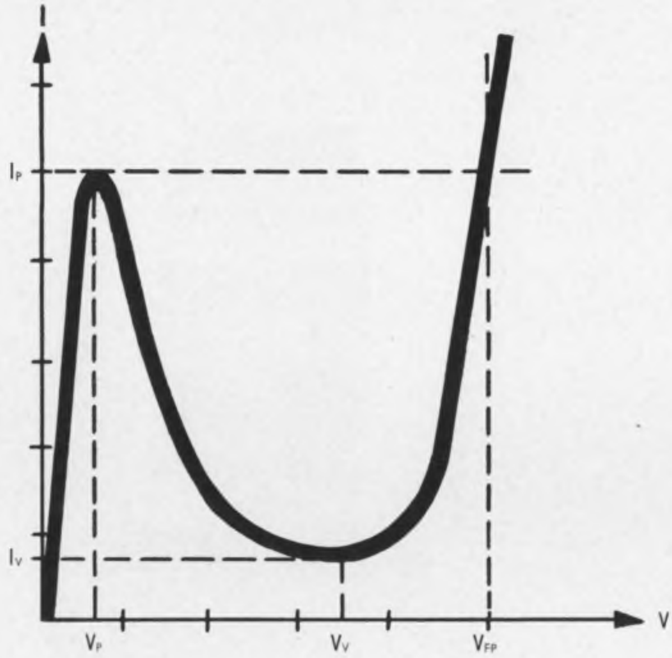
It has long been recognized that miniaturization of the television camera would require elimination of the bulky image orthicon tube and an even smaller sensor than the smaller vidicon. RCA, Westinghouse and Fairchild have been working on solid-state sensors. ■ ■



Main elements of Dactron's structure consists of p-type islands diffused into an n-type silicon substrate. The substrate is isolated from the scanning beam by a silicon dioxide coating. A gold overlay on each p-type island increases effective beam landing area of each diode .

ELECTRONIC INNOVATIONS IN ACTION

Now tunnel diodes cost as little as 50¢



Hadn't you better switch fast?

If tunnel diode performance at transistor prices sounds impossible, take another look at GE tunnel diodes.

Now you can get a typical switching speed of 1.5 nsec. or better in current ratings from 0.5 mA to 10 mA. Power dissipation is as low as 40 microwatts per unit.

All that performance can cost as little as 50¢.

And your circuits will benefit from greater packaging density, lower power consumption, and fewer components to perform a given function.

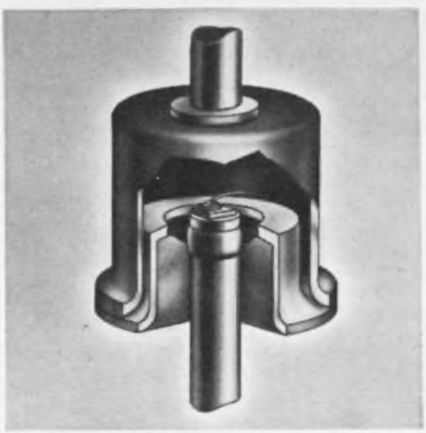
New General Electric tunnel diodes are available either in axial lead packages, or in pellet form for hybrid integrated circuits.

At the new low prices you can now use GE diodes in many new applications. Why not try them for current or time delay thresholding, high-speed logic circuits, high-frequency oscillators or amplifiers, UHF mixers, or sense amplifiers?

This is just one more example of the low-cost semiconductor leadership and total electronic capability GE offers you.

For further details call your nearest GE engineer/salesman, or semiconductor distributor. Or write to Section 220-50, General Electric Company, Schenectady, N.Y. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y.

Actual size low-cost GE tunnel diode



Planar and thin film fabrication techniques, used to form the germanium tunnel junction, make lower prices possible.

SEMICONDUCTOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC

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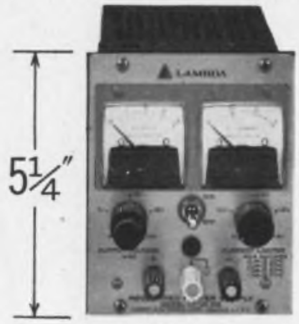
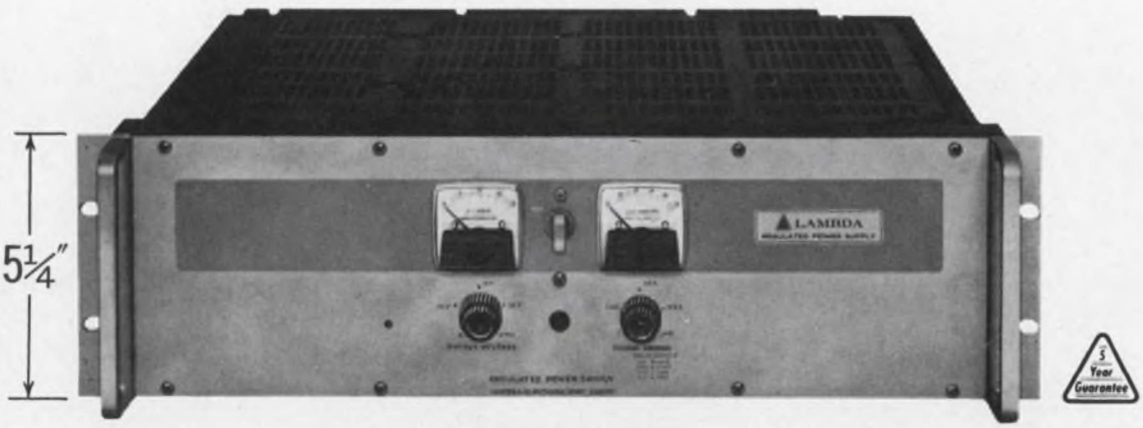
ON READER-SERVICE CARD CIRCLE 45

Now Lambda offers the power supplies for test



1/4 RACK—LH SERIES

HALF RACK—LK SERIES / LH SERIES



FULL RACK—LK SERIES

NEW AT IEEE SHOW—BOOTH 2A46

Be sure to see convection-cooled, 7" height LK Series • Up to 60 VDC • Up to 70 amps.

LA 177

broadest line of all-silicon equipment and laboratory use.

For Rack or Bench Use—From 1/2 amp to 35 amps, 0-10, 0-20, 0-40, 0-60, 0-120 VDC—with full five year guarantee on materials and labor

Features and Data

- **Convection Cooled**
- **Remotely Programable**
- **Remote Sensing**
- **Regulation**—.015% or 1 MV (Line or Load)
- **Temp. Coef.** .015%/°C
- **Transformer**—designed to MIL-T-27 Grade 6
- **Completely Protected**— Short Circuit Proof— Continuously Adjustable Automatic Current Limiting
- **Constant I./Constant V.** by automatic crossover
- **Series/Parallel Operation**
- **No Voltage Spikes or Overshoot** on "turn on", "turn off" or power failure
- **Meet Mil. Environment Specs.**
Vibration; MIL-T-4807A
Shock: MIL-E-4970A
• 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
- **Ripple**—
LK models—500 µV RMS
LH models—250 µV RMS, 1 MV P-P
- **Wide Input Voltage and Frequency Range**—
L K models—105-132 VAC, 47-63 cps
LH models—105-135 VAC, 45-480 cps.
- **LH models meet RFI Spec.**—Mil-I-16910
- **Rack Adapters**
LRA-1—5¼" Height x 16½" Depth (For use with chassis slides) Price $60.00
LRA-2—5¼" Height Price $25.00

3 full-rack LK models—Size 5¼" x 19" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 350	0-20VDC	0-35A	0-31A	0-26A	0-20A	$675
LK 351	0-36VDC	0-25A	0-23A	0-20A	0-15A	640
LK 352	0-60VDC	0-15A	0-14A	0-12.5A	0-10A	650

6 half-rack LK models—Size 5³⁄₁₆" x 8⅜" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 340	0-20VDC	0-8.0A	0-7.0A	0-6.1A	0-4.9A	$330
LK 341	0-20VDC	0-13.5A	0-11.0A	0-10.0A	0-7.7A	385
LK 342	0-36VDC	0-5.2A	0-5.0A	0-4.5A	0-3.7A	335
LK 343	0-36VDC	0-9.0A	0-8.5A	0-7.6A	0-6.1A	395
LK 344	0-60VDC	0-4.0A	0-3.5A	0-3.0A	0-2.5A	340
LK 345	0-60VDC	0-6.0A	0-5.2A	0-4.5A	0-4.0A	395

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $30.00 to price.
[3] Overvoltage Protection: Add suffix (OV) to model number and add $70.00 to the price for half-rack models; $90.00 for full-rack models.
[4] Chassis Slides: Add suffix (CS) to model number and add $60.00 to the price.

5 quarter-rack LH models—Size 5³⁄₁₆" x 4³⁄₁₆" x 15½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 118	0-10VDC	0-4.0A	0-3.5A	0-2.9A	0-2.3A	$175
LH 121	0-20VDC	0-2.4A	0-2.2A	0-1.8A	0-1.5A	159
LH 124	0-40VDC	0-1.3A	0-1.1A	0-0.9A	0-0.7A	154
LH 127	0-60VDC	0-0.9A	0-0.7A	0-0.6A	0-0.5A	184
LH 130	0-120VDC	0-0.50A	0-0.40A	0-0.35A	0-0.25A	225

5 half-rack LH models—Size 5³⁄₁₆" x 8⅜" x 15⅝"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 119	0-10VDC	0-9.0A	0-8.0A	0-6.9A	0-5.8A	$289
LH 122	0-20VDC	0-5.7A	0-4.7A	0-4.0A	0-3.3A	260
LH 125	0-40VDC	0-3.0A	0-2.7A	0-2.3A	0-1.9A	269
LH 128	0-60VDC	0-2.4A	0-2.1A	0-1.8A	0-1.5A	315
LH 131	0-120VDC	0-1.2A	0-0.9A	0-0.8A	0-0.6A	320

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $25.00 to price. For non-metered chassis mounting models, add suffix (S) to model number and subtract $5.00 from non-metered price.
[3] Overvoltage Protection; Add suffix (OV) to model number and add $60.00 to the price.

SEND FOR NEW LAMBDA CATALOG

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD • MELVILLE, L. I., NEW YORK • 516 MYRTLE 4-4200
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ON READER-SERVICE CARD CIRCLE 46

Probe analyzes Semiconductors

A method for analyzing the performance of high-power semiconductor devices by measuring the potential along the surface has been devised and successfully tested at Bell Telephone Laboratories, Murray Hill, N. J.

The measuring technique is based on the following phenomenon:

When pulses of current are sent through a semiconductor, an electric field results. Device nonuniformities—the quality of contacts, doping gradients, etc.—contribute to unusual device performance and show up as variations in field strength. These variations are sensed by a resistive potential probe as voltage pulses and are amplified and displayed on an oscilloscope. They can also be recorded and analyzed.

The probe is a tungsten wire with a 2-micron-diameter point (which, incidentally, limits the use of this method to devices longer than 6 microns). In operation, the probe is mounted on a micromanipulator and observed through a microscope (see photo). The setup can define the measurement point to within ± 1.5 microns.

The probe is reported superior to such others as the Gunn capacitive probe in that it measures the potential directly.

The new method, Bell Labs says, can be used to analyze experimental semiconductor devices, being studied as sources of microwave and millimeter-wave power for communications sytems. These devices include bulk gallium-arsenide diodes and avalanche diodes. The technique, however, is applicable to any type of semiconductor device.

The method can also be used to verify hypotheses relating to electron velocity as a function of field strength. And it can be used to measure the doping profile in bulk and epitaxial gallium arsenide.

As for future use, inspection tools could conceivably be built with the use of the new principle, and semiconductor manufacturers could use the tools in quality control. ■ ■

Does AE make the world's prettiest dry-reed switches?

Some of our customers think so. They go for the chic look of our PC Correeds on a printed circuit board.

Our designers are flattered. But they point out that the beauty of a PC Correed is more than skin-deep.

Take the contact leads. We keep them separate from the terminals—to eliminate strain. The terminals themselves have "I-beam" strength. They are longitudinally ribbed for extra rigidity—for easy insertion in PC boards.

The contact terminals are *welded*, not soldered. This makes a better electrical connection.

We filled the plastic bobbins with glass, to prevent moisture absorption. And to boost structural strength. You can pack these smart-looking switches as densely as you like. Because of their low profiles, magnetic shielding, and standard PC terminal spacing (multiples of 0.200").

PC Correeds are available with 1, 2, 3 and 5 reedcapsules, in contact forms A, B, C and magnetic latching. You can get many of these modules right from stock. So it's easy to put a little beauty in your life.

Want some helpful new design information? Ask your nearest AE representative for Circular 1070-B. Or drop a line to the Director, Electronic Control Equipment Sales, Automatic Electric Company, Northlake, Illinois 60164.

AUTOMATIC ELECTRIC

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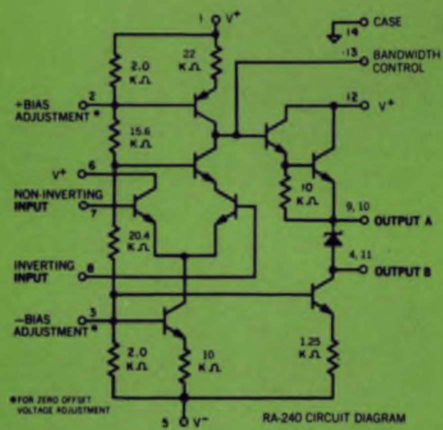
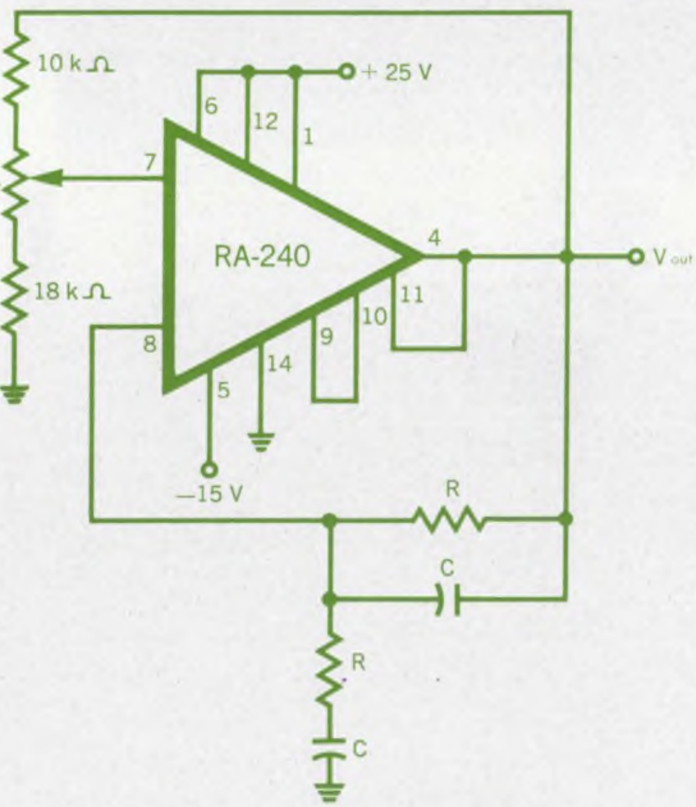
ON READER-SERVICE CARD CIRCLE 50

State of the design art

Radiation IC Amplifier simplifies design of highly stable Wien bridge oscillator





The flexibility of Radiation IC Operational Amplifiers is illustrated by the circuit at left. Here, the RA-240 is used in the design of a highly stable, uncompensated Wien bridge oscillator which is virtually unaffected by temperature variations.

Using the RA-240, engineers may select a wide range of RC combinations without regard to the active element of the circuit. Frequency of oscillation (up to 500 kHz) is defined by: $f_o = \frac{1}{2\pi RC}$

In this application, the amplifier offers the following typical performance characteristics:

@ $f_o = 10$ kHz; Undistorted $E_{out} =$ 9.6 V_{P-P} with $R_L = 2$ kΩ

@ $f_o = 150$ kHz; Undistorted $E_{out} =$ 1.7 V_{P-P} with $R_L = 2$ kΩ

The stability and versatility of Radiation Operational Amplifiers is made possible through advanced dielectric isolation and thin film over oxide technology.

VISIT US AT THE IEEE SHOW . . . BOOTH 4G32, 4G34.

A new line of universal building blocks for integrated analog circuitry is now available to design engineers. Radiation Incorporated supplies three different types of IC operational amplifiers to serve your individual requirements: general-purpose, broadband, and high-gain amplifiers.

These amplifiers provide outstanding performance. Parasitics are eliminated, thanks to our unique dielectric isolation technique. Tighter tolerances and improved temperature coefficients are achieved through use of precision thin film resistors over the oxide.

Thus, Radiation's technology simplifies system designs which were hampered by limitations imposed by conventional integrated circuit fabrication techniques.

Only Radiation can provide production quantities of inherently stable IC operational amplifiers. These circuits are stocked for immediate shipment in TO-84 flat packages.

Write or phone for our data sheets which include *worst-case limits* as well as all information required by design engineers. We'll also be glad to send you a copy of our new manual entitled: Operational Amplifier Technical Information and Applications. For your copy, request publication number ROA-T01/A01 from our Melbourne, Florida office.

Radiation IC Operational Amplifiers*

Typical characteristics ($T_A = +25°C$)	GENERAL PURPOSE RA-238	BROADBAND RA-239	HIGH GAIN RA-240	UNIT
Phase margin	60	60	45	Degrees
Bandwidth (unity gain)	7	15	6	MHz
Slew rate	3.2	23	3.2	V/μs
Voltage gain	2,700	2,700	33,000	
Offset voltage	2.0	2.0	2.0	mV
Offset current	80	400	80	nA
Thermal drift	±5 ±1	±5 ±5	±5 ±1	μV/°C nA/°C
Undistorted output swing	21	21	9 (11.6)†	V_{P-P}
Power dissipation	90	160	90	mW
Common mode rejection	100	100	100	dB
Power supply rejection	100	100	100	dB
Input bias current	0.4	1.0	0.4	μA

*Standard temperature range: −55°C to +125°C. $V^+ = +25V$; $V^- = -15V$.
†$V^+ = +20V$; $V^- = -20V$.

All Radiation integrated circuits are dielectrically isolated.

RADIATION INCORPORATED

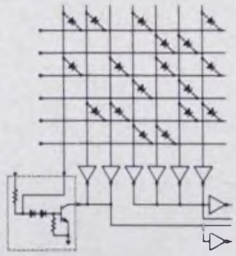
MICROELECTRONICS DIVISION

Sales offices: Suite 622, 650 North Sepulveda Blvd., El Segundo, Calif. (213) 772-6371—Suite 232, 600 Old Country Road, Garden City, N. Y. (516) 747-3730—Suite 201, 1725 Eye Street, N. W., Washington, D. C. (202) 337-4914—P.O. Box 37, Dept. ED-03, Melbourne, Florida (305) 723-1511, ext. 554

On Reader-Service Card Circle 245

State of the monolithic art

Radiation Diode Matrices are ideally suited for design of high speed, low cost full adders. These circuits, using Radiation Matrices, offer three major benefits:



Cost is reduced since low-volume special function circuits are eliminated. *High speed* is achieved through reduced levels of active gating. *Flexibility* in matrix sizes, in conjunction with Radiation's unique fuse link technique for "customizing" patterns, permits design freedom in the organization of an adder.

The binary full adder, schematic above, requires only one Radiation RM-30 6 x 8 Monolithic Diode Matrix in addition to Radiation RD-220 Hex Inverters and RD-234 Interface Circuits. This adder provides both complementary SUM and CARRY output.

For detailed information, refer to our ELECTRONICS advertisement of March 6.

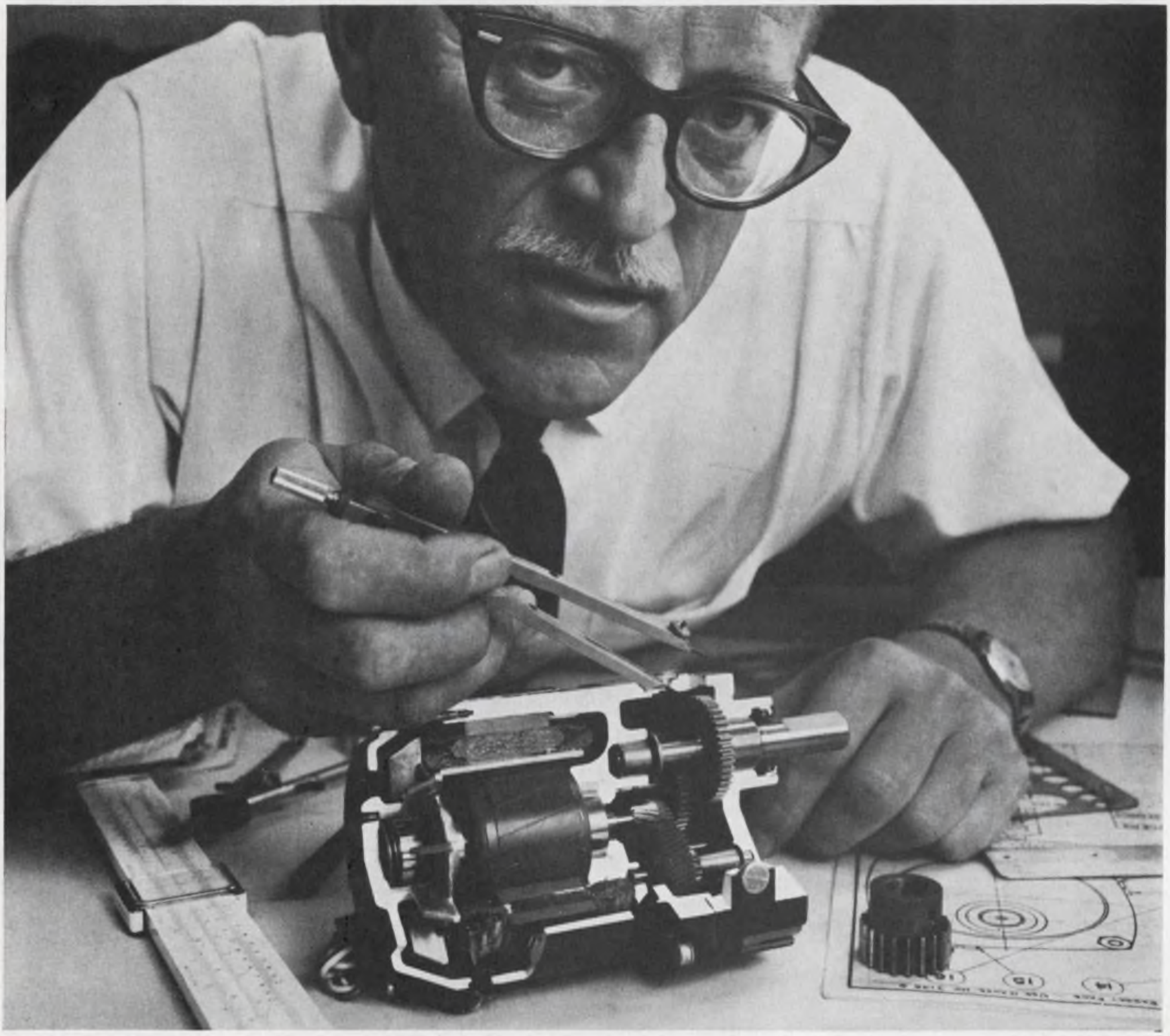
Our entire line of matrices contain all active devices within a single chip. A fusible link in series with each diode permits unlimited matrix patterns to be formed. Matrices can be combined to produce an infinite variety of size configurations.

We'll be glad to send data sheets which include *worst-case* limits. Our design manual, Monolithic Diode Matrix Technical Information and Applications, RDM-T01/A01, is also available. Write or call our Melbourne, Fla. office for your copy.

On Reader-Service Card Circle 246

Balanced design makes Bodine N-1RD gearmotors last and last

...giving you After Delivery Economies (ADE)



Each and every part used in Bodine's N-1RD speed reducer motor has been designed—and extensively tested—to assure approximately the same long life. This carefully balanced motor design results in lasting, rugged operation . . . consistent, reliable power.

Great overhung load capacity (needle bearings on output shaft). Remarkably high torque (25 in. lbs.) for its small size (5″ long, 3⅜″ square). Quality? . . . Check these *standard* features. Case hardened steel gearing with phenolic primary gear for quietness. Die cast construction. Ball bearings on rotor shaft. And modifications easily made at minimum extra cost.

Like all Bodine motors (over 3,500 standard specifications), the N-1RD gearmotor helps you cut end costs through After Delivery Economies (ADE):

1. Very, very few rejects in your receiving, production or final test stages.
2. Consistent performance in the field.
3. "Three-piece" design for easy servicing.
4. Reliability—few call-backs, low field service costs.
5. Enhancement of your product's quality, helping you earn customer satisfaction, repeat sales.

Write for Bulletin 1025—Bodine Electric Company, 2528 West Bradley Place, Chicago, Illinois 60618.

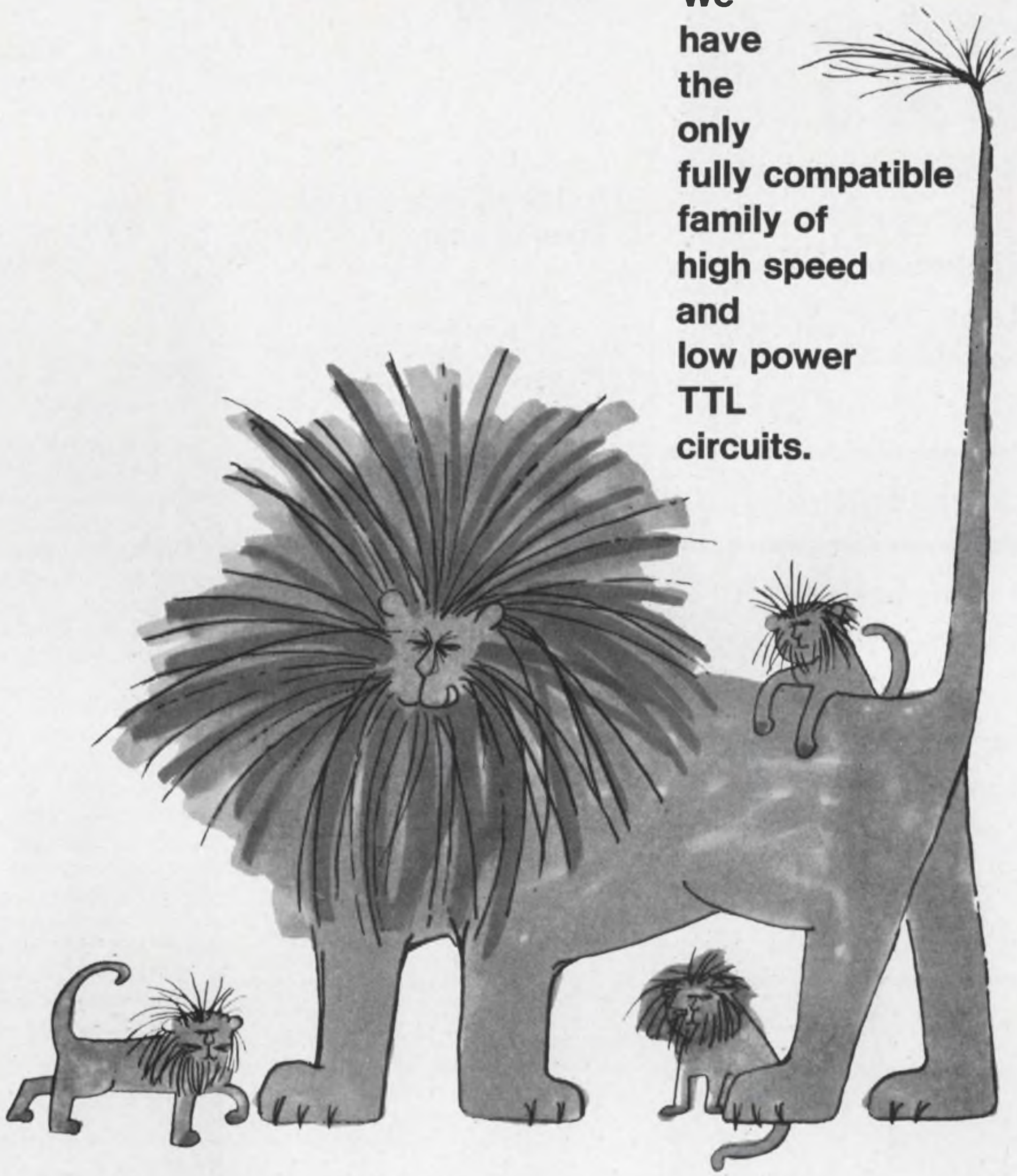
Bodine motors wear out—it just takes longer

BODINE fractional /horsepower MOTORS

the power behind the leading products

ON READER-SERVICE CARD CIRCLE 52

We have the only fully compatible family of high speed and low power TTL circuits.



You can go wild with Signetics new Designer's Choice 8000 Series: it gives you the widest selection of design trade-offs in speed, power, noise immunity and price ever offered in a TTL family. The family consists of a very high speed set (the 8800's) and a fully compatible but slower low power set which offers very high AC noise immunity. Now TTL system designs can be optimized without laborious calculations, unusually expensive and time-consuming special ground-plane designs, or extensive use of outboard discrete components in areas where the highest possible speed is not required. All you do is follow the published S8000-series usage rules. All circuits are compatible over the full MIL temperature range of −55°C to +125°C and are available off-the-shelf in Signetics 14-lead glass-Kovar flat pack. Hunt up your local Signetics distributor. For further information on the Designer's Choice 8000 Series, write Signetics, at 811 E. Arques Avenue, Sunnyvale, California 94086. ■ At the IEEE Show, be sure to check into Rooms 3000A & B at the New York Coliseum, for latest Signetics news.

TYPE	DESCRIPTION		
S8416	Dual 4-Input Nand Gate	S8816	Dual 4-Input Nand Gate
S8417	Dual 3-Input Nand Gate	S8825	DC Clocked J-K Binary Element
S8424	Dual AC Binary Element	S8826	Dual J-K Binary Element
S8440	Dual Exclusive-Or Gate	S8840	Dual 4-Input Exclusive-Or Gate
S8455	Dual 4-Input Buffer/Drive	S8855	Dual 4-Input Power Gate
S8480	Quadruple 4-Input Expander	S8870	Triple 3-Input Nand Gate
S8806	Dual 4-Input Expander	S8880	Quadruple 2-Input Nand Gate
S8808	8-Input Nand Gate		

SIGNETICS INTEGRATED CIRCUITS

A SUBSIDIARY OF CORNING GLASS WORKS

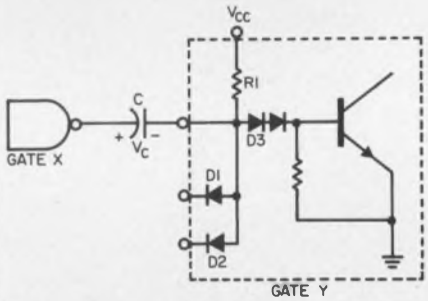
ON READER-SERVICE CARD CIRCLE 53

Letters

DTL NAND gate circuit is open to improvement

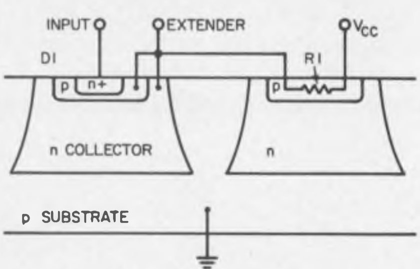
Sir:

G. M. Ammon's use of integrated-circuit gates in monostable and astable multivibrator configurations ("DTL logic NAND gates bring versatility," ED 22, Sept. 27, 1966, pp. 74-79) brought to mind our own experience with a similar application. The basic timing circuit used by Ammon is shown in Fig. 1.



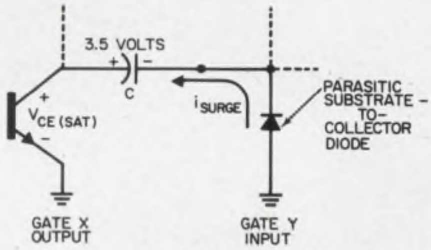
1. Basic timing circuit with IC.

When gate *X* in Fig. 1 goes low, approximately −3.5 volts is applied to the extender pin of gate *Y*. Ammon points out that the WM 226 DTL element has a reverse voltage rating at the extender pin of −7 volts. This is the key to the proper operation of his circuits. It should be noted that most, if not all, other manufacturers do not specify electrical ratings or characteristics for the extender pin. Therefore, a potentially dangerous situation occurs if this configuration is used with a DTL element other than the WM 226. An examination of the typical junction structure at the extender is given in Fig. 2.



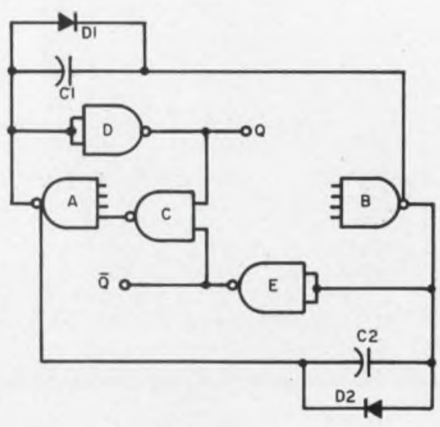
2. Junction structure at extender.

D1 is usually the base-emitter of a transistor with collector shorted to base; the n-doped collector region forms a normally back-biased diode with the p substrate. In this application, however, the parasitic diode is forward-biased without the benefit of a known value of current-limiting resistance, as shown in Fig. 3.



3. Forward bias of parasitic diode.

No problem exists if *D1* and *D2* do not have an n collector region common to the extender pin. However, the resulting so-called floating-collector diodes suffer from a higher forward voltage and a longer storage time delay than the diode in Fig. 2. *R1* (Fig. 2) is normally p type; *D3* (Fig. 1) can be a floating-collector diode since the properties of high forward voltage and long storage time are desirable in this diode. Since the extender pin connects only to p regions in this case, there is no danger of forward-biasing a normally reverse-biased junction by application of negative voltage to these p regions. Display of the extender-pin-to-ground-pin voltage-current characteristic on a curve tracer is a simple method of ascertaining the device's reverse voltage capability between these two points.

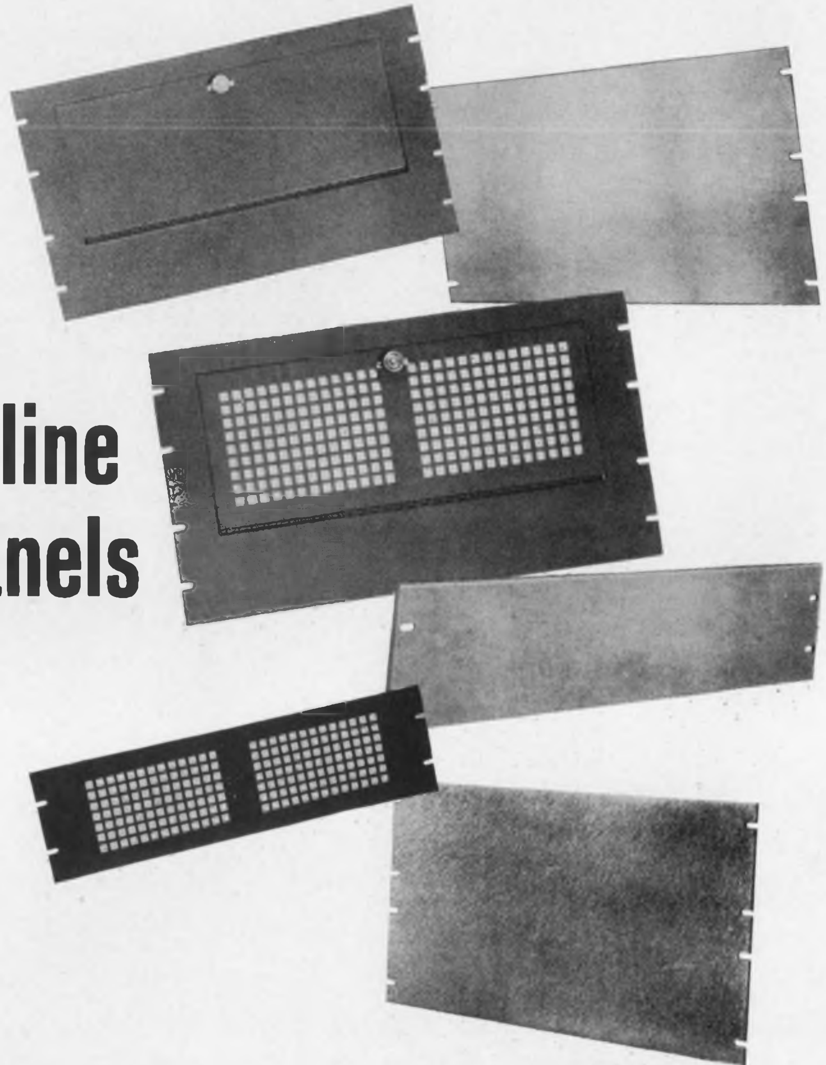


GATES A AND B MUST NOT BE "TOTEM—POLE" LINE DRIVER TYPE

4. Lock-up protection with 3 gates.

In order to extend this circuit's application for use with other manufacturers' DTL elements, the circuit of Fig. 4 is proposed. Gates

(continued on p. 78)



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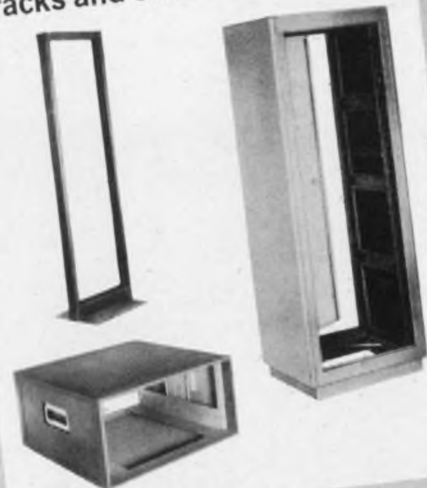

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Now you can get a low cost, small size integrating digital voltmeter with multimeter capabilities. With the new X-2 you can have AC, ohms, preamp and ratio functions in one compact package just by plugging in the appropriate circuit boards. And the X-2 has the exclusive NLS *anti-bobble* circuit. Unlike other low cost DVMs, the right hand (least significant) digit in the X-2 behaves as it would in a scan logic instrument . . . stays put, doesn't jump around.

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- Price—$980 (basic DC instrument)

The X-2 also offers display storage and the space saving *half rack* size. It all adds up to a new capability at a price that will make the grimmest budget-watcher happy.

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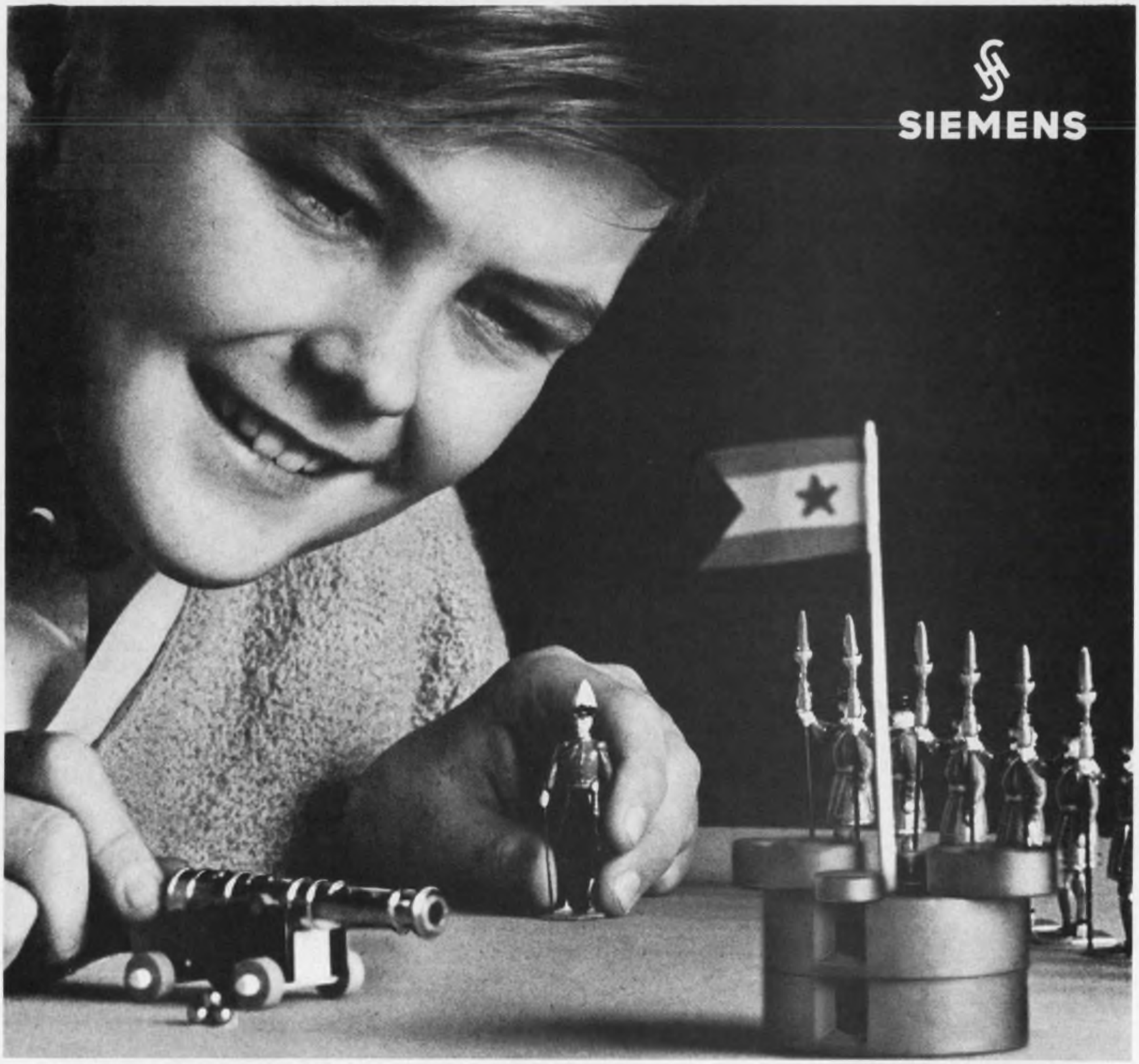
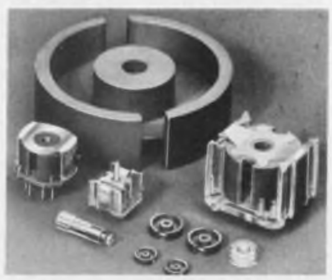
ON READER-SERVICE CARD CIRCLE 57



uniformity

Month after month, the electrical characteristics of Siemens pot cores are consistent. Precision engineered for adjustable high stability, high-Q coils, they meet the most critical requirements for filters used in multiplex and other carrier-frequency applications. Low distortion and self-shielding are two important plus features. Available out of stock, too. Let a Siemens engineer show you how Siemens pot cores fit into your application. It's child's play.



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8 different materials, 18 different sizes (.22 to 2.75 inches diameter) and more than 250 standard types afford optimum properties for all filter, oscillator and transformer applications. High Q value with high stability is typical: a 26 x 16 core of N22 or N28 material AL 315 at 100 kc/s shows a Q value of approx. 950. Siemens components include ferrite materials, metallized polyester and polystyrene capacitors, all electronic and microwave tubes, rectifiers and a complete line of semi-conductors.

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- Reliability—All solid-state construction (no mechanical choppers)
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Originator of the Digital Voltmeter

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ON READER-SERVICE CARD CIRCLE 59

(continued from p. 72)

C, *D* and *E* provide lock-up protection by driving gate *A* high if both gates *A* and *B* go low. The diodes clamp the timing capacitors, thereby preventing the development of a voltage destined to cause substrate current flow. Since the voltage swing at the extender pin is limited, some pulse width temperature stability is sacrificed; moreover, larger timing capacitors are required to achieve comparable pulse widths. Of course, if WM 226 gates are used, the diodes can be omitted.

Returning again to Ammon's article, the waveform labeled "PIN C TO GND" in his Fig. 2b [p. 75] should show that pin *C* starts in the *1* state. Even after the input trigger pulse has come and gone, pin *C* remains high, until capacitor C_T charges up to the gate threshold voltage. At this point, pin *C* goes low, causing the circuit output to return to its *1* state. When this output rise is coupled back through the circuit, pin *C* returns to the *1* state.

N. Panos and M. P. Trego
Electronic Engineers
General Dynamics/Convair Div.
San Diego, Calif.

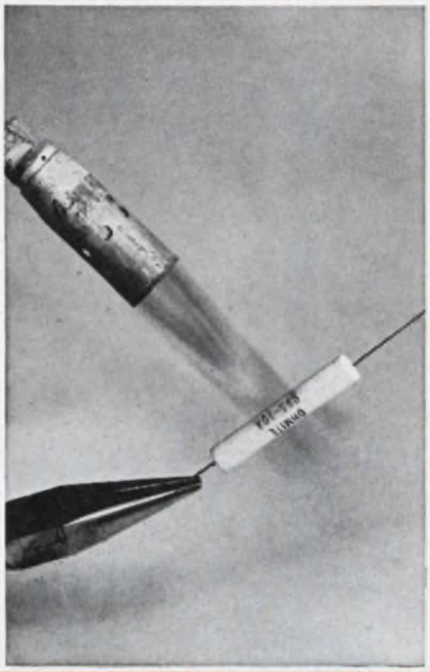
Accuracy is our policy

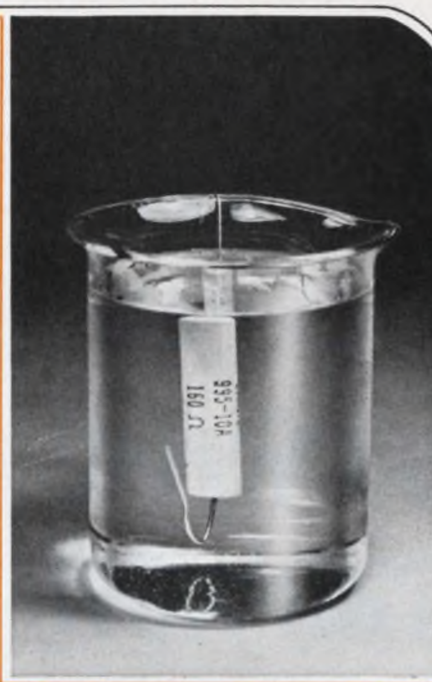
In "Don't ignore thermal paths," ED 29, Dec. 20, 1966, pp. 76-80, the definition of θ'_{ca} in Eq. 1 was omitted from the "Equivalent thermal circuits" box on p. 76. θ'_{ca} is the series parallel equivalent to the combination of θ_{cj}, θ_{ca}, and θ_{ja}.

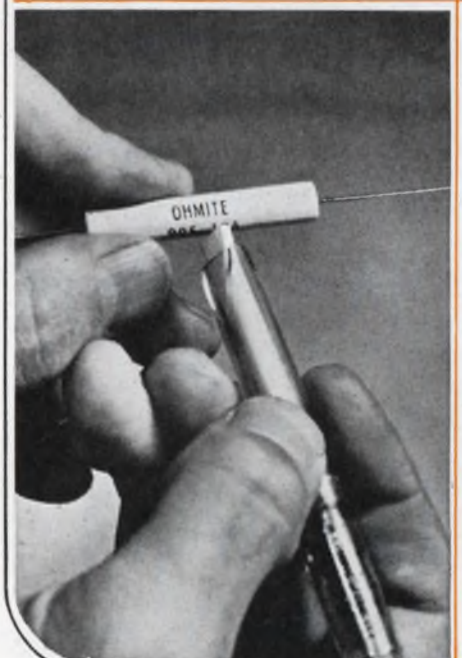
In "Will the machines eventually outwit man?" ED 1, Jan. 4, 1967, pp. 82-86, the author's affiliation was given as Project MAC, Massachusetts Institute of Technology. Mr. Jarnagin has been a consultant to Project MAC, but the views expressed in the article were his own and not those of the MIT project.

In "Submin EMI filters have low insertion loss," in the Components listing of the Products section of ED 2, Jan. 18, 1967, p. 98, the manufacturer, Sprague Electric Co., points out two errors. The filters have high (not low) insertion loss in order to reduce EMI, and operate up to 1000 MHz (not 100 MHz).

any other resistor would holler UNCLE...







but not the "99"

molded* in vitreous enamel

*Patent No. 3,229,237

The Series 99 is the resistor that won't soften or deform at a cherry-red 1500°F . . . that clings to its markings like a leopard to its spots against the onslaught of solvents, abrasion, and extreme overloads. This is the resistor that laughs at abuse because of its tough, exclusive "molded" coating of vitreous enamel. This is the resistor of such uniform shape and size that metal clips can hold it securely and also provide a big increase in heat dissipation.

No wonder design engineers throughout industry are hollerin' for the resistor of incomparable performance—the Series 99, molded in vitreous enamel.

Series 99 is supplied in commercial, MIL-R-26, and close tolerance types. *Commercial units are stocked in 5 sizes and 146 resistance values.*

WATTAGES (COMMERCIAL): 1.5, 2.25, 3.25, 5, 6.5, 9, 11 watts at 25°C.

RESISTANCE RANGE: 0.1 to 187K ohms.

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ON READER-SERVICE CARD CIRCLE 61

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IEEE USA

For engineers all over the country, here's a preview of the world's biggest electronics show.

Exploring the significant

It is 10 a.m. at Broadway and 60th Street in New York, March 20, 1967, and the doors of the city's Coliseum are opening for the annual IEEE show. Engineers who enter will find the four-story palace of electronics glittering with new features as well as many that are familiar.

New, advanced products fill the booths at the multimillion-dollar exhibition. Here are just a few highlights: gains in linear and digital integrated circuitry; plastic-encapsulated semi-conductors, cheaper and more reliable than ever; a man-made diamond temperature sensor with a fantastically wide environmental range.

For the first time, there is a movie theater, at which scientific, technical and educational films are being shown during the four days of the show.

On the first floor, exhibitors of production equipment and hardware are displaying their products. The second floor contains instruments and systems. The third and fourth floors feature components.

At the technical sessions, engineers may find some panel discussions in their specialties disappointing; few radical surprises are in store for the expert. But for the neophyte, or for those who seek to expand their interests to other fields of engineering, a broad choice of sessions and papers is available.

Come along on ELECTRONIC DESIGN's guided tour of the significant at the show.

at the IEEE booths and sessions

The world's oceans and the electronic engineer's efforts to tame them are featured in this year's IEEE Highlight Symposium.

The consumer industry wants YOU

But educators, businessmen and engineering societies must first unite on a plan of action to attract recruits

Maria Dekany, Technical Editor

Many an engineer is at the threshold of a new career in consumer industry, but will he cross it?

"Engineering is becoming alienated from the productive civilian economy, which makes possible our good life and our expenditures on defense and space."

This observation of Dr. John R. Pierce, an executive director of research at Bell Telephone Laboratories, has very valid foundation, according to prominent persons in industry and engineering education. They indicate, moreover, that the efforts of engineering societies—the IEEE show, for example—are failing to orient engineers sufficiently for careers in industrial and consumer electronics.

Space and military electronics attract most of the brightest engineers in the country, both the experienced and those fresh out of school, recruiters for the civilian electronics industry complain every year. "Glamour" and possibly better financial compensation have been cited as reasons for this trend.

However, some people, including Government officials are looking deeper into the problem and finding new answers: alienation starts, they say, during the educational process. The deep involvement of the Defense Dept. and military services in engineering education, especially at the graduate level, is blamed in part.

Civilian industry supports very few research projects in engineering colleges. About 80 per cent of graduate engineering education is supported by the Dept. of Defense, the National Aeronautics and Space Administration, and the Atomic Energy Commission, according to Dr. Herbert Holloman, Acting Under Secretary of Commerce and Assistant Secretary for Science and Technology. He feels that this support steers engineering education toward areas important for these agencies, and these areas do not necessarily coincide with the needs of civilian industry.

Engineering societies pay only lip service to the problem, civilian industry is either unwilling or unable to take a more active interest, and universities cannot fight it alone, Holloman and others conclude.

What is being done, and what could be done, to change the situation?

Societies need to widen outlook

Dr. Holloman says that the parochial interests of engineering societies prevent them from dealing effectively with broad engineering problems. What is needed is a forum in which engineers, the Government and industry can discuss problems of mutual concern. Holloman and others recommend the establishment of a first-class journal that would deal with broad national engineering problems and provide the open forum. So far there are no signs that his advice is being heeded.

Consider the potential role of engineering societies in offering technical guidance in areas of social significance. Wesley E. Gilbertson, chief of the Bureau of State Services in the U. S. Dept. of Health, Education and Welfare, says that engineering societies should exert a major influence in developing programs to deal with environmental pollution and effective exploitation of natural resources.

Do societies like the IEEE live up to such expectations? At this year's IEEE show the large majority of technical sessions relate to topics that deal with aerospace, deep-space and military systems. Not one session is devoted to consumer-product engineering. No paper explores the urgent technical problems of combating air pollution, for example.

No attempts are being made to acquaint engineers with the business ways of civilian industry; cost, profit and production appear to be outside the focus of the IEEE technical program. Some attention is being given to engineering education, but mainly to the effects of machines, visual displays and other tools of education and communication.

What industry needs

Civilian industries are looking for specific qualities in engineers. Any engineer who is interested in such a career should appraise his capabilities along these guidelines:

- He should be well-versed in the fundamental disciplines of engineering, not formula-minded but capable of adapting to changing technology, according to Vaughn L. Beals Jr., vice president and general manager of engineering and research at the Cummins Engine Co., Columbus, Ind.
- He should be able to "devise, design and build engineering systems that work," adds Dr. Gordon S. Brown, dean of engineering at the Massachusetts Institute of Technology. He must develop abstract ideas into useful products. By seeking the useful rather than the unknown, he must top the work of the scientist. As Dr. Brown has put it: "The creative engineer is a scientist who completed his education."
- He must realize that time and money are integral parts of engineering. A perfect product may be largely a loss if it is delivered three weeks late at four times the originally planned cost.
- He must have enough background to become a useful, contributing member of the staff soon after being employed. "Companies are highly financially oriented," Beals points out, "and want people who don't have to undergo extensive training programs."
- He should have a reasonable understanding of how his specialty relates to others. Beals says: "Expanding this point, he should also understand the business as a whole, so that he can relate sensibly to marketing, manufacturing and other organic functions."

What industry can do

What can industry do to encourage engineers to enter the civilian economy?

Public media, including television and radio, emphasize the technical challenges and personal satisfaction of the space age.

Most engineers plan to enter the space and defense industries upon graduation. This is almost inevitable, some authorities believe, since the graduate study of four out of five engineers is supported by the space and defense industries.

Public media, like TV and the press, emphasize the glamour and excitement of the space age. This, coupled with the vast outlay of Federal money for contracts and grants, makes the competition for engineers an uphill fight for civilian industries. To counter it, "industry just has to do a better sales job," Beals emphasizes.

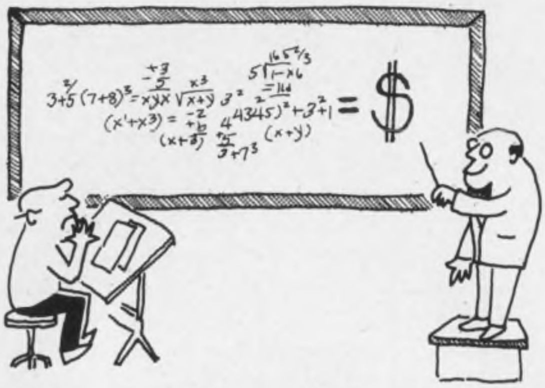
Engineering educators and industry leaders agree that they should work closer together. And civilian industry must offer financial rewards to experienced engineers that are equal to those in the military and space fields.

Industry should take every opportunity to spell out the needs of the civilian economy and to point out the challenges of designing consumer products, Beals says. Drawing on his experience in both the glamorized space industry and the civilian economy (he's former director of research and technology at North American Aviation), he questions the claim that space electronics offers more technical challenge and personal satisfaction to the engineer. "After a short period, even on the most exciting space program," he says, "the engineer finds himself facing fundamental problems, like materials and component selection. He soon forgets that it is a moon project."

Mapping out a strategy for civilian industry, Beals outlines a six-point plan to attract engineers:

1. Give adequate financial support to universities.
2. Assist the universities by encouraging a steady flow of freshman students through active recruiting at the high-school level.
3. Let the universities and engineers know the qualifications needed in civilian industries.
4. Provide opportunities to students and faculty members for part-time employment.
5. Lend top industrial people to universities for better communication.

To keep talented engineers, the consumer industry should match the rewards awaiting engineers in the military and space fields.



The profit-minded consumer industry is looking for engineers who can quickly become useful contributing members of the staff. Long training programs are usually not favored.

6. Learn how to use the engineers better and how to keep them.

Today only 5 per cent of all research and development funds spent in colleges and universities come from the consumer industry, Beals reports. This also effects the research projects that help support universities, he feels: "By default, we let DOD, NASA and others take over the financial support of most graduate engineering students."

Public education needed, too

Without the active support of such groups as engineering societies, the present picture does not seem destined to change rapidly. An executive spokesman for General Motors offers these comments:

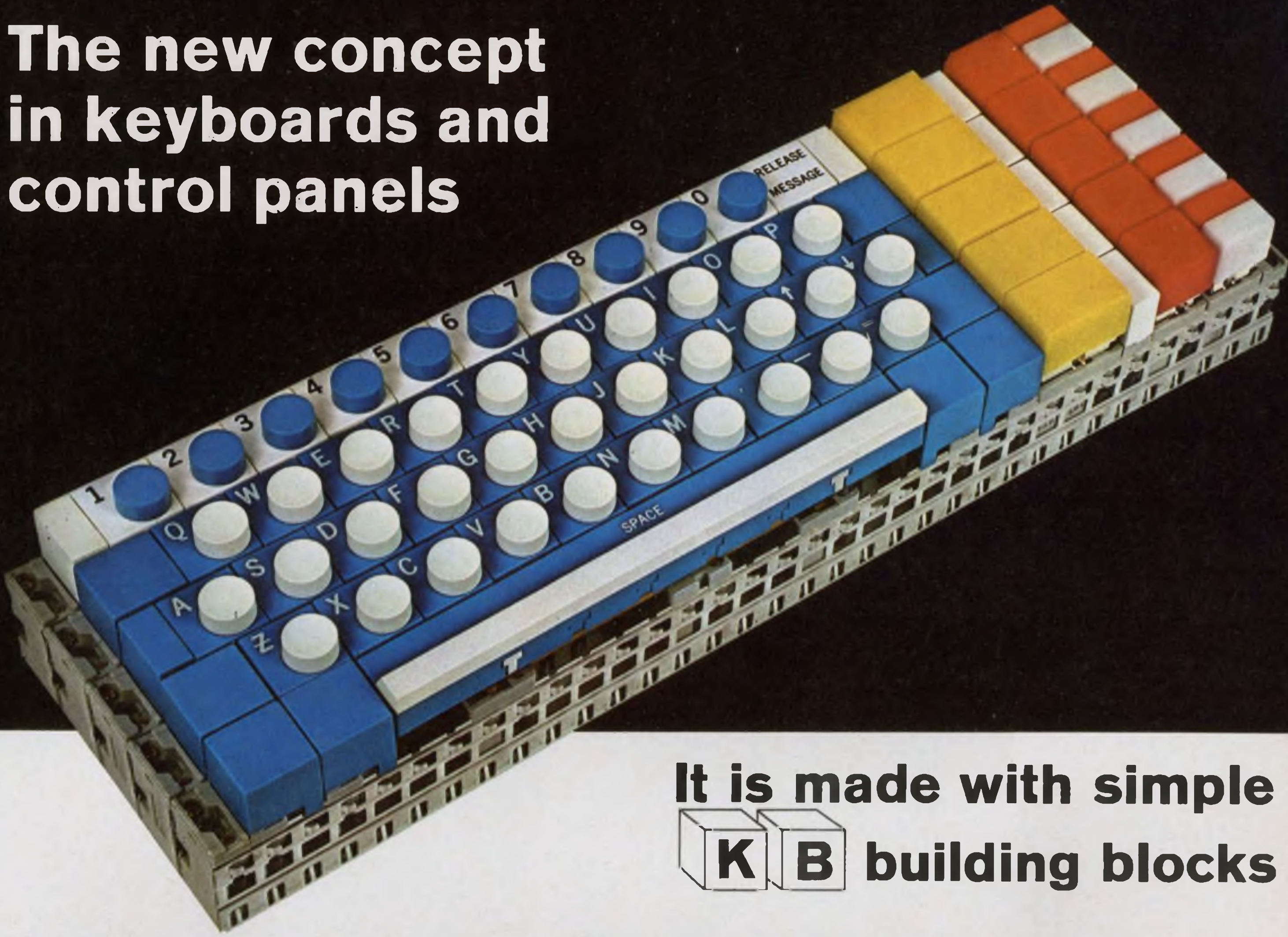
"We give about $2.5 million a year for graduate engineering education, with no strings attached. Admittedly it is but a small fraction of 1 per cent of our profits. But we have a hard time justifying even this to our shareholders. If we were to give more, we would have to pass it along to our customers, to those who buy our cars."

This view is echoed in other industrial quarters.

Dr. Holloman offers a suggestion that would not place undue financial burden on any one company. He recommends the establishment of a private agency, along the lines of the National Science Foundation, that would handle private and public donations and channel them to universities for research projects. This would help to lessen the dependence of universities on the Government, Beals agrees.

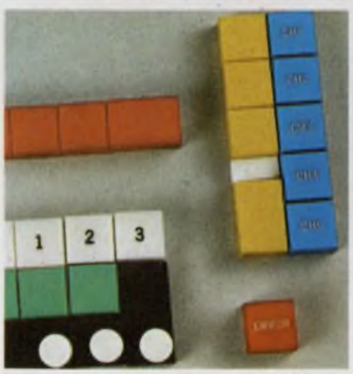
Some changes in college teaching seem called for, too. "Regrettably, engineering curricula don't stress engineering methodology," says A. Scheffer Lang, Deputy Under Secretary of Transportation and Research in the Dept. of Commerce. "I am appalled that modern engineers know so little about engineering economics, statistical decision theory, and economics of the firm or of public welfare." ■ ■

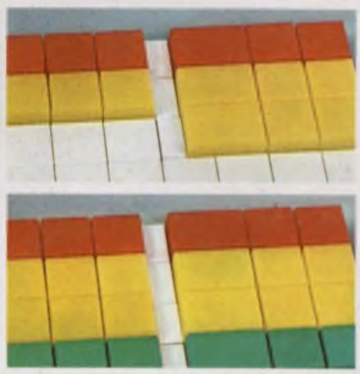
The new concept in keyboards and control panels



It is made with simple KB building blocks

KB offers these exclusive advantages:





KB allows new freedom of arrangement. Modular construction makes it easy to customize your panels—economical, too.

Switches and indicators available in a wide variety of colors, shapes, sizes. Arrange in vertical columns, horizontal rows, compact rectangles, or individually—all, in a single cutout.

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KB provides plug-in modularity. With KB plug-in switches, simply loosen two screws, lift out the unit and plug-in a replacement—all from the front of the panel.

Store a reserve unit right in the board—or "borrow" one that is not as urgently needed elsewhere on the panel. Downtime is practically eliminated.

KB simplifies expansion. KB modular construction makes planned or unplanned expansion easy, economical. In many cases, you simply remove spacers and plug-in additional switch or indicator modules to up-date your panel. No additional cut-outs, no wiring, no soldering, no behind-the-panel work required.

What is KB? The KB system provides all the components necessary for a complete, self-supporting matrix, including: Power Switches and Indicators with lighted display, Encoding Switches with up to eight output bits, Mechanical Interlock Modules for a variety of sequential functions, and a unique Modular Framework System.

Find out what KB can save you in engineering time, tooling costs, assembly costs, panel space and weight—and how KB can put more sales appeal into your panels.

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Now there's a "4th generation"

The engineer's view of technology

Here's a summary of the significant papers and products arranged by engineering specialty at the IEEE show

Aerospace Engineer

'Integrated avionics' is due for expansion

As the complexity of electronic equipment aboard an aircraft grows, one hears more and more about "integrated avionics." What is it?

Integrated avionics refers to the design and development of an over-all aircraft electronic system, as contrasted with many pieces developed independently of one another. The integrated approach matches the various subsystems to the over-all design, thereby assuring successful system performance.

Some of the major problems of integrated avionics include the following:

- Preparation of system and sub-system specifications.
- Coordination of system development, both hardware and software, when many design engineers and companies are involved.
- The need for a reliable display system.
- Managing, scheduling, and controlling the costs of design and development.

These and other problems facing the integrated-avionics engineer are discussed in Session 17. The scope of the papers ranges from the whys of integration ("Why Integrated Avionics?," by W. P. Beese, TRW Systems) to a "Status Report on Avionics System Integration," by L. S. Guarino, U.S. Naval Air Development Center.

Why should the average aerospace designer be interested in integrated avionics? For one thing, an understanding of the problems of integration will help him understand more clearly his own role in designing a small part of an aircraft or space system; the ultimate goal—reliable performance in an integrated system—must be his guide. Another point of interest: careers are opening up for a new classification in engineering—the integration specialist.

In-flight checkout systems

Recent combat experience in Vietnam with the Navy's E-2A Hawkeye airborne tactical control system has proved that the checkout of electronic subsystems on aircraft can be performed nearly 100 per cent of the time while the plane is flying. A paper in Session 26, "Combat Experience With Automatic In-Flight Fault Isolation on the E-2A Hawkeye," discusses this time-saver in maintenance. The author is Henry C. Kline of the Grumman Aircraft Engineering Corp., Bethpage, N. Y.

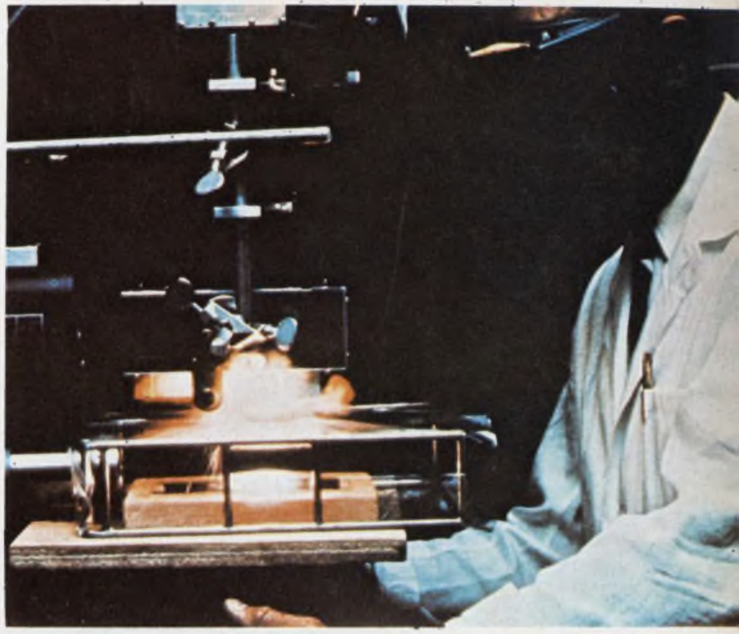
An on-board checkout system consists of a number of strategically placed sensors whose outputs are fed into a computer. The computer is programmed to evaluate continuously the performance of replaceable assemblies. Deviations from the specified performance are stored in the computer, and, the minute the aircraft returns to its base, this information can be played back to maintenance personnel in the form of instructions as to which assemblies must be replaced. The checkout system also plays an important role in preventive maintenance, by sensing gradual deterioration in the performance of subsystems.

The on-board checkout concept is being adopted both for longer space flights and for commercial aircraft, particularly in the case of the proposed supersonic transport. For commercial airliners, in-flight checkout means more flying time for the aircraft. In the case of prolonged space travel, on-board checkout will help prevent sudden, catastrophic equipment failures, by continuously advising the crew of the operation of subsystems.

Session 26, devoted completely to on-board checkout systems, covers space vehicles, aircraft and even deep-sea submersibles. Design problems, such as sensor selection, signal processing and reliability requirements, are also covered.

Special helicopter problems

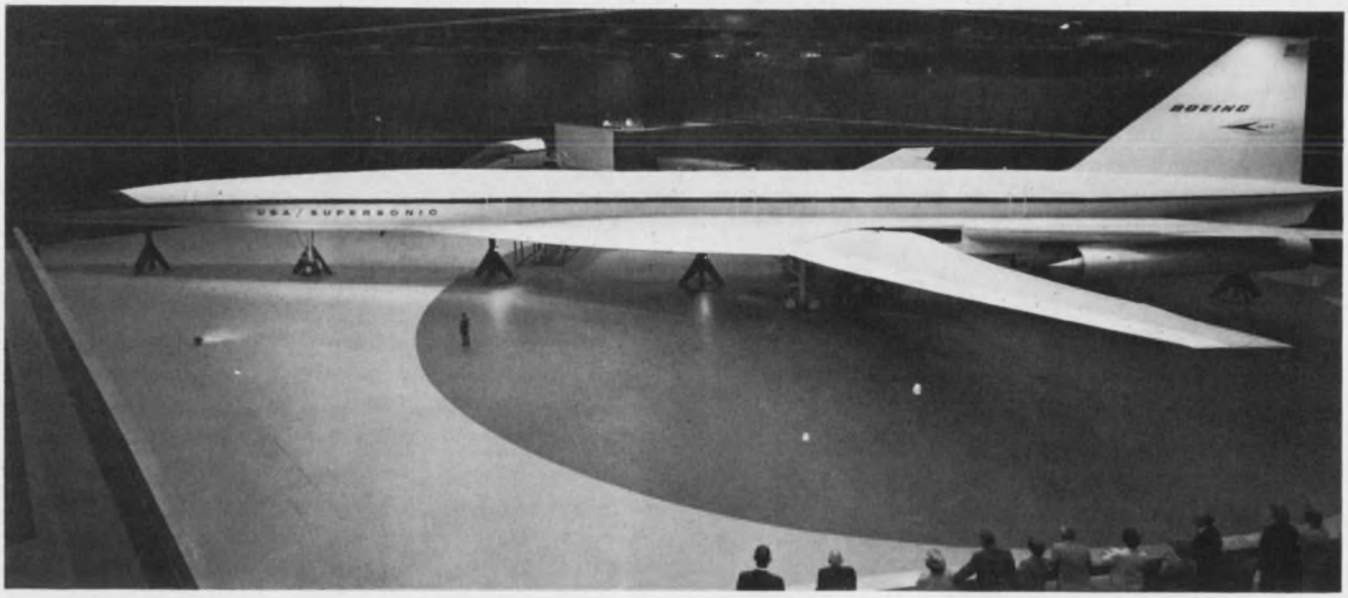
As more and more airports turn to helicopters to overcome city-to-airport traffic jams on the ground, the problems of helicopter traffic and airborne controls multiply. That such problems (and consequently the associated electronics) must be viewed apart from those of standard aircraft is amply evident in a paper, "Avionics for Rotary-Wing Aircraft," by L. G. Callahan Jr. of the Army Electronics Command, Fort Monmouth,



Laser effects on living tissues are determined in tests such as these conducted at the National Institutes of Health (Paper 18/1).

Behavior pattern of monkeys is controlled by means of implanted electronic stimulators that deliver pulses to defined portions of the animals' brain (Paper 27/4).

Microvolt null detector operated by Honeywell metrologist measures the potential difference between two standard cells (not shown) (Paper 59/2).



Supersonic airliner is expected to create problems in air traffic control. Each of the mammoth jets may carry as much as 1900 pounds of airborne electronic equipment. Each aircraft may cost as much as $35 million.

N. J. The paper is being given in Session 8.

The limited load capacity of helicopters implies a heavy reliance on microelectronics for on-board electronic equipment. And the unusual flying characteristics of helicopters place new demands on flight control, navigation, approach and landing systems. There is a possibility of utilizing the rotary wing as a part of the antenna system.

All these, and other problems, will be discussed in detail at the session.

SST—a boon for electronics?

With the U.S. aircraft industry committed to build eventually the world's fastest and largest supersonic airliner, the problem of traffic control becomes stickier than ever. Its importance is highlighted at the show by the IEEE decision to devote a complete session (No. 35) to the problem of controlling air traffic in the "super jet" age. The list of speakers includes Federal Aviation Agency and industry representatives and a guest from the French equivalent of the FAA, the Secretariat General a l'Aviation Civile et Commerciale.

—*Peter Budzilovich*

Circuit Designer

Plastic semiconductors: cost down, reliability up

"The application era for plastic semiconductors has arrived."

These words by Glenn Patterson, marketing engineer for Texas Instruments' industrial plastic silicon transistors, sum up the optimism of major semiconductor exhibitors at the show.

Last year was "the year of evaluation" for the plastic devices, Patterson says; this year will be "the year of utilization."

In the last three years an increasing number of manufacturers have been introducing "economy" lines of plastic semiconductors. The dime-a-dozen transistor is not here yet, but it may not be far off. Even today engineers can buy a 49-cent field-effect transistor, a 17-cent bipolar. IEEE showgoers are advised to check the booths of all semiconductor manufacturers for the latest information of new units, application hints and, possibly, free samples.

In the technical sessions, a circuit designer will find much practical and theoretical information, but little if any of it startingly new. Almost every session can be construed to relate to circuit design. A few will deal directly with the subject: Sessions 15, 23, 24, 49, and 61.

Session 23 is devoted entirely to state- and N-variable realizations and filter design. Session 49 deals with ultrasonics in modern signal processing, and Session 61 summarizes infrared techniques used for nondestructive testing. Sessions 15 and 24 deal with the solid-state and vacuum-tube state of the art, respectively.

Problems with plastic solved

Two major problems have slowed the development of plastic semiconductors:

- Poor moisture and humidity resistance.
- Inability to operate at elevated temperatures.

These problems, according to a number of semiconductor manufacturers at the show, have now been solved. Thus General Electric (Booth 3E01) has developed an epoxy compound capable of withstanding temperatures up to 200°C. Moreover it features high heat conductivity, a low coefficient of expansion and high moisture and humidity resistance (on a par with metal cans).

Texas Instruments (Booth 2F08) has completed a series of environmental tests that it started in early 1966 on its plastic units. These tests indicate conclusively, the company says, that the plastic semiconductors are on a par with metal ones, and they are available at bargain-basement cost.

Improvements in realiability and prices under 50 cents account for the glowing optimism in the semiconductor business. The Electronic Industries Association estimates that world use of the plastic devices will reach 1.8 billion units a year by 1971.

Military acceptance sought

Since the most attractive feature of plastic semiconductors is their low price, manufacturers aimed originally at the consumer and industrial markets, which were largely inaccessible to the metal units. Today, however, a number of companies are nearing the finish line in the race to meet military standards. Cost-conscious Defense Dept. officials are eying the plastic reliability figures (such as a 2000-hour moisture life test performed by Texas Instruments on 52 planar UJTs) with great interest. The day when the military will specify plastic semiconductors seems near.

At this time plastic units are available in a variety of configurations, parameter values and types:

- Bipolars all—major manufacturers.
- Field-effect transistors—TI and GE.
- UJTs—TI, GE, and Motorola.
- SCRs—most SCR manufacturers.

At least one exhibitor will disclose at the show a voltage rating in excess of 1000 volts; it looks somewhat like a TO-3. High-frequency units (by TI, for example) will also be unveiled.

Environment checks a must

In general, there is no difference between metal and plastic units with the same electrical characteristics. However, care must be taken in selecting plastic units for various environments. The user is strongly advised to get all the available test and reliability information that the manufacturer can provide. Such performance characteristics as power dissipation can be checked out quickly. For long-term performance (tied to the plastic unit's ability to soak up moisture) one has to rely on the manufacturer's figures and other users' reports.

As prices drop, it is obvious that many new markets will be opened or enlarged in the solid-state field. Here one can list home entertainment (hi-fi, stereo, radio, TV), radio amateurs, the computer industry, small and large appliances, industrial controls. In some cases, equipment now using vacuum tubes will jump to plastic semiconductors.

Another important industrial effect of plastic semiconductors is that it is accelerating the diversification of military-oriented electronic firms into consumer and industrial markets. One of the big stumbling blocks has been the cost of semiconductors in consumer markets.

Luckily for electronic designers, the upcoming plastic semiconductor trend will not threaten engineers with obsolescence, as was predicted with the advent of computers and ICs. On the contrary, the demand for engineers should increase, as trails into new, stable consumer markets are blazed.

The greatest challenge to the designer will be the need for simple hardware to cut manufacturing costs further. Individual ingenuity and creativity will be taxed considerably more than they were in the development of military hardware, where more often than not the precision of components rather than their cost was the overriding consideration.

—Peter Budzilovich

'City of Tomorrow'

From pollution to trains, it's an electronic challenge

Welcome to the Big City. Bumper-to-bumper traffic. Grime showering on people continuously. Fumes. People. More people. Noise. More noise.

Electronics can change all that. And it will, designers with foresight are saying. Not by eliminating people, but by helping to transform cities into pleasant places. This year Session 4 at the IEEE convention explores "The City of Tomorrow."

If it is to be a better place to live and work in than today's city, people must be able to move about swiftly and pleasantly; ways must be found to discard waste without contaminating the air and rivers; communications must be improved, and all improvements must be made without excessive disruption of the lives of inhabitants. Cities must be redesigned for people.

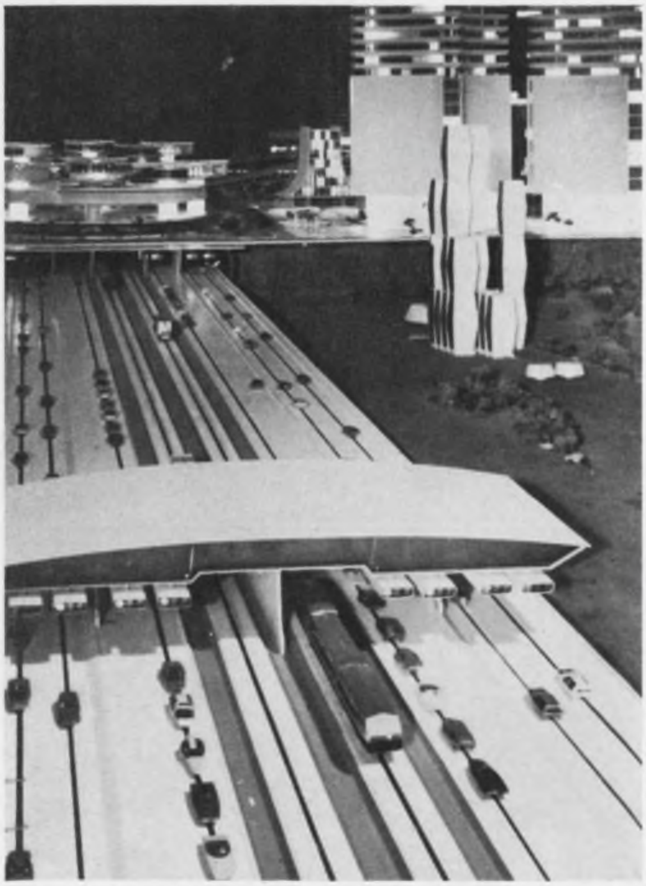
High-speed trains of future

When it takes a man longer to drive 15 miles to an airport than to fly a thousand miles from one airport to another, something is wrong. High-speed electric ground transportation between cities could solve the problem. And it could do it quietly and largely on existing rights-of-way. The route from Washington, D. C., to Boston, for example, is already under study. IEEE Session 58 presents papers that discuss such surface transportation systems—one by Ross McFarland and Howard Stoudt of Harvard University, and the other by Ezra Krende of the University of Pennsylvania.

The papers approach the problem from the point of view of the passenger. The transportation system must appeal to the public; it must be an attractive alternative to existing modes of conveyance. Electronics will play an important part in high-speed rail systems. Computers will keep the trains—which are to travel between 100 and 200 miles an hour—on schedule. Electronic controls are the natural interface between these computers and the trains' electric motors. Electronic sensors and ranging equipment will insure the safe passage of riders.

Traffic problems aloft

The jetliner has a lofty future for cross-country and intercontinental trips. The super jet is nearing production, and the supersonic transport is on the drawing boards. Session 35 will describe the progress being made in much-needed air-traffic controls. Papers on this topic are presented by R. J. Shamb of Airborne Instrument Laboratories and L. Lansalot-Basou, director of air navigation, Secretary General of Civil and Commercial Aviation, Paris, France.



High-speed trains run alongside rail-guided autos in the General Motors' city of tomorrow. Almost every futuristic urban plan includes unusual geometrical configurations for housing and offices, such as those shown in the background. Two papers at session 4 will evaluate the effect of structural form on the urban environment.

What of the electric car?

For the last eight months there has been increasing talk in the press about the feasibility of the electric car. Yet each announcement is accompanied by a word of caution: the car can't make its reappearance for several years, perhaps as many as 10. A paper at Session 33B by Manfred Altman of University of Pennsylvania analyzes the credence of recent optimistic reports.

The main problem with electric cars is power—storing enough electricity to push the car far enough to make it practicable for the average motorist. A car that rides 20 miles on one battery charge is of little value. But one that can roll up to 200 miles might sell well.

The power systems that have recently been in the spotlight are silver-zinc and sodium-sulfur batteries and hydrazine fuel cells. Silver-zinc batteries are prohibitively expensive for automotive use. Sodium sulfur has other drawbacks: the batteries must be heated to 500 F, and sodium explodes in water. Hydrazine fuel-cell tests by the Army produced mileage roughly equal to that obtained with gasoline, but hydrazine is highly toxic. Session 33B considers the shortcomings and alternatives. ■ ■

—Roger Kenneth Field

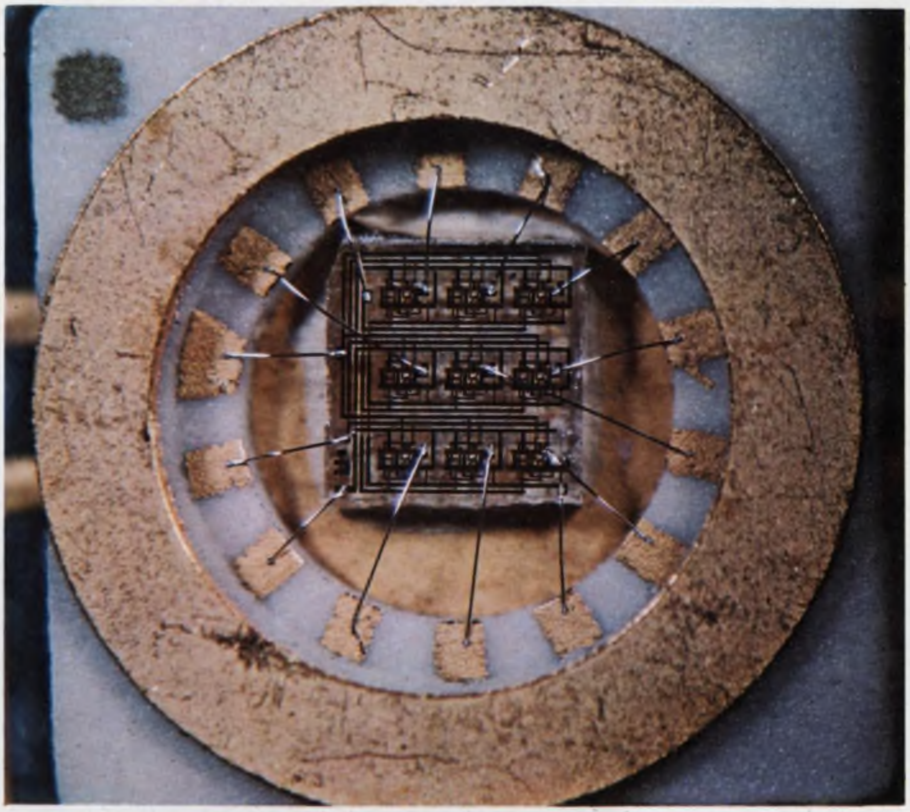
Communications Engineer

Bigger and faster systems leaning on digital control

The nation's largest communications network—the American Telephone and Telegraph Co.—is looking for electronic switching to replace electromechanical methods in virtually all telephone central offices in the U.S. by the year 2000. Two IEEE technical papers discuss the two largest electronic switching systems in use today.

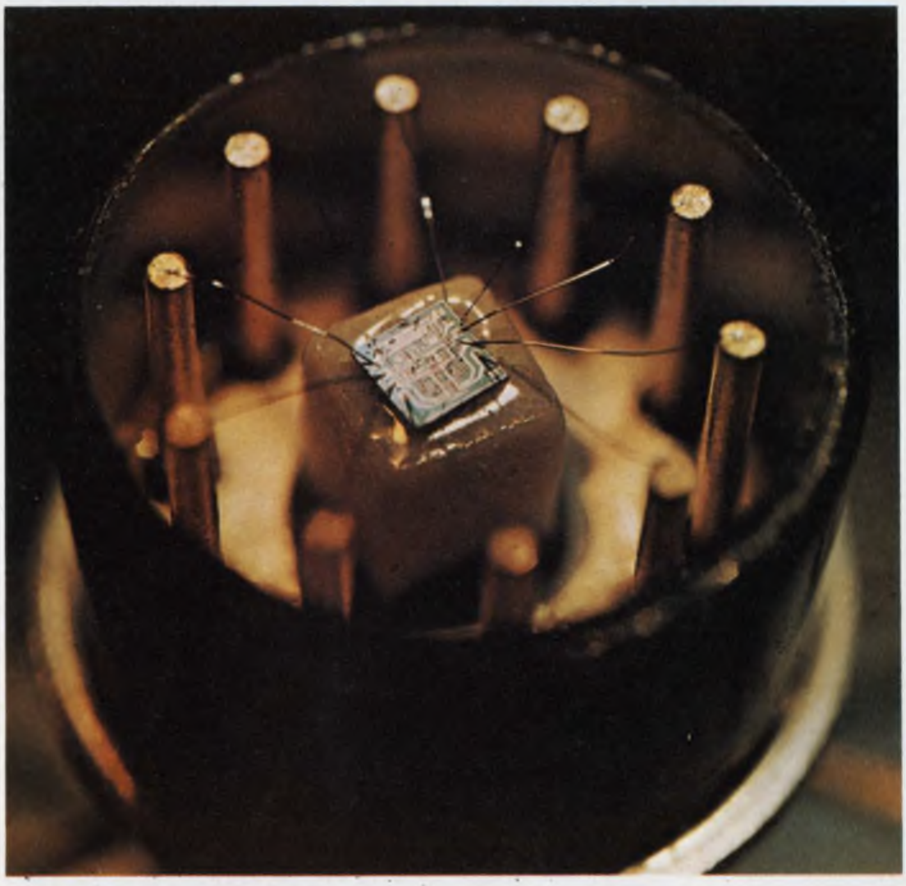
The papers, which are being presented at Session 66, are "Early No. 1 ESS Field Experiences: Part I, Two-Wire System for Commercial Applications," by G. Haugk, and "Early No. 1 ESS Field Experiences: Part II, Four-Wire System for Government and Military Applications," by H. N. Seckler, both of Bell Telephone Laboratories.

Communications hardware is rather scarce at the Coliseum this year. Components and test instruments are plentiful, but systems and func-



Nine-bit NDRO computer memory developed by RCA contains 90 silicon-on-sapphire MOS field-effect transistors (Session 15/2).

Complex hybrid circuit mounted in TO-5 can with top removed is made by Fairchild Semiconductor for commercial and military computers (Booth 4F03).



tional "block boxes" aren't too much in evidence.

Session 66 offers a fast, wide look at No. 1 ESS (Electronic Switching System), a large-scale electronic central office that uses stored program control, similar to the control system of a large-scale digital computer. Central offices of this type have been operating since the fall of 1964, and the papers by Haugk and Seckler describe the performance characteristics of these systems.

The electronic systems use parallel control and memory (both read-only and "scratch pad") to achieve the necessary reliability for maintenance of commercial and military telephone service.

No. 1 ESS is essentially a highly reliable computer communication system, an extension of the use of the digital computer to everyday life. The experiences obtained in its operation should prove helpful to both systems and circuit designers who are, or will be faced with, similar problems.

New opportunities for applications of telecommunications are outlined in "The Role of Telecommunications In Supporting Domestic Goals," a paper at Session 30. The authors, Harold R. Johnson and Charles E. Lathey of the Federal Office of the Director of Telecommunications Management, Office of the President, cite these potentials:

- Telecommunications can reduce costs dramatically and increase effectiveness in all areas of information exchange.
- Telecommunications can offer new concepts of education by providing visual and audio means for the transfer of information between teachers and students in different educational institutions.
- Telecommunications can help arrest the decay of cities by offering a practical way for people living outside the cities to communicate with the city in the conduct of social activities and commerce.
- Telecommunications can reduce costs and improve the effectiveness of travel by speeding reservation-making and providing safer patterns of flight.

Trends towards greatly increased cooperation between Federal, state and local governments may have an important impact in national telecommunications planning, the authors indicate.

Among the components on display, the Newport Beach Div. of Collins Radio (Booths 3B23-24) is showing a line of filters and other devices.

The Technical Materiel Corp. of Mamaroneck, N. Y. (Booths 2J03-07) is exhibiting a line of LF-MF-HF receivers and medium and high-power transmitters, along with antenna coupling units.

An interesting transmission measuring set that combines the functions of a selective voltmeter, tracking generator, spectrum display, attenuator and impedance matching panel is being shown by Sierra Electronic (Booth 2F07).

—Joseph J. Casazza

Computer Engineer

Role of data processing in daily life is explored

From the classroom to the courtroom, the digital computer's role is on the rise. The continuing expansion in applications is very much in evidence at the technical sessions of the IEEE convention.

The sessions stress computer applications rather than the machines' hardware—a trend that is likely to continue, at least until the next—the fourth—generation of digital computers appears. The next generation will probably take advantage of large-scale integration techniques to reduce the amount of "software" that is required in present-day computing systems.

Those interested in computer-aided learning should find Session 1 of great interest. The papers deal with the use of digital computers for education. Paul T. Shannon, Myron Tribus and Stanley Gembicki of Dartmouth College, in a paper entitled "Time-Shared Computers in Design Education," will report the college's experience in using a GE 265 time-shared computer system for three years. According to the authors, an educational environment has been created for the students in which the numerical answer to a problem becomes secondary to the problem's formulation. Also, the authors say, the use of the computer has made it possible to handle increasingly complex problems.

Computers as judges debated

The widening role of computers in decision-making in modern society is being debated from an unusual standpoint at Session 22. Here the visitor can hear the pros and cons of using the computer as a replacement for the judge in both civil and criminal court cases. Among significant aspects of the question that the panelists will explore are the emotions and variability of a human judge; the constitutionality of using computers to decide cases; the process of legal reasoning and the effect that a computer judge might have on litigants.

According to a paper by Roy N. Freed, division counsel of Honeywell's Computer Control Div., while many aspects of present judicial procedure do not readily lend themselves to mechanization, efforts to achieve mechanization could produce important improvements in the judicial process.

Design by computer draws attention

Computer-aided circuit design is the subject of two technical meetings. Sessions 42 and 51 examine the progress and promise, along with the problems, of this still young area of technology.

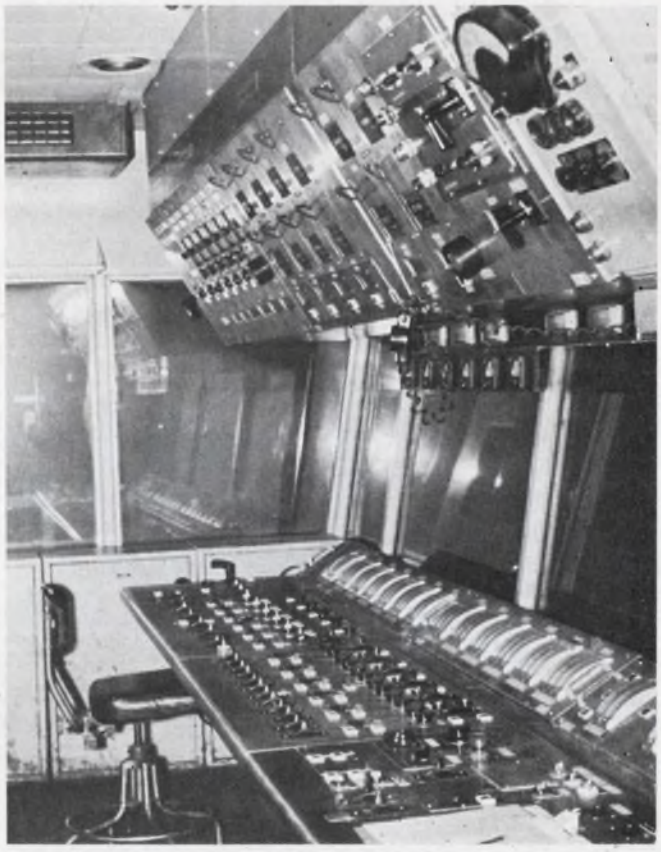
A paper by Dr. Allan F. Malmberg of the Los Alamos Scientific Laboratory describes the NET-2 Circuit Analysis Program. NET-2, an improved version of the classic NET-1, will give the electronic designer more powerful computational facilities along with more versatile device modeling capabilities.

The influence of the computer on network theory as well as on circuit design is being explored in a paper by Franklin H. Branin Jr. of IBM's System Development Div. Branin emphasizes the need for accurate statement of the problem to be solved, since the computer is capable of doing only what it has been explicitly instructed to do.

For maximum computational effectiveness, he continues, the computer also requires analysis techniques that differ from the methods used in the manual solution of network problems. Numerical methods, according to Branin, should at least supplement, if not supplant, Laplace transform techniques. One numerical method that he presents is said to give essentially all of the information that can be obtained through the use of Laplace transforms.

The matrix approach is used throughout the paper, as Branin considers this technique to be the most suitable for use with a digital computer.

—*Joseph J. Casazza*



Control room in the largest steel plant in the U. S.—the Sparrows Point Plant in Maryland—is an example of the headway that solid-state equipment has made in the industrial-controls area.

Industrial Electronics Engineer

Papers may disappoint, but new products abound

The designer in the large, ill-defined field of industrial electronics faces a mixed reception at this year's IEEE show. If he likes to listen to technical papers, he may be somewhat disappointed. But if he is looking for components, devices or instruments, he will find a wealth of products tailored to his needs.

Not too many design-oriented technical papers apply to industrial electronics. On the bright side, however, the product market is getting a large play from manufacturers, for a variety of reasons. Foremost is the fact that although military, aerospace and consumer business has been booming, there is no assurance that this will continue. Should business in these areas falter, the industrial market has the potential to take up the slack.

Typical of the efforts being made to woo industrial users are those of the semiconductor manufacturers, who this year are adding impressively to the galaxy of plastic-encapsulated devices already available. An 8-amp, 600-V SCR from Motorola (Booth 3A05), a line of planar unijunction transistors from Texas Instruments (Booth 2F08), and a variety of FETs are some of the new plastic units that will interest the industrial user. All of the devices are bargain-priced and have specifications very close to their standard military counterparts. General Electric (Booth 3E01) expects to narrow the specification gap between plastic-encapsulated and hermetically sealed units even further with a new cast-epoxy that it is introducing at the show. The material reportedly has a 200°C capability as well as excellent moisture and humidity characteristics.

Simplified selection available

Ease of selection is another inducement being offered to industrial users by semiconductor manufacturers. This is particularly important to the user who has only a limited knowledge of the intricacies of semiconductor selection and application. An example is the plastic unijunction transistors being shown by Texas Instruments. The units are members of an applications-oriented family, with one tailored for thyristor triggering, another for low-frequency control circuits and a third for general bistable circuit use. This allows a purchaser to zero in easily on a suitable device with a minimum amount of spec-sheet searching and a limited knowledge of the trade-offs involved.

Another example of simplified selection and application is Fairchild Semiconductor's new

Compatible Current Sinking Logic integrated circuits, which are a highlight at Booth 4F03. Three types of digital logic—TTL, DTL and low-power DTL—are available in these circuits, and all are logically, electrically and mechanically compatible. This means that the designer need not use the same type of logic throughout his circuit; he can vary the logic from stage to stage, as requirements dictate. Here again, no intimate knowledge of the trade-offs is required to select one type of logic or another for an entire circuit.

Analysis of drive equipment

On the technical program, designers interested in the control of electrical drive equipment, should find Session 50, "Drive Control Applications," interesting. Two of the papers cover speed control of ac induction motors, while a third analyzes the use of SCRs in controlling dc motors. The session may take on added meaning, and possibly produce a lively discussion period, as a result of the recent decision of the San Francisco Bay Area Rapid Transit District to employ dc motors for vehicle propulsion, despite their higher cost over ac units. The decision reportedly resulted from torque and speed deficiencies in the ac induction motors.

Another meeting of interest should be Session 61, covering various industrial applications of infrared. A particularly noteworthy paper of this session, by Dr. Riccardo Vanzetti and J. Fred Stoddard of The Raytheon Co, covers an automated infrared troubleshooter (the technique is described on page U107 of this section).

—Frank Egan

Materials Engineer

Uses instead of physics stressed at 'first' panel

For the first time, the IEEE convention will devote an entire session (No. 37) to materials for advanced electronic applications.

And on the Coliseum floor the unusual in products and technology will be evident. The products include:

- A laboratory-made semiconducting diamond thermistor, designed to operate from −325°F to 1200°F.
- Continuous-length, flexible glass fiber optics.
- An electrogasdynamic technique for coating powdered conductive or nonconductive material on the inside of hollow tubes.

Gustave Shapiro, chief of the engineering electronics section of the National Bureau of Standards, is the organizer of the materials session. He terms it a "natural."

"Materials," he says, "are truly as important a discipline in electronic engineering as any other specialty. For many years we have been publishing articles in our transactions on materials. It is natural that we should have an individual session for it—it just took a little longer to get started. Component considerations and materials considerations are part and parcel of one another."

Shapiro concedes that "the pendulum has swung all of the way over" from the components to the systems engineers, but he says emphatically that "one day it will have to swing back, at least part of the way."

Problem-solving approach used

The co-chairmen of Session 37—Alex Javitz of Commonwealth Services, Inc., New York, and James Godfrey of Bell Telephone Laboratories, Allentown, Pa.—have given the meeting a problem-solving tone. Godfrey says that he and Javitz want to stress "the applications of materials rather than the materials themselves."

"What we do not want," he continues, "is a bunch of solid-state physicists discussing basic structure and properties and things of this sort; so we're strongly engineering-oriented rather than material-science oriented. We will stress the application of new materials or the novel application of well-known materials to the solution of important new problems. We are not restricting ourselves to commercially available materials either. For example, witness the session on optical devices [by L. A. D'Asaro of Bell Telephone Laboratories, Murray Hill, N. J.]. There are not really very many of these devices on the market today."

Tomorrow's materials in today's R&D

Materials of the future are evident in the first two papers. In the first, J. E. Thomas of the General Instrument Co., Newark, N. J., concentrates on materials in integrated circuits, particularly problems of interconnection, insulation and environmental protection. Thomas feels that the IC revolution has been concerned with the physics and interior workings of the active devices. An IC evolution, he says, must solve the materials problems. He calls for a five-fold interdisciplinary attack involving electronics, chemistry, physics, optics and mechanics..

