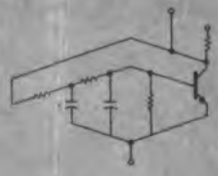
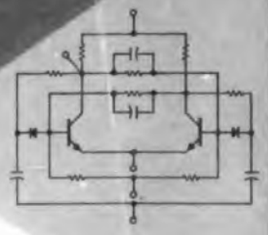
ELECTRONIC DESIGN





SOLID CIRCUITS FROM SINGLE CRYSTALS FOR SALE...p 106

COVER: The many facets of crystalline structures are used by *ELECTRONIC DESIGN*'s artist to emphasize the wide variety of circuit configurations which can be embodied in semiconductor Solid Circuits. One such circuit is now available off-the-shelf. Others can be custom-designed.

Selected Topics In This Issue

◄ CIRCLE 1 ON READER-SERVICE CARD

Sidelights Of This Issue

It was impossible for any one person to see everything and talk to everyone at the recent IRE show. Impossible for one person—but only part of *ELECTRONIC DESIGN*'s job. The staff had several projects going at the same time.

ELECTRONIC DAILY, the only daily magazine put out during the show, provided engineers with a day-to-day commentary on IRE highlights. Editors with cameras and pads not only visited the booths, but also attended the technical sessions held at the various hotels. Many a show-goer admired a photograph of himself in the *DAILY*'s picture section.

While the news staff was gathering material for the *DAILY*, the technical staff was equally busy interviewing exhibitors and speakers, as well as attendees, to get comments and opinions on the significant trends that affect you. The technical editors were primarily interested in getting a clear picture of the future in order to plan ahead for subsequent issues of *ELECTRONIC DESIGN*. But the impressions of those people interviewed proved to be invaluable in the final roundup of the show.

Before the show ended, the news and technical staffs got together to compare notes. "Was there anything that we missed?" "Did we cover everything of importance?" From their personal contacts with show-goers, the entire staff garnered enough material for a most thorough roundup of the industry. The last day of the show was spent in checking out conflicting and contradicting views that too often come from superficial reporting.

One of the things that came out of the show was a Special Tube Report that appears in this issue. *ED* editors Bob DeFloria, Howard Bierman, and Bob Haavind scooted around and spoke to all the people involved in the design and manufacture of the new tubes that are attracting so much attention. Some of these tubes were introduced at the show, others are still in the laboratory. You'll want to bring yourself up to date on advances in this field.

In fact, catch up with the latest in everything. Take advantage of *ELECTRONIC DESIGN*'s personal touch at the IRE show. The roundup begins on page 14. The Tube Report starts on page 98.

CONTENTS FOR APRIL 13, 1960 VOL. 8 NUMBER 8

ELECTRONIC DESIGN

Hayden Publishing Co., Inc.,
830 Third Avenue, New York 22, N. Y.

ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N. Y., T. Richard Gascoigne, President; James S. Mulholland, Jr., Vice-President & Treasurer. Printed at Hildreth Press, Bristol, Conn. Accepted as controlled circulation at Bristol, Conn. Additional entry, New York, N. Y.

Dual channel traveling wave maser developed for Project Echo is given the once-over by its inventors —H.E.D. Scovil and R.W. DeGrasse of Bell Labs, Murray Hill, N.J. Maser will operate down to 2390 mc with extremely low thermal noise.

New Designs For Project Echo Squeezing Out Last Db's

ULTRA-LOW-NOISE microwave gear is being readied for the imminent launching of Project Echo, NASA's experiment in long distance communication via reflecting satellites.

A low-noise, two-channel traveling wave maser operating down to 2390 mc has been developed by Bell Telephone Laboratories for use at the Holmdel, N.J., terminus of the experiment. The device is unidirectional and provides up to 40 db forward gain. Two modes of signal polarization can be handled simultaneously.

The maser will be fed by a 50-foot-long horn reflector antenna having a 400-square foot opening. The horn is now going up at Holmdel to receive Project Echo transmissions from the JPL site at Goldstone, Calif. The horn has a noise temperature of only 2 K and provides approximately 43 db of gain. Its beam angle is about 1.5 deg. The horn-maser combination should yield no more than 5 or 6 K of noise.

Transmission of music, voice, and audio tones via the satellite link will be by wide band (± 30 kc) fm. The specially-designed receivers to be used will include a fast-acting afc feedback stage operating within ± 3 kc of the base band. The net effect of this circuitry is to enhance the signal by some 30 db. Overall signal to noise ratio of the horn-maser-receiver combination should exceed 40 db.