In the second paper, D'Asaro of Bell Labs covers bulk and junction semiconductor devices as applied to optical devices. Materials requirements for such devices as lasers, detectors and modulators are discussed. Some evidence of commercial activity in the area is evident in the exhibit areas. In Booth 4B15, TRG is demonstrating an accessory to increase the peak power and switching speed of any rotating-prism, Q-switched ruby laser in

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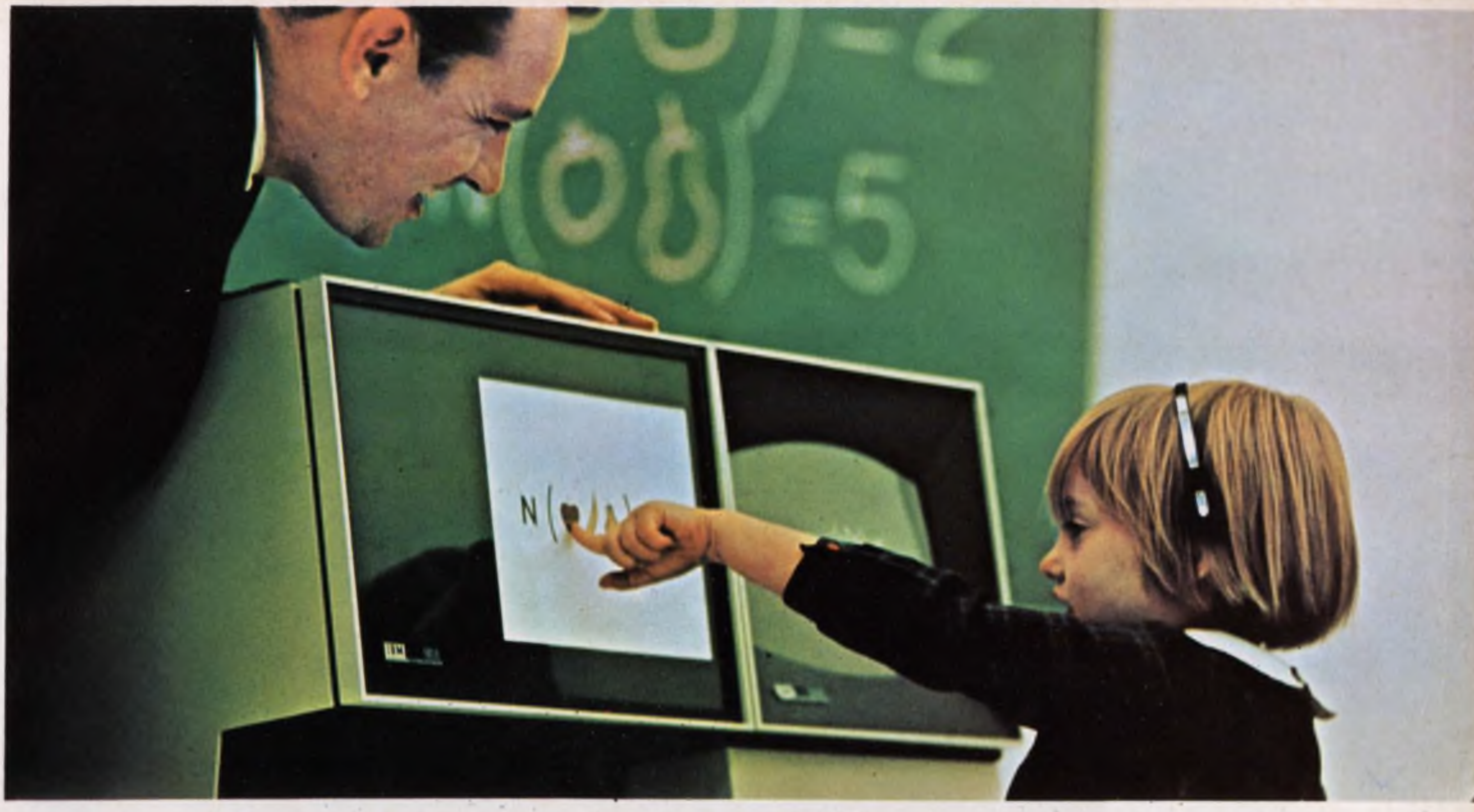
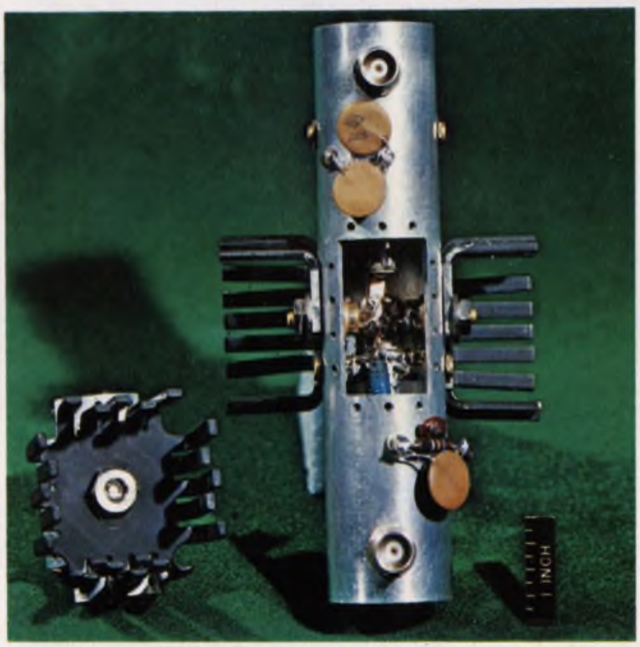
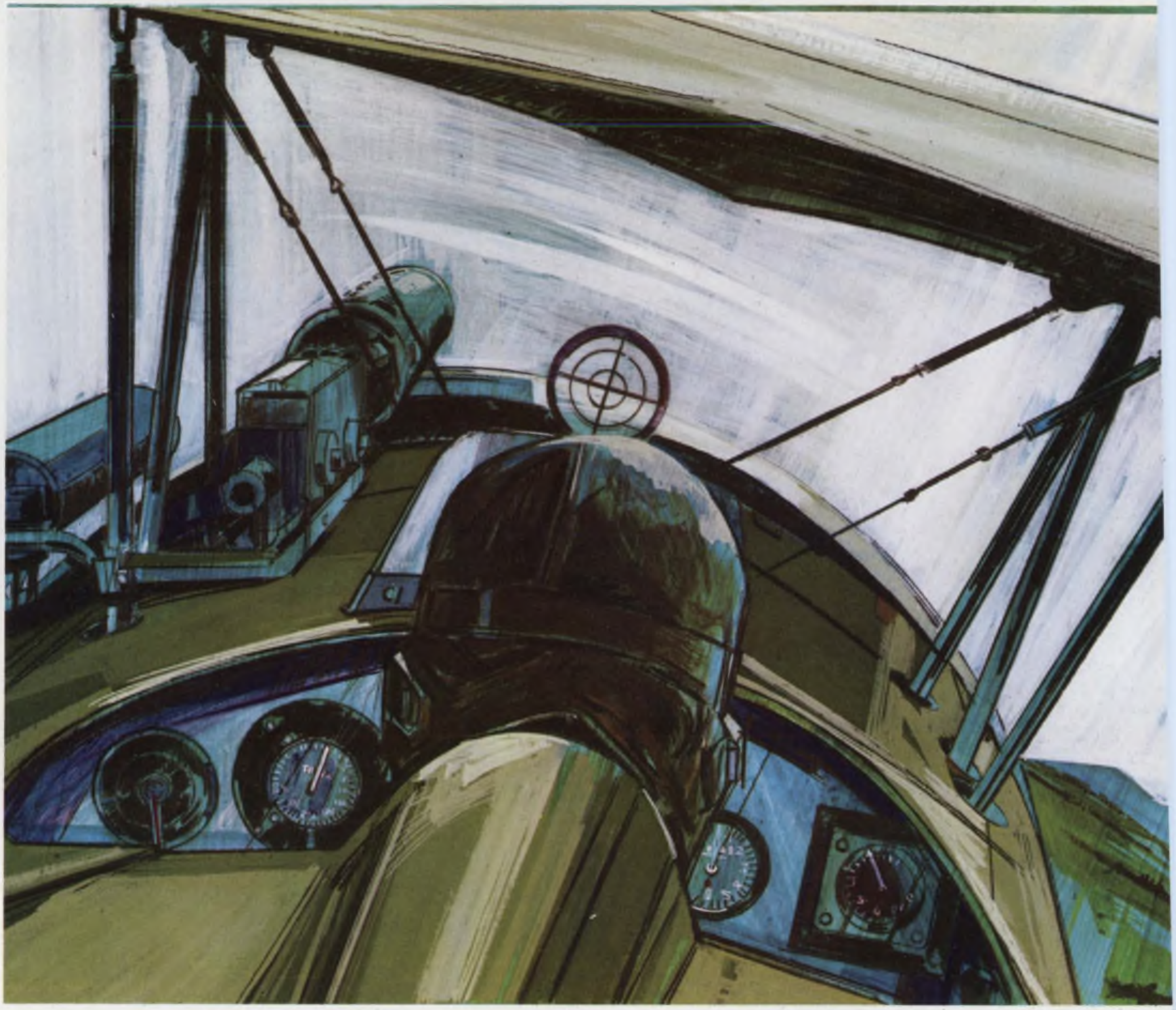


A little girl, using a computerized learning machine, not merely finds adding and subtracting fun, but also memorizes basic arithmetic processes faster and easier (Session 1).



Coaxial transistor amplifier uses four overlay transistors in parallel. Developed at RCA's David Sarnoff Research Center, the amplifier has a saturated power output of about 90 watts at 370 MHz (Session 7).

Design engineer uses a light pen to feed data into a digital computer which performs the computations necessary to solve a mechanical engineering problem (Paper 24/4).



The Kind of Knowledge that makes progress possible...

It was World War I. Man had already learned to fly, but he was an uneasy "bird" in flight. With the war came instrument flying. It gave man a new ability and confidence in the air, and galvanized his dream to conquer space. Now, in an age of electronic sophistication, man's dream beckons reality.

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(continued from p. U99)

single-pulse operation. The accessory contains two optical cells filled with a saturable dye solution. Either of the two cells can be positioned so the dye be put into the laser cavity. Peak power is increased by suppressing multiple pulses and obtaining a single pulse.

Down-to-earth capacitors

Capacitor dielectrics are probed in the third paper. David A. McLean, also of Bell Labs, explores dielectric materials and capacitors for thin-film devices and ICs. The effects of processing on dielectric materials properties will be discussed, while dozens of components manufacturers are displaying their wares on the exhibit floors. Capacitor chips, Mylar, paper, vacuum, air-variable and other types are being exhibited.

Multi-signal cable flattens out

Jack Spergel and W. V. Lane of the Army Electronics Command at Fort Monmouth, N. J., complete the session with a two-part discussion of materials for conductive elements. Lane covers thin-film conductive materials, while Spergel examines aspects of flat-cable materials and techniques.

Spergel reviews in his paper the potential for flat or ribbon cable. Based on a NASA study of a Saturn rocket prototype, the author cites weight savings of 75 per cent, cost savings of 33 per cent and installation and assembly time savings of 75 per cent compared with round cable.

Applications, however, are not limited to the missile. In Booth 1G18, W. L. Gore & Associates are exhibiting their multiconductor (20-signal) ribbon cable. Gore says it has already sold a large quantity to "the largest computer manufacturer" to be used in computer backplanes in place of coaxial cable. The company cites space savings of 90 per cent for its Teflon-insulated, 1.15-by-0.026-inch cable. Visitors to the booth will have the opportunity to see the cable stripped, terminated and soldered. Free samples will be available.

The ACI Div. of the Kent Corp., Princeton, N. J. (Booth 4E26) is showing its Signaflo multiconductor transmission lines. ACI designs its systems, complete with terminations, strictly to specific customer requirements of impedance, propagation velocity, cross talk and capacitance.

A diamond with unusual facets

Among the unusual products, General Electric is showing a thermistor of astonishing environmental range. The company's Magnetic Materials Section has successfully synthesized a semiconducting diamond, and GE engineers have designed the thermistor around the material. It can operate over a range from −325°F (where many gasses liquefy) to 1200°F (where metals glow red-hot). The material will be on display in Booth 3E13, and GE expects to deliver the first commercial diamonds by mid-summer. Incidentally, this is one of the few applications for diamonds that does not exploit the diamond's hardness.

Corning Glass is exhibiting the continuous-length, flexible, glass fiber-optics in Booth 4F20. The flexible, non-coherent bundles, jacketed in PVC, are said to be an industry first. They are available in single lengths up to 10,000 feet, priced at 10 cents a foot in lengths over 50,000 feet. They will be displayed along with fiber-optics faceplates and magnifiers.

An interesting exhibition is promised at Booth 2K29 by Jack McGruder, manager of product development for Gourdine Systems, Livingston, N. J. Gourdine has developed the electrogasdynamic technique for coating powdered conductive or nonconductive material on the inside surface of hollow tubes. The tubes may be of any inner geometry, and the coating is reported to be of almost perfect uniformity.

—David Surgan

Medical Electronics Engineer

New horizons are opening in surgery and prosthetics

To the biomedical design engineer, the IEEE show always poses a vexing problem, and this year it's no different. It is a general show and convention, and therefore must cater to all of the many areas of electrical and electronic technology. This naturally limits the number of technical papers and products for biomedical engineers to relatively few.

Two technical sessions are related directly to biomedical engineering: Session 18, "Engineering in Surgery," and Session 27, "The Design of Man: Man's Design." And no single booth at the show is devoted exclusively to biomedical electronics.

A wide sweep needed

Biomedical engineering cuts across many disciplines. To find out what really is new in his field, the conscientious biomedical engineer must sift through the entire technical program, picking out the sidelights that might be of concern to him—computer papers, for example, if his immediate interest is in time-shared systems for medical data; microelectronic papers, if his interest is in implantable telemetry systems; or materials or ultrasonics papers, if these are applicable.

Similarly in his tour of the Coliseum, if he is interested in recorders with medical applications, the biomedical engineer visits the booths of all major recorder manufacturers; if transducers are vital, he stops at the many points where transducers are on view.

The showgoer with a biomedical interest must ever be ready to bridge the gap between general electronic technology and its medical application.

The content of Technical Session 18 reflects the burgeoning interest in and use of electronics for surgical applications. In one of the papers, by Grant Riggle and Robert Hoye of the National Institutes of Health, the effects of laser power on living tissue are described. The findings are based on extensive tests conducted at the Government center. It is known that the effects of laser energy on living tissue depend on such factors as the laser's wavelength and power, as well as on the characteristics of the tissue. The aim of such tests is to make it possible to use lasers for selective tissue destruction—killing cancers, for example.

Electronics is also being widely used in an indirect way in surgical applications. This is in the area of patient monitoring during and after major surgery. With extensive measurement systems and displays, a wide variety of physiological conditions can be monitored for the physician. Such techniques are especially important in major heart surgery. Post-operative monitoring techniques are covered in Session 18 in a paper by John Lewis and John Jacobs of Northwestern University.

Wide range of techniques

The broad scope of today's biomedical engineering is evident in Session 27. It contains papers on subjects as practical as the control of prosthetic devices and as esoteric as computer analysis of the brain's physiologic language. A paper of particular interest to the designer is "The Electrode Interface Between Man and a Prosthetic Stimulator," by Wilson Greatbatch of the State University of New York. The discussion should prove informative not only to the designer of prosthetic devices but to everyone involved in the measuring or recording of human physiological parameters.

Greatbatch covers the design of the electrode interface between man and such supplemental electronic devices as cardiac pacemakers and bladder stimulators. This interface has very complex electrical and chemical properties, which vary greatly with current density and duration, as well as with electrode material. In particular, electrochemical polarization of the electrodes has a significant effect on their operation, and it is this effect on various electrode materials—and the way that it influences the design of the prosthetic devices—that is emphasized in the paper.

Another interesting paper, pointing to new directions for medical electronics, is "Man's Intervention in Intracerebral Functions," by J. Delgado of the Yale University School of Medicine. The author describes work that has been done with animals in direct electrical stimulation of the brain. Such techniques have been successful in eliciting a variety of behavioral and mental responses, such as walking, eating and sleeping. The techniques are limited, though, in that they only trigger physiological mechanisms that are already established in the neurons. They cannot, in effect, create new behavior. The paper also points out how research of this type will benefit significantly from impending developments in microminiaturization and new power sources.

—Frank Egan

Microcircuit Systems Designer

Two new trends pushing into consumer market

There are two discernible trends in the microelectronic papers at this year's IEEE show: linear microcircuits are penetrating deep into consumer products, and large-scale integration is the present goal of digital-microelectronic-circuit manufacturers.

In the exhibition booths, a variety of interesting linear and digital ICs is available. Since cost is always a major consideration in acceptance of a component by commercial and industrial buyers, plastic ICs are receiving a big play; they've been around for some time, it's true, but only comparatively recently have they become truly reliable.

Rise in linear circuitry

R. S. Pepper, director of integrated-circuit development at the Sprague Electric Co., North Adams, Mass., reports in Session 15 on linear microcircuit penetration into the consumer market. He says that linear microcircuits will account for half the dollar value of all ICs sold in the months ahead, but will represent only about a third of the total of IC units sold. This, he feels, is because the linear circuits will always have less general applicability than the more versatile, multifunctioned digital circuits. Large-volume, special-purpose linear circuits are expected to make their early appearances in automobiles and toys.

The linear ICs will also appear in telephones. The Bell System is planning to use a beam-leaded multitone oscillator in its pushbutton telephone. A paper in Session 69 by W. H. Orr, R. M. Rickert and D. M. Hill, all of Bell Telephone Laboratories, Inc., Murray Hill, N. J., describes this unusual RC oscillator.

Complex arrays sought

Digital-integrated-circuit manufacturers and users are hoping to develop more and more complex arrays, but production yields hamper LSI progress. Three approaches can be used to overcome the yield fall-off: computer-generated masks for discretionary wiring of circuits; manual probe-testing and hand-wiring; and brute-force methods aimed at improving yield and restraining circuit complexity.

Session 60 concentrates on two of these approaches: discretionary wiring and restraining circuit complexity. J. S. Kilby of Texas Instruments, Inc., Dallas, and D. L. Critchlow of the IBM Watson Research Center, Yorktown Heights, N. Y., are reporting on the methods. Another paper in the same session—by Robert Seeds of Fairchild Semiconductor, Palo Alto, Calif.—concludes that reasonable yields can be attained with a 100-by-100-mil active chip area.

Improvements in products

Among the linear and digital ICs on display at the booths are a five-amp integrated power switch by the Vector Co., a division of the United Aircraft Corp., Southampton, Pa. (Booth 4F26). Fairchild Instrumentation (Booth 4F03) is showing hybrid operational amplifiers that use field-effect transistors, integrated circuits and monolithic preamplifiers. A plastic operational amplifier and a complete, transformerless audio amplifier are being offered by the Radio Corp. of America (Booth 3C01-02). And Texas Instruments (Booth 2F08-20) has bolstered its popular TTL54 series with high-speed (54H) and low-power (54L) units.

Progress in plastic integrated circuitry is being eyed with interest by the makers of industrial controls, because it will enable them to shift from vacuum-tube equipment directly to microelectronics. The majority of IC manufacturers are displaying plastic devices.

—Roger Kenneth Field

Microwave Engineer

Solid-state applications emphasized at sessions

The systems engineer and the device man in microwave engineering are separated by an ever-widening gulf. Solid-state technology is the major cause; it has proliferated at an alarming rate. Hardly has the spec sheet on a new, high-frequency transistor reached the systems designer, when he hears of a new version that delivers more power at higher frequency, or another device that will do the job better.

This year the IEEE microwave sessions are trying to bridge the gap. Authorities are discussing the state of the art in areas most influenced by solid-state developments. Emphasising application, they offer designers a chance to catch up with the latest development and, at the same time, to get a comparative evaluation of these microwave building blocks, which are found in every system:

- Power sources.
- Receivers.
- Control circuits.
- Filters and duplexers.

Apart from systems applications, any new solid-state device must be considered a future candidate for integrated circuits. This thinking is also reflected in the technical program: the microwave semiconductor devices are being examined for both monolithic and hybrid circuits.

Wide choice of power sources

Dr. Mark R. Barber of Bell Telephone Laboratories, Murray Hill, N. J. (Session 15) compares the performance of microwave oscillators that use avalanche diodes, bulk gallium-arsenide devices and transistors with the potential of reflex klystrons.

One of the latest advances in microwave-power generation in a commercially available device is illustrated by the Type 0320 X-band, step-recovery diode of Hewlett-Packard (Booth 2F25). It puts out 150 mW at 10 GHz when driven at 2 GHz with 2 watts. For lower frequencies, engineers may consider the Fairchild (Booth 4F03) MT1062 stripline transistor, which delivers a gain of 7 dB at 2 GHz and 3.5 dB at 3 GHz. It can oscillate up to 4.5 GHz.

Dr. Fred Sterzer of the Radio Corp of America, Princeton, N. J., concentrates in Session 7 on the many ways transistors can be used in microwave and uhf power generation and amplification. Transistor-oscillator and amplifier multipliers, and transistor-driven harmonic generator chains, are two examples he includes.

One such transistorized amplifier uses four RCA TA2675 overlay transistors in parallel. The saturated output power of the device, on view at Booth 3C02, is about 90 watts at 370 MHz.

The continuous improvement of solid-state devices naturally leaves the design of systems that employ these—receivers, for example—in a state of change. Wesley G. Matthei of the Micro State Electronics Corp., Murray Hill, N. J., reviews in Session 7 the recent happenings in solid-state devices in the light of low-noise receiver design. He compares the new devices with competitive components, such as Schottky-barrier mixer diodes, transistors and tunnel diodes, and also takes a look at receivers that use only microwave integrated circuits.

Characteristic of the new generation of mixer diodes is Fairchild's FH 1100 silicon diode, which uses the hot-carrier (or Schottky-barrier) principle. Its switching time is in the tenths-of-a-nanosecond range, and, as a mixer, it has a maximum noise figure of 10 dB at 890 MHz.

Monolithic integrated versions of transistor amplifiers, oscillators, diode mixers and switches, bulk-effect devices and avalanche diodes are examined by Roger R. Webster of Texas Instruments, Inc., Dallas, in Session 16. The design and application of hybrid circuits is being discussed in the same session by James E. Dalley of Bell Telephone Laboratories, Reading, Pa.

Ferrites catching up with diodes

The story in control circuits is the competition between ferrites and semiconductors in such devices as switches, phase shifters, attenuators, limiters and modulators. The boundary between diode and ferrite devices is becoming vague, as the performances of both are upgraded, concludes Donald H. Temme of the MIT Lincoln Laboratory, Lexington, Mass. His conclusion, being offered in Session 7, is based on a comparison of parameters, including insertion loss, isolation, control speed and power, bandwidth and power-handling ability.

An example of diode-switching capabilities is furnished by the broadband PIN diode switch of Hewlett-Packard (Booth 2F25) that operates from 12 to 18 GHz. The shunt-connected Model 3560 PIN diodes and the bias network are built into a 50-ohm microwave transmission-line structure to achieve the broad bandwidth.

Programmable coaxial switches, introduced by Marconi (Booth 2D04), operate from dc to 1 GHz, using reed dry reed relays mounted in striplines.

The rapid advancement of ferrite technology is being demonstrated by the appearance of planar ferrite devices. They can be built into integrated circuits with conventional photo-etch techniques, says Hugh A. Hair of the Syracuse University Research Corp. He reports on the progress of the development in Session 16.

—*Maria Dekany*

Oceanographic Engineer

Interest in the seas rising to new heights

Interest in oceanography is swelling so rapidly that the IEEE has made it the subject of its Highlight Symposium. In addition, three technical sessions are devoted exclusively to design and engineering problems in exploiting the world's seas.

Last year two sessions were devoted to the field, and both were so well attended that Haig Manoogian, a prime organizer of this year's meetings, characterized them as "mob scenes." Standing-room audiences of more than 400 turned out for the single 1965 session.

The Highlight Symposium this year is entitled "Exploitation of the World's Oceans," and the keynote address, "Goals Being Developed by the National Council on Marine Resources and Engineering Development," is being given by Howard W. Johnson, president of the Massachusetts Institute of Technology.

The symposium is being held at 8 P.M. on March 21 in the New York Hilton grand ballroom. At a panel discussion, Dr. Thomas Kavanagh of the National Academy of Engineering will outline the engineer's role in oceanography, and Richard Fuller of the Bendix Corp. will give industry position. Robert W. Morse of the Case Institute of Technology will cover R&D in the field, while Dr. C. M. Herzfeld, director of the Advanced Research Projects Agency of the Defense Dept. will present the Government's view.

Technical orientation offered

The technical sessions offer little that is new for the experienced in oceanography, but they are a

An acoustic transponder signals the location of an undersea camera and helps to position it above the sea floor.

good introduction for newcomers, or for those who want to decide if their future lies in deep-sea electronics. Interest in the field is far out-pacing technical developments at present; the challenge to designers is virtually unlimited. Manoogian, an engineer with the Grumman Aircraft and Engineering Corp., Bethpage, N. Y., echoes a sentiment heard frequently in the field: most companies are waiting for the Federal Government to initiate large-scale projects and are reluctant to set up expensive projects with their own funds. In spite of the glowing promises, the market is not extensive. Aside from military antisubmarine equipment, most materiel is procured in small-lot quantities. This situation has led many companies to give oceanography a hard look—but to refrain from participation.

Exploitation: an in-depth view

Session 44 is a continuation of the Highlight Symposium's panel discussion in greater depth. The impact of electronics on the fishing industry is being covered by Dayton Alverson of the U. S. Bureau of Fisheries. He reviews the strides in adapting electronic navigational and search devices to commercial fishing. He outlines the future role of electronics in four basic areas: communications, navigation, search, and extractive processes.

Dr. Alan Berman, director of Columbia University's Hudson Laboratories, is discussing electronics in underwater search, rescue and recovery. He relates radio direction finding, surface radar and radio navigation to their undersea equivalents —largely acoustic methods. The severe requirements imposed on electronic instrumentation in remote underwater sensors and manipulators is underscored.

The Navy's navigational satellite system and its application to ocean navigation and geodesy is outlined by R. B. Kershner of Johns Hopkins University's Applied Physics Laboratory. The system has other applications besides its principal one of supplying position data to Navy combat ships. Simplified lightweight receivers are being used to establish precise coordinates for oceanographic surveys and map-making, and even aircraft are using the satellite system experimentally for navigation.

Economic considerations that influence the choice of electronic systems and devices on deep submersibles are discussed by W. H. Scott of the Grumman Aircraft Engineering Corp.

Hardware challenges analyzed

Session 55 is considering "The Deep Sea Challenge to Electronic Hardware Designers." Speakers are carrying the theme into such wide-ranging areas as sonar, scientific underseas instrumentation, propulsion machinery and controls for deep submersibles, and equipment for divers. The electronic hardware designer is challenged primarily by the severe ocean environment.

The experience of the U. S. Navy in using sonar in a variety of operational situations is the basis for a paper by Capt. S. W. W. Shor on sonar engineering. He is stressing the urgent need for sonar design based on proven principles.

Instrumentation for deep submersibles is discussed by George Tajima, vice president for systems development at Bissett-Berman, Santa Monica, Calif. He reviews the problems of gathering oceanographic data with instrumented buoy systems, describes some of his company's current projects and states the needs in the field.

The propulsion and control of deep submersibles, especially small versions for two and three men, present some unusual problems. Capt. F. A. Hooper of the Navy's Marine Engineering Laboratory describes progress in designing electric motors and furnishing the necessary power.

Before man can enter the sea at great depths and safely carry out explorations or perform work, he must have effective life-support and communications equipment. Martin Harrell of the Navy's Deep Submergence Systems Project Office reports on individual navigation systems and a translator to improve speech in a helium-oxygen atmosphere. The need for lightweight, high-capacity power sources is also outlined.

Instrumentation directions outlined

Session 65 describes new approaches to oceanographic instrumentation. Two University of Rhode Island oceanographers, for example, have found that underwater acoustic back-scattering from the ocean surface can be used to measure the roughness of the sea. Experiments in a model tank by R. F. Hill and L. O. Jacotin have demonstrated that the distortion of a back-scattered signal is directly proportional to the root mean square waveheight. The oceanographers are discussing the significance of their work at the session.

Digital hyperbolic chirp generators are being used by two oceanographers at Columbia University's Hudson Laboratories as signal sources in underwater research. M. Epstein and B. Harris are using the acoustic modulation scheme because the long-duration, wide-bandwidth signals are doppler invarient and acceleration intolerant. Their report to the session notes the high cross-correlation for signals on the order of 10 seconds long.

An "in situ" temperature-salinity depth recorder that transmits continuous records to the deck of a ship is discussed by T. M. Dauphinee of Canada's National Research Council. The instrument can record data effectively when the measuring head is raised and lowered as rapidly as 2 to 4 meters a second.

Litton Industries' Amecom Div. has developed an oceanographic instrument system that includes modules for sensing conductivity, temperature, pressure, water speed and direction. Lawrence R. Murdock of the company describes how the system telemeters the data to an off-shore tower in a digital format by means of an inductive power link. A deck unit provides automatic programming on magnetic tape.

The long-awaited introduction to the laser as an oceanographic instrument will be made in session 65. Ronald L. Kirk of Electro-Optical Systems, Inc., Pasadena, Calif., will describe a practical laser instrumentation scheme that can be used to measure sea surface parameters from aircraft. Amplitude, length, and direction of waves as well as the direction and velocity of surface winds can be determined.

The laser technique is tested and evaluated with an indoor water tank and air-circulation system that can produce a variety of wind and wave conditions.

—*Neil Sclater*

Systems and Reliability Engineer

Specialized reports limit interest for designers

The hardware-oriented atmosphere of much of the IEEE show has left its mark on the technical programs dealing with reliability. The practical, generalized viewpoint, based on test results, dominates the mathematical approach in papers. Engineers will have to interpret most of the conclusions to fit their own special problems.

Reliability-minded engineers can find discussions ranging from the evaluation of huge systems to the latest techniques in predicting performance. The reliability of electronic switching systems is under scrutiny in Session 66. Field reliability and maintenance data for electronic systems are compared with electromechanical ones. For example, the experience of Standard Elektrik Lorenz AG in Stuttgart, Germany, is reported by H. Willrett. He shows that a partly electronic system that combines electronic components with dry-reed contacts has excellent reliability. Figures for dry-reed contacts are compared with those of routing transistors to support his conclusion.

To predict the performance of subsystems, engineers can either apply statistical techniques or build a prototype and test it. In many instances it is more convenient to build the prototype; it is easier, for example, to put together a network and test it than to establish a mathematical model. Infrared detection offers a nondestructive versatile technique that can solve many problems that evade more conventional methods. Session 61 demonstrates that infrared detection is finally making the transition from the laboratory to practical technique. It is being used to check and maintain a wide range of engineering products, from jet rotor blades to semiconductors, according to Dr. Riccardo Vanzetti of the Raytheon Co., Wayland, Mass.

The infrared profile of the device under test indicates the temperature distribution, Dr. Vanzetti notes, and this reveals physical conditions that pass undetected with other checking techniques. By pinpointing thermal conditions in a printed-circuit board, for example, temperature-sensitive semiconductors can be protected against early failure due to heat. Unexpected hot spots in a circuit may indicate an error in component selection, a wrong connection or a bad weld.

Dr. Vanzetti has developed a pushbutton troubleshooter that permits a quick look at the thermal interaction on a printed-circuit board. Such a board may contain hundreds of components, and the complex thermal interaction cannot be analyzed by the designer.

"Only a computer program can give the correct information," Dr. Vanzetti says. "The designer can only make assumptions."

The automatic troubleshooter can analyze a printed-circuit panel in 100 seconds.

Infrared techniques can also be used to check bonding between metals, according to Dr. E. W. Kutzscer of the Lockheed-California Co., Burbank (Session 61). The method described is especially useful in testing jet rotor blades and honeycomb structures. In both cases good bonding between metals is essential. Imperfect bonding can cause delamination, which may eventually lead to the complete destruction of the blade.

Infrared detection also allows very precise control of welding—essential in the interconnections of integrated circuits, for example. S. N. Bobo of the Raytheon Co., Waltham, Mass., has built a novel sensor with optical fibers and a silicon photodetector that looks at the weld while it is being done. He describes the setup in Session 61. The optical fibers transmit the temperature of the molten metal—in the gap between the two parallel electrodes of the welding gun—to the detector. A feedback loop connects the detector to the current control of the gun. Therefore it is possible to maintain the optimum temperature for the optimum time required for perfect welding. The temperature pulse of the weld is displayed on an oscilloscope, mainly to check the cooling process. Fast cooling means good thermal conductivity between the metals and a good weld. Slow cooling means high thermal resistivity and a poor weld.

—*Maria Dekany*

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Technical Program

When, where and what to hear at IEEE

Here's a complete guide to all the technical papers at the show. The day, time and place for each paper are included.

Technical papers are grouped in these categories:

Airborne Electronics
Antennas and Scattering Techniques
Circuits
Circuit Theory
Communications
Components
Computer-Aided Design
Computers
Control Systems
Cybernetics
Engineering Education
Industrial Electronics
Lighting
Management
Materials
Medical Electronics
Microelectronics
Microwaves
Military Electronics
Municipal Planning
Nuclear Electronics
Oceanography and Underwater Systems
Power Generation and Control
Reliability
Sensing and Measuring
Signal Processing
Solid-State Devices and Theory
Space Electronics
System Engineering
Television
Test Equipment and Techniques
Transportation

Airborne Electronics

The Application of Overstress Testing to Failure to Airborne Electronics, A Status Report—*J. J. Bussolini, Grumman Aircraft Engineering Corp. (9.1, Mon./a.m./SS)*

Trouble/Failure Reporting System for Surveyor Spacecraft—*F. A. Paul, Jet Propulsion Lab. (9.5, Mon./a.m./SS)*

National Airspace System Enroute—*F. K. Seward, IBM-NAFEC (14.4, Mon./p.m./R)*

Communication Transmission Requirements as Seen by Astronauts and Aquanauts—*Scott Carpenter, Manned Spacecraft Center (72.5, Thurs./p.m./SN)*

Antennas and Scattering Techniques

The Use of Multi-Parameter Radar Imagery for the Discrimination of Terrain Characteristics—*R. D. Ellermeier, D. S. Simonett, L. F. Dellwig, Univ. of Kansas (70.1, Thurs./p.m./RS)*

Electromagnetic Scattering Phenomena Associated with Extended Surfaces—*J. J. Schindler, Air Force Cambridge Research Lab. (70.2, Thurs./p.m./RS)*

Direct Backscatter of HF Radio Waves from Land, Sea, Water and Ice Surfaces—*G. H. Hagn, Stanford Research Institute (70.3, Thurs./p.m./RS)*

Generalized Surface Impedance Properties—*R. K. Ritt, K. M. Siegel, Conductron Corp. (70.4, Thurs./p.m./RS)*

Antenna Processing for High-Resolution Mapping—*A. A. Ksienski, Hughes Aircraft Co. (70.5 Thurs./p.m./RS)*

Circuits

Microwave Control Circuits—*D. H. Temme, MIT Lincoln Lab. (7.4, Mon./a.m./RS)*

Design of Filters with Arbitrary Passband and Cheybyshev Stopband Attenuation—*G. C. Temes, M. Gyi, Ampex Corp. (23.1, Tues./a.m./R)*

F. E. T. Chopper Circuits for Low Level Signals—*J. J. Hitt, G. Mosley, Leeds and Northrup (59.3, Thurs./a.m./R)*

Amplifier Designs Using Repetitive Stabilized Gain Elements—*G. W. Haines, B. E. Amazeen, Sprague Electric Co. (69.1, Thurs./p.m./RN)*

Realization of Real Transmission Zeros Using Uniform Distributed RC Networks with Common Ground Connections—*J. J. Stein, Hughes Aircraft Co.; S. S. Shamis, J. H. Mulligan, Jr., City Univ. of New York (69.2, Thurs./p.m./RN)*

Circuit Theory

Design of Filters with Arbitrary Passband and Chebyshev Stopband Attenuation—*G. C. Temes, M. Gyi, Ampex Corp. (23.1, Tues./a.m./R)*

On the State Model Approach to the Realization of Portless RLC Networks—*Y. Tokad, J. C. Nordgren, Michigan State Univ. (23.2, Tues./a.m./R)*

Canonic and State Variable Characterization of Networks with Variable Elements—*N. DeClaris, R. Saeks, Cornell Univ. (23.3, Tues./a.m./R)*

Stable Realization of Impulse Response Matrices—*L. M. Silverman, Univ. of California (23.4, Tues./a.m./R)*

Multivariable Network Functions—*S. O. Scanlan, Leeds Univ., England (23.5, Tues./a.m./R)*

Computer Recognition of the Brain's Visual Perception Through Learn-

Guide to abbreviations

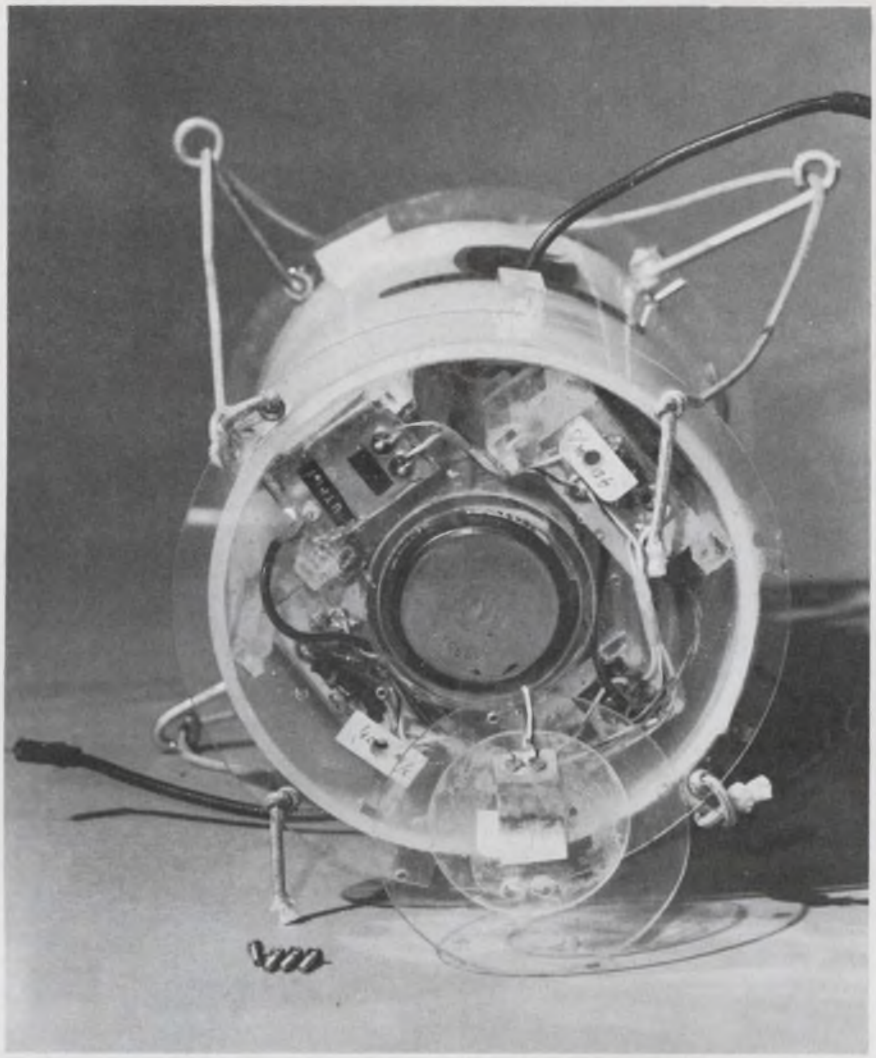
Session locations in the New York Hilton are:

- **G**—Gramercy Suite
- **MH**—Murray Hill Suite
- **N**—Nassau Suite
- **R**—Regent Room
- **SN**—Sutton Ballroom North
- **SS**—Sutton Ballroom South
- **RS**—Rhinelander Gallery South
- **RN**—Rhinelander Gallery North

Numerals refer to sessions and to papers in a session—for example, 14.2 is paper 2 of session 14.

The schedule for the technical sessions is:

Mon. 9:30 a.m.—12.00 noon
2:00 p.m.—4.30 p.m.
Tues. 9:00 a.m.—11:30 a.m.
Wed. &
Thurs. 2:00 p.m.—4:30 p.m.



Balloon-borne refractometer measures radio propagation in the lower atmosphere. The unit contains two 400-MHz vhf transmitters, temperature and refraction sondes, and battery (Paper 3/1).

ing the Brain's Physiologic Language—*Manfred Clynes, M. Kohn, J. Gradijan, Rockland State Hospital (29.5, Tues./p.m./MH)*

Numerical Methods of Network Analysis—*E. H. Branin, International Business Machines Corp. (42.1, Wed./a.m./RN)*

Network Analysis for Systems Applications: Present Capabilities of a Maintained Computer Program—*W. W. Happ, NASA (42.2, Wed./a.m./RN)*

A Program for Time-Shared Analysis of Nonlinear Electronic Circuits—*J. Katznelson, D. Evans, H. Lee, MIT (42.3, Wed./a.m./RN)*

NET-2 Circuit Analysis Program—*A. F. Malmberg, Los Alamos Scientific Lab. (42.4, Wed./a.m./RN)*

OLCA: AN On-Line Circuit Analysis System—*H. C. So, Bell Telephone Labs., Inc. (42.5, Wed./a.m./RN)*

Multilevel Design of Modern Networks: Summary—*J. D. Schoeffler, Case Institute of Technology; A. D. Waren, Cleveland State Univ. (51.1, Wed./p.m./RN)*

An Efficient Method for Numerical Laplace Transform Inversion Based on Error Control—*Michael Silverberg, Columbia Univ. (51.2, Wed./p.m./RN)*

Time-Domain Synthesis Using Linear and Quadratic Programing—*J. O. Bergholm, K. A. Fegley, Univ. of Pennsylvania (51.3, Wed./p.m./RN)*

One-Port Design for Prescribed Constant Phase Angle or Imaginary Part—*S. D. Bedrosian, D. B. Luber, Univ. of Pennsylvania (51.4, Wed./p.m./RN)*

A General-Purpose System of Digital Computer Codes for Linear/Nonlinear Network and System Analysis—*C. T. Kleiner, E. D. Johnson, W. D. Ashcraft, North American Aviation, Inc. (51.5, Wed./p.m./RN)*

Communications

An All-Solid-State Broadband 2-GHz Communication System—*K. Yamazaki, K. Takeda, M. Ogi, T. Sekizawa, J. Dodo, Fujitsu Labs. (3.2, Mon./a.m./MH)*

Design of Space Diversity Systems for Line-of Sight Microwave Links—*H. Makino, K. Morita, Nippon Telegraph and Telephone Co. (3.3, Mon./a.m./MH)*

Colorado River Storage Project Communication System—*A. H. Siniawsky, Stromberg-Carlson Co. (3.4, Mon./a.m./MH)*

Adaptive Control of Modulation Index in Tropo Scatter Communications—*R. T. Adams, J. Harvey, J. Craw-*

Highlight symposium

Exploitation of the World's Oceans (Tues./8:00-10:30 p.m./Grand Ballroom)

Keynote address: Goals being Developed by the U.S. National Council on Marine Resources and Engineering Development

Panel discussion—S.R. Keim, National Academy of Engineering; Richard Fuller, Bendix Corp.; R.W. Morse, Case Institute of Technology; Dr. C.M. Herzfeld, Director, Advanced Research Projects Agency, Dept. of Defense *ford, Communication Systems, Inc. (3.5, Mon./a.m./MH)*

Planning and Producing Better Visual Presentations—*J. T. McGarry, Eastman Kodak Co. (6.1, Mon./a.m./RN)*

Speech Compression in Theory and Practice: A Lecture-Demonstration —*S. F. Temmer, Gotham Audio Corp. (6.2, Mon./a.m./RN)*

The Implications of Speech Compression for Academic and Industrial Education—*Sam Duker, Brooklyn College (6.3, Mon./a.m./RN)*

Low-Noise Microwave Receivers—*W. G. Matthei, Micro State Electronics Corp. (7.2, Mon./a.m./RS)*

Coordination Activity Directed Toward Worldwide Standards—*C. R. Williamson, American Telephone & Telegraph Co. (12.1, Mon./p.m./MH)*

Military Global Networks—*Brig. Gen. J. B. James, Deputy Commanding General, U. S. Army Strategic Command (12.2, Mon./p.m./MH)*

Interface Between Global and Military Networks—*Robert Bright, Director Government Command Project, Western Electric Co. (12.3, Mon./p.m./MH)*

Civilian West European Fixed and Mobile Communications Related to Military Requirements—*General Edmond Combaux (12.4, Mond./p.m./MH)*

Data Rate and Reliability Requirements for Global Transfer in Terms of the Basic Properties of the Various Tandem Channels—*Steven Sussman, Adcom Inc. (12.5, Mon./p.m./MG)*

Satellite Communications in Global Networks, Including Mobile and Avionic Applications—*S. P. Brown, U. S. Army Satellite Command Agency (12.6, Mon./p.m./MH)*

Interconnecting Tactical and Strategic Networks—*Lorend Diedrickson, Office U. S. Project Manager, Project MALARD (12.7, Mon./p.m./MH)*

Testing the NORAD Command and Control System Man-Machine Interface—*R. T. Stevens, The Mitre Corp. (14.2, Mon./p.m./R)*

Design and Application of Multichannel Long-Haul Electronic Distribution System—*W. T. Smith, Superior Cable Corp. (21.1, Tues./a.m./MH)*

Field Evaluation of Cable Temperature Effects on Exchange Loop and Trunk Plant—*D. H. Potter, General Telephone Co. of Calif. (21.2, Tues./a.m./MH)*

Measurement of Unbalance Attenuation—*L. O. Olson, Western Electric Co., Inc.; J. C. Mau, General Telephone Co. of Florida (21.3, Tues./a.m./MH)*

Compact Solid-State Automatic Level Measuring Set—*C. B. Crane, Jr. Northeast Electronics Corp. (21.4, Tues./a.m./MH)*

A New System for Continuous Wide-Band Negative Impedance Coupling for Communication Facilities—*P. G. Lambidakis, Rural Electrification Administration (30.1, Tues./p.m./MH)*

The Role of Telecommunications in Supporting Domestic Goals—*H. R. Johnson, USAF Office of Telecommunications Management, Executive Office of the President (30.2, Tues./p.m./MH)*

Power Addition of Independent Random Variables Normally Distributed on a dB Scale—*Matthew Derzai, American Telephone & Telegraph Co. (30.3, Tues./p.m./MH)*

A New 25-MHz Transmission Measuring Set for High-Capacity Coaxial Carrier Systems—*H. H. Freytag, D. Seidel, Siemens America, Inc. (30.4, Tues./p.m./MH)*

Allocation of Multiple-Access Satellites to Multiantenna Terminals—*R. J. Hepps, A. L. Cohen, System Sciences Corp. (36.1, Tues./p.m./SS)*

A Frequency Time-Hopping Random Access Technique for Satellite Communications—*J. H. Wittman, Sylvania Electronic Systems (36.2, Tues./p.m./SS)*

Experimental Determination of Intermodulation Distortion Produced in a Wideband Communications Repeater—*A. L. Berman, I. E. Podraczky, Communication Satellite Corp. (36.3, Tues./p.m./SS)*

Ranging the 1967 Mariner to Venus—*R. C. Tausworthe, Jet Propulsion Lab. (36.4, Tues./p.m./SS)*

Techniques for Altering the Properties of Re-entry Plasmas—*M. P. Bachynski, A. I. Carswell, B. W. Gibbs, RCA Victor Research Labs. (36.5, Tues./p.m./SS)*

Dynamic capacitor housed in vacuum tube is part of electrometer that measures currents down to 10^{-17} amps (Paper 59/4).

Advances in the Facsimile Art during 1966—*W. H. Bliss, Radio Corp. of America (39.1, Wed./a.m./MH)*

Advances in Display Telegraphy—*C. R. Fisher, Stromberg-Carlson Co. (39.2, Wed./a.m./MH)*

Advances in Printing Telegraphy—*W. Y. Lang, Teleprinter & Data Apparatus (39.3, Wed./a.m./MH)*

The Touch-Tone Telephone Transmission of Digital Information—*J. H. Soderberg, R. R. Campbell, Bell Telephone Labs., Inc. (39.4, Wed./a.m./MH)*

Synchronous-Asynchronous Data Converter—*J. Deregnaucourt, Northern Electric Co., Ltd. (48.4, Wed./a.m./MH)*

New Horizons in Communications—*J. R. Pierce, Bell Telephone Labs., Inc. (52.1, Wed./p.m./RS)*

New Horizons in Television and Broadcasting—*G. H. Brown, Radio Corp. of America (52.2, Wed./p.m./RS)*

Analog Message Transmission: Bounds and System Performance Comparisons—*H. L. Van Trees, MIT (54.1, Wed./p.m./SS)*

Theoretical Ideals and Their Practical Attainment for Digital Communication on Telephone Channels—*R. W. Lucky, Bell Telephone Labs., Inc., (54.2, Wed./p.m./SS)*

Fading Radio Channels in Telecommunications—*B. B. Barrow, Sylvania Electronics Systems (54.3, Wed./p.m./SS)*

A Study of Codes for Deep Space Telemetry—*D. R. Lumb, NASA (54.4, Wed./p.m./SS)*

The Atmosphere as an Optical Communication Channel—*E. V. Hoversten, MIT (54.5, Wed./p.m./SS)*

New Services for Residential Telephone Customers—*R. E. Fortenberry, American Telephone and Telegraph Co. (57.1, Thurs./a.m./MH)*

Implementation of New Services for Residential Customers—*W. Whitney, Bell Telephone Labs., Inc. (57.2, Thurs./a.m./MH)*

Custom Calling Services—*M. H. Bland, W. H. Stewart, Stromberg-Carlson Corp. (57.3, Thurs./a.m./MH)*

New Services in PBX and Centrex Systems—*V. W. Witkus, American Telephone and Telegraph Co. (57.4, Thurs./a.m./MH)*

Implementation of New Services in PBX and Centrex Systems—*D. L. Rodkin, Bell Telephone Labs., Inc. (57.5, Thurs./a.m./MH)*

Field Experience with Quasielectronic Telephone Switching Systems—*H. Willrett, Standard Elektrik Lorenz AG (66.1, Thurs./p.m./MH)*

Reliability and Field Experience of Electronic Switching Systems—*W. P. Karas, Stromberg-Carlson Co. (66.2, Thurs./p.m./MH)*

Early No. 1 ESS Field Experiences, Part I: Two-Wire System for Commercial Applications—*G. Haugk,* *Bell Telephone Labs., Inc. (66.3, Thurs./p.m./MH)*

Early No. 1 ESS Field Experiences, Part II:Four-Wire System for Government and Military Applications—*H. N. Seckler, Bell Telephone Labs., Inc. (66.4, Thurs./p.m./MH)*

Electronic Reliability in the Field—*T. F. A. Urben, John Lawrence, British Post Office (66.5, Thurs./p.m./MH)*

Communication Transmission Requirements as Seen by Astronauts and Aquanauts—*Scott Carpenter, Manned Spacecraft Center (72.5, Thurs./p.m./SS)*

Components

Microwave Delay Lines—*R. W. Damon, Sperry Rand Research Center (7.3, Mon./a.m./RS)*

Microwave Filters—*Leo Young, Stanford Research Institute (7.5, Mon./a.m./RS)*

Design of Filters with Arbitrary Passband and Chebyshev Stopband Attenuation—*G. C. Temes, M. Gyi, Ampex Corp. (23.1, Tues./a.m./R)*

Comparison of Microwave Tubes for Phased Array Radar Transmitter Application—*Laurence Clampitt, R. A. Handy, N. W. Huse, Raytheon Corp., (24.1, Tues./a.m./RN)*

Modern Image Tubes and Their Applications—*Jay Burns, Northwestern Univ. (24.3, Tues./a.m./RN)*

Computer CRT Application and Future CRT Requirements—*G. M. Krems, International Business Machines Corp., (24.4, Tues./a.m./RN)*

Advances in Gas Lasers—*P. O. Clark, Hughes Research Labs. (33A.1, Tues./p.m./RN)*

Dispersive and Nondispersive IF Ultrasonic Delay Lines—*J. H. Eveleth, Anderson Labs., Inc. (49.1, Wed./p.m./N)*

Delay Line Transducer Materials—*D. A. Berlincourt, Clevite Corp. (49.2, Wed./p.m./N)*

Monolithic Crystal Filters—*R. A. Sykes, W. L. Smith, W. J. Spencer, Bell Telephone Labs., Inc. (49.4, Wed./p.m./N)*

Computer-Aided Design

Numerical Methods of Network Analysis—*E. H. Branin, International Business Machines Corp. (42.1, Wed./a.m./RN)*

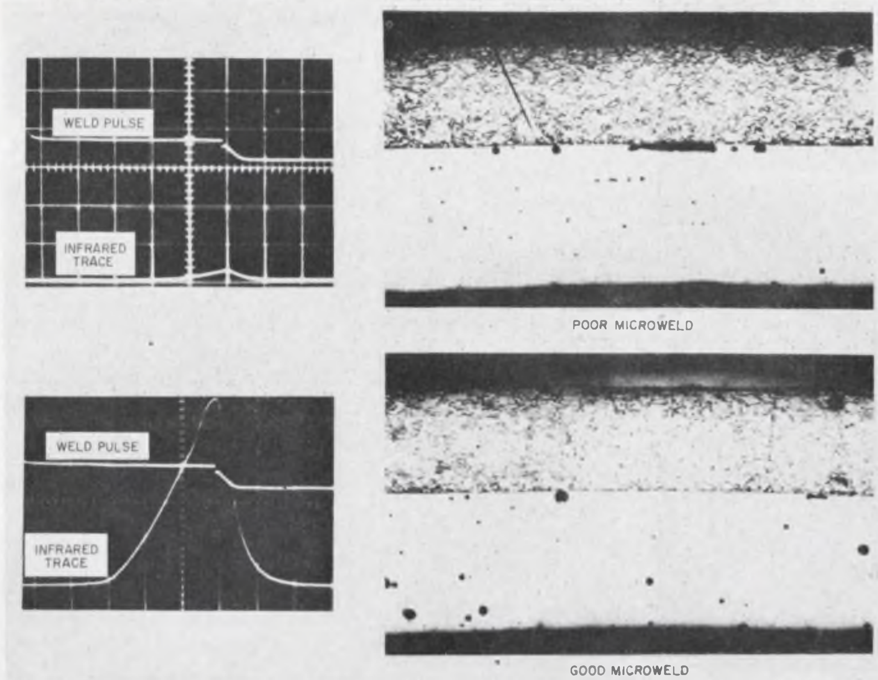
Network Analysis for Systems Applications: Present Capabilities of a Maintained Computer Program—*W. W. Happ, NASA (42.2, Wed./a.m./RN)*

A Program for Time-Shared Analysis of Nonlinear Electronic Circuits—*J. Katznelson, D. Evans, H. Lee, MIT (42.3, Wed./a.m./RN)*

NET-2 Circuit Analysis Program—*A. F. Malmberg, Los Alamos Scientific Lab. (42.4, Wed./a.m./RN)*

OLCA: An On-Line Circuit Analysis System—*H. C. So, Bell Telephone Labs., Inc. (42.5, Wed./a.m./RN)*

Multilevel Design of Modern Networks: Summary—*J. D. Schoeffler, Case Institute of Technology; A. D. Waren, Cleveland State Univ. (51.1, Wed./p.m./RN)*



Infrared detection picks out bad welds that would be passed by qualified visual inspection (top). On the oscilloscope (top left) the feeble thermal response calls attention to the large void in the joint (top right). A large response with exponential decay (bottom left) characterizes good thermal conductivity through the joint. Note that the void disappeared (bottom right) from the welded joint. (Session 61).

An Efficient Method for Numerical Laplace Transform Inversion Based on Error Control—*Michael Silverberg, Columbia Univ. (51.2, Wed./p.m./RN)*

Time Domain Synthesis Using Linear and Quadratic Programing—*J. O. Bergholm, K. A. Fegley, Univ. of Pennsylvania (51.3, Wed./p.m./RN)*

One-Port Design for Prescribed Constant Phase Angle or Imaginary Part—*S. D. Bedrosian, D. B. Luber, Univ. of Pennsylvania (51.4, Wed./p.m./RN)*

A General-Purpose System of Digital Computer Codes for Linear Network and System Analysis—*C. T. Kleiner, E. D. Johnson, W. D. Ashcraft, North American Aviation Inc. (51.5, Wed./p.m./RN)*

An Application of Computer-Aided Design Methods to the Near Optimal Control of a Damped Second-Order System—*W. L. Nelson, Bell Telephone Labs., Inc. (56.1, Thurs./a.m./MH)*

Computers

Time-Shared Computers in Design Education—*P. T. Shannon, Myron Tribus, S. A. Gembicki, Dartmouth College (1.1, Mon./a.m./G)*

Strategies for Design of Computer Aided Learning Exercises—*K. L. Zinn, Univ. of Michigan (1.2, Mon./a.m./G)*

The Eliza Program:Conversational Tutorial—*E. F. Taylor, MIT (1.3, Mon./a.m./G)*

Teaching by a Computer-base Instructional System—*D. L. Bitzer, Univ. of Illinois (1.4, Mon./a.m./G)*

Computational Aspects of Dynamic Programing—*R. Larson, Stanford Research Institute (2.3, Mon./a.m./MH)*

Rules for Applying Error Correcting Code to Computers—*D. Goldman, Hofstra Univ. (9.2, Mon./a.m./SS)*

DDC:Total Systems Approach—*W. Brandt, S. Opie, General Electric Co. (14.1, Mon./p.m./R)*

Integration of a Digital Computer into a Maneuvering Re-entry Vehicle—*H. Most, General Electric Co. (14.3, Mon./p.m./R)*

National Airspace System En Route—*F. K. Seward, IBM-NAFEC (14.4, Mon./p.m./R)*

Modern Image Tubes and Their Applications—*J. Burns, Northwestern Univ. (24.3, Tues./a.m./RN)*

Computer CRT Application and Future CRT Requirements—*G. M. Krembs, International Business Machines Corp. (24.4, Tues./a.m./RN)*

The Evolution of Computer Operating Systems—*W. C. Lynch, Case Institute of Technology (25.1, Tues./a.m./RS)*

Time-Sharing Systems: A Review—*B. W. Arden, Univ. of Michigan (25.2, Tues./a.m./RS)*

Computer Recognition of the Brain's Visual Perception Through Learning the Brain's Physiologic Language—*M. Clynes, M. Kohn, J. Gra-*

Panel discussions

Electromagnetic Compatibility in System Design—*J. Cohen, J. Roman, R. W. Evans and W. D. McKerchar (5, Mon./a.m./R)*

Avionics Systems for Rotary Wing Aircraft—*L. G. Cullahan, Jr. and H. S. Oakes (8, Mon./a.m./SN)*

Integrated Avionics: Today and Tomorrow—*W. P. Beese, J. Cohen, W. H. Barnard, H. Davis, L. S. Guarino and A. J. Stanziano (17, Mon./p.m./SN)*

The Computer for Basic Research in the Humanities and Behavioral Science—*I. Kayton, R. N. Freed, S. P. Sims, L. E. Allen, A. A. Leban and F. Kort (22, Tues./a.m./N)*

On-Board Checkout for Aerospace Systems—*Dr. R. W. Lanzkron, R. A. Neilson, Col. R. Powell and S. K. Sezack (26, Tues./a.m./ SN)*

Managerial Action and Organizational Effectiveness—*E. J. Tangerman, J. W. Haanstra, J. R. Ragazzine, R. R. Ritti, T. E. Woodruff and H. Zahl (31, Tues./p.m./N)*

How to Apply System Analysis Properly to Biological Systems—*G. Biernson, E. F. MacNichol, Jr., H. R. Blackwell, J. Lettvin and L. Stark (34, Tues./p.m./RS)*

The Impact of EDP on Engineers and Management—*J. P. Craven, A. G. Beged Dov, J. W. Forrester and H. M. Sarasohn (41, Wed./a.m./R)*

Exploitation of the World's Oceans II—*D. Alverson, A. Berman, R. B. Kershner and W. H. Scott (44, Wed./a.m./SN)*

The Electronics Industry: An Outlook for Engineers and Management—*A. H. Hartman, G. Howick, E. D. Kenna, W. Davis, G. A. Lodge and J. Stegner (62, Thurs./a.m./SN)*

Speech: Man's Natural Communication—*J.C.R. Licklider, G. A. Miller, J. Bram, F. S. Cooper, J. Lotz and M. R. Schroeder (63, Thurs./a.m./SS)*

Electrical Corona—*E. R. Bunker, Jr., T. Dakin, L. J. Frisco, L. W. Kirkwood, R. Lee and J. R. Perkins (64, Thurs./p.m./G)*

dijan, Rockland State Hospital (27.3, Tues./a.m./SS)

Electromechanical Control of an Artificial Leg—*G. D. Summers, Fairchild Hiller Corp. (27.5, Tues./a.m./SS)*

An Application of Analog Computer to Solve the Two-Point Boundary-Value Problem for a Fourth-Order Optimal Control Problem—*V. J. Darcy, R. A. Hannen, Air Force Institute of Technology (29.1, Tues./p.m./MH)*

Numerical Methods of Network Analysis—*E. H. Branin, International Business Machines Corp. (42.1, Wed./a.m./RN)*

Network Analysis for Systems Applications: Present Capabilities of a Maintained Computer Program—*W. W. Happ, NASA (42.2, Wed./a.m./RN)*

A Program for Time-Shared Analysis of Nonlinear Electronic Circuits—*J. Katznelson, D. Evans, H. Lee, MIT (42.3, Wed./a.m./RN)*

NET-2 Circuit Analysis Program—*A. F. Malmberg, Los Alamos Scientific Lab. (42.4, Wed./a.m./RN)*

OLCA: An On-Line Circuit Analysis System—*H. C. So, Bell Telephone Labs., Inc. (42.5, Wed./a.m./RN)*

Measuring the Impact of Automation—*J. Duncan, Battelle Memorial Institute (47.1, Wed./p.m./MH)*

Impact of Automation in the Materials-Processing Industries—*H. R. Chope, Industrial Nucleonics Corp. (47.2, Wed./p.m./MH)*

Process Automation in the Petrochemical Industries—*T. M. Stout, Profimatics, Inc. (47.3, Wed./p.m./MH)*

Automation in the Telephone Industry—*S. Washburn, Bell Telephone Labs., Inc. (47.4, Wed./p.m./MH)*

Social Aspects of Automation—*R. L. Cosgriff, The Ohio State Univ., (47.5, Wed./p.m./MH)*

New Horizons in Computers and Information Processing—*R. M. Fano, MIT (52.3, Wed./p.m./RS)*

Conversations with Computer in the Operation of Sea Traffic Control—*J. S. Elmaleh, J. S. Gustaferro, N. S. Prywes, Univ. of Pennsylvania Thurs./p.m./N)*

Information Retrieval (71, Thurs./p.m/SN)

Control Systems

Computational Algorithms in Optimal Control—*R. Kopp et al, Grumman Aircraft Engineering Corp. (2.2, Mon./a.m./MH)*

Microwave Control Circuits—*D. H. Temme, MIT Lincoln Lab. (7.4, Mon./a.m./RS)*

Identification for Control Purposes—*J. Eaton, International Business Machines Corp. (11.2, Mon./p.m./MH)*

DDC: Total Systems Approach—*W. Brandt, S. Opie, General Electric Co. (14.1, Mon./p.m./R)*

Speed Control of the Finishing Train of Hot Bar Mill—*R. M. Benza, Univ. of Pittsburgh (19.1, Tues./a.m./G)*

Direct Digital Control of a Reversing Slabbing Mill—*L. R. Berry, T. H. Bloodworth, Allis-Chalmers Mfg. Co. (19.2, Tues./a.m./G)*

Computerizing a Cold-Rolling Mill—*R. E. Slater, C. E. Trott, Jr., General Dynamics Corp. (19.3, Tues./a.m./G)*

A Steel Mill Engineer's Viewpoint of Solid-State Electrical Equipment—*G. C. Gingher, Bethlehem Steel Corp. (19.4, Tues./a.m./G)*

Minimum Norm Control of Discrete Systems—*C. H. Wells, Redstone Arsenal (20.1, Tues./a.m./MH)*

A Tunable Design Procedure for DDC—*R. W. Koepcke, W. G. Tuel, Jr., International Business Machines Corp. (20.2, Tues./a.m./MH)*

Maximum Likely Estimation of Rational Transfer Function Parameters—*A. E. Rogers, Univ. of Delaware (20.3, Tues/a.m./MH)*

CESSAM: Conversion Equipment System, Surface-to-Air Missile—*K. S. Bonwit, Johns Hopkins Univ. (20.4, Tues./a.m./MH)*

An Application of Optimal Control Theory to the Control of Color on the Paper Machine—*P. R. Belanger, Foxboro Co. (20.5, Tues./a.m./MH)*

An application of an Analog Computer to Solve the Two-Point Boundary-Value Problem for a Fourth-Order Optimal Control Problem—*V. J. Darcy, R. A. Hannen, Air Force Institute of Technology (29.3, Tues./p.m./MH)*

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Systems—*W. I. Nagel, Westinghouse Electric Corp. (32.1, Tues./p.m./R)*

Achievements in Industrial Electronics and Control Instrumentation—*E. A. Weiss, Sun Oil Co. (38.1, Wed./a.m./MH)*

Representation and Identification of Nonlinear Systems—*R. L. Cosgriff, H. Hemami, Ohio State Univ. (56.2, Thurs./a.m./MH)*

Predicting the Nonlinear Operating Characteristics for a Two-Phase Servo Motor—*D. Springett, E. R. Corneil, Xerox Corp. (56.3, Thurs./a.m./MH)*

Evolution of Heuristics by Human Operators in Control Systems—*R. E. Thomas, J. T. Tou, Battelle Memorial Institute (67.1, Thurs./p.m./N)*

STSD: A Language for the Analysis of Military Command and Control Systems—*J. L. Bloom Franklin Institute Research Labs. (67.3, Thurs./p.m./N)*

Cybernetics

The Brain of Yesterday and Today—*W. R. Ashby, Univ. of Illinois (13.1, Mon./p.m./N)*

Information Processing in Highly Damped Neural Nets—*E. M. Harth, Univ. of Syracuse (13.2, Mon./p.m./N)*

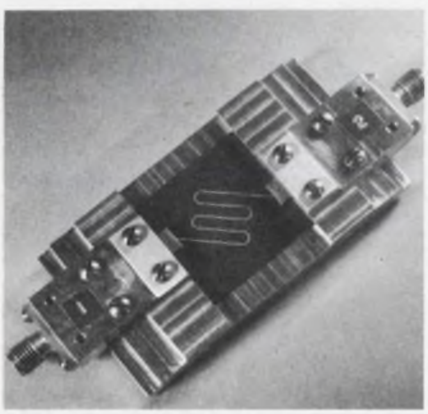
On the Applicability of Wiener's Canonical Expansion—*D. B. Brick, Information Research Associates (13.3, Mon./p.m./N)*

On the Complexity of Patterns—*L. N. Kanal, T. J. Harley, Jr., Philco-Ford Corp. (13.4, Mon./p.m./N)*

An Intelligent Automation—*C. A. Rosen, N. J. Nilsson, Stanford Research Institute (13.5, Mon./p.m./N)*

Engineering Education

Education: Technology's Stepchild—*J. G. Truxal, Polytechnic Institute of Brooklyn (10.1, Mon./p.m./G)*



Reciprocal latching phase shifter from Syracuse University Research Corp. has digital and analog control of the insertion phase in S-band. The ferrite planar substrate is 20 mils thick (Paper 16/1).

The Student-Machine Interface in Instruction—*Robert Glaser, Univ. of Pittsburgh, W. W. Ramage, Westinghouse Research Labs., (10.2, Mon./p.m./G)*

The Key Educational Problems Posed by Advancing Technology—*W. B. Shockley, Stanford Univ. (10.3, Mon./p.m./G)*

Behavioral Engineering and Educational Technology—*Israel Goldiamond, Institute of Behavioral Research (10.4, Mon./p.m./G)*

A Basic Introduction to Reliability Engineering—*H. C. Jones, Westinghouse Aerospace Div. (38.2, Wed./a.m./MH)*

New Horizons in Physics—*R. F. Sproull, Cornell Univ. (43.1, Wed./a.m./RS)*

New Horizons in Quantum Electronics—*Nicolaas Bloembergen, Harvard Univ. (43.2, Wed./a.m./RS)*

New Horizons in Chemistry—*F. W. Westheimer, Harvard Univ. (43.3, Wed./a.m./RS)*

New Horizons in Bio-Medicine (43.4, Wed./am.m./RS)

Industrial Electronics

DDC:Total Systems Approach—*W. Brandt, S. Opie, General Electric Co. (14.1, Mon./p.m./R)*

Achievements in Industrial Electronics and Control Instrumentation—*E. A. Weiss, Sun Oil Co. (38.1, Wed./a.m./MH)*

The Performance of the Two-Phase Induction Motor with Phase-Angle Control—*M. Ivison, Loughborough College of Technology, England (50.1, Wed./p.m./R)*

An Experimental Closed-Loop, Variable-Speed Drive Incorporating a Thyristor-Driven Induction Motor—*W. Shepherd, J. Stanway, Royal Military College of Science, England (50.2, Wed./p.m./R)*

Control and Protection of a dc Motor by Means of SCRs—*A. Alexandrovity, A. Emanuel-Eigles, Technion-Israel Institute of Technology (50.3, Wed./p.m./R)*

Test Circuit for Evaluation of Breaking Capacity of Motor Starters—*C. K. Eckels, L. H. Matthias, Allen-Bradley Co. (50.5, Wed./p.m./R)*

Overcurrent Protection Within the Motor Branch Circuit at Low Fault Currents—*R. E. Walters, Allen-Bradley Co. (50.5, Wed./p.m./o)*

A Direct Digital Control Stepping Motor Buffer—*K. J. Ayala, The Virginia Military Institute (56.4, Thurs/a.m./MH)*

Lighting

Equipment for Measuring Inrush Currents into Magnetic Components—*G. M. Bell, General Electric Co. (40.1, Wed./a.m./N)*

Study of Lighting Equipment in Corrosive Atmospheres—*C. B. Kenty, F. A. Stein, Holophane Co. (40.2, Wed./a.m./N)*

What's New in Lighting?—*R. Harz, Owens-Corning Fiberglas Corp. (40.3, Wed./a.m./N)*

Management

Measuring the Impact of Automation—*J. Duncan, Battelle Memorial Institute (47.1, Wed./p.m./MH)*

Social Aspects of Automation—*R. L. Cosgriff, Ohio State Univ. (47.5, Wed./p.m./MH)*

Registration—*H. A. Moench, Rose Polytechnic Institute (53.1 Wed./p.m./SN)*

Ethics—*R. L. Benford, Itek Corp. (53.2, Wed./p.m./SN)*

Intersociety Relations with the Professional Societies—*G. A. Kiessling, Radio Corp. of America (53.3, Wed./p.m./SN)*

Legislative Activities Affecting Engineers—*M. F. Lunch, National Society of Proefessional Engineers (53.4, Wed./p.m./SN)*

Materials

Introductory Remarks: The Materials/Design Interface—*A. E. Javitz, Commonwealth Services, Inc. (37.1, Wed./a.m./G)*

Materials Problems in Integrated Circuits—*J. E. Thomas, Jr., General Instrument Corp. (37.2, Wed./a.m./G)*

Semiconductor Materials for New Optical Devices—*L. A. D'Asro, Bell Telephone Labs., Inc. (37.3, Wed./a.m./G)*

Materials for Capacitor Dielectrics—*D. A. McLean, Bell Telephone Labs., Inc. (37.4, Wed./a.m./G)*

Materials for Conductive Elements, Part I and Part II—*J. Spergel, W. V. Lane, U. S. Army Electronics Command (37.5, Wed./a.m./G)*

Impact of Automation in the Materials-Processing Industries—*H. R. Chope, Industrial Nucleonics Corp. (47.2, Wed./p.m./MH)*

Delay Line Transducer Materials—*D. A. Berlincourt, Clevite Corp. (49.2, Wed./p.m./N)*

Medical Electronics

Effects of Laser Power on Living Tissue—*G. Riggle, R. Hoye, National Institutes of Health (18.1, Wed./p.m./SS)*

An Electronic Heart Motion Tracking System—*W. Schuette, Biotronex; A. L. Simon, National Institutes of Health (18.2, Wed./p.m./SS)*

Post Operative Monitoring—*J. Lewis, J. Jacobs, Northwestern Univ. (18.3, Wed./p.m./SS)*

A Method for Identifying Brain Structures During Parkinson Surgery—*A. Sauces, Jr., S. J. Larson, Marquette Univ. (18.4, Wed./p.m./SS)*

The Electrode Interface Between Man and a Prosthetic Stimulator—*W. Greatbatch, State Univ. of New York (27.1, Tues./a.m./SS)*

Endocrine Control Systems and the Control of Them—*F. E. Yates, Stanford Univ. (27.2, Tues./a.m./SS)*

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Those red and yellow ones at the left. They're for action, beyond the call of duty on a computer application. The little round one in the middle. Fighting at close quarters on a panel. The next two rows were on machine tools, office machines, guidance control and a few other items.

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ON READER-SERVICE CARD CIRCLE 68

Man's Intervention in Intracerebral Functions—*J. M. R. Delgado, Yale Univ. School of Medicine (27.4, Tues./a.m./SS)*

Electromechanical Control of an Artificial Leg—*G. D. Summers, Fairchild Hiller Corp. (27.5, Tues./a.m./SS)*

The Organism Reorganized?—*N. S. Kline, Rockland State Hospital (27.6, Tues./a.m./SS)*

Microelectronics

X-Ray Vidicon Analysis of Micro-electronics Devices—*H. F. Padden, Grumman Aircraft Engineering Corp. (9.4, Mon./a.m./SS)*

Linear Integrated Circuits: Today and Tomorrow—*R. S. Pepper, Sprague Electric Co. (15.1, Mon./p.m./RN)*

The Future Role of Field-Effect Devices in Electronics—*F. P. Heiman, Radio Corp. of America (15.2, Mon./p.m./RN)*

Microwave Hybrid Integrated Circuits—*J. E. Dalley, Bell Telephone Co. (16.2, Mon./p.m./R)*

Planar Ferrite Devices for Microwave Integrated Circuitry—*H. A Hair, Syracuse Univ. Research Corp. (16.3, Mon./p.m./R)*

Recent Advancements in Microwave Integrated Circuits Combining Semiconductor and Ferrimagnetic Elements—*J. C. Hoover, G. A. Foggiato, R. W. Peter, L. B. Valdes, Watkins-Johnson Co. (16.4, Mon./p.m./R)*

CESSAM:Conversion Equipment System, Surface-to-Air Missile—*K. S. Bonwit, Johns Hopkins Univ. (20.4, Tues./a.m./MH)*

Materials Problems in Integrated Circuits—*J. E. Thomas, Jr., General Instrument Corp. (37.2, Wed./a.m./G)*

Integrated Circuits: Their Current Technical and Economical Status—*E. F. Kvamme, Fairchild Semiconductor Co. (46.1, Wed./p.m./G)*

Monolithic Analog Circuits—*J. E. Solomon, Motorola, Inc. (46.2, Wed./p.m./G)*

MOS Devices and Arrays—*W. McKinley, Philco Microelectronics (46.3,* Wed./p.m./G)

Microwave Integrated Circuits—*R. Webster, Texas Instruments (46.4, Wed./p.m./G)*

Large-Scale Integration—*O. Baker, Signetics (46.5, Wed./p.m./G)*

New Horizons in Microelectronic Circuits and Systems—*N. F. Parker, North American Aviation, Inc. (52.4, Wed./p.m./RS)*

Functional Analysis of Integrated Digital Circuits—*J. J. Suran, General Electric Co. (60.1, Thurs./a.m./RN)*

Yield, Economic and Logistic Models For Complex Digital Arrays—*R. B. Seeds, Fairchild Semiconductor Corp. (60.2, Thurs./a.m./RN)*

Layout and Mask Generation in Large-Scale Integration—*D. L. Critchlow, International Business Machines Corp. (60.3, Thurs./a.m./RN)*

Discretionary Wiring: An Approach to Large-Scale Integration—*J. S. Kilby, Texas Instruments Inc. (60.4, Thurs./a.m./RN)*

Advanced Developments in Subnanosecond Integrated Logic Circuits—*J. A. Narud, Motorola Semiconductor Products Div. (60.5, Thurs./a.m./RN)*

An Integrated-Circuit Helmet Radio Receiver—*T. B. Quaid, Motorola, Inc. (69.3, Thurs./p.m./RN)*

The Application of Commercially Available Integrated Circuits in FM and AM Radio Receivers—*G. R. Madland, R. L. Hartley, Integrated Circuit Engineering Co. (69.4, Thurs./p.m./RN)*

An Integrated RC Oscillator for Touch Tone—*W. H. Orr, R. M. Rickert, D. M. Hill, Bell Telephone Labs., Inc. (69.5, Thurs./p.m./RN)*

Microwaves

Design of Space Diversity Systems for Line-of-Sight Microwave Links—*H. Makino, K. Morita, Nippon Telegraph and Telephone Co. (3.3, Mon./a.m./MH)*

Solid-State Microwave Power Sources—*F. Sterzer, Radio Corp. of America (7.1, Mon./a.m./RS)*

Low-Noise Microwave Receivers—*W. G. Matthei, Micro State Electronics Corp. (7.2, Mon./a.m./RS)*

Microwave Delay Lines—*R. W. Damon, Sperry Rand Research Center (7.3, Mon./a.m./RS)*

Microwave Control Circuits—*D. H. Temme, MIT Lincoln Lab. (7.4, Mon./a.m./RS)*

Microwave Filters—*L. Young, Stanford Research Institute (7.5, Mon./a.m./RS)*

New Solid-State Devices for Microwave Power Generation—*M. R. Barber, Bell Telephone Labs., Inc. (15.4, Mon./p.m./RN)*

Microwave Semiconductor Devices—*R. R. Webster, Texas Instruments Inc. (16.1, Mon./p.m./R)*

Microwave Hybrid Integrated Circuits—*J. E. Dalley, Bell Telephone Labs., Inc. (16.2, Mon./p.m./R)*

Planar Ferrite Devices for Microwave Integrated Circuitry—*H. A. Hair, Syracuse Univ. Research Corp. (16.3, Mon./p.m./R)*

Recent Advancements in Microwave Integrated Circuits Combining Semiconductor and Ferrimagnetic Elements—*J. C. Hoover, G. A. Foggiato, R. W. Peter, L. B. Valdes, Watkins-Johnson Co. (16.4, Mon./p.m./R)*

Effects of Laser Power on Living Tissue—*G. Riggle, R. Hoye, National Institutes of Health (18.1, Mon./p.m./SS)*

Comparison of Microwave Tubes for Phased Array Radar Transmitter Application—*L. Clampitt, R. A. Handy, M. W. Huse, Raytheon Corp. (24.1, Tues./a.m./RN)*

Solid-State vs Gas Discharge Techniques for Microwave Duplexing —*G. Klein, Westinghouse Defense and Space Center (24.2, Tues./a.m./RN)*

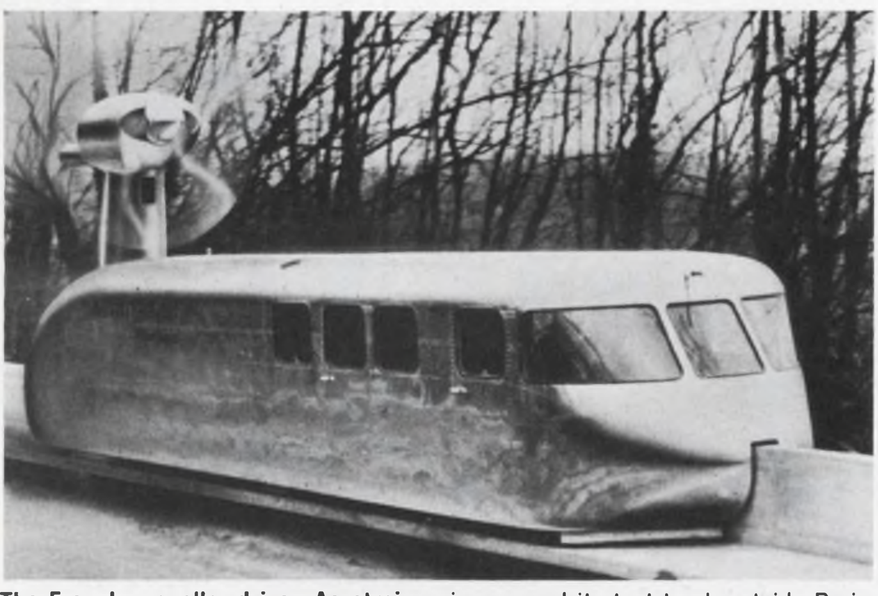
Microwave Scattering from Fluctuations in a Magnetoplasma—*R. F. Leheny, Y. G. Chen, T. C. Marshall, Columbia Univ. (28.3, Tues./p.m./G)*

Microwave Integrated Circuits—*R. Webster, Texas Instruments (46.4, Wed./p.m./G)*

Military Electronics

Military Global Networks—*Brig. Gen. J. B. James, Deputy Commanding General, U. S. Army Strategic Command (12.2, Mon./p.m./MH)*

Interface Between Global and Military



The French propellor-driven Aerotrain spins around its test track outside Paris. Clocked at 145 miles per hour, the French government and the French National Railroads are developing the Aerotrain for high-speed intercity passenger service (Session 58).

Networks—*R. Bright, Director Government Command Project, Western Electric Co. (12.3, Mon./p.m./MH)*

Civilian West European Fixed and Mobile Communications Related to Military Requirements—*General E. Combaux (12.4, Mon./p.m./MH)*

Data Rate and Reliability Requirements for Global Transfer in Terms of the Basic Properties of the Various Tandem Channels—*S. Sussman, Adcom Inc. (12.5, Mon./p.m./MH)*

Satellite Communications in Global Networks, Including Mobile and Avionic Applications—*S. P. Brown, U. S. Army Satellite Command Agency (12.6, Mon./p.m./MH)*

Interconnecting Tactical and Strategic Networks—*L. Diedrickson, Office U. S. Project Manager, Project MALARD (12.7, Mon./p.m./MH)*

Testing the NORAD Command and Control System Man-Machine Interface—*R. T. Stevens, The Mitre Corp. (14.2, Mon./p.m./R)*

Municipal Planning

Planners, Politicians and Popular Initiative: Squatter Settlements in Peru and Community Action in the U. S.—*W. Mangin, Univ. of Syracuse (4.1, Mon./a.m./N)*

Geometric Configurations: Their Systems and Social Implications—*W. A. Netsch, Skidmore, Owings and Merrill (4.2, Mon./a.m./N)*

Urban Structure—*C. Alexander, Univ. of California (4.3, Mon./a.m./N)*

The Urban Node in the Information Network—*P. Baran, Rand Corp; M. Greenberger, MIT (4.4, Mon./a.m./N)*

Nuclear Electronics

Progress in Controlled Thermonuclear Research—*A. S. Bishop, U. S. Atomic Energy Commission (28.1, Tues./p.m./G)*

Production of Dense Plasmas by Laser Radiation—*A. F. Haught, United Aircraft Research Labs. (28.2, Tues./p.m./G)*

Microwave Scattering from Fluctuations in a Magnetoplasma—*R. F. Leheny, Y. G. Chen, T. C. Marshall, Columbia Univ. (28.3, Tues./p.m./G)*

Oceanography and Underwater Systems

Design and Manufacture of Shipboard Centralized Engine-Room Control Systems—*W. I. Nagel, Westinghouse Electric Corp. (32.1, Tues./p.m./R)*

Shipboard Central Operation Systems: Design and Manufacture—*A. Nitsch, General Electric Co. (32.2, Tues./p.m./R)*

The Shipbuilder's Role in Shipboard Automation—*T. P. Campbell, W. E. Schmid, Sun Shipbuilding Co. (32.3, Tues./p.m./R)*

Operating Experience with Shipboard Engine Room Automation—*N. Bachko, United States Lines (32.4, Tues./p.m./R)*

A Retrospect on Automation in Marine Engineering—*E. C. Mericas, Lykes Brothers Steamship Co. (32.5, Tues./p.m./R)*

Sonar Engineering for Submarines and Underseas Use—*S. W. W. Shor, Department of the Navy (55.1, Thurs./a.m./G)*

Research and Development in Underseas Instrumentation—*George Tajima, Bissett-Berman (55.2, Thurs./a.m./G)*

Deep-Submergence Power Machinery and Controls—*J. F. McCartney, T. D. Morrison, Marine Engineering Lab. (55.3, Thurs./a.m./G)*

Delay-Line Memory and Time Compression Systems—*P. S. Fuss, Bell Telephone Labs., Inc. (55.4, Thurs./a.m./G)*

Sea-State Observation with a Continuous Underwater Acoustic Signal—*R. F. Hill, R. O. Jacotin, Univ. of Rhode Island (65.1, Thurs/p.m./MH)*

A Digital Hyperbolic Chip Generator for Oceanographic Applications—*M. Epstein, B. Harris, Columbia Univ., (65.2, Thurs./p.m./MH)*

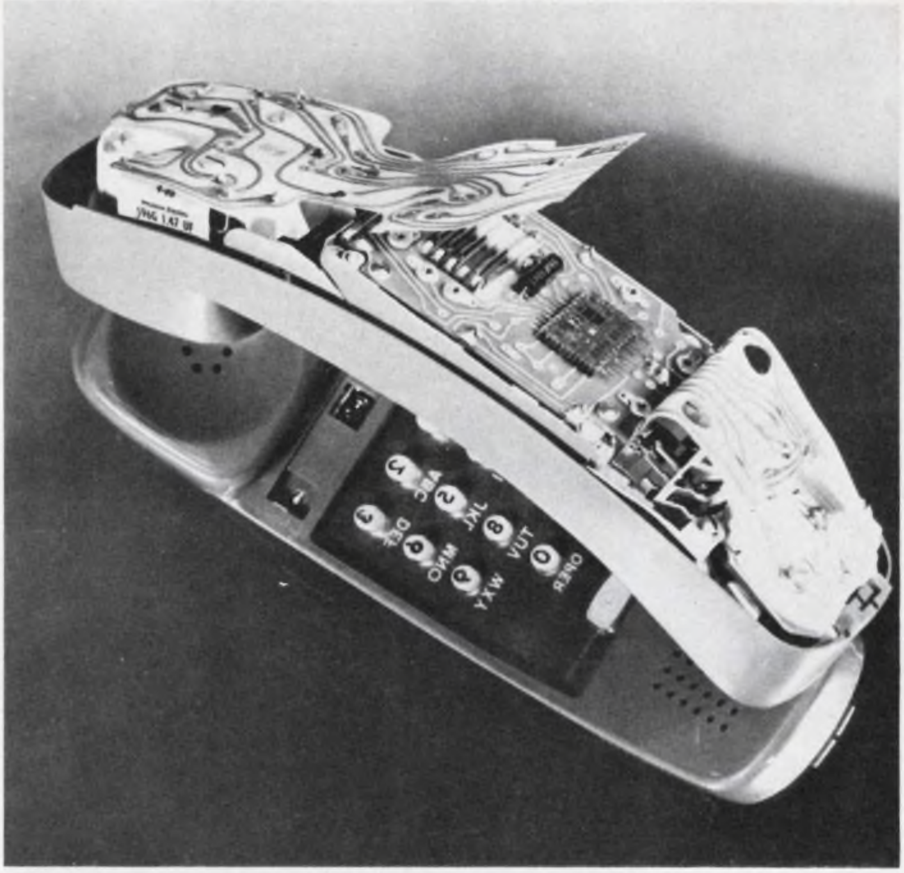
Ocean Surface Definition Utilizing Laser Techniques—*R. L. Kirk, Electro-Optical Systems, Inc. (65.3, Thurs./p.m./MH)*

An In Situ Temperature-Salinity-Depth Recorder for Oceanographic Applications—*T. M. Dauphinee, National Research Council (65.4, Thurs./p.m./MH)*

Digital Oceanographic Data Collection System for Off-shore Towers—*Lawrence Murdock, Litton Industries (65.5, Thurs./p.m./MH)*

Conversations with Computer in the Operation of Sea Traffic Control—*J. S. Elmaleh, J. S. Gustaferro, N. S. Prywes, Univ. of Pennsylvania (67.4, Thurs./p.m./N)*

Communication Transmission Requirements as Seen by Astronauts and Aquanauts—*Scott Carpenter, Manned Spacecraft Center (72.5, Thurs./p.m./SS)*



Integrated RC oscillators mounted in Touch-Tone telephone utilizes thin films and silicon beam leads. The microcircuits contain the equivalent of more than 50 discrete components (Paper 69/5).

Power Generation and Control

Solid-State Microwave Power Sources—*Fred Sterzer, Radio Corp. of America (7.1, Mon./a.m./RS)*

New Solid-State Devices for Microwave Power Generation—*M. R. Barber, Bell Telephone Labs., Inc. (15.4, Mon./p.m./RN)*

Progress in Controlled Thermonuclear Research—*A. S. Bishop, U. S. Atomic Energy Commission (28.1, Tues./p.m./G)*

Status of Thermionic Energy Conversion—*Ned Rasor (33B.1, Tues./p.m./RN)*

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The Application of Overstress Testing to Failure to Airborne Electronics: A Status Report—*J. J. Bussolini, Grumman Aircraft Engineering Corp. (9.1, Mon/a.m./SS)*

Rules for Applying Error Correcting Code to Computers—*D. Goldman, Hofstra Univ. (9.2, Mon./a.m./SS)*

A Method for Predicting System Down Time—*E. J. Muth, General Electric Co. (9.3, Mon./a.m./SS)*

X-Ray Vidicon Analysis of Microelectronics Devices—*H. F. Padden, Grumman Aircraft Engineering Corp. (9.4, Mon./a.m./SS)*

Trouble/Failure Reporting System for Surveyor Spacecraft—*F. A. Paul, Jet Propulsion Lab. (9.5, Mon./a.m./SS)*

Secondary Breakdowns in Power Transistors and Circuits—*W. C. Steffe, Fairchild Semiconductor Research & Development Labs. (15.3, Mon./p.m./RN)*

Sensing and Measuring

A New System for Continuous Wide-Band Negative Impedance Coupling for Communication Facilities—*P. G. Lambidakis, Rural Electrification Administration (30.1, Tues./p.m./MH)*

An Application of Mode-Locked, Laser-Generated Picosecond Pulses to the Electrical Measurement Art—*H. A. Heynau, A. W. Penney, Jr. United Aircraft Research Labs. (33A.2, Tues./p.m./RN)*

The Advantages of a Ten-Kilohm Transportable Resistance Standard—*R. M. Pailthorp, Electro Scientific Industries Inc. (59.1, Thurs./a.m./R)*

The Problems of dc Null Detection and Their Solution—*John Parnell, Frank Brem, Honeywell Inc. (59.2, Thurs./a.m./R)*

Measuring Currents Down to 10^{-17} Amps with a Low Noise Level by Means of a Dynamic Capacitor Electrometer—*A. G. van Nie, N. V. Philips' Gloeilampenfabrieken (59.4, Thurs./a.m./R)*

An Accurate, Semiautomatic Technique of Measuring High Resistances—*S. H. Tsao, National Research Council (59.5, Thurs./a.m./R)*

An Impedance Meter for Automatic Test Systems—*W. A. Plice, Honeywell Inc. (59.6, Thurs./a.m./R)*

Signal Processing

Rules for Applying an Error-Correcting Code to Computers—*D. Goldman, Hofstra Univ. (9.2, Mon./a.m./SS)*

Simplified Processing of Star Tracker Commands for Satellite Attitude Control—*R. D. Showman, Ames Research Center (29.4, Tues./p.m./G)*

Power Addition of Independent Random Variables Normally Distributed on a dB Scale—*Mathew Derzai, American Telephone & Telegraph Co. (30.3, Tues./p.m./MH)*

A Frequency Time-Hopping Random Access Technique for Satellite Communications—*J. H. Wittman, Sylvania Electronic Systems, (36.2, Tues./p.m./SS)*

Techniques for Altering the Properties for Re-entry Plasmas—*M. P. Bachynski, A. I. Carswell, B. W. Gibbs, RCA Victor Research Labs. (36.5, Tues./p.m./SS)*

An Adaptive Technique for Multiple Signal Detection and Identification—*J. W. Sammon, Rome Air Development Center (45.1, Wed./a.m./SS)*

Suboptimum Rank Detection Procedures Using Rank Vector Codes—*E. D. Stoll, Bell Telephone Labs., Inc.; Ludwik Kurz, City Univ. of New York (45.2, Wed./a.m./SS)*

Nonparametric Detection by Rank Statistics: A Unified View—*E. A. Feustel, L. D. Davisson, Princeton Univ. (45.3, Wed./a.m./SS)*

A Linear Residue Recurrent Code—*David Mandelbaum, Communication Systems, Inc. (45.4, Wed./a.m./SS)*

Digital Optimization of Exponential Representations of Signals—*R. W. Sears, Jr. (45.5, Wed./a.m./SS)*

Ternary Phase Difference Modulation for Data Transmission in Telephone Networks—*H. V. Voss, Siemens A. G. Central Labs., Germany (48.2, Wed./p.m./MH)*

Correlative Data Transmission with Coherent Recovery Using Absolute Reference—*Adam Lender, Lenkurt Electric Co., Inc. (48.3, Wed./p.m./MH)*

The Prevention of Transmission Buffer Overflow in Telemetry Data Compressors—*J. E Medlin, Lockheed Palo Alto Research Labs. (48.5, Wed./p.m./MH)*

Dispersive and Nondispersive IF Ultrasonic Delay Lines—*J. H. Eveleth, Anderson Labs., Inc. (49.1, Wed./p.m./N)*

Delay Line Transducer Materials—*D. A. Berlincourt, Clevite Corp. (49.2, Wed./p.m./N)*

Ultrasonic Light Modulation and Deflection—*Robert Adler, Zenith Radio Corp. (49.3, Wed./p.m./N)*

Delay Line Memory and Time Compression Systems—*P. S. Fuss, Bell Telephone Labs., Inc. (49.5, Wed./p.m./N)*

Correlation and Pulse Compression—*L. J. Cutrona, Conductron Corp. (49.6, Wed./p.m./N)*

A New High-Sensitive Subminiature Condenser Microphone—*Yasuhiro Rikow, Matsushita Communication Industrial Co., Ltd., Japan (72.1, Thurs./p.m./SS)*

Bandwidth Compression of Speech by Analytic-Signal Rooting—*M. R. Schroeder, J. L. Flanagan, E. A. Lundry, Bell Telephone Labs., Inc. (72.2, Thurs./p.m./SS)*

Experimental, Limited-Vocabulary Speech Recognizer—*C. F. Teacher, H. Kellett, L. Focht, Philco-Ford Corp. (72.3, Thurs./p.m./SS)*

Speech Processing Techniques and Applications—*H. F. Olson, H. Belar, E. S. Rogers, Radio Corp. of America (72.4, Thurs./p.m./SS)*

Communication Tranmission Requirements as Seen by Astronauts and Aquanauts—*Scott Carpenter, Manned Spacecraft Center (72.5, Thurs./p.m./SS)*

Solid-State Devices and Theory

Solid-State Microwave Power Sources—*Fred Sterzer, Radio Corp. of America (7.1, Mon./a.m./RS)*

The Future Role of Field-Effect Devices in Electronics—*F. P. Heiman, Radio Corp. of America (15.2, Mon./p.m./RN)*

Secondary Breakdowns in Power Transistors and Circuits—*W. C. Steffe, Fairchild Semiconductor Research & Development Labs. (15.3,* Mon./p.m./RN)

New Solid-State Devices for Microwave Power Generation—*M. R. Barber, Bell Telephone Labs., Inc. (15.4, Mon./p.m./RN)*

Microwave Semiconductor Devices—*R. R. Webster, Texas Instruments Inc. (16.1, Mon./p.m./R)*

Microwave Hybrid Integrated Circuits—*J. E. Dalley, Bell Telephone Labs., Inc. (16.2, Mon./p.m./R)*

Recent Advancements in Microwave Integrated Circuits Combining Semiconductor and Ferrimagnetic Elements—*J. C. Hoover, G. A. Foggiato, R. W. Peter, L. B. Valdes, Watkins-Johnson Co. (16.4, Mon./p.m./R)*

Space Electronics

Satellite Communications in Global Networks, Including Mobile and Avionic Applications—*S. P. Brown, U. S. Army Satellite Command Agency (12.6, Mon./p.m./MH)*

Integration of a Digital Computer into a Maneuvering Re-entry Vehicle—*Herb Most, General Electric Co. (14.3, Mon./p.m./R)*

Interaction of the Solar Wind with the Magnetosphere—*W. I. Axford, Cornell Univ. (28.4, Tues./p.m./R)*

Allocation of Multiple-Access Satellites to Multi-Antenna Terminals—*R. J. Heppe, A. L. Cohen, System Sciences Corp. (36.1, Tues./p.m./SS)*

A Frequency Time-Hopping Random Access Technique for Satellite Communications—*J. H. Wittman, Sylvania Electronic Systems (36.2, Tues./p.m./SS)*

Experimental Determination of Intermodulation Distortion Produced in a Wideband Communications Repeater—*A. L. Berman, I. L. Podraczky, Communications Satellite Corp. (36.3, Tues./p.m./SS)*

Visual Sensors in Space—*J. J. Dishler, Radio Corp. of America (48.1,* *Wed./p.m./MH)*

New Horizons in Space Technology—*A. L. Kelly, NASA (52.5, Wed./p.m./RS).*

System Engineering

A Method for Predicting System Downtime—*E. J. Muth, General Electric Co. (9.3, Mon./a.m./SS)*

Trouble/Failure Reporting System for Surveyor Spacecraft—*F. A. Paul, Jet Propulsion Lab. (9.5, Mon./a.m./SS)*

Nonlinear Regression and Stochastic Approximation—*Arhur Albert, ARCON (11.1, Mon./p.m./MH)*

Identification for Control Purposes—*James Eaton, International Business Machines Corp. (11.2, Mon./p.m./MH)*

A Survey of Direct Optimization Techniques—*Douglas Wilde, Stanford Univ. (11.3, Mon./p.m./MH)*

The Evolution of Computer Operating Systems—*W. C. Lynch, Case Institute of Technology (25.1, Tues./a.m./RS)*

Time-Sharing Systems: A Review—*B. W. Arden, Univ. of Michigan (25.2, Tues./a.m./RS)*

The Digital Simulation of a Marine Gas Turbine and Its Controls Using MIMIC—*J. C. Fistere, Jr., Westinghouse Electric Corp. (29.1, Tues./p.m./MH)*

Simulation of a Large Central Station—*R. G. Abraham, F. E. Wallace, Westinghouse Electric Corp. (29.2, Tues./p.m./MH)*

An Application of an Analog Computer to Solve the Two-Point Boundary-Value Problem for a Fourth-Order Optimal Control Problem—*V. J. Darcy, R. A. Hannen, Air Force Institute of Technology, Wright-Patterson Air Force Base (29.3, Tues./p.m./MH)*

Process Automation in the Petrochemical Industries—*T. M. Stout, Profimatics, Inc. (47.3, Wed./p.m./MH)*

Systems Engineering in Surface Transportation Systems—*R. M. Micheals, U. S. Department of Commerce (58.1, Thurs./a.m./N)*

Field Experience with Quasi-Electronic Telephone Switching Systems—*H. Willrett, Standard Elektrik Lorenz AG, Germany (66.1, Thurs./p.m./MH)*

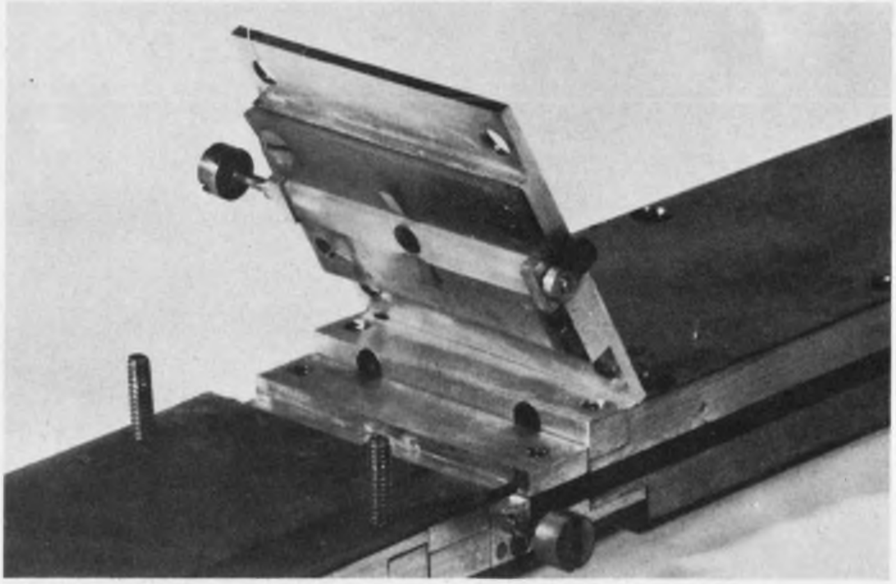
Human Communication in Complex Systems—*R. L. Ackoff, Univ. of Pennsylvania (67.2, Thurs./p.m./N)*

Television

New Horizons in Television and Broadcasting—*G. H. Brown, Radio Corp. of America (52.2, Wed./p.m./RS)*

Practical Application of a High-Level CATV Transmission System—*J. R. Palmer, C-Cor Electronics Inc. (68.1, Thurs./p.m./R)*

Expanded Broadcast Coverage (TV) Through the Medium of CATV—*L. Reinsch, Cox Broadcasting Corp. (68.2, Thurs./p.m./R)*



Pure YIG disk filter can resonate to below 2 GHz. It is tuned by adjusting the applied (static) magnetic field (Paper 7/5).

An 18-GHz CATV Distribution System: Propagation Tests—H. J. *Schlasly, TelePrompter Corp. (68.3,* Thurs./p.m./R)

Test Equipment and Techniques

Measurement of Unbalance Attenuation—*L. O. Olson, Western Electric Co., Inc.; J. C. Mau, General Telephone Co. of Florida (21.3, Tues./a.m./MH)*

Compact Solid-State Automatic Level-Measuring Set—*C. B. Crane, Jr., Northeast Electronics Corp. (21.4, Tues./a.m./MH)*

The Advantages of a Ten-Kilohm Transportable Resistance Standard—*R. M. Pailthorp, Electro Scientific Industries, Inc. (59.1, Thurs./a.m./R)*

The Problem of dc Null Detection and Their Solution—*John Parnell, Frank Brem, Honeywell Inc. (59.2, Thurs./a.m./R)*

An Accurate, Semiautomatic Technique of Measuring High Resistances—*S. H. Tsao, National Research Council (59.5, Thurs./a.m./R)*

An Impedance Meter for Automatic Test Systems—*W. A. Plice, Honeywell, Inc. (59.6, Thurs./a.m./R)*

Thermal and Infrared Methods for Nondestructive Testing of Adhesive Bonded Structures—*E. W. Kutzscher, K. H. Zimmerman, Lockheed-California Co. (61.1, Thurs./a.m./RS)*

A Novel Sensor for Microelectronic Weld Quality Evaluation—*S. N. Bobo, Jr., Raytheon Co. (61.2, Thurs./a.m./RS)*

Automated Troubleshooter Works on Infrared Signatures—*Riccardo Vanzetti, J. F. Stoddard, Raytheon Co. (61.3, Thurs./a.m./RS)*

Infrared Radiometry of Semiconductor Devices—*D. A. Peterman, Wilton Workman, Texas Instruments Inc. (61.4, Thurs./a.m./RS)*

Infrared Pinpoints Second Breakdown Before Failure—*N. F. Nowakowski, F. A. Laracuente, NASA (61.5, Thurs./a.m./RS)*

Transportation

Electric Automobile: Fact or Fiction—*Manfred Altman, Univ. of Pennsylvania (33B.2, Tues./p.m./RN)*

ATC in the "Super Jet" Age—*R. J. Shank, Vice President Airborne Instruments Lab. (35.1, Tues./p.m./SN)*

Anglo-French ATC Preparations for the Concorde—*L. Lansalot-Basou, Director, Air Navigation, Secrétariat Général à l'Aviation Civile et Commerciale (35.2, Tues./p.m./SN)*

The Airplane Manufacturer Looks at the Environment of the 1970's—*A. F. Norwood, The Boeing Co. (35.3, Tues./p.m./SN)*

Airline Preparations for SSTs and Jumbo Jets—*N. E. Halaby, Pan American World Airways, Inc. (35.4, Tues./p.m./SN)*

United States ATC preparations for the "Super Jet" Age—*J. Blatt, Associate Administrator for Development, Federal Aviation Agency (35.5, Tues./p.m./SN)*

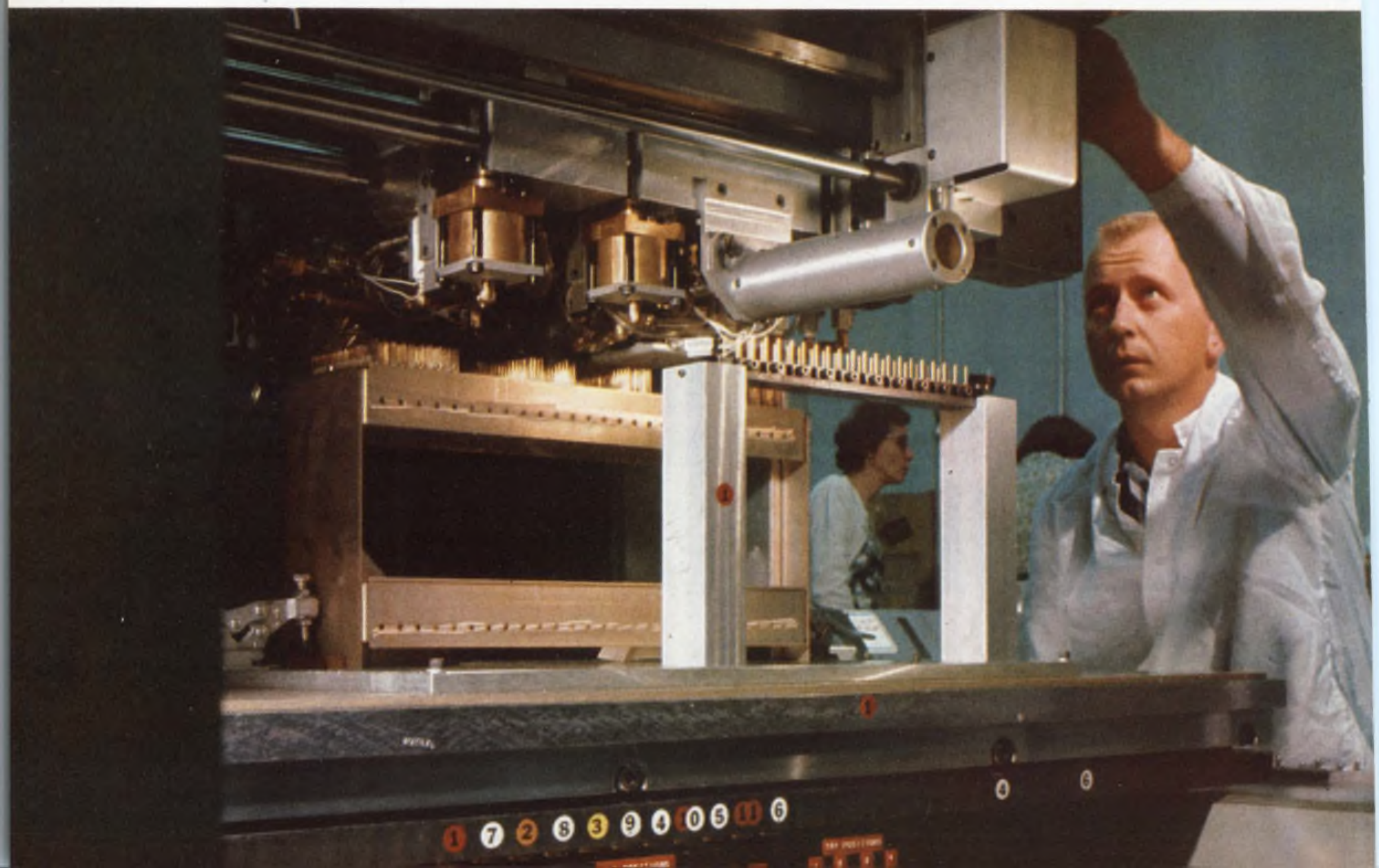
Systems Engineering in Surface Transporation Systems—*R. M. Michaels, U. S. Department of Commerce (58.1, Thurs./a.m./N)*

Restraint Systems and Novel Human Packaging—*Carl Clark, Martin Co. (58.2, Thurs./a.m./N)*

Designing for Passanger Comfort in High-Speed Transportation—*R. A. McFarland, H. W. Stoudt, Harvard School of Public Health (58.3, Thurs./a.m./N)*

Human Decision-Making and High-Speed Transportation—*T. B. Sheridan, MIT (58.4, Thurs./a.m./N)*

Reliable electrical connections



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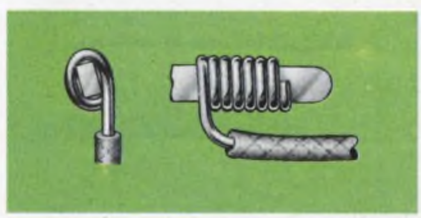

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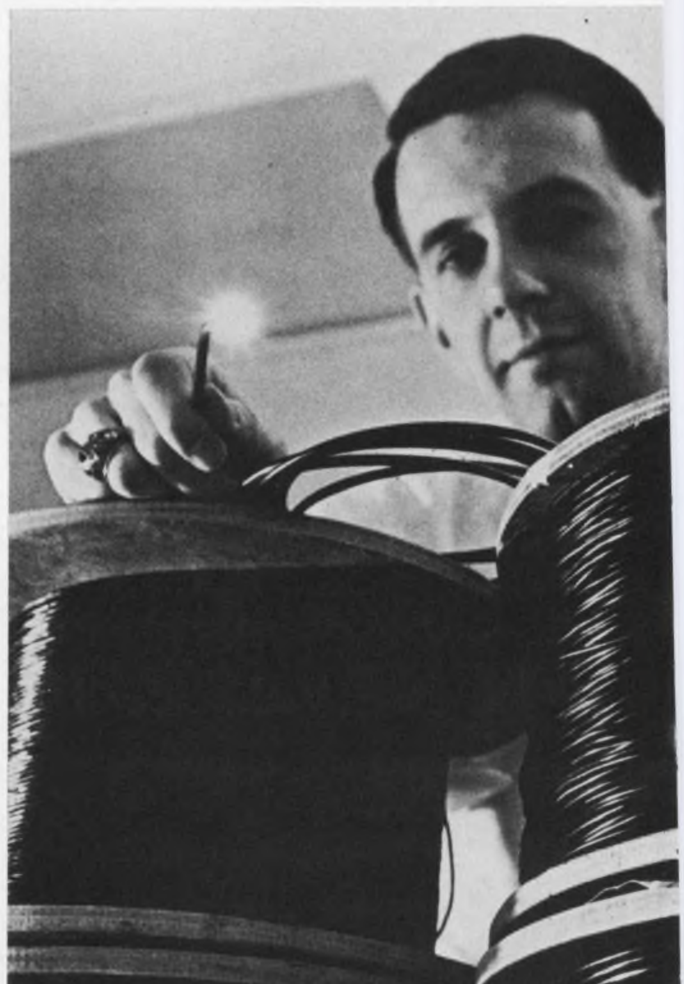
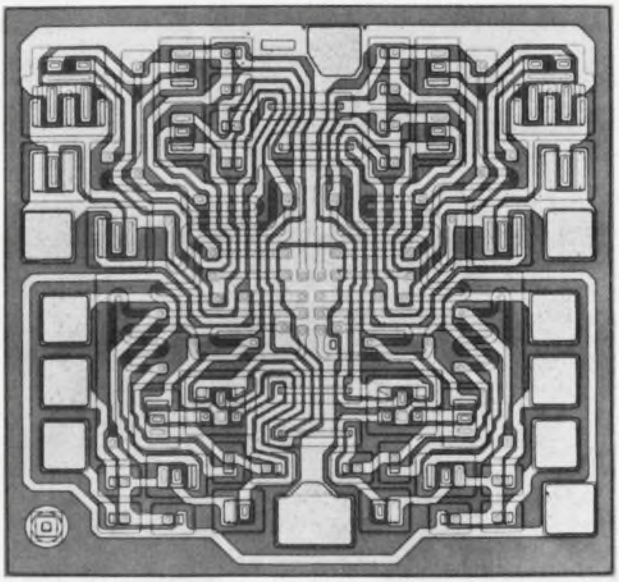
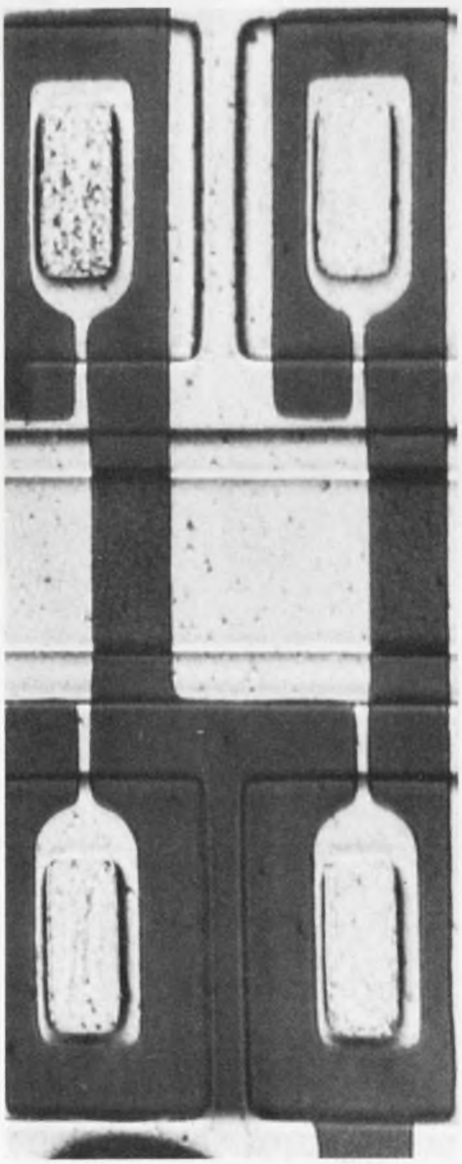
Ribbon cable saves space. Using Teflon TFE as the dielectric, 95-Ω, 20-signal transmission line can replace coaxial with a 90% space saving and easy assembly. Page U128.



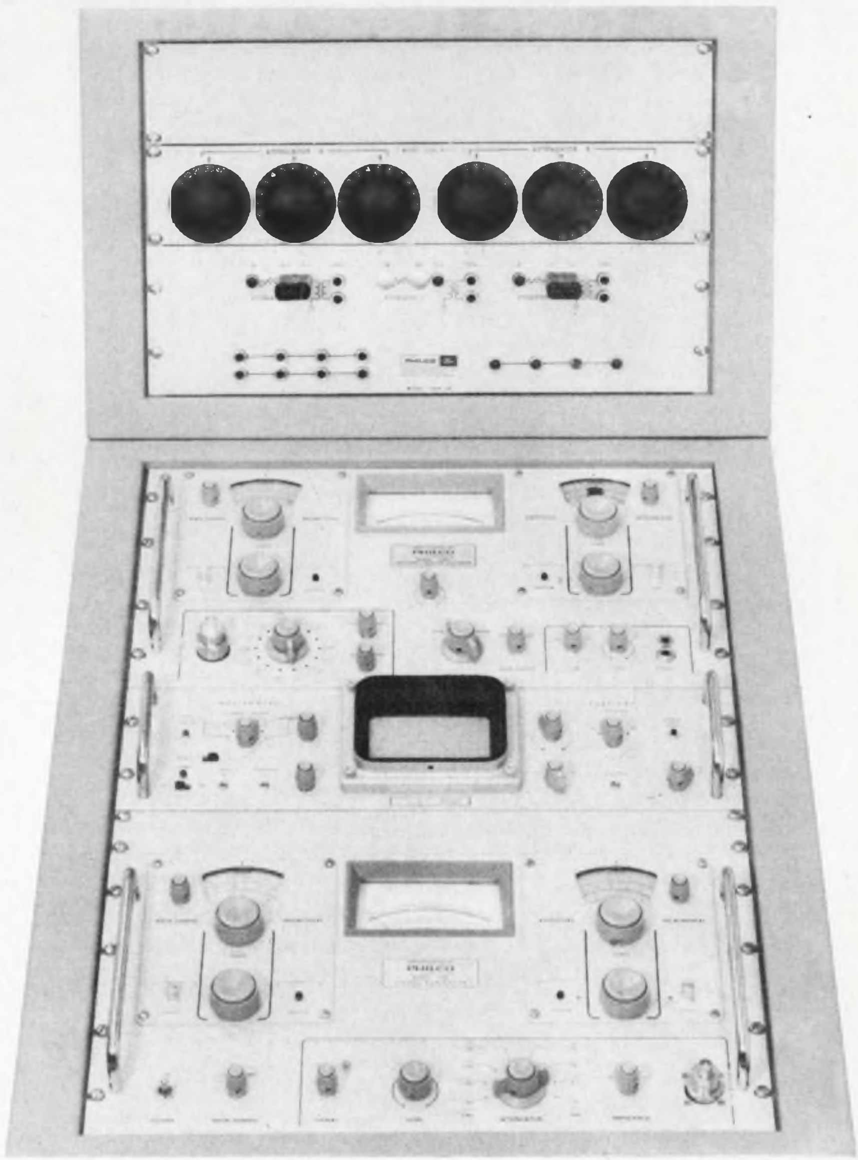
Two miles of glass fiber optics. Jacketed in PVC, the continuous-length noncoherent bundles are available in lengths to 10,000 feet. Page U219.



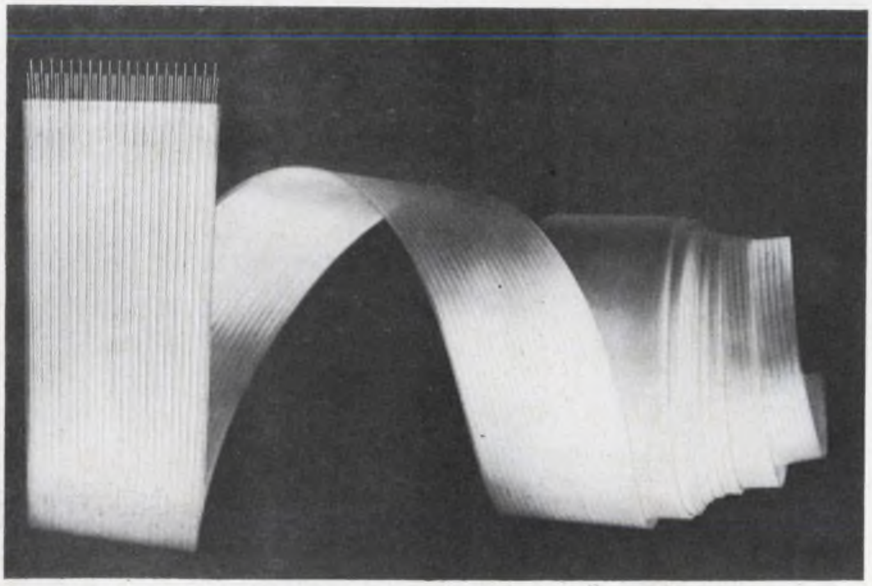
Built-in avalanche emitter cuts noise in logic ICs. A second emitter with avalanche breakdown characteristics is built into the output transistor of DTL circuits, such as this master-slave R-S flip-flop. Page U188.



Generate complex logic functions with simple diode logic. Diode matrices and interface circuits team up. Page U208.



Console contains complete transmission tester. The set combines all the functions of a selective voltmeter, tracking generator, spectrum display, attenuator and impedance-matching panel in one. Page U178.



Ribbon cable replaces coax in one-tenth the space

W. L. Gore & Associates, Inc., 555 Paper Mill Rd., Newark, Del. Phone: (302) 368-0651. P&A: $1.20/ft (5000 to 25,000 ft), 90¢/ft (25,000 to 100,000 ft); 3 to 6 wks.

A 95-Ω ribbon cable transmission line is reported to take the place of coaxial cables at a 90% saving of space. The cable has already been used in the back plane of computers to carry signals from one section to the next. The over-all size of the 20-signal line is 1.15 by 0.026 inches.

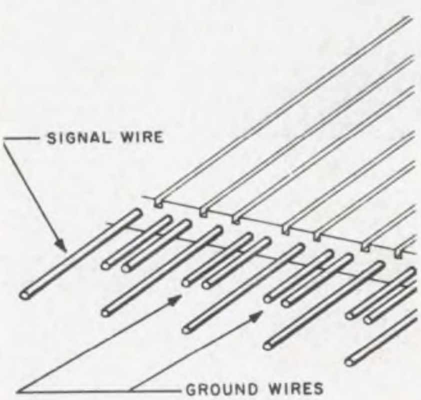
Over-all size has been kept down by the parallel line geometry and the choice of insulation, Teflon TFE. TFE has the lowest dielectric constant (about 2.1) of any solid dielectric. This allows compact conductor spacing for a required impedance and high propagation velocities. Attenuation losses are also held down since TFE's dissipation factor also is low (about 0.0002).

Crosstalk is effectively controlled through the use of a three-wire group; each signal lead is centered between ground wires. The basic three-wire unit is repeated 20 times across the cable for a total of 60 conductors. Stacking capability is good; since the geometry controls crosstalk, attenuation and impedance, these characteristics can be precisely defined.

A mechanical stripping tool prepares the cable for termination. When the cable is stripped, a small tab of Teflon is left on to permit easy separation of the signal leads. The signal leads are held by the tab. By bending the tab down, all of the ground leads are separated and are soldered to one side of a PC card. The card is flipped over so that the signal leads line up with termination points. They are then soldered.

The Teflon has almost universal chemical inertness. This inertness keeps cable properties stable regardless of exposure to ultraviolet radiation, high temperature, solvents or aging. The cables are very flexible and have a long flex life, dependent only on conductor fatigue.

Booth No. 1G18 Circle No. 523



Signal wires are flanked by ground wires. This basic three-wire unit is repeated 20 times across the cable.

PPO dielectric for microwave PC use

Polymer Corp., Reading, Pa. Phone. (215) 929-5858.

Z-Tron H, a modified PPO (polyphenelene oxide) base material with a dielectric constant of 2.72 is for use in stripline, microwave and high-frequency printed circuits. Available in copper-clad or unclad sheets, the material combines the strength, rigidity, thermal and dimensional stability of thermosets with the low, high-frequency electrical loss characteristics of thermoplastic olefins. The dielectric is designed for use in stripline circuitry and microwave printed circuits in missile ground support, general communications, warning systems, navigational and fire control systems, radar computers and other wide-temperature-range systems. Manufactured in 14 x 18 and 16 x 24-inch sheets, it can be obtained in larger or smaller sizes. Z-Tron H boards are operable over a wide temperature range (−270 to 375°F) and are produced to tolerances of ±0.001 inch.

Booth No. 1D26 Circle No. 288

Accessory speeds harness tying

Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. Phone: (312) 532-1800.

Strap tying time on wiring harnesses can be reduced with a plastic Pan-Ring. Pan-Rings can be used on both point-to-point and harness board tying. They are available to tie bundles up to 1-1/4-inches in diameter.

Booth No. 1C16 Circle No. 291

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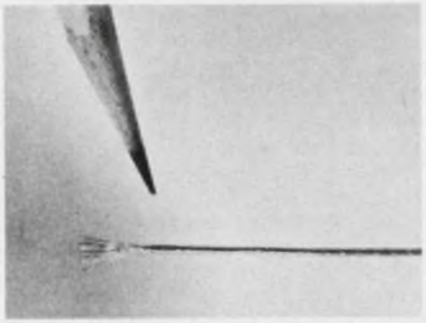
Aerospace wire cuts weight

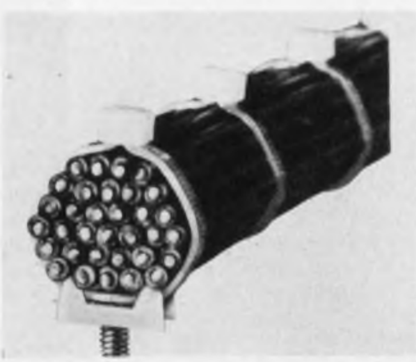


Rockbestos Wire & Cable Co., P. O. Box 1102, North Haven, Conn. Phone: (203) 787-1141.

Interzone X is constructed with a heat-sealed film insulation system over stranded silver-coated copper conductors. Maximum temperature rating is 200°C. The film insulated wire and cable claims weight savings of 22 to 36% and space savings of 35 to 50%. The insulation burns only in direct contact with flame, and there is no after-flame or melting.

Booth No. 1E29 *Circle No. 290*

Tie anchor provides 'dual support'



Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. Phone: (312) 532-1800.

A dual-support tie anchor secures wire harnesses more firmly. The nylon anchor is suitable for application in areas subject to vibration, high-G loads or shock. Two anchor points, instead of the usual one, form a platform to support the cable bundle, resulting in a more rigid mount with increased harness stability.

Booth No. 1C16 *Circle No. 292*

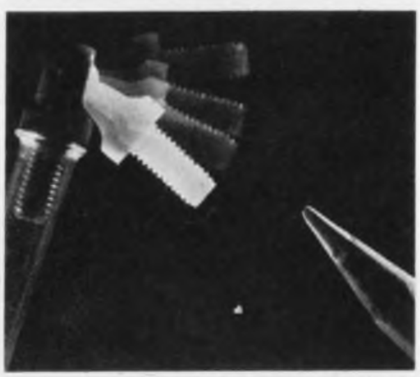
Thread insert strengthens fasteners

Heli-Coil Corp., Danbury, Conn. Phone: (203) 743-7651.

Significant weight reduction as well as addition of strength to threaded assemblies are claimed for this thread insert. The #2-56 Heli-Coil insert is a spiral coil of stainless steel wire that clads the thread of a tapped hole. When installed in aluminum, magnesium or titanium it permits the use of a smaller, less bulky boss area with actual gain in thread strength.

Booth No. 1F27 *Circle No. 293*

Plastic ball joints double as dielectric

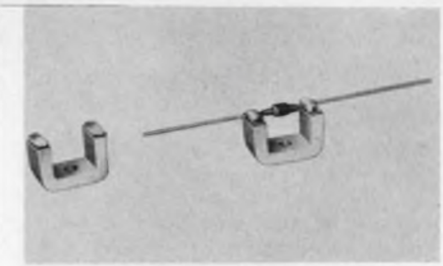


Gries Reproducer Co., New Rochelle, N. Y. Phone: (914) 633-8600.

Nylon-acetal ball joints are designed for light loads in push-pull linkages or for use in mechanisms where ability to compensate for misalignment during assembly or operation is necessary. Design of the ball joints permits up to 40° of angular motion on any axis. In electrical equipment, the dielectric strength provided enables the joints to link components mechanically, while isolating them electrically.

Booth No. 1G08 *Circle No. 289*

Heat sink for fused glass diodes



Wakefield Engineering, Inc., Wakefield, Mass. Phone: (617) 245-5900.

Type 258 thermal links heat sink fused glass diodes. Copper solder points are isolated from, but bonded to, the aluminum U-form. Dielectric coating extends down the legs to provide a long creepage path. All units are tested at 1000-V hipot. The unit is screw-mounted.

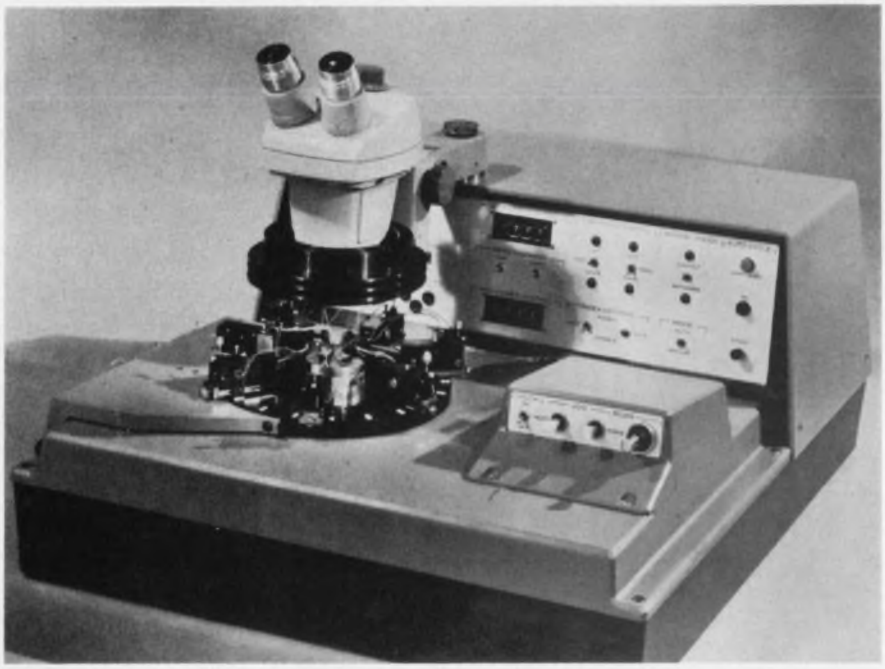
Booth No. 4B04 *Circle No. 370*

Self-adhesive tabs indicate temperature

Tempil Corp., 132 W. 22nd St., New York. Phone: (212) 675-6610.

Self-adhesive temperature monitoring tabs combine the accuracy of a phase change (melting) with a color change. Each of the bull's eye spots within the indicator circles will transform from white (or near-white) to black at the temperature ratings specified on the Tempilabel. The change is irreversible and occurs at the stated temperature with an accuracy of ±1%. Transparent Mylar or mica windows protect the temperature indicating spots and minimize the possibility of contamination. Tempilabel singles are available in a choice of 47 single temperature ratings, spaced in the range of 100 to 500°F. The multiple type contain a sequence of 4 temperature ratings and are available in 49 temperature combinations.

Booth No. 4A06 *Circle No. 372*



Semiconductor wafers probed at rate of 20,000 per hour

Electroglas, Inc., 150 Constitution Dr., Menlo Park, Calif. Phone: (415) 325-1536. P&A: $12,700; April.

A fully automated semiconductor wafer system is capable of operating rates of 19,700 devices per hour with inking or 27,000 devices per hour without inking. In addition, the model 900 prober, which is 92% ICs, has 100% electronic sequencing, edge-sensing circuitry and an inking reject system so that the probing rate is not affected unless inking actually occurs.

The manufacturer, Electroglas Inc., credits a proprietary technique for progaming and control of X- and Y-axis stepping motors as responsible for the high acceleration and deceleration rates. Despite the high speeds, indexing accuracy is maintained at ±0.0001 in./in. over an X- and Y-indexing range of 0.005 to 0.9995 inch.

All but 8% of the control electronics and logic circuitry of the unit are DTL ICs. All the transistors are silicon planar types, 50% derated. The electronics are housed on a swing-out card cage, using plug-in PC boards.

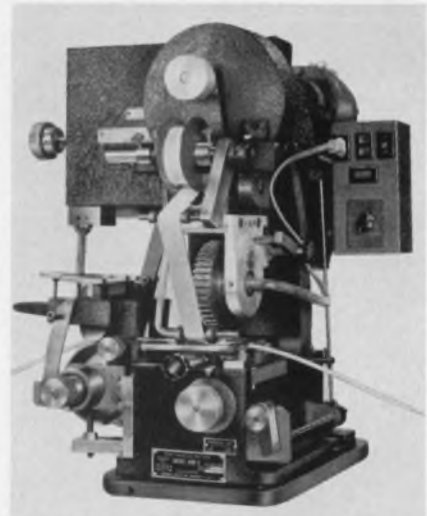
Edge-sensing circuitry (proprietarily called Wafer Profiler) eliminates "waste" probing in areas beyond the periphery of the test wafer. Maximum wafer size capacity is 2-inch diameter. The sensing circuitry permits programing of reversal and row change delay from 0 to 9 steps of the wafer. This ensures testing of all devices—even those on partial or broken wafers. In all cases, the machine stops automatically 10 steps off the wafer. The Wafer Profiler also locks out the external test set when probers are in an off-wafer position. Thus, the counter only records the actual number of devices tested.

The unit's ring assembly has provision for mounting any combination of probes and inkers totaling twenty. The standard unit comes fitted with six inkers. Inking time (nominally 0.05 second) is automatically subtracted from the probing cycle when inking is not required or desired.

Utilities required are 110 to 125 Vac at 50 or 60 Hz, single-phase, 1.25 kW; 18 to 25 inch/minute Hg vacuum and 40 to 80 psi air pressure. The complete unit weighs 190 pounds and occupies 25 by 22 inches of bench space.

Booth No. 1G26 Circle No. 522

Wire marker makes 175 imprints per minute



Ackerman-Gould Co., Inc., 10 Neil Court, Oceanside, N. Y. Phone: (516) 678-4110.

Wire can be marked at 175 imprints per minute with this automatic machine. Printing pressure and spacing between markings can be controlled during operation. For printing on insulated hookup wire, guide blocks are required. For printing on flexible tubing, an adjustable self-centering device is necessary. Each wheel has forty letters (or numbers) and one blank.

Booth No. 1A07 Circle No. 378

Machine inserts wide variety of components

United Shoe Machinery, 140 Federal St., Boston. Phone: (617) 542-9100.

All kinds of axial-lead components from small diodes to large capacitors can be handled by this component inserting machine. Insertion units can be used interchangeably for different components, with a changeover time of less than 2 minutes by operators with little training. High product uniformity is claimed.

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When you use the probe to make true RMS measurements with the Fluke 931A AC differential voltmeter, you don't do a thing to the circuit or the meter. All you do is move the input 30 inches closer to the measurement without added loading or loss of sensitivity. That's just one more reason AC metrology isn't the same anymore.

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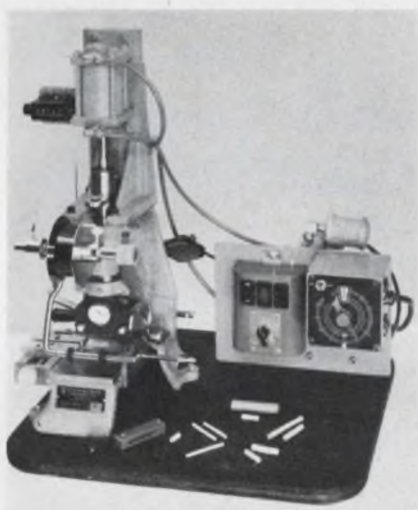
Drag solderer is complete system

Zeva Electric Corp., 11 Park Pl., New York. Phone: (212) 227-8288. Price: $3304.

A complete soldering system features foam or rotating brush fluxer, pre-heating station and soldering station. It features independent and automatic speed control of the conveyor when the PC board enters and leaves the solder bath. The system is ready to operate within 40 minutes.

Booth No. 1G05 Circle No. 267

Mark wire and cable to #26 AWG

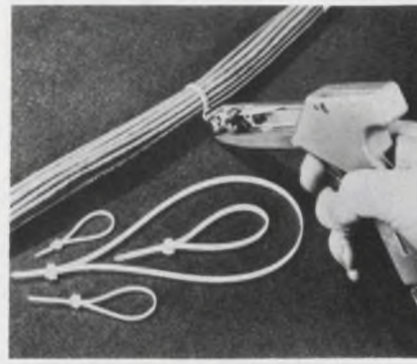


Ackerman Gould Co., Inc., 10 Neil Court, Oceanside, N. Y. Phone: (516) 678-4110.

An air/electric roll leaf imprinting machine for end marking and identification of insulated wire and cable works in conjunction with a wire stripper and cutoff machine. By use of a foot pedal, model KU-EM operates independently of the stripper and can be used to imprint insulated wire and/or cable. Imprints can be spaced up to four inches apart. All wire from 10 to 26 AWG can be printed and stripped.

Booth No. 1A07 Circle No. 252

One cabling tool does the work of three

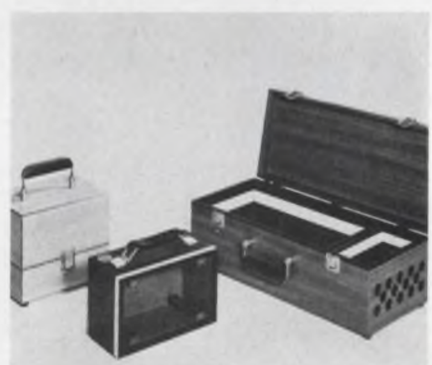


Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. Phone: (312) 532-1800.

A universal cabling tool eliminates the need for three different tools to accommodate different sized cable ties. It incorporates a three-position knob that can be adjusted in two seconds to suit the precise cable tying job. An easy adjustment on the tool sets the tension so that every cable tie is tensioned precisely.

Booth No. 1C16 Circle No. 254

Instrument cases made of formica



W.A. Miller Co., Oquossoc, Me. Phone: (207) 854-3344.

Ruggedized formica cases claim high strength. In manufacture, 1/16-inch formica is laminated to a mahogany core with waterproof epoxy resins and bonded under heat and pressure. Cases can be designed in any size or shape with any desired cutouts, partitions, panel seats, panel mounts or hardware. Light in weight, moisture and dust resistant, the cases have passed Navy shipboard requirements.

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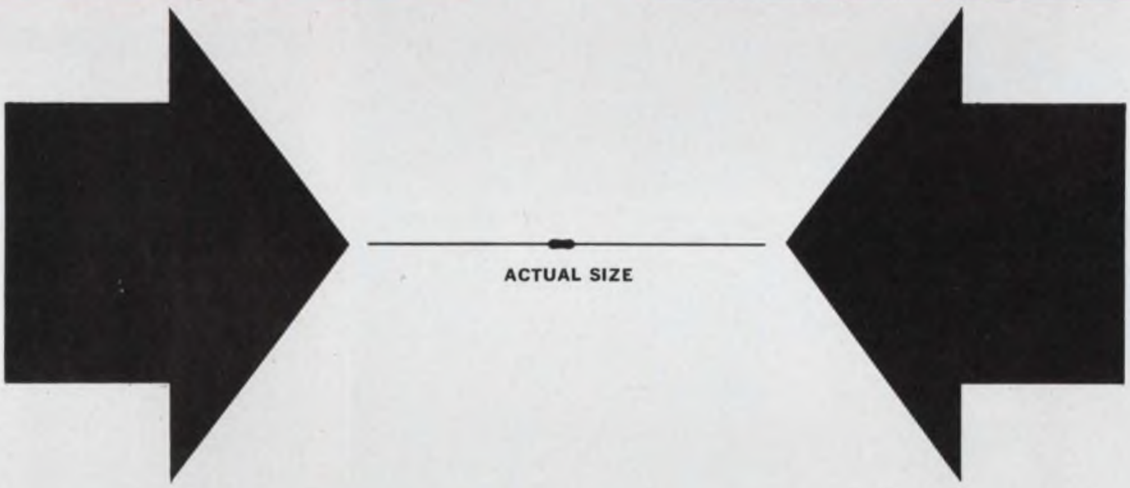
UC*



New! Ultra-miniature metal film resistor

offers precision, stability and reliability of higher-rated units

IRC, leader in metal film technology, introduces a new ultra-miniature precision metal film unit that bridges the gap between available discrete resistors and microcircuitry.

Significantly smaller than style RN-50, the UC resistor provides the precision, stability and close tolerance not available with microcircuits. It meets or exceeds all of the performance and environmental requirements of MIL-R-10509.

These tiny resistors feature gold dumet leads and the same rugged termination as all IRC premium metal films. Not a "lab item" or "special," production quantities are immediately available. Write for data, prices and evaluation sample. IRC, Inc., 401 N. Broad St., Phila., Pa. 19108.

CAPSULE SPECIFICATIONS

BODY SIZE	.125″ long x .047″ dia.
POWER	1/20 watt @ 100°C
TOLERANCES	±1, 2, 5%
TEMPERATURE COEFFICIENTS	±50, 100ppm/°C
RESISTANCE	50 ohms to 10K

IRC

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ON READER-SERVICE CARD CIRCLE 74

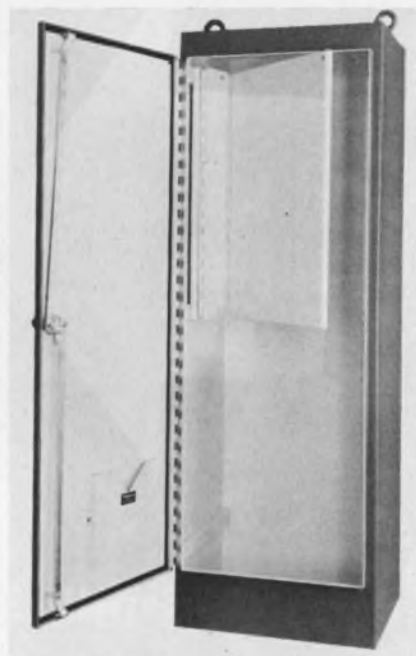
ICs encapsulated with 75-ton press

Hull Corp., 7591-A Davisville Rd., Hatboro, Pa. Phone: (215) 675-5000. Price: $15,000.

A 75-ton semiautomatic encapsulating shuttle machine, model 359C, encapsulates integrated circuits with production molds. Parts too large for conventional loading frames can be unloaded and loaded in the bottom half of the production mold while the second half is in the molding cycle.

Booth No. 1H02 Circle No. 270

Free-stand enclosures to NEMA specs



Hoffman Engineering Co., Anoka, Minn. Phone: (612) 421-2240.

Dual-access free-standing enclosures are made to NEMA 12 (industrial use) standards. The enclosures (gasketed doors front and rear) permit the use of 2 or more subpanels and are constructed of seam welded 12-gauge steel. Half and full-length relay rack angles are available for most models. Four dual-access and seven single-access stock sizes are available ranging from 72 x 24 x 18 to 90 x 36 x 24.

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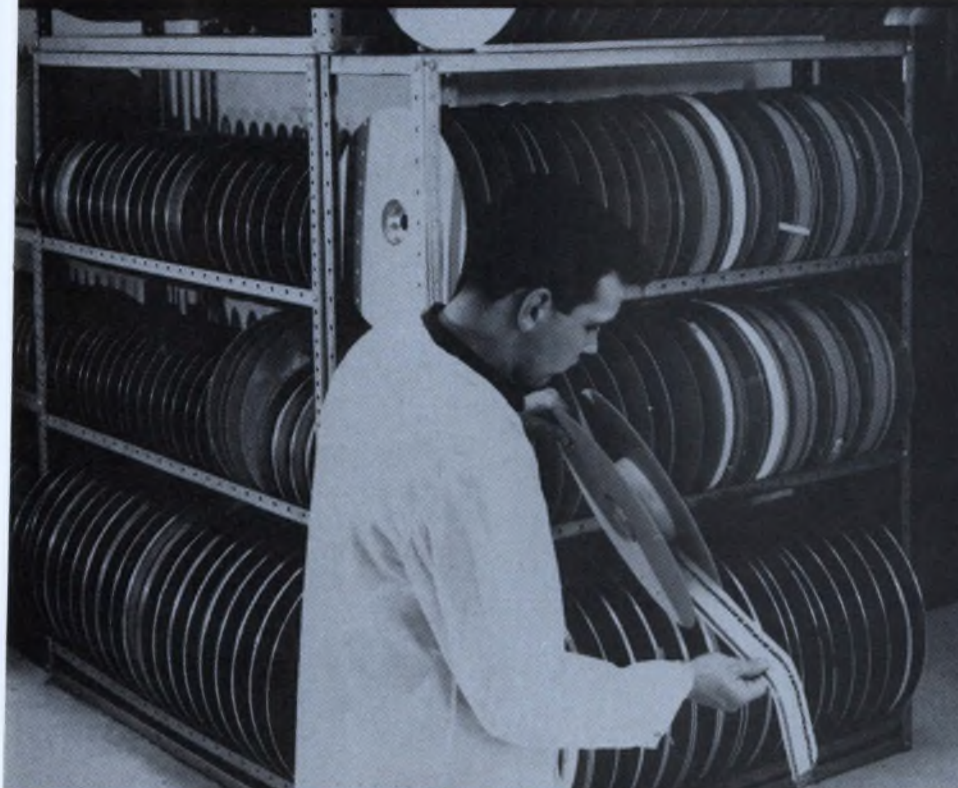

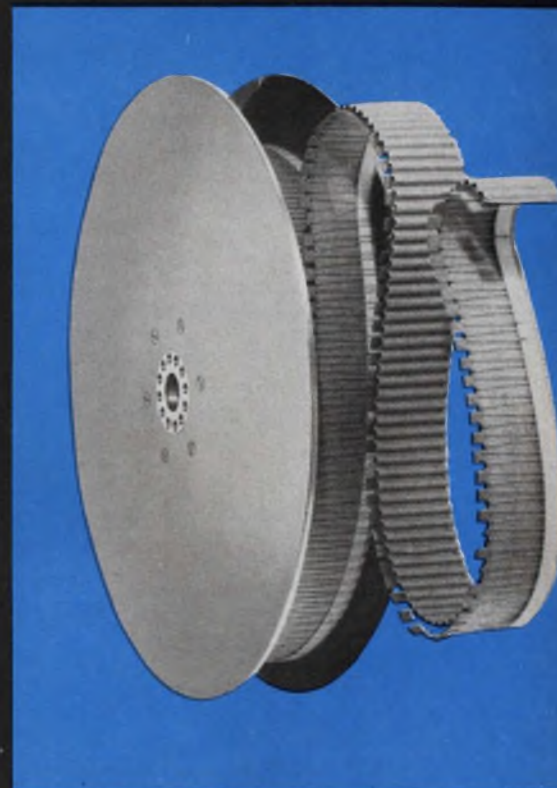

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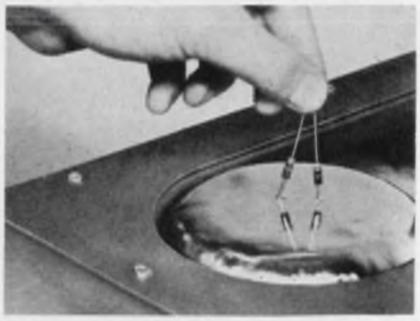


Electrovert, Inc., 86 Hartford Ave., Mt. Vernon, N. Y. Phone: (914) 664-6090. P&A: $750; stock.

A flat 4-inch diameter, dross-free and constant-temperature molten solder surface for tinning component leads and dip-soldering small parts is provided by this wavedipper. By pumping the solder upwards from a reservoir through a circular nozzle, a mirror-like dipping surface with a stable working level is formed. Because the solder is constantly recirculated, there is no surface cooling and no dross contamination on the wave surface.

Booth No. 1H22 Circle No. 269

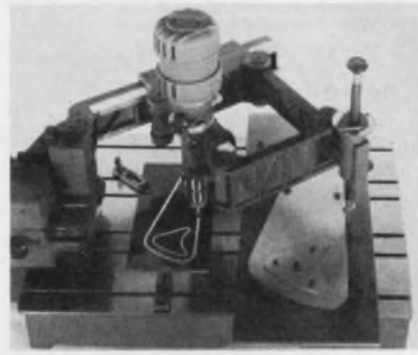
Accurate grid drill has programable spindles

Gardner Denver, Grand Haven, Mich. Phone: (217) 222-5400.

A four-spindle grid drill is available with spindles arranged to suit customer requirements. Modular construction in spindle arrangement allows the user to add spindles to the machine as the work load increases. The control systems are standard for full spindle programability for up to 16 spindles. The positioning system is accurate to 0.001 inch.

Booth No. 1G12 Circle No. 253

Engraving machine enlarges and reduces



Scripta Machine Tool Corp., 575 E. Linden Ave., Linden, N. J. Phone: (201) 925-1950. P&A: $1060; stock.

A bench-model pantograph engraving machine is applicable to instrument panels, engraving of stamps and cylindrical parts, copying, profiling, beveling, drilling, milling, and electromarking into hardened materials. The machine can reproduce a master template at 23 different reduction ratios and can also be used for enlarging. At its largest reduction ratio, it will cover an area of 4-3/4 by 9-1/4 inches in one setup.

Booth No. 1J16 Circle No. 255

Embossed labels at your finger-tip

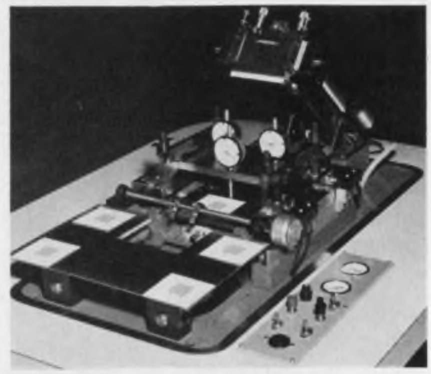
W. H. Brady Co., 727 W. Glendale Ave., Milwaukee. Phone: (414) 332-8100. P&A: $16.95 (3/8-in.), $18.95 (1/2-in.); stock.

Fast, finger-tip embossing of self-sticking labels is accomplished with this heavy-duty table-top machine. Tape labels can be embossed continually without squeezing, lifting or handling motions. The machine can deliver individually cut-and-tabbed labels, or multiple precut labels on a continuous dispenser strip up to 36 feet long.

Booth No. 1E12 Circle No. 319


GUARDIAN®
SOLENOIDS

Automatic testing for semiconductors



Affiliated Manufacturers Inc., Box 248, Whitehouse, N. J. Phone: (201) 534-2103.

A versatile machine for visual inspection or automatic test of diodes and other electronic parts requiring top and bottom probing permits simple conversion from one operating mode to the other. The parts are transferred one at a time via vibratory feeders to a stage mounted in front of the transfer device. At this point, the operator can inspect and sort the parts into four different categories by means of buttons.

Booth No. 1A01 Circle No. 337

New sun throws light on spaceman's problems

Genarco, Inc., Jamaica, N. Y. Phone: (212) 658-5850.

A 120-kW carbon-arc light source is presented as the most powerful single-source solar radiation simulator developed to date. The highest power previously developed is 30 kW. The new unit will irradiate an area eight feet in diameter with one solar constant, the space of the sun's rays in the vicinity of the earth. This is considered large enough to cover an astronaut practicing a walk in space. Lamps used for this purpose have been unstable, noisy and even explosive. The new simulator is said to have overcome these defects.

Booth No. 1G30 Circle No. 338

Don't forget to return your **ELECRONIC DESIGN** renewal card.

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NO BLANKS
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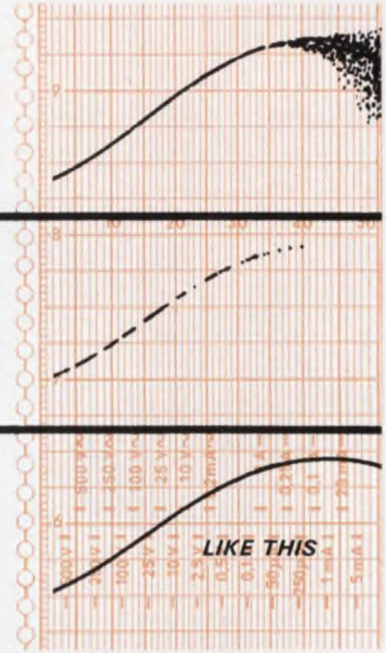
A PERFECT RECORD every time



Simpson Multicorder®

22 SINGLE ELECTRICAL RECORDERS WRAPPED IN ONE
STANDARD 3 CHART SPEEDS 1″, 3″, 12″ PER HOUR

Impressions every 2 seconds. Additional speeds (30″, 60″, 90″ per hour) with the optional gear unit Catalog #0682. This voltage-current recorder has a wide selection of ranges and functions to eliminate the need for separate recorders. The pressure-sensitive paper means that there is no conductive paper to burn, no ink to run dry. Meter movement features shock-proof **TAUT BAND SUSPENSION.** AC and DC indicating accuracy is ±1.5% FS; recording accuracy ±2.5% FS. These are just a few of the features that make the Simpson Model 604 Multicorder the most versatile and economical recorder on the market. For the full story, write for Bulletin 520.

RANGES

DC VOLTS: 0-0.1, 0.5, 2.5, 10, 25, 100, 250, 500 @ 20,000 Ω/V
AC VOLTS: 0-10, 25, 100, 250, 500 @ 5,000 Ω/V
DC MICROAMPERES: 0-50, 250
DC MILLIAMPERES: 0-1, 5, 25
DC AMPERES: 0-0.1, 0.25, 1.0
AC MILLIAMPERES: 0-0.2

Multicorder Model 604 .... $200.00

ACCESSORIES
Gear Unit No. 6082 (30″, 60″, 90″ per hour) 30.00
Chart Paper No. 02612, Per Roll 2.50
Ever-Redy Vinyl Carrying Case No. 02611 .... 25.00

Simpson
INSTRUMENTS THAT STAY ACCURATE

Representatives in Principal Cities
... See Telephone Yellow Pages

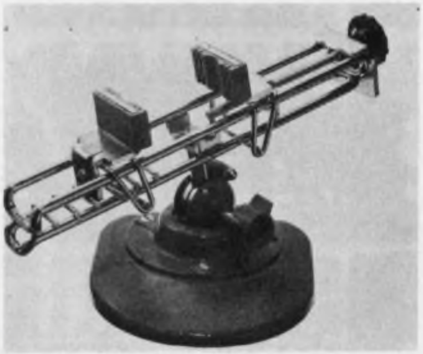
AGM DIVISION

SIMPSON ELECTRIC COMPANY
5202 W. Kinzie Street, Chicago, Illinois 60644 • Phone: (312) 379-1121
Export Dept: 400 W. Madison Street, Chicago, Illinois 60606, Cable, Simelco
IN CANADA: Bach-Simpson Ltd., London, Ontario
IN INDIA: Ruttonsha-Simpson Private Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT

ON READER-SERVICE CARD CIRCLE 80

Holding device for quick adjustment

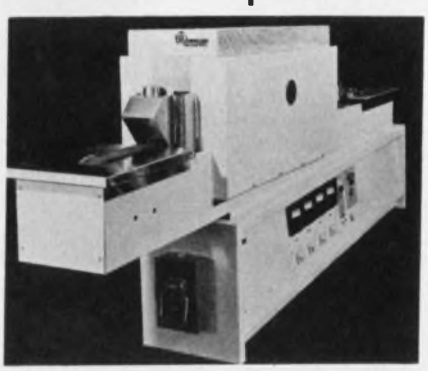


Hunter Tools, 9851 Alburtis Ave., Santa Fe Springs, Calif. Phone: (213) 692-7281. P&A: from $6.65 to $24.85; stock.

This unit is designed to meet the need for a fully positionable, holding device. It has a newly designed quick-adjust jaw, which allows one of the jaws to be changed from its widest opening to the center position instantly by the operator. The assembly is a combination of three separate units: vise, positioner and base.

Booth No. 1B08 Circle No. 375

Laboratory oven for research and process

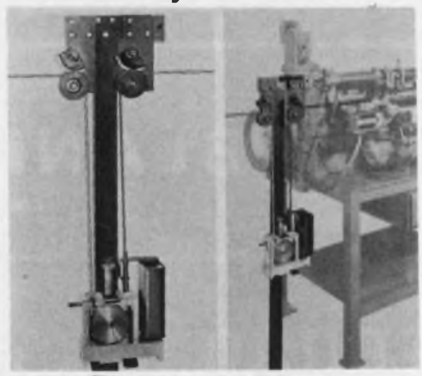


BTU Engineering Corp., Bear Hill, Waltham, Mass. Phone: (617) 894-6050. P&A: furnace, $3657, dryer $2700; 6 to 8 wks.

A versatile inclined laboratory furnace is offered for research and process development of hybrid circuits. It has an inclined quartz muffle, thermosensitive hearth, laminal flow of air, and uniform temperature profile from load to no-load. The dimensions are 76 by 18 by 51 inches. A dryer is optional.

Booth No. 1F18 Circle No. 374

Wire color coder colors vinyl cotton

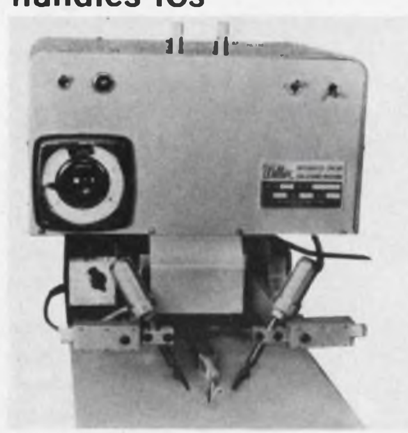


Artos Engineering Co., 15598 W. Lincoln Ave., New Berlin, Wis. Phone: (414) 782-3300. Price: $85.

White insulated wire can be used to produce wire leads in all required colors by means of a new color coder unit. The machine handles vinyl-plastic and cotton-insulated wire, and will color two wires being processed simultaneously. It is mounted at the feed end of a stripping machine. The unit operates at the same speed as the machine.

Booth No. 1J22 Circle No. 376

Soldering machine handles ICs

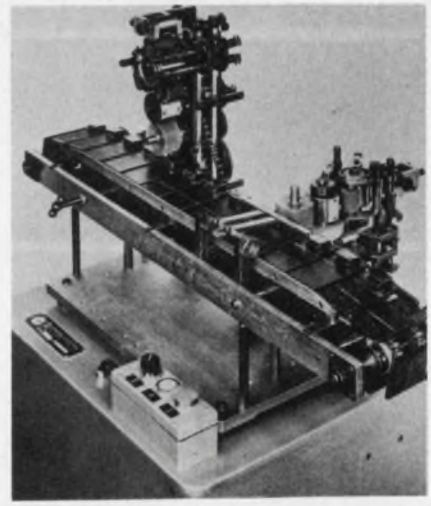


Weller Electric Corp., 100 Wellco Rd., Easton, Pa. Phone: (215) 258-5371.

Model C-700 integrated circuit soldering machine features dial-variable temperature control. Designed for production and lab use, the unit solders all leads, both sides in one operation, for prototype use as well as volume production.

Booth No. 1B12 Circle No. 258

Machine prints on flat or irregular components



Eastern Marking Machine Corp., 30 Alabama Ave., Island Park, N. Y. Phone: (516) 889-9090.

A machine for high-speed printing on flat or irregular components or packages uses the dry-offset printing method. This ensures perfect prints even where there are variations or irregularities from piece to piece. Inexpensive photoengraving or foundry type is used, keeping the cost of printing to a minimum. Production rate is 6000 units per hour.

Booth No. 1H27 Circle No. 320

Machine trims 3000 resistors per hour

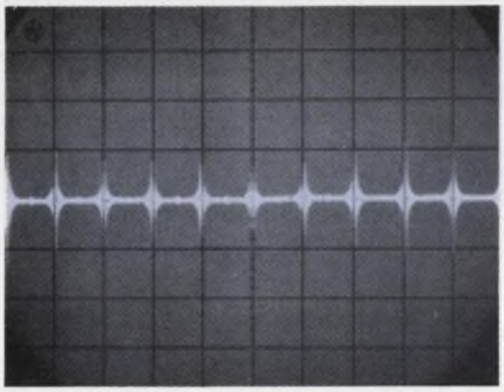
S. S. White Co., Industrial Div., 201 E. 42nd St., New York. Phone: (212) 661-3320.

An automatic resistor trimmer can process 3000 resistors per hour. Resistors are brought within tolerance automatically, and a built-in memory system recognizes three categories and controls the machine accordingly. Resistors are monitored constantly to stop the machine within 0.5% of the desire value. The cutting and measuring sequence takes less than 2 seconds.

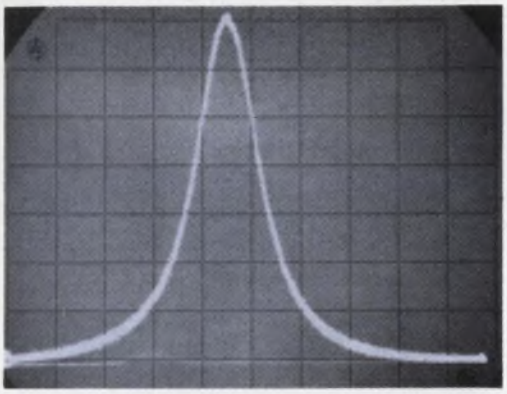
Booth No. 1D30 Circle No. 377

Don't forget to return your **ELECRONIC DESIGN** renewal card.

Wide and Narrow Sweeps with this



Oscillogram of a 10 to 110 MHz sweep with 10 MHz birdie markers added to show excellent sweep linearity. Specified 0.5% linearity and 1% frequency accuracy permit easy identification of intermediate sweep points, eliminating need for tedious pre-calibration.



With low residual FM and very linear sweeps, you can measure narrow-band characteristics easily. Shown here is the response of a 20 MHz crystal filter over narrow 100 kHz sweep width (10 kHz/cm.); just read the 10 kHz pass band directly from oscilloscope.

The Hewlett-Packard 8690A/8698A Sweep Oscillator (0.1 to 110 MHz) offers all the performance and operating conveniences you've been looking for in an RF sweeper:

- **Two independent broadband sweeps, each with 1% end-point frequency accuracy and 0.5% linearity.**
- **Calibrated ΔF sweeps (sweeps 0 to 10% of frequency range) for narrow sweeps, maintaining 0.5% linearity.**
- **CW operation; external FM (DC to 2 kHz with full band deviation).**
- **Automatic, manual or triggered sweeps; sweep times from 0.01 to 100 seconds.**

Frequency accuracy, frequency stability, sweep linearity, residual FM and spurious signal levels are all *specified* parameters (rarely done for RF sweepers).

The 8690A/8698A provides full band sweep capabilities and excellent narrowband performance, eliminating the need for two separate sweepers. Both high-Q and wideband devices can be swept with just one instrument. In addition, the frequency stability, signal purity, calibrated output power and precision output attenuator of the 8690A/8698A commend it for many applications calling for a precision signal generator.

And the 8690A Sweep Oscillator main unit accepts 17 other HP microwave sweeper units covering 1 to 40 GHz in octave- and waveguide-bands.

Performance of 8698A RF Sweeper Generator

(installed in 8690A Sweep Oscillator)

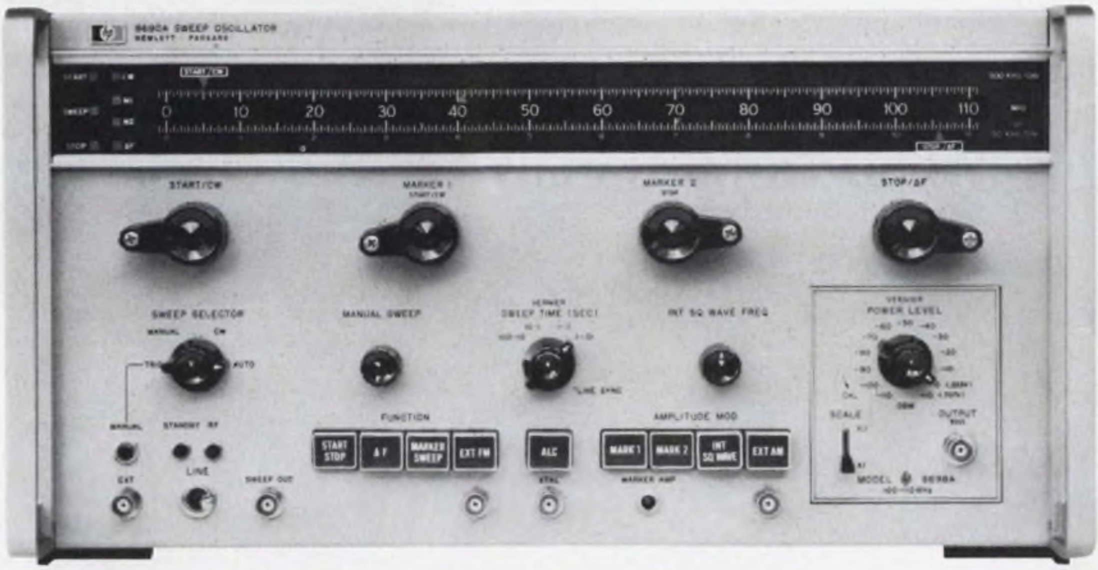
FREQUENCY SPECIFICATIONS

Frequency Range:
0.1 to 11 MHz and 1 to 110 MHz, selected by front-panel switch.

Frequency Accuracy:
0.1 to 11 MHz, ±1% or ±10 kHz, whichever is greater; 1 to 110 MHz, ±1% or ±100 kHz, whichever is greater.

Frequency Linearity:
±0.5%

Linear RF Sweeper



Residual FM:
0.1 to 11 MHz <150 Hz peak, 1 to 110 MHz <500 Hz peak.

Frequency Stability:
With temperature: 0.1 to 11 MHz, ±0.01%/°C or ±200 Hz/°C, whichever is greater; 1 to 110 MHz, ±0.01%/°C or ±2 kHz/°C, whichever is greater.

With 10% line voltage change: 0.1 to 11 MHz, ±5 kHz; 1 to 110 MHz, ±50 kHz.

Spurious Signals:
Non-harmonics at least 40 dB below CW output. Harmonics at least 35 dB below +10 dBm CW output.

POWER SPECIFICATIONS

Power Output:
At least +20 dBm max. (2.23 VRMS into 50 ohms). Calibrated power output adjustable in 10 dB steps from +10 dBm to −110 dBm; 10 dB vernier permits continuous adjustment between steps. Source impedance is 50 ohms.

Power Accuracy:
±1 dB + attenuator accuracy (vernier in CAL position).

Attenuator Accuracy:
±1 dB to 70 dB attenuation; ±2 dB to 120 dB attenuation.

Output Flatness:
±0.25 dB (±0.1 dB over any 10 MHz bandwidth).

Price: Model 8698A RF Sweeper Generator, $950.
(Model 8690A Sweep Oscillator, $1550.)

For more information contact your local HP field engineer or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304, Tel: (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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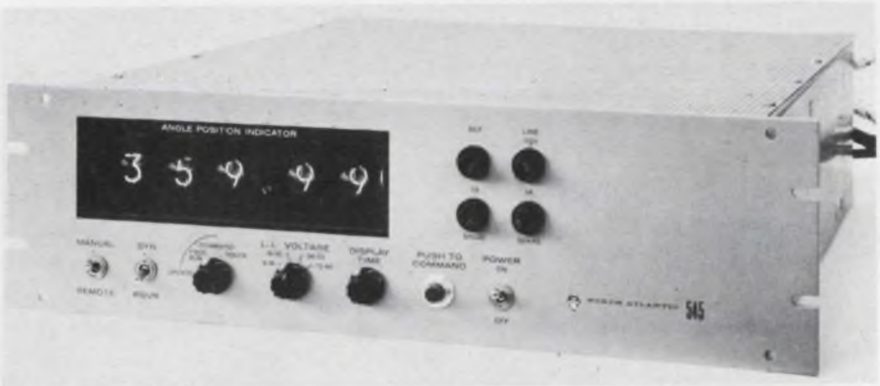
See New Hewlett-Packard instrumentation
at the IEEE Show, New York Coliseum, March 20-23

2470

ON READER-SERVICE CARD CIRCLE 83



Angle position indicator employs inductive dividers for stability

North Atlantic Industries, Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600. P&A: $5900; 60 days.

An angle position indicator that gives direct reading of synchro or resolver shaft angle achieves long-term stability through the use of inductive dividers in the synchro bridge.

The input-to-output ratio of the inductive divider depends primarily on its turns ratio, which is inherently constant. The inductive divider also offers a high input impedance, about 1/2 MΩ, to reduce loading of the resolver or synchro output. It also provides a low output impedance which reduces error due to loading by stray capacitance or low-impedance null detectors.

Figure 1 shows a simplified circuit of a manually operated bridge on which the automatic version is based. One inductive divider has output taps arranged in a cosine relation, and the other in a sine relation. The two dividers are simultaneously switched by decade switches reading directly in synchro or resolver shaft angles. Here manual switches are used to alter the inductive dividers' ratios. The voltages across the dividers are proportional to the sine and cosine, respectively, of the shaft angle θ. The ratio of the divider output, K_1/K_2, at null reading gives the tangent. One must go to the trig tables and look up $\tan^{-1} K_1/K_2$ to find θ.

In manual systems, as the switch positions are increased from one angle reading to the next, one divider output changes as the cosine of the angle, and the other as the sine. If the bridge dial reading is designated as angle α, then the ratio of the two divider outputs when both are excited by the same input voltage is $\sin \alpha / \cos \alpha = \tan \alpha$.

The divider tapped in sine relation is fed by the resolver's cosine winding, and the divider tapped in cosine relation, by the sine winding. At null, the ratio $\sin \alpha/\cos \alpha$, or tangent of the resolver shaft angle, is equal to $\tan \alpha$. This relationship involves a 180° ambiguity, since $\tan \theta = \tan \pm\theta$, but phase-sensitive null detection ensures that the correct value is chosen. In this way, direct reading of shaft angle is obtained.

The new automatic shaft angle indicator model 545 utilizes these methods with the added advantages outlined above, obtained by replacing the tapped resistive dividers with precision autotransformers and switching the autotransformers with solid-state switches.

The unit is an automated version of a direct-reading resolver or synchro bridge. In effect, it is a digital servo, in which the null detector's electrical output drives the semiconductor tap switches toward a null balance.

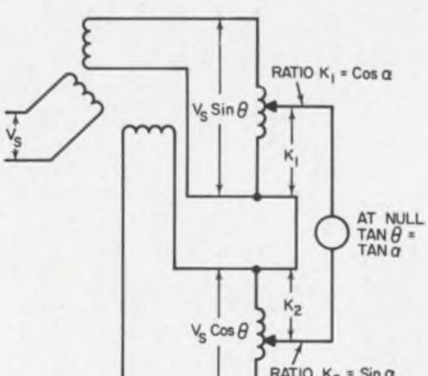
The converter operates in either the tracking or successive approximation mode. In the tracking mode, the divider taps are switched in smallest increment steps until null balance occurs.

In the successive approximation mode, the logic circuits switch the divider settings to 180° in order to interrogate the incoming data and decide whether the input angle is above or below 180°. If above, the most-coarse logic levels hold the dividers at the 180° setting, and the next stage of interrogation advances their setting toward balance at some, as yet unknown, angle between 180° and 360°. The second step chops the unknown angle in half again, and a succession of further steps carries the degree of approximation to the instrument's final 15-bit resolution.

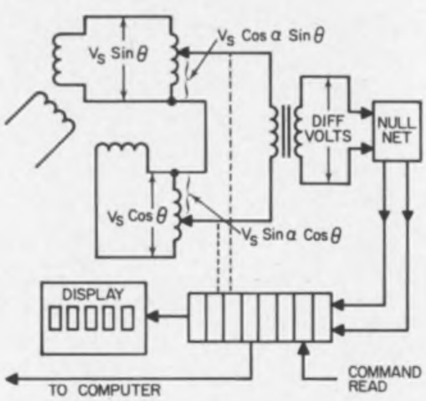
At this point, the unknown angle has been halved many times, and the final logic step resolves the last 36 arc-second decision.

The logic circuits then turn on the display and transmit the angle in binary or other code to a computer data center. The readout is a 5-decimal Nixie display. Display resolution is 0.01° of arc.

Booth No. 2H19 Circle No. 521



1. **Simplified circuit** of synchro or resolver bridge using inductive dividers for increased stability.



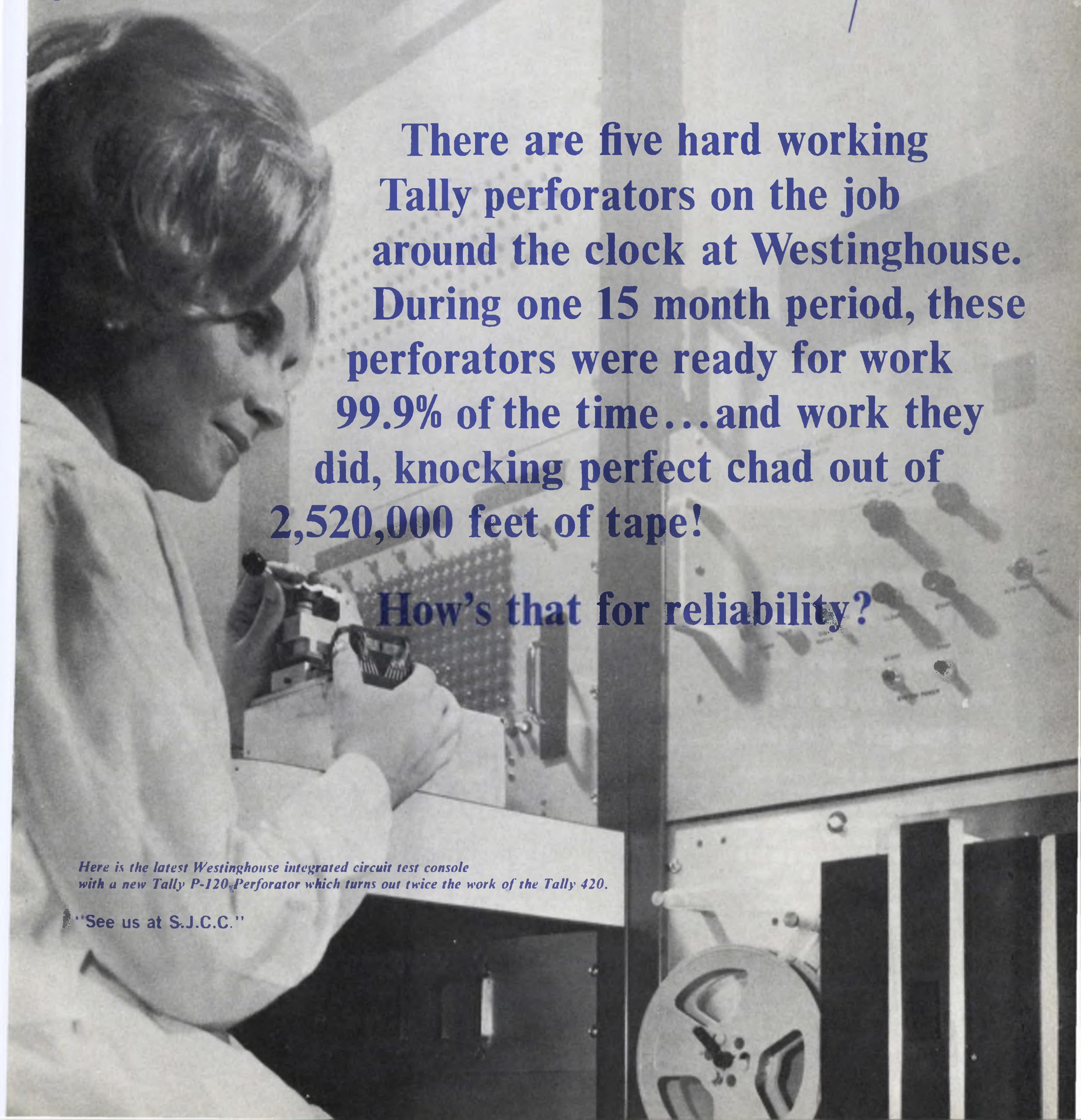
2. **Over-all diagram.** Up-down counter backtracks divider settings for correct angle.

Testing integrated circuits is a key step in their production. At the Molecular Electronics Division of Westinghouse Electric Corporation, Tally perforators are used to log data as each module is run through a series of parameter checks. Data logged on the tape is then analyzed by computer.

According to W. DeLauder, Foreman of the Instrumentation Section at Westinghouse, the five Tally Model 420 perforators worked extremely well during a fifteen month period just ended. Fewer than eight calls per perforator were made to keep all five perforators on duty over the entire period. The average time per call was 2.23 hours with an average cost for parts of $3.05.

During the fifteen month period, the five perforators punched with precision over 478 miles of tape. There are a lot of good solid engineering reasons why Tally perforators are extraordinarily reliable. For all of them, please address Ken Crawford, Tally Corporation, 1310 Mercer Street, Seattle, Washington 98109. In the U.K. and Europe, address Tally Europe, Ltd., Radnor House, 1272 London Road, London, S.W. 16, England.

TALLY



There are five hard working Tally perforators on the job around the clock at Westinghouse. During one 15 month period, these perforators were ready for work 99.9% of the time...and work they did, knocking perfect chad out of 2,520,000 feet of tape!

How's that for reliability?

Here is the latest Westinghouse integrated circuit test console with a new Tally P-120 Perforator which turns out twice the work of the Tally 420.

"See us at S.J.C.C."

Frequency comparator reads 1 part in 10^9

Vectron Laboratories, Inc., 146 Selleck St., Stamford, Conn. Phone: (203) 324-9925.

A frequency comparator accepts test and reference input signals of 1 MHz, 100 kHz and other sub-harmonics of 1 MHz with the optional added capability of accepting 5-MHz and 2.5-MHz test inputs. The comparator accepts a broad range of input levels at each of the frequencies without requiring any internal adjustments or front-panel switching. To further simplify operation, the test and reference inputs are each synthesized to 1 MHz in such a manner that the output is always referred to 1 MHz; this permits the output to be read as a percentage error without interpolation, independent of the input frequencies. If a 1-MHz test input were read directly on a frequency counter, the counter would provide a resolution of one part in 10^6 in one second. In order to improve the resolution, the two synthesized signals are processed through three tandem "times-ten frequency difference multiplier" circuits, each of which increases the resolution by a factor of ten. The resulting resolution with all three multiplier circuits switched into operation is one part in 10^9 in one second, and one part in 10^{10} in ten seconds. A front panel switch alllows selection of any one of four resolutions by connecting none, one, two or three of the multipliers into the system. The unit is applicable to measurement of the frequency difference between two oscillators, adjustment of two frequency sources to the same frequency, measure-mean of long-term stability (oscillator aging) and short-term stability analysis.

Booth No. 2J27 Circle No. 519

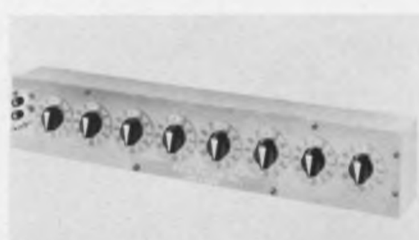
Coaxial switches have low vswr

Marconi Instruments, 111 Cedar Lane, Englewood, N. J. Phone: (201) 567-0607.

Low-vswr, high-isolation, single-pole two-, four- and eight-way programable coaxial switches cover dc to 1 GHz. For routing high-frequency signals and for propagation of fast-rise-time pulses, the switches offer power handling of 10 W up to 250 V peak. Switching is performed by dry-reed relays mounted in strip line configuration. Isolation figures are typically 95 dB at 10 MHz, 80 dB at 30 MHz, 75 dB at 100 MHz and 55 dB at 1 GHz.

Booth No. 2D04 Circle No. 500

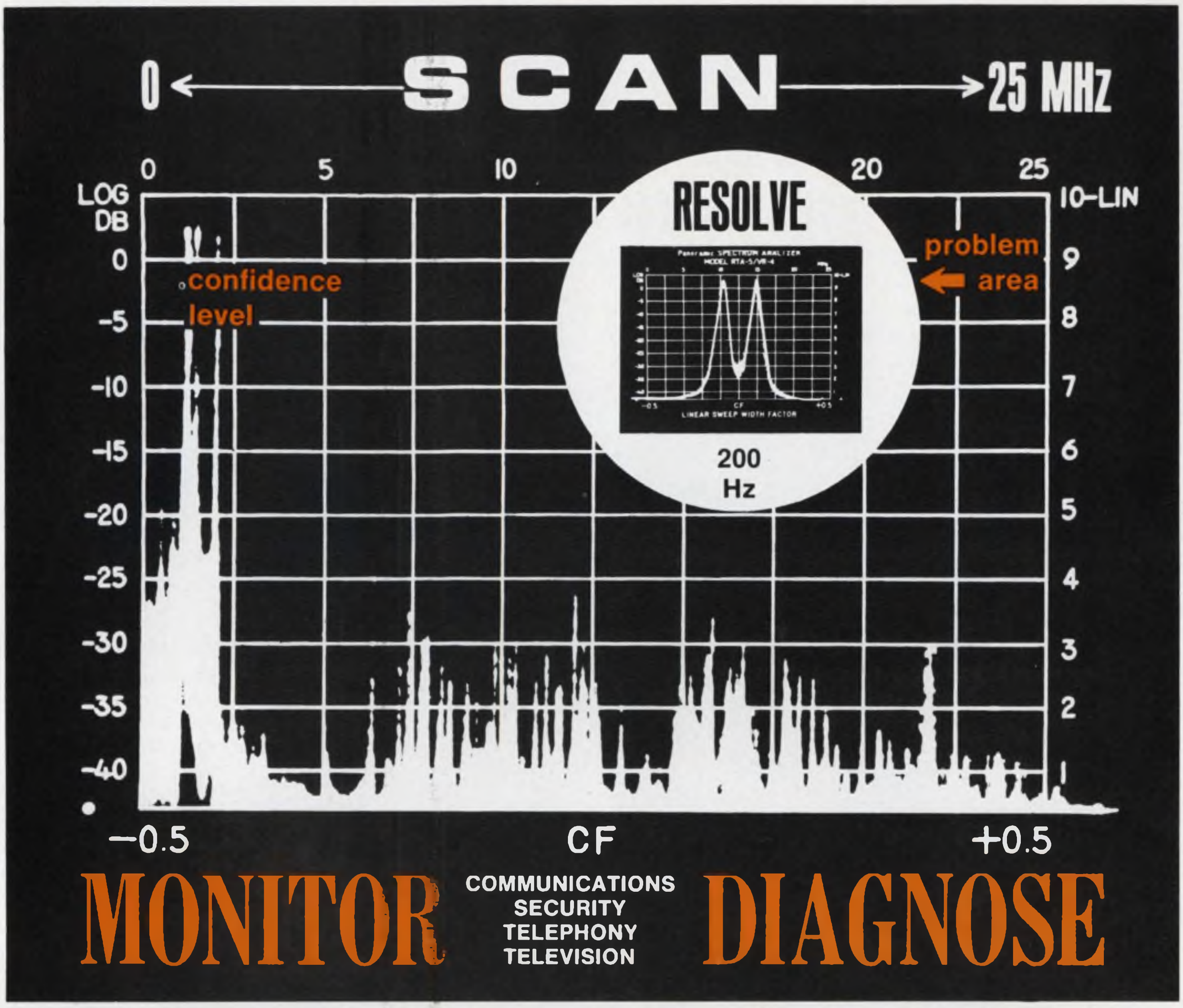
Low-cost divider has 1-ppm resolution



General Resistance, Inc., 430 Southern Blvd., Bronx, N. Y. Phone: (212) 292-1500. Price: $339.

A low-cost decade divider has eight dials and provides 0.01-ppm resolution. All dials are discrete-position decades since the unit contains no potentiometers. Features include accuracy (terminal linearity) for settings from 0.1 to full scale of ± 1 ppm; for settings below 0.1 accuracy improves to 0.004 ppm.

Booth No. 2H44 Circle No. 512



only with the Panoramic* VR-4/RTA-5 modular† spectrum analyzer

ON DISPLAY AT IEEE
BOOTHS 2B25-2B30

SPECIFICATION HIGHLIGHTS

Frequency range: 1 kHz-27.5 MHz digital readout
Scan widths: 50 kHz-5 MHz, or 500 Hz-50 kHz phase locked, digital readout; preset 0-25 MHz full dispersion
Resolution: 200 Hz
Sensitivity: 30 μv linear full scale
Log display: 40 db calibrated
Display flatness: $\pm$1 db
Frequency calibration: $\pm$0.02% internal crystal markers
Main frames: rack-mount or portable

† *Currently-available interchangeable modules: sonic (AR-1), log-scan sonic (AL-2), ultrasonic (UR-3), and video (VR-4).*

Panoramic*

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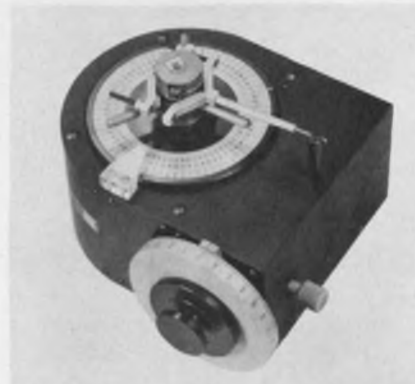
P-67-1

ON READER-SERVICE CARD CIRCLE 86

Dividing head has continuous rotation



Gertsch, Div. of Singer Co., 3211 S. La Cienega Blvd., Los Angeles. Phone: (213) 870-2761. Price: $800.

This dividing head features continuous rotation for testing pots and similar components for linearity. For rotary applications, an angular readout in 0.01° increments may be selected. The dividing head may also be used for field tests of synchros and resolvers.

Booth No. 2B25 Circle No. 398

Transistor oscillator sweeps clean

Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428.

High power output (1 V into 50 Ω) makes this sweeper useful for testing with large signals and thus minimizing noise and interference. The unit sweeps from 100 kHz to 2 GHz in four bands. Frequency calibration is made with a 1% accurate indicator dial and 0.01% accurate crystal-controlled markers.

Phase-locking provision is built in for locking to an external frequency standard. Provision is made for external programing of frequency, power output, sweep width and sweep repetition rates.

Booth No. 2F43 Circle No. 503

Adlake Mercury Wetted Relay — Application Data

Measurement of "Dynamic Contact Noise" for Low Level Signal Applications

Adlake AWCS 26000 Series Relay— 2 Switch Form C

In small signal applications, such as computers, telemetric systems, strain gauges, etc. generated emf. within the system's relays must be taken into account.

Dynamic Contact Noise is a "coined" phrase used to indicate an undesired generated emf. upon contact closure. It is the result of mechanical oscillation of the armature—caused by the impact of the armature on the stationary contacts — sweeping the coil flux.

Typical illustrations of this noise are shown in the oscillograms, with the relay being driven at nominal voltage in the test circuit shown below. The frequency and amplitude are integral functions of system bandwidth and coil drive conditions.

The slight ripple seen at the end of each trace is not noise, but due to resolution of test equipment and test circuit.*

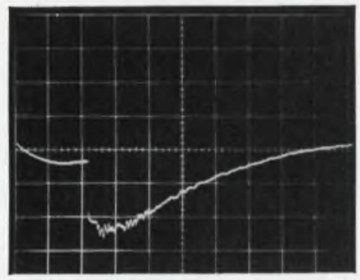


FIGURE 1

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	20 μV/cm
Systems Bandwidth	.06—60 Hz.

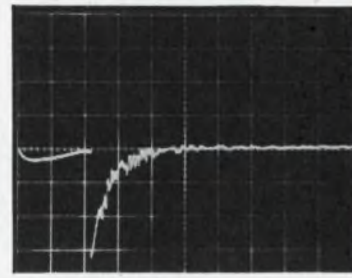


FIGURE 2

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	100 μV/cm
Systems Bandwidth	.06—600 Hz.

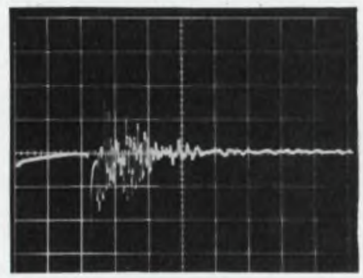


FIGURE 3

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—6K Hz.

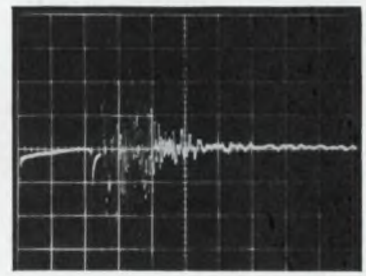
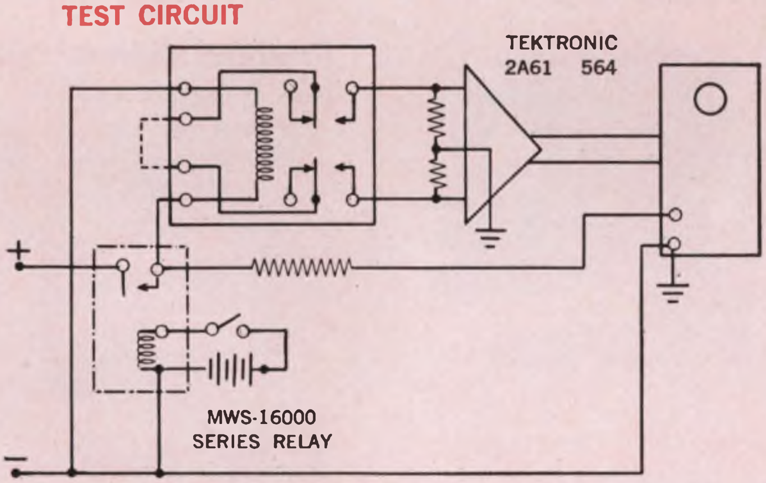


FIGURE 4

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—60K Hz.

TEST CIRCUIT



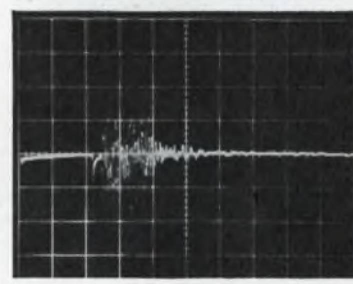


FIGURE 5

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	500 μV/cm
Systems Bandwidth	.06—100K Hz.

* If you have a problem regarding relay applications to a particular system our engineering staff is ready to help you. Contact Mr. Le Roy Carlson, Chief Project Engineer.

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

Adlake SINCE 1857

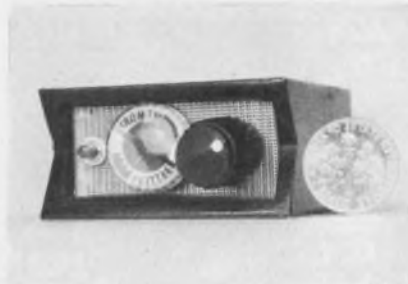
THE ADAMS & WESTLAKE COMPANY

Dept. 1037 Elkhart, Indiana, U.S.A. 46514 • (AC 219) 264-1141

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

ON READER-SERVICE CARD CIRCLE 88

Peak detector reads 10-ms transients



Roveti Instruments, 1643 Forest Dr., Annapolis, Md. Phone: (301) 974-0876. P&A: $44.50; 2 to 4 wks.

Transients as short as 10 ms can be reliably detected and locked in with this unit to indicate the cause of failure in solid-state equipment. The unit has a floating input so it can monitor positive or negative levels from 50 millivolts to 50 volts at any point. An external resistor will increase the upper end of the range to hundreds or thousands of volts (sensitivity is 20,000 Ω/V).

Booth No. 2A18 Circle No. 516

RF load resistors rated 100, 225 W

Bird Electronic Corp., 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200. P&A: $125; stock.

Dry high-power coaxial loads are designed for 50-Ω RF line and system termination in any position. The 100-W model 8160 is completely independent of extraneous heat sinks or cooling liquids. Mating it with an axial air-flow device in the model 8161, the "sun-burst" radiator permits a safe RF power dissipation of 225 watts. Maximum vswr limits are 1.1 from dc to 1 GHz, and 1.2 to 2.5 GHz.

Booth No. 2F39 Circle No. 390

Wheatstone bridge accurate to 1 ppm

General Resistance, Inc., 430 Southern Blvd., Bronx, N. Y. Phone: (212) 292-1500. P&A: $3750; 60 to 90 days.

A completely self-contained resistance measurement system consists of a wheatstone bridge, solid-state null detector, regulated power supply and automatic go, no-go per cent selector programer. The go, no-go feature reads error in per cent or ppm of the component under test. Over 600 resistors per hour can be measured and sorted with 1-ppm relative or ±10-ppm absolute accuracy.

Booth No. 2H44 Circle No. 513

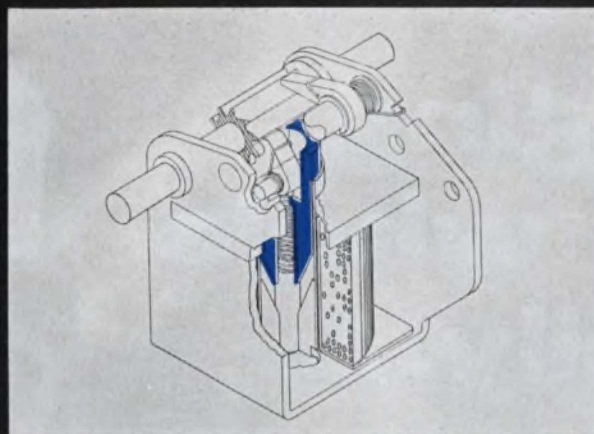
Predetermining counter has 5-figure count

Veeder-Root, Hartford, Conn. Phone: (203) 527-7201.

The electronic predetermining sections of this counter are of modular design with sealed, plug-in relays for each preset level. The mechanical input shaft can accept up to 5000 counts a minute. The basic model has five-figure count capacity and accommodates up to four preset knock-off channels.

Booth No. 2D45 Circle No. 506

Our new little stepping motor has two very interesting features:



1. A linear-motion armature
2. A price below ten dollars*

Rotary-type stepping motors work pretty well, but as we see it, they're unnecessarily complicated (and expensive).

Consider rotor overshoot compensation. We don't need any. The linear, solenoid-and-plunger design of our Roto-Netic® stepping motor obviates the problem.

When the solenoid is de-energized, the armature moves straight upwards, under positive spring pressure, and directly drives the actuator that turns the starwheel. Neat and simple as that.

The plunger configuration also eliminates the need to compensate for lateral shaft movement. Because the output shaft turns on its own axis, there is no axial thrust motion to worry about. (The output shaft, incidentally, is double-ended so that you have a built-in choice of either clockwise or counterclockwise rotation.)

Yet another advantage of our linear design is a relatively high torque output. The Model SC1 motor shown here will deliver a starting torque of 0.1 inch-pounds (1.6 inch-ounces). Pounds or ounces, that's good performance for a unit that is about the size of an ice cube and weighs a scant six ounces.

The SC1 provides a step increment of precisely 36°. The mathematically minded will immediately recognize that this works out to ten steps for one complete revolution. The motor should therefore be very attractive to those of you working with decade functions.

At present, we're stocking 12VDC and 115VAC models. We can and will produce other voltage ratings to your order. At any rated voltage, the motor is capable of 600 operations per minute.

We'll be glad to send you a descriptive spec sheet. Just ask us for Bulletin 701. If you're inclined to be daring, you can send us ten bucks for a sample unit and investigate further on your own lab bench. Either way, let us hear from you. Heinemann Electric Company, 2616 Brunswick Pike, Trenton, N.J. 08602.

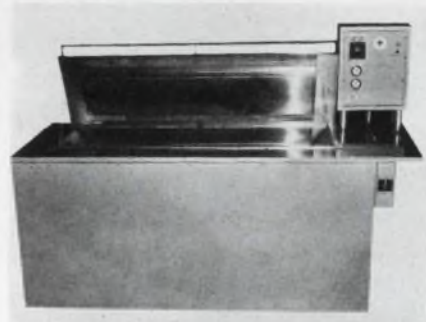
HEINEMANN

3629

*$8.00 to be exact, for OEMs, in quantities of 100 to 499.

ON READER-SERVICE CARD CIRCLE 90

Wire tester operates to 1500°F



Procedyne Corp, 221 Somerset St., New Brunswick, N. J. Phone: (201) 249-8347. P&A: $6850; 8 to 10 wks.

A constant temperature bath for wire and heat testing operates at temperatures up to 1500°F. The unit is designed for testing wire cable sheaths at their specification temperature. The tester permits putting about 30 cables into the air-fluidized solids for checking at specification temperature. The unit provides a temperature uniformity of ±0.5°F and control of ±1°F.
Booth No. 2F44 *Circle No. 389*

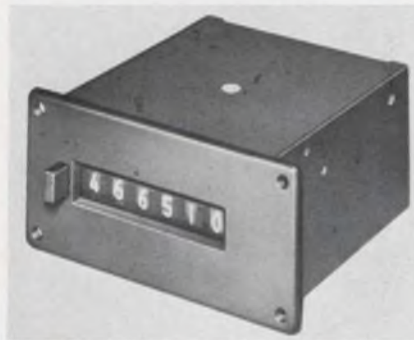
Noise, field intensity by automatic scanning

Singer Co., Metrics Div., 915 Pembroke St., Bridgeport, Conn. Phone: (203) 366-3201.

Automatic scanning within any portion of the 20-Hz-to-15-kHz range is possible with this noise and field intensity meter. Upper and lower limits of the sector to be scanned are selected remotely, or by means of a front panel scan limit control. This permits continuous spectrum scanning or single sweep, upward or downward in frequency. Three separate calibrated scales are provided: peak, average and rms.
Booth No. 2B25 *Circle No. 387*


Now the industry-accepted TTL has a double, pin for pin...
Westinghouse TTL. Available now.
The new direct replacement for industry-accepted SUHL II is here. Westinghouse TTL is a true mechanical and electrical replacement, pin for pin. Here's a second source TTL that can help keep your products competitive into the 1970's. □ Circuits now available in industry standard dual-in-line and flat packages include: 6G241 Dual NAND/NOR Gate; 6G221 Quadruple NAND/NOR Gate; 6F251 JK Flip-Flop, AND input; 6F261 JK Flip-Flop, OR input. □ For evaluation quantities, contact your Westinghouse Electronic salesman. Or phone Westinghouse at (301) 796-3666. Or write Westinghouse, Molecular Electronics Division, Box 7377, Elkridge, Maryland 21227.
You can be sure if it's Westinghouse
J-09141

Six-figure counter to 2400 per minute



Durant Manufacturing Co., 622 N. Cass St., Milwaukee. Phone: (414) 271-9300.

High-speed six-figure counters panel or base mount, offer manual or electric reset options. They are said to be the only electrical reset counters with the entire mechanism housed within the case. Count speed is 2400 counts/minute dc and 1800 ac. Leads are accessible and provide for permanent installation without extraneous hardware.