Transmission loss between the two stations with the satellite at the optimum (midway) position will be on the order of 183 db; at less favorable satellite positions, an additional 10 db of attenuation is expected.

Coast To Coast—Both Ways

Simultaneously two-way transmission will take place between Holmdel and Goldstone. The transmitting antenna at Holmdel will be a 60-foot dish broadcasting at 980 mc. Transmitting and receiving antennas at Goldstone will be 85-foot parabolic reflectors. Goldstone will broadcast at 2930 mc. Power at each site will be 10 kw cw.

Commercially available tropo-scatter equipment with klystron final stages will do the job at both sites. The Goldstone receiver will use a varactor diode parametric amplifier rather than the Bell Labs maser because of the lower frequency to be received. Beam angle of the Goldstone dishes is 1 deg, but inherent thermal noise will be on the order of 50 K.

Satellite tracking is expected to be the real headache in Project Echo. Pointing accuracies of 0.1 deg are needed to follow the sphere in its 12 to 15 minute maximum swing across the common tracking horizons of both stations. As one JPL scientist put it, "About 80 per cent of our effort on Project Echo in terms of manpower and electronic equipment involves tracking."

Side-Looking X-Band Radar Gives Photo-

AN X-BAND doppler-type side-looking radar, used for precision mapping from low-altitude aircraft, has been declassified by the Air Force. The system is designated AN/APQ-55.

The radar mapping equipment, under development by Texas Instruments, Inc., Dallas, since 1955, is designed for operation at altitudes from 1,000 to 5,000 ft. Mapping of either three or six-mile strips on both sides of an airplane is possible at ground speeds of 200 to 800 mph either during the day or at night, reports the company.

A 12-ft long linear slotted antenna, actually two side-looking antennas placed back to back, is placed in a tubular radome which can be slung under the fuselage of an airplane. Radar pulses can be alternately fed to the two antennas, so that mapping of strips on both sides of the plane can be accomplished simultaneously with the use of only one transmitter, according to a TI spokesman. This design keeps weight of the entire system, including antenna, down to 350 lb.

Echoes Modulate Electron Beam

Returning echoes are used to intensity-modulate an electron beam writing on a moving film strip. The speed of the film strip is controlled so that it is proportional to the speed and altitude of the aircraft. The fine-resolution lines printed on the film strip thus correspond to the reflectivity of the terrain covered by the side-looking radar's narrow beam.

The resulting picture of the strip of terrain covered looks more like a photograph than a radar display. The mapping system operates in fog or bad weather, and is also able to penetrate camouflage.

Two modifications of the basic TI system have been developed. One allows mapping of either 10 or 20 mile strips with the positioning of a selector switch. The second steps up ground speed to 2,200 mph, so that the system can be easily adapted to future high speed aircraft.

Distance perspective is electronically adjusted in the AN/APQ-55 so that objects at the edge of the scanned strip are on the same scale as those at the center. In aerial photography ground distances become compressed in perspective as distance increases. Also an aerial camera scanning a fixed angle maps less area as altitude decreases. The Texas Instruments system scans a constant ground area regardless of altitude.

(continued on p. 7)

Side-looking radar precision mapping equipment produced this high resolution portrait of Dallas, Tex., from an airplane at night. Downtown Dallas is at upper left, Mountain Creek Lake next to Grand Prairie at the center of the strip at right. Split down the center represents the path of the aircraft.

The problem begins with initial location of the sphere to establish its orbital path. A radar beacon is provided in the third stage of the Thor-Delta booster, but the satellite itself is entirely passive.

"A beacon on the satellite would make our job a darn sight easier," commented a Bell Labs engineer.

Radar and optical tracking facilities at Goldstone will gather orbit data for real-time transmission to a 7090 computer at NASA's Goddard center near Washington. Orbit predictions will then be sent to the two sites for the next swing of the vehicle. Monitoring will be continuous since the high drag to weight ratio of the 100-foot, 150-pound sphere may result in a rapidly changing orbit—even at 1000 miles up. Pointing accuracies of the antennas are adequate, but aiming information must be constantly up-dated.

Useful life of the sphere may be limited to about three weeks because of deflation resulting from vapor leakage. During that time, as a Bell

(continued on p. 6)

Detailed Aerial Map

NEWS

Business end of Project Echo. 100-foot inflatable mylar sphere is packed into nose of Thor-Delta rocket for release 1000 miles up.

Project Echo

(continued from p. 5)

Labs engineer stated, "We're going to work like mad to get all the information we can."