Booth No. 2H48 Circle No. 518

Variable filter covers 20 Hz to 2 MHz

Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass. Phone: (617) 491-3211. P&A: $695; 90 days.

Providing basic low-pass and high-pass modes, this unit can, by interconnecting its two independent channels, be operated as either a band-pass or band-reject filter. In addition, cascading the two channels can increase the basic 24-dB-per-octave attenuation slope to 48 dB per octave in the low-pass and high-pass modes. Each channel has response characteristics for frequency or time-domain applications.

Booth No. 2H11 Circle No. 514

Vector voltmeter is battery-operated

Industrial Test Equipment Co., 20 Beechwood Ave., Port Washington, N. Y. Phone: (516) 767-9190.

A battery-operated portable vector voltmeter is available for operation over a range of 1 mV to 300 V full scale. It has a voltage accuracy of 2% of full scale, and a phase angle accuracy of ±1%. The frequency range is 50 Hz to 10 kHz. Noise and harmonic rejection is 40 dB.

Booth No. 2H02 Circle No. 515

Programable attenuator ranges dc to 1 GHz

Marconi Instruments, Englewood, N. J. Phone: (201) 567-0607.

Programable attenuators for systems use cover dc to 1 GHz. They accept 1-2-4-8 BCD and have a range of 139 dB in 1-dB steps. Accuracy at 1 kHz is ±0.5%, ±0.1 dB to 120 dB; at 1 GHz it is ±1%, ±2 dB to 100 dB. Setting speed is less than 100 ms and at no time during switching is the attenuation less than the initial or final programed value.

Booth No. 2D04 Circle No. 385

Solid-state ac voltmeter ranges 2 Hz to 6 MHz

Ballantine Labs., Inc., P. O. Box 97, Boonton, N. J. Phone: (201) 334-1432. P&A: $320 (battery/line), $290 (line only), $62 (probe and cable); June.

Frequency range of this voltmeter is from 6 MHz down to 2 Hz. Its voltage range is 300 μV to 350 V when used without model 1303 probe, or 1 mV to 1000 V when used with the probe. Accurate measurements may be made to as low as 100 μV over the narrower range of 10 Hz to 1 MHz without the probe, or to 300 μV with the probe.

Booth No. 2G26 Circle No. 392

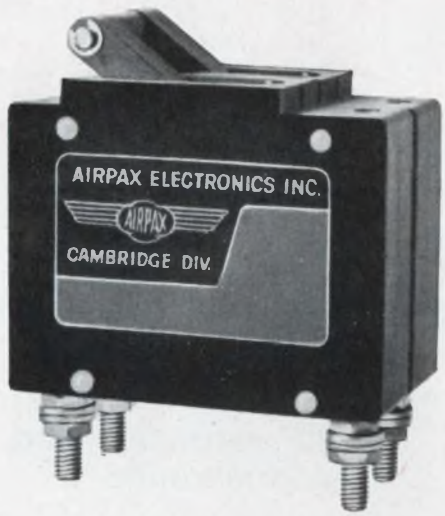
Squarewave generator has 5-ns rise time

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $375; stock.

A solid-state squarewave generator covers 1 Hz to 10 MHz. Squarewave rise and fall times are less than 5 ns; overshoot, preshoot and ringing are less than 5%; and jitter is less than 0.2% of waveform period at any repetition rate. The generator takes only half the width of a 7-inch-high space when rack-mounted, and weighs 9 lbs.

Booth No. 2F25 Circle No. 501

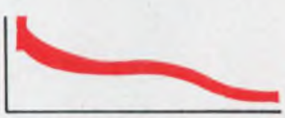
MATCH PROTECTOR TO HARDWARE



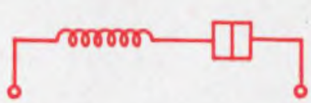
An APL Circuit Protector–

will rupture a fault of 5,000 amperes at 240 volts!

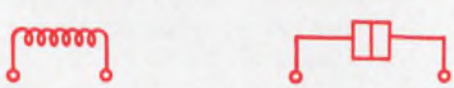
provides a time delay for every demand!



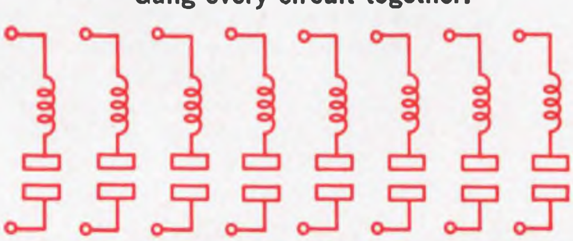
is entirely magnetic — no heater elements!

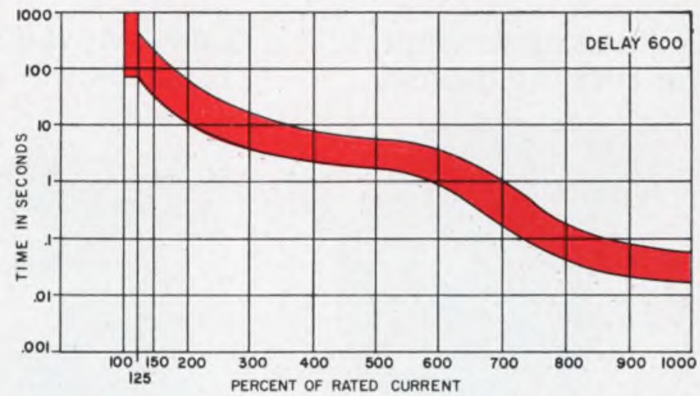


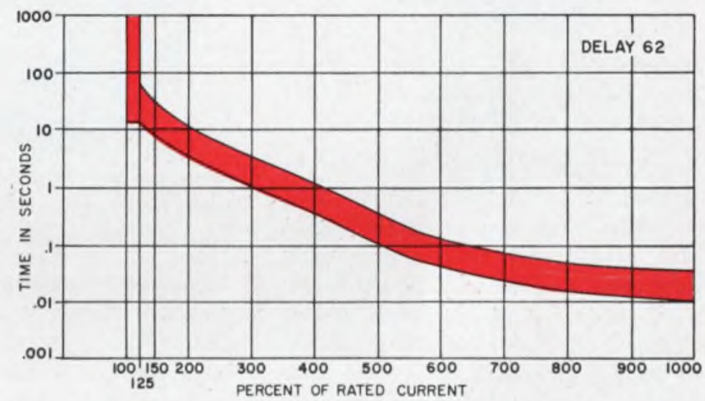
Tripping coils can be completely isolated!

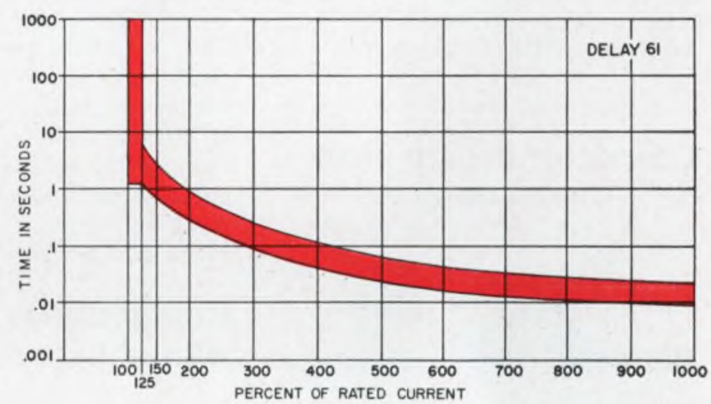


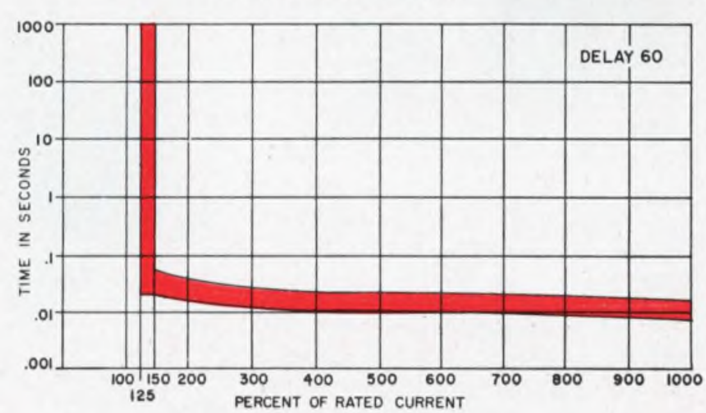
Gang every circuit together!











TYPICAL 60 CYCLE DELAYS

AIRPAX ELECTRONICS

CAMBRIDGE, MARYLAND 301-228-4600

ON READER-SERVICE CARD CIRCLE 101

Solid-state monitor for rotating devices

Himmelstein & Co., 2500 Estes Ave., Elk Grove Village, Ill. Phone: (312) 439-8181. Price: $59.50.

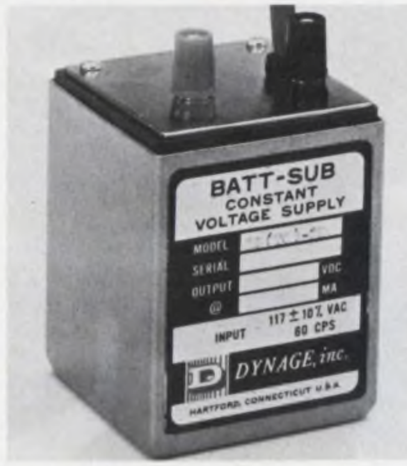
A rotating switch monitor is offered for protection and control of rotating components, without slip-ring problems. It monitors contacts on rotating devices coupled through a 2-channel rotary transformer. Status lights indicate the condition of the rotating switch. A solid-state circuit drives an electromechanical relay with form C contacts.
Booth No. 2B46 Circle No. 396

Connector design gives 50% more contacts

Winchester Electronics, Div. of Litton Industries, Main & Hillside, Oakville, Conn. Phone: (203) 274-8891.

A new arrangement of contacts is claimed to permit 50% more contacts in this connector than is usual for its size. Crimp contacts, 0.03 inch diameter, rated at 5 A, accommodate AWG 20 through 30 wire. The shell is of thermoplastic; the connector mounts with a single jackscrew and is polarized.
Booth No. 2K21 Circle No. 384

Constant voltage supply replaces wet cells



Dynage, Inc., 390 Capitol St., Hartford, Conn. Phone: (203) 249-5654. P&A: $125; stock to 2 wks.

Guarded constant voltage supplies are offered as replacements for dry or wet cells used to supply the standard current to laboratory potentiometers. The unit includes a guard feature that prevents leakage currents from passing from the positive output terminal to ground within the unit. Voltage regulation is 0.0005% for a ±10% input change. The temperature coefficient is ±0.0005%/°C over a range of 15 to 35°C.
Booth No. 2F02 Circle No. 520

Ku-band coax switching with shunted pin diodes

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $325 (1 to 9), $308.75 (10 to 24), $292.50 (25 to 99); stock to 2 wks.

Two broadband solid-state switches achieve operation in the 12-to-18-GHz (Ku) band with insertion loss of 1.5 dB, isolation of 50 dB and vswr of 1.6 in the on condition. Switching is accomplished by changing bias levels on two pin diodes that shunt the transmission line. The signal is passed when diode bias is zero or reverse, and hence diode resistance is high. When forward-biased, the matched diodes shunt the transmission path with a low impedance that reflects RF signals. The amount of forward bias current determines the magnitude of the shunt impedance and thus the amount of reflection. Full reflection is obtained with bias currents on the order of 50 mA.
Booth No. 2F25 Circle No. 399

RF wattmeter/load is dual-range

Bird Electronic Corp., 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200.

For design, service and maintenance of transmitters in the 2-to-30-MHz range when the system cannot be terminated in its antenna, model 6155 is an RF wattmeter and integral load. The wattmeter consists of a logarithmic coaxial-line load resistor, which serves as a 150-watt dummy load within a finned radiator, and a voltmeter circuit coupled to a direct-reading meter calibrated in watts. A slide-switch selects either the 50 or the 150-W scale. The load is a 50-Ω termination from dc to 1000 MHz with a vswr of less than 1.1.
Booth No. 2F39 Circle No. 391

ON READER-SERVICE CARD CIRCLE 300 thru 307 ➤

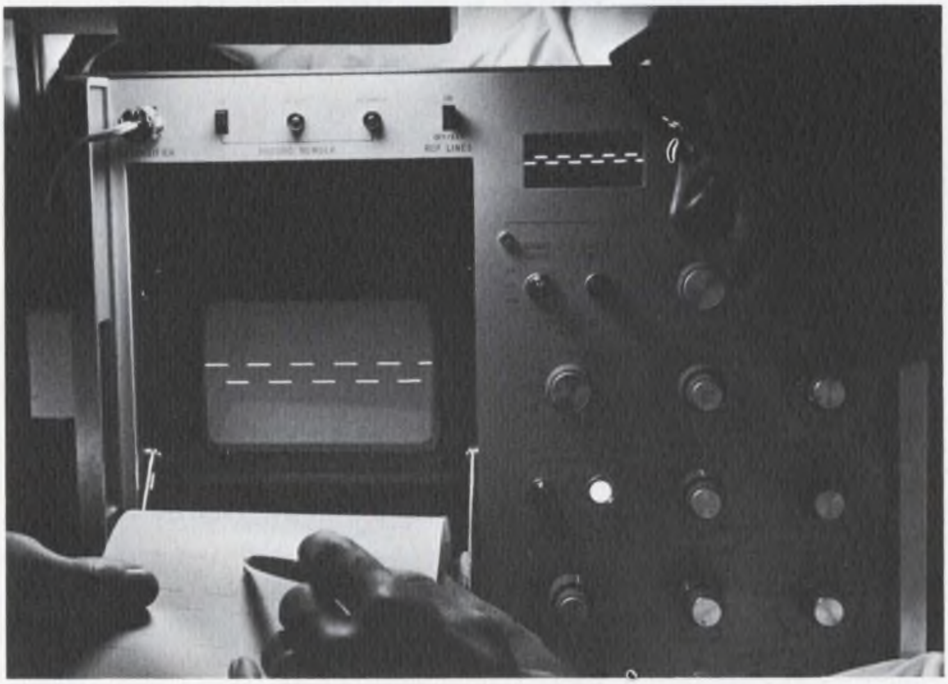
Component and Circuit Design

IDEAS

from SYLVANIA Electronic Components Group

CRTs

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



Honeywell's new Model 1806 CRT Visicorder

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

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

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

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

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

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

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

(continued)

This issue in capsule

CRTs *(continued from page 1)*

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

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

CIRCLE NUMBER 300

Sylvania's SC-4082E fibre-optic CRT

BASIC CHARACTERISTICS OF TYPICAL FIBER OPTIC CRTS

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

INTEGRATED CIRCUITS

How to step servo motors with SUHL/TTL ICs

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

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

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

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

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

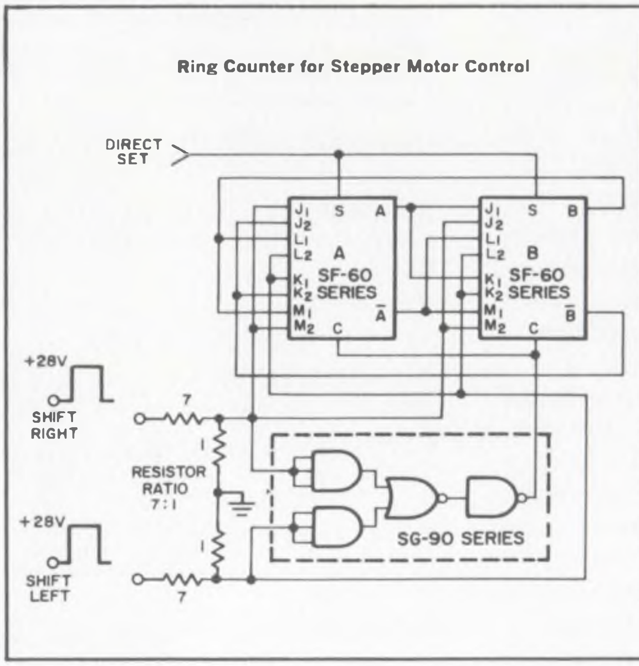
The +28 V dc supply is cut to 4.5 to 6.0 V to provide dc for the ICs. This is done with a series dropping resistor. However, if the motor causes voltage spikes of considerable amplitude, a zener diode can be used for regulation.

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

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

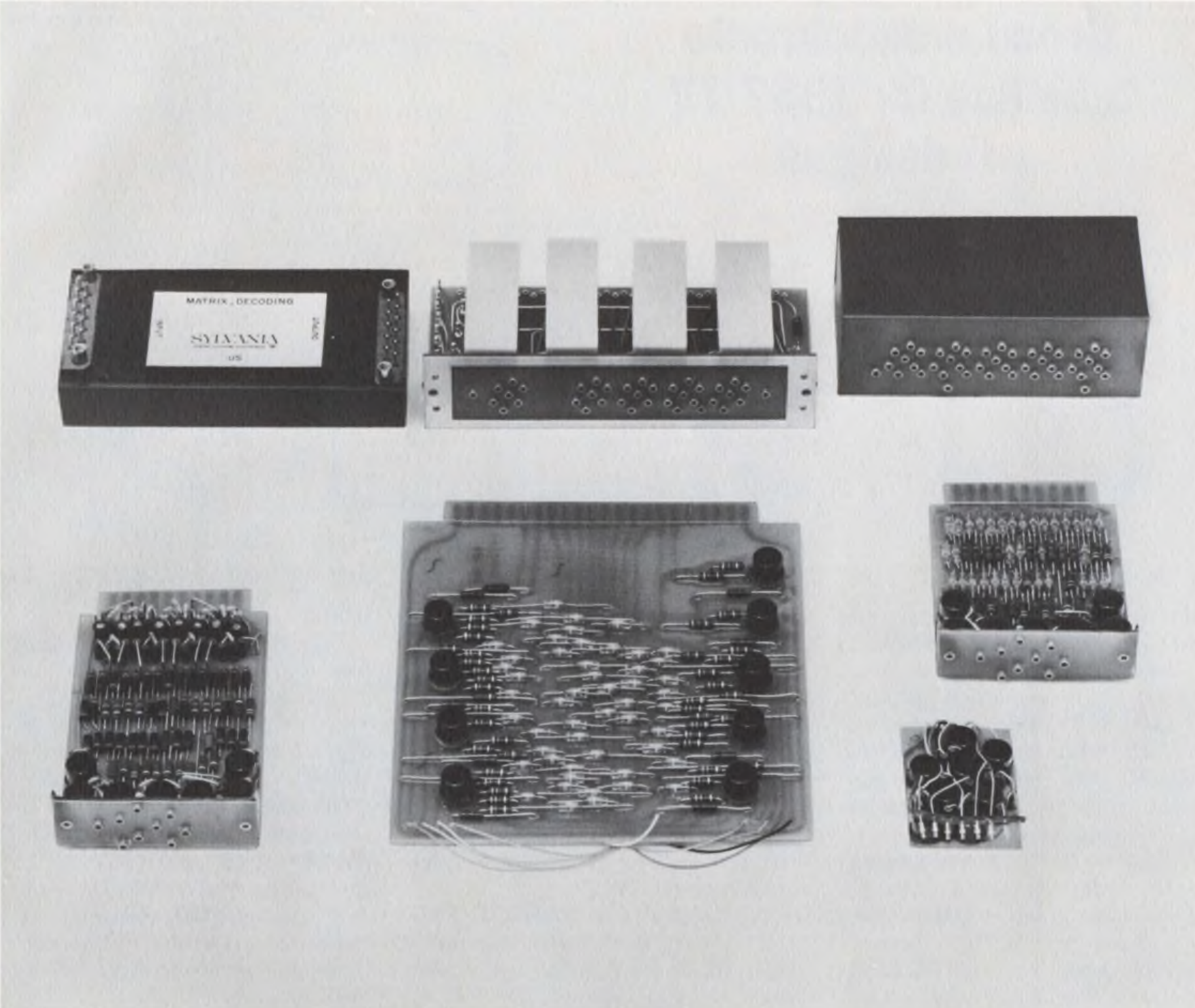
CIRCLE NUMBER 301

Ring Counter for Stepper Motor Control



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

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



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

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

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

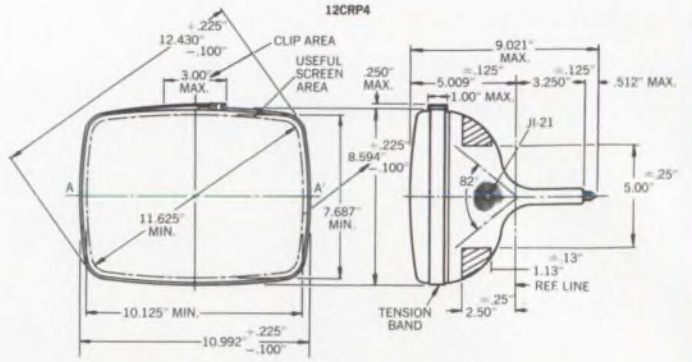
In all applications, translators and drivers combine to perform the double function of input translation and EL panel segment switching. They feature compact design, low-power requirements, fast switching, low-level logic input, long life, modular design and solid state reliability. In addition, they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

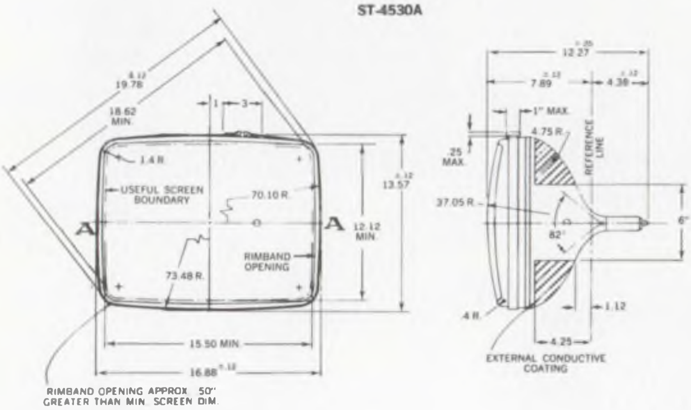
Typically, in these Sylvania units, binary input codes are translated to numeric readout by diode logic circuits and El readout panel power is switched by SCRs.

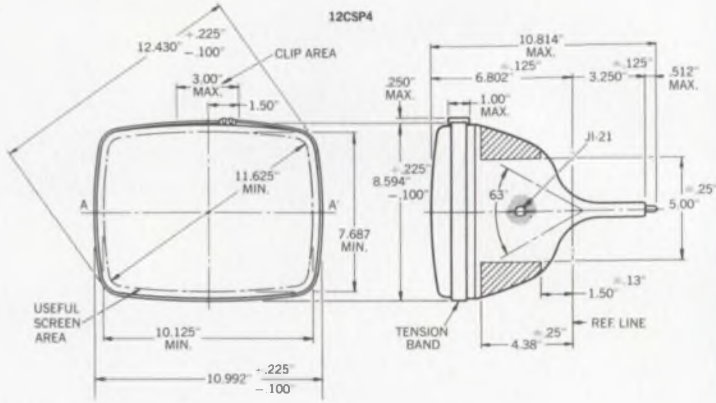
Translator power requirements are a low 6 to 12 volts at a few milliamperes. Readout driver power depends on the size and type of the EL readout used. Units can have either positive or negative logic inputs of as low as 6 volts at 2 ma per data bit and pulse widths of 1 μsec.

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

Broad monochrome tube line for 1967 TV set designs







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

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

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

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

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

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

CIRCLE NUMBER 303

MICROWAVE COMPONENTS

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

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

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

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

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

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

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

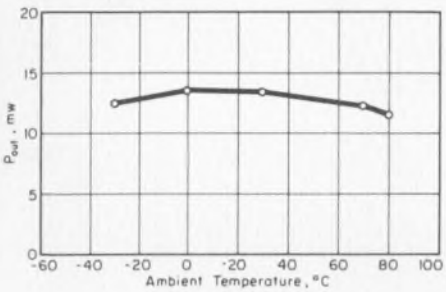
CIRCLE NUMBER 304

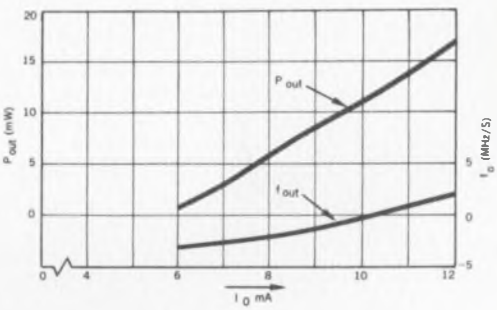
ELECTRICAL CHARACTERISTICS OF SYA-3200

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

*To be specified within this range.

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





MARKETING SERVICES MANAGER'S CORNER

"Trade shows are a waste of time"

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

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

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

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

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

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

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

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

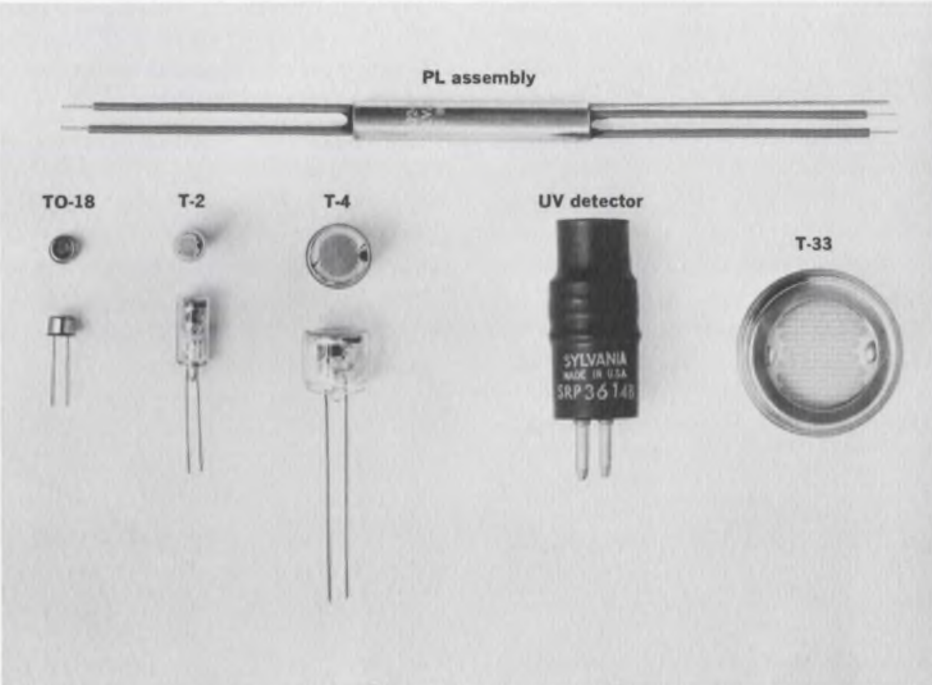
We want people to know more of what Sylvania can do today and in the years to come.

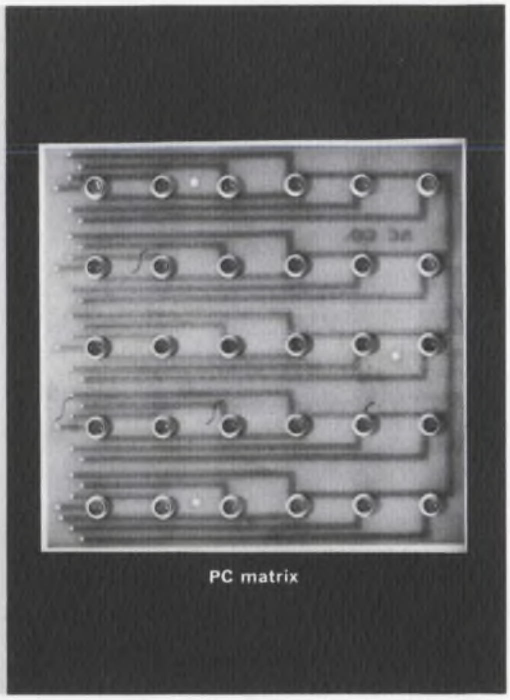
For your company, trade shows can be a waste of time, but there is also the opportunity to learn a great deal at a relatively small cost. We sincerely hope you share our thoughts for maximizing the time and money devoted to the trade show concept. Sylvania wants to make good use of the time you give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

Bill Dixon

W. R. DIXON

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





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

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

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

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

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

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

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

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

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

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

CIRCLE NUMBER 305

SUHL circuits can simplify noise and power problems in systems design

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

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

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

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

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

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

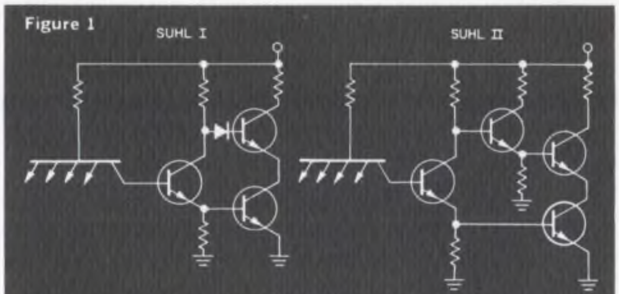
By using an output circuit shown in Figure 1, the pull-up network effectively removes the charge stored in the output transistor and virtually eliminates storage time as a factor in output characteristics. The result is a circuit having a propagation delay time which is constant over the full temperature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

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

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

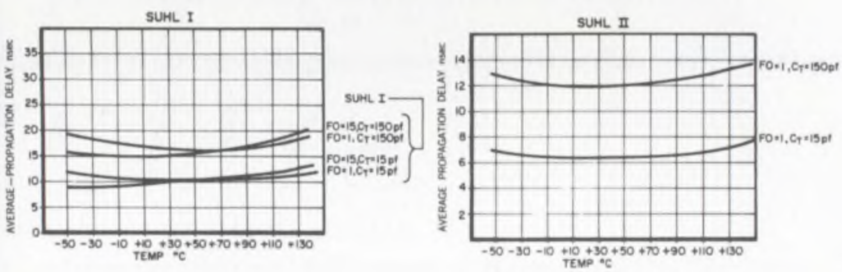
CIRCLE NUMBER 306

Figure 1



TWO SUHL CIRCUITS WITH "LOW RESISTANCE SWITCHED OUTPUTS"

Figure 2



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

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

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

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

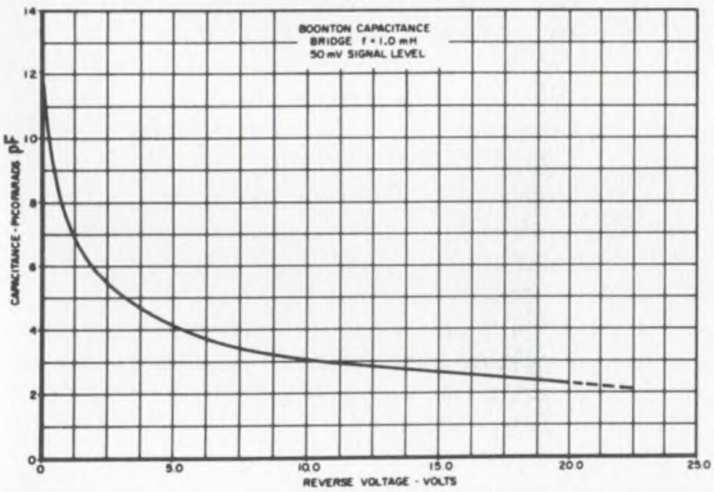
All units have a power rating of 250 mW, and a junction temperature range of −65° C to +175° C. Typical specifications show minimum forward currents of 100 ma at 1V, breakdown voltages of from 30 to 420 volts, and maximum reverse leakage currents of 2 to 50 nanoamps.

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

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

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

TYPICAL CAPACITANCE VS VOLTAGE DF-7



CIRCLE NUMBER 307

NAME ______

TITLE ______

COMPANY ______

ADDRESS ______

CITY ______ STATE ______

Circle Numbers Corresponding to Product Item

300 301 302 303 304
305 306 307

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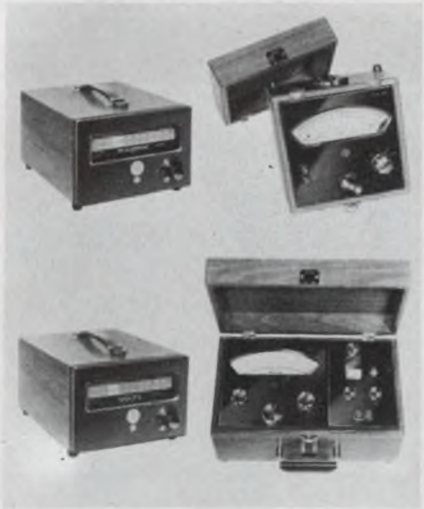
True rms ammeter accurate, stable



Greibach Instruments Corp., 315 New Ave., New Rochelle, N. Y. Phone: (914) 633-7900.

True rms Transquare microammeters have a low full scale range of 50 microamperes. The instrument achieves an accuracy of ±0.5% full scale for irregular wave forms with crest factors in excess of 8; also square waves up to several kHz. Exceptional stability, with repeatability of better than 0.1%, is reported since no amplifiers, power supplies, or other active electronic components are used in the meter design.

Booth No. 2H45 Circle No. 386

Circuit breaker has wide threshold range

Roveti Instruments, 1643 Forest Dr., Annapolis, Md. Phone: (301) 974-0876. P&A: $39.50; 2 to 4 wks.

Any dc power supply from 4 to 35 V will operate this circuit breaker and protect both power supply and load. The threshold value is adjustable from 1 to 100 mA with ranges of 0.1 to 10 mA, and 10 mA to 1 A optional. Units in the 1.5-to-200-V range are also available. Dimensions are 1 in. by 2 in.².

Booth No. 2A18 Circle No. 517

Remember to return your **ELECTRONIC DESIGN** renewal card. Don't miss any issues in '67.

Hall-effect gaussmeter operates triple-mode

RFL Industries, Inc., Boonton, N. J. Phone: (201) 334-3100. P&A: $1000; June.

A Hall-effect gaussmeter, model 3265, is useful for work with magnetron assemblies, TWTs, d'Arsonval meter gaps, accelerometers, mass spectrometers, loudspeaker gaps, motor fields, torque motors, magneto and alternator fields and any other device where a permanent or ac magnetic field is encountered. The unit performs three separate functions. It measures flux densities from 0.02 gauss to 50 kilogauss, dc and ac to 400 Hz. It measures incremental determinations of field variations to a resolution of 1 ppm when used as an expanded scale gaussmeter. In the differential mode it permits simultaneous measurement of two separate fields or single field gradients.

Booth No. 2A35 Circle No. 502

Network analyzer sweeps 2 Hz to 30 MHz

Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428. P&A: $4925; 8 wks.

Swept frequency Smith chart plots can be made automatically with this network analyzer. It also plots phase vs frequency, level vs frequency and return loss vs frequency and can plot the transmission measurements in polar form. Swept frequency is performed in the 2-to-30-MHz range. Phase is measured with 0.1° resolution over a 360° range where amplitude variations are up to 60 dB. Amplitude is also measured over a 60-dB range for impedance plotting. The directivity of the internal coupler is 40 dB which permits the measurement of vswr as small as 1.02.

Booth No. 2F43 Circle No. 395

RBM CONTROLS

Open Construction Bi-Reed Relays

This new family of standard size Bi-Reed relays offers true economy with RBM's industry-recognized high reliability. They feature straight, unstressed contact leads which prevent damage to capsule seals, and the contact terminals are welded (or soldered) to the printed circuit terminals which are on 2.5″ centers with .218″ terminal spacing. Standard 1 thru 6-pole and 12-pole forms are available with coil voltages thru 48 volts D.C.

Of course, RBM makes the complete unit . . . including the switch . . . with automatic equipment in "white room" facilities. This *single source responsibility* means consistent characteristics and total reliability in every RBM Bi-Reed you use! Call your local RBM Controls sales engineer or write for Technical Bulletin 2020.

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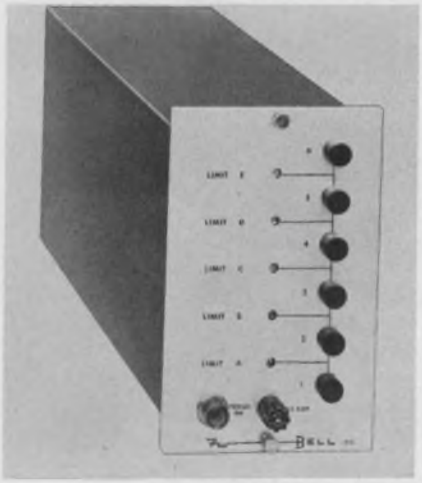
ON READER-SERVICE CARD CIRCLE 105

Eddy current tester with new limit unit



F. W. Bell Inc., 1356 Norton Ave., Columbus, Ohio. Phone: (614) 294-4906. P&A: $980; stock.

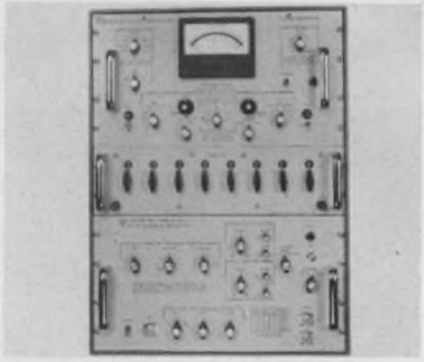
A voltage-sensitive switching instrument, acting as a six-state electronic gate, will accept dc inputs of either positive or negative polarity. Any five dc signal levels between −2 V and 2 V can be selected as switching levels. Upon selection of five levels within this range, six states are defined. When used in conjunction with a test application, these states may represent normal, marginal, and out-of-tolerance conditions for a test part. For use with an instrument that furnishes an output level range of 0 to 2 V, the switching levels (or limits) may be set at five different levels between 0 and 2 V.
Booth No. 2B10 Circle No. 341

Delay distortion measured to 5 MHz

Wiltron Co., 930 East Meadow Dr , Palo Alto, Calif. Phone: (415) 321-7428. P&A: $6900; stock.

The entire 30-kHz-to-5-MHz frequency range is covered in a unit designed for delay distortion measurements of carrier frequencies in the range. Crystal-controlled frequency and counter techniques are used for getting stable and accurate time delay measurement. The unit has crystal-controlled reference delays in 10-ms steps up to 200 ms for use in offsetting the time delay.
Booth No. 2F43 Circle No. 537

Phase standard reads 0° to 360° in 7 digits



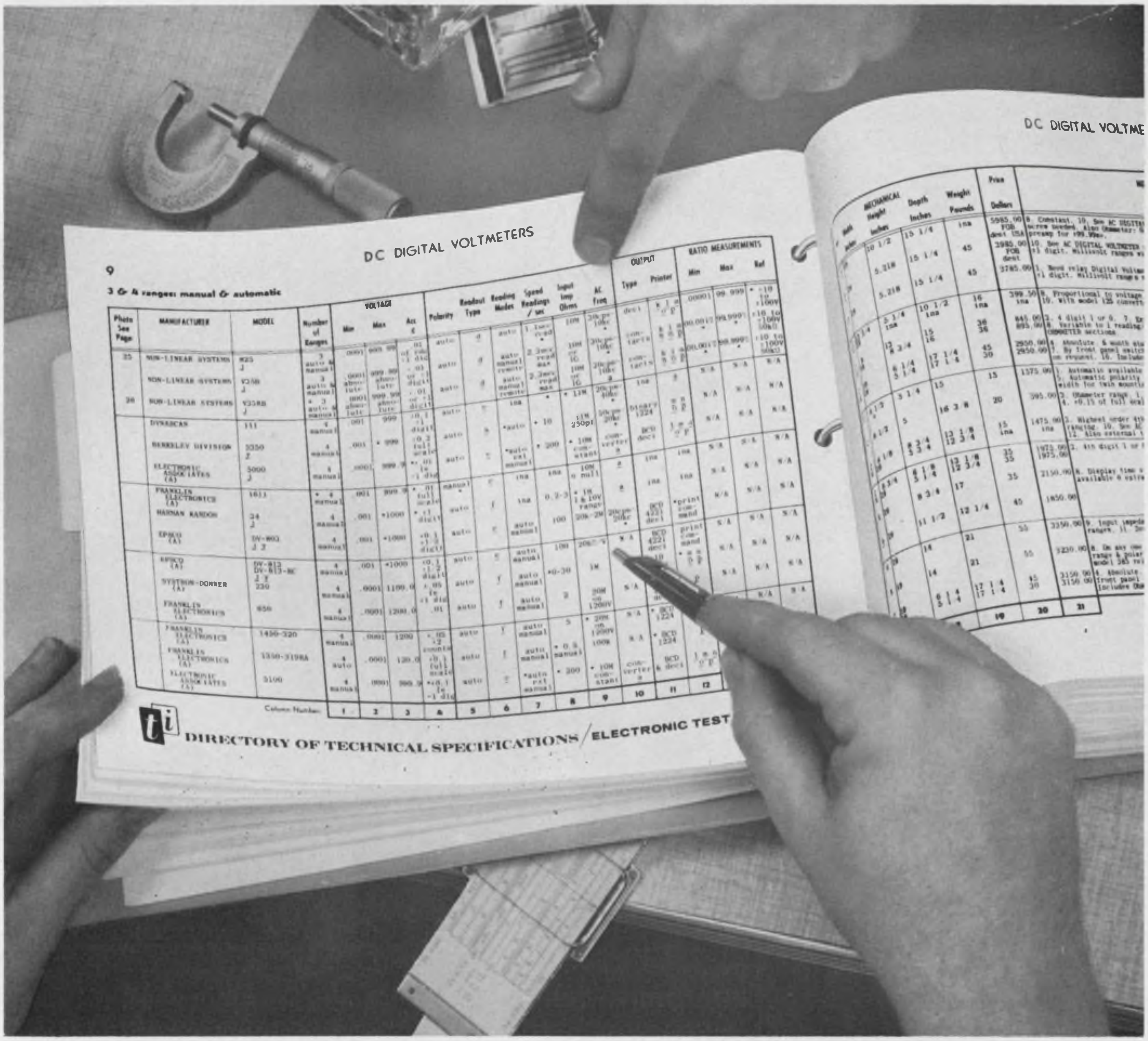
Ad-Yu Electronics, Inc., 249-259 Terhune Ave., Passaic, N. J. Phone: (201) 472-5622. P&A: $4365; 4 wks

Self-calibration and self-checking by means of fundamental bridge balancing without the use of an external standard is featured in this phase standard. The instrument receives a signal from a sine wave generator with good frequency stability, then produces two output signed for serviceability, utilizing can be adjusted from 0° to 360° with 7-digit resolution.
Booth No. 2J43 Circle No. 531

Digital voltmeter takes PC plug-ins

United Systems Corp., 918 Woodley Rd., Dayton, Ohio. Phone: (513) 254-6251 P&A: $585; stock.

The basic unit of a series of solid-state digital voltmeters is designed for serviceability, utilizing plug-in PC boards and modular construction. The common circuitry—display drivers readout storage, control logic, and power supply—are packaged in the main frame.
Booth No. 2B02 Circle No. 532



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ON READER-SERVICE CARD CIRCLE 107

Microvoltmeter ignores noise

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $800; 60 days.

Unlike conventional tuned voltmeters, this microvoltmeter uses a phase-locked synchronous detector rather than narrowband filters to separate the effects of noise from the signal. The detector is an electronic gate controlled by an oscillator phase-locked to the input signal. Alternate half cycles of the input signal are passed by the gate, and the output of the gate is smoothed by a low-pass filter to obtain a dc voltage proportional to the average value of the input waveform. Since both the positive and the negative excursions of noise and other randomly varying signals pass through the gate when open, these average to zero and do not affect the reading. Rms noise voltages up to 2 dB above full scale do not affect the accuracy of the reading, even for signal levels that are 1/10 of full scale.

Booth No. 2F25 Circle No. 330

Phase meter covers audio to 2 MHz

Wiltron Co., 930 East Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428 P&A: $935; 10 weeks.

Calibrated offsets in 10° steps permit expansion around any phase angle in this 10-Hz-to-2 MHz phase meter. The instrument offers 0.1° resolution around any phase angle.

Booth No. 2F43 Circle No. 536

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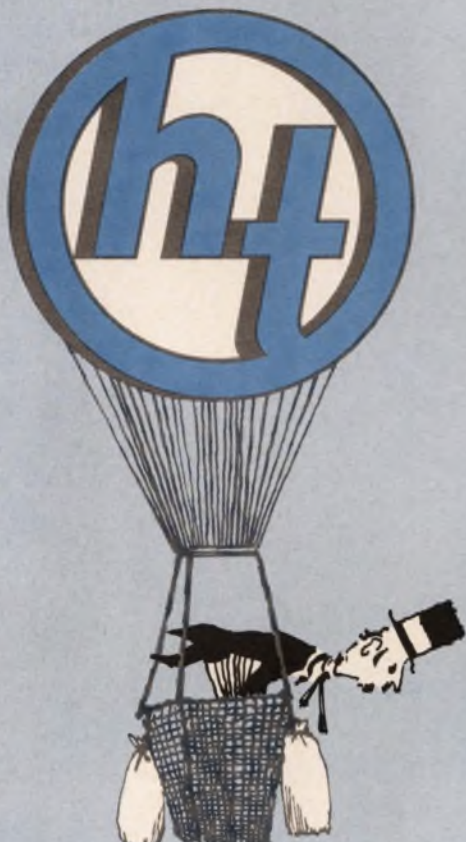
Looking for a quick way to solve your housing problem? Descend on one of our standard units built with a precision approach. With over 5000 varied shape enclosures to choose from, landing the right combination of design and material is a navigator's delight.

If you search our entire city without finding the desired accommodation, we'll alter the skyline — just for you!



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ON READER-SERVICE CARD CIRCLE 122

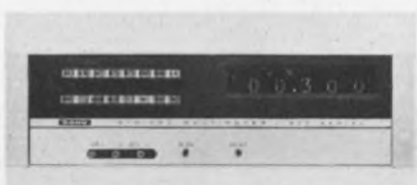
Temperature profiler reads 1/4° differences

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia. Phone: (215) 329-4900.

Temperature distribution differences on the order of 1/4 to 1/2°C (at ambients above 1000°C) can be found with this furnace temperature profiler. It offers complete line power operation, stable null detector, easily changeable automatic reference junction, Zener diode measuring current, and digital readout to two or three decimal points.

Booth No. 2A32 Circle No. 327

Digital multimeter has pushbutton control

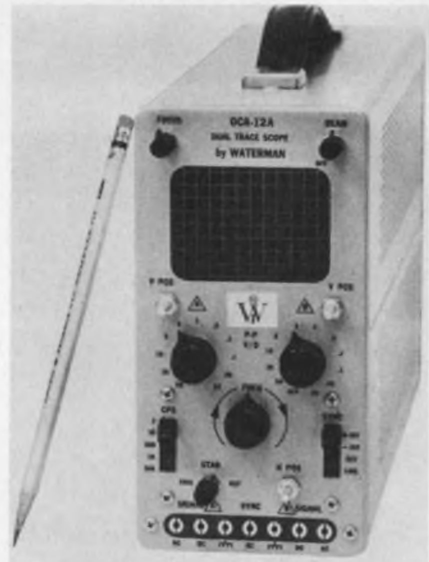


Cohu Electronics, Inc., Box 623, San Diego, Calif. Phone: (714) 277-6700. P&A: $1495; 3 wks.

Bidirectional tracking logic used in this series offers a fast and accurate method of measuring parameters with small variations, such as those that occur when trimming or adjusting. A stable Zener-diode reference supply and a digital pot assure accuracy. The pushbutton instrument offers automatic ranging on the dc voltage function (1 μV to 1000 V), resistance measurements from 0.1 Ω to 100 MΩ, ac voltages from 1 mV to 1 kV, dc-to-dc voltage ratios with 100-μV sensitivity and dc currents from 0.1 nA to 100 mA.

Booth No. 2D13 Circle No. 322

Dual-trace scope sits in 9-lb package



Waterman Instrument, 400 S. Warminster Rd., Hatboro, Pa. Phone: (215) 672-7400. P&A: $325; stock.

A dual-trace oscilloscope set, 7-1/4-in. high, 3-1/2-in. wide and 13-5/32-in. deep, is offered as portable servicing equipment. It has a sensitivity of 20 mV p-p per division, and a bandwidth of dc to 200 kHz. The input impedance is 1 MΩ shunted by 30 pF. The unit weighs 9 lbs.

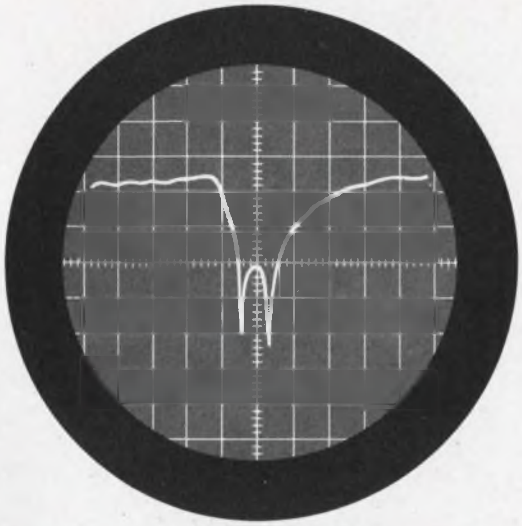
Booth No. 2A26 Circle No. 323

Frequency meter counts to 3 GHz

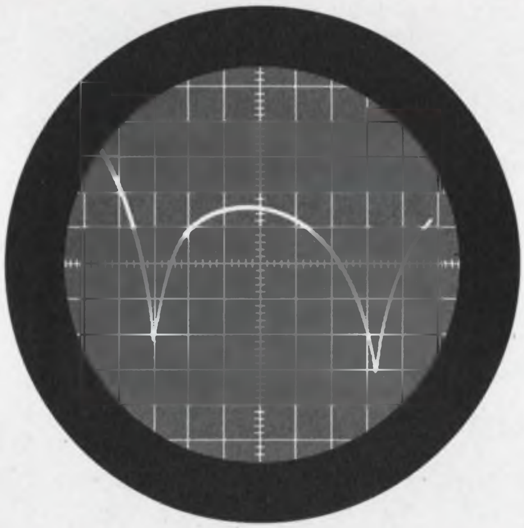
Northeastern Engineering, Inc., 130 Silver St., Manchester, N. H. Phone: (603) 622-6485. P&A: $1675; 30 days.

Frequency measurement to 50 MHz can be accomplished with a basic counter, which will accept plug-in converters to extend its range to 3 GHz. Seven-digit in-line display with automatic decimal point and legend are featured in addition to two switch-selectable input impedances of 50 Ω and 10 kΩ

Booth No. 2B43 Circle No. 533



First you look at the big picture*...
then...presto...zoom...



see all the fine detail!

Alfred Sweep Analyzers speed and simplify microwave measurements including insertion loss or gain, return loss (VSWR) or gain, and absolute or relative levels of CW power over a 60 db dynamic range with direct db or dbm readout.

It's not too much to say that Alfred Sweep Network Analyzers, Models 8000/7051 and 8000/7052, present a new dimension to microwave metrology. They take the agony out of designing and testing microwave instruments and components. Do in minutes what used to take hours.

The Model 8000/7051 Sweep Network Analyzer provides three signal channels to permit simultaneous, independent ratio measurements. It compares any two signal input levels with a common reference signal which eliminates the need for a leveled source. When the rf test loop is driven by a leveled sweeper, the lower cost single-channel Model 8000/7052 measures performance response directly.

Price of the Model 8000/7051 is $1680. The Model 8000/7052 costs $1250.

New Catalog Ready

For complete information ask your full service Alfred Sales Engineer for a copy of the Alfred '67 catalog just off the press. Or, if you prefer, you may address us at 3176 Porter Drive, Palo Alto, California 94304. Phone (415) 326-6496.

ALFRED ELECTRONICS

*Upper and lower photos display, respectively, transmission characteristics of a passive microwave device examined by an Alfred Sweep Network Analyzer with wide sweep (10 db/div sensitivity) and then automatically zooming in with a narrow sweep (5 db/div).

Project responsibility opportunities exist for qualified engineers on our technical staff. An equal opportunity employer.

ON READER-SERVICE CARD CIRCLE 124

Reflectometer couplers for L and S bands

Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000. Availability: 4 to 6 wks.

Reflectometer couplers feature a precision 7-mm output connector, and minimum directivity of 40 dB in L and S bands, 35 dB in C band and 33 dB in X band. Resultant vswr measurement capability is less than 1.02, 1.035 and 1.05 respectively. In applications such as production line testing, they present a more convenient method of measuring reflection coefficient, vswr and impedance than slotted lines.

Booth No. 2F46 Circle No. 538

Rotary transformers are multichannel

S. Himmelstein and Co., 2500 Estes Ave., Elk Grove Village, Ill. Phone: (312) 439-8181.

Moderate-speed multi-channel rotary transformers are offered as instrumentation devices suitable for excitation and monitoring of resistive and reactive transducers. Standard windings are compatible with commercial carrier systems and wideband dynamic measuring techniques. The drive shaft itself can be strain-gaged.

Booth No. 2B46 Circle No. 527

WE'LL JET THESE REEDS TO YOU TODAY!

Now ready for immediate air shipment, these six new Cook Electric relays bring you all the latest technical advances in reed relay design.

—Individually supported reed switches to eliminate glass breakage.

—All coils wrapped with magnetic foil to minimize flux leakage.

—Non-magnetic terminals assure stable operating characteristics.

—Highly weld-resistant rhodium plated contacts assure extra long life.

Order yours today, or for technical data write:

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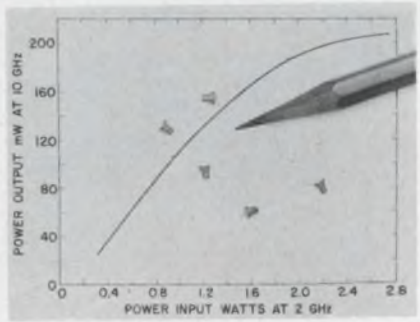
See the new Cook Electric Jet-Reeds at Booth 4E-33 . . . IEEE, New York Coliseum, March 20-23

ON READER-SERVICE CARD CIRCLE 126

Step-recovery diodes for microwave power



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $92.50 (1-9), $75 (10 to 99); stock.

A step-recovery diode claims increased power output as a high-order multiplier at microwave frequencies; X-band and above. Driven at 2 GHz with 2 W in a single stage X5 multiplier, the new diode provides 150 mW at 10 GHz. It is an epitaxial, surface-passivated silicon device with an abrupt junction gradient. The thermal resistance of the junction-to-mounting-stud path is 50°C/W and maximum permissible junction temperature, either operating or in storage, is 200°C. Device breakdown voltage is 20 V.

Booth No. 2F25 Circle No. 340

Wide-sweep generators and pulse markers

Kay Electric Co., Pine Brook, N. J. Phone: (201) 227-2000.

Wide-sweep and marker generators cover video, IF and vhf in a single frequency sweep. The additional features of continuously variable sweep width and continuously variable center frequency adapt these wide sweeps to stable narrow sweep generators. A multiturn center frequency control provides fine touch setting of narrow sweeps.

Booth No. 2D25 Circle No. 530

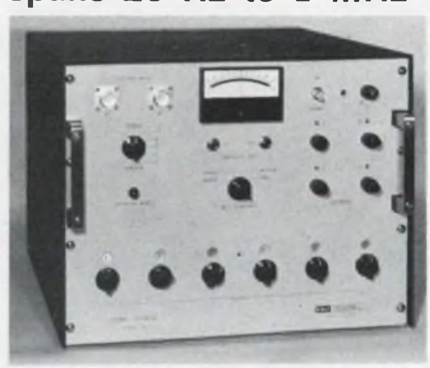
Edgewise panel meters RFI-shielded

International Instruments Incorporated, Marsh Hill Rd., Orange, Conn. Phone: (203) 795-4711. P&A: $80, $50, $550.

Special-purpose edgewise panel meters are designated models 1124, 1125, and 1126. The 1124 meets MIL-M-17275 and MIL-STD-810 and incorporates a Lucite crystal. The 1125 and 1126 are designed to meet MIL-M-17275 and RFI-shielding requirements. Initial accuracy for dc meters is ±3% of full scale; for ac ±5%. Available models include 16 dc ranges from 0 to 100 μA to 0 to 3 A, 7 dc voltage ranges from 0 to 50 mV to 0 to 100 V and three rectifier-type ac voltmeter ranges.

Booth No. 2H12 Circle No. 325

Thermal voltmeter spans 20 Hz to 1 MHz



Holt Instrument Laboratories, P. O. Box 230, Oconto, Wis. Phone: (414) 834-2222.

A solid-state thermal voltmeter is an ac-dc standard with 1 to 1111 volts, 20 Hz to 1 MHz with dc reversal detector. Complete protection against overload, push-button reset and one-year recalibration are featured.

Booth No. 2A20 Circle No. 541

IEEE BOOTH: 4J31-33

500 to 1,000 V.

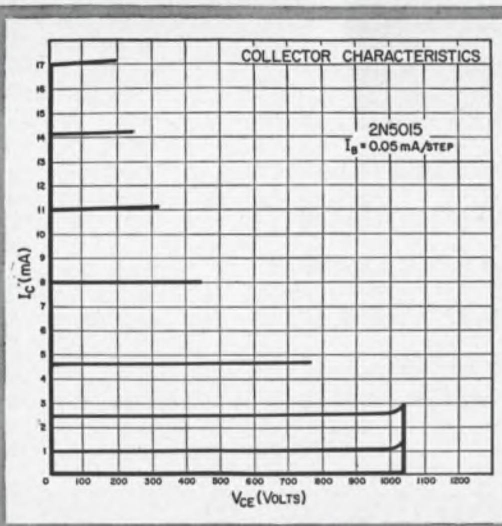
VOLTAGE

NPN SILICON TRANSISTORS

DESIGN LIMITS					
Type	BVCBO Volts		BVCER Volts	BVEBO Volts	PT Watts
	I_C = 0.1 MA	I_C = 0.2 MA	I_C = 0.2MA R = 1KΩ	I_E = 50 μA	@100°C Case
	Min.		Min.	Min.	Max.
2N5010	500		500	5	2
2N5011	600		600	5	2
2N5012	700		700	5	2
2N5013		800	800	5	2
2N5014		900	900	5	2
2N5015		1000	1000	5	2

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

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



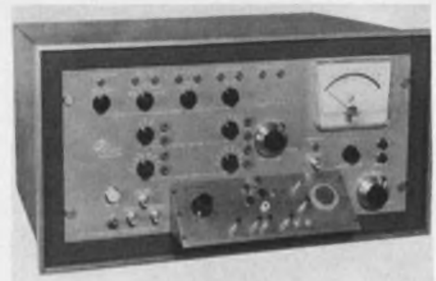
M. S. TRANSISTOR CORPORATION

SUBSIDIARY OF SILICON TRANSISTOR CORPORATION

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

ON READER-SERVICE CARD CIRCLE 128

Op-amp test set for many parameters

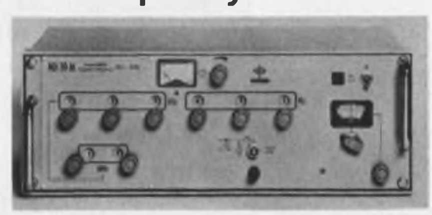


Optimized Devices, Inc., Pleasantville, N. Y. Phone: (914) 769-6100. P&A: about $1950; 90 days.

Integrated circuit, hybrid and conventional operational amplifiers can be tested for dc open-loop gain, input currents, offset voltage, output swing and common-mode voltage. In addition to these tests, there are two extra test positions for specialized dynamic tests such as frequency for full output, and unity gain frequency. A self-balancing circuit eliminates the need for a manual balance of offset voltage prior to test.

Booth No. 2G35 Circle No. 529

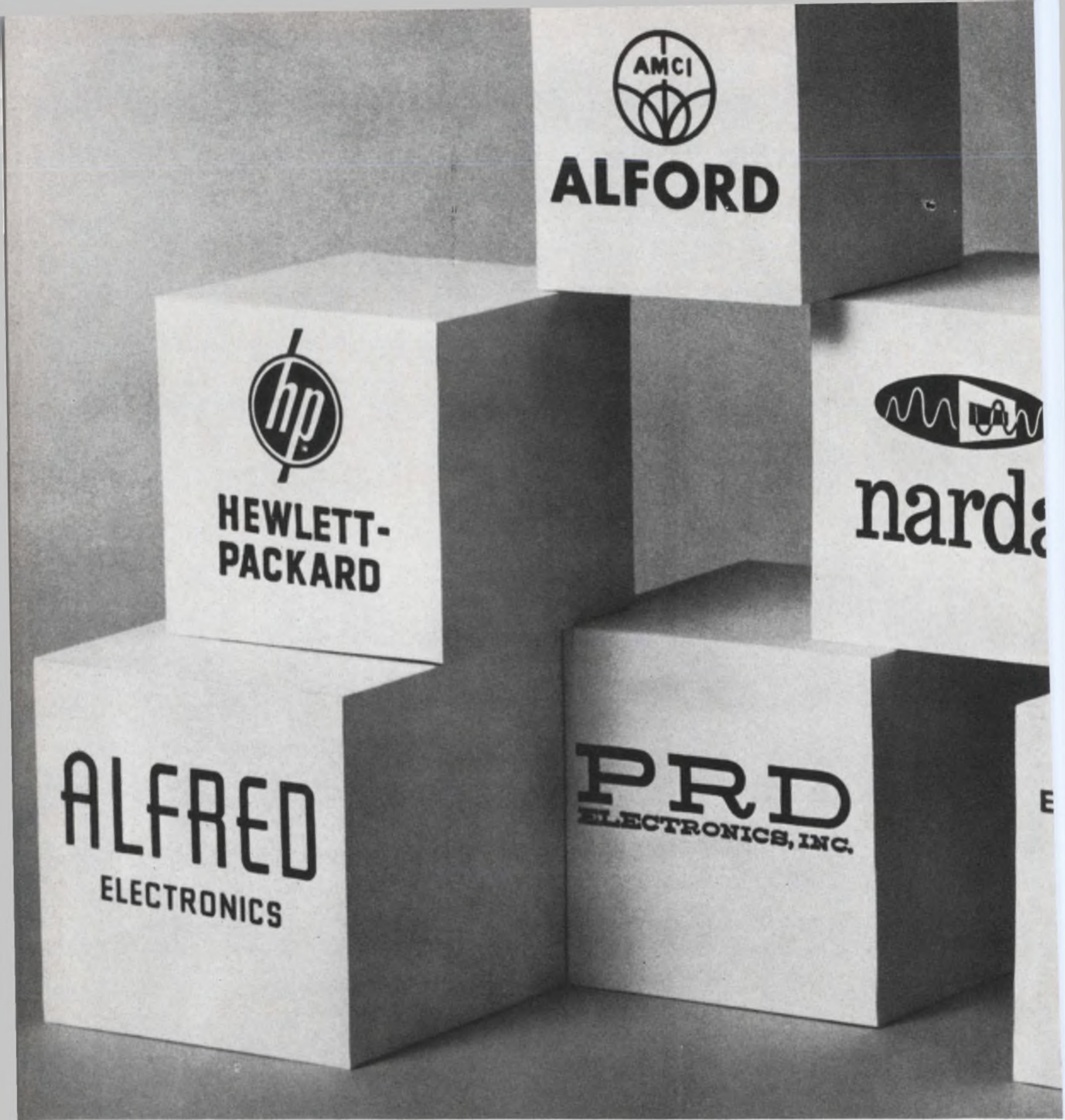
Modular synthesizers aid frequency resolution



Rohde & Schwarz, 111 Lexington Ave., Passaic, N. J. Phone: (201) 773-8010. P&A: $4095 to $6455; 30 days.

Modular construction of the manufacturer's frequency synthesizers has made possible expanded frequency resolution to satisfy special requirements. Units feature decade tuning, illuminated readouts, a metered output, spurious and noise suppression of over 80 dB and a built-in 1-MHz crystal in a temperature-controlled oven, with stability of 5 x $10^{-9}/°C$. Applications include bridge measurements, work with filters, networks and nuclear magnetic resonance.

Booth No. 2H03 Circle No. 342



We have connections with the leaders

When test equipment manufacturers select the Amphenol APC-7 precision connector for their equipment, there have to be good reasons.

There are.

With VSWR's less than 1.028 through X band, 1.037 at 17GHz and with the electrical length defined within .002", their equipment can now perform coaxial microwave and short rise time pulse measurements with accuracies never achieved before.

When you have to make measurements you believe impossible, write to one of these leading manufacturers.

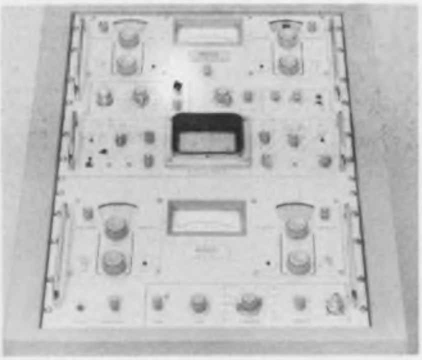
When you need APC-7 precision connectors for your test equipment, write to **Amphenol RF Division,** 33 E. Franklin St., Danbury, Conn. 06810.

AMPHENOL TM

Specify Amphenol . . . the leading name in cable, connectors, assemblies, RF switches, potentiometers, motors, microelectronics

ON READER-SERVICE CARD CIRCLE 132

Console is complete transmission tester



Sierra Electronic Operation, Philco Ford Corp., 3885 Bohannon Dr., Menlo Park, Calif. Phone: (415) 322-7222. P&A: $10,695.

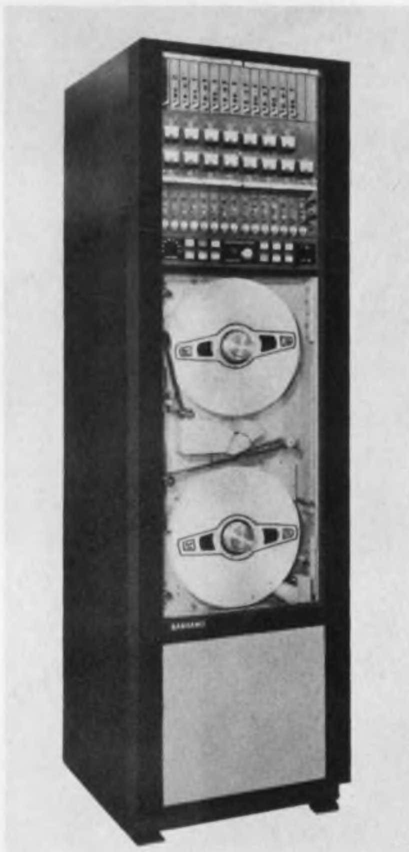
This transmission test set console combines all functions of selective voltmeter, tracking generator, spectrum display, attenuator and impedance-matching panel in one. The console is used for initial line-up and maintenance of carrier multiplex and high-frequency communications systems. It permits analysis of operating carrier systems showing levels of carrier signalling tone, carrier leak, crosstalk, noise, telegraph and telemetry subcarriers and rapid identification and isolation of circuits having out-of-limit signal, overload or noise condition. Frequency range is 4 kHz to 15 MHz and frequency measurement accuracy is 10 ppm. ± 300 Hz.
Booth No. 2F07 Circle No. 275

Digital printer uses IC modules

Clary Corp., San Gabriel, Calif. Phone: (213) 287-6111. P&A: $1795; 90 days.

Model 7100 digital printer uses integrated circuit modules. Paper is loaded through the front panel, eliminating the need for removal of the printer from its normal operational installation. Standard printing rate is 10 lines per second, maximum column capacity is 20 columns and maximum selection in each column is 12 characters. Printing occurs only when the typewheels are stationary.
Booth No. 2D52 Circle No. 281

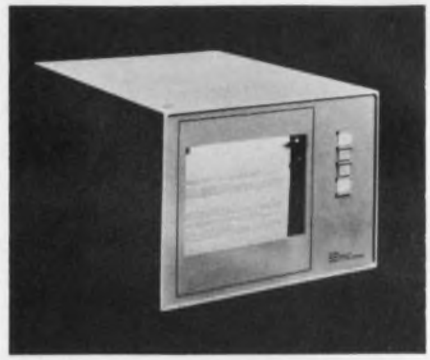
Recorder/reproducer has inertial damping



Sangamo Electric Co., P. O. Box 359, Springfield, Ill. Phone: (217) 544-6411.

Smoother tape handling, extreme flexibility, and data accuracy are claimed for this recorder/reproducer. The 4784 system includes a type path with variable inertial dampening roller, eliminating many flutter components. Other features such as vacuum tape tensioning, cleaning and guiding, a high-torque drive and low-mass capstan with 0.004% crystal-controlled servo are included.
Booth No. 2E07 Circle No. 283

Print alphanumerics at a half-million per second



Datalog Div. of Litton Industries, 9370 Santa Monica Blvd., Beverly Hills, Calif. Phone: (213) 273-7500.

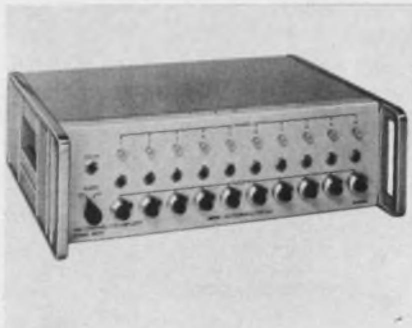
Alphanumeric page printers record over a half-million characters per minute on photosensitive paper. The MC 8800 Datalog is a CRT printer designed for compatibility with computers and communications equipment. It accepts data serially at a rate from zero to 8800 characters/second. The unit has an MTBF of over 8000 hours through the use of integrated cricuits.
Booth No. 2K21 Circle No. 505

Coordinatograph produces PC masters

Aero Service Div. of Litton Industries, 4219 Van Kirk St., Philadelphia. Phone: (215) 533-3900.

The Micro/Plotter is a high-precision coordinatograph to produce art master layouts for printed or integrated circuits or resolution targets for optical characteristic data. It is offered in three separate working area sizes and eight individual configurations ranging from 32 x 32 to 48 x 60 inches.
Booth No. 2K21 Circle No. 264

'Call-up unit' tunes any of 10 frequencies



Singer Co., 915 Pembroke St., Bridgeport, Conn. Phone: (203) 366-3201. P&A: $880; 30 days.

A frequency "call-up unit" permits any of ten discrete frequencies from 1 to 10 GHz to be tuned automatically on command. The unit is designed to work with Singer/Metrics' noise and field intensity analyzer for microwave surveillance, electromagnetic compatibility analysis, and noise and field intensity measurements. In operation, the user adjusts the frequency control (directly calibrated in GHz) for each channel and the corresponding vernier (calibrated in 100-MHz increments), permitting tuning with a precision of 0.01 GHz. Depressing the channel selection button "commands" the analyzer to automatically scan to the selected frequency.
Booth No. 2B25 Circle No. 279

Desk top computer stores 4000 bits

Mathatronics, 241 Crescent St., Waltham, Mass. Phone: (617) 893-1630. P&A: $6990; 90 days.

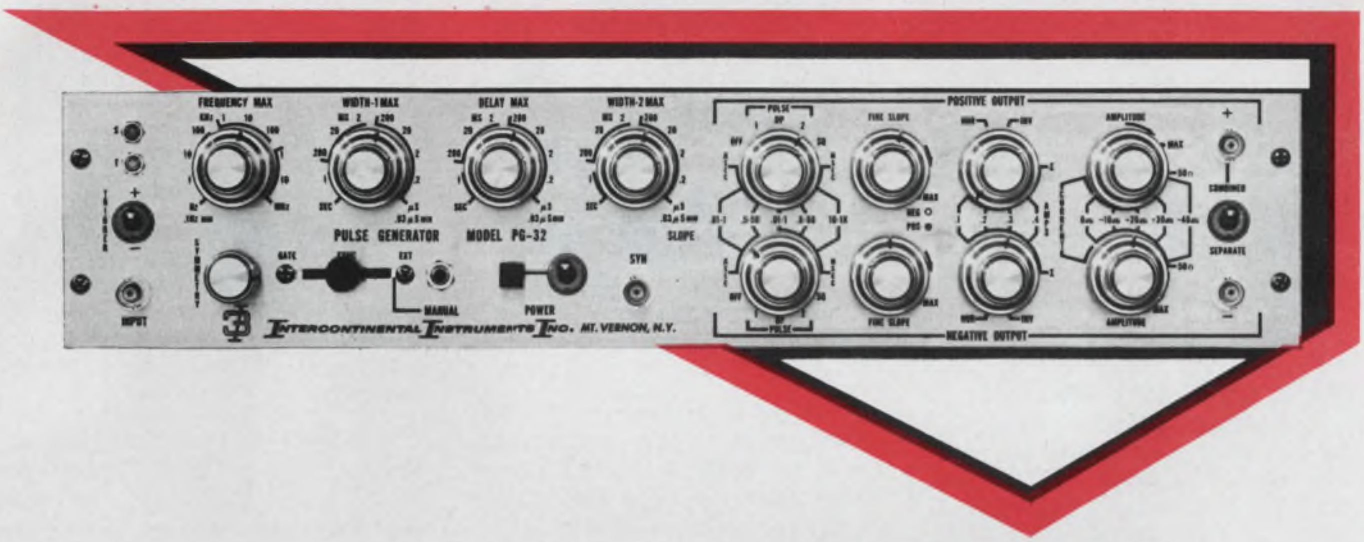
A desk-size computer/calculator is designed to solve complex mathematical problems. With over 4000 bits of storage, this digital machine accepts standard algebraic and decimal numbers and includes automatic operators for square root, log, antilog, sine, arc-tangent and parenthesis. Up to 82 individually addressable storage registers are available with internal programable memory of 480 program steps. Master programs can automatically branch to sub-programs, execute them and then continue along the original path. Input/output devices include direct entry numeric keyboard, alphanumeric typewriter keyboard, punched paper tape, serial strip and page printers, and electronic interface.
Booth No. 2J50 Circle No. 256

Recorder/reproducer is cartridge-loading

Sangamo Electric Co., P. O. Box 359, Springfield, Ill. Phone (217) 544-6411.

Utilizing a standard 1/4-inch tape cartridge, the model D/C-1 magnetic tape data cartridge recorder/reproducer is available with either FM or direct electronics, with frequency responses to 5 kHz and 50 kHz respectively. Up to eight channels may be recorded and reproduced simultaneously.
Booth No. 2E07 Circle No. 282

To Those Of You Who Haven't Been Buying III Pulse Generators:



CUT IT OUT!

Tell you why you should: THREE-I makes unusually versatile, high performance pulse generators and makes them much better. And they cost less. Two of them are shown here, our PG-2 and our PG-32. They aren't NEW! NEW! NEW! just GOOD, GOOD, GOOD. *Sophisticated, reliable* and *good*.

For example: The extremely versatile PG-32 gives you two fast rise time, independent output channels (+ and —). These can be combined to provide a bipolar output with pulses that can be slid across each other, adding, subtracting or forming complex waveshapes. A switch lets you select the normal output or its complement. The PG-32 can be used in an E-Mode (50 ohm source impedance) or an I-Mode (500 ohm source impedance, min.). In the I-Mode each channel can provide up to 400 mA. Outputs are DC-coupled. Rep rates are continuously variable up to 20 MHz (double pulse mode). You can get single pulses, double pulses or square waves plus a sync output. Rise times, fall times, output widths, delays, etc. are all continuously adjustable. You can gate it, trigger it or operate it as a manually controlled one-shot. You can get DC-offsets to 10 volts. It's 3-1/2" high, all silicon and costs $1385.

The PG-2 is a single channel version of the PG-32. Same adjustability and performance; single or double pulses to 20 MHz (double pulse) plus sync pulse and square waves. I-Mode or E-Mode operation. Same solid-state, printed circuit, meticulous construction. Same 3-1/2" rack height. $925. An ideal production test pulser.

There's a whole line of THREE-I pulse generators including three highly advanced new ones, among which is the most sophisticated 100 MHz, 2.5 ns rise time, 20 volt output instrument in the field.

So if *you* haven't been buying THREE-I pulse generators: CUT IT OUT!

Please?

Intercontinental Instruments Inc., an affiliate of CHRONETICS.

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IEEE Convention—Booth 2B48

ON READER-SERVICE CARD CIRCLE 135

Xenon arc lamps rated to 6500 W

Christie Electric Corp., 3410 W. 67th St., Los Angeles. Phone: (213) 750-1151.

Complete illuminator systems for xenon, xenon-mercury, and mercury arc lamps produce a high intensity "point source" of light. Applications in photochemistry and semiconductor photoresist processes are cited. The systems include power supply, lamp housing with optics and igniter, and lamp. Systems are available in lamp ratings from 200 to 6500 watts.

Booth No. 2J16 Circle No. 276

Serial entry printer lists 10 columns

Victor Comptometer Corp., 3900 N. Rockwell St., Chicago. Phone: (312) 539-8210.

Victor's serial entry digital printer features a 10-column list and 11-column total on accumulating models and 10-column list on listing models. The Digit-Matic operates on either 24- or 48-Vdc solenoid voltage. Standard features on listers and accumulators include 0 to 10 digits and print command and a choice of 24 Vdc at 0.98 A or 48 Vdc at 0.63 A solenoid voltage.

Booth No. 2B08 Circle No. 280

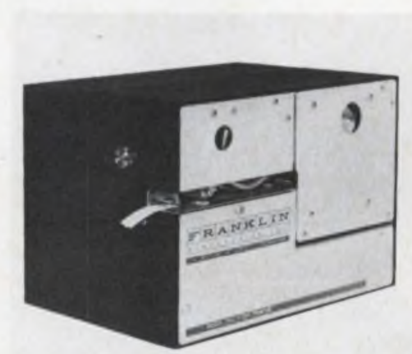
SSB spectrum analyzer ranges 2 to 40 MHz

Singer Co., 915 Pembroke St., Bridgeport, Conn. Phone: (203) 366-3201.

A 2-to-40-MHz analyzer provides stable, high-resolution spectrum analysis for monitoring, and the low distortion two-tone generators needed for checkout of single-sideband transmitters and receivers. Applications include distortion, interference, spurious sideband, carrier level and noise measurement to better than -60 dB from the peak reference level.

Booth No. 2B25 Circle No. 278

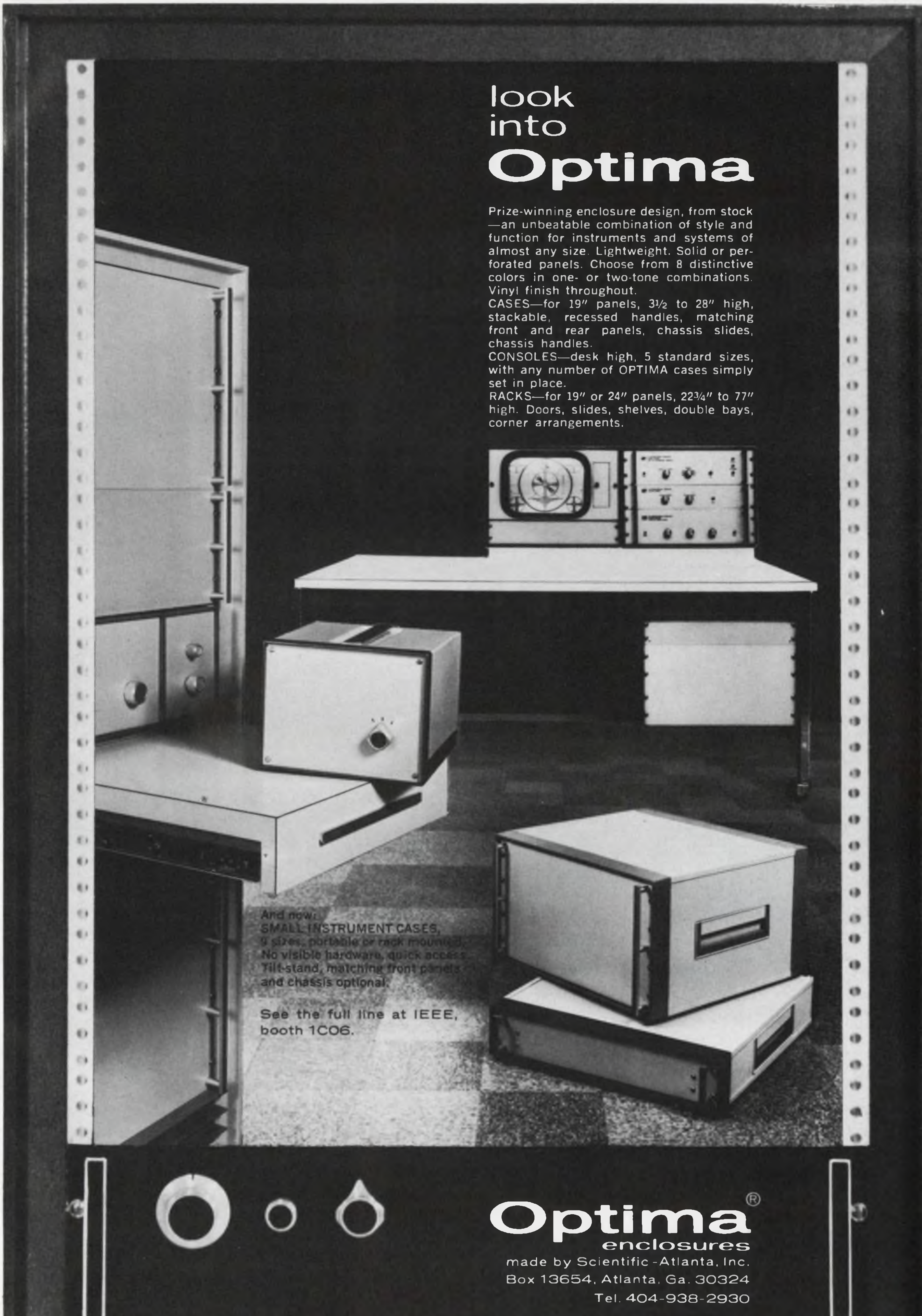
Strip printer fully buffered



Franklin Electronics, Inc., E. Fourth St., Bridgeport, Pa. Phone: (215) 272-4800.

Model 120AX strip printer has a 64-character font and provides continuous printout along a 1/2-inch wide paper tape at a rate of 1200 characters per minute. The printer includes the electronics for operating and controlling. It is designed for systems manufacturers who prefer an operating printer complete with electronics.

Booth No. 2H33 Circle No. 274



ON READER-SERVICE CARD CIRCLE 137

2-pen recorder compares variables

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia. Phone: (215) 329-4900.

Using the Speedomax 2-pen recorder, you can compare or contrast two related variables, using the same or different types of primary elements. Among the features are all-solid-state amplifiers which use all-silicon transistors, input filtering and shielded circuitry to maintain high common-mode and transverse rejection. An optional chart-drive selection of up to five chart speeds, ranging from 1 inch/hr to 6 inches/minute are available.

Booth No. 2A34 Circle No. 388

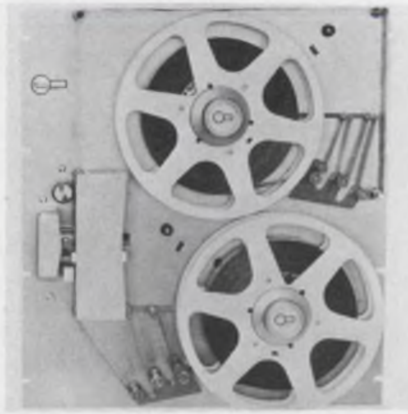
Plug-in system for digital measurement

Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland. Phone: (216) 541-8060. P&A: main frame, $320, plug-ins, $75 to $240; stock.

Frequency or period, dc voltage, resistance and capacitance can be measured by a system consisting of a main frame that accepts only five plug-ins. Counting can also be performed. The main frame has a 3-digit Nixie display, automatic polarity indication and automatic decimal indication.

Booth No. 2C26 Circle No. 540

Tape reader/spooler all solid-state

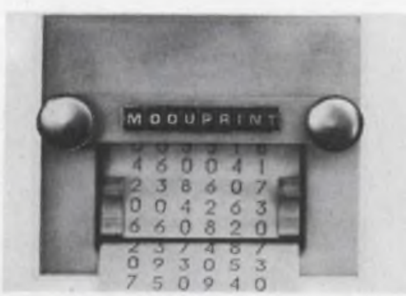


Remex Electronics, 5250 W. El Segundo Blvd., Hawthorne, Calif. Phone: (213) 772-5321. P&A: $3435; 10 wks.

A high-speed photocell punched-tape reader/spooler features a 500-characters-per-second reader and a 50-inch-per-second spooler equipped with 10-1/2-inch reels. The electronics is all solid-state with a choice of output signals available. The reader/spooler operates at 500 characters per second in the continuous mode.

Booth No. 2G43 Circle No. 277

6-digit data printer is small package



Presin Co., Inc., Trap Falls Rd., Shelton, Conn. Phone: (203) 929-1495.

With a capacity of 6 digits, this data printer measures only 3 inches high x 3-1/2 inches wide on the panel x 9 inches deep. Each digit may be individually energized to step to position (any of 10 or 12 per wheel), or count serially, cascaded as desired. A variety of printing wheels, normally 0.1 inch high, is available.

Booth No. 2J40 Circle No. 539

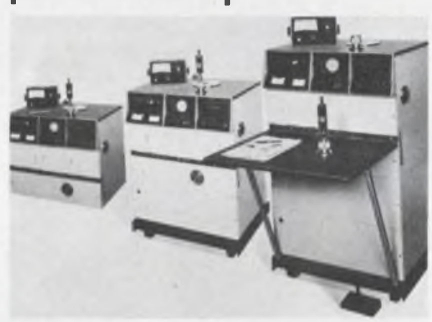
Recorder prints quietly at 20 lines/second

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1750; May.

A digital recorder with 18-column capacity prints at rates up to 20 lines per second. The recorder has a photoelectric coding system in place of rotating electrical contacts, and there is no "start-stop" inked-ribbon mechanism. Formatting and coding are flexible, and are changed when required. Model 5050A converts binary-coded decimal data (BCD) into printed decimal form on paper similar to that used in adding machines.

Booth No. 2F25 Circle No. 265

Detect leaks at production speeds



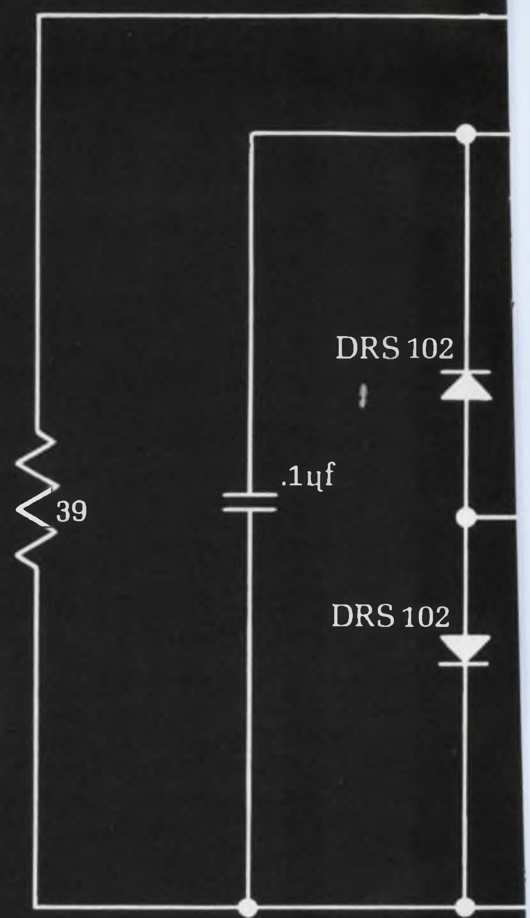
Veeco Instruments, Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8300.

Split-sector leak-test stations feature minimum detectable leak capability of 5×10^{-12} atm•cm^3/second at production speeds with direct readout. The MS-12 is available in three modular-convertible models. The bench model includes the basic automatic leak detector with the complete roughing station in a portable cabinet. The "roll-around" version features a mobile, completely enclosed housing. The high-speed, "sit-down" model is designed for production use.

Booth No. 2A46 Circle No. 271

ON READER-SERVICE CARD CIRCLE 139 ➤

Want to convert high energy at high efficiency?



Convert to circuit designs using Delco high voltage silicon power.

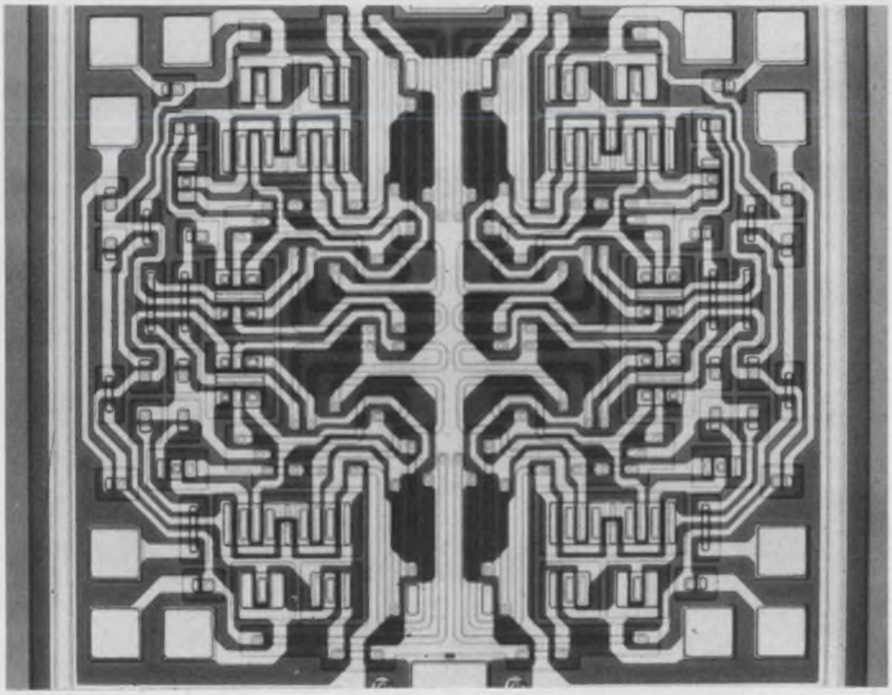
The DC to DC converter above operates directly from a 150V DC source and delivers 180 watts to the load at an efficiency of over 94 percent. The 1.1 kHz circuit operates over a temperature range of −65°C to 100°C. Frequencies of up to 25 kHz may be obtained with selected transformer core materials. And the switching job is handled easily by just two Delco NPN DTS-423 silicon transistors—priced at just $4.95 each in 1,000 and up quantities.

Delco pioneered the development of high voltage silicon power transistors to provide you high energy capability at the lowest cost. Among the many circuit benefits you get are: high reliability, reduced assembly time, and a reduction in the number, weight and complexity of the electronic components needed. Coupled with the low prices of the Delco silicon power line, these benefits mean real cost advantages to you.

Other applications? They've proven their capability in such high energy circuits as: DC and switching regulators, ultrasonic power supplies, VLF class C amplifiers, off-line class A audio output and CRT deflection (several major TV manufacturers use them for big screen horizontal and vertical deflection).

Availability? With Delco's lead in know-how and plant facilities it's no problem. Samples or production quantities can be shipped promptly. Contact one of our distributors or a Delco sales office right now and see.

For more details on the DC-DC converter circuit—ask for application note number 32.



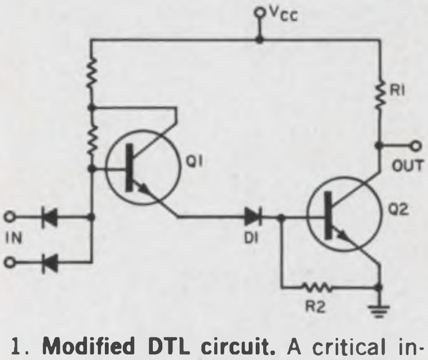
Built-in avalanche emitter cuts noise in logic ICs

Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $3.50 (dual 4-input gate with active pull-up), $3.50 (dual 4-input gate with conventional output transistor), $6.10 (dual J-K flip-flop) $4.05 (master-slave R-S flip-flop), (1000 to 4999); stock.

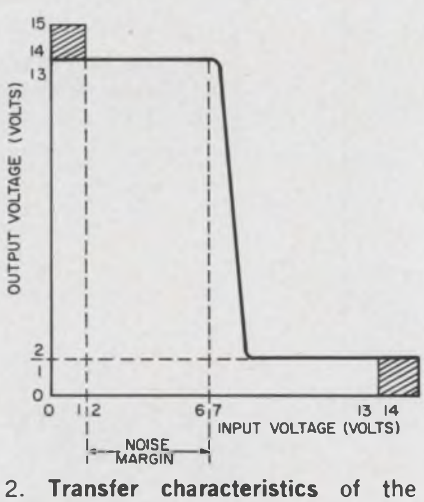
A new IC logic family features a high noise margin, obtained by building into the output transistor of a DTL circuit a second emitter, with an avalanche breakdown characteristic.

Currently popular modified DTL circuitry can provide noise margins of the order of 0.7 V, adequate for general purposes. To satisfy the requirements of industrial applications, the new family of logic ICs, called MHTL, provide noise margins about seven times as high.

This can be best understood by first looking at a conventional DTL circuit, Fig. 1. The output is determined by the state of transistor *Q2*. When *Q2* is off, its base is held at ground potential through *R2*. In order to turn *Q2* on, its base must be raised from ground to 0.75 V. This requires a substantial current through *Q1* and *D1*. Since, for substantial conduction, the transistor base-emitter junction and the diode anode-cathode junction each introduce another 0.75-V drop, the minimum voltage on the base of *Q1* that will cause the output to go low is 2.25. Because the input diodes are reversed relative to *Q1*, *D1*, and *Q2*, the input voltage corresponding to 2.25 V on the base of *Q1* is 1.5 V. This is the transition voltage for a modified DTL circuit. Allowing for production variation, a transition region is usually more useful than a single voltage. In MDTL the transition region is between 1.1 and 1.9 volts at 25°C.



1. **Modified DTL circuit.** A critical input voltage swings the output high or low.



2. **Transfer characteristics** of the MHTL. Inputs from 1.1 to 1.9 volts swing output state.

In the transfer characteristic of an MDTL, the difference between the normal output of a preceding stage and the edge of the transition region is the noise margin of the circuit. For MDTL, this noise margin is usually about 0.7 V. Figure 2 shows the transfer characteristic of the new circuit. The low output is just a saturation drop above ground, and the high state only a little below 15 V. The transition point is approximately 7.5 V.

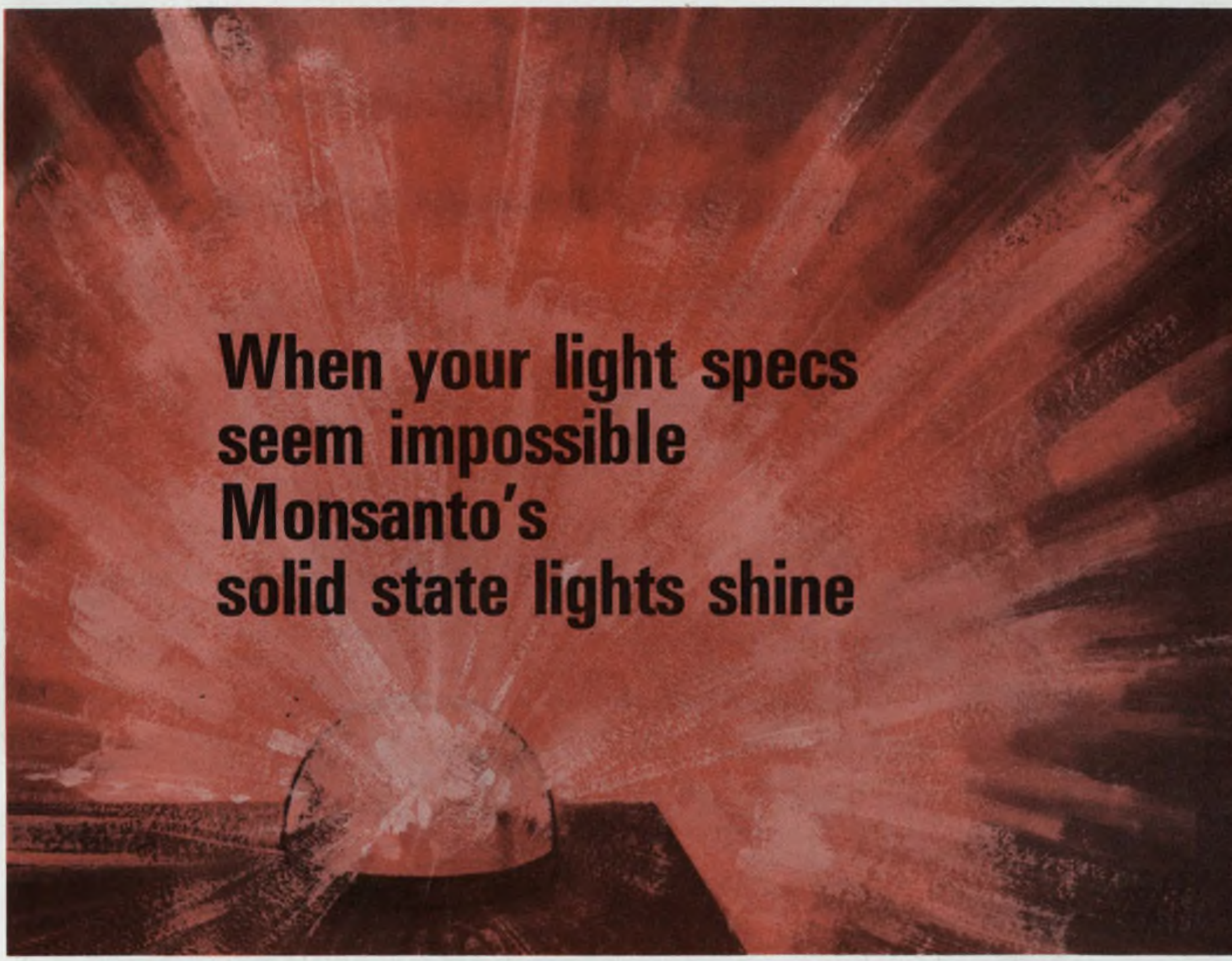
The logic swing of almost 15 V is obtained by using the emitter-base breakdown of an additional emitter in the base of the transistor.

The transition region of the MHTL circuits is between 6.5 and 8.5 V. With the maximum low-state output voltage of 1.5 and the maximum high-state output voltage of 13.5, the MHTL circuits provide a noise margin of 5 V. This makes possible an IC logic line that can be operated in high noise environments.

An additional advantage of this design is improved temperature stability. In an ordinary modified DTL circuit, the offset diode and the base-emitter diode of *Q2* are additive and introduce temperature instability. In the new device, the avalanche diode has a positive temperature coefficient that offsets the negative coefficient of the output transistors' base-emitter diode.

The initial circuits offered in the new series include dual 4-input gates with active pull-up, dual 4-input gates with a conventional single output transistor, a dual J-K flip-flop (shown above) and a master-slave R-S flip-flop.

Booth No. 3A05 *Circle No. 524*



Now you can get a new line of visible and infrared emitting diodes that feature long life, maximum reliability and fast switching speed . . . at low cost.

These rugged light sources from Monsanto offer you design opportunities never before available in their price range. Just look at the following specifications and unit costs and see why they fit into your design for profit.

MVE-100 Visible Light Emitter. The MVE-100 gallium arsenide phosphide diode is suitable for use as an instrument signal light, panel indicator and for many computer uses. Price ranges from $14.50 each in lots of one to nine, to $8.00 each in lots of 1,000.

MVE-101A Visible Light Emitter. The MVE-101A gallium arsenide phosphide diode is packaged in a smaller coaxial package allowing high packing density for those applications where space is critical. Use the MVE-101A for film annotating, reticle illuminations and as indicators. Price ranges from $16.50 each in lots of one to nine, to $8.00 each in lots of 1,000.

MVL-150 Visible Laser. The MVL-150 is a gallium arsenide phosphide semiconductor laser which is available with emission at any desirable wave length between 6,500 A and 8,300 A. This laser is designed for operation at 77 K. Price ranges from $19.50 each in lots of one to nine, to $13.00 each in lots of 1,000.

MIE-200 Infrared Emitter. An infrared radiation source consisting of a gallium arsenide mesa diode. It matches efficiency with silicon detectors, providing enough radiated power to work in common mode isolation, card reading, and chopping applications. Price ranges from $9.85 each in lots of one to nine, to $6.00 each in lots of 1,000.

MVA-300A Visible Light Emitter Array. The MVA-300A 5x7 Array is a solid state read-out made with 35 MVE-101A diodes mounted on a metal heat sink. The display is used for visual read-out and film annotation applications. Price $495.00 each.

For more information on low-cost Monsanto light sources, call (314) OXford 4-2136 or write: Monsanto Company, 800 N. Lindbergh Boulevard, St. Louis, Missouri 63166

Monsanto

ELECTRONICS

ON READER-SERVICE CARD CIRCLE 141

Semiconductor diamond has many facets

General Electric Co., Edmore, Mich. Phone: (517) 427-5151. Availability: summer 1967.

Semiconducting diamond, very rare in nature, is made synthetically in a high-temperature, high-pressure growing process. The starting material is graphite. It is transformed into diamond by the action of a molten metal catalyst under pressure of about one million pounds per square inch, and at a temperature above 9000°F.

Impurities such as boron, beryllium and aluminum are added in the growing process. The result is a diamond crystal weighing about 0.0004 carat.

A principal advantage is the wide temperature range. A temperature sensor built around this crystal operates from -325 to 1200°F. At this high temperature metals glow red-hot.

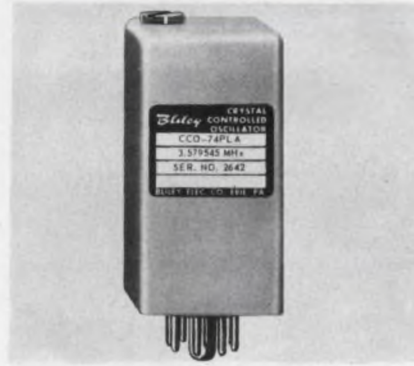
The diamond crystal has an electrical conductivity in the semiconductor range that decreases with temperature. Its wide temperature range makes it an ideal sensing element in thermistors designed for use in extreme temperatures.

In shape, the diamond approaches a cube, with a side of about 0.015 inches. Because of its small size and high thermal conductivity, it offers extremely fast response to temperature changes. The small size of the crystal also makes it useful in probes and permanent installations.

The thermistor offered has a diamond sensing element to which two wires are sealed by a tiny glass bead, which covers the whole diamond and the tips of the wires, resulting in a hermetically sealed, corrosion-resistant unit.

Booth No. 3E13 Circle No. 257

Subcarrier oscillator for color TV

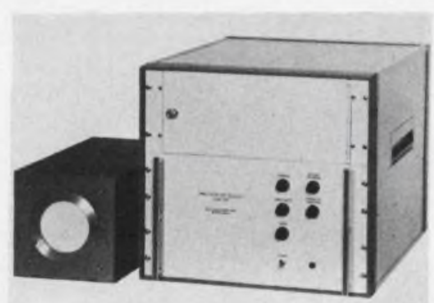


Bliley Electric Co., 200 Union Station Bldg., Erie, Pa. Phone: (814) 456-7561.

For the color TV standard frequency of 3.579545 MHz this subcarrier oscillator is packaged as a plug-in module. It maintains the reference signal within 2 ppm over an ambient temperature range of 0 to 65°C. The solid-state oscillator provides a 1-V sine-wave output into 10 kΩ. Power requirements are 115 Vac for proportional control oven and 12 Vdc for the oscillator.

Booth No. 3D03 Circle No. 394

High resolution from CRT displays

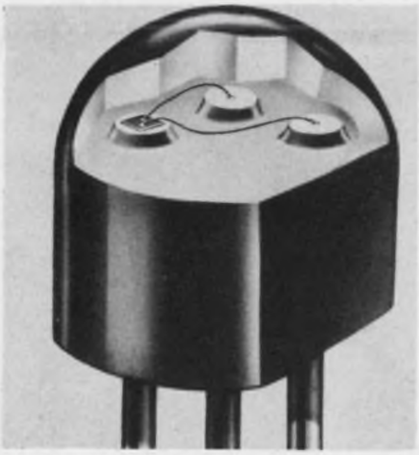


Beta Instrument Corp., 377 Elliot St., Newton Upper Falls, Mass. Phone: (617) 969-6610.

High-resolution CRT displays utilize all-solid-state circuitry. Applications are in film and hard-copy printing recorders, flying spot scanners, film readers, radar displays, computer output displays, TV monitors or any application requiring a precision programable light source. The displays utilize 5-inch flat face magnetically deflected CRTs.

Booth No. 3A09 Circle No. 507

Plastic transistors for general applications

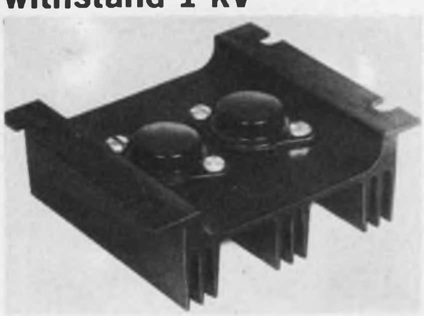


Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. Phone: (617) 245-4500. P&A: 17¢ to 41¢ (10,000 lots); stock.

Thirteen families of silicon planar plastic packaged transistors are offered in both npn and pnp types for the following applications: high-gain, general-purpose amplifier, general-purpose high-frequency amplifier and driver; high-frequency logic and vhf and uhf units for high frequency oscillator and amplifier service. Each package has a locating flat, and leads which will fit the TO-18 standard socket without preforming.

Booth No. 3K16 Circle No. 273

Aluminum heat sinks withstand 1 kV

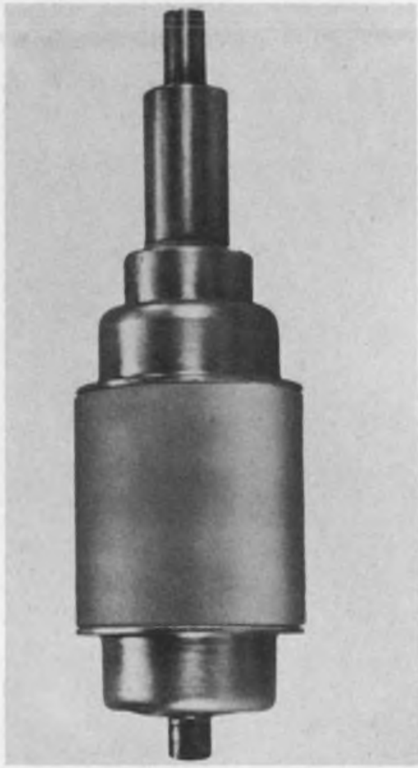


Vemaline Products Co., Inc., Franklin Lakes, N. J. Phone: (201) 891-3200.

Aluminum heat sinks are suitable for regular or stud-mounted semiconductor devices. They come in a black-anodized or a special hardcoat anodized finish that withstands 1 kV rms.

Booth No. 3B18 Circle No. 263

Vacuum-variable cap takes high vibration



ITT, P. O. Box 1278, San Jose, Calif. Phone: (408) 292-4025.

Designed for communications systems in aircraft and other mobile applications, a line of vacuum-variable capacitors claims unusually high resistance to vibration. In the capacity range from 25 to 2500 pF, the average capacity shift is 1.5 pF at vibrations of 5 G from 55 to 500 Hz. Voltage rating is 5 kV peak; current rating is 70 A rms at 16 MHz.

Booth No. 3B49 Circle No. 266

Flat-faced CRT for high frequencies

General Atronics, 1200 E. Mermaid Lane, Philadelphia. Phone: (215) 248-3700.

Designed for high-frequency operations, an all-electrostatic CRT has a rectangular helix and a mesh deflection system to insure good high-frequency performance. It is flat-faced with a 4 x 5-inch viewing area and features high light output at good resolution. The M1252 is designed with an aluminized screen for maximum light output and minimum charging effects.

Booth No. 3K02 Circle No. 510

Numerical controller has mirror-image capability

Superior Electric Co., Bristol, Conn. Phone: (203) 582-9561. Price: $4950.

Several features previously available only as options are now incorporated as standard in this line of numerical tape controls. The units offer a choice of either two-axis models or models having two axes plus a time shared third axis. The X and Y axes can be operated simultaneously with the Z axis operated sequentially. Mirror-image capability, true 45° milling and tape-actuated rapid traverse during milling are also offered.

Booth No. 3B03 Circle No. 261

The wrapped tubular explosion!

When you think of wrapped mylar capacitors, you naturally think of Cornell-Dubilier. Over the years, our type WMF has become an industry standard.

But our wrapped mylars are just a small part of the biggest selection of wrapped tubular capacitors made. The CDE line also includes type MFP pressed mylars, military grade type CTM mylars, type MMW metallized mylars and two brand new types. WCR polycarbonates and MCR metallized polycarbonates.

All are SPRINT stock standards. All are available through CDE's Authorized Industrial Distributors.

CDE CORNELL-DUBILIER

—STOCK STANDARDS—WRAPPED TUBULAR CAPACITORS—

WMF — GENERAL PURPOSE MINIATURE

STANDARD STOCK RATINGS

‡ Tolerance ±20% or ±10

Cap. Mfd.	100V DCW †Type WMF-	100V DCW Size DxL (In.)	200V DCW †Type WMF-	200V DCW Size DxL (In.)	400V DCW †Type WMF-	400V DCW Size DxL (In.)	600V DCW †Type WMF-	600V DCW Size DxL (In.)
.001	1D1	.156 x ½	2D1	.156 x ½	4D1	.156 x ⅝	6D1	.170 x ¾
.0012	1D12	.156 x ½	—	—	—	—	—	—
.0015	1D15	.156 x ½	2D15	.156 x ½	4D15	.156 x ⅝	6D15	.170 x ¾
.0018	1D18	.156 x ½	—	—	—	—	—	—
.0022	1D22	.156 x ½	2D22	.156 x ½	4D22	.156 x ⅝	6D22	.187 x ¾
.0027	1D27	.156 x ½	—	—	—	—	—	—
.0033	1D33	.156 x ½	2D33	.160 x ½	4D33	.190 x ⅝	6D33	.203 x ¾
.0039	1D39	.156 x ½	—	—	—	—	—	—
.0047	1D47	.156 x ½	2D47	.170 x ½	4D47	.200 x ⅝	6D47	.234 x ¾
.0050	1D5	.156 x ½	—	—	—	—	—	—
.0056	1D56	.156 x ½	—	—	—	—	—	—
.0068	1D68	.175 x ½	2D68	.200 x ½	4D68	.250 x ⅝	6D68	.265 x ¾
.0082	1D82	.175 x ½	—	—	—	—	—	—
.01	1S1	.200 x ½	2S1	.230 x ½	4S1	.300 x ⅝	6S1	.290 x ¾
.012	1S12	.215 x ½	—	—	—	—	—	—
.015	1S15	.235 x ½	2S15	.290 x ½	4S15	.360 x ⅝	6S15	.312 x ⅞
.018	1S18	.255 x ½	—	—	—	—	—	—
.022	1S22	.275 x ⅝	2S22	.260 x ⅝	4S22	.320 x ¾	6S22	.335 x ⅞
.027	1S27	.300 x ⅝	—	—	—	—	—	—
.033	1S33	.300 x ⅝	2S33	.270 x ¾	4S33	350 x ⅞	6S33	.350 x 1
.039	1S39	.245 x ¾	—	—	—	—	—	—
.047	1S47	.265 x ¾	2S47	.320 x ¾	4S47	.400 x ⅞	6S47	.415 x 1
.050	1S5	.265 x ¾	—	—	—	—	—	—

Cap. Mfd	100V DCW †Type WMF-	100V DCW Size DxL (In.)	200V DCW †Type WMF-	200V DCW Size DxL (In.)	400V DCW †Type WMF-	400V DCW Size DxL (In.)	600V DCW †Type WMF-	600V DCW Size DxL (In
.056	1S56	.265 x ¾	—	—	—	—	—	—
.068	1S68	.280 x ¾	2S68	.350 x ¾	4S68	.390 x 1	6S68	.500 x 1
.082	1S82	.270 x ¾	—	—	—	—	—	—
.1	1P1	.290 x ⅞	2P1	.410 x ⅞	4P1	.465 x 1	6P1	.520 x 1[illegible]
.12	1P12	.315 x ⅞	—	—	—	—	—	—
.15	1P15	.335 x ⅞	2P15	.500 x ⅞	4P15	.515 x 1¼	6P15	.625 x 1[illegible]
.18	1P18	.350 x 1	—	—	—	—	—	—
.22	1P22	385 x 1	2P22	.500 x 1⅛	4P22	.565 x 1⅜	6P22	.660 x 1[illegible]
.27	1P27	.380 x 1⅛	—	—	—	—	—	—
.33	1P33	.415 x 1⅛	2P33	.550 x 1⅛	4P33	.600 x 1⅝	6P33	.687 x 2
.39	1P39	.460 x 1⅛	—	—	—	—	—	—
.47	1P47	.475 x 1¼	2P47	.600 x 1¼	4P47	.700 x 1⅝	6P47	.855 x 2
.50	1P5	.500 x 1¼	—	—	—	—	—	—
.56	1P56	.525 x 1¼	—	—	—	—	—	—
.68	1P68	.570 x 1¼	2P68	.650 x 1⅝	4P68	790 x 1¾	6P68	.970 x 2
.82	1P82	585 x 1⅜	—	—	—	—	—	—
1.0	1W1	625 x 1½	2W1	.750 x 1¾	4W1	.875 x 2	6W1	1.165 x 2[illegible]
1.25	1W1P25	.690 x 1½	2W1P25	825 x 1¾	4W1P25	.950 x 2	6W1P25	1.340 x 2[illegible]
1.5	1W1P5	770 x 1¾	2W1P5	.900 x 1¾	4W1P5	.975 x 2¼	6W1P5	1.275 x 3
2.0	1W2	.955 x 1¾	2W2	.980 x 1⅞	4W2	1.250 x 2¼	6W2	1.460 x 3
3.0	1W3	1.100 x 2 5/16						
4.0	1W4	1.250 x 2.500						

† Order by complete type no.; e.g., WMF1D68 Type numbers listed are ±10%; Available to 1.0 mfd in ±20% tolerance. To specify ±20% add —20

MFP — FLAT MYLAR* WRAP

STANDARD STOCK RATINGS

‡ Tolerance ±20% or ±10%

Cap. Mfd.	100V DCW †Type MFP—	100V DCW L x W x T (Inches)	200V DCW †Type MFP—	200V DCW L x W x T (Inches)	400V DCW †Type MFP—	400V DCW L x W x T (Inches)	600V DCW †Type MFP—	600V DCW L x W x T (Inches)
.01	★		★		★		6S1	.750 x .343 x .218
.015	★		2S15	.500 x .312 x .187	4S15	.625 x .437 x .312	6S15	.875 x .343 x .218
.022	1S22	.625 x 343 x .218	2S22	.625 x .343 x .218	4S22	.750 x .375 x .250	6S22	.875 x .406 x .281
.033	1S33	.625 x .312 x .187	2S33	750 x 343 x .218	4S33	.875 x .406 x .281	6S33	1.000 x .406 x .281
.047	1S47	.750 x .312 x .187	2S47	.750 x .375 x .250	4S47	.875 x .500 x .343	6S47	1.000 x .468 x .343
.068	1S68	.750 x .343 x .218	2S68	.750 x .437 x .250	4S68	1.000 x .437 x .312	6S68	1.000 x .562 x .406
.1	1P1	.875 x .343 x .218	2P1	.875 x .500 x .312	4P1	1.000 x .531 x .375	6P1	1.375 x .593 x .406
.15	1P15	.875 x .406 x .250	2P15	.875 x .562 x .375	4P15	1.250 x .562 x .406	6P15	1.375 x .687 x .531
.22	1P22	1.000 x .468 x .281	2P22	1.125 x .562 x .406	4P22	1.375 x .625 x .500	6P22	1.625 x .750 x .531
.33	1P33	1.125 x .500 x .312	2P33	1.125 x 625 x .500	4P33	1.625 x .656 x .500	6P33	2.000 x .781 x .562
.47	1P47	1.250 x .531 x .375	2P47	1.250 x .656 x .500	4P47	1.625 x .781 x .593	6P47	2.000 x .937 x .718
.68	1P68	1.250 x .687 x .468	2P68	1.625 x .718 x .531	4P68	1.750 x .875 x .687	6P68	2.000 x 1.062 x .843
1.0	1W1	1.500 x .718 x .500	2W1	1.750 x .812 x .625	4W1	2.000 x .937 x .750	6W1	2.500 x 1.250 x 1.062
1.25	1W1P25	1.500 x .718 x .562	2W1P25	1.750 x 960 x .687	4W1P25	2.000 x 1.062 x .843	6W1-P25	2.500 x 1.437 x 1.218
1.50	1W1P5	1.750 x .843 x .656	2W1P5	1.750 x 1.000 x .781	4W1P5	2.250 x 1.062 x .843	6W1P5	3.000 x 1.406 x 1.093
2.0	1W2	1.750 x 1.062 x .843	2W2	1.875 x 1 062 x .843	4W2	2.250 x 1 312 x 1.125	6W2	3.000 x 1 593 x 1.281

★ Covered by Parent Case size. Use next higher voltage for same case size. † Order by complete type no.; e.g., MFP1S22. ‡ Type numbers listed are ±20%; to specify ±10% add —10 to type no.

MMW — MINIATURE MYLAR WRAP — METALLIZED

STANDARD STOCK RATINGS

Tolerance ±20%

Cap. Mfd.	200V DCW Type† MMW—	200V DCW D x L (Inches)	400V DCW Type† MMW—	400V DCW D x L (Inches)	600V DCW Type† MMW—	600V DCW D x L (Inches)
.01	★		4S1	.180 x 9/16	6S1	.200 x ¾
.015	★		4S15	.180 x 11/16	6S15	.250 x ¾
.022	★		4S22	.210 x 11/16	6S22	.300 x ¾
.033	2S33	.180 x 9/16	4S33	.250 x 11/16	6S33	.370 x ¾
.047	2S47	.200 x 9/16	4S47	.300 x 11/16	6S47	.325 x 1 1/16
.068	2S68	.200 x 11/16	4S68	.350 x 11/16	6S68	400 x 1 1/16
.1	2P1	.240 x 11/16	4P1	.325 x 1	6P1	.450 x 1 1/16
.15	2P15	.280 x 11/16	4P15	.375 x 1	6P15	.475 x 1¼

Cap. Mfd.	200V DCW Type† MMW—	200V DCW D x L (Inches)	400V DCW Type† MMW—	400V DCW D x L (Inches)	600V DCW Type† MMW—	600V DCW D x L (Inches)
.22	2P22	.340 x 11/16	4P22	.400 x 1¼	6P22	.575 x 1¼
.33	2P33	.390 x 11/16	4P33	.450 x 1½	6P33	.560 x 1¾
.47	2P47	.370 x 1	4P47	.520 x 1½	6P47	.675 x 1¾
.68	2P68	.420 x 1	4P68	.625 x 1½	6P68	.800 x 1¾
1.0	2W1	.500 x 1	4W1	.675 x 1¾	6W1	.950 x 1¾
1.5	2W1P5	.540 x 1¼	4W1P5	.825 x 1¾		
2.0	2W2	.620 x 1¼	4W2	.950 x 1¾		

★ Use next higher voltage rating. † Order by complete type number; e.g., MMW2S33.

MCR — FILM WRAP METALLIZED POLYCARBONATE

STANDARD STOCK RATINGS

Tolerance ±20%

Cap. Mfd.	200V DCW †Type MCR—	200V DCW Size D x L (In.)	Lead Size	400V DCW †Type MCR—	400V DCW Size D x L (In.)	Lead Size	600V DCW †Type MCR—	600V DCW Size D x L (In.)	Lead Size
.01	2S1	.150 x 9/16	24	4S1	.200 x 9/16	24	6S1	.245 x ¾	24
.015	2S15	.175 x 9/16	24	4S15	.200 x 11/16	24	6S15	.295 x ¾	24
.022	2S22	.185 x 9/16	24	4S22	.225 x 11/16	24	6S22	.350 x ¾	24
.033	2S33	.215 x 9/16	24	4S33	.260 x 11/16	24	6S33	.420 x ¾	22
.047	2S47	.240 x 9/16	24	4S47	.320 x 11/16	22	6S47	.375 x 1 1/16	22
.068	2S68	.215 x 11/16	24	4S68	.375 x 11/16	22	6S68	.435 x 1 1/16	22
.1	2P1	.275 x 11/16	24	4P1	.345 x 1	22	6P1	.525 x 1 1/16	22
.15	2P15	.310 x 11/16	22	4P15	.400 x 1	22	6P15	.565 x 1¼	22
.22	2P22	.370 x 11/16	22	4P22	.425 x 1¼	22	6P22	.670 x 1¼	22
.33	2P33	.430 x 11/16	22	4P33	465 x 1½	22	6P33	.670 x 1¾	22

Cap. Mfd.	200V DCW †Type MCR—	200V DCW Size D x L (In.)	Lead Size	400V DCW †Type MCR—	400V DCW Size D x L (In.)	Lead Size	600V DCW †Type MCR—	600V DCW Size D x L (In.)	Lead Size
.47	2P47	.370 x 1	22	4P47	.550 x 1½	20	6P47	.775 x 1¾	18
.68	2P68	.450 x 1	22	4P68	.650 x 1½	20	6P68	.925 x 1¾	18
1.0	2W1	.530 x 1	22	4W1	.725 x 1¾	18	6W1	1.125 x 1¾	18
1.5	2W1P5	.575 x 1¼	20	4W1P5	.865 x 1¾	18	—	—	—
2.0	2W2	.650 x 1¼	20	4W2	.990 x 1¾	18	—	—	—
3.0	2W3	.700 x 1½	18	4W3	1.062 x 2¼	18	—	—	—
4.0	2W4	.745 x 1¾	18	—	—	—	—	—	—
5.0	2W5	.825 x 1¾	18	—	—	—	—	—	—

† Order by complete type number; e.g., MCR2S22

WCR — FILM WRAP POLYCARBONATE

STANDARD STOCK RATINGS

Tolerance ±10%

Cap. Mfd.	100V DCW †Type WCR—	100V DCW Size (D x L (Inches)	Lead Size	200V DCW †Type WCR—	200V DCW Size (D x L (Inches)	Lead Size
.001	1D1	.200 x 13/16	24	2D1	.200 x 13/16	24
.0022	1D22	.220 x 13/16	24	2D22	.220 x 13/16	24
.0033	1D33	.260 x 13/16	24	2D33	.260 x 13/16	22
.0047	1D47	.290 x 13/16	24	2D47	.290 x 13/16	22
.0068	1D68	.340 x 13/16	24	2D68	290 x 13/16	22
.01	1S1	.235 x ¾	24	2S1	.290 x 13/16	22
.015	1S15	.245 x ¾	24	2S15	.320 x 13/16	22
.022	1S22	.295 x ¾	22	2S22	.385 x 13/16	22
.033	1S33	.345 x ¾	22	2S33	.465 x 13/16	22
.047	1S47	.395 x ¾	22	2S47	.405 x 1 3/16	22

Cap. Mfd.	100V DCW †Type WCR—	100V DCW Size (D x L (Inches)	Lead Size	200V DCW †Type WCR—	200V DCW Size (D x L (Inches)	Lead Size
.068	1S68	.415 x ⅞	22	2S68	.485 x 1 5/16	22
.1	1P1	.450 x 1	22	2P1	.585 x 1 5/16	20
.15	1P15	.525 x 1⅛	20	2P15	.700 x 1 5/16	18
.22	1P22	.590 x 1⅛	20	2P22	.675 x 1⅞	18
.33	1P33	.645 x 1⅜	20	2P33	.815 x 1⅞	18
.47	1P47	.735 x 1⅝	18	2P47	.950 x 1⅞	18
.68	1P68	.765 x 1⅞	18	2P68	1.000 x 2⅜	18
1.0	1W1	.925 x 1⅞	18	—	—	—

† Order by complete type number; e.g., WCR1D22

* DuPont T.M.

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ITT, 970 McLaughlin Ave., San Jose, Calif. Phone: (408) 292-4025.

For applications where a capacitance must be fine-tuned to a fixed value, this vacuum capacitor has a sufficient range of adjustment to eliminate stocking of a variety of fixed capacitors. It is applicable for tuning cavities in the vhf and uhf bands. It has a capacity range of 3 to 30 pF. Peak test voltage is 15 kV, and at 16 MHz the current rating is 40 A rms.
Booth No. 3B49 *Circle No. 318*

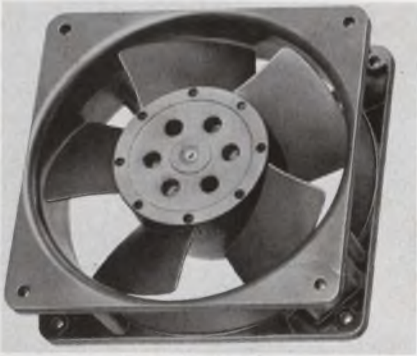
Temperature controllers free from RFI

Harrel, Inc., 16 Fitch St., E. Norwalk, Conn. Phone: (203) 866-2573.

Temperature controllers said to be free from RFI are entirely solid-state. Circuitry is provided to ensure that power shall always be switched both on and off when the voltage of the power source is zero.
Booth No. 3K35 *Circle No. 272*

◄ ON READER-SERVICE CARD CIRCLE 145

Miniature axial fan has dual-sleeve bearings

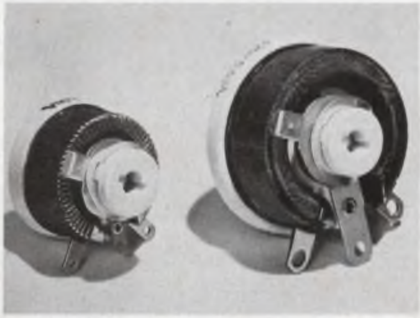


Pamotor, Inc., 312 7th St., San Francisco, Calif. Phone: (415) 863-5440.

Designed for 117 V, 50 to 60-Hz operation, this shaded-pole, miniature axial fan is of all-metal construction. It incorporates a broached dual-sleeve bearing system for longer and more reliable operation. In addition to having Underwriters Yellow Card Component Recognition, it offers a lubrication-free life expectancy of 20,000 operational hours, continuous duty at 55°C.

Booth No. 3K39 *Circle No. 339*

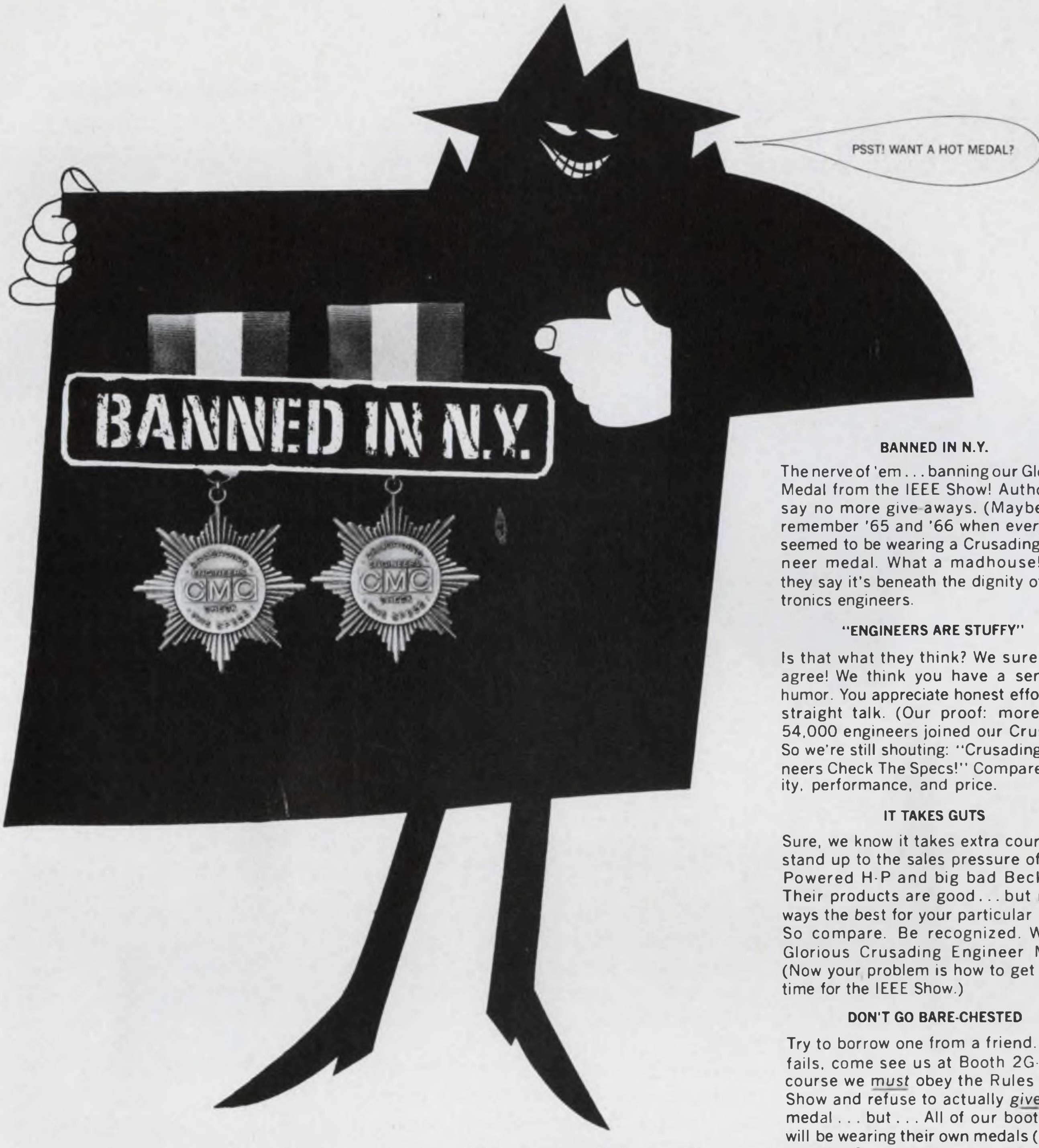
Rheostat-potentiometers for 25- to 50-W control



Ward Leonard Electric Co., 87 South, Mt. Vernon, N. Y. Phone: (914) 664-1000.

Available in 25 and 50-watt sizes, style MP, these rheostat-potentiometers feature all-ceramic construction (core, base, hub), vitreous enamel bonding, self-lubricating shoe, compact design and high-resolution action. Stocked in all popular resistance values to 5 and 10 kΩ for 25 and 50-W sizes respectively, the units are directly interchangeable with those of other manufacturers.

Booth No. 3K04 *Circle No. 360*



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The nerve of 'em . . . banning our Glorious Medal from the IEEE Show! Authorities say no more give-aways. (Maybe they remember '65 and '66 when *everybody* seemed to be wearing a Crusading Engineer medal. What a madhouse!) But they say it's beneath the dignity of electronics engineers.

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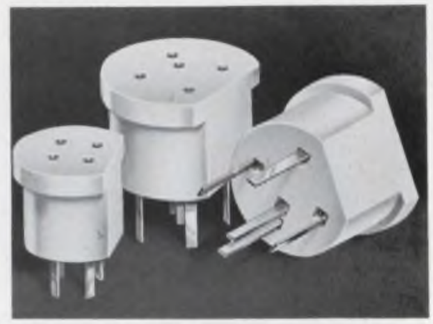
ON READER-SERVICE CARD CIRCLE 148

PC transistor sockets only 1¢ per contact



Industrial Electronic Hardware Corp., 109 Prince St., New York. Phone: (212) 677-1881. Price: 1¢ per contact.

PC transistor sockets are available for JEDEC transistor bases TO-5, TO-9, TO-11, TO-12, TO-33, TO-39 and TO-40. Another series will accept transistor bases TO-18, TO-46, TO-52, and TO-72. Both sockets feature restricted entry, which assures proper alignment and the elimination of damage to transistor leads.

Booth No. 3A32 *Circle No. 373*

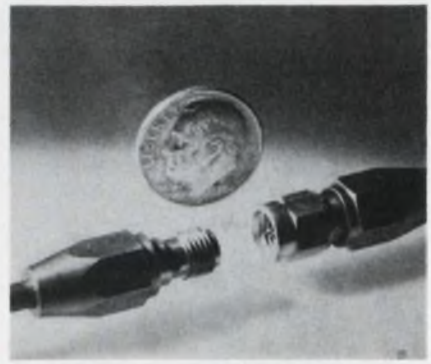
Differential amplifier accepts nanoamp input

Burr-Brown Research Corp., International Airport Industrial Pk., Tucson, Ariz. Phone: (602) 294-1431. P&A: $125 (1 to 9); stock to 4 wks.

Input currents well down into the nanoamp range are feasible with this op-amp. Output currents range up to ±10 mA (50 mA with optional booster). Maximum amplifier voltage is ±10 V. Output current can be used to drive motor coils, galvanometers or deflection coils where the output is used for display or steering purposes. Gain is 100 dB and bandwidth is 1.5 MHz.

Booth No. 3A26 *Circle No. 508*

RF connectors field-serviceable

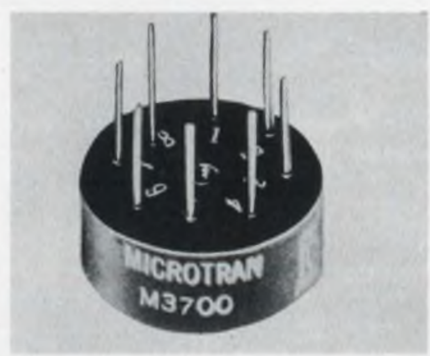


Star-tronics, Georgetown, Mass. Phone: (617) 352-2741.

Supplied as integral assemblies which cannot be disassembled, these RF connectors permit field repair of RF cables, being easily removed and reused many times. No special tools are required and cable preparation is reduced to a single operation, which is the same for both the plug and jack ends. Soldering is also eliminated, thus removing the cause of dielectric distortion common to solderable assemblies.

Booth No. 3B37 Circle No. 336

Toroidal transformers mount PC boards



Microtran Co., Inc. 145 E. Mineola Ave., Valley Stream, N. Y. Phone: (516) 561-6050.

Toroidal power transformers (400 Hz) are designed for low-voltage silicon rectifier power supply and isolation applications for transistorized equipment. Stocked items are available with 28, 56 or 115-V secondary ratings with 115-V primaries in both 9 and 20-VA capacities. Units are of printed-circuit construction.

Booth No. 3B22 Circle No. 346

Precision-fabricated MYCALEX glass-bonded mica and SUPRAMICA ceramoplastics are exclusive products of the Mycalex Corporation of America. These materials are available in machined component form solely from Mycalex Corporation of America.

This insures the user of maximum quality, lowest cost and speediest deliveries. For nearly a half century we have been developing the skills and techniques for the manufacture of complex, close toleranced MYCALEX and SUPRAMICA components. These facts coupled with our intimate knowledge of our own formulations gives the application the ultimate in technical know how.

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MYCALEX — SINCE 1919
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125 Clifton Boulevard, Clifton, New Jersey

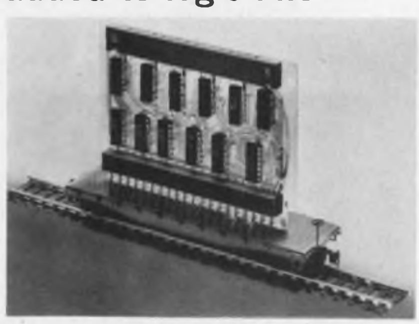
ON READER-SERVICE CARD CIRCLE 152

Microwave mixers with replaceable diodes

Sage Laboratories, Inc., 3 Huron Dr., Natick, Mass. Phone: (617) 653-0844. P&A: $250 (dual-output), $225 (single-output); stock to 30 days.

Eight models have been added to a line of miniature microwave balanced mixers. The line covers 1 to 4 GHz in two bands and has replaceable diodes in each band. Dual and single IF outputs are available with 1/4-36 connectors or solder lugs. Typical vswr is 1.3 and minimum isolation is 8 dB for all models. Noise figure is typically 8 dB from 1 to 2 GHz and 8.5 dB from 2 to 4 GHz with point contact diodes.
Booth No. 3K32 Circle No. 335

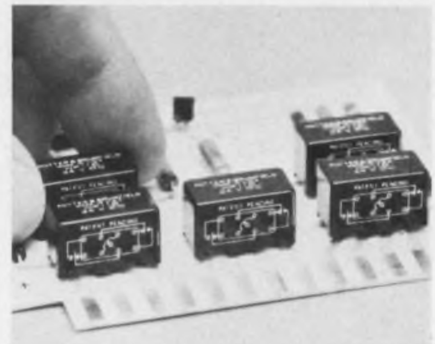
Dual-in-line cards added to logic line



Monitor Systems Inc., Ft. Washington, Pa. Phone: (215) 646-8100.

Dual in-line diode-transistor logic and transistor-transistor logic IC circuit cards have top-mounted test points, and gold-plated spring-pin connectors. The cards are designed to fit into the manufacturer's Monipak files, which hold 16 to 32 cards each, depending on the model.
Booth No. 3A21 Circle No. 382

Miniature relays for plug-in or PC board



Potter & Brumfield, Div. of American Machine & Foundry Co., Princeton, Ind. Phone: (812) 385-5251. P&A: about $10; stock.

Relays weighing only 0.3 oz fit into cases 1/2 the size used for small crystals. They have a high-impact dust cover, and are suitable for plug-in or PC board soldering, with terminals arranged on an 0.200-in. grid. The relays are intended for commercial applications, and have dpdt gold-plated silver contacts. Coils are rated for continuous duty with an operate time of 5 ms max, and a release time of 3 ms max. They are available at coil voltages of 6, 12, 24, 36 and 48 V.
Booth No. 3G14 Circle No. 328

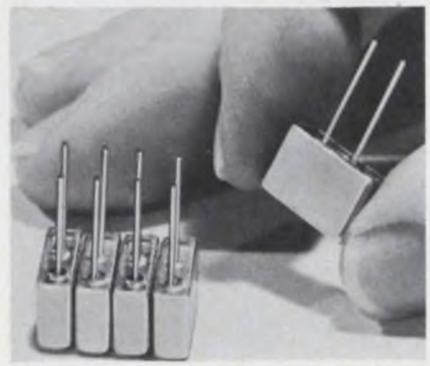
Ac power controller is solid-state, continuous

Semi-Elements, Inc., Saxonburg Blvd., Saxonburg, Pa. Phone: (412) 352-1548. Price: $17.50.

Stepless control of ac power is achieved with a solid-state unit. The controller can replace the more expensive variable voltage transformers. Ac output voltage can be varied from 0 to 98% of input voltage. The brushless unit is operable at distances up to 50 feet by means of a flexible cord and control dial.
Booth No. 3J17 Circle No. 359

ON READER-SERVICE CARD CIRCLE 862 ➤

Tantalum capacitor stacks up small

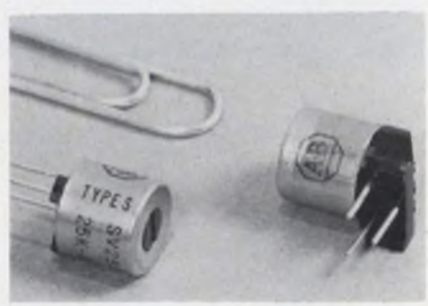


Union Carbide Corp., Electronics Div., 270 Park Ave., New York. Phone: (212) 551-3105.

Solid tantalum capacitors are so compact in shape that 14 of them can be stacked in less than 1 cubic inch. The F—Series polar capacitor starts as a high-purity slab (rectangular) anode, fitting tightly into a metal case that is hermetically sealed to an all-metal top. Working voltages are 6, 10, 15, 25, 35 and 50. Each capacitor has solder-coated Kovar wire leads spaced 0.2-in. apart to fit PC boards. The glass seal eliminates the problem of destroying hermeticity during wave-soldering.

Booth No. 3J06 Circle No. 371

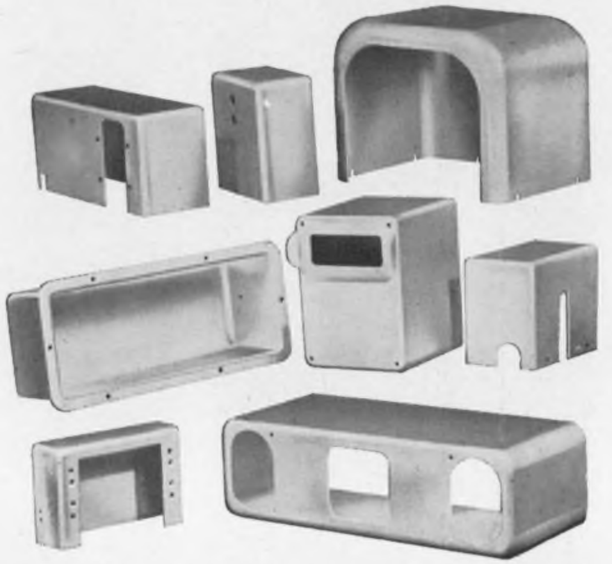
Cermet trimmer mounts vertical or horizontal

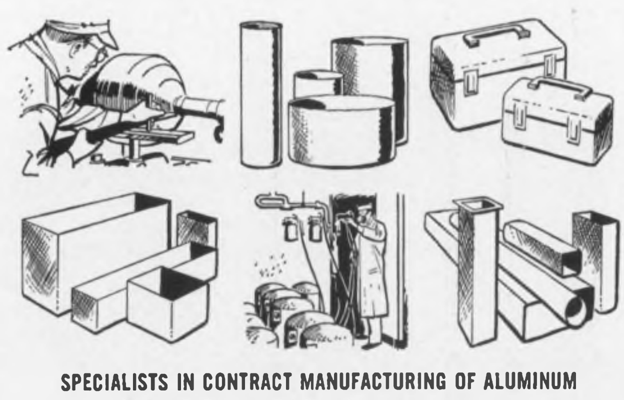


Allen-Bradley Co., 1201 S. 2nd St., Milwaukee. Phone: (414) 671-2000.

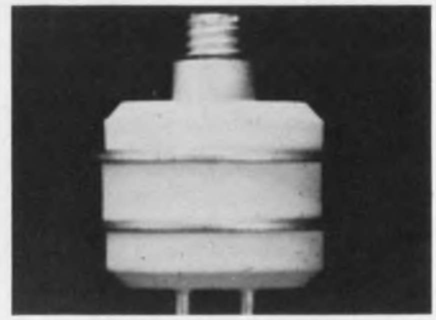
A cermet trimmer for vertical or horizontal mounting is rated at 1/2 W at 85 C, derated to 0 at 150°C. It has a continuous dc working voltage of 300. It is available in a range of resistance values from 50 Ω to 1 MΩ in tolerances of ±5%, ±10% and ±20%. It is designed to exceed requirements of MIL-R-23285A.

Booth No. 3K42 Circle No. 334





Ceramic planar triodes for TACAN and DME

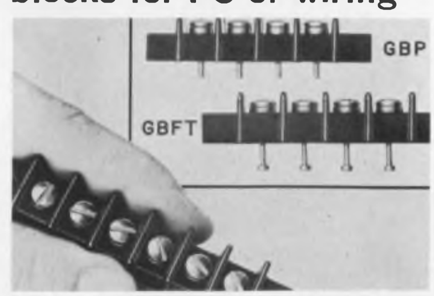


General Electric, 2100 Gardiner Lane, Louisville, Ky. Phone: (502) 459-4323.

Four new ceramic planar triodes for application in airborne micro-TACAN and DME equipments are available. The tubes are being designed into the amplifier chains of a new generation of TACAN and DME equipments. Three are intended for the low-level, high-gain stages, the intermediate driver, or output stage, the output stage, and one serves all of these functions in the lower powered commercial and private aircraft designs.

Booth No. 3E01 Circle No. 381

Feed-thru terminal blocks for PC or wiring

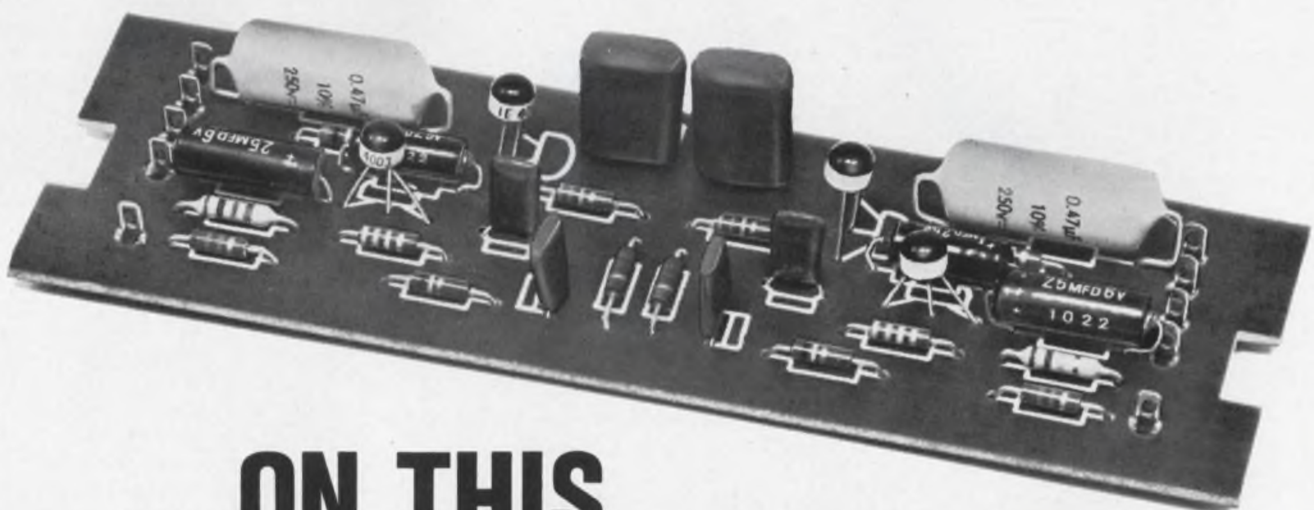


Curtis Development & Mfg. Co., 3250 N. 33rd St., Milwaukee. Phone: (414) 445-1817.

Flat-base, feed-thru terminal blocks, with a choice of printed circuit pins or turret-type solder terminals for internal connections are offered. The molded black thermoset phenolic blocks with 7/16-in. center-to-center terminal spacing are available with 1 to 18 terminals per block. The tinned screw machine inserts have #6-32 terminal screws for external connections of up to #12 AWG wire.

Booth No. 3K15 Circle No. 333

IEC REDUCED THE CUSTOMER'S COST $.87 PER BOARD



...ON THIS STEREO PREAMPLIFIER

We supplied 4 NPN **Silicon planar transistors (2N3391A type), 4 miniature aluminum electrolytic capacitors, 6 subminiature polyester film capacitors** and **2 metalized mylar capacitors at a cost of $1.63 per board** (production quantities). Our customer had been paying **$2.50 per board** for these same components.

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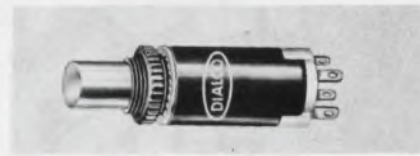


Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. Phone: (212) 497-7600. Price: from $1.11 (1000).

Pushbutton switches designed for computer and data processing equipment claim a life rating of one million operations. They are useful for dry circuits or with low currents at higher voltages. Lighted switches use permanently mounted T-2 neon lamps with or without the current-limiting resistor.

Booth No. 3H14 Circle No. 380

IC logic cards are voltage-decoupled

Datascan, Inc., 1111 Paulison Ave., Clifton, N. J. Phone: (201) 773-8803.

Complete voltage decoupling on IC logic cards is accomplished through the use of an emitter-follower driven by a highly regulated, low-ripple power supply. Capacitive decoupling on each board permits power supply bussing without detrimental power loss or noise generation. The logic cards have test points located at all convenient circuit nodes where oscilloscope display is required.

Booth No. 3A14 Circle No. 361

X-Y positioner for welding and soldering

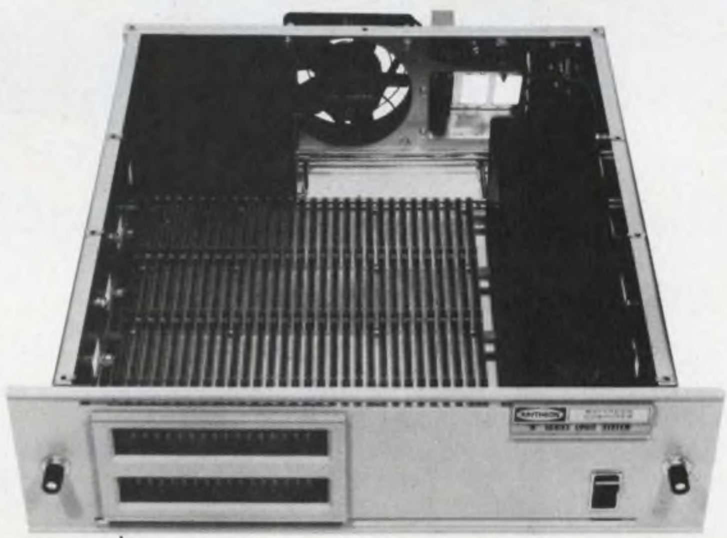
Hughes Aircraft Co., Welder Dept., 2020 Oceanside Blvd., Oceanside, Calif. Phone: (714) 722-2101.

Positioners, consisting of precision slide tables for positioning material in both X and Y axes, are designed for production welding and soldering. The systems are modular in design so that compatible subsystems can be combined into several standard configurations of complete working stations.

Booth No. 3A48 Circle No. 362

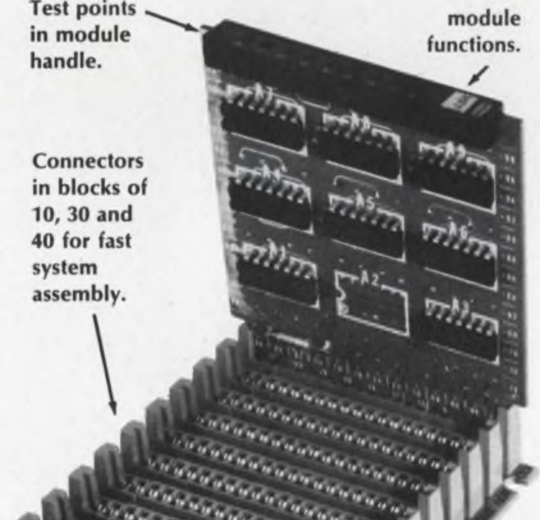
The Unbeatable IC System:

Your logic design and Raytheon Computer modules and hardware.



Indicator lights display system operation.

This case holds 120 modules. There's also one for 40; another for 400.



Test points in module handle.

Color-coded module functions.

Connectors in blocks of 10, 30 and 40 for fast system assembly.

Ready for our automatic wire wrap service.

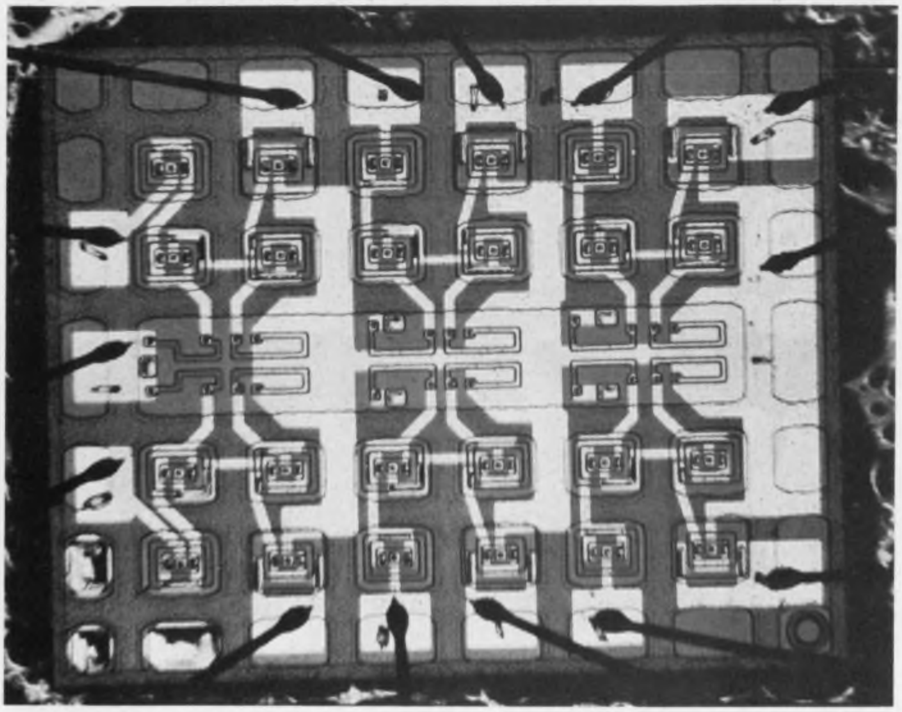
Laminated power bus bars installed and wired in each module case. Reduces noise, eliminates power inter-connections, cuts hours from assembly and test time.

Raytheon Computer's M-Series — more than 30 modules— connectors, cases, power supplies and power distribution are so thoroughly engineered you can concentrate on logic and electronic design, not mechanical details. Every step— design, assembly, test, check-out, troubleshooting—is easier than you thought it could be.

We'll even help you design your logic. Call or write today for a visit from a helpful applications engineer or for the whole story in print. Ask for Data File M-136. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif., 92705, Phone: (714) 546-7160.

RAYTHEON

ON READER-SERVICE CARD CIRCLE 180



Obtain complex logic functions with simple diode logic

Radiation, Inc., P. O. Box 220, Melbourne, Fla. Phone: (305) 723-1511. P&A: $7 (MIL 5-V inverter), $9 (MIL 35-V driver, $3.50 (industrial 5-V inverter), $4.50 (industrial 35-V driver); stock.

Input/output matrix interfaces can be integrated using monolithic interface circuits together with monolithic diode matrices. Data processing systems, presently discrete, will be lighter, less complex and lower in cost according to the manufacturer, Radiation, Inc.

The new circuits include low-voltage hex interface inverters, high-voltage hex interface drivers and hex indicator drivers.

The inverters provide the necessary low-voltage interface between standard 5-volt ICs and the diode matrices. The interface drivers adapt matrix input/output to high-voltage interfaces (up to 35 volts) while the indicator drivers (presently developmental) provide output drivers in excess of 50 volts.

The approach finds application in code conversions such as BCD to decimal. Speed of computation is claimed to exceed that of any other integrated logic circuitry.

A typical application is shown in Fig. 1. Here, two 6 x 8 diode matrices, an interface inverter and a DTL hex inverter generate a variety of logic functions. Typical logic transition times from input to output are in the 8 to 20 ns range.

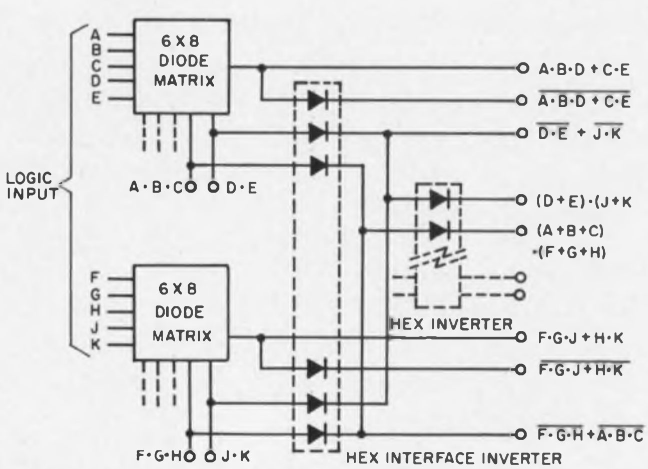
In Fig. 2, two diode matrices, an interface inverter and a DTL hex inverter convert a 5-bit data input to a "custom-selected" modified 5-bit output.

A read-only memory may also be constructed with 260-ns cycle time and 150-ns access to data. Clear cycle is 70 ns and setup and clock address can be performed in 40 ns.

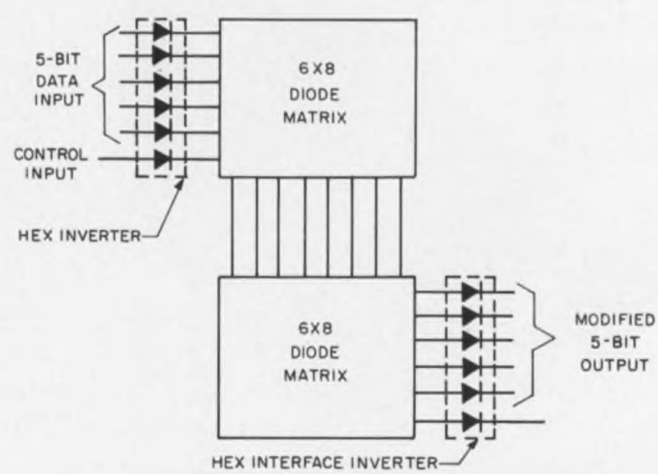
The hex indicator driver can be used in BCD decode networks to simplify control circuit design (such as Nixies). Other BCD decoders are limited to one weighted binary code, but these matrices can be "customized" to any weighted code due to the fusing technique used by Radiation for selection of coding patterns.

The circuits are available in TO-84 flat-packs or ceramic dual-in-lines in −55 to 125°C MIL units and 0 to 75°C industrial units.

Booth No. 4G32 Circle No. 383

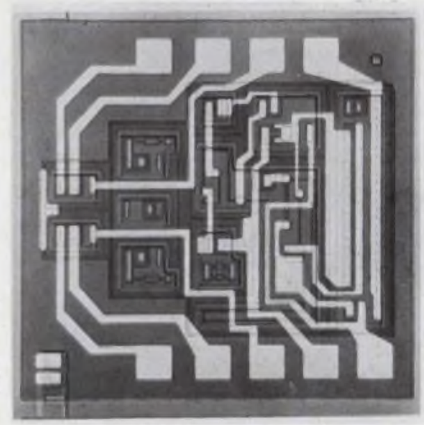


1. **Generate a variety of logic functions** with a few circuit packages. Here, two 6 x 8 diode matrices, a hex interface inverter and a DTL hex inverter are combined.



2. **Use diode matrices and interface circuits** to convert codes. A 5-bit data input is converted to a modified 5-bit output using the same 4 circuits as in Fig. 1.

Monolithic preamp temperature-stable



Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $12.50, $25 (MIL), (100 to 999); stock.

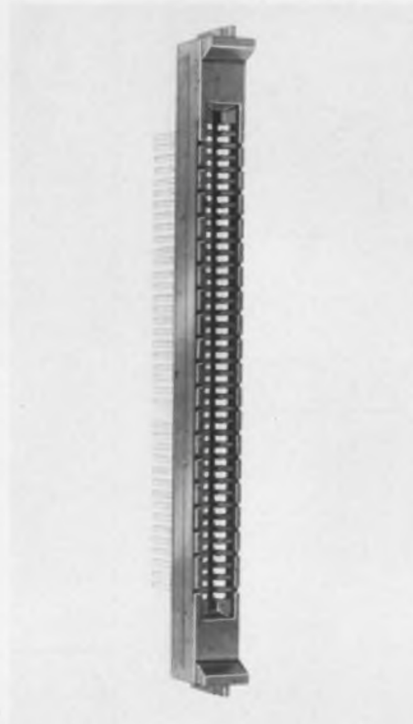
A temperature-stable monolithic preamplifier operates with an offset voltage temperature coefficient of 1 μV/°C. Temperature tracking is typically 30 pA/°C. The IC, constructed on a 45-mil square silicon die, is aimed at preamplifier, operational amplifier and instrumentation applications. Functionally, the μA-726 consists of a matched differential transistor pair and a temperature control amplifier. Temperature is controlled by power dissipation on the chip. The sensing function is provided by two transistors whose emitter-base voltages are summed and applied across a resistor to produce a current which is approximately inversely proportional to the chip temperature. This current is amplified by the gain of the two transistors, one a high-power device. Dissipation at the collector-emitter occurs at 30 V with a maximum current of 50 mA. This gives 1.5-watts available power to heat the chip, which reaches a stabilization temperature in less than 1 second. As the chip temperature rises, the output stage current is reduced until the final chip temperature is reached. Quiescent power for most applications runs about 250 mW.

The circuit design and die layout are arranged so that the temperature-sensing elements are centrally located with the power dissipation device on one side and the differential pair on the other.

Booth No. 4F03 Circle No. 286

COMPONENTS—4TH FLOOR

PC edge connector up to 80 contacts



Continental Connector Corp., Woodside, N. Y. Phone: (212) 899-4422.

Printed-circuit card edge connectors are designed for commercial communications applications. The units are available with 80, 75, 52 or 30-contact terminations on 0.1-inch center-to-center spacing. Contact terminals can be supplied straight or with staggered right-angle configuration to permit wire-wrapping for up to three #24 AWG wires. All sizes are dual readout, and accept 1/16-inch PC boards.

Booth No. 4D12 Circle No. 298

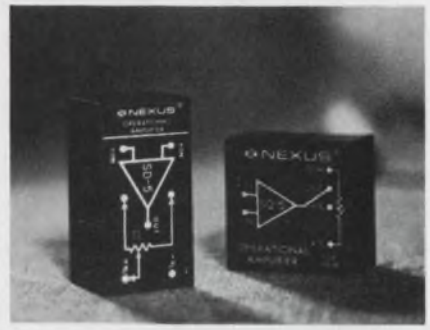
Silicon planars plastic-packaged

International Electronics Corp., Melville, N. Y. Phone: (516) 694-7700. P&A: 40¢ to 90¢; stock to 4 wks.

Designated IE3011, an economy npn silicon planar unit is available in a solid encapsulated package with electrical characteristics and lead configurations similar to type 2N918. The transistor is suited to low-power, small-signal vhf and uhf oscillator and amplifier applications.

Booth No. 4H24 Circle No. 311

General purpose op-amp priced under $10



Nexus Research Lab., Inc., 480 Neponset St., Canton, Mass. Phone: (617) 828-9000. P&A: $9.75 (10 to 99); stock.

This encapsulated low-cost unit is fully protected for input overdrive and indefinite short circuit to ground. To ensure stability with a variety of feedback elements, it is internally compensated for a controlled −6 dB/octave gain-bandwidth roll-off. Output is ±10 V at 2.2 mA and open-loop gain at dc is 10,000. Common-mode input impedance is 20 MΩ and differential is 200 kΩ.

Booth No. 4D25 Circle No. 316

Thermistors meet tight tolerances

Yellow Springs Instrument Co., Inc., Box 279, Yellow Springs, Ohio. Phone: (513) 767-7242. P&A: $6.90 (100 lots); stock.

Thermistors match a common resistance temperature curve with an interchangeability of ±0.1°C (±0.5% or better resistance tolerance) over a range from −10 to 75°C. They are interchangeable to slightly looser tolerances from −50 to −10°C and from 75 to 100°C. The thermistors give the circuit designer great flexibility in temperature measuring circuits such as multiple-point monitoring with a single readout and in temperature compensation and temperature control.

Booth No. 4B23 Circle No. 314

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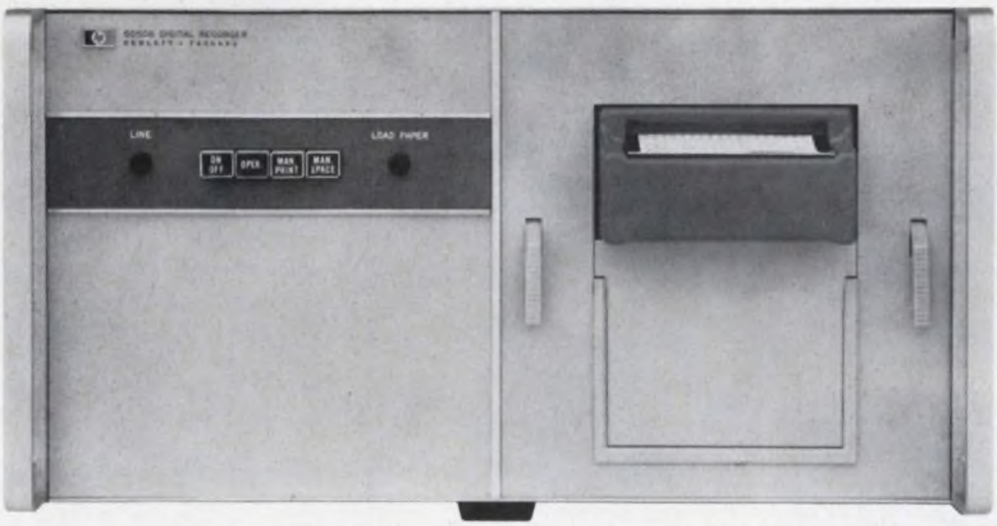
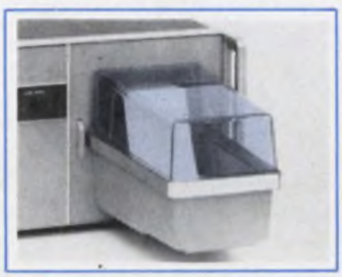




The HP 5050A Digital Recorder is no quitter. New mechanical techniques make this 20-line-per-second printer rugged, quiet, economical and simple. For example, there are no rotating electrical contacts for decoding, and no start-stop operation of printwheel and ink ribbon. Instead, photo-electric decoding is used, and the print drum rotates continually against an ink-impregnated roller. Fewer parts lead to increased reliability potential, which is necessary in printers with the 5050A's speed. Zero suppression is available.

The 5050A is quiet, too . . . measured noise is less than an electric typewriter, less than other printers in its speed class. It accepts 4-line BCD data from one or two sources, which can be in different BCD codes. For extra versatility, formats and codes are easily and economically changed by mechanical means without buying new circuitry for driving the printer.

The 5050A can print up to 18 columns at rates to 20 lines per second . . . and without making a lot of noise about it.

Notice the unusual transparent hood. It muffles the sound. It lets you hear yourself think. It keeps your printed records in a neatly folded stack, instead of streaming over equipment, bench and floor. And it stores completely within the recorder when you're not using it.

The 5050A is, of course, fully compatible with other HP solid-state equipment. Price is favorable, too: $1750 without the driving electronics (which are an additional $35 per column).

For more information call your local Hewlett-Packard field engineer or write Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

Brief Specifications

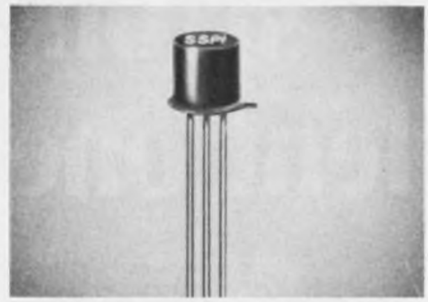
Print Cycle Time:	50 msec, asynchronous.
Maximum Capacity:	18 columns, 16 characters each.
Data Input:	Parallel entry, BCD (1-2-2-4, 1-2-4-8 or 1-2-4-2); "1" must differ from "0" by 4.5 V min. to 75 V max.
Reference Voltage:	±150 V max.; both "0" and "1" states are required.
Input Impedance:	Approximately two megohms.
Hold-off Signals:	Both polarities diode coupled, simultaneously available; 10 mA load max. +15 V open circuit from 1 K source −15 V open circuit from 1 K source
Print Command:	+ or − pulse, 6 to 20 V amplitude, 1 V/μsec min. rise time, 20 μsec or greater in width, AC coupled.

HEWLETT hp PACKARD

2561

ON READER-SERVICE CARD CIRCLE 165

Planar silicon SCRs radiation resistant

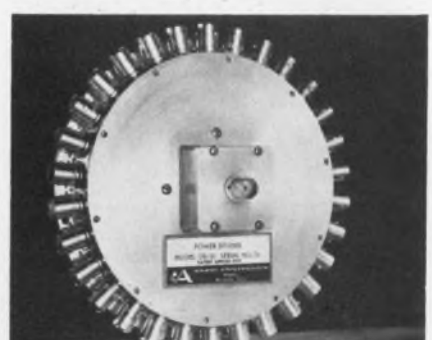


Solid State Products, Inc., 1 Pingree St., Salem, Mass. Phone: (617) 745-2900. P&A: $44 (100 lots); stock.

Radiation-hard pnpn SCRs have design limits fully specified after exposure to 3 x 10^{14} nvt. Post-radiation specs are pulse currents to 30 A, max trigger current of 20 mA, max holding current of 30 mA and continuous dc forward current to 400 mA. They are in a JEDEC TO-18 case. The devices are for use in squib firing circuits, inverters and converters, pulse generators, relay drivers and modulator switches. They are free of "secondary breakdown" and can be operated in high-voltage circuits.

Booth No. 4D16 Circle No. 262

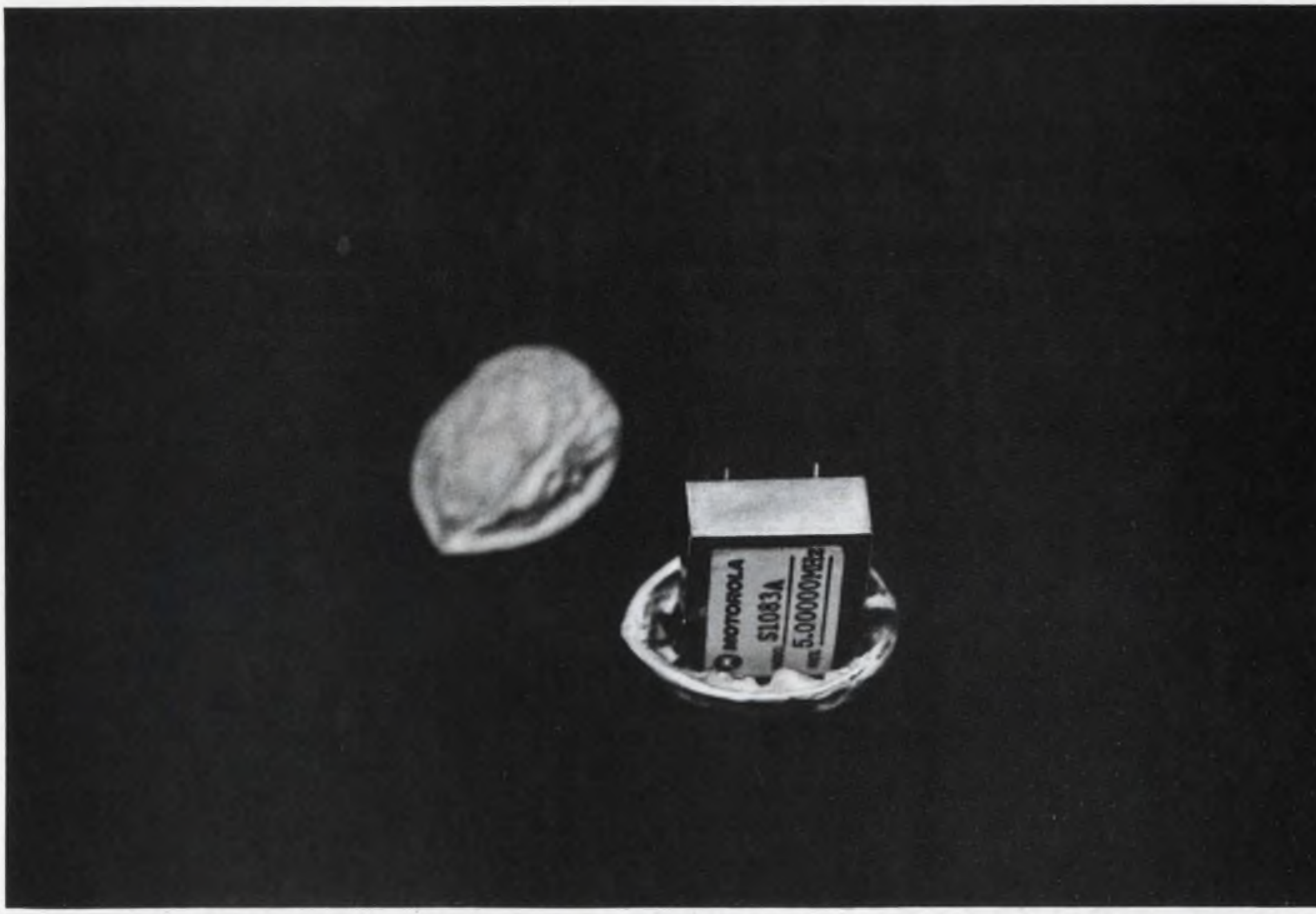
30-way power divider ranges 10 to 500 MHz



Anzac Electronics, Inc., Moody's Lane, Norwalk, Conn. Phone: (203) 838-8451. P&A: $590; 3 to 6 wks.

Frequency range of this 30-way isolating power divider and summer is 10 to 500 MHz. Total power input is a max of 2.4 watts. Insertion loss is 18.5 dB from 10 to 300 MHz and 19.5 dB from 300 to 500 MHz. Vswr in 50-Ω systems is 1.25 at the output ports and 1.9 at the input port.

Booth No. 4C23 Circle No. 313



a TCXO that fits almost anywhere

and offers exceptional frequency stability between −55°C and +85°C

Only about ½ of a cubic inch in size, this TCXO (temperature compensated crystal oscillator) offers excellent frequency stability; 5 ppm over a temperature range of −55°C to +85°C. It's one of four new miniature TCXO's from Motorola. The slightly larger models offer stabilities as low as ±1 ppm. Zener diode regulated compensating circuits provide on-frequency operation the instant they're turned on. All-silicon solid-state construction provides exceptional reliability. Take a look at these facts.

SMALL SIZE: Sizes range from 0.58 cubic inch to 3.4 cubic inches.

WIDE TEMPERATURE RANGE: From −55°C to +85°C.

HIGH FREQUENCY STABILITY: Available as low as ±1 ppm.

WIDE FREQUENCY RANGE: From 1 MHz to 30 MHz.

LOW POWER CONSUMPTION: As low as 100 milliwatts.

NO WARM-UP TIME: Adjusts instantly to temperature conditions.

FOR MORE INFORMATION contact your Motorola representative. Or write for bulletin TIC-3213.

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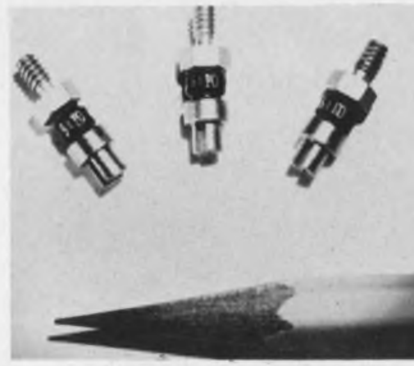
ON READER-SERVICE CARD CIRCLE 167

Stud-mount rectifier recovers quickly

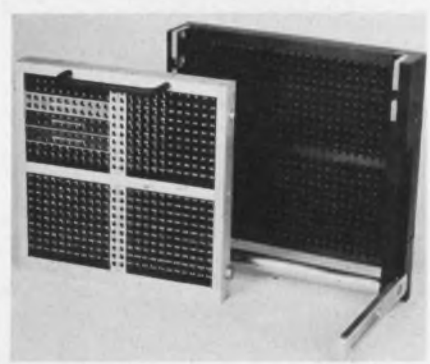


Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404. P&A: $8.50 to $22; stock.

Miniature fast-recovery rectifiers offer a 9-A current rating and PIV up to 400 V with all models having controlled avalanche characteristics. Surge ratings are as high as 150 A for one cycle. Recovery times as low as 250 ns permit full power operation at frequencies as high as 40 kHz square-wave, or higher frequencies sine-wave.

Booth No. 4K19 Circle No. 294

Patchboard programer completely shielded



Virginia Panel Corp., 1400 New Hope Rd., Waynesboro, Va. Phone: (703) 924-8376.

Completely shielded programing systems utilize the locking concept in patchcords and a molded conductive-shielded board. The paddle contacts are completely isolated from each other by means of a metallic shielding around each contact. This reduces crosstalk and restricts outside interference. All contacts are on 3/8-inch centers. The systems are available with 120 to 4200 contacts.

Booth No. 4K14 Circle No. 315

Glass fiber optics in continuous length

Corning Glass Works, Corning, N. Y. Phone: (607) 962-4444. P&A: about 10¢/foot (over 50,000 feet); stock.

Flexible non-coherent glass fiber optic bundles jacketed in PVC are available in single lengths up to 10,000 feet. The fibers can be twisted and flexed without degradation of light transmission. The jacketed fibers can be cut, terminated, end-finished and installed to light source and output devices. A 10-foot length of flexible glass fibers with polished ends will transmit 40% of input light. Light acceptance angle is 65° minimum.

Booth No. 4F20 *Circle No. 284*

Silicon diode uses Schottky principle

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $2 (100 to 1000); stock.

A new type of silicon diode uses the Schottky barrier or hot-carrier principle to provide higher performance in uhf mixer circuits and faster switching times. FH1000 hot carrier diodes are packaged in the DO-7 package with standard 20-mil axial leads. Maximum power dissipation rating is 100 mW. Maximum forward voltage is 0.55 V at I_F of 10 mA and leakage current is typically 50 nA at V_R of 1 volt. When employed as a mixer at 890 MHz, noise figure is 10 dB max. Switching time is in the "tenths of nanoseconds" range.

Booth No. 4F03 *Circle No. 285*

Single pulse accessory ups laser power

TRG Control Data Corp., Route 110, Melville, N. Y. Phone: (516) 531-6464.

Model 104A-6 single pulse accessory is an optical device that increases peak power output of a rotating-prism, Q-switched ruby laser by introducing a saturable dye solution into the resonant cavity. This device can be used to effectively increase the switching speed of any rotating reflector Q-switch. The accessory contains two optical cells filled with a saturable dye solution. The cells are mounted in a disk that can be rotated to index either of the two cells or a clear aperture into the laser cavity. The second cell is provided as a convenience to alter the transmission characteristics of the dye solution for experimental purposes. The increase in peak power is obtained by suppressing multiple pulses common to rotating reflector Q-switches and obtaining a single narrow pulse, which contains essentially all the energy previously in the multiple pulses.

Booth No. 4B15 Circle No. 299

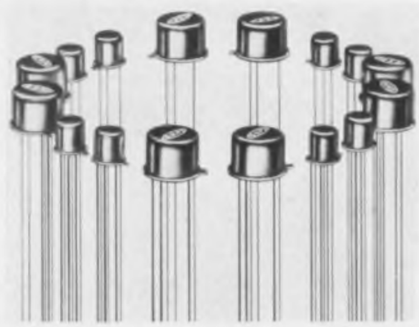
600-V relays measure 2-3/4 inches square

Struthers-Dunn, Inc., Pitman, N. J. Phone: (609) 922-2349.

For 600-V applications, the SC relay line requires a panel area of only 2-3/4 inches square. The units reportedly take no more space than most 300-V industrial relays. Available in 4-pole and 8-pole models with any combinations of NO and NC double-break contacts, the relays claim an operating life of 10 million operations at rated loads.

Booth No. 4J25 Circle No. 366

Industrial SCRs have 0.2-μs turn-on



Solid State Products, Inc., 1 Pingree St., Salem, Mass. Phone: (617) 745-2900. P&A: under $1 (100 lots); stock.

Silicon planar passivated SCRs combine low-level triggering, high pulse power, and fast switching. They are packaged in hermetically sealed metal cases and come in three sizes: TO-46, TO-18 and TO-5. The units are available in anode voltage ratings from 30 to 200 V and feature peak forward currents to 40 A, max trigger currents of 200 μA, 8-μs recovery times, and 0.2 μs turn-on times.

Booth No. 4D16 Circle No. 259

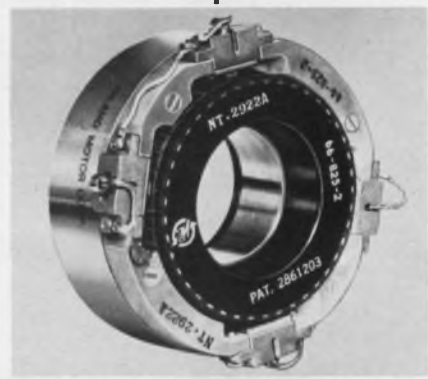
'Doorbell' rectifier rated to 10 kV

Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 926-0404.

Unitrode is offering a larger version of its high-voltage "doorbell" rectifier modules. Twelve new models offer ratings from 2.5 to 10 kV and are available in regular and fast recovery versions. Continuous current is 6 A in air or 15 A in oil. Surge rating is 200 A for 8.3 ms. They may be connected in stacks or in any of the usual bridge circuits using the integral threaded connections. Reverse transient ratings are as high as 20 joules.

Booth No. 4K19 Circle No. 369

Dc torquer meets all drive requirements



Inland Motor Corp., 501 First St., Radford, Va. Phone: (703) 639-3973.

One dc direct-drive torque motor covers the drive requirements of all standard reel sizes, tape tensions and tape speeds. The NT-2922A torquer also provides extremely low ripple torque. The frameless design permits mounting directly on the shaft. Direct-drive with the elimination of gear trains provides servo stiffness and the complete absence of backlash.

Booth No. 4E32 Circle No. 349

Heat exchanger cools cabinets

McLean Engineering Labs., Princeton Junction, N. J. Phone: (609) 799-0100. P&A: about $175; 4 to 5 wks.

Rack-mounted, water-cooled heat exchangers maintain interior cabinet temperature at a maximum of 80°F with a 1-kW heat dissipation. They use chilled water within a temperature range of 66 to 70°F. Air is recirculatated within the electronic enclosure and cooled by the heat-exchanger installed within the blower case. The system does not use room ambient air, nor does it exhaust warm inside cabinet air into the atmosphere.

Booth No. 4K12 Circle No. 368

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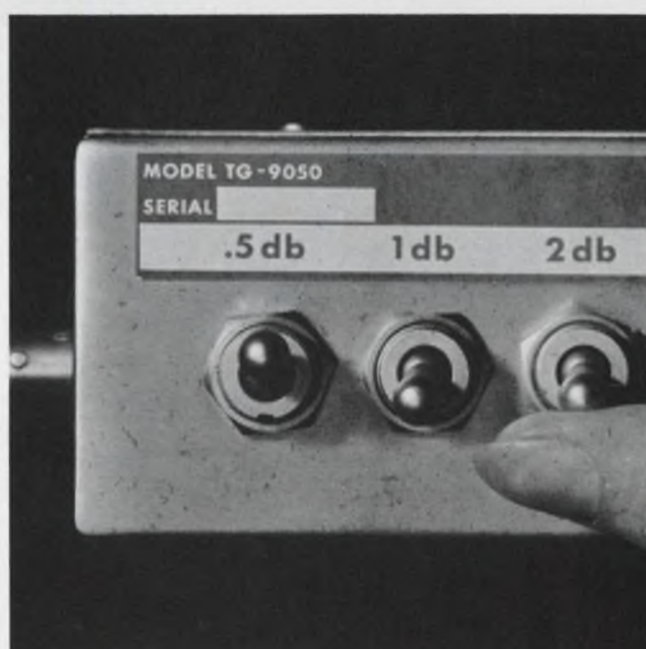
0.5 dB

steps, and to 42 and 102 dB in 1 dB steps. To assure long life and precise repeatability these Telonic toggle switch attenuators are heavy-duty type incorporating switch controls with a double knife edge and self-wiping action. Pads are shielded, individually, to prevent leakage, and to permit maximum range. The attenuators operate to 250-300 MHz, and can be furnished in 50 or 75-ohm versions. The unit shown below is a Model TG-9050A with additive steps of .5, 1, 2, 3, 6, 10, 20, 20, and 20 dB.

If you're using these attenuators (or other RF equipment) up to



"See Telonic at IEEE, Booths 2G02-2G10"

ON READER-SERVICE CARD CIRCLE 864

Firewall connector rises from the ashes

The Pyle-National Co., 1334 N. Kostner Ave., Chicago. Phone: (312) 342-6300.

Phoenix series firewall connectors incorporate the D-hole type receptacle mounting and bayonet coupling. The series meets Classes R and G requirements of MIL-C-26500B while exceeding Class K, MIL-C-5015D fireproof provisions. Environmental sealing provides 1000 hours of electrical continuity at 460°F and corrosive atmosphere resistance. Stainless steel shells are available in sizes 14, 16, 18 or 22. Contacts offered in 12, 16 and 20 sizes are rhodium- (or gold) plated.

Booth No. 4G20 Circle No. 355

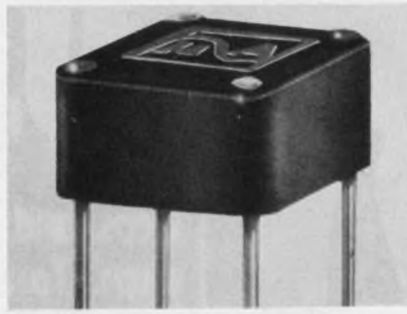
Low-noise preamps cover uhf and vhf

International Microwave Corp., River Rd., Cos Cob, Conn. Phone: (203) 661-6277.

Low-noise, solid-state broadband vhf-uhf preamps cover 200 to 550 MHz with a noise figure of 2.5 to 3.5 dB. Case and filter designs claim a high degree of protection against RFI. Gain is ±1 dB, input and output impedance is 50 Ω and operating power is −24 Vdc at 17 mA.

Booth No. 4E12 Circle No. 363

Schottky diode quads processed 'bilithic'

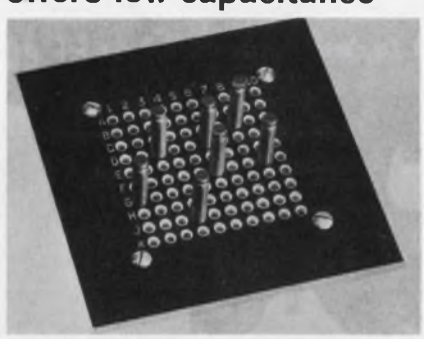


Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Schottky-barrier junction diodes are closely matched for use as balanced modulators from low frequencies through the uhf range. They are also available as single units and matched pairs for detector and discriminator usage. The MA-4860 and MA-4878 series utilize a "bilithic" process which encapsulates the metal-silicon junction in a hermetic glass seal. This technique allows a large-area, low-loss top contact to the diode junction for improved reliability. Pulse burnout is rated at 5 ergs.

Booth No. 4E12 Circle No. 364

Matrix assembly offers low capacitance

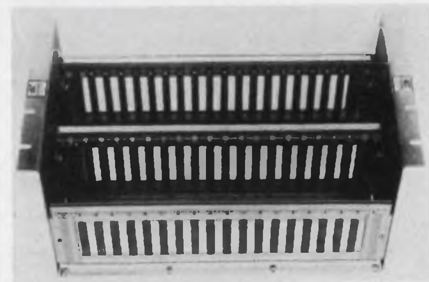


Taurus Corp., Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

Offering a new type of contact arrangement, this matrix-assembly is used in telemetry, monitoring, programing and automated functions. Its low capacitance insures good ac performance. Any combinations. Its low capacitance ensures the insertion of the appropriate number of terminals. The assembly features high insulation resistance between adjacent rows.

Booth No. 4K38 Circle No. 511

PC card enclosure designed to stack



Elco Corp., Willow Grove, Pa. Phone: (215) 659-7300. P&A: $20 to $25; stock.

Double-tier Varipak printed-circuit card enclosures are designed for stacking. Available in 16 standard sizes and made completely of aluminum, the guides are easily insertable and removable without damage to guides or guide plates. The guides have sufficient "float" to allow for tolerance accumulation between card guides and connectors.

Booth No. 4F21 Circle No. 352

Overlay transistors rated 20 W at 400 MHz

Vector Div. of United Aircraft Corp., Southampton, Pa. Phone: (215) 355-2700. P&A: $63; stock.

Large-signal, high-power overlays are for application in class B and C RF power amplifiers for military and commercial communications equipment. The V-408 offers a power output of 15 W at 400 MHz and 22 W at 225 MHz. The V-410 has a minimum power output of 20 W at 400 MHz. Both use an overlay multiple-emitter geometry and perform with efficiencies on the order of 65%. Packaging is TO-60.

Booth No. 4F26 Circle No. 347

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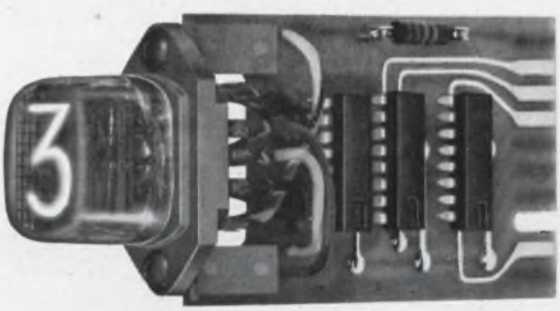
ON READER-SERVICE CARD CIRCLE 866



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ON READER-SERVICE CARD CIRCLE 867

1 GHz

frequency, you will find Telonic's Coaxial Switches a boon in establishing test systems, checkout stations, or in any area of RF circuitry switching. Silver-plated with point-contact design, they give excellent service life and repeatability. The frequency range permits application to microwave, video, VHF and UHF systems. Two series and six models permit selection of 2 or 4 poles, 2 or 6 positions and an optional ganged wafer switch. Shown; the TS-103A, 4 pole, 2 position on both coax and wafer sections.

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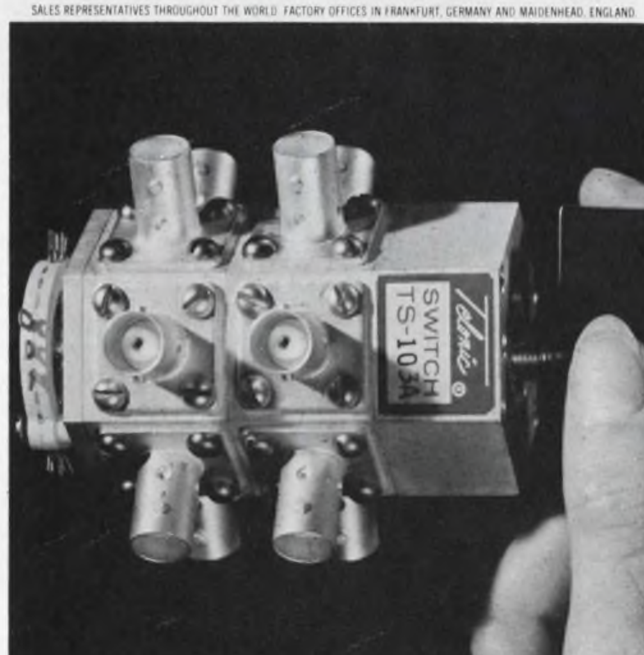
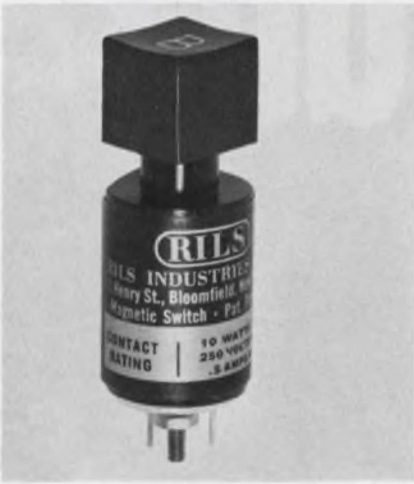


"See Telonic at IEEE, Booths 2G02-2G10"

ON READER-SERVICE CARD CIRCLE 868

Pushbutton reeds mount PC board



Gordos Corp., 250 Glenwood Ave., Bloomfield, N. J. Phone: (201) 743-6800.

Pushbutton reed switches for printed circuit mounting claim a life of over 20 million operations. Contact rating is 1/2 A at 10-W resistive load and minimum breakdown is 35 Vdc. Insulation resistance is 5 x 10^{10} Ω. They are available spst, spdt or 3pst in flat or angled-base designs.

Booth No. 4K31 Circle No. 295

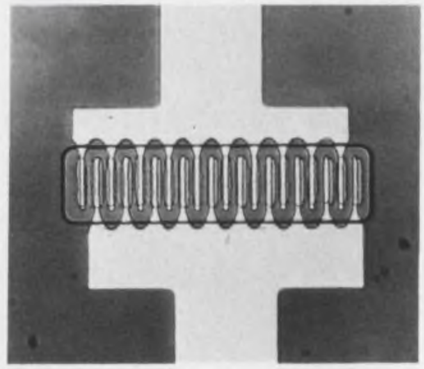
Adjustable P-clips handle loops to 2 in.

Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N. Y. Phone: (914) 664-6090. P&A: from $24/1000; stock.

Only nine sizes of these adjustable P-clips will fit all loop diameters from 1/8 through 2 inches. Each of the sizes can be used with a wide range of bundles and the tension on each can be controlled. Typical applications include cables, bundles of wires, components, pipes and tubing where a clamp, strain-relief or strap is required.

Booth No. 4B27 Circle No. 350

Stripline transistor oscillates at 4.5 GHz

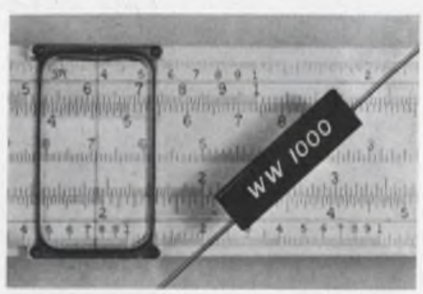


Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. P&A: $42.50 (10 to 99); stock.

A microwave transistor, offering a maximum frequency of oscillation of 4.5 GHz, is intended for use in preamplifier and local oscillator applications through S-band. It is capable of delivering a maximum available gain (MAG) of 7 dB at 2 GHz and 3.5 dB at 3 GHz. The MT1062 is packaged in the TO-51 stripline package.

Booth No. 4F03 Circle No. 287

Wirewound resistor slide-adjustable

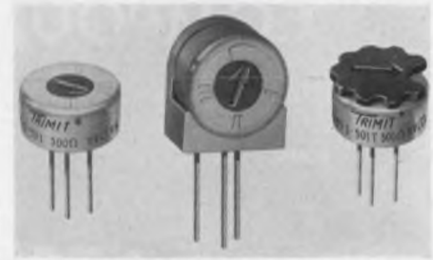


Radio Products International, 1501 S. Hill St., Los Angeles. Phone: (213) 746-0325.

Wirewound, variable resistors slide along the center lead to provide ±20% variations in resistance. The center lead is attached to a multi-tang wiper and is insulated on one side. The resistance element consists of an extremely fine wire wound on a metal mandrel. Stability and temperature coefficient are in the range of 20 ppm°C. Models are available in 1, 1/2 and 1/4-W ratings. Nominal resistance ranges are available from 10 Ω to 250 kΩ.

Booth No 4E39 Circle No. 542

Single-turn pot mounts PC boards



Bourns, Inc., Trimpot Div., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. P&A: $2.30 (100 to 249); stock to 3 wks.

A low-cost, single-turn, industrial potentiometer measures 1/2 inch diameter by less than 1/4 inch long. It has a standard resistance range of 10 Ω and a power rating of 0.5 watt at 40°C. Model 3365 is housed in an all-plastic case, has sealed pins for printed circuit applications and stops at each end of adjustment. Each style is available with thumb adjustment knob.

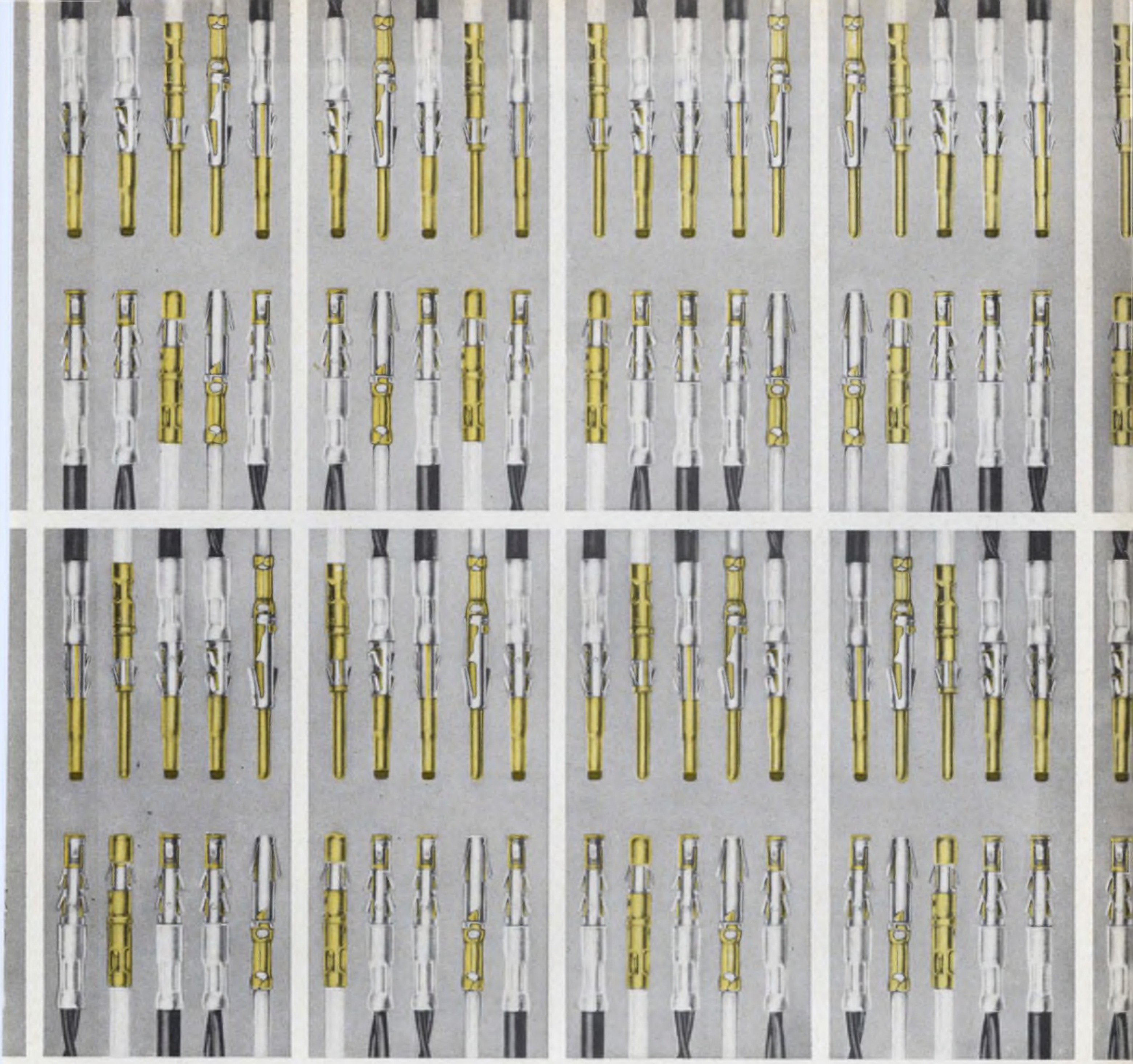
Booth No. 4E11 Circle No. 326

Rotary reeds in new configuration

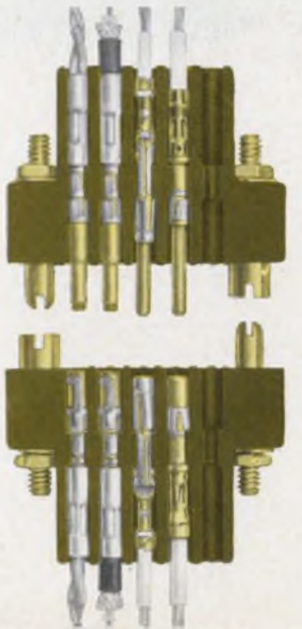
Arthur Ansley Mfg. Co., New Hope, Pa. Phone: (215) 297-5606.