The experiment is designed to evaluate the feasibility of passive satellite communication and to provide data for future experiments along similar lines. Studies to be performed include:

- Check of propagation theory against measured results.
- Tests of wide-band fm system in voice transmission. If time permits, equipment may be rewired to provide greater bandwidth for multichannel and TV transmissions.
- Measurement of reflective properties of the sphere including polarization of reflected signals, faraday rotation and doppler shift.

Other groups have made plans to use the satellite for related experiments outside Project Echo. These include the Signal Corps, Collins Radio, ITT and the Jodrell Bank observatory in England. Transatlantic communication may be attempted with Jodrell Bank. ■ ■

50-ft Horn reflector receiving antenna for Project Echo (foreground) at the Holmdel, N.J., station of the experiment. Other antenna is a 60-ft transmitting dish to bounce 980 mc signals off the satellite to Goldstone, Calif., receiving station.

Side-Looking Radar

(continued from p. 4)

Other elements of the side-looking radar system developed by Texas Instruments include the film-pulling mechanism that controls the speed of film advance, and microwave data link equipment which can transmit directly from one radar receiver to ground stations. A rapid film processor develops the map traced by the electron beam in about 60 sec.

An electrohydraulic stabilization system feeds correction signals to the antenna to compensate for roll of the aircraft. Some yaw correction is provided by trace displacement in the cathode ray tube, according to a TI spokesman.

Tolerances in the production of the slotted antennas are crucial. Special cutting equipment was developed to cut the slots. Depth of cuts are held to better than ± 0.0003-in., width of cuts to better than ± 0.002-in., and spacing between cuts to ± 0.0005-in. over the entire 12-ft antenna length. Each slot is cut at a different angle, with an angular tolerance of ± 0.010 deg.

The system is said to be capable of mapping thousands of square miles of terrain per hour.

In tactical military applications the equipment can provide field commanders with detailed information on movement and location of troops, supplies, and targets.

Used in Iceberg Mapping

The Coast Guard has already used the radar to map iceberg positions on the North Atlantic shipping lanes. Fog has been a constant problem with photographic iceberg charting, and conventional search radars have not been capable of distinguishing between small fishing vessels and floating icebergs. The TI system was able to distinguish between trawlers and floating ice, and also to penetrate fog.

Although details were not disclosed, Texas Instruments says that it is developing a more advanced system with greatly extended range. This system is currently undergoing flight testing at TI's Avionic Flight Test Center in Dallas.

Other companies are known to be working in the side-looking radar precision mapping and reconnaissance field. Industry sources say that these include Westinghouse Electric Corp.'s Baltimore Div.; Philco Corp., Phila., Motorola, Inc., Phoenix; and Bendix Aviation Corp., Detroit.

Other known applications include antisubmarine warfare in which ocean reconnaissance aircraft are able to spot submarine periscopes or snorkels because of the fine resolution obtainable. Cathode ray tube manufacturers are working on higher resolution tube-types to increase the effectiveness of the precision radar mapping techniques. (See p 98, this issue.) ■ ■

Technician seated at the control panel of the Remington Rand Univac 1105 has just completed a preliminary test on the equipment. Census Director Robert W. Burgess (right) observes the procedure at the Bureau of Census Headquarters, Suitland, Md.

Photos by Remington Rand—Curt Gunther

4 Univac 1105 Computers Will Help U.S. Count Population This Year

FOUR Remington Rand Univac 1105 computers will be used in tabulating the final data for the 1960 U.S. census. The machines replace Univac I, used in the 1950 census.

The 1105 is a large-scale, random-access computer with a magnetic-drum storage. Its access times are put at 34 msec maximum and 17 msec average. It has a transfer rate from drum to core of 32 μsec.

The magnetic-tape storage includes up to 20 uni-servo tape-handling units. The non-volatile magnetic core storage

Census workers view a section of microfilm comparable to what will be used in the Census Bureau's FOSDIC Div. to transfer data from page to film. This roll contains the data from 1,500 form sheets. FOSDIC will transfer it to magnetic tape, which the 1105 computer will then use for arithmetic operations.

Final results of Univac 1105 computations are recorded on this high-speed printer. The machine turns out 600 lines per min. in tabular form (shown here) or other formats.

consists of 36 magnetic core matrices. Storage capacity is said to be 12,288 36-bit words. According to Remington Rand, any word is available in 8 μsec. The large capacity of the 1105 will permit an accurate census report to be available by December 1, 1960, it is expected.

Two of the machines are installed at the Bureau of Census Headquarters at Suitland, Md. They will be used in conjunction with the bureau's FOSDIC equipment. FOSDIC transfers data from census form sheets into magnetic tape for feeding into the 1105. Census Bureau personnel operate all the equipment.