A new rotary reed switch configuration consists of hermetically sealed reeds mounted around a drum-type support with the activating magnet rotating in the center. This results in a smaller diameter switch. In the version above, two sections are mounted on the same drum with a common shaft and ball bearings. One section consists of 16 evenly-spaced reeds with a break-before-make action. The other section has only two reeds, each of which is closed for just under 180°.

Booth No. 4C18 Circle No. 509



Mix these signal, power and coax leads in any combination.



Burndy Trim Trio Connectors—available in many shapes—accept three contact styles, all crimp-removable, for signal and power leads #16 thru #24, twisted pair #24 and #26, and subminiature coaxial cables.

Changing conductors is fast and simple, whether for lower voltage drop or better shielding or mechanical reasons. This makes Trim Trio Connectors ideal for breadboard and prototype work as well as production. For large production runs you can take advantage of the economies offered by the automatic Burndy Hyfematic™ with a crimp rate of up to 3000 contacts per hour.

Get more details on how you can take advantage of the Burndy Trim Trio System—THE ACCEPTED METHOD OF INTERMIXING CONTACTS.

BURNDY
Norwalk, Connecticut

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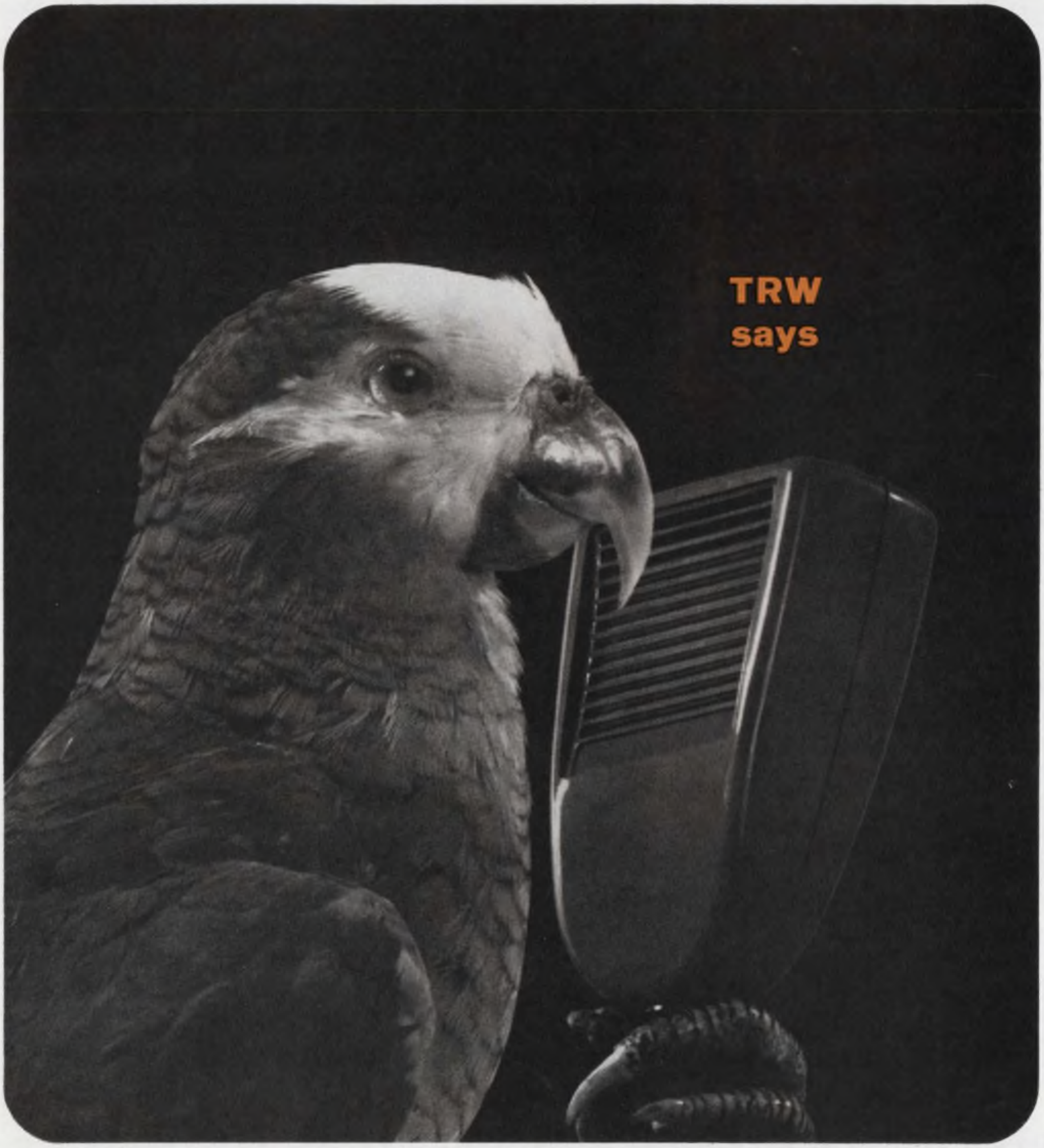


...if you need transistors for mobile radio you should be talking to us!

TRW will talk to you about RF output of 20 watts in the UHF Mobile Band...35 watts in the high band ...60 watts in the low band! And from what power source? From a *12 Volt* automobile battery!

TRW will show you reliability—mobile transistors that keep on going under the most extreme conditions of heat, cold, moisture, road shock. Improper tuning...even a broken antenna can't knock them out, and that spells reliability in any tough mobile service!

TRW is delivering now!

Contact TRW Semiconductors Inc., 14520 Aviation Blvd., Lawndale, Calif. 90260 Phone: (213) 679-4561 TWX: 910-325-6206. *TRW Semiconductors is a subsidiary of TRW INC.*

TRW

ON READER-SERVICE CARD CIRCLE 192

EDITORIAL

What happens to your job if peace breaks out?

We hear much talk these days about peace prospects in Vietnam, better relations with the Soviet Union, a possible détente in the development of costly antimissile defenses. Hopes for reduced military spending are riding high. At the same time there is excited discussion of the great part that the electronics industry can play in solving such peaceful problems as air and water pollution, urban development, transportation snarls on the ground and aloft, and unfilled demands for new and improved consumer and industrial products.

Where do you fit into this picture? If you're an average military-oriented engineer, one thing is clear: you are largely unemployable in the civilian sector of the economy. In any major swing toward the civilian market, your training as a "cost-plus-fixed-fee engineer" is largely useless. You are a highly skilled specialist; consumer and industrial-equipment concerns need engineers who can wear many hats—those fitted for design, development, production and even sales.

Since most engineers today are engaged in work for the military, it follows that a retraining program to equip them for civilian production would have to be big. Federal, state and local governments, industry officials, engineering societies and educators—all are involved. To date, none appears seriously concerned.

There is a story that former President Harry S. Truman once defined a recession as the loss of a job by your neighbor, and a depression as the loss of a job by yourself. If military spending ebbs drastically, will you face a depression?

If the answer is yes, try asking yourself these questions:

Shouldn't the engineering societies be devoting more time and effort to retraining programs?

Shouldn't government and industry officials begin meaningful discussions to pinpoint the urgent civilian problems that might be solved by "reborn" military engineers?

Shouldn't there be a formal program—sponsored by government or industry, or possibly both—to develop "specs" for detailed training and placement programs; for helping engineering schools to shape their curricula to match new demands?

Unless somebody starts moving soon, unless a workable plan is implemented, many perfectly capable engineers seem destined to join the army of the unemployed if peace should break out suddenly.

PETER N. BUDZILOVICH

Galvanometer with brains

ESI has combined the best features of the classic galvanometer and the modern electronic voltmeter in the new Model 900 Nanovolt Galvanometer.

How do you create a galvanometer with true nanovolt sensitivity that is really *practical* to use . . . an instrument that doesn't require hours of delicate dial twiddling, trap-door adjustments or experimental hook-ups?

You give it brains. Brains in the form of feedback circuits that automatically control speed of response and damping for each of its 12 calibrated ranges. *It operates from any source resistance without changes in speed of response or damping characteristics.* Noise is less than 2 nanovolts regardless of the source impedance. With all this working for you, it's easy to make effective use of the extreme sensitivity of our Model 900 Nanovolt Galvanometer.

The instrument consists of *two* units—the control unit shown above, which is the brains of the outfit, and a galvanometer unit. The Model 900 is ideal for use with high-accuracy and high-resolution potentiometers and bridges; for the calibration of thermo-couples, strain gauges, thermopiles, standard cells and the like. It also has myriad applications in the measurement of tiny voltages or currents in experimental chemistry, physics, biology or medicine. A fixed input resistance of 1 kilohm allows calibrated ranges for *both* voltages and current.

Through solid state circuitry, we've been able to combine the best of two worlds in the Model 900. It has the high sensitivity and ac rejection of mechanical galvanometers. But it also has the multiple calibrated ranges, meter readout, and operation simplicity of modern electronic voltmeters. It's an honest nanovoltmeter whose high sensitivity and complete guarding also simplify measurements in the microvolt area.

You'll have more time to use your own brains if your galvanometer has some of its own. ESI, 13900 NW Science Park Drive, Portland, Oregon 97229.

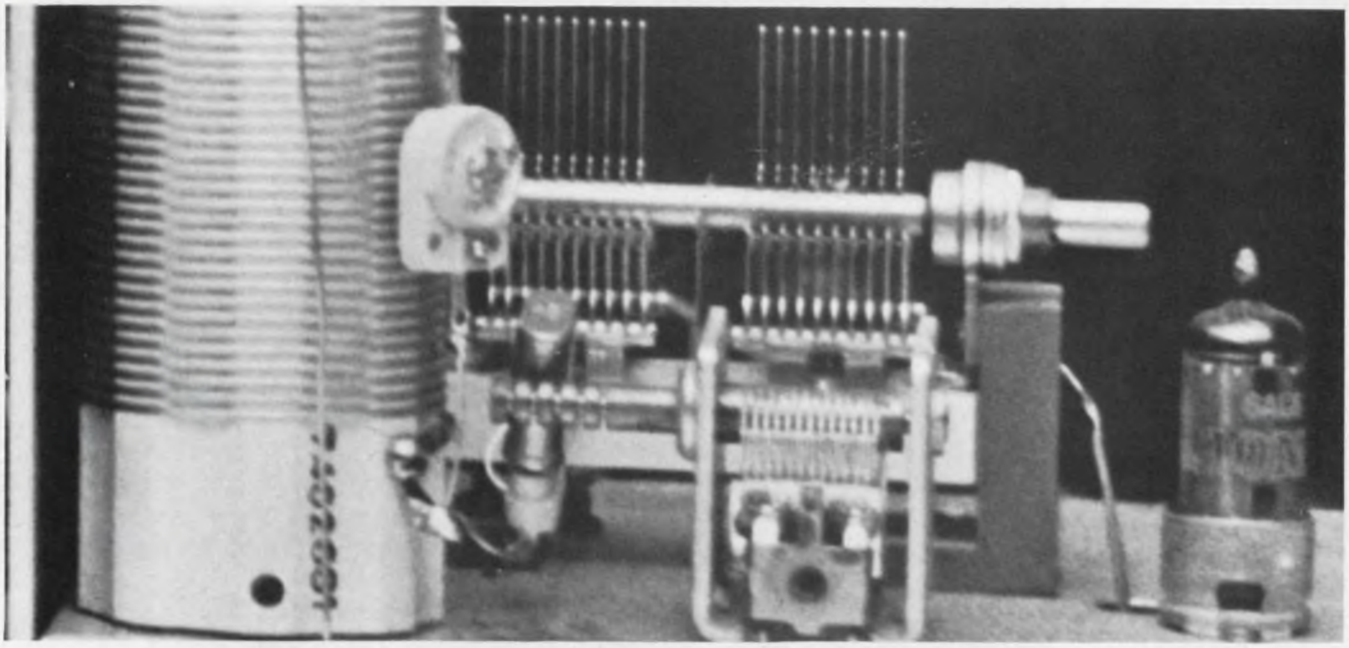
Model 900 Nanovolt Galvanometer
Ranges: 10nV (10pA) end scale to 3mV (3μA) end scale on zero-centered meter; 12 overlapping ranges in 1, 3, 10 sequence.
Accuracy: 2% of end scale for voltage and current.
Input Resistance: 1kΩ on all ranges.
Minimum Detectable Signal: Less than 2nV or 2pA.
Superimposed AC Rejection: Greater than 120 db (Infinite common mode rejection).
Noise: Less than 2nV or (2pA) peak-to-peak for all source resistances.
Damping: Slightly less than critically damped for all source resistances (adjustable).
Zero shift with source resistance change: None.
Price: $1975.

IEEE Booth Numbers 2A02-4-6

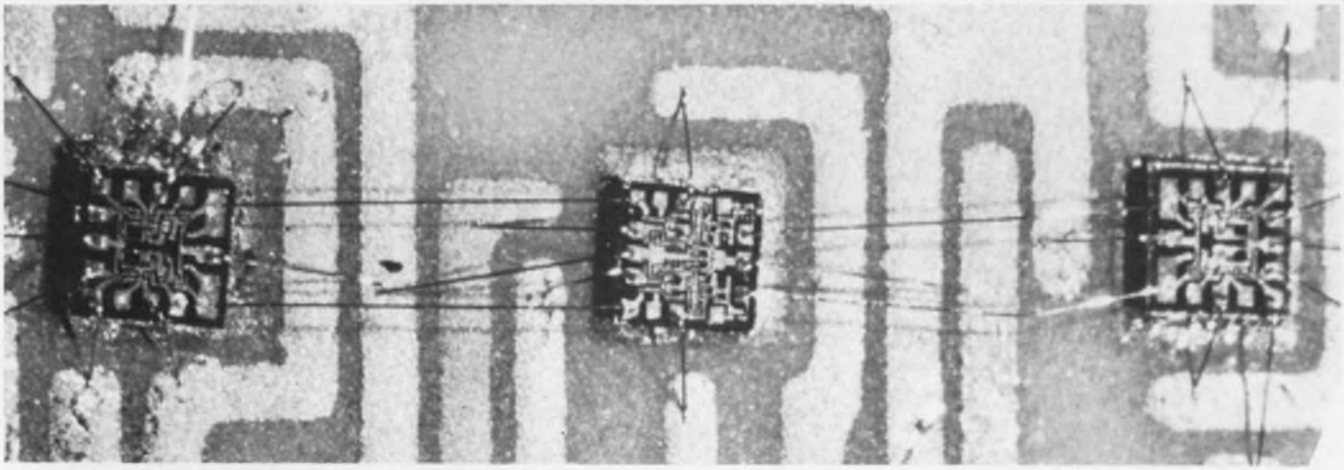
Electro Scientific Industries, Inc. esi®

ON READER-SERVICE CARD CIRCLE 193

Technology



Inductor increases the bandwidth of crystals to 2 per cent—20 times that of conventional oscillator designs. The wider band and simple design offset slight stability loss. Page 244



Hybrid circuits combining ICs and transistors can improve on circuits that use either type of device alone. The key to success is selecting the right passive units for the job. Page 250

Also in this section:

SCEPTRE gives designers new power

to design and analyze electronic circuits accurately and rapidly. Versatile modeling capability is a major feature.

SCEPTRE (Systems for Circuit Evaluation and Prediction of Transient Radiation Effects) is a newly designed circuit analysis program that is:

- Readily available to users (see the accompanying box).
- Relatively easy to adapt to a number of computers because it is written in FORTRAN IV language.

It is a system of IBM 7090/94 programs which supersedes PREDICT.* In addition to everything that PREDICT can do, SCEPTRE incorporates these extra features:

- Higher computational efficiency.
- Optional stored models.
- Rerun capability.
- Automatic termination conditions.
- Dc capability.
- Flexibility.

Engineer need not be a programer

Both SCEPTRE and PREDICT are automatic circuit analysis programs. An automatic circuit analysis program can be described as one that does not require the user to write any circuit equations or to do any real programing. The circuit, including its topology and element values, is supplied to the program in a circuit description language which is easy to use and learn. All automatic programs can be categorized as either ac, dc or transient,[1] or any combination of these three. The basic operation of a transient analysis program such as SCEPTRE is reviewed with the aid of Fig. 1.

At the beginning of the nth solution interval, the vector of state variables $\dot{\mathbf{Y}}(\mathbf{n})$ is a known quantity. A pass through the equation solution process produces all of the desired output quantities that are valid at that point in time, as well as the derivatives of the state variables $\dot{\mathbf{Y}}(\mathbf{n})$. These derivatives together with the state variable values $\mathbf{Y}(\mathbf{n})$ are integrated into the state variables that are valid at the $(n+1)$th solution interval. From this point on, the process repeats itself until the end of the transient problem is reached. The importance of the highly simplified block diagram of Fig. 1 is that it helps to illustrate the primary factors involved in the amount of computer time required for the solution of any given problem. The numerical integration routine controls the size of the solution increments that can be taken and, therefore, the number of solution increments that are required. The efficiency with which the equation solution operations are carried out controls primarily the amount of computer time required per solution increment. It is thus important to make some effort to optimize the set of circuit equations that are used to compute the transient response of the circuit under investigation.

*The PREDICT program has been operational for about two years and is scheduled for replacement by SCEPTRE on or about February 1, 1967. Both programs have been sponsored by the United States Air Force Weapons Laboratory at Kirtland Air Force Base, N. M., and their dissemination is controlled by this agency. They were developed and are maintained by the IBM Electronics Systems Center at Owego, N. Y.

Stephen R. Sedore, Staff Engineer, and **John R. Sents,** Staff Programer IBM, Federal Systems Div., Owego, N. Y.

New solution approach improves efficiency

Computational efficiency is improved by a new approach to the solution of circuit equations. While the mathematical formulation remains essentially the same as PREDICT's, the manipulation of topological and coefficient matrices in order to solve the equations has been greatly reduced. Instead, a set of actual circuit equations is created from a simple topological description of the circuit presented to the computer. These equations are similar to those that could be written by an experienced circuit analyst or engineer. To do so manually, however, would be an extremly tedious task and open to error.

Before the program generates the circuit equations, it conducts a very elaborate investigation of the circuit topology to determine how the equations should be written. This analysis establishes a set of equations which, when solved repeatedly, as indicated in Fig. 1, produces a significant reduction in computer time. A detailed description of the actual formulation of these circuit equations can be found elsewhere.[2]

As SCEPTRE proceeds with the creation of the circuit equations, a FORTRAN subprogram is generated which contains these equations. This subprogram also contains the instructions required to control the computer's handling of circuit element and parameter values, equation solution and numerical integration as well as the output of computed results. After the subprogram has been completely generated, it is automatically compiled and executed. It is during execution of the subprogram that the circuit response is computed.

Optional models can be stored

Storing a frequently used device model can save the designer considerable time. SCEPTRE allows the user to store and recall easily any equivalent circuit that he has a frequent need for. Most contemporary circuits include various types of diodes and transistors that require equivalent circuits of varying degrees of complexity. For example, a large-signal equivalent circuit for a transistor usually requires four to six passive elements and at least three or four current generators. If the computer program lacks a stored-model feature, the user has no alternative but to insert each component individually into the overall circuit. A partial remedy for this problem would be to provide an exclusive stored model of conventional form for diodes and transistors. The word exclusive is used in the sense that the user must use whatever topology is provided in the stored model; little, if any, provision is made for flexibility.

A better solution, and the one used in SCEPTRE, is the optional stored-model feature. The user may himself store any equivalent circuit that is composed of resistors, capacitors, inductors (including mutual inductance), and voltage and current sources. This makes it possible to store frequently used subnetworks, such as biasing networks and filter sections, as well as equivalent circuits of active devices. Once stored, any of the models can be called out for use as many times as needed in a given circuit application.

Effect of value changes is easier to calculate

It is often desirable to know how a given network would function if one or more of its components or forcing functions were varied in size. Of course, it is always possible to submit entirely new runs which contain the variations of interest, but there is a better way.

A master run is first described; this includes the nominal values of all components and forcing functions. The user appends to this description a list containing the number of reruns desired and the elements that are to be changed for each rerun. The FORTRAN program containing the circuit equations is then executed once for the original run and again for each rerun. Since it is only necessary to create the FORTRAN program once, less computer time is required than for

SCEPTRE print-out of design problem results is analyzed by authors Sents (l) and Sedore (r).

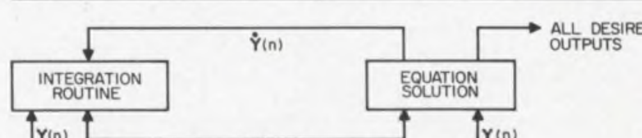
SCEPTRE'S availability

SCEPTRE for the IBM 7094 computer is available to users who get clearance from:

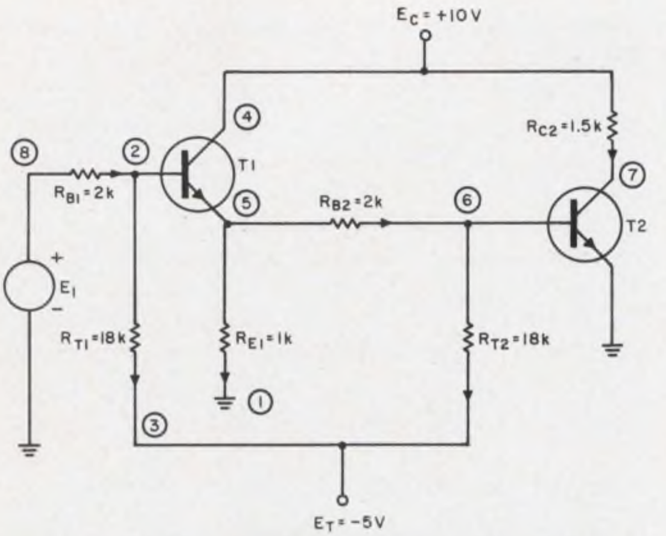
Lt. Gary Pritchard, WLRET,
U.S. Air Force Weapons Lab.,
Kirtland Air Force Base,
Albuquerque, N. M. 87118.

After receiving the necessary clearance, the user can arrange to obtain manuals and have his own tape magnetized at no charge by contacting:

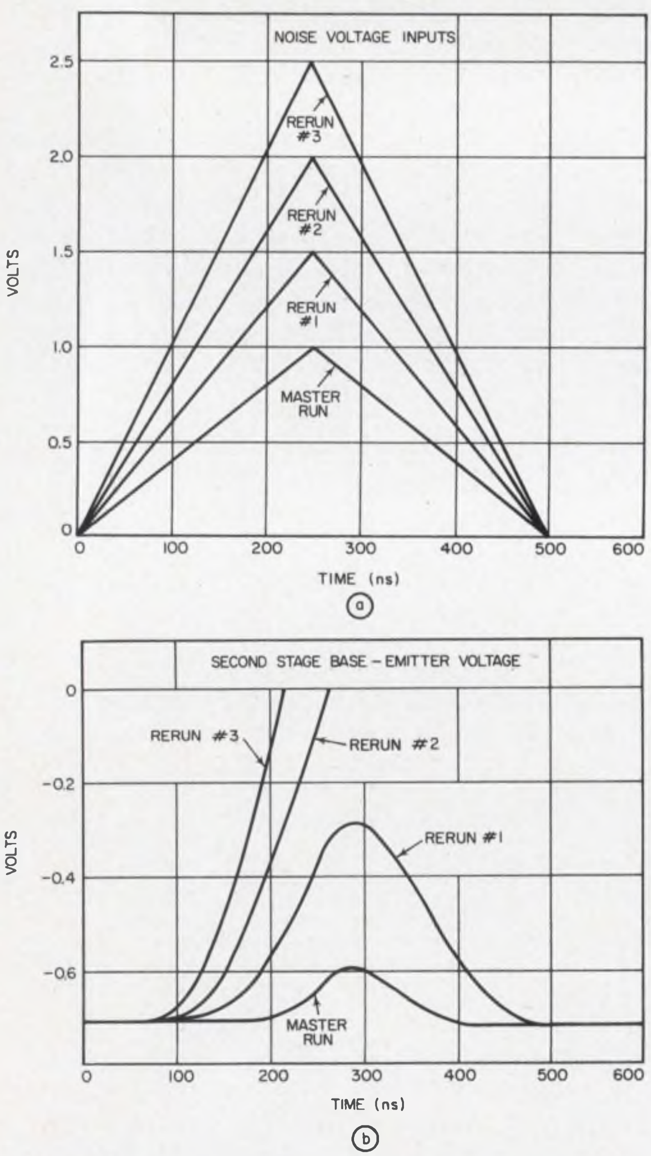
Harry Mathers,
IBM,
Radiation Effects Department,
Owego, N. Y. 13126.



1. **SCEPTRE operates by repetitive solution** of circuit equations until the desired transient solution is obtained. The numerical integration routine determines the size of the solution increments that can be taken and, therefore, the number of solution increments required.



2. **Performance of SCEPTRE can be demonstrated** by using this circuit. The program is used to determine the effects of a noise spike at the two-stage circuit's input.



3. **The spread of input pulses is applied to the circuit** in four runs (one master and three succeeding runs) (a). Corresponding output plots of the base-emitter voltage for the second stage are shown in (b).

separately repeated runs.

The fact that SCEPTRE provides a rerun facility does not imply that anything like true statistical analysis is economically feasible. Solution times per run are still measured in minutes, so a large number of reruns can become an expensive proposition.

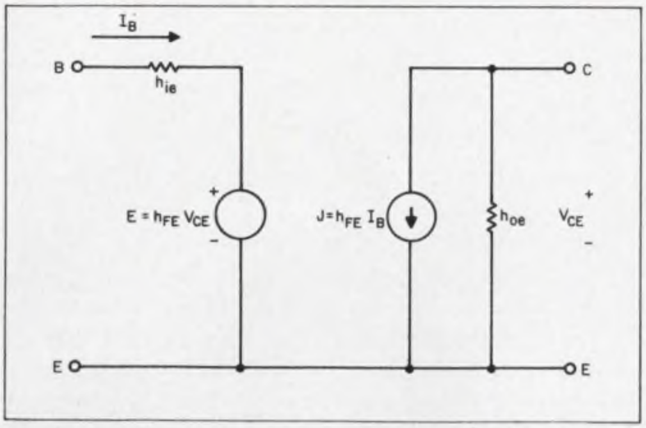
Transient runs automatically stop at preset limits

In some instances the user will have no interest in carrying a transient run to completion, if it is known that some voltage or current has exceeded, equaled, or dropped below some other quantity or criterion. A single entry into the program can set up the logic necessary to monitor and automatically terminate a run.

The practical application of both the rerun and the automatic-termination features may be illustrated with the circuit shown in Fig. 2. The node numbers and reference current directions have been arbitrarily chosen. The aim is to determine the effects of a noise spike at the input of a two-stage logic circuit. Both stages are normally held in the off condition, so that no current flows in the load resistor, R_{L2}, of the inverter stage. It is assumed that the error criterion of this circuit is the turn-on of stage T2. This would be indicated by a positive voltage across the base-emitter capacitance of that stage. Once this occurs, the analyst has no further interest in the rest of the transient response. The spread of input pulses shown in Fig. 3a is to be applied to the circuit in four runs (one master and three runs). The corresponding output plots for the base-emitter voltage of the second stage are given in Fig. 3b.

It can be seen that the results of the master run (with the 1-volt input) show little effect on the input to the second stage. The first rerun (with the 1.5-volt input) does indicate that a substantially larger signal reaches the second stage. Both these runs are carried through to the originally specified problem duration of 1000 nanoseconds. The second rerun (with the 2-volt input) shows that the effect of the input signal was sufficient to forward-bias the base of the second stage and therefore trigger the automatic-termination feature. This run was automatically stopped at a problem time of approximately 260 nanoseconds. The third rerun followed the same pattern, with the exception that the larger input signal turned the second stage on sooner, with the result that this run terminated at approximately 210 nanoseconds.

All four runs can be obtained with one submission of a single deck of cards. If the equivalent circuit for the transistors has been stored at some previous time as Model X1 (designation for a particular model), the only cards required for the solution of the master runs and the three runs



4. **Though not as versatile as the Ebers-Moll equivalent,** the low-frequency n-parameter model is often very useful because of its simplicity. Generally this type of model is not available in automatic transient programs because of the dependent sources. SCEPTRE, however, has provisions for accommodating this type of model.

(including initial conditions) are those containing the following FORTRAN statements (symbols used refer to quantities shown in Fig. 1):

```
CIRCUIT DESCRIPTION
ELEMENTS
EC, 1-4=0
ET, 3-1=5
E1, 1-8=TABLE 1 (TIME)
RB1, 8-2=2
RT1, 2-3=18
RE1, 5-1=1
RB2, 5-6=2
RT2, 6-3=18
RL2, 4-7=1.5
T1, 2-5-4 MODEL X1
T2, 6-1-7 MODEL X1
OUTPUTS
VCET1, VCET2, IRL2, IRE1, PLOT
FUNCTIONS
TABLE 1
0, 0, 250, 1, 500, 0, 600, 0
RUN CONTROLS
RUN INITIAL CONDITIONS
TERMINATE IF (VCET2, GT, 0)
STOP TIME 1000
RERUN DESCRIPTION (3)
FUNCTIONS
TABLE 1
0, 0, 0, 0,
250, 1.5, 2, 2.5
500, 0, 0, 0,
600, 0, 0, 0,
END
```

Iterative technique gives dc results

There are a great many situations in which the analyst is concerned with the steady-state dc status of a given network without regard to any transient. In many practical cases, these situations are merely the initial conditions that prevail in a circuit at the instant that transient forcing functions are applied. The correct initial conditions must be determined as a prerequisite to obtaining a correct transient solution. In other cases, the dc result itself is the objective and a transient solution is not even desired. Dc solutions can usually be obtained much more efficiently and economically than can transient solutions since a complete time history is not required. An iterative technique, which is entirely independent of the transient-problem formulation, yields the dc results.

PREDICT was not equipped with any special means for dc problem solution; SCEPTRE is. The capability can be used in conjunction with the transient program, or can operate quite independently with a great degree of flexibility.

SCEPTRE affords increased flexibility

Some idea of the trend toward flexibility has already been mentioned in connection with optional stored models, but there is considerably more to the subject. As an example, consider the use of a class of small-signal equivalent circuits in Fig. 4. This low-frequency h-parameter equivalent is not nearly as versatile as the large-signal Ebers-Moll equivalent, but applications do arise when its simplicity of form (as well as the comparative availability of parameters) makes its use desirable. Generally, models of this type are not available for use with automatic transient programs because of the source dependencies involved. It can be seen in the figure that the model contains a voltage source that is dependent on a resistor voltage, and a current source that is dependent on a resistor current. Neither of these independent variables is specifically provided in the general formulation[3] of the transient problem, since they are not state variables. Special provision is made in SCEPTRE's formulation to accommodate these types of sources and, therefore, this entire class of equivalent circuits.

Another example of the trend toward flexibility is the fact that the user may determine the power dissipation in any resistor, say R1, by simply defining a pseudo circuit parameter. This parameter would be defined in the circuit description language as PR1 = (R1 * IR1** 2). In FORTRAN IV, * means multiply and ** means square, i.e., $P=IR^2$. The user who is more computer-oriented may write subprograms in FORTRAN IV himself, which will work in conjunction with the main program to perform a great variety of tasks. In this respect, the only limitation is the user's own knowledge and imagination.

The program may also be used to solve systems of first-order differential equations that may or may not have any connection with the electrical network. Consider this system:

$$x = -6x + 5y + 10$$
$$y = 5x + 7y + 2z$$
$$z = 0.2y - 0.2z - 0.5$$

where $x(t_0)$, $y(t_0)$, $z(t_0)$, the initial conditions, are all known.

The complete transient response to this system can easily be obtained with just a few input data cards.[1] Finally, as output, SCEPTRE will produce a listing of the results of the steady-state initial-conditions computation, if this type of analysis has been requested. For transient runs, a listing of the time histories of the computed results is produced along with machine-plotted graphs of these computed quantities, plotted against time or any other computed quantity. None of these examples of program flexibility is possible in PREDICT.

SCEPTRE uses FORTRAN IV language

SCEPTRE is written entirely in FORTRAN IV programing language and it is run using a 7090/94 computer. An IBM System/360 conversion effort is also anticipated but no definite plans exist at this time.

Program modularity, program debugging aids, and the use of the less exotic or standard, FORTRAN statements were the major considerations in writing the program. The purpose of this approach was to enhance the convertibility of the program for use on computing systems other than the IBM 7090/94. Such an effort requires only a conversion from 7090/94 FORTRAN IV to the FORTRAN of computer X, rather than symbolic machine language for the 7090/94 to computer-X machine language. A secondary benefit is derived from a system programed in FORTRAN if a user wishes to make modifications to the program to suit his specific needs, for changes in a FORTRAN program can normally be made more easily than in machine language versions. ■ ■

Acknowledgement:

The authors wish to acknowledge the vital contributions that were made by Dr. Ralph M. Warten, IBM, Palo Alto, California.

The work described in this paper was sponsored by the U.S. Air Force Weapons Laboratory, a part of the Air Force Systems Command's Research and Technology Division, under contract AF 29 (601)-6852 with the Air Force Special Weapons Center, Kirtland AFB, N. M.

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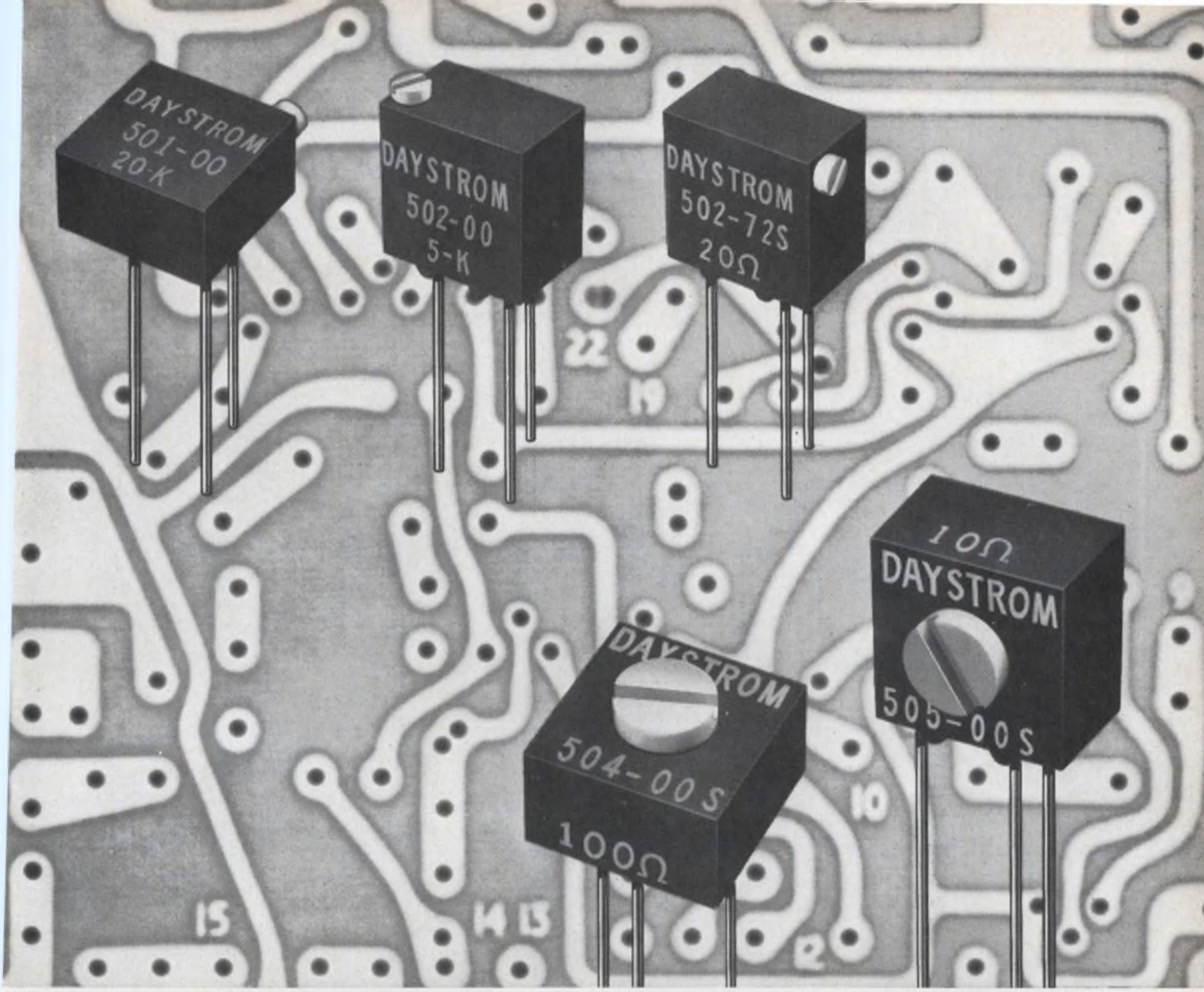
1. Stephen R. Sedore, "Computers Aid Circuit Design," Electronic Design, XIV, No. 1 (Jan. 4, 1966), 96-99.
2. "Automated Digital Computer Program for Determining Responses of Electronic Systems to Transient Nuclear Radiation," Vol. II, IBM File No. 66-928-6II, Owego, N. Y., Sept., 1966.
3. T. R. Bashkow, "The A Matrix, New Network Description," *Trans. RE (Prof. Group on Circuit Theory)*, Vol. CT04, Sept., 1957, 117-119.
4. "Automated Digital Computer Programs for Determining Responses of Electronic Systems to Transient Nuclear Radiation," Vol. 1, IBM File No. 66-928-6II, Owego, N. Y., Sept., 1966.



Savings across the board just took a new turn

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

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

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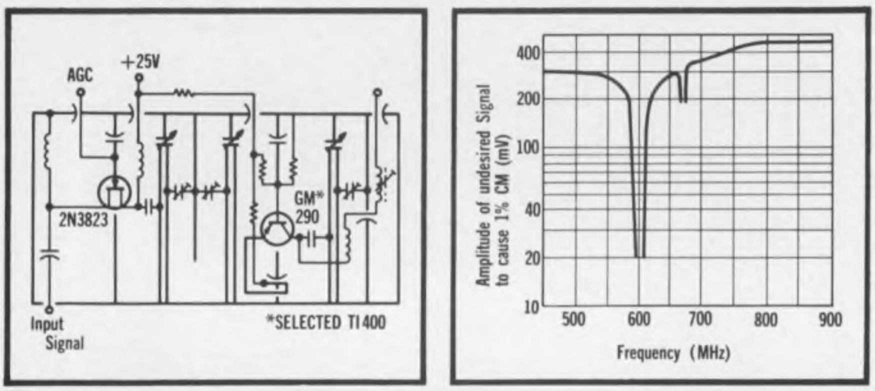
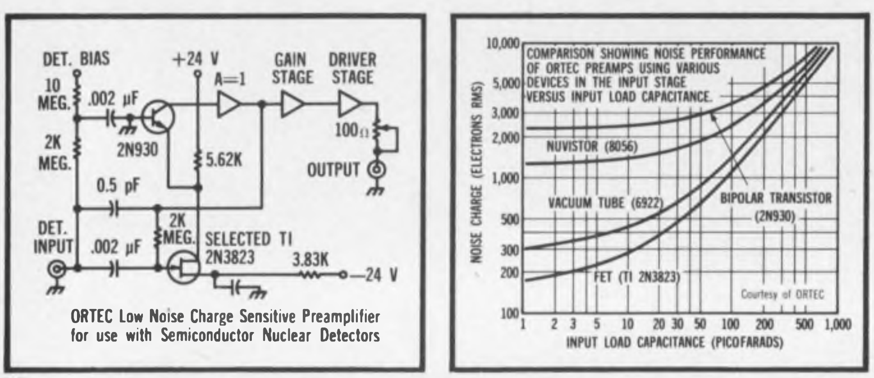
ON READER-SERVICE CARD CIRCLE 195

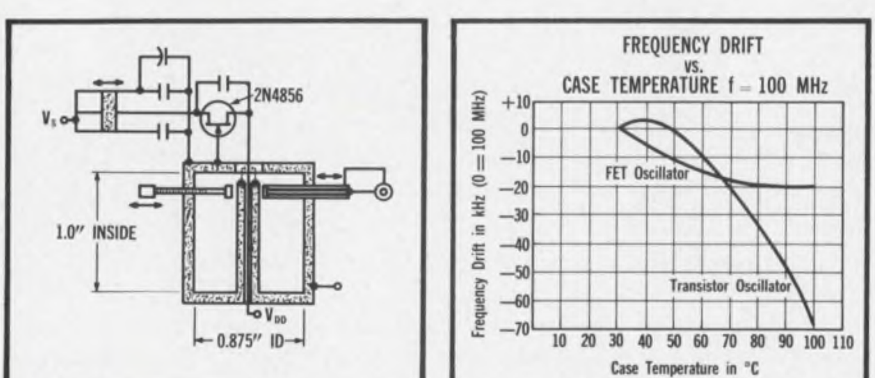
Five unique applications of FETs from



1. UHF tuner employs a TI 2N3823 N-channel silicon FET for improved cross modulation performance



2. ORTEC charge-sensitive preamplifier uses FET for accurate measurement of low-energy radiation



3. 500 MHz FET oscillator. Graph shows frequency stability over a temperature spread of 75°F

TI cannot assume any responsibility for any circuits shown or represent that they are free from patent infringement

1. UHF tuner employs FET for low cross modulation

Here — for the first time — is a practical UHF tuner which offers considerable cross-modulation improvement in the RF stage. This circuit is made possible by the superior high-frequency performance of TI's 2N3823 N-channel silicon FET. In addition to its low cross-modulation characteristics, the circuit has a power gain of 12 to 15 dB from 400 to 900 MHz and a VSWR of less than 2 from 500 to 900 MHz with an input impedance of 50 Ω.

The accompanying graph shows the excellent cross-modulation performance of the tuner.

Circle 91 on the Reader Service card for application note on this tuner.

2. Charge-sensitive preamplifier uses TI FET for lowest noise, highest resolution

This preamplifier, developed by Oak Ridge Technical Enterprises Corporation for nuclear detectors, limits noise to only 170 electrons rms when used with low-capacitance detectors. The extremely low noise level of field-effect transistors from TI permits detection and accurate measurement of low energy X-rays and gamma rays (less than 20 keV).

ORTEC determined that specially-selected 2N3823s resulted in superior amplifier performance. The graph at the left illustrates improvement in noise level compared with vacuum tubes, nuvistors and bipolar transistors.

Circle 92 on the Reader Service card for data sheet on the 2N3823.

3. 500 MHz FET oscillator achieves frequency stability without temperature compensation

This oscillator demonstrates the excellent high-frequency characteristics of the 2N4856 N-channel silicon FET from Texas Instruments. Power output, at 500 MHz with a V_{DD} of 20 V, is greater than 140 mW.

Frequency stability is a major advantage of FET oscillators. The graph at left compares frequency drift with temperature change for a 100 MHz FET oscillator versus a bipolar transistor. FET oscillators result in simpler biasing and possible elimination of AFC circuitry.

Circle 93 on Reader Service card for Silicon Technology Seminary paper on FET oscillators.

demonstrate versatility
Texas Instruments

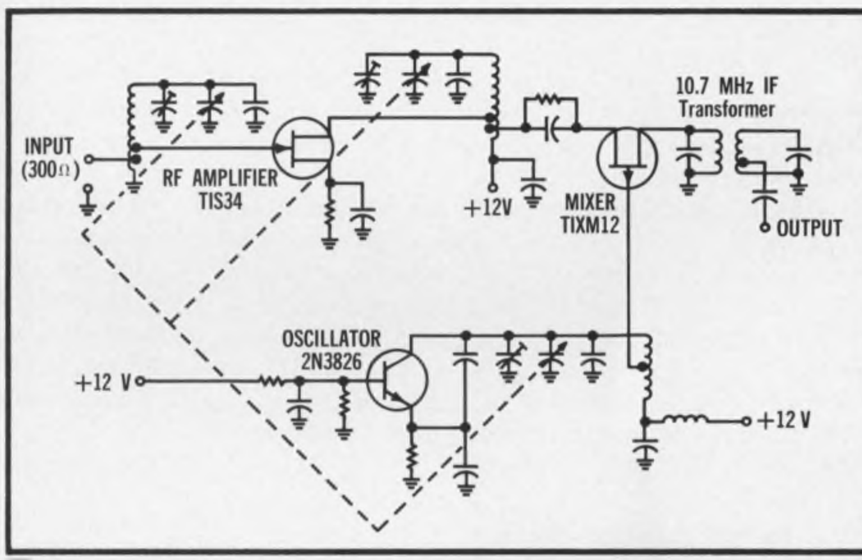
4. FM tuner employing FETs has <2.0 μV sensitivity, spurious response rejection > 79 dB

This FM tuner uses both N-channel silicon and P-channel germanium FETs for high performance with simple circuitry and low component costs.

The RF stage employs a TIS34 N-channel silicon FET for better than 2.0 μV sensitivity with 30 dB quieting.

For maximum conversion gain, the RF stage is coupled to a TIXM12 P-channel germanium FET. The TIXM12, being an almost perfect "square law" device, gives better than 79 dB spurious response rejection. Image rejection of the tuner is 70 dB, 6-dB bandwidth is 525 KHz, and power gain neglecting loss of IF transformer secondary is 25 dB.

Circle 94 on Reader Service card for application information on this circuit.



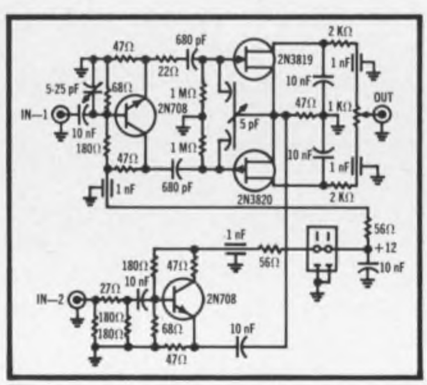
4. FM tuner employing complementary FET's features simple circuitry and low component cost

5. Wideband correlator uses complementary FETs for signal multiplication

This correlator, developed by the National Laboratory for Radio Astronomy, Bologna, Italy, employs SILECT™ FETs from TI to provide exceptional rejection of unwanted responses. A 35 dB rejection of uncorrelated components is achieved for random signals on a 10 percent band centered at 300 MHz. Previously tested correlators had rejections ranging from 15 to 30 dB.

Complementary 2N3819 and 2N3820 silicon FETs are used as direct multipliers operating in the near-zero region of the I_{DSS} vs. V_{DS} curve. Spurious responses are balanced out by the complementary characteristics of the FETs.

Circle 95 on the Reader Service card for data sheets on 2N3819 and 2N3820 plastic-encapsulated, economy FETs.



5. Wideband correlator uses complementary FETs for 35 dB rejection of unwanted responses

6. FET Fact File—industry's most comprehensive FET reference guide—contains 270 pages

6. FET Fact File by TI — the most complete collection of FET information available

Here, in one handy 8½ x 11" file folder, is 270 pages of the most up-to-date FET information. Included are data sheets, performance and reliability data, and application notes containing circuit diagrams, circuit theory, and design suggestions.

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Get pnp Class-B stage efficiency

in an all-npn transformerless integrated circuit that has a flat frequency response from dc to 30 MHz.

A long-standing problem in the design of efficient integrated-circuit (IC) output stages has been the inability to build IC facsimiles of the classic Class-B configuration. The problem stems from the fact that the quality of the required complementary pnp devices does not so far match that of the npn ones.

A novel circuit arrangement (patent applied for in the U.K.) using npn devices throughout can be constructed to yield a Class-B amplifier output stage with high efficiency, flat response from dc to well in excess of 30 MHz, and propagation delays of less than 5 ns.

Applications for the circuit include:

- Fast, nonsaturating digital push-pull stages.
- Audio and servo amplifiers.

Why use the proposed circuit?

A general Class-B output stage that uses complementary (npn and pnp) transistors is shown in Fig. 1. It has served as an audio amplifier output stage, a servomotor bidirectional drive, an analog operational amplifier output stage—in fact, anywhere where current has to be both driven into and taken out of a load.

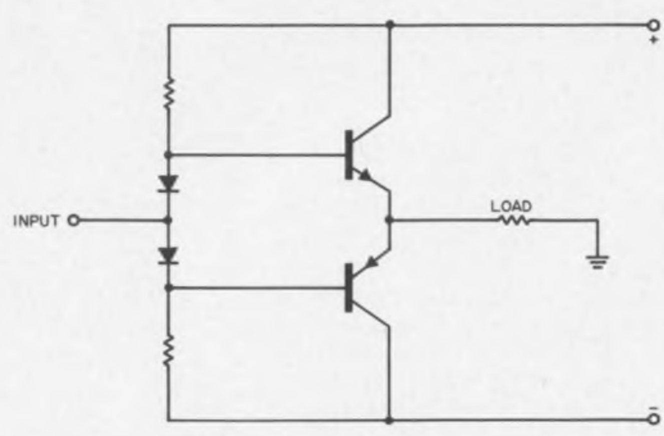
The fundamental difficulty in producing an integrated circuit of the same configuration lies in the need for complementary transistors. The present IC processes result in pnp transistors that are of poor quality compared with npn ones. Specifically, their current gain and frequency response are inferior to those of discrete pnp transistors. The low current gain of these pnp transistors can be overcome by using npn-pnp pairs to simulate discrete pnp transistors. However, the poor frequency response which they exhibit remains a fundamental limitation to their performance at high frequencies.

The pure npn approach solves the problem

The ideal solution to this problem is a circuit analogous to the simple npn-pnp complementary emitter-follower but constructed only of npn transistors. This implies the use of two voltage-amplifying stages, one driving positive current into the load and the other drawing negative current from it. These two stages are easily designed, the first being an npn emitter-follower and the other an npn grounded-emitter stage with voltage feedback. However, when these stages are connected together to provide the required push-pull function, there arises the basic difficulty of preventing a large idling current from flowing between them. It is the prevention of this large idling current by a very simple arrangement that is the feature of the present circuit.

The principle is simple

Figure 2 shows four transistors with shorted collector-to-base leads. This means, in effect, that they are connected as a diode quad. The current flowing in either arm of this quad will be dependent upon the voltage/current characteristics of the four base-emitter junctions. Herein lies the fundamental principle because, if the four transistors are constructed on a single integrated-circuit chip, they will all have base-emitter junctions with closely matched current/voltage relationships. Thus current (i_{D_1}) flowing through one pair of diodes (*D1* and *D2*) will cause a voltage drop across *D1* and *D2*. This will define the current that



1. **Classic Class-B stage configuration** employing complementary pair of transistors is difficult to make with present IC techniques.

M. J. Teague, The Plessey Co., Ltd., Towcester, Northamptonshire, Enlgand.

must flow through the other paid of diodes ($D3$ and $D4$) as equal to i_{D1}. Consequently, if a current i_L, which is greater than i_D, is made to flow in one diode ($D3$) of a pair, then the current i_{D4} flowing through the other diode ($D4$) of that pair must reduce to a value that is less than i_{D1}, in order to maintain the correct voltage drop defined by i_{D1}.

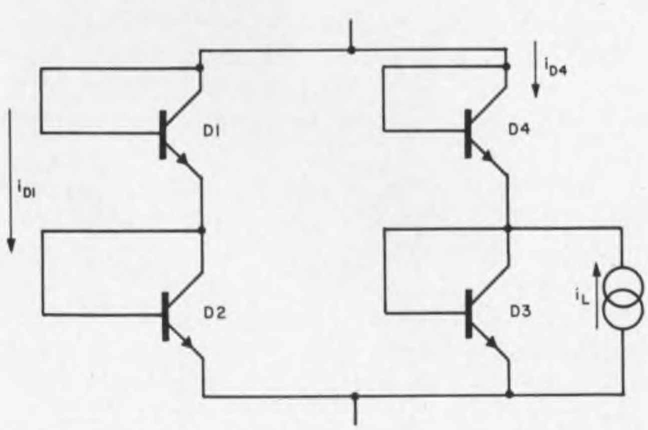
Let's design a circuit

A practical Class-B circuit-coupled output stage employing the foregoing principle is shown in Fig. 3. The basic quad consists of $D1$, $D2$, $D3$, and the base-emitter junction of emitter-follower $Q1$. The resistor R_b is chosen to provide sufficient base current for $Q1$ when the output voltage is positive, and consequently any current flowing through it will be small compared with the maximum load current. $Q2$ is a grounded-emitter stage with voltage feedback through R_f; it is driven by the collector current of $Q3$. $D4$ and $Q3$ are identical-geometry devices. Since they are on the same chip, the collector current of $Q3$ is defined by input current i_s because of the close base-emitter voltage match of the two devices. Thus the output voltage is determined by signal current i_s flowing through the resistor R_f. Neglecting for the moment the action of the diode quad, it can be seen that this is the basic arrangement for a push-pull stage—that of two voltage amplifiers, one to drive current into the load ($Q1$) and the other to draw current from it ($Q2$). It can also be seen that these two stages could have a large idling current flowing between them were it not for the diode quad. The operation of the quad to limit this idling current is as follows.

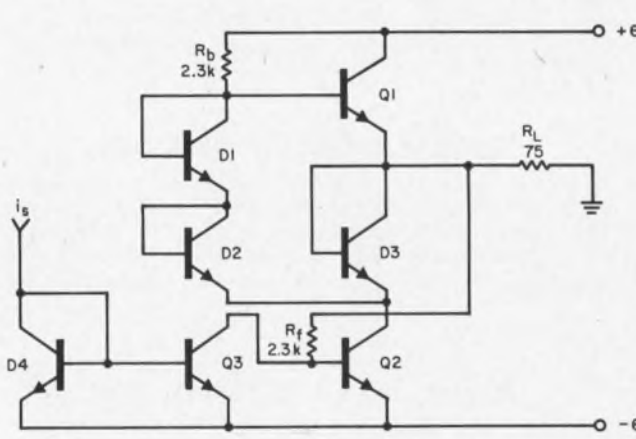
The idling current is minimized

If the output voltage is positive, then load current will flow through $Q1$ causing its base-emitter voltage to increase. The current taken by $Q2$ through diode $D3$ is consequently reduced to a value below that of i_{D1}. Similarly, if the output voltage is negative, then the voltage developed across $D3$ due to load current will reduce the bias voltage available for $Q1$ and lower its current to a value below i_{D1}. When the output voltage is zero, there is no load current and the idling current flowing through $Q1$, $D3$ and $Q2$ will be defined by the current flowing through R_b, $D1$ and $D2$.

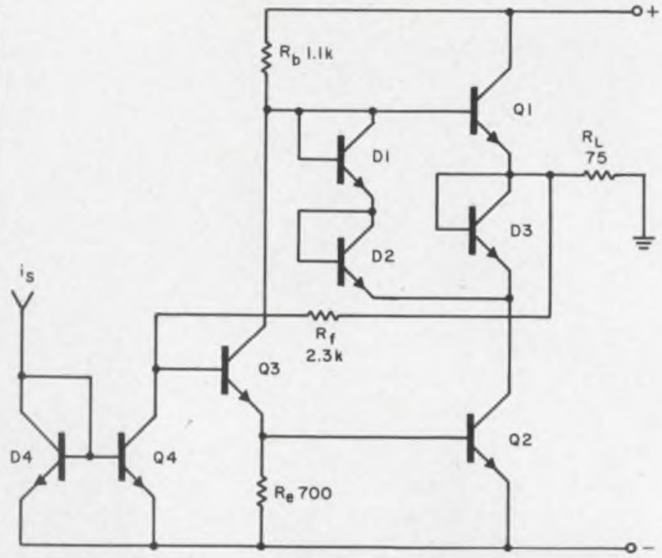
The diode quad has quite simply performed the feat of limiting the idling current of this output stage to a value that is small in comparison with the peak load current. Because of this, almost true Class-B efficiency can be obtained with a complete absence of crossover distortion. It should be noted that, in addition to limiting the idling current to an efficient value, the diode quad allows the output potential to be defined entirely by voltage



2. **A diode quad of npn transistors on a single chip** features very close current/voltage match between the transistors' base-emitter junctions.



3. **The complete all-npn Class-B stage** built around the quad (D1, D2, D3, Q1) has very low idling current.



4. **Even more efficient circuit than that of Fig. 3** can be made with only slight modifications. Its frequency response is flat from dc to well beyond 30 MHz; its propagation delay is less than 5 ns.

feedback stage *Q2* and R_f, forming the rather unusual arrangement of an emitter-follower without any direct drive to its base.

The values given in Fig. 3 are those for a video output stage which was designed to drive a ±3-volt signal into a 75-ohm load from a 6-volt supply. The design minimum h_{fe} of the transistors was 40.

An even more efficient arrangement is shown in Fig. 4 where the current flowing through R_b is used to provide base drive current for *Q2* when the output voltage is negative. *Q3* has an emitter resistor to keep its current at a level consistent with having a good f_T. The use of *Q3* also provides an input buffer that allows all the signal current to flow in the feedback resistor, instead of being shunted into the base of *Q2* when the output is negative, as in Fig. 3. This improves the linearity of output voltage to input current without impairing efficiency. The method of driving this stage presents no difficulty: current generator i_s is simply a resistor that is large compared with the dynamic impedance of diode *D4*. If this resistor is made equal to R_f, then the stage would have approximately unity voltage gain. Higher gain can be achieved by making *Q4* a larger-geometry device than *D4*.

The circuit shown in Fig. 4 has been made by the Plessey Company's silicon integrated-circuit process. It gives excellent results, with an efficiency previously associated only with pnp transistor stages, and a frequency response that is flat from dc to well beyond 30 MHz. This circuit is being considered for use as a fast, nonsaturating, digital push-pull drive stage. In this application measurements show that propagation delays less than 5 ns can easily be attained. ■ ■

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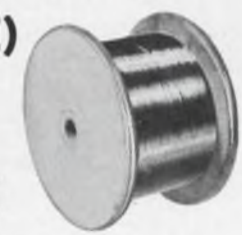

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Inductor ups crystals' bandwidth to 2%

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Inductive loading of crystal oscillators can increase their bandwidths to 2%—twenty times better than the range of conventional designs.

Bandwidths in excess of the usual 0.1% of capacitive-loaded oscillators are required in many applications, in particular in master oscillators for transmitters, RF test generators and local oscillators for receivers. These applications need a frequency stability that is better than LC oscillators' but not so high as that of conventional crystal oscillators.

Wider frequency range is achieved by operating the crystal below its resonant frequency and loading it with a variable inductance.[1,2] Some sacrifice of frequency stability ensues, but a well-designed unit will still hold stability to about two parts per million per hour at its least stable setting. The same unit without the variable inductance would have roughly one-seventh the frequency range and about ten times better stability.

The relationship between a crystal's characteristics and the load, and the effect of these on frequency range and stability, are shown by a simple analysis of the crystal's equivalent circuit.

The crystal should oscillate over a range from slightly above to about two percent below its resonant frequency. Since the crystal is capacitive below its resonant frequency, it must be inductively loaded if oscillation is to occur. Good variable inductors, however, are not readily available and are too bulky. A series combination of a fixed inductance and a variable capacitance does an equally good job and is much easier to handle. To examine the loading effects on the crystal, consider first its impedance in terms of its resonant frequency.

The negative value of the impedance of a lossless quartz resonator[3] is:

$$-Z_x = (\omega_r^3 - \omega^2)/\omega C_0 (\omega_a^2 - \omega^2) \text{ ohms}, \quad (1)$$

where:

$\omega = 2\pi f$,
f = frequency (Hz),
ω_r = crystal resonant frequency,
ω_a = crystal antiresonant frequency,
C_0 = crystal shunt capacitance.

Let:

$$\omega_r = \omega + \Delta\omega, \quad (2)$$

where $\Delta\omega$ is a frequency change, which is small compared with ω. Then:

$$\omega_r^2 \cong \omega^2 + 2\omega(\Delta\omega), \quad (3)$$

where the $(\Delta\omega)^2$ term has been discarded as negligible. The square of the antiresonant frequency is:[4]

$$\omega_a^2 = \omega_r^2 (1 + C_1/C_0), \quad (4)$$

where C_1 is the electrical equivalent of the mechanical compliance of the crystal. Substituting Eqs. 3 and 4 into Eq. 1 and simplifying yield:

$$-Z_x = 1/\omega C_0[1 + (C_1/C_0) + (C_1\omega/2C_0\Delta\omega)]; \quad (5)$$

$$-Z_x \cong 1/\omega_r C_0[1 + C_1 f_r/2C_0 \Delta f]. \quad (6)$$

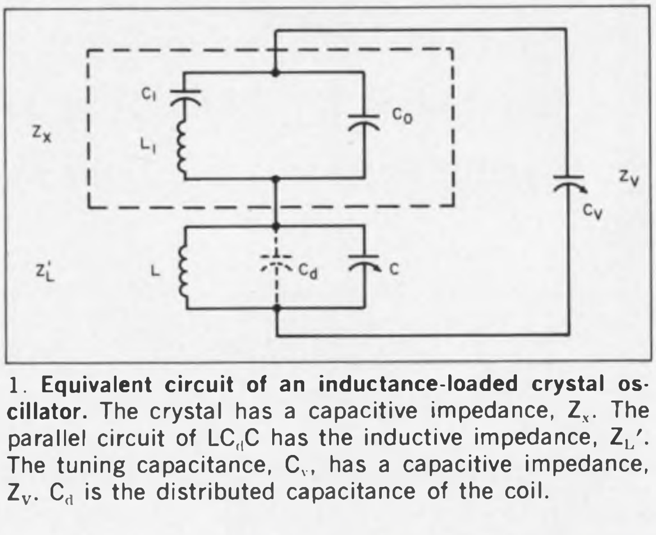
For CR-18 crystals, in which $C_0 = 7$ pF and $C_1/C_0 = 1/250$, the impedance becomes:

$$-Z_x \cong 22.7/f_r [1 + 2f_r/\Delta f], \quad (7)$$

where

Z_x = crystal impedance in kΩ,
f_r = crystal resonant frequency in MHz,
Δf = frequency change in kHz.

When the crystal is loaded with the series combination of a fixed inductance and a variable ca-



1. **Equivalent circuit of an inductance-loaded crystal oscillator.** The crystal has a capacitive impedance, Z_x. The parallel circuit of LC_dC has the inductive impedance, Z_L'. The tuning capacitance, C_v, has a capacitive impedance, Z_V. C_d is the distributed capacitance of the coil.

Frank W. Noble, Electronics Engineer, Laboratory of Technical Development, National Heart Institute, Bethesda, Md.

pacitor, a series circuit is formed, consisting of Z_x, Z_v and Z_L', where Z_v is the impedance of the variable capacitor and Z_L' is the impedance of the fixed inductor, as shown in Fig. 1.

The crystal will oscillate at a frequency for which the net circuit impedance is zero:

$$Z_x + Z_v = Z_L'. \qquad (8)$$

The easiest way to select the proper components and estimate stability is to plot the crystal's impedance variations with frequency. The curve for a CR-8 crystal is shown as a dashed line in Fig. 2. The curve actually represents the negative of the impedance, since that is more useful when Z_L' must be found (see Eq. 8).

The impedance-vs-frequency curve for any other type of crystal can be obtained by substituting the proper values of C_0 and C_1 into Eq. 6.

Variable capacitor depends on practical factors

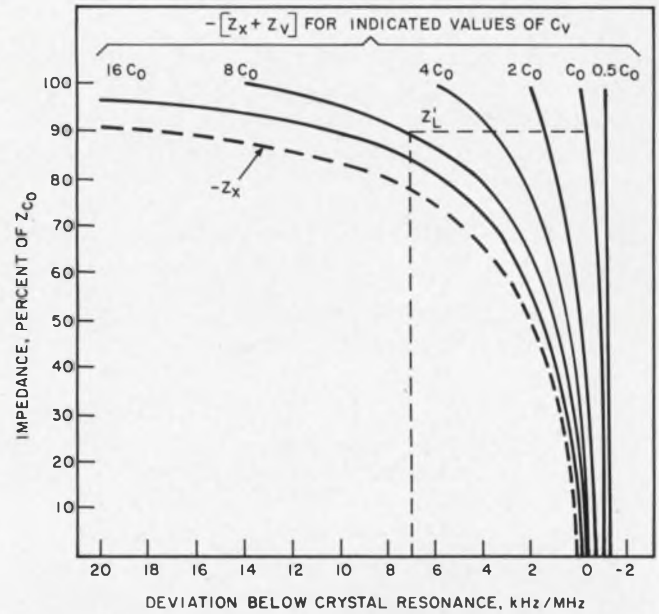
The extreme values of the variable capacitance (C_v) are a function of the circuit configuration and manufacturing limitations (Fig. 3).

The minimum capacitance of a commercial air capacitor with large capacitance ratio tends to be in the range from 5 to 8 pF. In addition, the total minimum value of C_v cannot exceed the sum of stray capacitance to ground and that part of C_v which is in series with the crystal. Experience shows that a minimum value of about 7 pF is acceptable, provided that stray capacitances are kept low. The capacitor's impedance at its minimum value is denoted as $Z_{v\ max}$.

The maximum value of C_v should be so chosen that the capacitor's impedance at its fully meshed state is small in comparison with the crystal's impedance, which depends on its capacitance, C_0. The maximum available value of C_v in commercial units is about 8 C_0. It would be difficult to exceed this value with commercially available devices and still maintain the low minimum capacitance, the capacitance ratio and calibration linearity.

As an example, suppose a 7-MHz CR-18 crystal has to operate over a range of approximately 50 kHz. In Fig. 2, the lower dashed curve is a plot of the negative of the crystal impedance versus frequency. The value of the maximum capacitance of C_v, which will have an impedance $Z_{v\ min}$, is 8 C_0, or 56 pF .The negative of the sum of Z_x and $Z_{v\ min}$ is plotted as the solid line labeled 8 C_0. A minimum value for C_v of about 7 pF is a reasonable assumption, on the basis of the previous discussion. The solid line labeled C_0 is a plot of the negative of the sum of Z_x and $Z_{v\ max}$.

To determine the required inductance, its impedance must equal the negative of the sum of the crystal impedance and the impedance of the variable capacitor, at any setting of the capacitor. Thus, when the capacitor is fully meshed, the in-



2. **Impedance-vs-frequency deviation** for inductive-loaded (LC) quartz resonator (VXO). The dashed line is the negative of a CR-18 crystal's impedance, the solid lines are the sum of the crystal's and the variable capacitor's impedances, as C_v is changed through its full range (from 0.5 C_0 to 16 C_0). The required operating range, 7 kHz/MHz, yields the value of the fixed inductor, 0.903 Z_{co}, or 66.5 μH ($Z_{co} = 22.7/f_r$, the first term in Eq. 7).

tersection of the 7 kHz/MHz line with the 8-C_0 curve yields an impedance of 0.903 Z_{c0}, or about 2930 ohms for a 7-MHz crystal. This impedance will be supplied by an effective inductance, L', of 66.5 μH. If this value is used and the variable capacitor is set to its fully open position, the intersection of 0.903 Z_{c0} with the C_0 curve yields the maximum frequency, − 0.2 kHz/MHz, or about 1.4 kHz above the resonant frequency. This is shown by the dashed lines in Fig. 2.

A calibration of frequency deviation versus values of C_v may be obtained from the intersections of the dashed horizontal line with curves for various values of C_v. This calibration curve will be very nonlinear if semicircular plates are used. A reasonably linear calibration will result if mid-line plates are selected.

During the actual design of these oscillators, engineers will come across two difficulties. Fortunately, a single expedient solves both.

The first problem is that a very definite value of inductance is required to cover a particular frequency range. As stated earlier, good variable coils are not convenient, and coil pruning is a nuisance.

The second is that a change in the distributed capacitance of the coil will alter its effective inductance. The case of two mechanically different coils designed for the same inductance at low frequencies illustrates this effect: the coils' effective inductances become different as the operating frequency approaches the self-resonant frequency of each coil.

The solution to both difficulties is to adjust the distributed capacitance by means of a small variable capacitor connected in parallel with the coil. This makes use of the fact that the effective inductance is:[5]

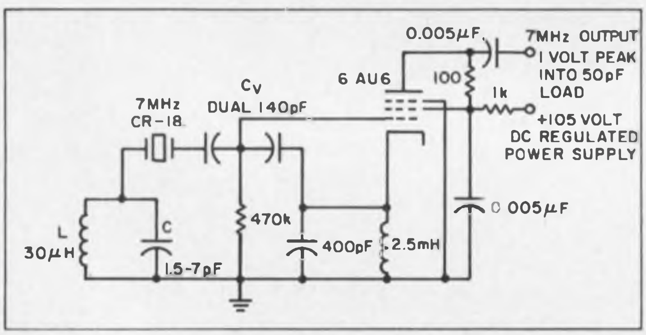
$$L' \cong L/[1-\omega_r^2 L(C+C_d)] = L/[1-(\omega_r/\omega_0)^2], \quad (9)$$

where

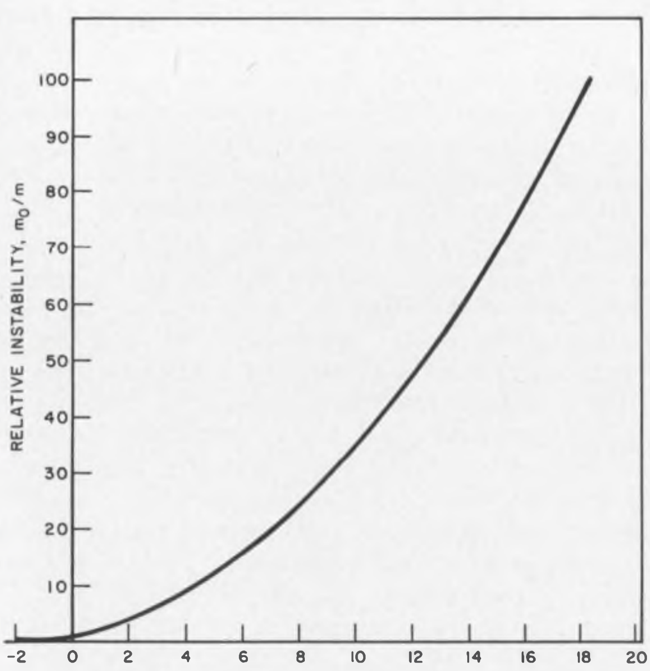
L = coil inductance when $(\omega/\omega_0) \ll 1$,
C = capacitance of the variable capacitor,
C_d = distributed capacitance of the coil,
$\omega_0^2 = 1/L\,(C + C_d)$ = "adjusted" self-resonant frequency of the coil.

In the case illustrated in Fig. 2, a suitable value of L is about 30 μH. Its effective value, L', is set to the required 66.5 μH by adjustment of capacitor C.

The advantages of the circuit in Fig. 3 are that the minimum capacitance is very low and stable,



3. **Typical oscillator circuit uses inductive loading.** L is 34 turns of #18 tinned wire wound on a 2-inch-diameter ceramic form with a winding length of 3 inches. The output voltage is virtually independent of the position of C_v.



4. **Stability-vs-frequency range** for LC-loaded oscillator (VXO) shows rapid deterioration with large deviations. The crystal is a CR-18.

and the output voltage is virtually independent of the setting of C_v. Also, its range adjustment is extremely simple. The maximum frequency, occurring where C_v is a minimum, approximates the normal value for the crystal operating with a 32-pF capacitive load. This frequency is affected only slightly by variations in L'. The minimum frequency is set by adjusting C_v to its maximum value and then adjusting C to yield the proper value of L' for resonance at 49 kHz below the crystal's resonant frequency.

What happens to stability?

The increased frequency range is obtained at the price of reduced frequency stability. If we make the reasonable assumption that the coil is the major contributor to instability, then variations in L' will shift the dashed horizontal line of Fig. 2 up and down. The frequency deviations thus produced depend on the slope of the particular $-[Z_x + Z_v]$ line at the operating point. Since this slope is minimum where Z_v is minimum, it follows that the least stable point is always where the Z_L' line intersects the curve $-[Z_x + Z_{v\,min}]$. It is also apparent that the stability at this poorest point decreases as the range is made larger by increasing Z_L', i.e., by increasing C.

The variations in stability may be clearly appraised by examining Eq. 7, the impedance of the crystal. The first term is the impedance of C_0 at the resonant frequency. The characteristic of the crystal cut (AT in this case) is given by the second term in the denominator. Rewritten, this term is:

$$y = 1/(1 + 2/x) = x/(x + 2), \quad (10)$$

where $x = \Delta f/f_r$ in kHz/MHz. Therefore:

$$dy/dx = m = 2/(x + 2)^2. \quad (11)$$

The frequency stability of the resonator will be proportional to m. As normally used, the crystal operates close to its resonant frequency where $x = 0$ and the slope, $m_0 = 0.5$. The stability at any other point will be related to the m/m_0. It is more convenient to plot the relative instability as:

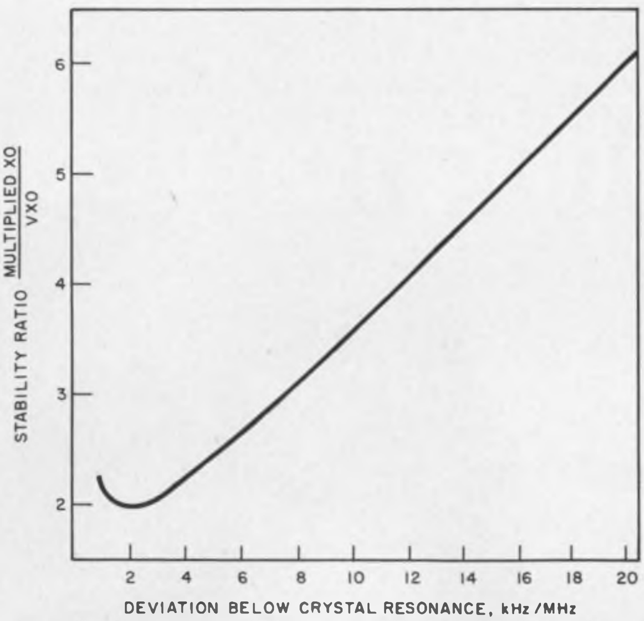
$$m_0/m = (x + 2)^2/4, \quad (12)$$

as has been done in Fig. 4. It is clear that frequency stability decreases rapidly with deviation.

Inductive loading compared with conventional design

To illustrate the change in stability caused by inductive loading, suppose that a given deviation, x, is required, where x is an integer.

One way to obtain this value of x is to use a stable capacitance-loaded oscillator, which will yield a deviation of approximately 1 kHz/MHz at the crystal's fundamental frequency, with a slope, m_0. If this frequency is multiplied by x in a fre-



5. **Plot of stability** ratio offers a simple way to compare the stability of a frequency-multiplied capacitance-loaded oscillator (XO) with that of an LC-loaded oscillator (VXO) over the same frequency range. (Both oscillators use a CR-18 crystal.) As expected, the XO is more stable, but requires complex circuitry.

quency multiplier, the deviation will be the desired x kHz/MHz of the fundamental, while the effective slope will be reduced to m_0/x.

A second method of obtaining the deviation, x, is to use LC-loading directly on the crystal fundamental. The slope will be given by Eq. 11.

The ratio, G, of the stability of the multiplied, C-loaded crystal oscillator (XO) to that of the LC-loaded circuit (VXO) is the ratio of the slopes:

$$G = m_{xo}/m_{vxo} = (x + 2)^2/4x. \qquad (13)$$

A plot of Eq. 13 is given in Fig. 5. Although the stability of the VXO is always less than that of a frequency-multiplied XO, the complexity and spurious signal generation, inherent in frequency multiplication, can be eliminated with the VXO.

It must be pointed out that Eqs. 12 and 13 and Figs. 4 and 5 are correct only if we assume that the loading impedances are of equivalent quality. Since the LC load is less stable than the capacitive load, it will be found in practice that the stability of the VXO is not as great as predicted above. Hence, Fig. 5 represents an ideal case which can be approximated by the use of the best possible components in the resonant circuit. ■ ■

References:

1. Frank W. Noble, "Variable-frequency crystal oscillators," *Proc. IEEE*, LIV, No. 12 (Dec., 1966), 1976-1978.
2. H. Shall, "VXO—A Variable Crystal Oscillator," *QST*, XLII, No. 1 (Jan., 1958), 11.
3. Landee *et al.*, *Electronic Designers' Handbook* (New York: McGraw-Hill Book Co., 1957), pp. 6-14 *et seq.*
4. *Ibid.*, Eq. 6.38.
5. *Reference Data for Radio Engineers* (3rd ed.; Federal Telephone and Radio Corp., 1949), p. 83.

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Pick the right hybrid technique and you'll get the most suitable passive components for your circuit. Thick films and thin films both have their place.

The hybrid circuit—one that contains two or more semiconductor chips on a substrate, with either thick- or thin-film resistors and capacitors —is a popular alternative to monolithic integrated and discrete-component circuits.

It is not plagued by the parasitics that may mar the performance of monolithics, and it requires far fewer masks and far less time to make the first unit. Moreover, it is a lot less bulky and more reliable than circuits that are made with discrete components.

But the designer must choose between thick films, alloy thin films and single-metal thin films. Regardless of whether the hybrid circuit contains integrated circuits alone (see Fig. 1) or a mixture of discrete transistors and ICs (Fig. 2), it will be a success only if the passive components are the best match for the job.

Depending on application, these factors will affect the choice: size, tolerance, power dissipation and processing problems. Examine them before you begin the design.

Consider the size of the design

By a lengthy derivation based on skin and bulk resistance effects,[1] it can be shown that the resistance of a resistor (thick or thin) is related to its material through the following equations:

$$R = \rho L/WD,$$

where:

R = bulk resistance of the film,
ρ = resistivity of the material,
L, W, D = respective dimensions of the film (see Fig. 3).

Rearrangement of the equation shows that:

$$R = (\rho/D)\ (L/W);$$
$$R = KN;$$
$$K = \rho/D;$$
$$N = L/W;$$

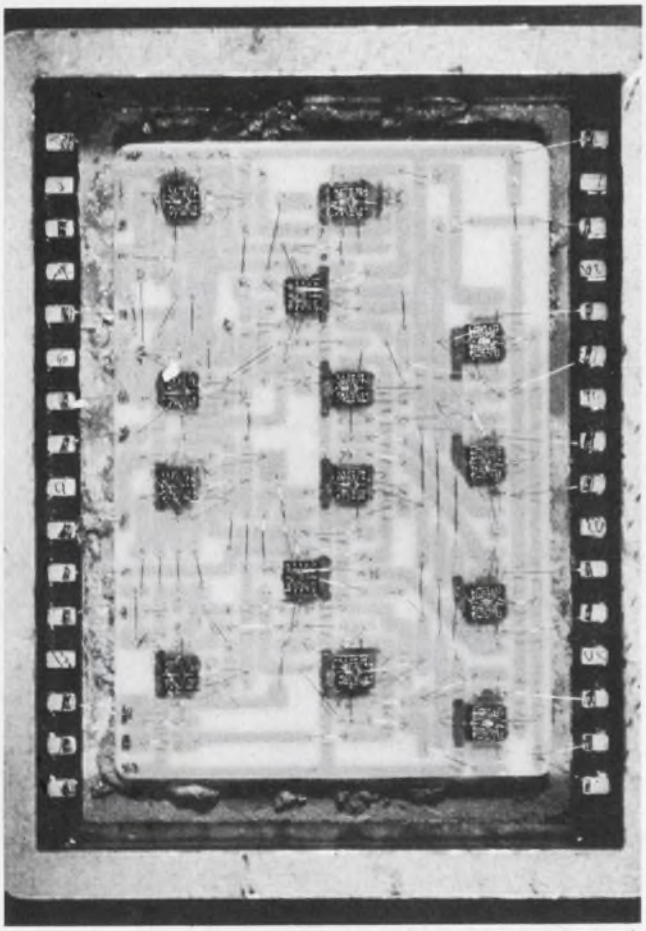
where the constant K is the ohms/square, and N is the number of square widths.

Consider this example: Given that the resistivity of nichrome is 150 Ω/square, the minimum width is 0.25×10^{-3} inches, and process tolerance is $\pm 0.03 \times 10^{-3}$ inches, determine the length of the resistor. By rearrangement of the equation, it is known that:

$$L = WR/K.$$

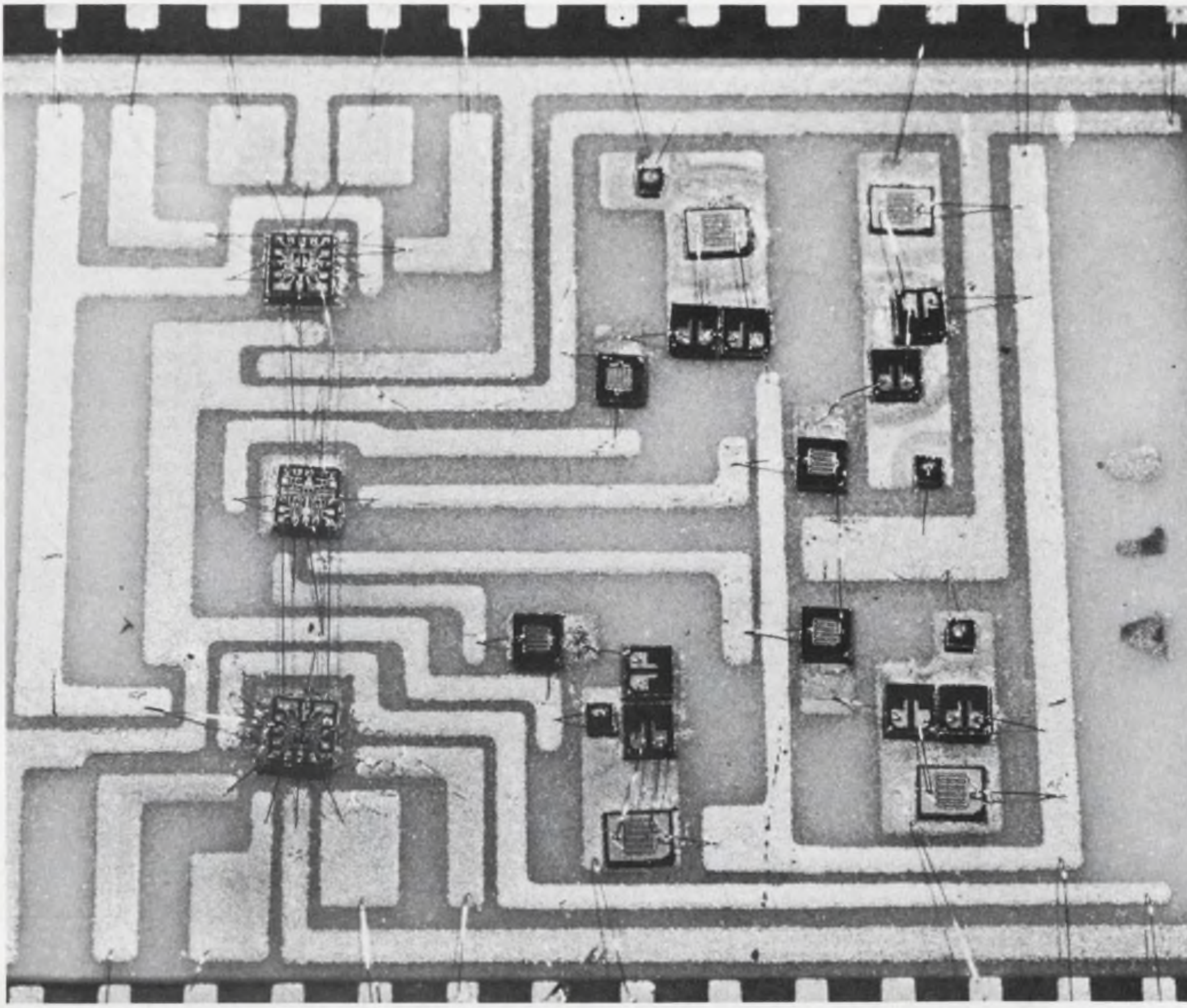
If the width of the resistor is 1/4 mil, then:

$$L = (3 \times 10^{3}/150)\ (1 \times 10^{-3}/4)$$
$$= 5 \times 10^{-3} \text{ inches.}$$



1. **Fourteen integrated circuits** nestle in one 1-by-0.8-inch package.

Richard F. Bader, Hybrid Circuit Product Manager, Fairchild Semiconductor Div., Fairchild Camera and Instrument Corp., Mountain View, Calif.



2. **Transistors mix with integrated circuits** in this 3/8-by-3/8-inch flat pack.

If the width of the resistor is 4 mils, then:

$$L = (3 \times 10^{3}/150)\ (4)\ (10^{-3}) \\ = 80 \times 10^{-3} \text{ inches.}$$

Check positive and negative tolerance

To determine which size to use, weigh the effect of the mechanical tolerance on the design. Since most mechanical deviations are in the same direction, it is necessary to investigate only the positive and negative tolerance changes:

$$R = N\left(\frac{L + \Delta l}{W + \Delta w}\right)$$

and

$$R = N\left(\frac{L - \Delta l}{W - \Delta w}\right).$$

If the line width of the resistor is 1/4 mil, then:

$$R = (150)\frac{5 \times 10^{-3} + 0.03 \times 10^{-3}}{0.25 \times 10^{-3} + 0.03 \times 10^{-3}}$$
$$= 2.7\ \text{k}\Omega$$

or

$$R = (150)\frac{5 \times 10^{-3} - 0.03 \times 10^{-3}}{0.25 \times 10^{-3} - 0.03 \times 10^{-3}}$$
$$= 3.4\ \text{k}\Omega.$$

Hence, with a resistor of 1/4-mil line width:

$$R = 3\ \text{k}\Omega \begin{array}{l} +13\% \\ -10\% \end{array}.$$

By the same procedure, a like analysis shows that with a 4-mil line width:

$$R = 3\ \text{k}\Omega \begin{array}{l} +3.0\% \\ -2.7\% \end{array}.$$

If space, then, is the prime consideration, the 1/4-mil-line-width resistor is the one to use. But the larger resistor exhibits better power dissipation and tighter tolerance.

It is important also to consider power in the design of resistors. An analysis of the thermal resistance between the resistor and the heat sink will yield the following equation (see Fig. 4):

$$\theta_T = \theta_{R/D} + \theta_{D} + \theta_{D/S} + \theta_S + \theta_{S/HS},$$

where:

θ_T = thermal resistance (TR) between resistor and heat sink,
$\theta_{R/D}$ = TR between resistor and dielectric,
θ_D = TR between dielectric and substrate,
θ_S = TR of substrate,
$\theta_{S/HS}$ = TR between substrate and heat sink.

Normally $\theta_{R/D}$ and $\theta_{D/S}$ are small compared with the other terms in the equation. All bulk thermal resistance terms are available from a materials handbook[2] or from a ceramic manufacturer. Resistances are dependent on the area of the materials. Since power is the prime concern. the equation can be rewritten so that:

$$P = (T_{MAX} - T_{HS})/\theta_T,$$

where

P = power,
T_{MAX} = maximum allowable resistor temperature,
T_{HS} = heat sink temperature.

Since T_{MAX} for most resistors is less than 200°C, and on the assumption that the heat sink is maintained at 25°C, then:

$$P_{MAX} = 175°C/\theta_T.$$

For 96% alumina, the equation reduces to:

$$P_{MAX} = 15 \times 10^{-6}\ W/mil^2 \text{ of resistor area.}$$

All the previous equations and examples were based upon a rectangular resistor. If, however, the resistor's size had to be larger than its substrate length, the resistor may be doubled back. To minimize hot spots due to abnormally high current densities forming at corners, all double-backs should be rounded. If the film's turns are separated by a spacing equal to the film's width, the entire rectangular area covered by the resistor may be used for the power calculation rather than just the area under resistor.

Definition of resistor cannot be hard and fast

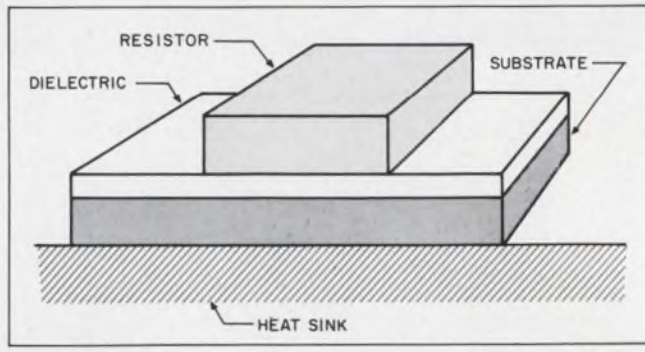
There are a number of different definitions of what constitutes a thin-film resistor. These two are common:

- Any metal film deposited on a substrate by vacuum evaporating or sputtering techniques.
- A metal film 500 to 1000 Å thick.

Unfortunately there are exceptions to both definitions. Consequently a much safer, though less sophisticated, definition simply specifies the metals used. The most popular films are nickel-chromium alloys, chrome, tantalum and tin oxide.

Analyze two production techniques

Two techniques are commonly used for film production: RF sputtering and vacuum deposition.



3. **Calculate the thermal resistance** between the resistor and the substrate to determine whether or not a particular configuration can handle the power that the circuit requires.

Both make use of vacuum chambers, which reduce the internal pressure. Typically, an evaporator produces pressures in the 10^{-5}-to-10^{-8} torr range (1 torr = 1 mmHg at 0°C at standard gravity = 1333.2 bars). Cathode sputtering takes place at a pressure of 10^{-3} torr. In either case the time needed to load the systems and charge the evaporators is too long for mass production. Typically, 100 depositions a week can be performed with one system. Continuous process systems are under development but as yet are unreliable.

The actual resistor may be formed by evaporating through a mask inside the chamber or by etching after deposition over the whole substrate. There are many experts, though, who feel that the latter method permanently damages the crystal structure. Such damage affects long-term stability and reliability.

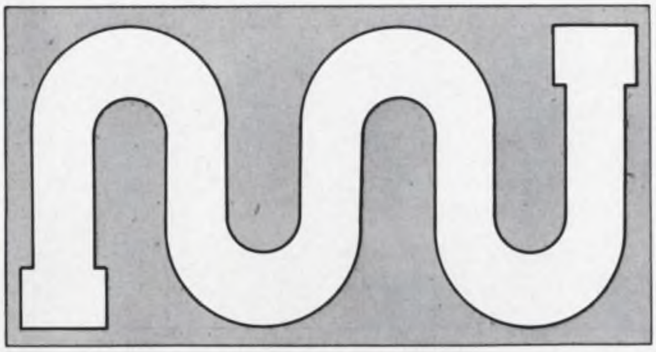
Nichrome and tantalum preferred

For thin films, nickel-chromium alloys and tantalum have been the preferred metals used. The major advantages of nickel-chromium alloys are:

- Line widths are narrow (0.25×10^{-3} inches).
- T_c is excellent (typically 100 ppm/°C but can be controlled to 0 ±20 ppm/°C).
- End-of-life (EOL) stability is excellent (0.1% after 10,000 hours).
- Initial tolerance depositions are good (0.05×10^{-3} inches).
- Control during deposition is easy to achieve by a variety of methods.
- Adhesion qualities to glass or ceramic are good.

Nickel-chromium's disadvantages are:

- Oxides are formed by endothermic reactions when the alloys are heated above 380°C. This changes resistivity.
- Flexibility in resistivity selection is little



4. **Heat spots won't occur at the bends,** if the resistors have no sharp elbows and no constrictions. If the distance between the loops is equal to their width, include it in heat calculations.

(typically 50 Ω/square).

- Power handling capabilities are limited (typically 15 W/in^2).
- Trimming is inconvenient and generally executed mechanically.
- A stabilization overcoating of silicon oxide or organic material is required.
- Production is costly.
- Resistance values are low (500 kΩ).

There are two significant processing problems associated with nichrome:

- Awkward impurity problems arise with low-vacuum depositions. These impurities adversely affect the sheet resistivity and the temperature coefficient of resistance.
- It is difficult to maintain a uniform bulk composition of nichrome during deposition. This adversely affects long-term stability at high temperatures (200°C).

One metal deposits uniformly

The problems associated with nickel-chromium alloy during deposition have caused many thin-film manufacturers to prefer a one-metal system. Tantalum is by far the most popular one-metal system, although chromium and tin oxide resistors are also being used.

Tantalum is usually deposited by RF sputtering. Some of its major advantages are:

- Higher resistivities are available (150 Ω/square, 1 kΩ/square, 5 kΩ/square).
- Easily automatable trimming is usually accomplished by anodization: 0.1% resistors are possible. Tantalum can be trimmed by localized laser annealing.
- Good line widths are possible (1 mil).
- The temperature coefficient of resistance is controllable to a more predictable degree than with other films.
- The anodizing process automatically forms a stabilizing film over the resistor.
- Capacitors may be deposited with the same material and equipment.

The disadvantages of tantalum films include the following:

- End-of-life tolerances are questionable at higher resitivities. There seems to be disagreement about the validity of some long-term stability data reported, especially at the high resistivity values.
- Stability of the films at die-attach temperature (420°C) is also questionable. Some authorities indicate the type of anodization used materially affects this property.
- To prevent oxidation during evaporation and to improve stability, it is necessary to evaporate a gold layer between the tantalum layers. This extra step makes more complex processing equipment necessary.
- The process does not lend itself to mass production techniques, thus adding to the expense of the resistor substrate.
- Resistance values are limited (up to one megohm).

Tantalum has some advantages over nichrome: it is easier to trim, and it allows a greater range of values. But there are many unknowns in tantalum processing, and the resistor values do not reproduce well. Nichrome, however, does possess reproducibility characteristics. It is the workhorse of the industry.

Thick films have come into production

If the electronics industry were subject to fads, one of the biggest today would be the thick film. This passive component technique has a number of advantages, but probably the biggest is that the process is commercially available. Thick films require no costly process development programs, and the equipment is cheap.

Thick films are generally either conductive inks or cermet (ceramic to metal). Four materials that are often found in commercially available thick films are gold-tungsten, platinum-tungsten, platinum-tantalum, or gold-tantalum. These conductive metals are usually combined with a dielectric compound.

Whatever the composition, essentially the same technique is used for mass fabrication. The resistors are deposited onto the substrate by an automatic wiper arm, which forces the ink through a silk screen. The arm is set for a particular speed and pressure, and it wipes the ink across the silk-screen pattern. The inked impression on the substrate is then dried and fused in an oxidizing atmosphere. This process is easily automatable and reproducible.

Here are the advantages to be gained by using thick films:

- Initial investment to buy equipment is low.

Masking costs are relatively inexpensive ($75 to $100 a mask).

- The process lends itself to the techniques of mass production.
- Many resistivities are available for flexibility in resistance tolerance (1Ω/square to 20 kΩ/square in decades).
- Trimming is easily automatable by the use of sand blasting or mechanical trim.
- Power ratings on resistors are high (50 W/in²).
- Capacitors are possible.

But thick films do have disadvantages, and among these are the following:

- Thick films tend to be unstable at high temperatures (380°C).
- End-of-life data are questionable.
- Thick films are noisy at high resistivities.
- Their lines are wide (10-15 mils).
- Each resistance change greater than a factor of 10 above the basic resistivity selection requires an additional screening.
- In mass production runs, more than two screenings seriously affect yields.

Examples show when to use which film

If size is the most important factor in design, the following examples should indicate when to use thick and thin film:

Example 1: a 1-kΩ ±5% resistor

Assume that a 1-kΩ ±5% resistor has to be made. With a thin film of 150 Ω/square and a tolerance of ±0.05 mils, the resistor size can be determined as:

Length = 5.35 mils,
Width = 0.80 mils,
Area = 4.27 mil².

If a thick film of 1 kΩ/square and a tolerance of ±2 mils is used, and the minimum width is 10 mils, the resistor size will be:

Length = 10 mils,
Width = 10 mils,
Area = 100 mil²,

and the resistor will have to be trimmed.

Example 2: a 500-kΩ ±5% resistor

When a 500-kΩ ±5% resistor has to be made, thin film must be trimmed in order to keep the size down:

Length = 8.3 in.,
Width = 5.0 mils,
Area = 41.5×10^3 mil².

Thick film of a 20-kΩ/square material has also to be trimmed:

Length = 250 mils,
Width = 10 mils,
Area = 2.5×10^3 mils².

These examples demonstrate that in situations where size is the most important factor, small-value resistors are handled better with thin film, and large-value resistors are handled better with thick film.

Table. Compare thick and thin films

Circuit requirements	Thick film	Thin film
1. Mass producible	Lower cost	Higher cost
2. Close initial tolerance	±10% absolute ± 1% match	±5% absolute ±0.1% match
3. Close trimming tolerance	±1% easily mass-producible	±0.1% mass-producible (using tantalum)
4. Temperature coefficient	±200 ppm/°C	0 ppm/°C
5. Power handling	50 W/in²	15 W/in²
6. Line width	10 mils ± 2 mils	0.25 mils ± 0.02 mils
7. Resistivities	1 Ω/sq to 20 kΩ/sq	0.1 Ω/sq to 1 kΩ/sq
8. EOL tolerance	±2%	±0.1%
9. Capacitance available	10,000 pF maximum	0.01 μF maximum

Breadboard the hybrid circuit

Unlike monolithic integrated circuits, hybrid circuits can be designed and breadboarded in the same way that discrete component circuits can. The circuit designer should consider both thick- and thin-film fabrication techniques before he executes his design. The table makes the trade-offs clear.

A relatively recent development that makes either of the film techniques attractive for production circuits is the proliferation of new inverted ceramic packages. These allow transistors to be bonded directly to either thick-film or thin-film substrates.[3] ■ ■

References:

1. E. Stern, "Precision Thin-Film Resistors," *Proc. Electronic Components Conference, Washington, D. C., 1966.*
2. *Bulletin No. 651* (Chattanooga, Tenn.: American Lava Corp.), p. 9.
3. "Mount transistors in topsy-turvy holders," ELECTRONIC DESIGN, XIV, No. 17 (July 19, 1966), 17.

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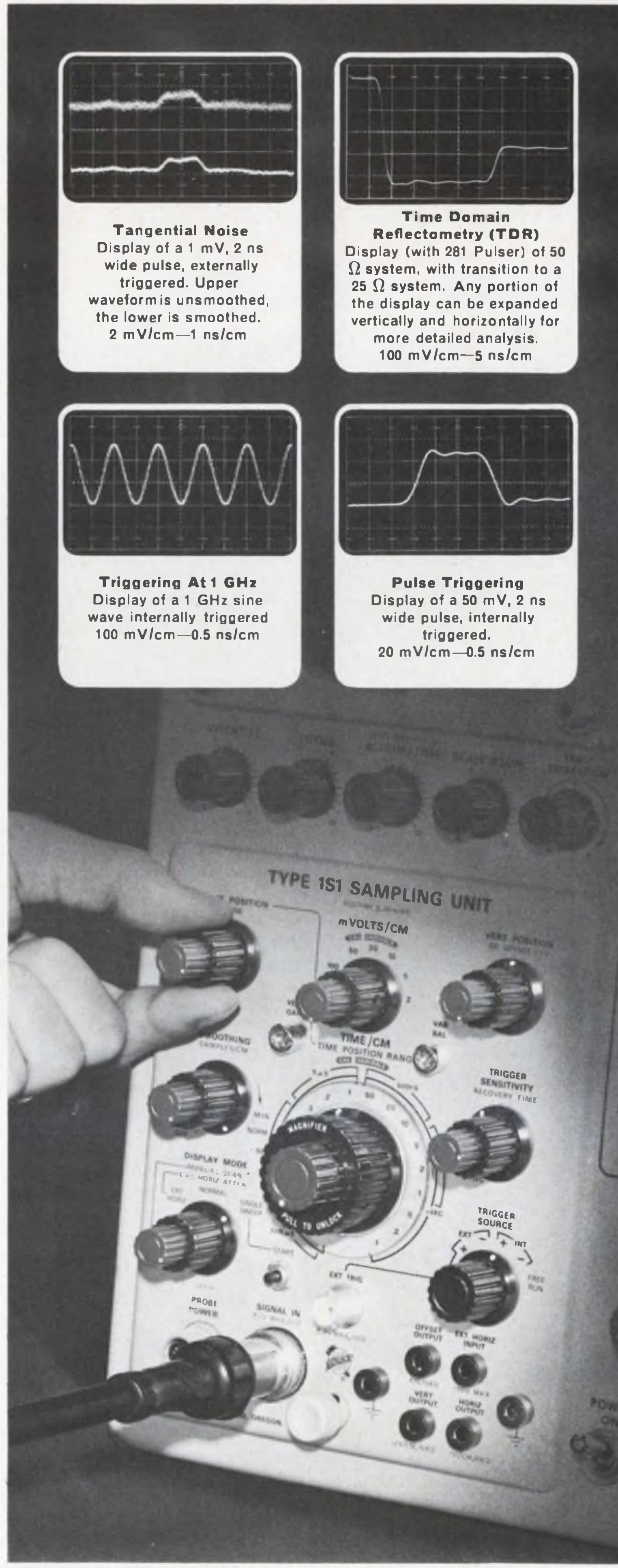

Tangential Noise
Display of a 1 mV, 2 ns wide pulse, externally triggered. Upper waveform is unsmoothed, the lower is smoothed.
2 mV/cm—1 ns/cm

Time Domain Reflectometry (TDR)
Display (with 281 Pulser) of 50 Ω system, with transition to a 25 Ω system. Any portion of the display can be expanded vertically and horizontally for more detailed analysis.
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Display of a 1 GHz sine wave internally triggered
100 mV/cm—0.5 ns/cm

Pulse Triggering
Display of a 50 mV, 2 ns wide pulse, internally triggered.
20 mV/cm—0.5 ns/cm

ON READER-SERVICE CARD CIRCLE 199

Simplify capacitance measurements

with this handy nomograph. It allows you to correct for lead inductance quickly and easily.

In capacitance measurements, the series inductance of component leads produces errors by causing an apparent increase in the capacitance. The effect of the series inductance becomes increasingly great as the capacitance, the test frequency, or the inductance increases. When low frequencies are involved, the resulting errors are negligible. However, with the advent of instruments capable of providing precise, high-resolution measurements of large values of capacitance at high frequencies, the influence of series inductance becomes significant.

A correction factor, C_{corr}, for the effect of series inductance can be calculated from the equation:

$$C_{corr} \approx \omega^2 C^2 L$$

where:

C = the measured capacitance,
L = the combined inductance of both leads of the component.

The computed correction factor is then subtracted from the measured value to obtain the true capacitance of the specimen.

The accompanying nomograph simplifies this calculation by defining the lead inductance in terms of lead-wire size (AWG) and the combined length of both leads.

Three lines laid off on the nomogram are required to arrive at the value of C_{corr}. These lines are as follows:

- From lead-wire size to total lead length, extended to turning line No. 1.
- From turning line No. 1 to measured capacitance value.
- From the intersection of the above line with turning line No. 2 to the measurement frequency. This line then intersects the correction-factor capacitance.

Shown on the nomogram is an example of its use for the following measurement situation:

Lead length	= 1/2+1/2=1 inch
Wire size	= #22
Measured capacitance	= 10 pF
Measurement frequency	= 100 MHz
Correction factor	= 0.9 pF
Actual capacitance	= 10.0−0.9=9.1 pF

To extend the range of the nomograph, select appropriate decade multipliers for capacitance and frequency from the table, and multiply the capacitance correction by the indicated factor. For example, for a measured capacitance of 1 pF and a frequency of 100 MHz:

C = 1 pF = 10 pF $\times 10^{-1}$ (decade multiplier is 10^{-1}).
f = 100 MHz (decade multiplier is 1).

Since the two decade multipliers intersect at 10^{-2} on the table, the correction factor, C_{corr}, is multiplied by 10^{-2}.

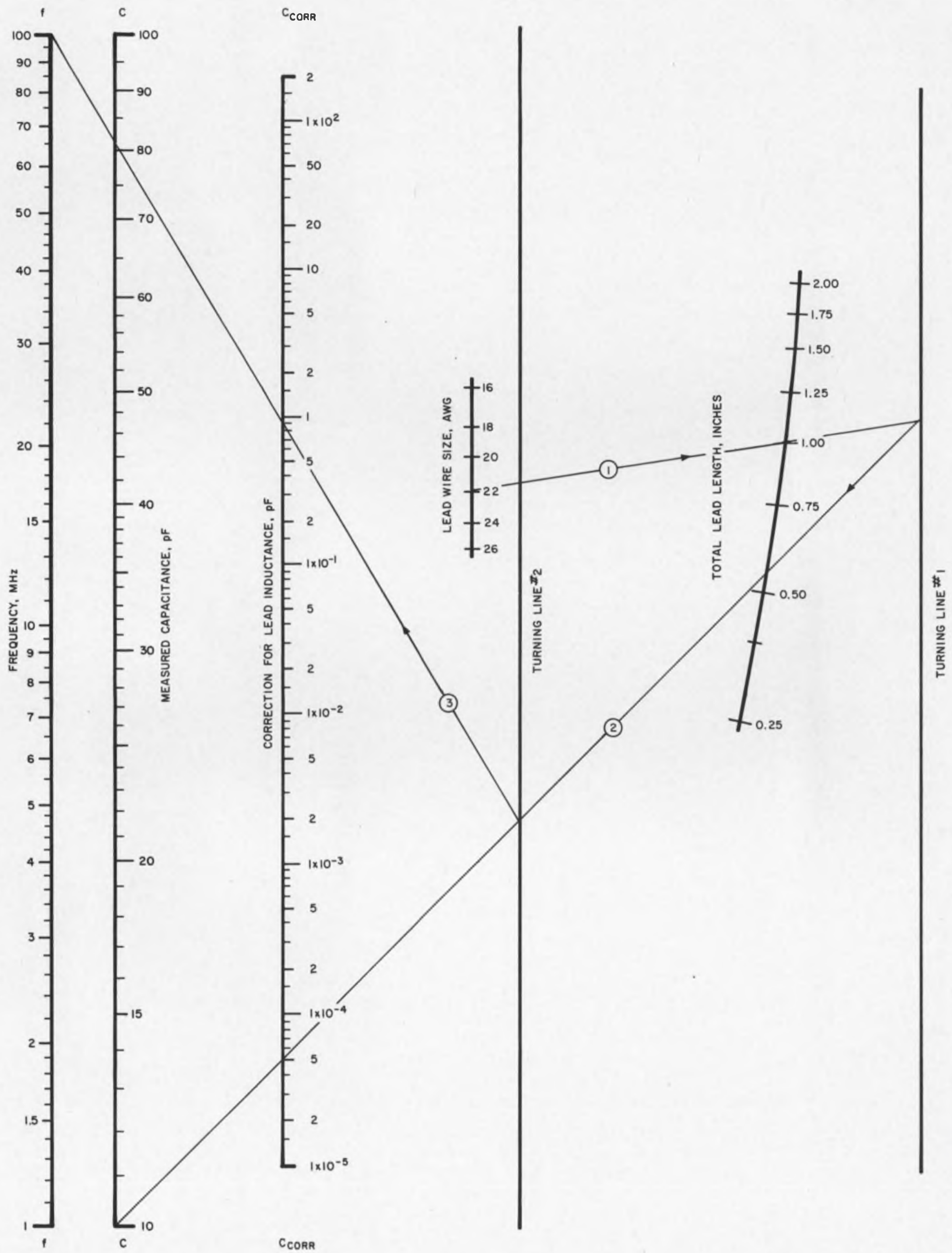
Similarly, if the measured capacitance is 0.1 μE and the measuring frequency is 100 kHz:

C = 0.1 μF = 10 pF $\times 10^{4}$ (decade multiplier is 10^4).
f = 100 kHz = 1 MHz $\times 10^{-1}$ (decade multiplier is 10^{-1}).

Thus, according to the table, the correction factor is multiplied by 10^6. ■■

Multiply correction by		Multiply frequency by 10^{-2}	10^{-1}	1	10
Multiply capacitance by	10^{-1}	10^{-6}	10^{-4}	10^{-2}	1
	1	10^{-4}	10^{-2}	1	10^{2}
	10	10^{-2}	1	10^{2}	10^{4}
	10^{2}	1	10^{2}	10^{4}	10^{6}
	10^{3}	10^{2}	10^{4}	10^{6}	10^{8}
	10^{4}	10^{4}	10^{6}	10^{8}	10^{10}

Richard Lee, Development Engineer, Boonton Electronic Corp., Parsippany, N. J.



FREQUENCY, MHz
MEASURED CAPACITANCE, pF
CORRECTION FOR LEAD INDUCTANCE, pF
LEAD WIRE SIZE, AWG
TURNING LINE #2
TOTAL LEAD LENGTH, INCHES
TURNING LINE #1
f
C
C_{CORR}

Variable-duty-cycle switching circuit

controls illumination intensity of a reticle within a crewman optical alignment sight.

Conservation of electrical power in manned space vehicles is of prime importance. Accordingly, all power control circuits are designed for the highest efficiency possible. A requirement for a continuous control of the illumination intensity of a reticle within a crewman optical alignment sight was thus met with a variable-duty-cycle power-switching circuit.

The advantages of this circuit, aside from its high efficiency, include:

- Versatility in providing illumination intensity patterns.
- High resolution for the illumination control.
- Circuit simplicity.
- Ease of analysis.

The circuit principles developed here can be used in most applications which require pulse width modulation and power switching. Such applications include motor controllers in servo systems, switching voltage regulators in power supplies, and information coding in logic circuits.

Operator controls illumination intensity

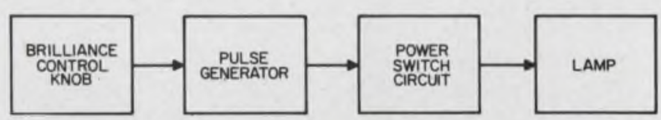
A block diagram of the circuit is shown in Fig. 1. The operator adjusts the brilliance control knob for the desired illumination level from the lamp. The brilliance control determines the pulse duty cycle of the pulse generator. The pulse generator drives the power switch in accordance with the pulse duty cycle. The power switch applies the power supply voltage across the lamp in accordance with the power switch duty cycle, and thus fixes the lamp's brilliance.

How the circuit works

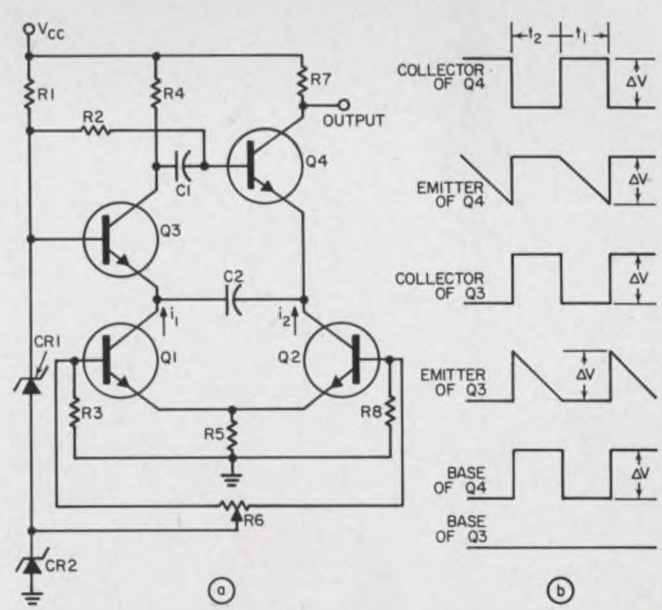
The pulse generator is shown in Fig. 2. Transistors *Q1* and *Q2* form two constant current generators. Potentiometer *R6* adjusts their current distribution.

Power supply current through Zener diode *CR2* provides the voltage bias for the bases of *Q1* and *Q2*. Power supply current through Zener diode *CR1* in series with Zener diode *CR2* fixes the bias voltages for the bases of *Q3* and *Q4*.

The pulse generator circuit operates in the following manner. Initially, transistors *Q3* and *Q4* are forward-biased, but because of circuit imbalance only one transistor will switch on first. Assume that *Q3* switches on first. Current from *Q1* flows through resistor *R4*, causing the collector voltage of *Q3* to drop. This voltage drop is coupled through capacitor *C1* to the base of *Q4*, forcing transistor *Q4* off. While *Q4* is off, the current from *Q2* charges capacitor *C2*. Eventually, the base-emitter threshold voltage of *Q4* is exceeded and it begins to conduct. The conduction through *Q4* reduces the emitter current through *Q3*, thereby in-

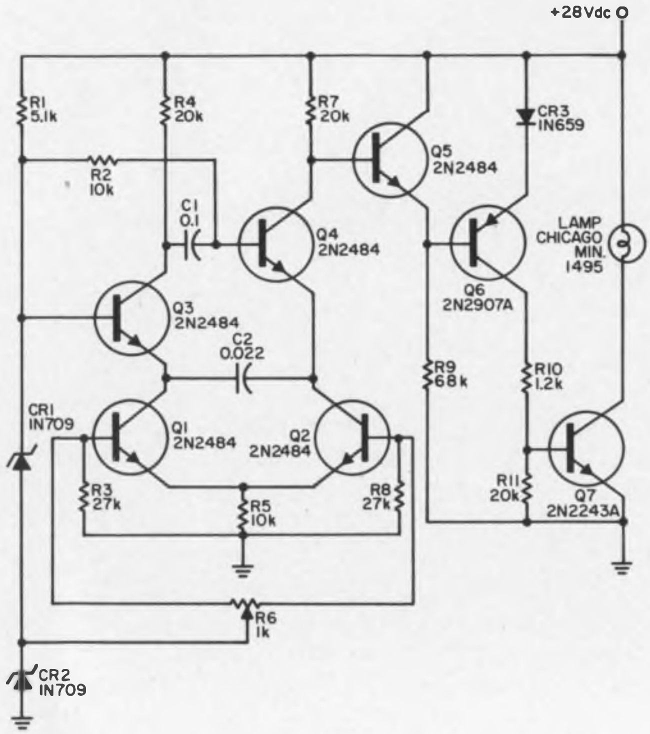


1. **Simplicity of the lamp control** circuit is demonstrated by the above block diagram. Circuit details are given in Figs. 2 and 3.

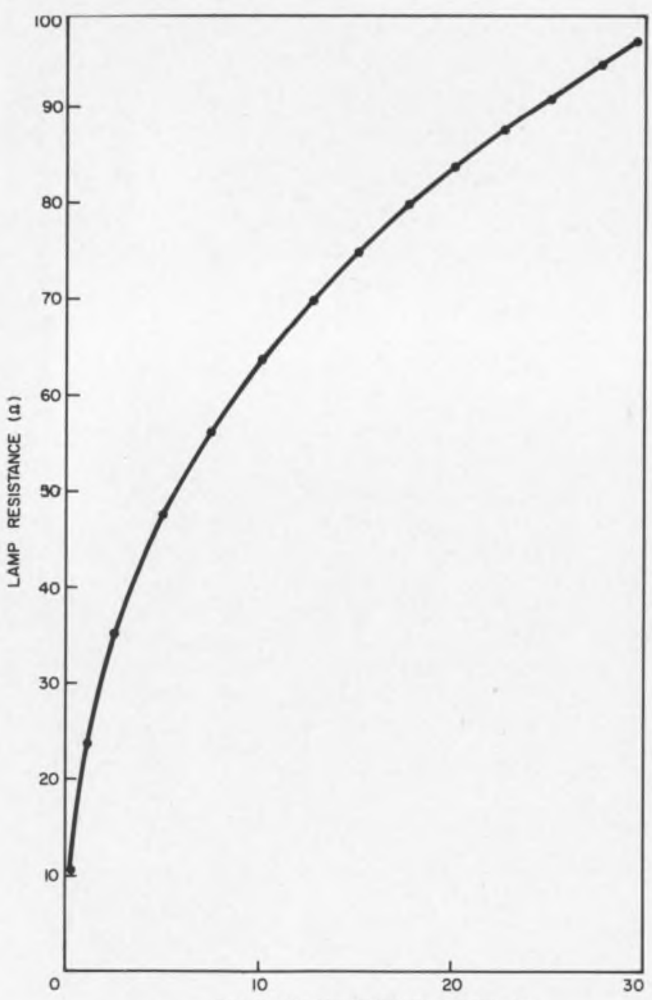


2. **Pulse generator** is controlled by Q1 and Q2 which, in turn, are controlled by the setting of R6 (a). Voltage waveshapes at various points within the circuit are shown in (b).

George W. Candel, Research Engineer, Autonetics Div. of North American Aviation, Inc., Anaheim, Calif.



3. **Addition of three transistors** to the pulse generator of Fig. 2 completes the "lossless" lamp control circuit.



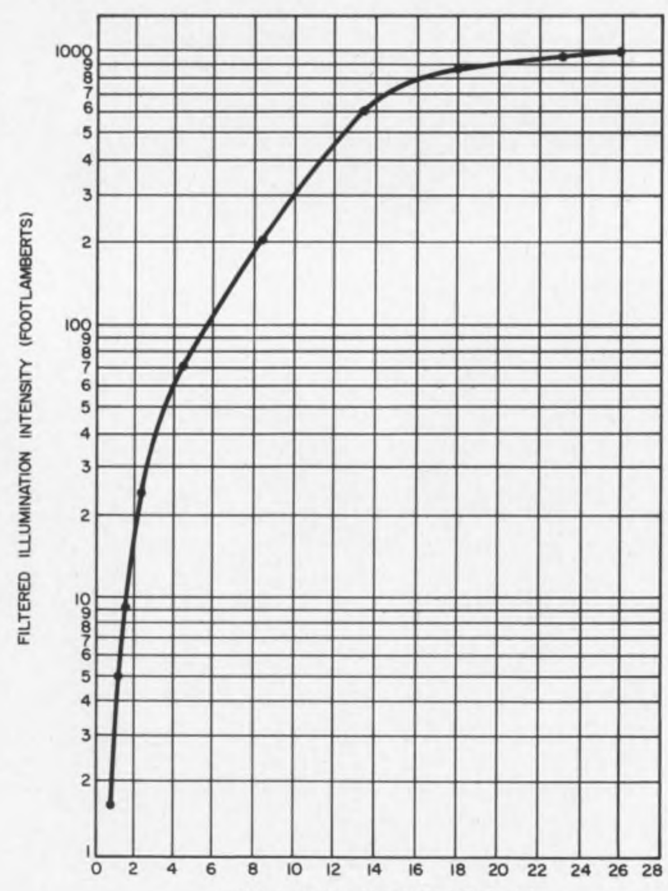
4. **Lamp resistance vs voltage** curve can be used to select the proper lamp.

creasing the collector voltage of *Q3*. The positive-going voltage at the collector of *Q3* is applied through capacitor *C1* to the base of *Q4*, forcing *Q4* into heavier conduction. Also, the emitter voltage of *Q4*, following its base drive, rises and is applied through capacitor *C2* to the emitter of *Q3*, forcing *Q3* into cutoff. These actions proceed rapidly until *Q3* is switched off and *Q4* is switched on. While *Q3* is off, the current from *Q1* charges capacitor *C2*. Eventually, the base emitter threshold voltage of *Q3* is exceeded and it begins to conduct. This reduces the emitter current through *Q4* and decreases the collector voltage of *Q3*. The negative-going voltage at the collector of *Q3* is coupled through capacitor *C1* to the base of *Q4*, forcing *Q4* toward cutoff. This action proceeds rapidly until *Q4* is switched off and *Q3* is switched on. The cycle then repeats itself. The waveforms of the circuit are shown in Fig. 2b.

Circuit analysis is easy

The analysis of the pulse generator circuit (Fig. 2a) can be separated into two parts: *Q3* is on for time t_1 and *Q4* is on for time t_2.

The approximate equation for the case of *Q3* on is:



5. **Illumination intensity** as a function of average applied voltage combined with the curve of Fig. 4 narrows down the choice of the lamp.

$$\Delta V_1 = i_1 R4 = i_2 t_1/C2,$$
where all symbols are those of Fig. 2. Therefore:
$$t_1 = R4\, C2(i_1/i_2).$$
The approximate equation for the case of $Q4$ on is:
$$\Delta V_2 = i_2 R7 = i_1 t_2/C2.$$
So that:
$$t_2 = R7\, C2(i_2/i_1)$$
The period of oscillation equals $t_1 + t_2$.

The currents i_1 and i_2 are determined by the voltage across Zener diode *CR1* and the adjustment of the potentiometer *R6*.

When the potentiometer arm is set at the base of *Q1*, $i_1 = (V_{cr2} - V_{be1})/R5$. The voltage at the base of *Q2*, V_{b2}, is given by:
$$V_{b2} = V_{cr2}[R8/(R8+R6)].$$
The resistor values are selected so that:
$$V_{cr2}[R8/(R8+R6)] < (V_{e2}+V_{be2}),$$
enough just to cut *Q2* off and make $i_2 = 0$.

When the potentiometer arm is set at the base of *Q2*, $i_2 = (V_{cr2} - V_{be2})/R5$. The voltage on the base of *Q1*, V_{b1}, is given by:
$$V_{b1} = V_{cr2}[R3/(R3+R6)].$$
The resistor values are selected so that:
$$V_{cr2}[R3/(R3+R8)] < (V_{e1}+V_{be1})$$
enough just to cut *Q1* off and cause $i_1 = 0$.

As the potentiometer arm is moved from the base of *Q1* to the base of *Q2*, i_1 varies continuously from $(V_{cr2} - V_{be1})/R5$ to zero, while i_2 varies continuously from zero to $(V_{cr2} - V_{be2})/R5$. This, in effect, provides the required duty cycle variation from 0 to 100%.

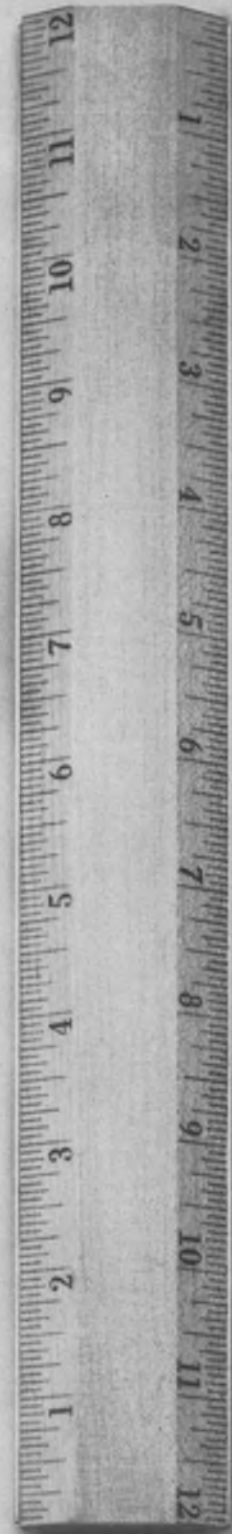
Power switch puts the finishing touch

The complete brilliance control circuit is shown in Fig. 3. The pulse generator output at the collector of *Q4* drives emitter-follower switching transistor *Q5*. During time t_1, the base voltage of *Q5* is slightly less than the power supply voltage by the forward bias voltage drop $i_{b7} R7$. Since $i_{b7} R7 + V_{be5} < V_{cr3} + V_{eb6}$ transistor *Q6* is cut off. Therefore, transistor *Q7* is also cut off and the lamp is off. During time t_2, the collector voltage of *Q4* drops by ΔV_2 volts. The circuit resistance values are selected so that $\Delta V_2 > V_{cr3} + V_{eb6}$.

Since the emitter voltage of *Q5* is clamped to $V_{cc} - V_{cr3} - V_{eb6}$, transistor *Q5* is reverse-biased and so cut off. Resistor *R9* provides forward bias current to switch *Q6* on; this in turn switches *Q7* on, supplying power to the lamp.

The lamp illumination intensity is proportional to its dissipated average power. The average power, P_{AV}, is approximately:
$$P_{AV} = [t_2/(t_1+t_2)](V_{cc})^2/R_{lamp}.$$
Fig. 4 shows how the lamp resistance increases with the applied average voltage. Fig. 5 shows how the filtered lamp illumination intensity increases with the applied average voltage. ■ ■

When you measure operational amplifier value



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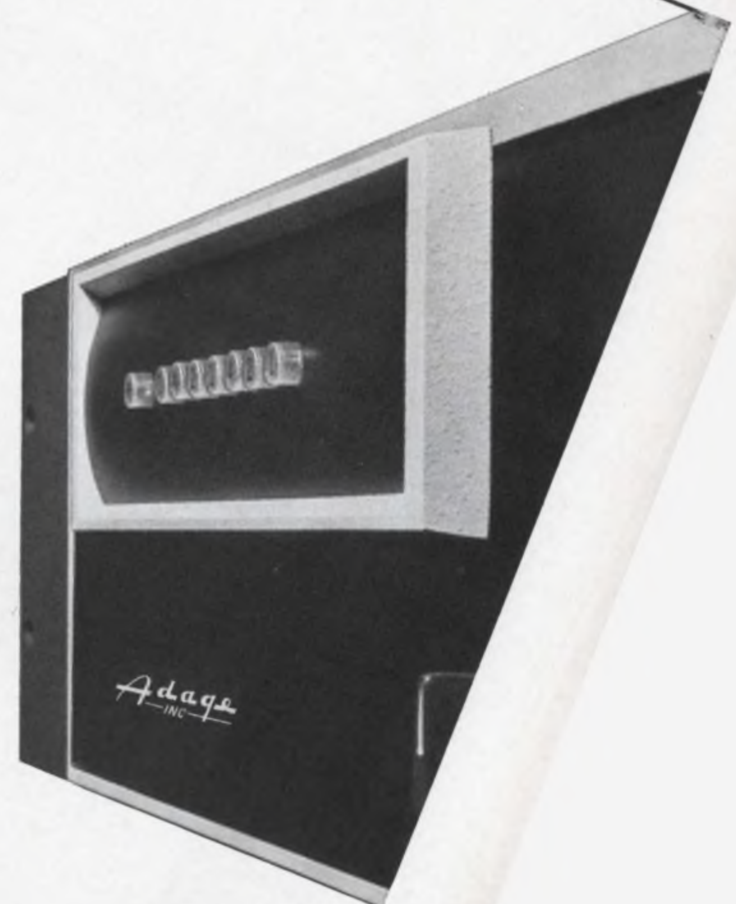

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ON READER-SERVICE CARD CIRCLE 203

Capacitive voltages are found easily

with this simple nomograph which does away with the need for tricky calculations with log table or slide rule.

When performing a transient analysis of a digital circuit, the designer is often interested in knowing the instantaneous value of voltage V_c. This appears across a capacitance, connected across the circuit's output (see schematic), at some arbitrary time after switching begins. He may also want to know how much time is required for this voltage to reach a specified value.

The formula for the first case is:

$$V_c = E(1-\epsilon^{-t/RC});$$

for the other case the formula is:

$$V_c = E\,\epsilon^{-t/RC}.$$

Evaluation of these expressions normally requires either a logarithm table or a good slide rule. The accompanying nomograph, however, eliminates the exponent. It then becomes a simple matter to calculate time constant T from the formula $T = t/RC$, and read out V_c as a percentage of maximum voltage E on the nomograph. Alternatively, t can be calculated if V_c is read into the nomograph as a percentage of E and time constants are read out and applied to the formula $t = TRC$.

Two examples show how to use nomograph

Example 1: Suppose R to be 2 kΩ and C 1000 pF, making sure that the driver gate Z_o and C_o are included in R and C. Assume that E_1 is 5.25 volts and that $V_{CE}(s)$ of the driver gate is 0.25 volt; E is then 5.0 volts. If you need to know the turn-off time required to reach 1.75 volts, subtract 0.25 volt from 1.75 volts. The difference, 1.5 volts, is 30% of 5.0 volts. From the nomograph, 30% E = $0.35T$. From the formula $t = TRC$:

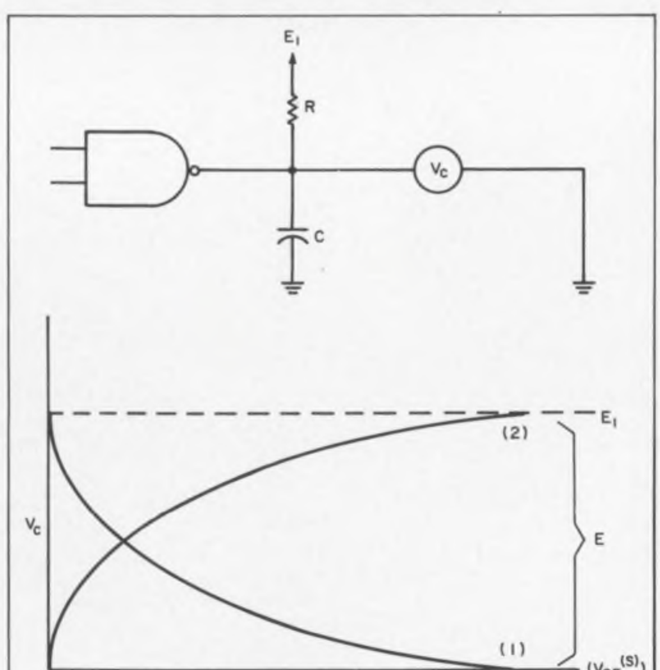
$$t = 0.35\times2\times10^{3}\times10^{-9}$$
$$= 0.7\times10^{-6}\text{ s.}$$

Example 2: Assuming the same conditions as in the previous example, suppose you wish to calculate V_c at 18 ns after the driver output turns on. In addition, assume that output impedance is 10 ohms. (For heavily loaded outputs, the effective resistance $R = Z_o/(1-Z_o/R_L)$, but in this example R_L can be ignored.) From the formula $T = t/RC$:

$$T = (18\times10^{-9})/(10\times10^{-9})$$
$$= 1.8\text{ s.}$$

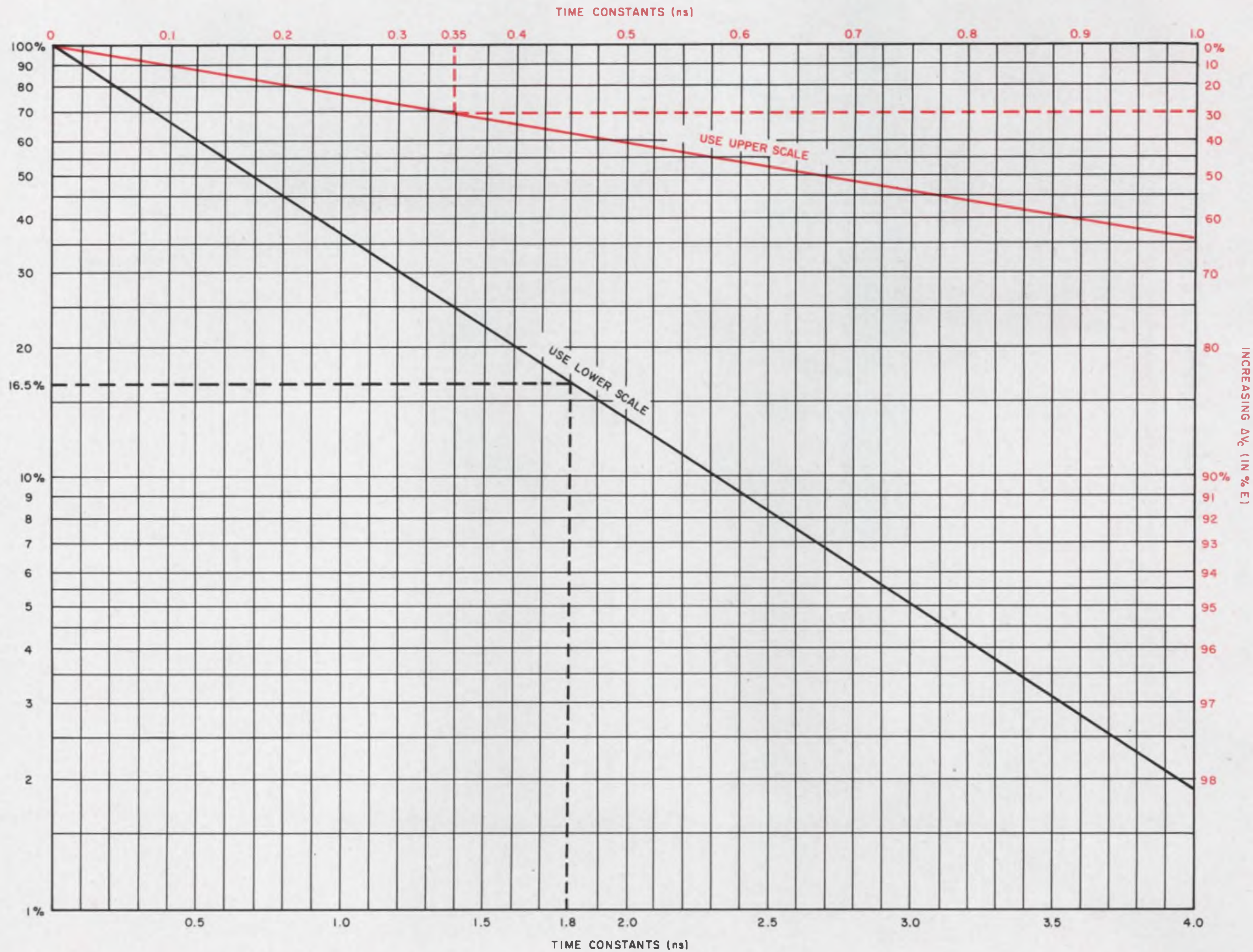
From the nomograph it can be seen that 1.8 T = 16.5% E when V_c = 0.825 volt. Be sure to return to ground reference by adding $V_{CE}(s)$ to V_c. This gives 1.075 volts—the instantaneous output voltage after 18 ns.

Although this nomograph has been applied specifically to digital circuitry, its use is certainly not restricted to this type of circuitry alone. The nomograph will find capacitive voltages in a wide variety of other circuits. ■ ■



Finding the instantaneous voltage across C is simple with the accompanying nomograph. The steps involved are straightforward and avoid the need for error-prone manual calculations with slide rule or log tables.

Arvid Rosenboom, Engineer, Signetics Corp., Sunnyvale, Calif.


TIME CONSTANTS (ns)
0
0.1
0.2
0.3
0.35
0.4
0.5
0.6
0.7
0.8
0.9
1.0
100%
90
80
70
60
50
40
30
20
16.5%
10%
9
8
7
6
5
4
3
2
1%
0%
10
20
30
40
50
60
70
80
90%
91
92
93
94
95
96
97
98
USE UPPER SCALE
USE LOWER SCALE
DECREASING ΔV_C (IN % E)
INCREASING ΔV_C (IN % E)
0.5
1.0
1.5
1.8
2.0
2.5
3.0
3.5
4.0
TIME CONSTANTS (ns)

Cut the 'noise' out of your next article

and editors will beat a path to your typewriter. A good manuscript distills the essence from your work.

We are told that 90 per cent of all the scientists who have ever lived are living today—and writing! The technical information available more than doubles every 10 years; about 100,000 journals in more than 60 languages are published throughout the world, and the number doubles every 15 years. This plethora of paper has elicited from scientist Albert Szent-Györgyi this whimsical definition: "A drug is a substance which, if injected into an animal, produces a paper." As an engineer, you know the problem of keeping abreast of technology.

Accept your obligation to publish—in the most readable form—data that are useful, but bury forever the manuscript that only adds to the confusion.

Consider your writing job as you would any design task. A published article is one part of an information link. The information source is your storehouse of knowledge on the subject and the references you will use for your article. The transmitter is, of course, you, the author. The channel is the medium you select. The receiver of the signal you send is your reader and it is he who will apply the new knowledge you impart.

"There is a great discovery still to be made in Literature, that of paying literary men by the quantity they do not write."

Thomas Carlyle

To help the reader get the point, you must eliminate all interference, which is anything that hinders his understanding of the subject. Interference may be a missing signal: if you have not supplied the reader with all the details, he will be forced to supply the missing ones himself—and he may do so wrongly. Interference may be a term he does not understand, a formula or drawing that is not clear, or just plain involved writing. Your job is to design into your system the lowest possible interference level to ensure maximum signal reception.

Most poor technical writing suffers from the same shortcoming—poor organization. You are familiar with the report or article that seems to have something to say, but even after reading it several times, you are not sure what. Organization is usually the problem. And often, the solution is simple. Ask yourself, "What point am I trying to make in my article?" Then organize your material in such a manner that the point is unmistakable.

"The place for a writer to work is in his head."

Ernest Hemingway

Good communication is a state of mind. You can communicate, if you put your mind to it. What is the purpose of your article? Why are you writing it in the first place? What is your main concept?

Put the most important points first. Do not back into the subject. Your busy reader may not have time to follow you. Take a direct approach. Do not go off on interesting but distracting side tracks. You can get back to them later if necessary. Before you put a word on paper, try to summarize your message in one succinct statement.

Organize your information by drafting a good outline—either in your head or preferably on paper. Then follow that outline when you write. Keep in mind the what, why, when, where, who, how, and so what of your thesis. The outline, which serves as the framework of your article, should be built carefully. These steps will help in its preparation:

- Jot down on paper each idea as it comes to mind, disregarding its importance in the final draft.
- Classify these ideas into major ideas or groups and subgroups.
- Arrange the subgroups into logical order under the main groups.
- Check the completed outline for sequence, importance, duplications, omissions, clarity.
- Rearrange and make changes as needed.

Begin your outline before you finish your project. Then you will be sure to have collected all the data necessary for a good paper. Spend as much time as possible organizing the article while it is in the outline stage; you will save a lot of time rewriting later.

Arrange your ideas so that your reader can

Dewey E. Olson, Manager of Engineering Publications, IBM Systems Development Div., Rochester, Minn.

easily follow the development of your message. Be sure to write ideas, not just verbiage. As you expand your outline into paragraphs, keep one idea to a paragraph and be sure that each paragraph has a topic sentence. If your organization is good, your article will flow smoothly. If it does not, go back and check the organization. Organize according to five steps to successful salesmanship:

- Gain attention with a succinct, informative and pertinent first sentence. For example, you may begin with: "A new approach to integrated-circuit design may halve the cost of your next logic syssem." You can be pretty sure that your reader will want to find out what your new approach is.
- Arouse interest by telling your reader how he will benefit from your article—and tell him early.
- Induce conviction by appealing to your reader's mind, not his emotions. He wants facts. Why is your approach better? Why should he use it? Do not just unload facts on an unsuspecting reader, though. Analyze them for him.
- Create desire by clearly showing your reader how he can use your idea to help him solve everyday problems. Tell him why your idea works.
- Get action by spelling out the steps that will produce the desired result. Do not present "obvious" conclusions that are not obvious to your reader. Do not insult his intelligence, but do not assume he is gifted with extrasensory perception.

"A sentence should read as if the author, had he held a plow instead of a pen, could have drawn a furrow deep and straight to the end."

Henry David Thoreau

When you are ready to write, be sure you start at the beginning. Someone outside your specialty may need an orientation; therefore, you must give him sufficient background in the introduction. You must walk the fine line between two extremes: do not give so little detail that your reader is readily lost or does not really grasp the significance of your paper, nor give so much detail that your reader is bored.

The main body of your paper tells your technical story—how the device works, the experimental setup, the method, the analysis. Use it to provide informative copy and to answer your reader's questions about your project. Most engineers have little trouble writing this section. You know more about how your circuit works than anyone else. You know why your design offers advantages.

Good subheadings help the reader

Use subheadings to break up your article. If you do not, the editor will, so you may as well express your preference. Subheadings indicate organization to the reader who only scans the article. They emphasize the main points of what you have to say. They also help the busy reader find his place again if he is interrupted.

Organization of the main body of your article depends on your subject. An article describing a process, for example, takes a different shape from one describing a device or circuit. If, for instance, you are describing the operating theory of a circuit or device, state precisely how it works, what it can do well and why one method was chosen over others.

"It has always been much like writing a check . . . It is easy to write a check if you have enough money in the bank, and writing comes more easily if you have something to say."

Sholem Asch

Sometimes it will be necessary to describe the experimental or analytical setup you used to obtain your data, since the reader may evaluate your conclusion in the light of how you accumulated your data. For the same reason, you may be required to describe in detail how you actually performed the experiment or made the analysis. Present the necessary details, analyze the data, and explain how you reached your conclusions.

Unless your particular article calls for a special approach, try to emphasize the important findings rather than the techniques used. Try to make your article instructional rather than purely descriptive. One of the most telling ways to make a point is with an appropriate analogy. Do not be afraid to permit a conscious inaccuracy if it aids understanding. In other words, it may not be completely accurate to draw an analogy between water flowing through a pipe and electrons traveling along a conductor, but such an analogy may make the reader grasp your point more easily.

Be positive, be natural, be confident. To be a successful writer, you must develop a successful style. What is style? Jonathan Swift defined style as "proper words in proper places." Maybe it is just that simple.

When an engineer talks about his paper, he usually has no trouble expressing his complex idea in simple terms. Often, however, he clouds things as soon as he tries to put his thoughts on paper. The permanence of the written word makes him want everything to be just right. So it should be. But avoid being pompous or self-conscious on paper. And above all, do not complicate your treatment of your subject.

Study the styles that have made certain writers effective communicators. Consciously analyze the techniques that made a paper, magazine article, or other written communication memorable. When you read something that you particularly like, go back to see how the writer stated his case.

The author E. B. White said, "Write in a way that comes naturally." For most people, it works. Do not try to impress, just say what you have to say. Keep in mind that your reason for writing is to inform. Write to be understood.

"By being so long in the lowest form [at Harrow School] I gained an immense advantage over the cleverer boys. . . . I got into my bones the essential structure of the ordinary British sentence—which is a noble thing."

Sir Winston Churchill

There is no short cut to good writing. Writing is an art rather than a science. Considerable time and effort are required to learn to write well. But the simpler you keep it, the less trouble you will get into. Most engineers have an idea of good sentence construction, basic subject-verb-object order, agreement of verbs. Most engineers can spell (or have secretaries who can). Punctuation is important, but not the insurmountable problem your English teacher made it. What is the secret, then? Keep sentences simple and make them live.

One way to add vitality is to write in the active voice rather than the passive voice. Instead of saying "x is exceeded by y," say "y exceeds x." The sentence is not only shorter but also livelier.

Just as you should not back into your subject matter by starting your article with unimportant details, do not back into your sentences or paragraphs, either. For example, in this sentence the most important element is buried: "The continual need for minor adjustments is eliminated through pinpoint calibration of the power supply." Rather say, "Pinpoint calibration of the power supply eliminates minor adjustments."

Short, crisp, fresh words have impact. Make room for them by avoiding longer, more pedantic words. Concrete words rather than intangible concepts can enliven writing. They help you to have impact by telling your reader not merely the theory behind something, but also what happened, how it happened, and what made it happen.

" 'When I use a word,' Humpty-Dumpty said, 'it means just what I choose it to mean—neither more nor less.' "

Lewis Carroll

There exists no advice that will instantly transform an illiterate into a great writer. The road to good writing is strewn with discarded pages, paragraphs, sentences and words pruned from manuscripts. It is no exaggeration to say that one of the writer's best friends is his wastepaper basket. There are, however, a number of simple procedures that will improve the presentation of a manuscript and, hence, its chances for publication.

Type it with a decent ribbon. Typing should be double-spaced on one side of each page. Leave wide margins so that there is room for an editor's changes. Proofread the manuscript carefully and keep a carbon copy.

Be sure that each page is numbered. Check your illustrations and make certain that your references to them are correct. Do not bind the pages, clip them together. Do not fold the manuscript. If you send photographs, type your caption on a sheet of paper and tape the sheet to the back of the photograph. Do not write on the back of the photograph and do not clip captions to it with staples. Most importantly, submit with the manuscript an outline that briefly describes is contents and explains your reason for writing it.

"We are all apprentices in a craft where no one ever becomes a master."

Ernest Hemingway

We all have some communications faults. Do your best to eliminate whatever yours may be. The technologist is often accused of obscure writing because he packs too much message into too few words—his writing is too dense. The lawyer tries to make his meaning so exact that no one can misinterpret his writing—his writing is too precise. The doctor is accused of using so many complicated terms that only other doctors can read his writing—his writing is too specialized. The scientist is accused of hedging too much to ensure that his results will not be misinterpreted when they are applied to a similar experiment by another scientist—his writing is too qualified.

The engineer is accused of all these faults and others. But you can overcome most communications faults by carefully writing and rewriting your manuscript before you submit it. Let another engineer not connected with your group read your piece. Then find out if he really followed it by having him describe your main ideas back to you. If he can do this—you have communicated. If some points are fuzzy, sharpen up that portion of your explanation.

And remember, despite any suggestions or assistance you may receive from your colleagues or your manager, the paper is yours. Its contents reflect your technical ingenuity; its literary worth reflects your ability to communicate complex ideas. Put your best effort into making the paper accurate, exact, thorough, adequate, and readable. Do what you can to make your article convey your ideas in a manner that is completely intelligible. Then you are on the road to writing well. ■ ■

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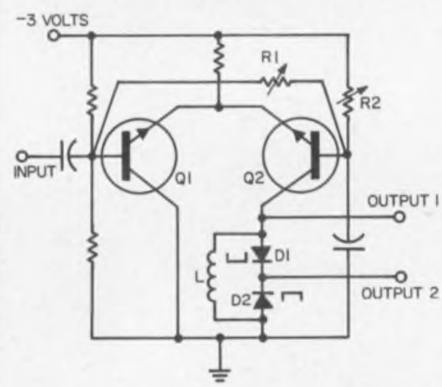
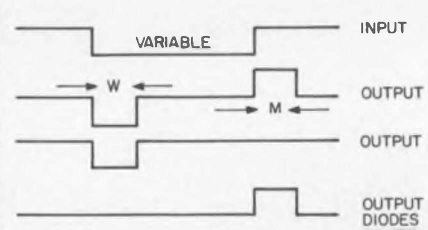
Threshold detector gives ns pulses

Problem: Generate fixed-duration output pulses in the nanosecond range at input pulse repetition rates up to 5 MHz.

Solution: A solid-state device consisting of two tunnel diodes back-to-back in parallel, with an inductance driven by a constant-current generator. Input pulses of variable width in the nanosecond range yield output pulses of fixed width. The circuit produces pulse repetition rates in the megacycle range and has low power drain.





Stages Q_1 and Q_2, together with tunnel diodes D_1 and D_2 form the threshold detector circuit. The voltage across D_1 switches to its high-voltage state and produces the output pulse W whenever the input exceeds the threshold level. Diode D_2 remains in its low-voltage state and presents a very low impedance. The current through inductance L, starting at zero, will increase with time, thereby decreasing current flow through D_1 and D_2. The voltage across D_1 will decrease to near zero and D_1 will switch to its low-voltage state at a point in time when most of the current is flowing through L.

(continued on p. 276)

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The output voltage will be approximately zero for the remainder of the input pulse.

As the input pulse reaches zero, current through L now flows through D_1 and D_2 in the opposite direction, causing D_2 to switch to its high-voltage state and produce the output pulse M as D_1 remains in its low-voltage state.

The threshold level in D_1 and D_2 is set with R_1 and R_2. The value of L determines the output pulse width. The circuit configuration shown yielded 50-nsec pulses for an inductance of 56 μH.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Md., 20771. (B65-10310).

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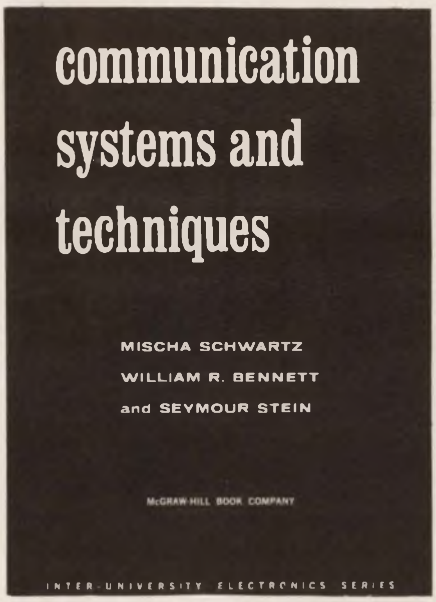
Book Reviews



New communications reference is team effort

Communications Systems and Techniques, Mischa Schwartz, William R. Bennett and Seymour Stein (McGraw-Hill Book Company, New York, N. Y.), 618 pp. $16.50.

Practicing communications engineers should find this new volume a useful reference source. Designed to serve as both a graduate text and a reference for the experienced engineer, the book provides an interesting mixture of both the theoretical and practical aspects of communications.

Each of the book's three authors prepared one section of the three-section volume.

Part I, by Schwartz, summarizes the fundamental aspects of modern communication theory and then develops applications to pulse and continuous wave systems. This section covers general tutorial material, statistical communication theory as applied to digital communications, cw communications, and a comparison of AM and FM.

Part II, by Bennett, develops in detail the technology of modern communications systems. This section covers amplitude modulation and related cw systems, angle modulation in cw systems, and pulse modulation.

(continued on p. 278)

Part III, by Stein, discusses basic binary communication techniques, general analysis of single-channel binary systems in additive noise, fading communication media, linear diversity combining techniques, and decision-oriented diversity for digital transmission.

—*Joseph J. Casazza*

Magnetoelectric devices

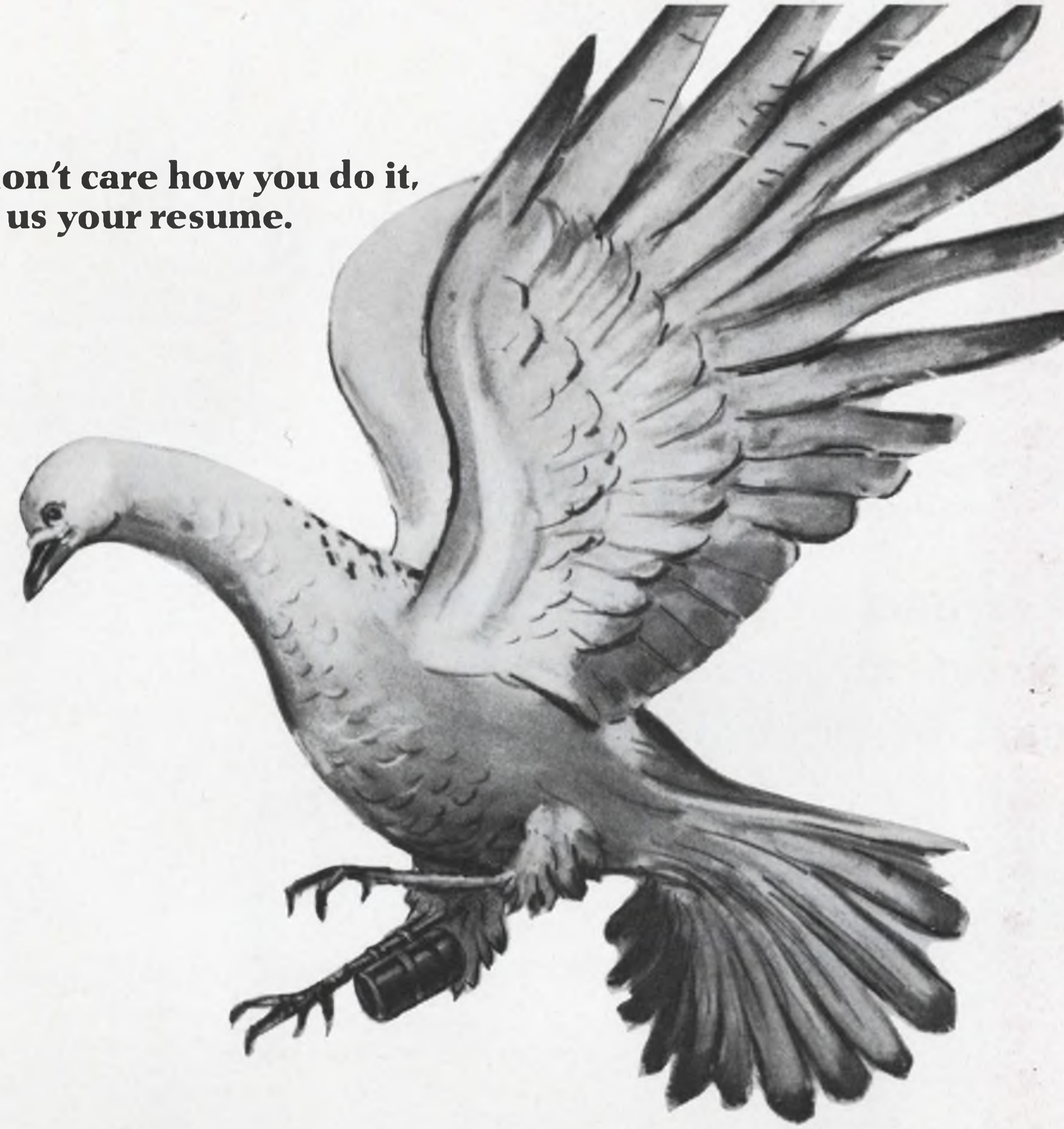
Magnetoelectric Devices: Transducers, Transformers, and Machines, Gordon R. Slemon (John Wiley & Sons, New York), 544 pp. $11.50.

This introduction to magnetoelectric devices is concerned with understanding, modeling, analyzing and designing those devices that are used to convert, transform and control electrical energy. Included are transducers, actuators, transformers, magnetic amplifiers and rotating machines. The book concentrates on an engineering rather than solely an applied-mathematics approach. A large part of the book is devoted to the development of analytical models for devices, usually in the form of equivalent circuits. A number of problems, some with answers, are given at the end of each chapter as an aid to study.

Linear circuits

Principles of Linear Circuits, Eric A. Faulkner (Barnes & Noble, New York), 116 pp. $4.50.

Here is a compact and logical presentation of the basic principles involved in the design and analysis of linear ac and dc circuits. Particular attention is paid to the properties of the linear amplifier and its use in feedback systems. Although no practical designs are described in detail, the discussion is oriented toward practical applications and includes an account of the characteristics of silicon junction transistors and the methods by which they are biased for use in linear circuits.



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Testing reference guide

Electronic Testing, compiled and edited by L. L. Farkas (McGraw-Hill, New York), 304 pp. $12.00.

For the advanced engineer or technician as well as for the student, this is a practical guide to all major types of electronic equipment, their uses, and methods for aligning them and for testing their performance. It is written in clear and simple style, has numerous illustrations and employs a minimum of mathematics.

The 14 chapters are divided into three major parts: Receiving and Transmitting Equipment, Special Equipment, and Computers. Among the recent advances covered are digital-computer circuitry and troubleshooting techniques, display methods, and ordnance systems. Previously unpublished material is contained in chapters on such special topics as radio frequency interference, ordnance devices and systems, and digital-computer testing.

Mathematics for engineers

Matrices and Linear Transformations, Charles G. Cullen (Addison-Wesley, Reading, Mass.), 227 pp. $8.95.

The first five chapters of this book comprise a one-term text for science, engineering and mathematics students that covers those topics most frequently encountered in applications. The text approaches its subject from the matrix-theory point of view rather than from the more abstract approach using linear transformations. Vector spaces and linear transformations are nevertheless treated extensively, and carefully related to matrices. Key features include spectral theory and the Jordan form, the solution of the matrix equation $AX=XB$, matrix analysis and numerical methods, and numerous problems, many with answers.

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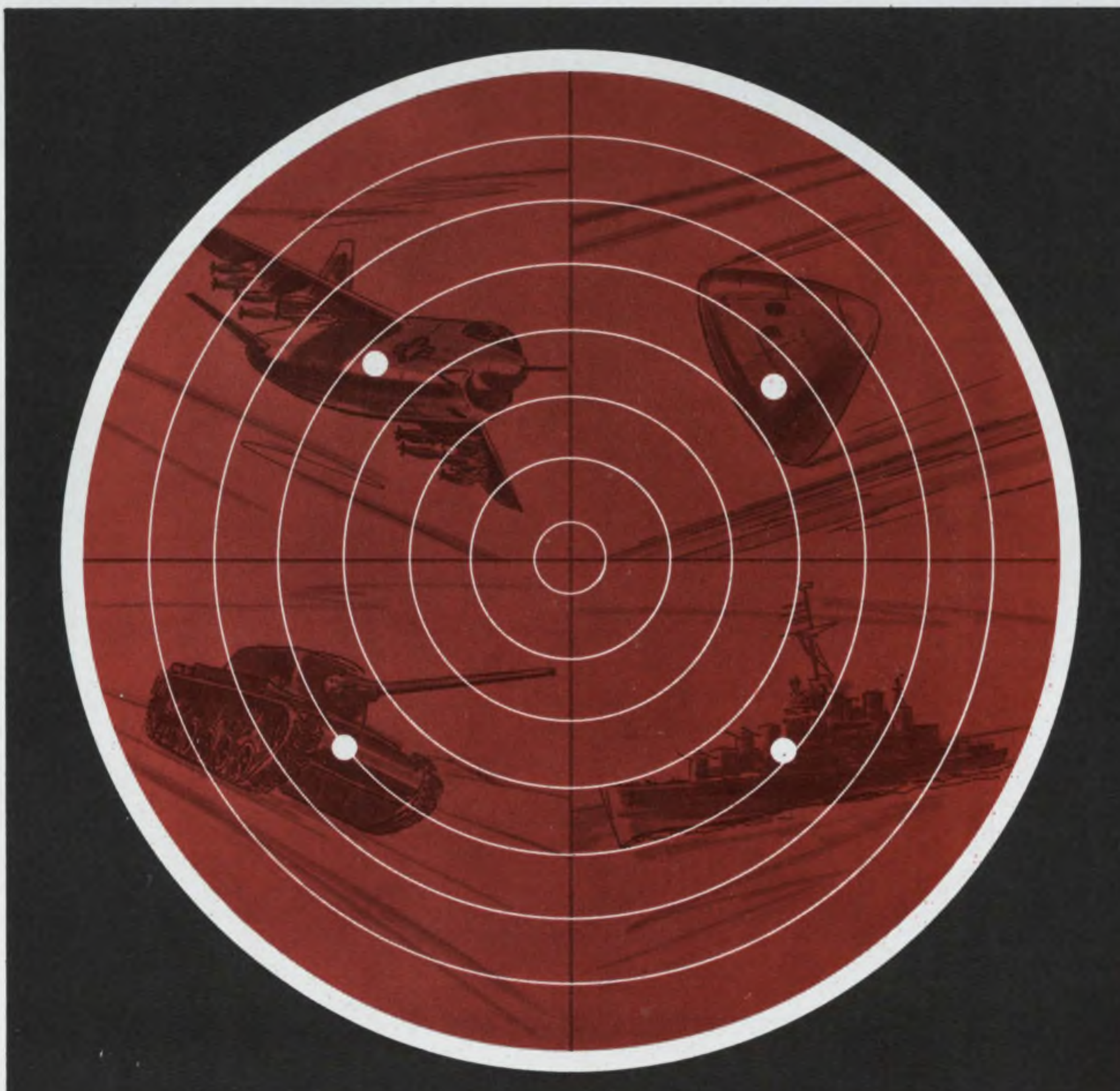


Tunnel diode, shunted with a resistor, shapes pulses

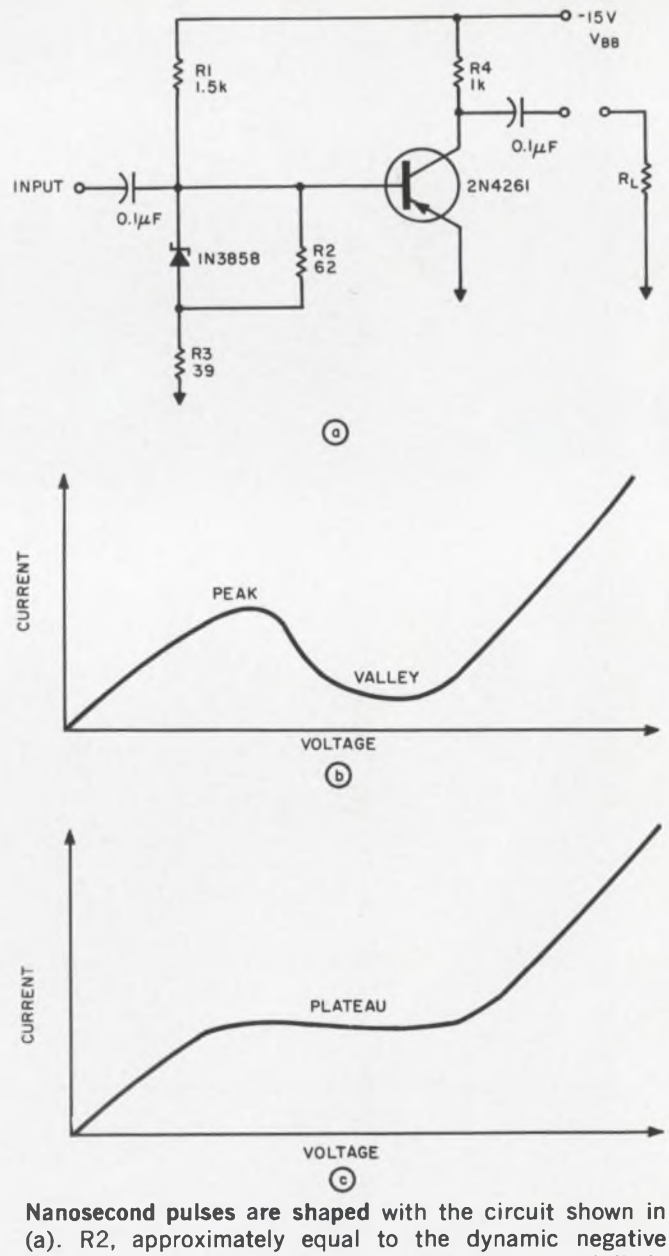
A nanosecond, pulse-shaping circuit fulfills the need for a simple means of sharpening the leading edge of relatively slow rise-time pulses. It is a modification of the well-known technique of pulse-sharpening by shunting a tunnel diode from the switching-transistor base to the emitter. This latter technique requires a reasonable matching of tunnel diode and transistor characteristics. The addition of resistors *R2* and *R3*, however, makes this requirement considerably less exacting and allows greater freedom of component choice.

The circuit shown in Fig. 1a was capable of output pulse rise times of less than two nanoseconds when driven by a slower input pulse. The output voltage was limited approximately by the ratio of load resistance R_L to collector load resistance *R4*, which in turn was limited by the current capabilities of the transistor.

The following design procedure is simple and allows construction of the circuit from a wide variety of components. Select *R4* on the basis of transistor current specifications. Next choose a voltage drop across *R3* and a tunnel diode such that the sum of this drop and the tunnel-diode valley voltage add up to the $V_{BE(sat)}$ of the transistor, while this sum added to the tunnel diode peak voltage equals a value corresponding to a low state of transistor conduction. This choice ensures that the transistor will go into saturation from the cutoff condition when the tunnel diode changes state.

Now divide the voltage drop across *R3* by the tunnel-diode peak current. This yields the value of *R3*. It is assumed that the sum of currents through the tunnel diode and resistor *R2* equals the tunnel-diode peak current and remains constant. This is an important condition which is explained in greater detail below. Resistor *R1* is determined by the tunnel-diode peak current and voltage difference, $V_{BB} - V_{BE(sat)}$. Since the tunnel diode is shunted by finite resistance *R2*, the actual current through it is less than the peak value and it normally remains in the low state.

Resistor *R2* has a key role. It is selected to be approximately equal to the diode dynamic, negative resistance. It provides a current bypass so that, when the diode changes states, the sum of currents through the diode and resistor *R2* remains constant. Consequently, the current through



Nanosecond pulses are shaped with the circuit shown in (a). R2, approximately equal to the dynamic negative resistance of the diode, changes the familiar tunnel-diode IV-curve (b) to the one with a constant-current plateau (c).

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R3, and hence the voltage drop, are constant. This is the condition initially assumed for circuit operation.

Bypassing the tunnel diode with this particular value of resistance *R2* changes its current-voltage characteristic from the familiar negative resistance shape (see Fig. 1b) to that shown in Fig. 1c. The negative resistance shape has degenerated into a constant-current "flat" in the characteristic. It is this constant-current plateau that makes V_{BE} step a predictable, known increment when the tunnel diode changes state.

The value of *R2* should be chosen to be slightly greater than the diode dynamic, negative resistance so that the constant-current plateau has enough negative slope to make the diode switch rapidly. Otherwise, no use is made of the fast switching property of the tunnel diode.

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

VOTE FOR 110

Motor has dynamic braking with a two-wire control

In *400 Ideas for Design,*[1] DeFir shows how two-wire control of a limit-switched motor can be accomplished by use of two diodes. His circuit is adequate provided that the motor does not coast after hitting the limit switch. If dynamic braking is required to ensure rapid deceleration after hitting a limit switch, two additional diodes, *CR3* and *CR4*, are needed, as shown in the accompanying figure. The limit switches must be of the spdt type.

Assuming the current directions shown, if *Terminal 1* is positive, the motor will run in a down direction until the down limit switch *LS1* is activated. When *LS1* is activated, current flow from the control unit is blocked by *CR1;* dynamic braking is achieved by allowing braking current to flow through the NO contact of *LS1*, the braking resistor and *CR4*.

If *Terminal 2* is positive, current will flow through the NC contact of *LS2*, the motor armature and *CR1* back to the control unit. Thus the motor will run in the up direction. Current flow through the braking resistor is prevented by *CR4* until the up limit switch *LS2* is activated. When *LS2* is activated, current flow from the control unit is blocked by *CR2*, and dynamic braking is achieved by allowing braking current to flow through the NO contact of *LS2*, the braking resistor and *CR4*.

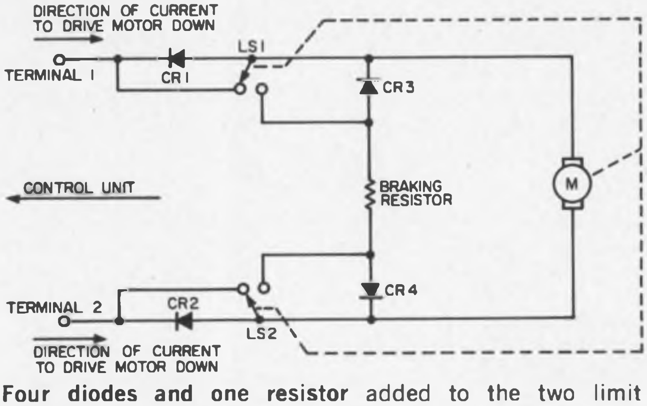
In this application, the motor coasted past the limit switch arms until *CR3*, *CR4* and the braking resistor were added to the circuit.

Reference:

1. Charles C. DeFir, "Diodes Allow Two-Wire Control of Limit-Switched Motor," *400 Ideas for Design* (New York: Hayden Book Co., Inc., 1964), p. 99.

Dr. George E. Cook, Vice President, Merrick Engineering, Inc., Nashville, Tenn.

VOTE FOR 111

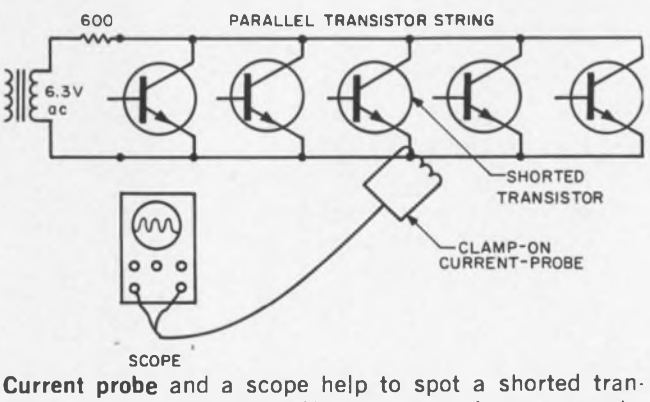


Four diodes and one resistor added to the two limit switches provide dynamic braking.

Probe spots shorted transistor in a parallel string

A current probe and a source of low-voltage ac are all that is needed to spot a shorted transistor in a parallel string.

Ordinarily, the transistors might be disconnected for individual testing—a time-consuming task. Instead, the string can be hooked up as shown to pass about 10 mA of ac. The current probe is then used to check for current flowing through the



Current probe and a scope help to spot a shorted transistor in a parallel string. Note the use of an ac supply.

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emitter or collector of each transistor. The majority of the current will be found in the leads of the shorted transistor, pinpointing the defect.

J. A. Wisnia, Project Engineer, Comstock and Wescott, Inc., Cambridge, Mass.

VOTE FOR 112

16-bit matrix built with four IC packages

X-Y matrices are utilized in any application where a two-register or any other dual information source is used to select a given point, as in core memory schemes.

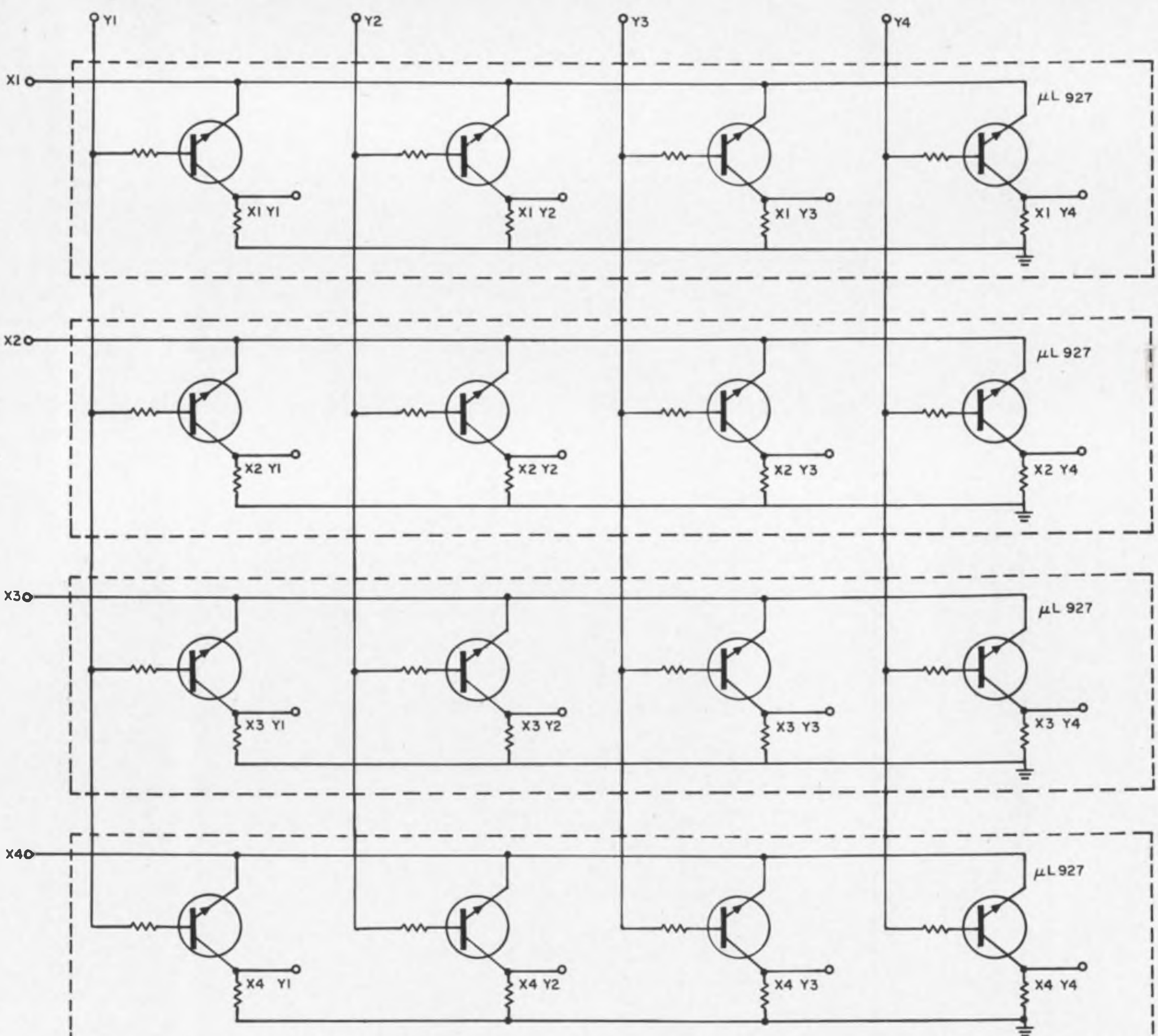
The conventional approach to implementing this function involves a total of 32 diodes and 16 resistors and has an offset of one diode drop. The four integrated-circuit packages needed to form the 16-bit matrix afford a great saving in component count and board space. The normal diode drop is also eliminated in the integrated-circuit version, since the matrix transistors are operated in the inverse saturation mode.

All *X* lines are strobed by a minus-3-to-5-volt level while ground is required to select the *Y* lines. The selected output is then the *X*-line strobe voltage minus the inverse transistor drop. All lines are terminated in a 640-ohm resistor.

Robert Ricks, Application Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 113

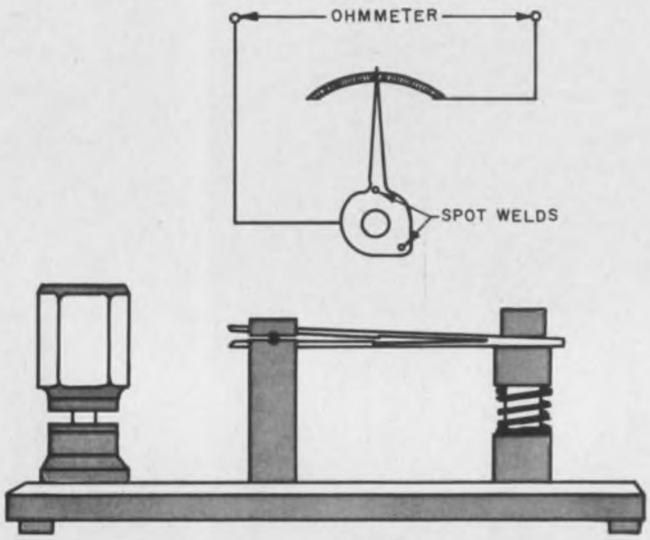
(continued on p. 288)



Integrated 16-bit matrix is built with four μL927 packages. This compares with 32 diodes and 16 resistors which are used in a similar matrix built with discrete components.

Wiper-centering fixture allows easy alignment

When potentiometric instruments are designed to meet high shock and vibration requirements, it is frequently necessary to use a double-wiper configuration. This is particularly the case when small movements must be amplified through a lengthy wiper. Greater wiper travel gives higher resolution, and therefore allows more latitude for such things as linearity corrections. Where very small mechanical displacements are monitored, the designer is often limited to a choice between such a double-wiper configuration and an even less desirable mechanical linkage. The double-wiper potentiometer is useful when its torque level can be tolerated. The primary problem with this type of wiper is establishing and verifying that the two wipers are electrically centered.



Double-wiper blades can be aligned electrically by use of this simple fixture.

This procedure is simplified by use of the fixture shown in the accompanying figure. Both wipers are placed on a spring-loaded post. The lower wiper is held captive in some position while the upper wiper is free to rotate. An ohmmeter is connected to the fixture through the binding posts and will read the average of the two wipers to coil-end resistances. When the wiper post is depressed, the lower wiper will leave the coil and only the upper wiper will be in contact. The difference in readings will indicate misalignment between the two wipers. Adjustment may be made and readings continued until both wipers are on the same turn of the wirewound coil. Then the wipers may be spot-welded to hold this orientation.

Fred W. Kear, Production Engineer, Spartan Southwest, Inc., Albuquerque, N. M.

VOTE FOR 114

Block the sneak paths in a crossbar readout

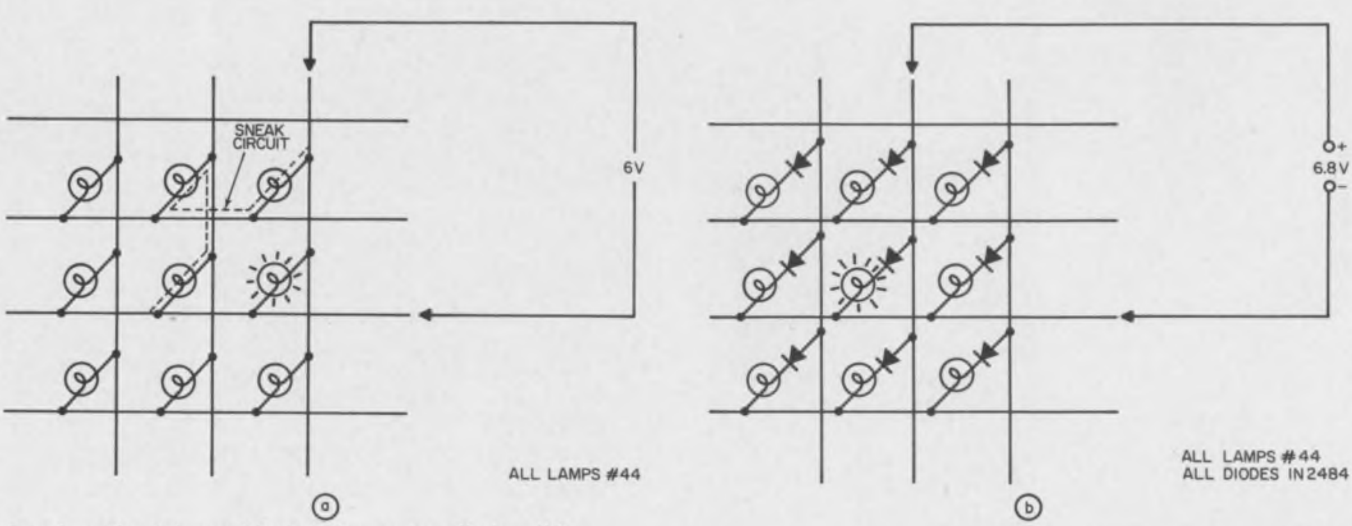
Matrix or crossbar readouts built with neon lamps usually suffer from lack of brightness, particularly under high ambient illumination. If incandescent lamps (such as #44) are used instead, sneak paths occur (Fig. 1a). The addition of diodes in series with each lamp eliminates this problem (Fig. 1b).

In the case of neon lamps, no sneak paths can occur, because each lamp requires some minimum breakdown and maintaining voltages.

The circuit of Fig. 1b can be built with almost any incandescent lamps, provided that the diodes can carry the required current.

Ronald L. Ives, Palo Alto, Calif.

VOTE FOR 115



Sneak paths (a) are blocked by series diodes (b).

Protect your panels from scratches and burrs

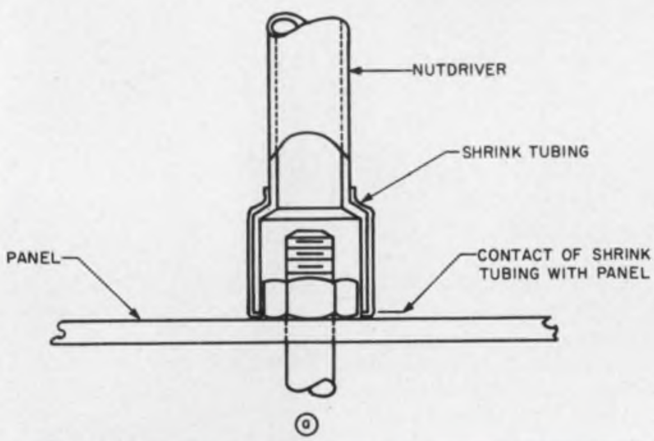
A persistent and annoying problem in assembly operations is the marring of panel surfaces or terminal lugs by the face of the nut-driver head when nuts are being tightened.

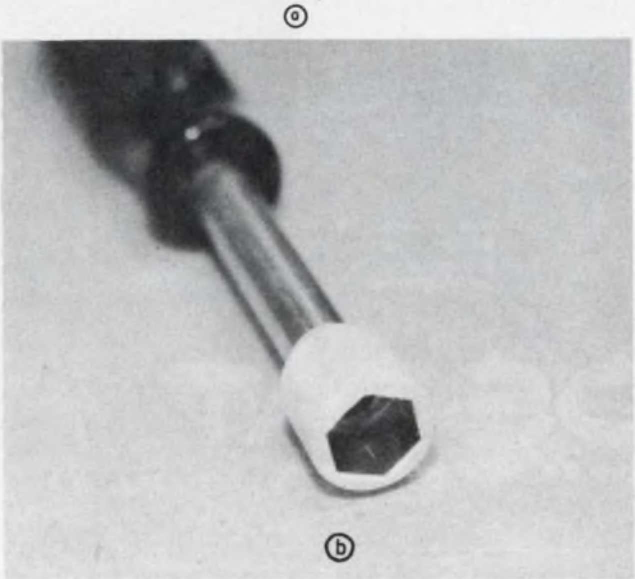
A simple and practical wrinkle to overcome this annoyance (see Figures) is to shrink a piece of shrink tubing over the nut-driver head. Select the proper size tubing and allow sufficient overlap beyond the front edge of the driving head for it to fit snugly round the face of the head when it is recovered. Then trim off the excess tubing overlapping into the interior of the driving head.

This will protect panel surfaces and terminal lugs from being grazed by the driver head.

Milton Dickfoss, Grumman Aircraft Engineering Corp., Bethpage, L. I., N. Y.

VOTE FOR 116



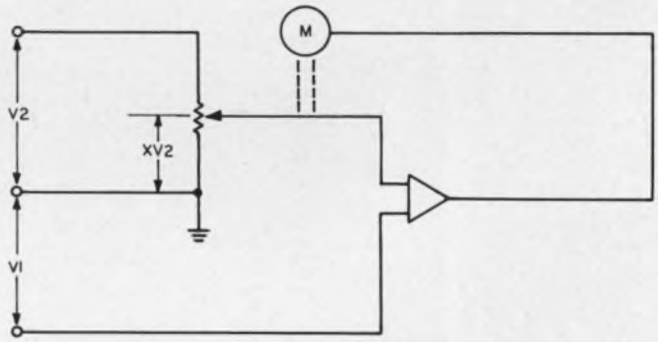


Piece of shrink tubing over the nut-driver head (a) gives the tool a "soft touch" (b).

Standard recorder permits ratios to be read directly

Ratio recording provides a very convenient means for measuring electrical or nonelectrical quantities derived from a quotient of two variables, for example, resistance = voltage/current or heat conductivity = heat flow/temperature difference. The method can also be used to measure resistance changes by means of a bridge circuit, according to the relation $V_o = kRV_i$, where V_o = output voltage, V_i = bridge supply voltage, R = resistance change, and k = constant. If $V_o/V_i = k\,R$ is recorded, fluctuations of the supply voltage are compensated for and do not influence the result.

The basic diagram of a ratio recorder is shown in Fig. 1. The motor will adjust the potentiometer until the input voltage of the differential amplifier is zero. This condition is fulfilled when $xV_2 - V_1 = 0$, or $x = V_1/V_2$. Hence, the position of the potentiometer (and the pen of the recorder) is a direct measure of the quotient V_1/V_2.



Ratio of two voltages can be read out directly by use of any of several commercially available recorders in the above configuration.

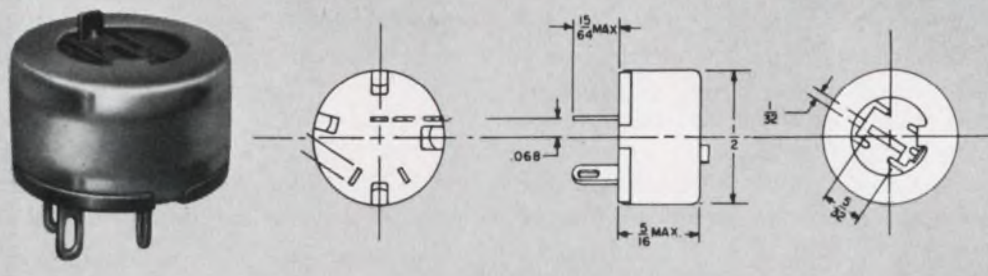
Most potentiometer recorders can easily be converted into ratio recorders. For dc ratio recording, the reference voltage is disconnected and the denominator voltage V_2 is applied to the potentiometer. The chopper has to be bypassed for ac (line frequency) ratio recording. Care must be taken that the voltages V_1 and V_2 are in phase with each other and with the line voltage feeding the two-phase motor.

The accuracy obtained is essentially that of the recorder. At low input levels, however, the accuracy is limited by the finite gain of the amplifier. Tests with a Speedomax-G recorder showed that, when the denominator voltage V_2 was lowered from 1 V to 0.03 V, the error in the quotient remained less than 2%.

A. G. Engelter, Solid State Electronics Div., National Research Institute for Mathematical Sciences, Pretoria, Republic of South Africa.

VOTE FOR 117

TRIMMED



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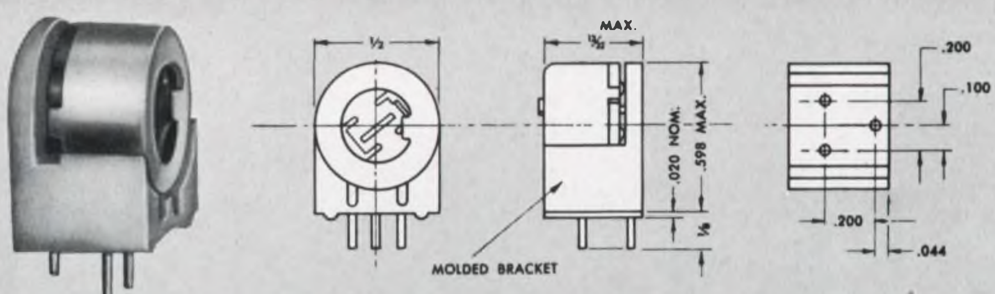

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Resistance Range: 100Ω to 1 Megohm.
Resistance Tolerance: ±20% Standard, ±10% Special.
Power Rating: .375 watt @ 70°C, derated to 0 watt @ 120°C.
Taper: Linear.
Dielectric Strength: Variable arm hot to case.

Working Voltage: 350 Vac maximum.
Mechanical Rotation: 290° ±5°.
Stop Torque: 20 oz.in.
Operating Torque: 7.0 oz. in. maximum.

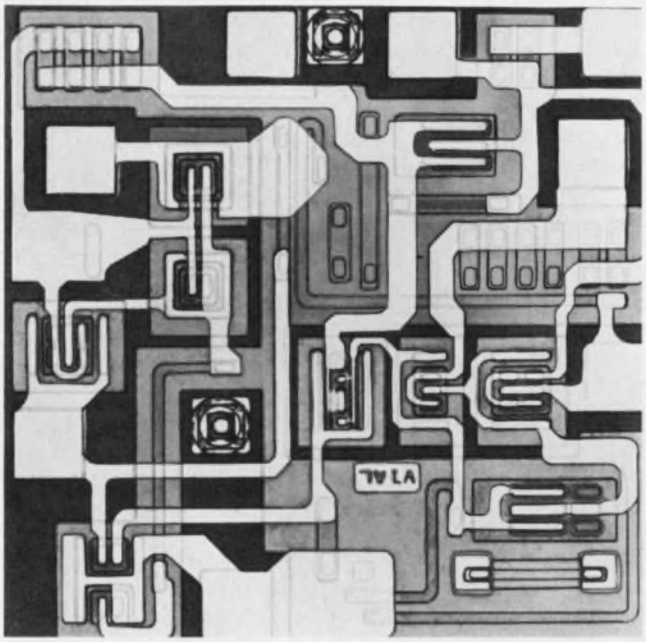
CLAROSTAT

CLAROSTAT MFG. CO., INC. DOVER, NEW HAMPSHIRE

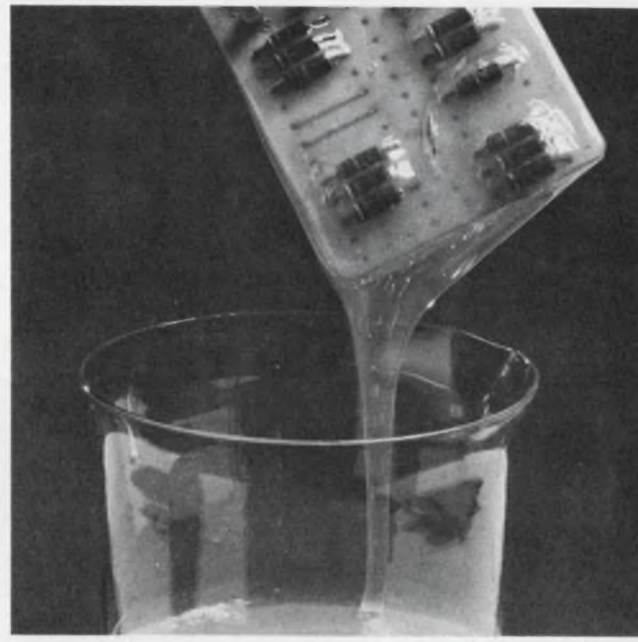
SEE US AT IEEE BOOTH 4H-32

ON READER-SERVICE CARD CIRCLE 211

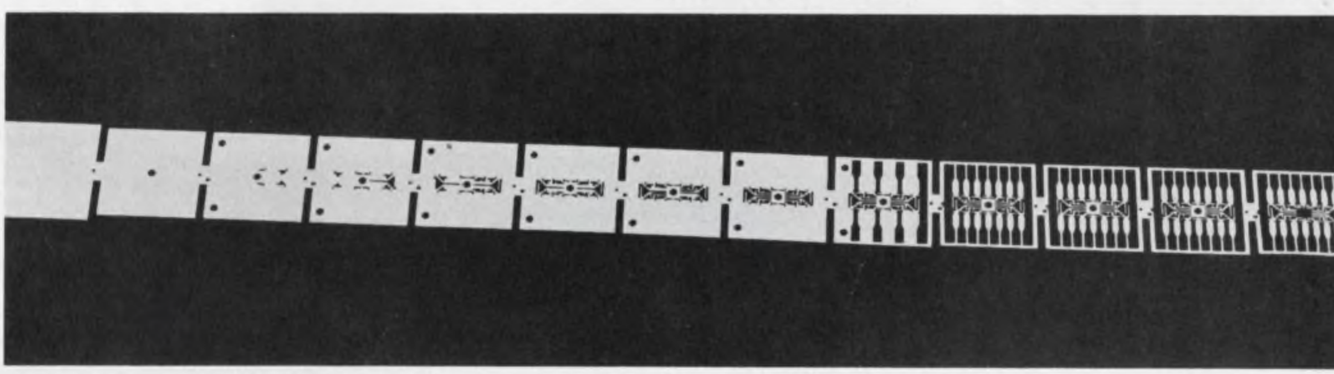
Products



Gain-bandwidth products to 7 GHz are offered by this monolithic video amp. Page 292



One-part silicones cure corrosion free. Acetic acid by-products are eliminated. Page 320



Subminiature Kovar IC frames are stamped by 13-stage progressive carbide dies. The ±0.00001-inch tolerance dies stamp at rates exceeding 200 per parts minute. Page 322

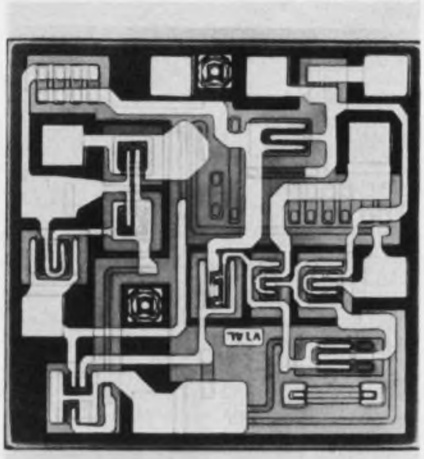
Also in this section:

Rectifier modules can be series-strung for PRVs to 150 kV. Page 302

Analog module multiplies in all four quadrants. Page 306

Design Aids, Page 336 . . . . **Application Notes,** Page 338 . . . . **New Literature,** Page 340

Video amplifier offers high gain



Motorola Semiconductor Products, Inc, P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $8 (over 100); stock.

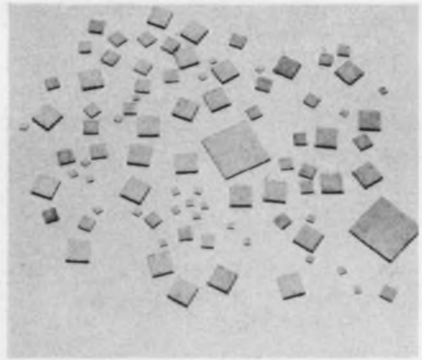
A pair of monolithic integrated video amplifiers offering high gain and wide bandwidth are designed for use as wideband linear or fast-rise pulse amplifiers. While basically the same structure, the pair are internally connected somewhat differently. In addition, each offers two gain-bandwidth combinations selectable by external pin connection. The MC1552G has a nominal gain of 50 or 100 and the MC1553G a choice of 200 or 400. Each gain level provides a different bandwidth (25, 21, 23 and 9 MHz.). The gain features for both devices are stable within ±1 dB. The voltage gain variation with temperature is ±0.2 dB across the range of −55 to 125°C. The dc output voltage variation is ±0.05 dB from −55 to 125°C. Quiescent output voltage is 2.9 V with a ±6 V supply.

The basic circuit is a three-stage direct-coupled common-emitter cascade, incorporating feedback from the third-stage emitter to the first-stage emitter. The output stage is an emitter-follower with a separate dc feedback path to the base of the input transistor. This sets the dc quiescent point so that approximately half the supply voltage appears at the output permitting a maximum output voltage swing for any supply voltage or temperature.

The common emitter configuration gives noise of 5 dB at 30 MHz and a 3-MHz bandwidth.

CIRCLE NO. 567

Capacitor chips available to 180 pF

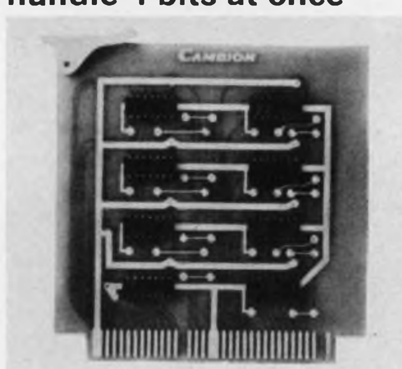


American Lava Corp., Titania Div., Chattanooga, Tenn. Phone: (615) 265-3411. P&A: about $20 in large quantity; stock.

Small capacitor inserts for microminiature and integrated circuits can be supplied in sizes from 0.02 in.^{2} in values to 180 pF. Available electrodes include palladium-gold, platinum-gold, gold and silver. The capacitors are produced from thin sections of high-K temperature-compensating ceramic materials. Dielectric constants range from 6 to 9000.

CIRCLE NO. 568

Binary comparators handle 4 bits at once

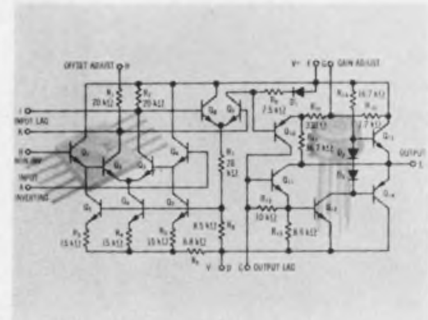


Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 876-2800. P&A: $38.50 (10 to 49); stock.

Designed to determine if one binary number is greater than, equal to, or less than another, this series of binary comparators can compare as many as four bits simultaneously with a single logic assembly, and can be cascaded to permit the comparison of long word lengths. Also available are a one-bit serial comparator and an equal-to comparator.

CIRCLE NO. 569

Op-amp has 60,000 open-loop gain



Motorola Semiconductor Prod., Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: metal can, $15; ceramic flatpack, $19; stock.

Typical open-loop voltage gain of this IC op-amp is 60,000. The output voltage swing is typically ±13 V with a power supply voltage of ±15 V. This large output swing makes the voltage gain usable at higher input levels. The unit can be used as a summing amplifier, an integrator, or for any application requiring an amplifier with operating characteristics as a function of external feedback components. It is available in both the 10-pin metal can and the 1/4 x 1/4-inch ceramic flatpack.

CIRCLE NO. 570

Five-amp power switch is integrated

Vector Div. of United Aircraft Corp., Southampton, Pa. Phone: (215) 355-2700. P&A: $325; 6 wks.

V-1030 integrated power switches use a Darlington circuit with output diode protection. They have built-in thermal protection and are offered in a family of units switching up to 5 A with good LV_{CEO}. The monolithic unit is designed to meet military environments and features switching times of less than 1 μs. Packaging is a standard TO-60. The switches are suited for use with digital power control for motor or servo systems in the military and commercial fields.

Booth No. 4F26 Circle No. 343

Don't forget to return your **ELECTRONIC DESIGN** renewal card.

Marker generators crystal controlled

Jerrold Electronics, 401 Walnut St., P.O. Box 1467, Philadelphia. Phone: (215) 925-9870.

Two marker generators for superimposing crystal-controlled ac or dc marks on scope displays of response curves can be programed to provide any fundamental frequency between 2 and 100 MHz. Rack-mounted Model CM-10 has a frequency range of 100 kHz to 100 MHz. In the higher frequencies (20 to 100 MHz), up to the 20th harmonic will be visible.