After computing census material, the 1105's will remain at the bureau and be used in preparing various monthly reports to Government agencies.

The other computers are at the University of North Carolina at Chapel Hill and in the Armour Research Laboratories of the Illinois Institute of Technology in Chicago. These institutions will work in conjunction with the Census Bureau. When the census is complete, they will use the computers for their own research projects.

According to Remington Rand, large-scale use of the computers will result in the most rapid availability of statistics yet possible. ■ ■

NEWS

Dummy Missile Aiding Navy Polaris Training

Dummy missiles launched from submerged submarines are facilitating testing and crew training in the Navy's Polaris program.

Developed by Lockheed's Missile and Space Div., the dummy is designed to:

- Check all submarine launching systems before insertion of live missiles.
- Train submarine crews in missile launching.
- Determine underwater trajectories of missiles in sea conditions ranging up to hurricane force.

In addition to this program, tests to ignite propellant charges in undersea-launched Polaris models are also being made.

The dummy missile contains a sealed, watertight instrument package that has 10 pickups, batteries and a tape recorder.

The package conducts self-calibration of each measurement channel immediately before and after every launch. It does not require any attention after it is installed in the dummy, nor does it need maintenance nor field adjustment, Lockheed reports.

The sealed package is returned to the company for opening, data analysis and resetting.

The launch and training vehicle, called Dolphin, is as long and as thick as the Polaris and resembles it in appearance.

Launch and training vehicle leaping from the waters off San Clemente, Calif., is designed to perform like the Polaris. It houses an instrument package that tests launching systems and trajectories.

◄ CIRCLE 10 ON READER-SERVICE CARD

Printed-Circuit Makers Warned To Keep Up With Solid State

An Air Force electronics specialist has warned printed-circuit manufacturers that their present techniques are inadequate—"not quite exotic enough"—for handling the problems that solid-state electronics will face.

The specialist, Lt. Col. J. K. Schloss, assistant chief of the Electronics Technology Laboratory at Wright Air Force Base, Ohio, urged the manufacturers to use their ingenuity to adapt their products for the rapidly advancing solid circuit art. He spoke before the Institute of Printed Circuits.

Interconnection Techniques Needed

With solid circuits no longer requiring conventional resistors, capacitors, and inductances, Colonel Schloss noted, there will be no need for the printed-circuit "interconnecting" board in use today. Until the solid circuits are operationally reliable in complete system packages, engineers will be dependent upon new interconnection techniques, he said.

A possible new technique, Colonel Schloss suggested, is the use of diffusion methods for making the printed conductor paths. Rather than plate the copper paths onto the surface of the laminate, it may be possible to diffuse conducting material through the laminate, he said. Another method would use a stratified laminate board. The conducting paths would be placed on the board in insulated layers, which would accommodate the number and sizes of the micromodules in the system.

Colonel Schloss' remarks were made during a panel discussion on "What The Military Wants in Printed Circuits." The program was part of the semi-annual meeting of the Institute of Printed Circuits in New York during the IRE Convention.

Institute Pressing Goals

Organized two years ago to set up printed-circuit standards and promote their use, the institute has grown from a founding membership of five to its present 34. Members include both makers and users of printed circuitry. At present there are five active committees, organized to set standards and improve reliability. These committees deal with repair problems, raw materials, through-hole connections and design-dimension tolerances. In addition there is a committee to establish a working liaison between Government and industry.

Robert L. Swiggett, executive vice president of the Photocircuits Corp., Glen Cove, L. I., is president of the institute. Elected in March for a one-year term, he succeeds W. J. McGinley of the Methode Manufacturing Corp., Chicago.

Fig. 1. A developmental 15-w MADT transistor, capable of switching 1 amp at a 5-mc clock rate.

Etching By Transmitted Light Brightens Outlook For Boosting Power Of Fast-Switching MADT's

BY MEANS OF an improved fabrication process termed ETL (etching by transmitted light), high-power, fast-switching MADT transistors will soon be available. At the recent IRE International Show, Philco Corp's Lansdale (Pa.) Div. demonstrated a 15-w MADT (microalloy diffused-base transistor) developmental unit capable of switching 1 amp at a clock rate of 5 mc (Fig. 1).

Standard precision-etch transistors are fabricated by a jet-etching technique in which an electrochemical solution is sprayed against the surface of a semiconductor wafer. Small pits of accurately controlled diameter and depth are formed. Collector and emitter electrodes are then plated or evaporated into the pits. The surface being etched is illuminated directly, and pits up to 12 mils in diameter can be fabricated. Larger pits are difficult to etch because of an uneven distribution of hole recombinations over the full area of etching. Maximum dissipation levels average 75 mw.