CIRCLE NO. 571

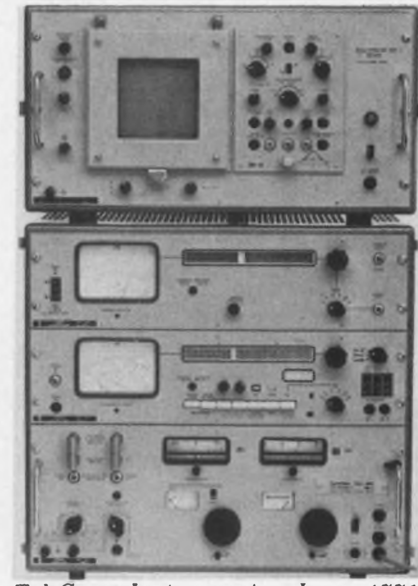
Timing system has high resolution

Nanofast, 416 W. Erie, Chicago. Phone: (312) 943-4223.

Model 535-7C continuous timing system measures the time between input start and stop pulses on a continuous basis. Features are 10-ns resolution and continuous timing with rep rate up to 50 kHz. Included is a 100-kHz preset counter which provides an output and optionally resets the unit when the measured time equals the preset value. Timing range is 10 ns to 0.1 s.

CIRCLE NO. 572

Sweep measuring set ranges 10 kHz to 36 MHz

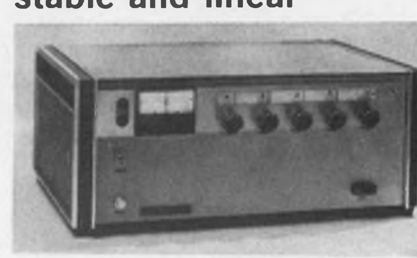


Tel-Com Instruments, Inc., 17715 Chatsworth St., Granada Hills, Calif. Phone: (213) 360-2278.

The manufacturer's level-measuring set and display unit are combined with a plug-in unit to form a sweep measuring set. Automatic level and attenuation measurements of active and passive 4-pole networks, and display of frequency response in the 10-kHz-to-36-MHz range are obtained with this combination. Wideband or narrowband (crystal) devices can be measured.

CIRCLE NO. 573

Digital gaussmeter is stable and linear



Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

A direct field reference, rather than indirect current reference of a power supply, eliminates difficult current cycling procedures in the use of this digital gaussmeter. Field settings up to 30 kilogauss can be repeated to within 50 megagauss with absolute field accuracy of ±0.1%. A temperature-controlled Hall-effect probe is employed.

CIRCLE NO. 574

200,000 OHMS PER VOLT

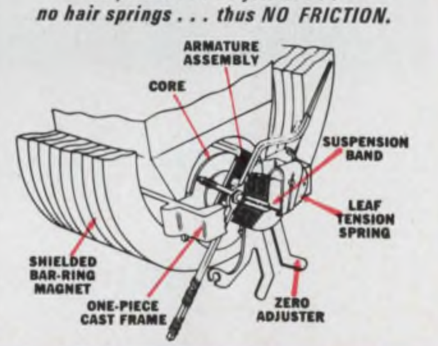
TRIPLETT

Model 630-NS
VOLT-OHM-MICROAMMETER

$100.00
SUGGESTED U.S.A. USER NET

TRIPLETT SUSPENSION MOVEMENT

no pivots . . . no jewels . . . no hair springs . . . thus NO FRICTION.



FACTS MAKE FEATURES

1. 200,000 OHMS PER VOLT D.C. for greater accuracy on high resistance circuits. 20,000 OHMS PER VOLT A.C.
2. 5μa SUSPENSION METER MOVEMENT. No pivots, bearings, hairsprings, or rolling friction. Extremely RUGGED. Greater sensitivity and repeatability.
3. 62 Ranges, usable with frequencies through 100 Kc. Temperature compensated. 1½% D.C. ACCURACY, 3% A.C.

Low voltage ranges and high input impedance make the 630-NS especially useful in transistor circuit measurement and testing. Input impedance, at 55 volts D.C. and above, is *higher than most vacuum tube voltmeters.*

The unit is designed to withstand overloads and offers greater reading accuracy. Reads from 0.1μa on 5μa range. Special resistors are rigidly mounted and directly connected to the switch to form a simplified unit. Carrying cases with stands are priced from $11.00.

TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

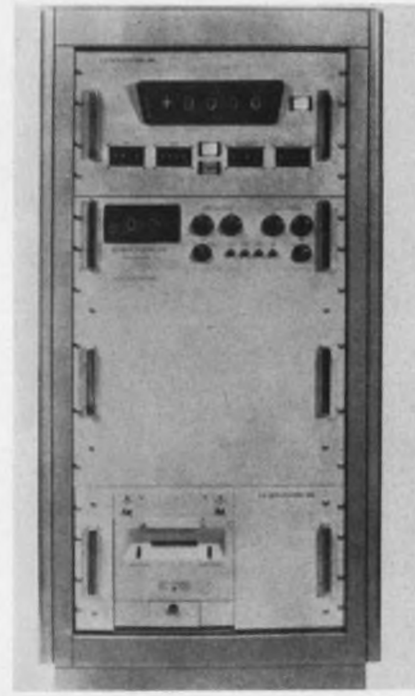
62 RANGES

D.C. VOLTS	0-0.6-3-12-60-300-1200 at 100,000 Ohms/Volt. 0-0.3-1.5-6-30-150-600 at 200,000 Ohms/Volt. 0-0.150 at 60μa
A.C. VOLTS	0-3-12-60-300-1200 at 10,000 Ohms/Volt. 0-1.5-6-30-150-600 at 20,000 Ohms/Volt.
DB	-20 to 77 in 10 ranges.
D.C. MICRO-AMPERES	0-5 at 300 MV. 0-60-600 at 150 MV. 0-120 at 300 MV.
D.C. MILLI-AMPERES	0-6-60-600 at 150 MV. 0-1.2-12-120-1200 at 300 MV.
D.C. AMPERES	0-6 at 150 MV. 0-12 at 300 MV.
OHMS	0-1K-10K-100K (4.4-44-440 at center scale)
MEGOHMS	0-1-10-100 (4400-44,000-440,000 Ohms center scale)

OUTPUT: Condenser in series with A.C. Volt ranges.

THE WORLD'S MOST COMPLETE LINE OF V-O-M'S. AVAILABLE FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK.

Resistance deviation in digital readout



A. D. Data Systems, Inc., 830 Linden Ave., Rochester, N. Y. Phone: (716) 381-2370.

The resistance deviation checker gives a direct digital indication of the deviation between the standard resistor and the resistor under test. This approach eliminates the inherent inaccuracies which result from subtraction of two large numbers to obtain a small difference. These can be arranged to comply with MIL-R-11, MIL-R-22684 and MIL-R-39017 voltage requirement for lower test voltages at higher resistances.

CIRCLE NO. 575

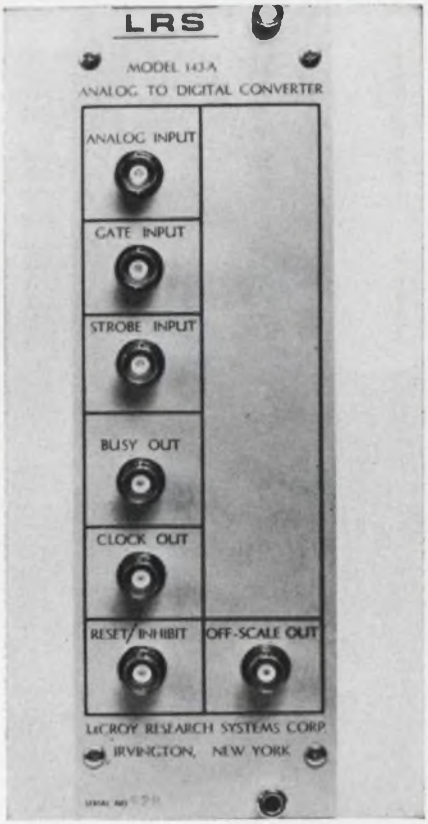
Bridge measures capacity, dissipation

Landis & Gyr, Inc., 45 W. 45th St., New York. Phone: (212) 586-4644.

For checking standard insulations and the newer liquid and solid insulations, this high-sensitivity bridge has operation contingent on 4 capacitors (not resistors) to insure large bridge independence. Measuring range is 0 to 2000 V, measuring frequency is 60 or 50 Hz, dissipation-factor measuring range is 10^{-5} to 10 and capacitance range is 9 to 10,000 pF. Power supply is 110 to 220 V.

CIRCLE NO. 576

A-to-D converter for nanosecond pulses



LeCroy Research Systems Corp., 1 Hayes St., Elmsford, N.Y. Phone: (914) 592-5010.

Designed to digitize nanosecond photomultiplier pulses directly, this A-to-D converter gives direct read-out onto magnetic tape or on-line computer, or into a multichannel analyzer memory. The unit combines a linear gate, stretcher amplifier, amplitude-to-time converter, clock, scaler and output multiplexer in one AEC standard module.

CIRCLE NO. 577

Frequency scaler converts pulse rate

Fischer & Porter Co., 143 Jacksonville Rd., Warminster, Pa. Phone: (215) 675-6000.

You can convert the actual pulse rate from a transmitter or transducer to a more conveniently handled and decimally related pulse rate with this frequency scaler. Several input-output ratios are available. The unit also amplifies and shapes input signals to drive electromechanical counters, batch controllers and printers.

CIRCLE NO. 578

Video amplifier has 5 ranges

American Electronic Laboratories, Inc., P. O. Box 552, Lansdale, Pa. Phone: (215) 822-2929. Price: $495.

This portable, low-noise video amplifier has 5 basic adjustable-bandwidth frequency ranges from 0.5 to 5 MHz. It features a gain of 65 dB at 10 kHz, and an input impedance at 1 MHz of greater than 350 kΩ and less than 10 pF ±10%. A bias supply is built-in with a front panel meter covering 0 to 85 μA in two ranges.
Booth No. 4K11 Circle No. 353

Audio oscillator needs no bandswitching

General Radio Co., West Concord, Mass. Phone: (617) 369-4400. P&A: $325; stock.

"Sync-able" RC oscillators cover the frequency range from 10 Hz to 50 Khz with both sine- and square-wave outputs. The entire frequency range is covered in one turn of the frequency dial, with no bandswitching required. Thus, there are no switching transients and no multipliers or decimal points.

CIRCLE NO. 579

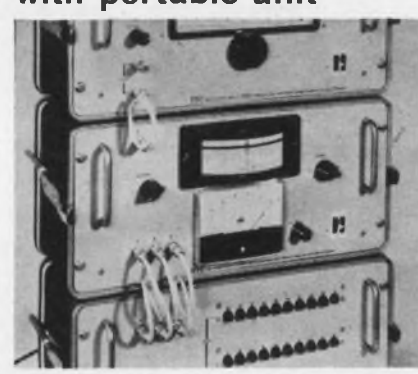
Differential preamp has remote gain control

Scientific-Atlanta, Inc., Box 13654, Atlanta. Phone: (404) 938-2930. P&A: $2275; 90 days.

This remote differential preamplifier for high-impedance transducers has differential or single-ended FET input. Gain is −20 to 60 dB in 10-dB steps. Output is 1 V rms into 75 Ω and is flat to ±1 dB over a max bandwidth of 20 Hz to 2 MHz. Selectable upper and lower cutoff-frequency filters have an 18-dB-per-octave attenuation slope.

CIRCLE NO. 580

Insertion loss test with portable unit



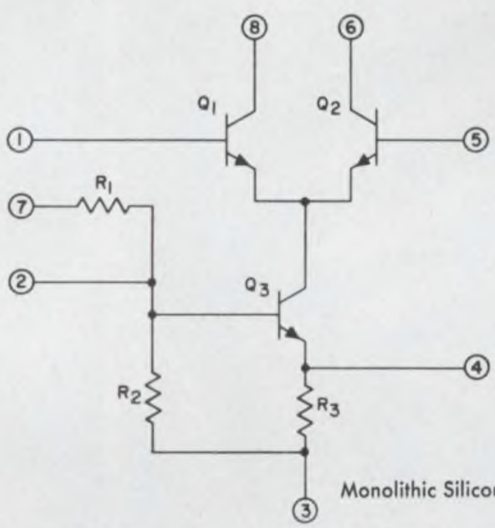
ITT Industrial Products Div., 15191 Bledsoe St., San Fernando, Calif. Phone: (213) 367-6161. Price: $3940.

Equipment to measure the insertion loss of circuits and networks up to 60 dB (and up to 70 dB with lower accuracy) is available. A comparison method of measurement is used, so that the accuracy depends only on passive networks. Three portable units form the complete equipment: a sending unit and a measuring unit, both employing solid-state circuits, and a push-button attenuator.

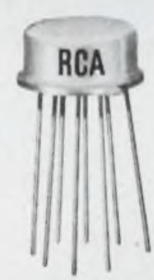
CIRCLE NO. 581

RCA integrated circuits

NOW... Break the "Dollar Barrier" with RF-IF Ampl CA3028 ...98¢ (1,000+)



Monolithic Silicon Integrated Circuit, CA3028



TYPICAL SPECIFICATIONS

Power Gain	@ 10.7 MHz	Cascode	39dB	Differential Ampl 32dB
	@ 100 MHz	Cascode	20dB	Differential Ampl 17dB
Voltage Gain ($R_L = 1K\ \Omega$)	@ 10.7 MHz	Cascode	98	Differential Ampl 32

AGC Range (Max. power output to full cut-off) @ 10.7 MHz 62dB

APPLICATIONS

IF Ampl (differential or cascode)
Converter in the Commercial FM band
Limiter
Mixer
Oscillator

AVAILABILITY FROM STOCK

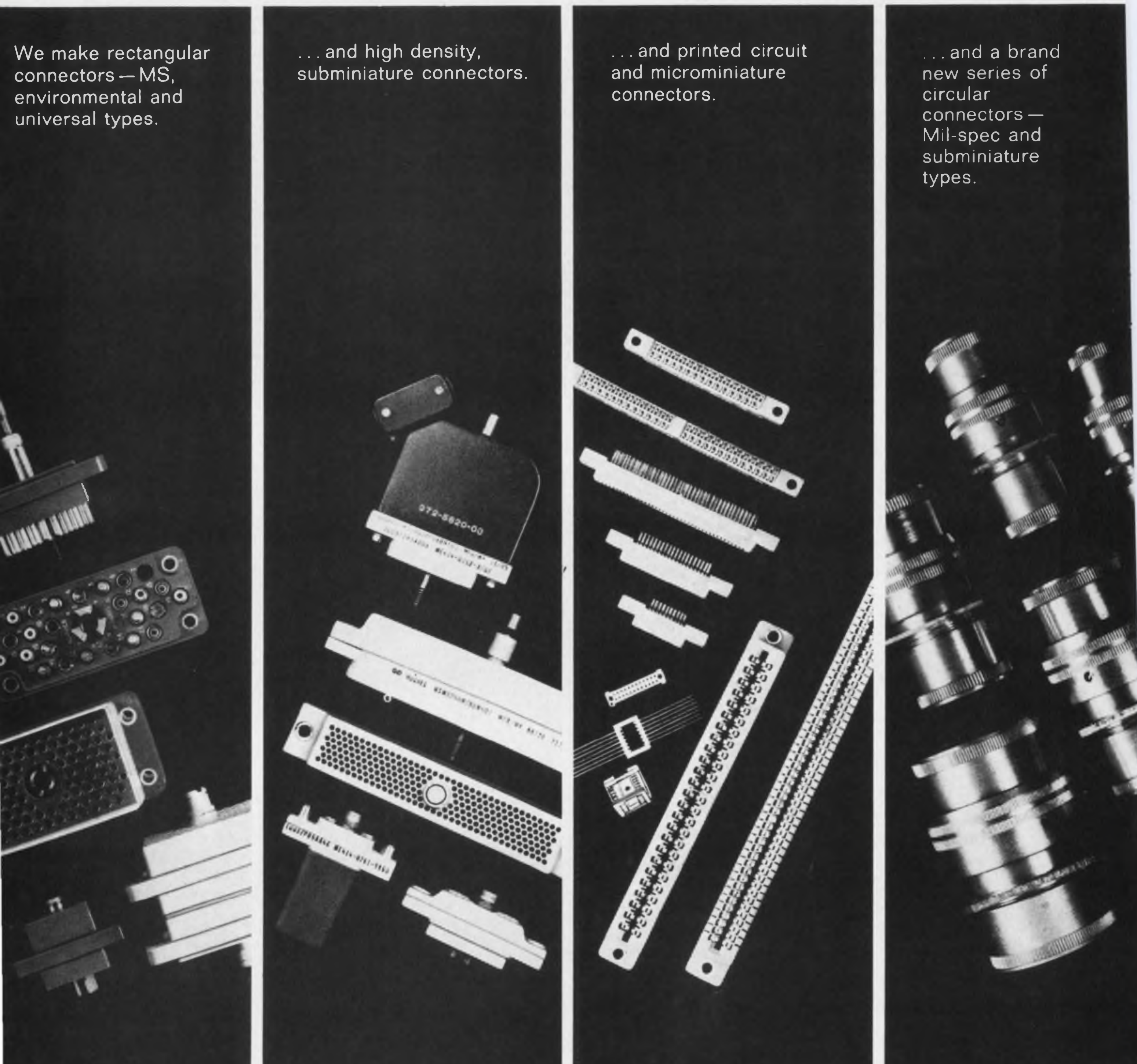
Ask your RCA Representative about CA3028. Check your RCA Distributor for his price and availability schedule. Or send for complete data, including Application Note, ICAN-5337, to Commercial Engineering, RCA Electronic Components & Devices, Section IGG3-3, Harrison, N.J. 07029

Check Your RCA Distributor for His Price and Delivery

RCA ELECTRONIC COMPONENTS AND DEVICES

The Most Trusted Name in Electronics

What's our line?



Our real line is solutions to tough interconnection problems. What we show above is just a cross section of the precision connecting devices we've developed to solve both standard and special problems. Chances are, we've already solved yours. If not; we'd welcome a crack at it. May we send you our descriptive literature? Or answer your questions about special types? You'll receive a prompt answer.

Transient recorder for single events

E-H Research Labs., Inc., 163 Adeline St., Oakland, Calif. Phone: (415) 834-3030.

Single-event recording and reproduction is accomplished by this transient recorder. The analog input signal is sampled up to as many as 1000 points along the X-axis (time axis.) At each time slot the signal amplitude is digitized at 10 μs by an analog-to-digital converter, and stored in the Y-axis of the core memory. The reproduction mode is nondestructive so that the stored signal may be regenerated continuously as a repetitive waveform. The speed of generation ranges from one time slot per second to 100,000 time slots per second. This feature may be used to time compression or expansion of repetitive functions which have been recorded. In addition to the analog output of the recorded signal, 3-digit BCD is available at a rear-panel connector.

Booth No. 2H02 Circle No. 525

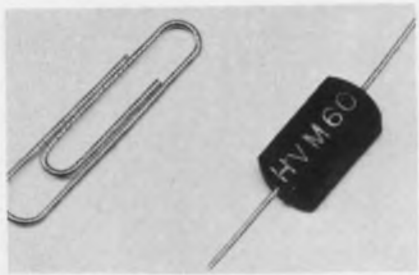
Multiscaler systems have central display

LeCroy Research Systems Corp., 1 Hayes St., Elmsford, N. Y. Phone: (914) 592-5010. P&A: $1950 to $2450 (24-bit); $750 to $1090 (12-bit).

A modular counting technique provides more economical data readout by employing one centralized visual display to provide selective monitoring of any number of scalers. Strobed outputs fed into a common binary buss allow sequential interrogation into any of the manufacturers' data processors.

Booth No. 2D51 Circle No. 331

Rectifier modules series-strung to 150 kV

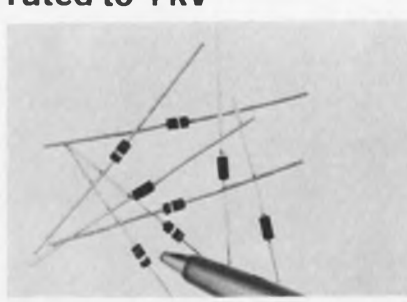


General Instrument Corp., Semiconductor Products Group, 600 W. John St., Hicksville, N. Y. Phone: (516) 681-8000. Price: 50¢/kV (production quantity).

High-voltage rectifier modules are designed for use in long series strings for high-voltage rectifier assemblies. The devices have PRV ratings from 2000 to 6000 volts at 250 mA; in typical non-compensated diode strings, PRV ratings to 150,000 volts are obtainable. Eight diode-diffused silicon cells are connected in series in the module, which is encapsulated in high thermal-conductivity epoxy. Applications include series strings for CRTs, photomultipliers, vidicon power supplies and other higher power applications.

CIRCLE NO. 582

Avalanche diodes rated to 4 kV

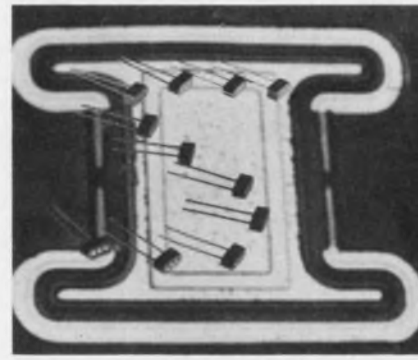


MicroSemiconductor Corp., 11250 Playa Ct., Culver City, Calif. Phone: (213) 391-8271. Price: 25¢/kV (100 lots).

High-voltage avalanche diodes and assemblies are rated to 4000 volts. Single silicon junctions are glass-sealed and have typical peak inverse ratings between 1000 to 1500 volts. Mechanical size of the 1000-to-4000-volt series is 0.1 by 0.3 inches, with 0.02-inch leads. Higher voltages are available.

CIRCLE NO. 583

Current-limit diodes bias transistors



Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-1000. P&A: $3.15 to $6.30 (100 lots); stock.

Nine current-limiter field-effect diodes are designed for constant-current biasing of transistors, FETs, differential amplifiers and Zener reference diodes. The current limiter is useful in place of a logic pull-up resistor for high-speed switching, as a high-impedance load with low supply voltage and as a current-limiting protecting device. The CL2010 series offers current values from 220 A to 4.7 mA.

CIRCLE NO. 584

Npn power transistors leak like planars

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

A transistor has been developed with the characteristics of low-leakage planar units, combined with resistance to secondary breakdown offered by homogenous devices. This Isoltaxial npn silicon power transistor is available in a TO-3 case. The devices feature low leakage currents, freedom from secondary breakdown, a flat gain curve and low saturation voltages.

CIRCLE NO. 585

Just push a button to select one of five different functions and make measurements in a total of 23 ranges.

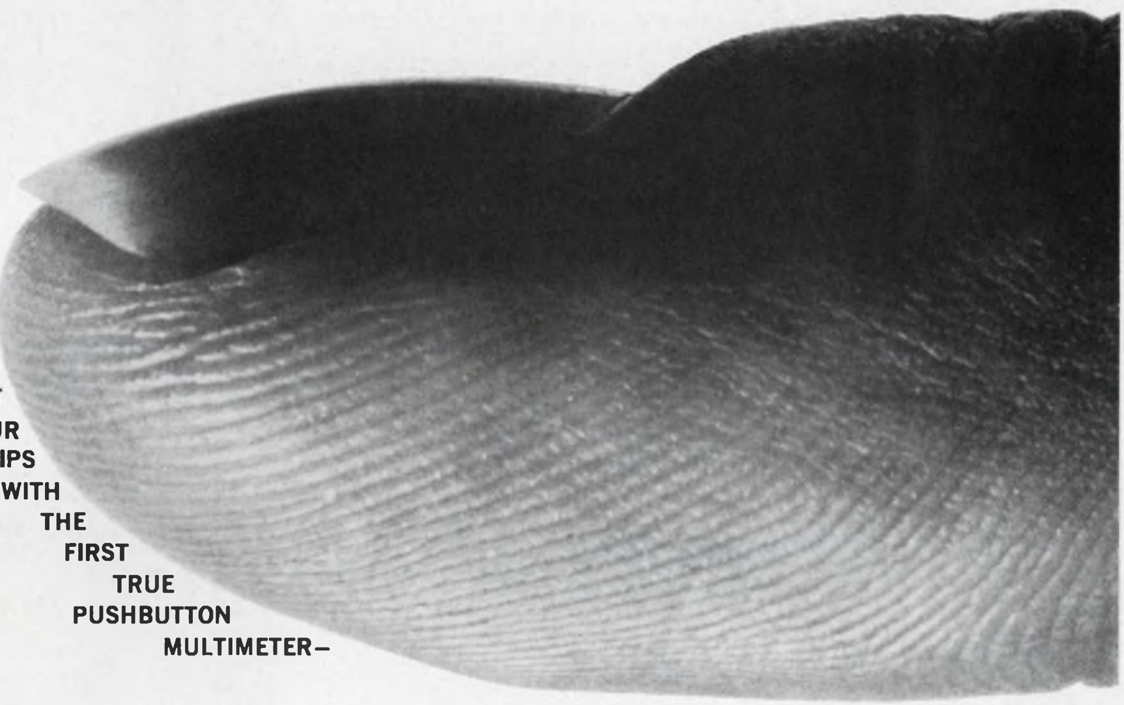
Measure (1) dc voltage in 3 ranges from 0.0000 to ±999.99 volts with automatic and manual ranging. Accuracy: .005% ±1 digit. Sensitivity: 100 microvolts. Measure dc millivolts in 2 ranges from 00.000 to 100.00 millivolts. Accuracy: .02% ±1 digit. Sensitivity: 1 microvolt. Stability: 30 days with 10°C temperature variation. Push a button for (2) DC/DC ratios in 3 ranges from .00000:1 to ±99.999:1. Standard feature: automatic polarity selection. Push a button to measure (3) ac in 3 ranges from 00.000 to 1000.0 volts rms; (4) dc current in 6 ranges from 0.0000 microamperes to ±100.00 milliamperes; (5) resistance in 6 ranges from 0.0000 kilohms to 100.00 megohms.

Each button lights up for positive identification. And this versatile instrument takes up just $5\frac{1}{4}$ inches in a 19-inch rack. Model 533-4810, rackmount: $2,750.

Also available: our new 530 Series DC DVM/Ratiometer, which measures dc voltage in 3 ranges from 0.0000 to ±999.99 volts and DC/DC ratios in 3 ranges from .00000:1 to ±99.999:1. Accuracy: .005% ±1 digit. Automatic ranging and pushbutton function selection are included in both cabinet (half-rack) Model 531-1000 and rackmounting Model 531-3000 at $1,495.

Prices FOB San Diego. Additional export charge. Better get full details now from your nearest Cohu engineering representative. Or contact Ken Walker, Manager, Instruments and Systems. Phone 714-227-6700, or write Box 623, San Diego, California 92112.

COHU
ELECTRONICS, INC
SAN DIEGO DIVISION



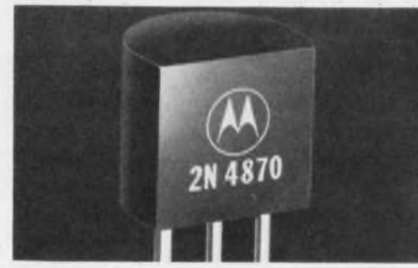
NOW FIVE FUNCTIONS AT YOUR FINGERTIPS WITH THE FIRST TRUE PUSHBUTTON MULTIMETER—

COHU'S NEW 530 SERIES

ON READER-SERVICE CARD CIRCLE 221

SEE US AT IEEE, BOOTH 2D13

Plastic UJTs priced at 64¢



Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: 64¢ (over 100); stock.

A plastic unijunction transistor series, 2N4870 and 2N4871, are priced at 64¢ in quantities of 100 up. This series features the annular structure where the emitter junction and base contact areas are formed by diffusion rather than alloy techniques. The construction provides higher frequency capability, lower values of I_{EO} and I_P which are important in timing circuits.

CIRCLE NO. 586

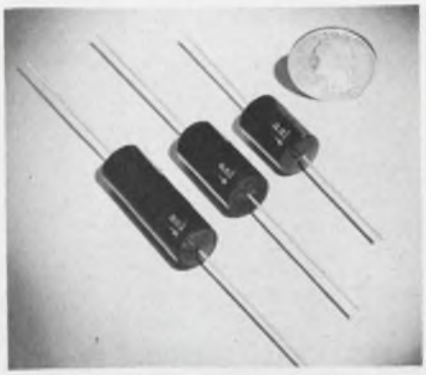
Monolithic diodes break down at 8 kV

Semicon Inc., Sweetwater Ave., Box 328, Bedford, Mass. Phone: (617) 275-8542. P&A: $15 (1 to 99); stock.

High-voltage breakdowns from 1 to 8 kV are built into a single crystalline diode structure in a glass axial-lead package. Resulting properties of the diodes are I_R of 25 nA at 8 kV, C_j of 0.2 pF at 0 volts, T_{RR} of 200 ns and V_f of 10 volts at 15 mA. Designed specifically for voltage multipliers, the combination of low junction capacitance, low reverse current, low forward voltage and fast recovery makes the diodes ideal for laser and flash tube power supplies, fiber optic image amplifiers, ion pulse sources, radiation and pulse detection, deflection systems, solar plasma experimentation and infrared and RF power supplies.

CIRCLE NO. 587

Silicon rectifier stacks rated to 30 kV



Atlantic Semiconductor, Inc., 905 Mattison, Asbury Park, N. J. Phone: (201) 775-1827. P&A: $2 to $12.50 (100 lots); stock.

High-voltage, high-current avalanche silicon rectifier stacks are capable of supplying 350 mA at ratings varying from 3000 to 30,000 volts. The type 35-ST stacks have built-in reverse avalanche voltage characteristic at a minimum of 20% or 2000 volts above the rated PIV. They have built-in short circuit surge of capacity of 15 A for 8 ms.

CIRCLE NO. 588

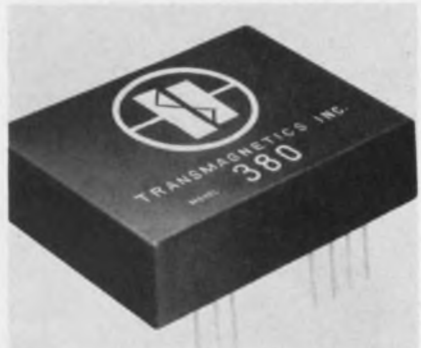
Pnp integrated choppers have low 'on' resistance

Crystallonics Div. of Teledyne, Inc., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $7.50 (1 to 99); stock.

Pnp silicon integrated choppers feature R_{ON} of 15 Ω, I_{OFF} of 0.1 nA, V_o of 25 mV and C_{ee} of 3.0 pF. The package is a 4-lead TO-72 common collector. Typical applications include digital-to-analog converters, multiplexers and chopper-stabilized amplifiers.

CIRCLE NO. 589

Analog module multiplies in all four quadrants

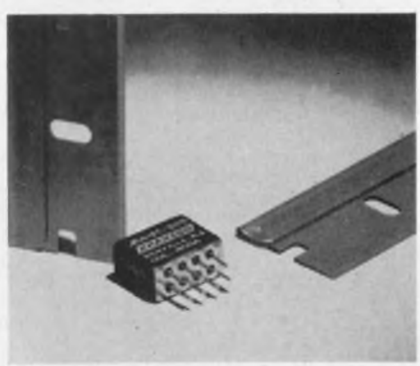


Transmagnetics, Inc., 134-25 Northern Blvd., Flushing, N. Y. Phone: (212) 539-2750. P&A: 258; stock to 6 wks.

True analog multiplication in all four quadrants with 0.5% full-scale product accuracy is performed by this module. Inputs range from dc to 30 kHz and output is ±10 V into 10 kΩ. Applications are polar-to-rectangular transformation, trigonometric computation, dc-to-ac conversion servo modulation and variable gain control.

CIRCLE NO. 590

1/6 crystal can relay switches 1 A

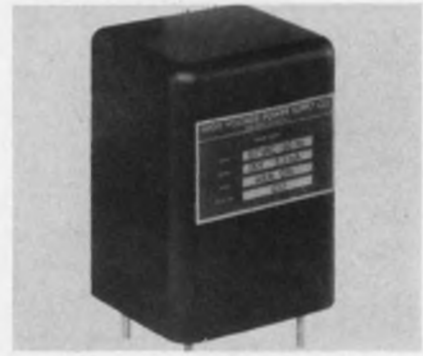


Branson Corp., Vanderhoof Ave., Denville, N. J. Phone: (201) 625-0600.

Dpdt 1/6 crystal can size relays are capable of switching 1 A. The JR relay meets MIL-R-5757/19 and is available in 6, 12 and 24 Vdc with corresponding coil resistance of 100, 400 and 1600 Ω. Minimum operating life is 150,000 operations, insulation resistance is 1000 MΩ at 25°C and volume is 0.04 in.^{3}. Four case styles and three header styles are available.

CIRCLE NO. 591

2500-Vdc supply in 2-lb package

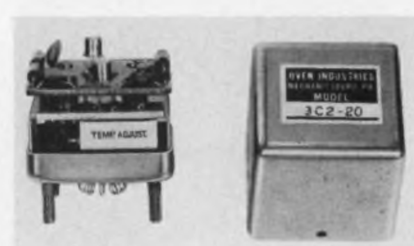


High Voltage Power Supply Co., 15820 Stagg Ave., Van Nuys, Calif. Phone: (213) 780-5526. Price: $195 to $238.

Small, light-weight, regulated power supply modules are available with 200- to 2500-Vdc output at 6 W for application with CRTs, photomultipliers, TWTs, BWOs and other general-purpose high-voltage sources. These 117-Vac, 60-Hz input modules are regulated to 0.05%, have ripple of less than 0.1% peak to-peak voltage, and output is adjustable ±80 V. The modules weigh approximately 2 lbs.

CIRCLE NO. 592

Proportional controllers adjust from 60 to 70°C



Oven Industries, Div. of Greenray Industries, Inc., 5235 E. Simpson Rd., Mechanicsburg, Pa. Phone: (717) 766-0721. P&A: $59.50 (1 to 100 W); $65 (1 to 20 W); 2 to 3 wks.

Ac and dc proportional controllers, when used in conjunction with a resistive load or heater, will accurately control temperature on any object which cannot be easily placed in an oven. Controlling temperature is 60 to 70°C. The 1-to-100-W units have 0.05°C resolution; the 1-to-20-W units, 0.01°C resolution.

CIRCLE NO. 593

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Profit in space-saving with smaller physical sizes operating at higher current density . . .

Profit in reduced costs with 45-volt quadruple density Uni-Sel . . .

Profit with Higher Temperature Capability, 50% ratings at 70°C. ambients . . .

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283

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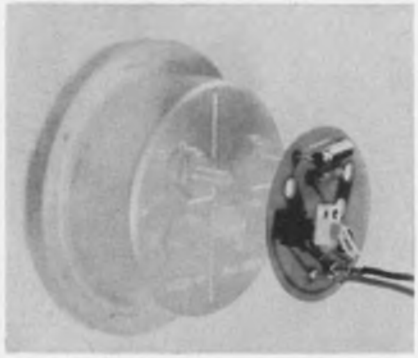
ON READER-SERVICE CARD CIRCLE 225

COMPONENTS

Module converts tach gen ac to dc

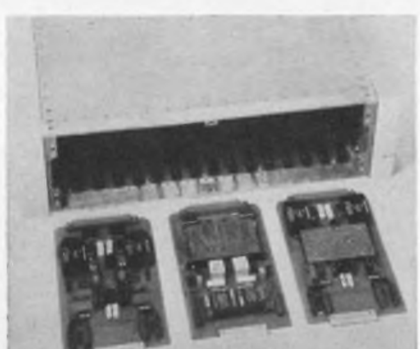


Vibrac Corp., Alpha Industrial Pk., Chelmsford, Mass. Phone: (617) 256-6581.

A "voltage responsive module" mounts directly on the rear of most 2-1/2, 3-1/2 and 4-1/2-inch panel meters. It converts the ac voltage from a tachometer generator to dc to drive the meter. A system consisting of a tach gen and module will give 1-mA output to drive a meter full scale at speeds as low as 300 rpm. A screwdriver adjustment permits the range to be set as high as 100,000 rpm for full-scale output.

CIRCLE NO. 594

Signal conditioners for airborne use



Aeroscience Electronics, Inc., 3181 Roswell Rd. N. E., Atlanta, Ga. Phone: (404) 231-1278.

A versatile family of signal conditioners is offered for airborne use to prepare signals from various kinds of transducers for use with FM subcarrier oscillators, PAM-PDM-PCM multiplexers and other data-handling devices. The signal conditioners are constructed with two circuits per plug-in printed wiring card.

CIRCLE NO. 595

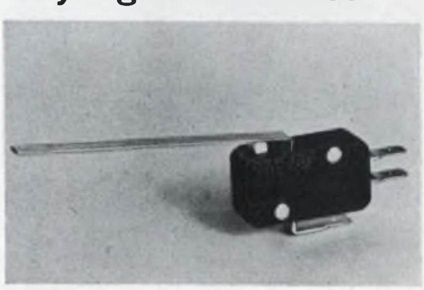
Transient arrester protects antennas

Joslyn Electronic Systems, P. O. Box 817, Goleta, Calif. Phone: (805) 968-3551.

Fast-responding antenna transient arresters feature low-clamping level and expanded signal operating range (10 kHz to 300 MHz). Installed in series with an external antenna (insertion loss is less than 0.5 dB at 300 MHz) as close to the receiver as possible, the arrester will attenuate an input transient before damage to active elements can occur. It can be used in single-element systems, or in multiple-element antenna arrays. A transient of 10-kV peak (1.5 x 40-μs waveform) will be clamped to 50 V within 0.5 μs.

CIRCLE NO. 596

Miniature switch needs only 6 grams of force

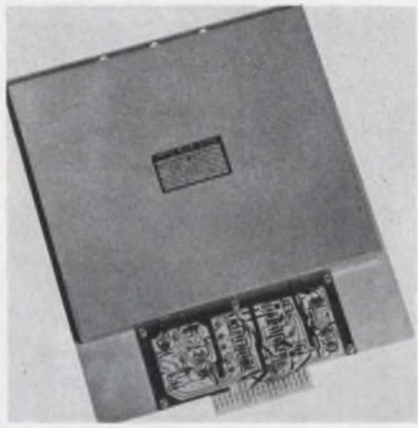


Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Pk, Ill. Phone: (312) 432-8182. Price: $1.23; $0.566 (2000).

Using the same coil spring mechanism as in the regular line of miniature switches, the manufacturer claims a record low operating force of 6 grams. This is ascribed to a special internal actuator. The ratings remain at 5 A, 1/4 hp, and 125 and 250 Vac.

CIRCLE NO. 597

Delay line memories store 16,660 bits



Computer Devices Corp., 63 Austin Blvd., Commack, N. Y. Phone: (516) 543-4220. P&A: under $200 (100); 2 to 3 wks.

Model MS 2150 serial memory uses a magnetostrictive delay line with a delay of 8.33 ms as the storage element. It is supplied for operation in the return-to-zero and the bipolar mode at 1-MHz bit-rate or in the non-return-to-zero mode at 2 MHz, thus offering a storage of 8330 and 16,660 bits respectively.

CIRCLE NO. 598

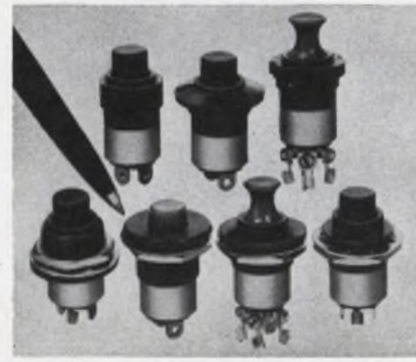
Cartridge heater has shaded heat gradient

Vulcan Electric, Danvers, Mass. Phone: (617) 774-1730.

Heat envelopes using a cartridge heater will have more heat loss at the ends than at the middle. This can be corrected by use of a shaded density which provides uniform heat curve over the entire surface. While the systems designer tries to minimize the effect of gradients by careful location of heaters and controls in the envelope, more even heating is easier to achieve by the use of heaters that incorporate gradient heat balance.

CIRCLE NO. 599

Pushbutton series meets MIL-S-8805



Controls Co. of America, Control Switch Div., 420 Delmar Dr., Folcroft, Pa. Phone: (215) 586-7500. P&A: From $4.83; stock.

New military specifications MIL-S-8805 replaces MIL-S-6743 and the MS25089 drawing although the MS2508 part numbers have not been changed. This series is claimed to be the first meeting this MIL-spec. There are 110 moisture-proof push-button switches rated for loads of 10 A resistive, 5 A inductive, and 3 A lamp at 28 Vdc or 115 Vac, 60 and 400 Hz.

CIRCLE NO. 600

Air velocity detector with sensing element

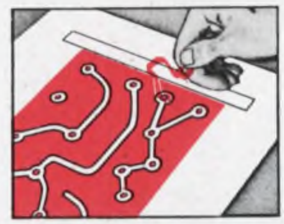
Fenwal Electronics, Inc., 63 Fountain St., Framingham, Mass. Phone: (617) 875-1351.

An air velocity detector that can be used in critical cooling and ventilating applications, utilizes a thermistor sensing element. Used with a simple relay circuit and mounted in the airstream of a cooling fan or blower, the detector will actuate a visible or audible alarm, and also shut down equipment when output velocity falls below a critical level.

CIRCLE NO. 601

In Making Masks for Electronic Components...
...there's no Margin for Error!

With sharp blade, outline the areas to be masked. **Do not cut through the backing sheet.** The Ulano Swivel Knife does the job quickly, easily.



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ON READER-SERVICE CARD CIRCLE 232

Pressure cell weighs only 24 ounces

C-E Electronics, Inc., 363 W. Glenside Ave., Glenside, Pa. Phone: (215) 887-8900. P&A: $230; stock.

This pressure cell is a precision electro-mechanical transducer for converting pneumatic signals into electrical equivalents of dc current or voltage. The unit features a frictionless floating core which provides infinite resolution, and a self-contained power package which permits easy conversion to a number of different output options. The unit is 3 in. diameter by 4 in. high and weighs 24 oz.

CIRCLE NO. 602

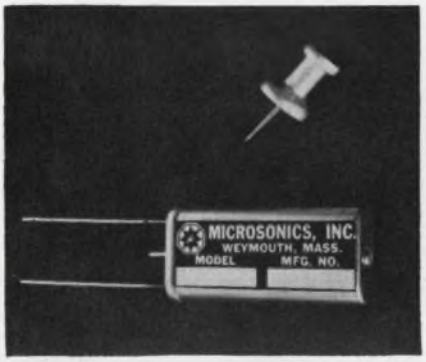
Bellows contact springs mount diodes

Servometer Corp., 82 Industrial E., Clifton, N. J. Phone: (201) 773-0474.

Miniature bellows type contact springs for microwave applications are used for mounting diodes where compensation for environmental changes is required. They are non-inductive and have extremely low dc electrical resistance. Size range is from 0.066 to 0.25-inch OD. Force necessary for compression ranges down to 1 oz.

CIRCLE NO. 603

Delay trimmers fixed or variable



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

Ultraminiature wideband electromagnetic delay trimmers are for use in digital and RF applications. Designed for PC board mounting, the delay lines are supplied either as fixed or variable units. Delays range from 5 to 60 ns for the fixed series, and up to 30 ns for the variable units. Variable units are provided with a lead screw adjustment and feature delay resolution of 1% of total delay.

CIRCLE NO. 604

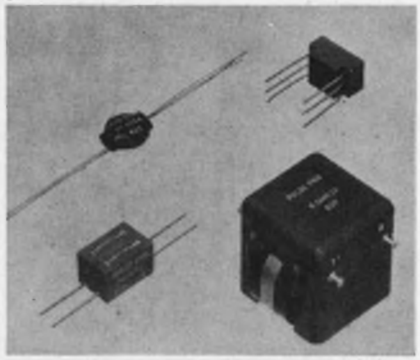
3-digit shaft encoder popularly priced

Theta Instrument Corp., Saddle Brook, N. J. Phone: (201) 843-6060.

A 3-digit shaft encoder features built-in logic and power drivers. Regardless of load characteristics, current and voltage through the brush structure remain controlled and a life of 50 million revolutions at max speed is claimed. Applications include remote digital readout of shaft position, data logging, and digital computer inputs.

CIRCLE NO. 605

Pulse transformers for SCR control circuits



Pulse Engineering, Inc., 560 Robert Ave., Santa Clara, Calif. Phone: (408) 248-6040. P&A: under $1; stock.

A series of miniature pulse transformers for use in SCR control circuits is offered. The units are tested to MIL-T-21038B, grade 7, class S, life X. The high-voltage unit is rated at 15 kVdc and provides a large safety factor in triggering high voltage SCRs or in cascade operation of SCRs.

CIRCLE NO. 606

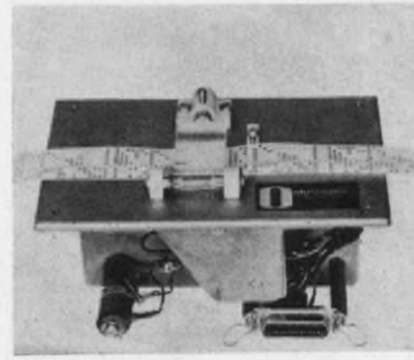
Flat-face CRT is all-glass

Thomas Electronics, Inc., 122 8th St., Passaic, N. J. Phone: (201) 473-4040. P&A: $1200; 30 to 45 days.

A 24-in. all-glass flat-face cathode ray tube is designed for such large console displays as air-traffic control, military displays and computer-driven displays. Features include a flat face for wide-angle viewing, useful screen diameter of 22 inches, an all-glass tube, magnetic focusing and deflection and a 57° deflection angle for high-precision displays.

CIRCLE NO. 607

Readers for 8 bits at 30-Hz speed

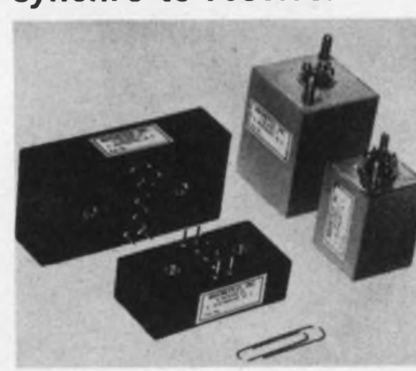


Ohr-Tronics, Inc., 305 W. Grand Ave., Montvale, N. J. Phone: (201) 391-7000. Price: $345 to $415.

Two readers are available, employing standard reading mechanism and reading up to 8 bits at speeds of 30 Hz serially. The flat-bed reader is designed for horizontal flush-mount, and the edge-punched card reader mounts on a 19-in. rack panel. Any edge-punched card having 8 channel paper tape codes along its edge can be fed through the latter model individually or in a fanfold series.

CIRCLE NO. 608

Transformers convert synchro to resolver



Magnetico, Inc., 6 Richter Court, East Northport, N. Y. Phone: (516) 261-4502.

A line of precision miniature toroidal transformers has been designed for use in solid-state synchro-to-digital and digital-to-synchro converter systems. These units convert 3-wire synchro inputs to 4-wire resolver outputs, and resolver inputs to synchro outputs. Conversion accuracy of 30 seconds to 2 minutes of arc is standard.

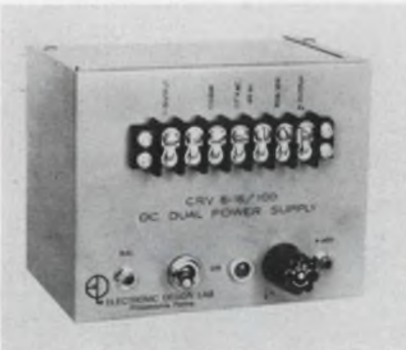
CIRCLE NO. 609

the new magazine machine

this novel application of mechanism, to the purposes of periodical publications, is the invention of an ingenious litterateur. the hoppers above being fed with subjects of all sorts, from "semiconductors" to "materials," the handle is turned, and the fountain-pens begin to write articles upon everything.

if you are wondering who fills the hoppers, our editors do. they are engineering men who like to write. if you would like to be a news editor in this fast paced industry or, if you like to write about computer design or digital circuitry, we would like to talk with you. call howard bierman, electronic design's editor, new york (212) plaza 1-5530, or drop by booth-4G39/41 at the ieee show.

Dual power supply for 1 to 18 V adjustable

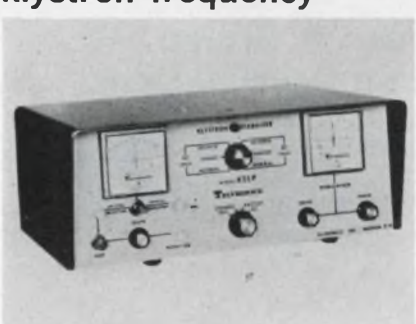


Electronic Design Lab, P. O. Box 7837, Philadelphia. Phone: (215) 925-9500. P&A: $99; stock to 2 wks.

Two independent regulated power supplies with temperature-compensated Zener diode voltage reference, are offered in one 3-by-4-by-5-in. case. Positive and negative voltages are independently adjustable from 1 to 18 V by multiturn potentiometers, with 10-mV resolution. The current rating is 100 mA for each section. The unit is designed for reference voltage or power source for IC packages and solid-state operational amplifiers.

CIRCLE NO. 614

Unit stabilizes klystron frequency

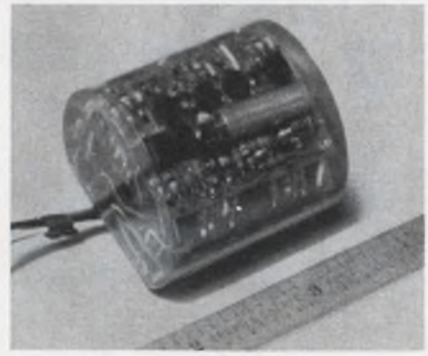


Teltronics, Inc., 23 Main St., Nashua, N. H. Phone: (603) 889-6694.

Klystron frequency can be stabilized by a unit that operates from line voltage or rechargeable battery. The unit generates a modulating signal, accepts a frequency error signal from a reference cavity detector, and develops a reflector correction voltage.

CIRCLE NO. 615

'Caseless' commutator withstands high shock

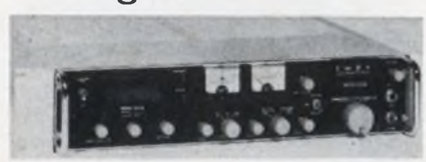


Stellarmetrics, Inc., 416 E. Cota St., Santa Barbara, Calif. Phone: (805) 963-3566. P&A: under $500; 30 days.

A "caseless" telemetry commutator withstands 40,000-G shocks. The "caseless" package is rigid shock-proof epoxy with input-output terminals molded into the commutator body. The complete unit is less than 2 inches long and weighs about 60 grams. It is single-pole, high-level PAM RZ 18-channel unit with a channel rate of 450 samples per second. Input power is ± 0.2 Vdc at 30 mA, linearity is within $\pm 0.1\%$ and crosstalk is less than 0.1% full scale. Input to output offset is less than ± 25 mV with a 200-kΩ load.

CIRCLE NO. 616

AM-FM receiver has own signal monitor

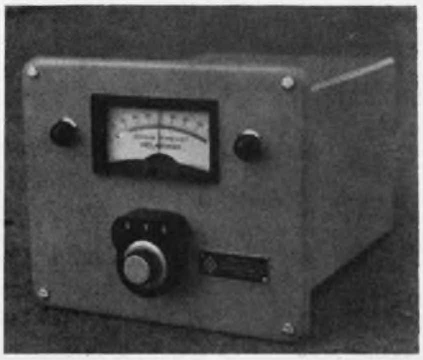


Communication Electronics, Inc., 6006 Executive Blvd., Washington Science Center, Rockville, Md. Phone: (301) 933-2800. P&A: $3,-200; 60 days.

This 20- to 70-MHz receiver, providing AM, FM and cw reception, has a built-in signal monitor with a max sweep width of 300 kHz and a resolution of 2.5 kHz, audio squelch and tunable BFO. Three IF bandwidths are provided: 4, 10 and 50 kHz. They are selectable by a front-panel switch.

CIRCLE NO. 617

Set-point controller temp compensated



Helm Instrument Co., Inc., 4216 W. Alexis Rd., Toledo, Ohio. Phone: (419) 479-2951. P&A: from $355; 30 to 60 days.

This solid-state unit features digital set-point, a calibrated deviation indicator and independently adjustable high and low alarms. Ambient temperature compensation and automatic time proportioning are also included. Plug-in accommodation is provided for accessory cards. It is available in either 2- or 3-position control.

CIRCLE NO. 618

Counter-timer uses 90% ICs

Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N. J. Phone: (201) 228-3800.

Direct counting to over 100 MHz is obtained with these electronic counter-timers. Ninety per cent of the active circuit elements are microelectronic. With an eight-digit readout it has six modes of operation: manual, frequency, frequency ratio, period, time interval and time interval A-B.

CIRCLE NO. 619

Remember to return your **ELECTRONIC DESIGN** renewal card. Don't miss any issues in '67.

One-part silicones cure corrosion-free

Dow Corning, Midland, Mich. Phone: (517) 636-8507. Price: $11/lb. (40-lb. lots).

Two one-component silicone rubbers, a clear conformal coating and a high-strength sealant, feature a curing system which does not give off corrosive by-products. Previously available rubbers give off a small amount of acetic acid during the cure, and this acid by-product may cause corrosion of copper during the curing period under humid conditions. The conformal coating, designated 3140 RTV, is a clear, solventless, self-leveling, fluid material with a viscosity of 660 poises. It cures on exposure to moisture vapor in the air to form a tack-free surface in about two hours. Typical thickness of the clear rubber, when applied by a single dipping operation is about 25 mils. The non-corrosive elastomer, 3145 RTV adhesive/sealant, is a high-strength, grey material in a toothpaste-like consistency. It withstands longterm-exposure at 200 to 250°C, and short-term use at 300°C. Tensile strength is about 800 psi; elongation, about 675%; and tear strength, 125 ppi.

CIRCLE NO. 620

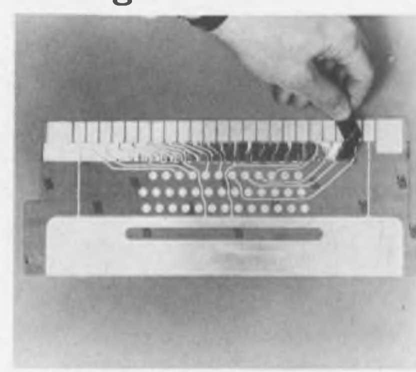
Platinum-gold coating bonds hybrid ICs

Electro-Science Labs., Inc., 1133-35 Arch St., Philadelphia. Phone: (215) 563-1360. P&A: $72.25/oz.; stock.

Platinum-gold coating for electronic components and hybrid integrated circuit packages features good adhesion and scratch and peel resistance on high-alumina surfaces. The fired deposit is dense, uniform and free from pinholes or cracking. It forms good ohmic contacts to resistive coatings. Conductivity of a 1-mil-thick film is 0.05 to 0.1 Ω/square. Because of the coating's ability to withstand acidic plating baths, conductivity can be increased by depositing a metallic overlay. The paste has a peak temperature firing-range from 850° to 1000°C, and may be soldered with normal or high temperature lead-tin alloy solders, using conventional techniques with resin fluxes.

CIRCLE NO. 621

Copper foil plates PC finger contacts



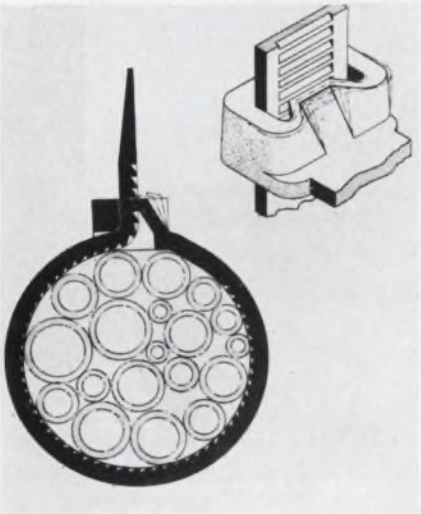
3M Company, 2501 Hudson Rd., St. Paul. Phone: (612) 733-4033. P&A: $3.69 (36-yd., 1/4-in. roll, 3-in. ID core); stock.

Copper-foil plating tape aids in gold-plating the finger contacts on printed circuit boards. The tape is made with an electrically conductive, pressure-sensitive acrylic adhesive applied to a copper backing. This provides a means of conducting the plating circuit to the PC board finger contacts. The adhesive has a relatively high conductivity which is resistant to common etching and plating solutions without thermosetting, and will not corrode the copper circuitry. The tape comes with a removable paper liner to facilitate cutting to a precise length or shape with minimal wrinkling of the backing. Typical properties include 40 oz/inch adhesion, 20 lbs/inch tensile strength and 0.085 Ω/inch resistance. It is 2.5 mils thick.

CIRCLE NO. 622

FOR THE CHASSIS TRAK, INC. INSERT ON READER-SERVICE CIRCLE 761 ➤

Nylon cable tie self-locking



Milton Ross Co., 511 Second St. Pike, Southampton, Pa. Phone: (215) 355-0200. P&A: $24.50/1000; stock.

A self-locking device is featured in this one-piece molded cable tie. Produced from lightweight nylon, the unit permits harnessing of wires and cables up to 1-3/4 inches in diameter. Installation is made without special tools and no extra fasteners are required. The locking device holds permanently and is an integral part of the molded one-piece unit. All ties are reusable, releasable and adjust to size.

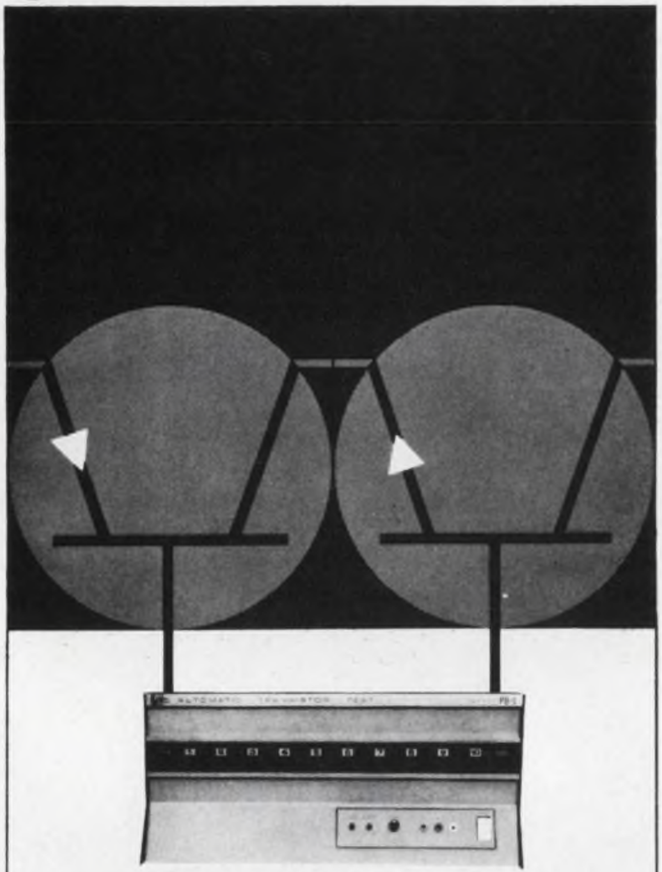
Booth No. 4K09 Circle No. 312

Electroless nickel plates silicon

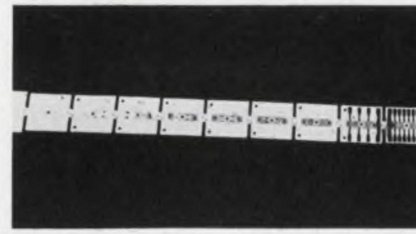
Nitine, Inc., 45 S. Jefferson Rd., Whippany, N. J. Phone: (201) 887-6000.

A solution for nickel-plating small parts without electrical plating equipment is formulated especially for silicon and other metals widely used in electronics. It is essentially non-corrosive, and can be used in any well-ventilated area. Plating occurs at a rate of 0.3 mil per hour at a temperature of 90°C. No special equipment is necessary. Glass-plating vessels are recommended, and provision must be made for maintaining a temperature of 90°C during plating.

CIRCLE NO. 623



Carbide dies stamp IC frames



Hydro-Cam Engineering Co., 1900 E. Maple Rd., Troy, Mich. Phone: (313) 588-2900.

Frames for ICs produced by the stamping process of rate of up to 200/minute are possible with these carbide dies. The dies are a 13-stage progressive type with 72 tungsten-carbide inserts and a total of 129 different details. All die sections are ground to a tolerance of ±0.00001 inch.

CIRCLE NO. 624

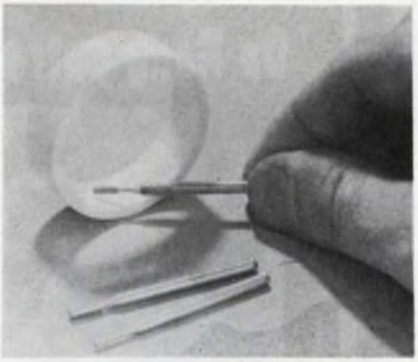
'Universal' test clamp grips fine wire

Hunter Associates, 321 Highland Ave., Orange, N. J. Phone: (201) 672-0423. Price: $1.50.

The "universal" test clamp consists of a fine retractable spring clamp which is activated by light pressure on the head of the handle. The clamp will grip the finest wire and then retract into the insulating sleeve for use in high-density circuitry without any danger of short circuits. The head contains a standard banana plug jack.

CIRCLE NO. 625

Diamond-plated tools work ceramics



Aremco Products, Inc., P. O. Box 145, Briarcliff Manor, N. Y. Phone: (914) 762-0685. P&A: $6.50 to $6.90; 30 days.

The 113-series line of diamond plated mandrels are designed for grinding and polishing small holes in ultra-hard ceramics such as alumina and beryllia. The line includes 10 standard diamond "quills" ranging in diameter from 0.025 to 0.12 inch. The mandrels can make cuts of 0.0005 in. using water as a lubricant.

CIRCLE NO. 626

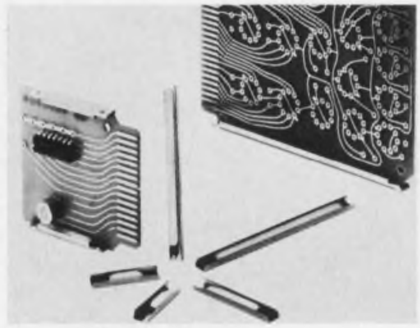
Photoresist spinner controls coatings

Plat Engineering Co., 518 Ryers Ave., Cheltenham, Pa. Phone: (215) 379-4900. P&A: $825; stock.

Model 102 photoresist spinner provides an accurate controlled coating of photoresist on semiconductor, thin- and thick-film and microelectronics devices. Features include dual acceleration to 10,000 rpm in either 30 ms or 1 second. Low vacuum safety prevents loss of work in case of vacuum failure. A timer and tach are built in. The unit handles devices to 3 x 3 inch.

CIRCLE NO. 627

PC board retainers save space

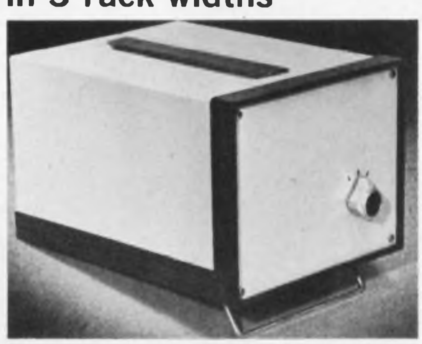


The Birtcher Corp., 745 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 268-8584.

Printed-circuit board retainers are designed for IC boards and for applications where space is at a premium. They use 1/8 inch of board height while providing the spring retention and shock protection qualities of standard-size retainers. Board spacing as close as 1/4 inch is possible. Retainers are available for 1/32- and 1/16-inch boards, in lengths from 1 to 6 inches in 1/2-inch increments.

CIRCLE NO. 628

Aluminum cabinets in 3 rack widths

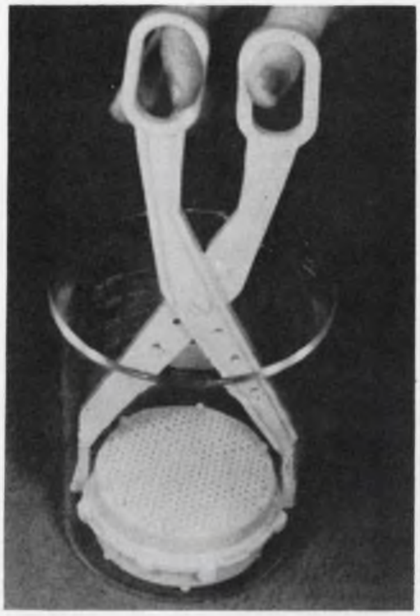


Scientific-Atlanta, Inc., Box 3654, Atlanta. Phone: (404) 938-2930. P&A: $22 to $41; 4 wks.

Small aluminum cabinets come in half, one-third and two-third rack width with optional rack adapters. Nine sizes are available. Heights range from 6-1/2 to 10 inches. Removal of two screws in the rear of the case allows the case body to be lifted from the front bezel and bottom pan. Front panel and chassis are held in place by two additional screws in the rear of the cabinet.

CIRCLE NO. 629

Acid-resistant tongs handle semiconductors



Fluoroware, Inc., County Rd. 17, Chaska Industrial Pk., Chaska, Minn. Phone: (612) 448-3131. P&A: $5.50 (PVC), $12.50 (FEP); stock.

Designed for use with strainer trays, acid-resistant tongs are 10 inches long and are made of natural teflon FEP. The material is corrosion-resistant for use in strong acids and is capable of withstanding temperatures up to 400°F. Model C40 tongs feature four-position adjustable jaws.

CIRCLE NO. 630

Gold plater 100% uniform

Technic, Inc., P. O. Box 965, Providence, R. I. Phone: (401) 661-3400.

Virtual 100% uniformity is promised by the FP 100 gold plating system for IC flat packs. The system consists of a plating unit, an acid bright gold solution and a plating rack. The FP 100 system is said to reduce rejects through its ability to avoid edge buildup and overplating of the leads. Rate of the system is approximately 350 to 500 pieces in five minutes.

CIRCLE NO. 631

Sequencer inserts PC components

Universal Instruments Corp., E. Frederick St., Binghamton, N. Y. Phone: (607) 772-1710. P&A: $19,-000; 90 days.

This machine sequences and inserts axial-lead components of different body diameters into PC boards at rates up to 3000 per hour. The unit is designed for PC board assembly applications where ten or less components are to be mounted. Components may be either reel-wound or magazine-loaded. Custom fabricated templates, master grid templates or an actual PC board can be used by the operator for stylus positioning.

CIRCLE NO. 632

Eyelets fed, positioned, set in PC boards

Edward Segal, Inc., 132 Lafayette St., New York. Phone: (212) 966-3935.

An automatic eyelet attaching machine feeds eyelets as small as 0.02-inch ID. A carrier-type raceway feeds all types of eyelets used in PC boards, including funnel, flat or roll flange. Single bolt mounting provides quick change from one size eyelet to another. An oscillating agitator eliminates damage to plated eyelets. A limited travel spindle prevents tool damage.

CIRCLE NO. 633

Printer stamps over 180 parts per minute

James H. Matthews & Co., 6516 Penn Ave., Pittsburgh. Phone: (412) 362-6500.

Electronic component printers are offered that may be tooled with product feeding systems to suit the particular component, and used for axial-lead diode marking, flat-pack modules, TO-5 transistors and others. The units are also adaptable to printing two surfaces simultaneously, including round and flat surfaces. Standard operation is about 180 per minute, but the printers are capable of printing as fast as the components can be fed.

Booth No. 1J20 *Circle No. 321*

Transistor test set fully automatic

Micro Tech Mfg. Inc., 703 Plantation St., Worcester, Mass. Phone: (617) 755-2515. P&A: $2880, $350 (optional counter); stock.

An automatic transistor probe test set features high testing speeds and simple programing. Model 8005 test set has a unique "first fail-end-of-test" mode which terminates testing of a device when the first failure is detected in a test series. The total time per individual test is 10 ms including switching delays. The test set is transient-free and has built-in current-limiting. All leads are automatically grounded between tests for device protection. Worst-case accuracy of the Model 8005 is ±2%. Other features include probe continuity pretesting, IC logic circuitry, solid-state programing of function generators and limit comparators and dry-switching of reed-relay lead and range connections. Optional features and accessories include counters, sorting, punch-card programing, multiplexing and extended ranges. The testing capability can also be extended to ten tests.

Booth No. 1E08 *Circle No. 324*

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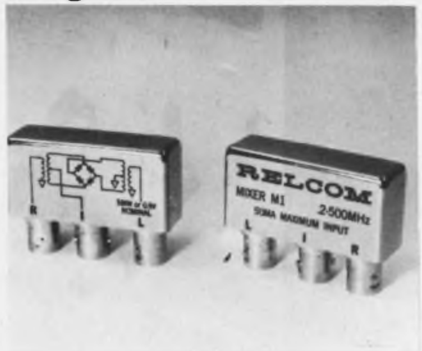
Double-balanced mixer ranges dc to 500 MHz

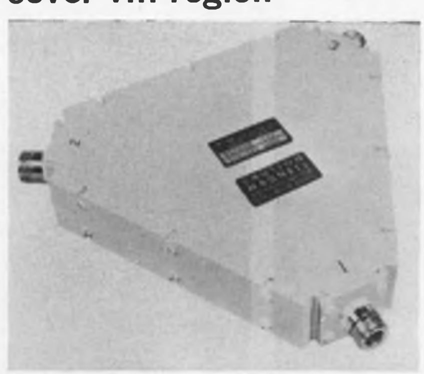


Relcom, 2164 E. Middlefield Rd., Mountain View, Calif. Phone: (415) 962-6265. P&A: $126 to $150; stock.

A double-balanced broad-band mixer is designed for frequency mixing, phase detection, amplitude and pulse modulation, current-controlled attenuation, or up or down frequency conversion. Frequency range is dc to 500 MHz. Noise level is typically 6 dB SSB at 50 MHz and isolation is 50 dB at 50 MHz. The mixer is designed for 50-Ω systems and comes with female BNC connectors.

CIRCLE NO. 634

Coax circulators cover vhf region

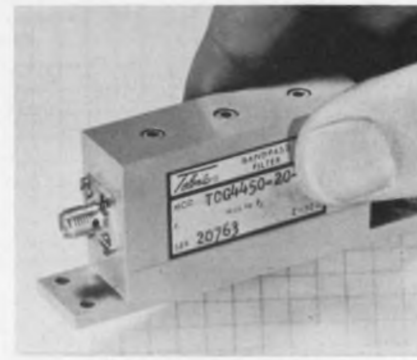


E&M Laboratories, 7419 Greenbush Ave., N. Hollywood, Calif. Phone: (213) 875-1484.

Vhf coaxial circulators feature bandwidths ranging from 10 to 30% in the 100-to-300-GHz region. The models have typical characteristics of 15-dB isolation, 0.7-dB insertion loss and 1.35 vswr. They are designed for system incorporation in common carrier, television, FM, aeronautical and military service.

CIRCLE NO. 635

Bandpass filters range to 6 GHz



Telonic Engineering, Box 277, Laguna Beach, Calif. Phone: (714) 494-7581. P&A: $215 to $396; 6 to 8 wks.

Miniature bandpass filters operate at any center frequency from 2 to 6 GHz, with 3-dB bandwidths from 0.3 to 3%. They are available with 2, 3, 4, 5 or 6 sections, and exhibit vswr of 1.5 up to 4 GHz, and 2 from 4 to 6 GHz. Iris-coupled, capacity-loaded coax cavities, the filters use quarter-wavelength resonators for minimum size, maximum Q and low insertion loss.

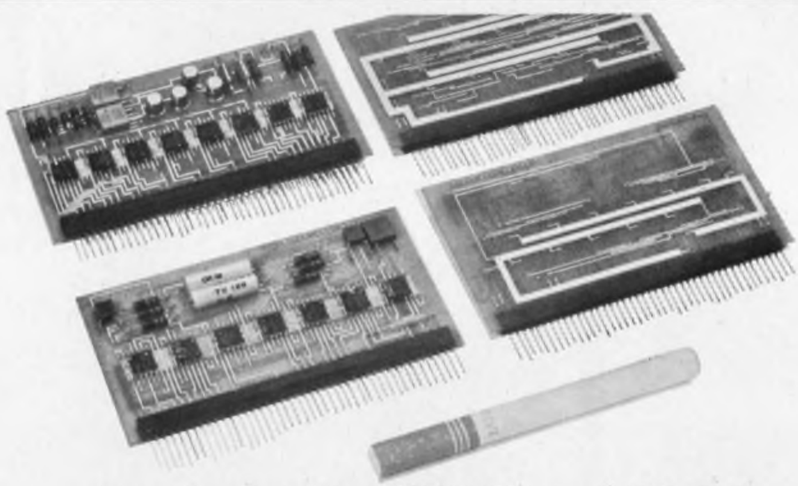
CIRCLE NO. 636

Coax diode switch handles 2.5 kW

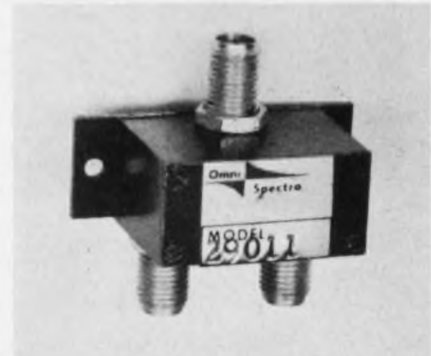
Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Coaxial spdt diode switches feature replaceable diodes. The MA-8306-2L24S is a lightweight unit which operates in the 1020-to-1100-MHz frequency range with a switching speed of 200 ns. Peak power is 2.5 kW; average power is 25 W. Isolation is 25 dB and insertion loss is 5 dB. The switch is suited for antenna lobing in military and commercial IFF systems.

CIRCLE NO. 637



Double-balanced mixer ranges 5 to 500 MHz



Omni Spectra, Inc., 19800 W. Eight Mile Rd., Southfield, Mich. Phone: (313) 444-8890. P&A: $160, $100; 60 days.

Typical conversion losses of 6.5 to 7 dB over the 5-to-500-MHz range are featured in these double-balanced mixers. Field-replaceable Schottky diodes are used. Model 29011 is a 3/8-in.³ package weighing 1/2 ounce and using OSM jack connectors. Model 49011 is a 1/8 in.³ package with 0.05-inch solder pins for application in stripline and printed circuit boards.

CIRCLE NO. 638

Crystal detectors range dc to 18 GHz

Microlab/FXR, 10 Microlab Rd., Livingston, N. J. Phone: (201) 992-7700. P&A: $35; stock.

Miniaturized crystal detectors operate from dc to 18 GHz. Three models are available; all feature MFM connectors. Two units for use with crystals such as type IN23 and IN78 measure 2 inches long and weigh 6 ounces each. The third, for use with crystals such as type D5223, is 1 inch long and weighs 0.4 ounce.

CIRCLE NO. 639

L-band oscillator has micrometer tuning

Trak Microwave Corp., 4726 Kennedy, Tampa, Fla. Phone: (813) 877-8341.

A low-noise master oscillator for L-band radar or microwave communications systems has a lead screw tuning mechanism with 12 oz-in. max torque, and frequency resolution of over 30 kHz. Frequency range is 1210 to 1330 MHz; RF power output, 17 dBm from two outputs (34 dBm total).

CIRCLE NO. 642

Frequency doublers have low spurious signals

Elpac Systems, 3760 Campus Dr., Newport Beach, Calif. Phone: (714) 546-8640.

Broad, instantaneous bandwidth is the feature of these solid-state frequency doublers. Each model is internally biased and fixed-tuned. Merely inserting the RF input provides twice the frequency at the output. Typical spurious signals are as low as −27 to −30 dB, assuming a clean input signal. The units are epoxy-finished. The band is 300 to 6000 MHz.

CIRCLE NO. 643

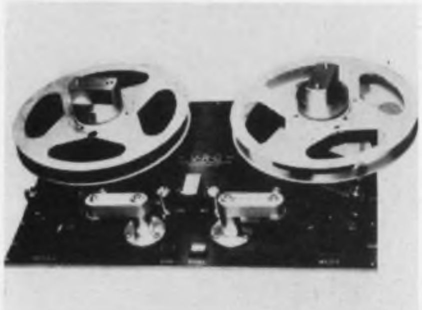
Klystron output is 100 W in S-band

Eimac Div. of Varian, 301 Industrial Way, San Carlos, Calif. Phone: (415) 592-1221.

An electrostatically-focused klystron designed for aerospace communication systems operates at output levels of 20 to 100 W. The S-band tube exhibits 3-dB electronic bandwidth in excess of 30 MHz, with 35% efficiency and 42-dB gain at the 100-W power level.

CIRCLE NO. 644

Tape transport has speeds to 120 ips

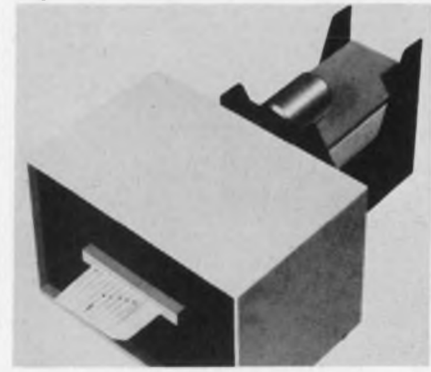


Video Research Corp., 761 N. Washington St., Rockville, Md. Phone: (301) 762-5999.

A flexible, high precision magnetic tape transport mechanism is supplied with a variety of options, including bidirectional capability, to satisfy most analog or digital performance requirements. Tape speeds are available from 15 or 16 ips to 120 ips, and the unit accommodates 10-1/2-in. standard NAB reels of 1/4-1/2-, or 1-in.-wide tape.

CIRCLE NO. 645

Card reader accepts special symbols



Taurus Corp., Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

Standard 80-column, 12-row cards are read serially, column by column, by this unit. Cards may be prepared in Hollerith or other coding systems. All alphanumeric or special symbols are accepted. It may be used on-line to a computer, interfaced with typewriter or adding machine, or used for card duplication or correction. Reading time is 10 or 40 columns per second.

Booth No. 4K38 Circle No. 344

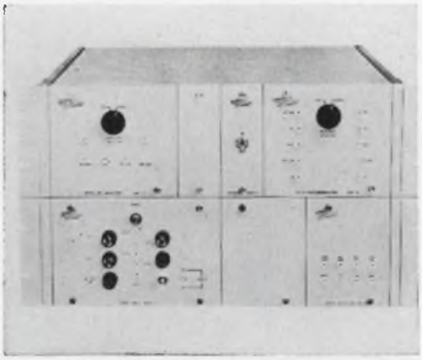
Strip chart recorders in multiple, single-span

Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000. P&A: $795, $745; 30 to 45 days.

Five-inch strip-chart recorders are offered in 2 models: the G-1010 multiple-span unit for general lab work and the G-1110 single-span unit for OEM applications. Sensitivity is 0.1% of the 5-inch span, accuracy is 0.25% and pen response is 0.35 second, full scale. The solid-state design and electronically regulated reference circuit ensure stability.

CIRCLE NO. 646

Data set tolerates line distortion

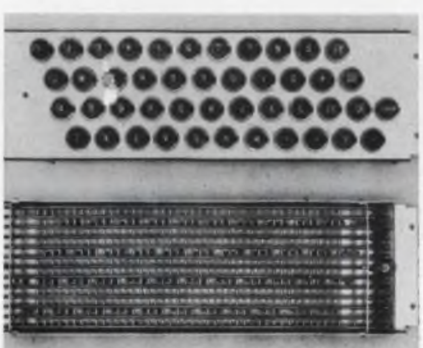


Rixon Electronics, Inc., 2120 Industrial Pkwy., Silver Spring, Md. Phone: (301) 622-2121.

Data can be transmitted over a type 3003 (4A) telephone circuit at 2400 bits per second without adjustment, due to high tolerance to delay and amplitude distortion of this data set. The 4-phase modulation technique which the unit employs makes it ideal for computer systems to poll remote stations for data.

CIRCLE NO. 647

Modular keyboard for 12-bit words

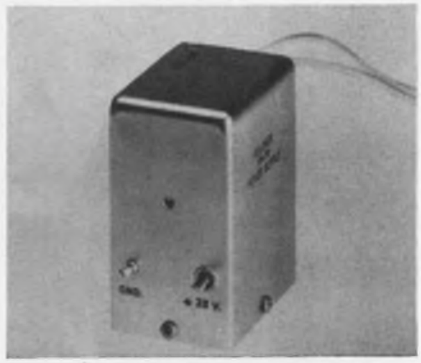


Computronics Engineering, Box 6606 Metropolitan Station, Los Angeles. Phone: (213) 876-1944. P&A: $150; 2 to 3 wks.

A modular keyboard unit provides word length of 12 bits by means of a mechanical X-Y matrix. The method reduces switch contacts by as much as 15 to 1. Interface problems are eliminated by bounce-free action of the switch contact output. The module can generate either Morse, 3 BCDs, ASCII, IBM, EBCDIG or CCIT.

CIRCLE NO. 648

Modular supplies power klystrons and TWTs

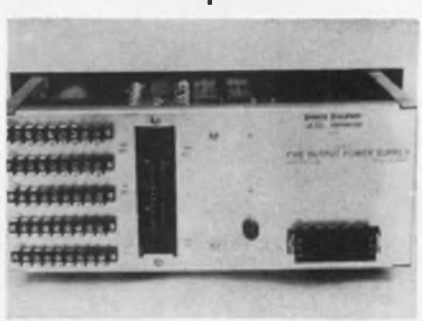


Velonex, 560 Robert Ave., Santa Clara, Calif. Phone: (408) 244-7370. P&A: $400 to $470; stock to 2 wks.

Ten-watt Pico-Pac power supplies measure approximately 6 in.^{3}. The units are packaged to survive a wide range of operating environments common to aircraft, balloons, sounding rockets and satellites. The supplies are for use with CRTs, klystrons, TWTs, photomultiplier tubes and other high-voltage applications. Seven units span a variable range of 150 to 4000 V.

CIRCLE NO. 649

Systems power supply has five outputs



Advanced Development Corp., 137-24 S. Prairie, Hawthorne, Calif. Phone: (213) 679-1691.

A systems power supply produces five voltages from 20 to −20 Vdc at 1 to 7 A. The supply accepts inputs of 100 to 250 Vac at 47 to 63 Hz, and incorporates four series and one shunt regulator. Additional features include 1% envelope regulation, margin-checking, turn-on and turn-off sequencing, and remote sensing. Also provided are automatic current limiting, interlocks, and high pulse load capabilities.

CIRCLE NO. 650

High-voltage converter is programable

Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles. Phone: (213) 870-7014. P&A: $285; 1 to 6 wks.

Designed for use as a control for transducers, VFOs and BWOs, model SMU-P is a 3-V static converter. Output voltage is directly variable by means of a 9±4-Vdc control signal applied to a 2-kΩ input. Resulting output voltage ranges from 30% to 105% of rated output. Deviation from linearity is ±5% of rated output.

CIRCLE NO. 651

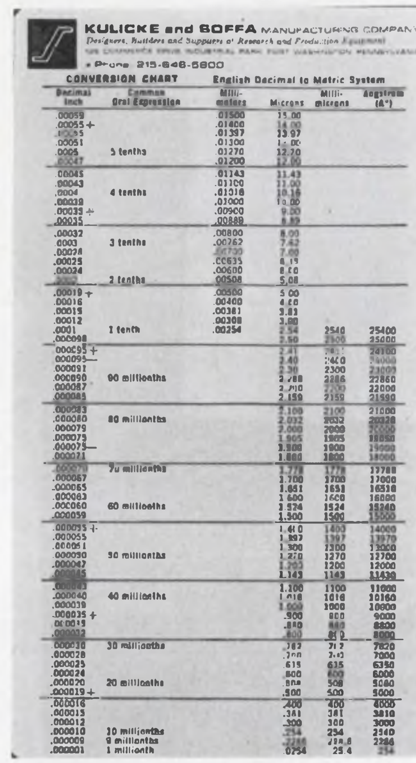
Line conditioner for 1-kVA power level

Elgar Corp., 8046 Engineer Rd., San Diego, Calif. Phone: (714) 279-0800.

Isolation of sensitive electronic equipment from all forms of power line disturbance is achieved with this line conditioner. Response times of less than 50 μs, and input-output isolation of 100 dB are claimed, with max output distortion of 0.25% and regulation of ±0.05%. Circuits are all-silicon solid-state. The unit operates at the 1-kVA power level.

CIRCLE NO. 652

Design Aids



Decimal equivalents

A plastic pocket-sized chart converts from the English decimal to the metric system. The handy table relates decimal inches to millimeters, microns, millimicrons and Angstroms. Kulicke & Soffa.

CIRCLE NO. 653

Photoelectric design rule

This application and design slide rule aids in the use of plug-in logic modules for industrial photoelectric applications. By dialing the application, a choice of modules appears in the window. Also included is a speed conversion table, 17 applications and a scanning distance chart for both direct and reflected light installations. A manual of instructions is included.

Available for $1 from Farmer Electric Products Co., Inc., Tech Circle, Natick, Mass.

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A special AND logic relay in the new "UF" configuration.

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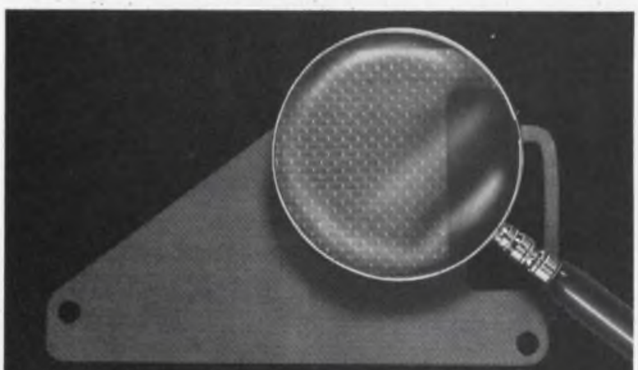

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...seals and shields with more RF pinch to the inch

Porcupine Metalastic is distorted solid monel sheeting in silicone rubber. Its great number of contact points give it more RF shielding pinch to the inch. Its compression characteristics make it excellent for vacuum, atmosphere or moisture seal. Porcupine Metalastic is also available without the silicone rubber to withstand the highest temperature of any flat gasket. Standard width is 8" ...thickness .030". Other sizes also available. About 6¢ per sq. in. Write for free samples, prices and literature.

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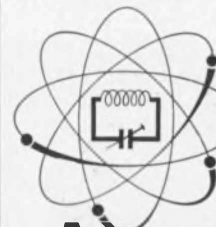

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Application Notes

Comparing heat sensors

Temperature sensing devices cannot be selected by comparison of manufacturers' data because of the different specifications used, according to this 5-page article. Three popular sensors are compared. A two-page application note is included. Harrel, Inc.

CIRCLE NO. 654

Photochoppers

Four pages of descriptive matter and schematics describe the principal applications of the manufacturer's spst and spdt photochoppers. Applications to dc servo loops, power supplies, op-amps and voltage comparators are included. Leeds & Northrup Co.

CIRCLE NO. 655

Semiconductor heat sinks

A twelve-page treatment of the application of heat sinks to semiconductor power devices includes charts, tables and explanatory text. Natural convection and forced-air sinks are discussed, and the computation methods of heat sink requirements are outlined. Westinghouse Electric Corp.

CIRCLE NO. 656

Instrument notes

Nine data sheets and folders on the general subject of instrumentation and measurement are available. Capacitance and inductance, interference, tone-burst, two-port devices, and impedance of coax connectors are treated. General Radio Co.

CIRCLE NO. 657

Saturable core reactors

The theory of saturable core reactors and their applications to high-power-factor loads are presented in six pages of text and diagrams. Their use in regulating power for large loads is discussed. Ordering information is supplied. Acme Electric Corp.

CIRCLE NO. 658

Digital plotting systems

Two 4-page brochures describe automatic plotting systems for use with digital computers. One system performs on-line or off-line plotting from almost any standard computer output. The other plots from a remote teletypewriter using lowspeed data transmission lines. California Computer Products, Inc.

CIRCLE NO. 659

Electrical schematics

Symbols, circuits and text deal with the construction and interpretation of electrical schematic diagrams of power and control devices, in this 8-page informative article. Tables are included giving terms, functions and symbols of the most commonly used electrical components. The Clark Controller Co.

CIRCLE NO. 660

Low-current SCRs

The low-current SCR, a 4-layer semiconductor switch with 3 layers accessible to the user, is the subject of a 40-page brochure. Text, schematics and formulas clarify the many applications of the device. GE Semiconductors Dept.

CIRCLE NO. 661

Electrical isolation

Isolation by photon coupling permits the use of small, lightweight components. In a 4-page brochure, the manufacturer describes applications of a photon-coupled isolator to a number of circuits. Schematics and charts are included. hp Associates.

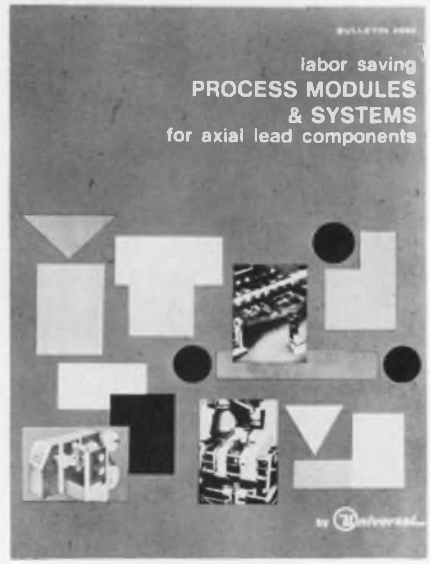
CIRCLE NO. 662

IF and RF amplifier

Applications of a direct-coupled microcircuit amplifier designed for video, IF and RF are available in a 6-page brochure illustrated with charts and schematics. Philco-Ford Microelectronics Div.

CIRCLE NO. 663

New Literature



PC assembly machines

Numerically controlled and pantograph-operated PC board assembly machines, component sequencers, axial-lead component reel packaging equipment, and axial and radial-lead component processing and production systems are described in a new 12-page catalog. Universal Instruments Corp.

CIRCLE NO. 664

Molecules and microwaves

A new technical journal, to be called "Molecules and Microwaves," will be published on a periodic basis. Initially this journal will feature data on microwave spectroscopy applications. The first loose-leaf sheet shows that pertinent molecular structural information can be obtained from fast-scan, lower-resolution microwave spectroscopic data. Microwaves Div., Hewlett Packard Co.

CIRCLE NO. 665

Switch uses

Eleven unusual switch operations for industrial and military installations are described in an 8-page illustrated brochure. Coordinated controls and switch consoles in current use in space, submarine and other operations are described with illustrations. Micro Switch, Div. of Honeywell.

CIRCLE NO. 666

Adjustable speed drives

Covering drive ratings from 1/6 through 7-1/2 hp, a brochure fully describes and illustrates the design features, product selectability and options of adjustable-speed drives. It deals with special design measures to assure electrical, environmental and thermal protection, fully enclosed, solid-state controllers and design compatibility. U. S. Electrical Motors.

CIRCLE NO. 667

ISA publications

The 20-page 1967 ISA Publications Catalog lists some 76 proceedings of ISA-sponsored and cosponsored conferences and symposia, standards books and 33 ISA Recommended Practices, and over 40 books, monographs and reference works. International Federation of Automatic Control publications, educational aids and periodicals that represent the most comprehensive and current data available in instrumentation are included. Instrument Society of America.

CIRCLE NO. 668

Automatic speech

Educational and industrial uses of the company's line of speech generating equipment are described in this brochure. Telephone lines are identified by seven spoken digits with these devices. Cognitronics Corp.

CIRCLE NO. 669

Flexible cables

A brochure on applications and manufacturing techniques traces the history and manufacturing procedures in the development of flexible cables and circuitry. Photographs, diagrams, charts and descriptive copy outline the advantages, as well as the disadvantages of their use in military and commercial applications. Methode Electronics, Inc.

CIRCLE NO. 670

Measuring instruments

Potentiometers and voltage standards, dc resistance bridges, galvanometers and magnetic flux meters are a few of the electrical measuring instruments described in three pages of specs, photos and explanatory material. Yokagawa Electric Works.

CIRCLE NO. 671

Permanent magnets

Ten pages of charts, diagrams and text deal with the magnetization methods used in producing permanent magnets. Magnetic properties of several metals and alloys are tabulated. Permanent Magnet Association.

CIRCLE NO. 672

DTL handbook

Schematics and specs on the company's line of DTL-compatible ICs are offered in a 57-page catalog. Characteristic curves and test results are included. ITT Semiconductors.

CIRCLE NO. 673

Components catalog

This 48-page catalog is a complete guide to the manufacturer's line of electronic components such as: battery holders, terminals, terminal boards, pre-punched boards, plug-in-housings, bushings, staking tools, and includes photographs and descriptions of each item. Keystone Electronics Corp.

CIRCLE NO. 674

Servo motors

A pocket-size, 36-page stock list of gearhead servo-motors and generators is designed to serve as a reference manual for prototype and breadboard requirements. Electrical and mechanical specs, diagrams, tables and BuOrd listings are included. Vernitron Corp.

CIRCLE NO. 675

Transformer catalog

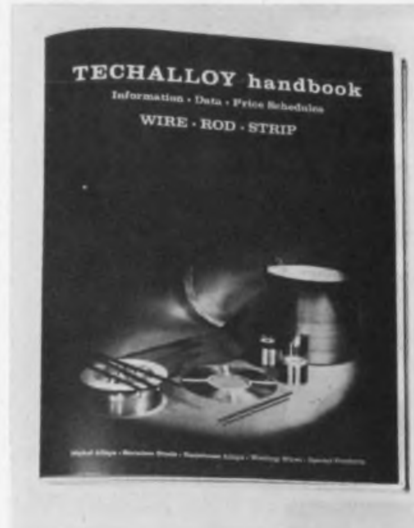
Transformers and toroids in MIL-T-27B and industrial constructions are outlined in a 34-page catalog. Charts, graphs, applications, schematics and data for transformer specification are included. Microtran Co., Inc.

CIRCLE NO. 676

Mass spectrometer

An eight-page brochure on a mass spectrometer gas analyzer with mass range to 300 AMU, unit resolution at 100 AMU and sensitivity in the 10^{-12} torr range is available. Aero Vac Corp.

CIRCLE NO. 677



Wire, strip and rods

More than 100 different metals and alloys are discussed in a handbook on wire, strip and rods. Quick-reference tables give prices and mil limits with tolerances for the complete range of sizes. Techalloy Co., Inc.

CIRCLE NO. 678

Firing circuits

With over 50 diagrams, wave forms and other illustrations, this booklet presents a study of SCRs and their control by magnetic amplifiers. Single and 3-phase systems, high di/dt and high dv/dt conditions, protection of the firing circuit from failure, on-to-off ratio, sensitivity and gate pulses are discussed. Firing Circuits, Inc.

CIRCLE NO. 679

Transfer molding

Reprints of a 12-page article are available, describing: selection of plastic, its relation to good part design and molding method; liquid resin systems for molding and encapsulating; machine molding, compression, transfer, and injection methods. Hull Corp.

CIRCLE NO. 680

Stock bobbins

A 12-page folder gives charts and tables of a broad line of bobbins stocked by the manufacturer. Square and rectangular stacks and bobbins for cup cores and reed switches are included. Wilcox Products Co.

CIRCLE NO. 681

Potentiometer catalog

A 32-page illustrated catalog of potentiometers, field-assembled controls, power rheostats and resistors includes photographs, engineering drawings and descriptions. A section describing potentiometers for military use is included. Clarostat Mfg. Co.

CIRCLE NO. 682

MIL spec procurement

A 7-page data sheet gives part numbers under MIL specifications with a cross reference to the company's catalog listing. The purpose of the data sheet is to increase effectiveness in using the specification MIL-S-8805B, and to reduce delivery time for switches procured to the specification. Micro Switch, Div. of Honeywell.

CIRCLE NO. 683

Deposition control film

An eight-minute, 16-mm color sound movie describes the latest techniques for automatically controlling multi-layered, multi-source depositions. It is available on a one-week loan basis. Sloan Instruments Corp.

CIRCLE NO. 684

Guard circuits

A brochure offers 6 pages of text and schematics dealing with circuits for guarding measurement devices against loss of accuracy due to unwanted common-mode voltages. Hewlett-Packard, Moseley Div.

CIRCLE NO. 685

Test equipment

A 16-page brochure contains a complete line of test instruments and adapters, VTMs, a recording VOM, general purpose micro-testers, scopes, temperature measuring instruments, carrying cases and other accessories. Simpson Electric Co.

CIRCLE NO. 686

Nickel-cadmium cells

Characteristics and uses of nickel-cadmium batteries are discussed at length in a 24-page brochure with curves, photos, diagrams and tables. Battery principles, charging practices, idle storage and battery selection are among the subjects treated. International Nickel Co., Inc.

CIRCLE NO. 687

Power supply aid

Prepared in flow chart form, this capsule guide presents four basic parameters of power supply operation, making it possible for the engineer to progressively narrow down his choices on the basis of output regulation, voltage output, programing speed, and power output. Hewlett-Packard, Harrison Division.

CIRCLE NO. 688

Firing circuit modules

Schematics, specs and explanatory text describe a line of firing circuit modules designed to eliminate SCR failures due to di/dt and misfiring and interaction troubles. Crydom Labs., Inc.

CIRCLE NO. 689

RTL line

An RTL integrated circuit line is covered in 18 loose-leaf pages. Product descriptions, logic diagrams, pin arrangements and schematics are included. Sperry Semiconductor.

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March 1	Jan. 30	Feb. 9	Sept. 1	July 31	Aug. 10
March 15	Feb. 13	Feb. 23	Sept. 13	Aug. 14	Aug. 24
April 1	Feb. 27	March 9	Sept. 27	Aug. 28	Sept. 7
April 12	March 13	March 23	Oct. 11	Sept. 11	Sept. 21
April 26	March 27	April 6	Oct. 25	Sept. 25	Oct. 5
May 10	April 10	April 20	Nov. 8	Oct. 9	Oct. 19
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171

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173

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175

Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard.

Electrostatic Instrumentation

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176

Designer's Datebook

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S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

APRIL

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23/30	24	25	26	27	28	29

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Mar. 20-23
IEEE International Convention (New York City) Sponsor: IEEE; The IEEE, 345 E. 47 St., New York, N. Y. 10017

CIRCLE NO. 694

Mar. 22-24
International Symposium on Modern Optics (New York City) Sponsor: Polytechnic Institute of Brooklyn, AFOSR, NOR; Symposium Committee, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, N. Y. 11201

CIRCLE NO. 695

Mar. 29-31
Symposium on Microwave Power (Stanford, Calif.) Sponsor: IMPI: Dr. Donald Dunn, IMPI, P. O. Box 2335, Stanford, Calif. 94305

CIRCLE NO. 696

Apr. 5-10
International Exhibition of Electronic Components (Paris) Sponsors: Five specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

CIRCLE NO. 697

Apr. 10-15
International Conference on Electronics and Space (Paris) Sponsor: Two specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

CIRCLE NO. 698

Apr. 14-21
Mesucora 67 (International Exhibition and Congress on Measuring and Test Equipment and Automation) and Physics Exhibition (Paris) Sponsor: Société Française de Physique (French Physics Society); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

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  Char. V: 3% max. Δ R after 2,000 hours at full rated power
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