In the ETL process (Fig. 2), high-intensity light is focused on one side of a semiconductor wafer, and the electrochemical jet is directed onto the opposite side. Light diffuses through the material and makes hole-electron pairs available at the surface being etched, thus increasing the speed and accuracy of fabrication. Pits up to 120 mil diam and larger are possible with the technique. Rated dissipation levels can be raised from 75 mw with the standard etch process to 500 mw using ETL.

Light plays an essential role in creating holes to aid the etching process. The surface of a germanium wafer is composed of hydrated germanium atoms tightly bound by pairs of electrons to germanium atoms deeper in the crystal. Holes must be added to replace the bonding electrons to permit the surface

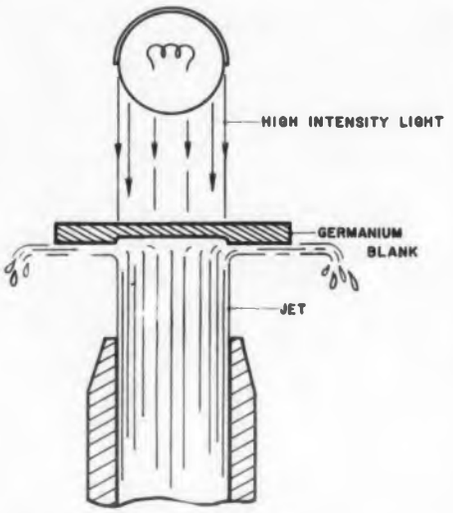


Fig. 2. In the ETL process, a high concentration of light is placed behind the semiconductor wafer, and a jetstream is directed at the opposite side.

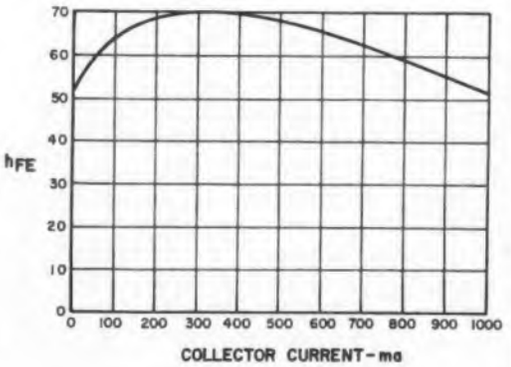


Fig. 3. Current gain, h_{FE}, is substantially uniform over a wide range of collector current ($V_{CE} = -1$ v).

atoms to dissolve in the jetstream. By directing light energy or phonons on a germanium atom, hole-electron pairs are created. The electrons drift to the external circuit, and the holes move to the surface being etched. Pit etching takes place at a uniform rate and a flat bottom is obtained.

High current-density MADT's have been produced with typical rise, fall and storage times of 40, 75 and 35 mμsec respectively at a collector current of 1 amp. At an emitter current of 150 ma, a typical gain-bandwidth product is 33 mc. Beta is relatively flat, varying from 75 at 300 ma collector current to 51 at 1 amp (Fig. 3).

Philco is currently expanding ETL developmental work to include solid-state circuits. ■ ■

after routing, clip and save

a continuing series on technical topics of specific interest to engineers

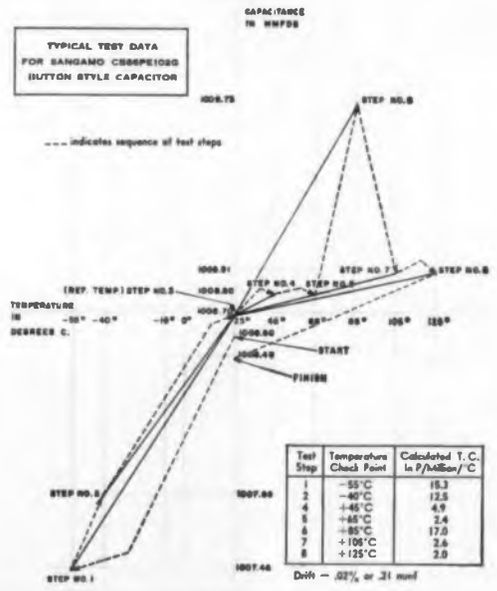
Folio 60-10 REFERENCE DATA FILE SANGAMO

A Typical Example of Capacitor Characteristic

Sangamo Reference Data File 60-9 was aimed at clarifying the meaning of the word "characteristic" as it applies to the capacitor industry. It cited the ways in which the term was defined and gave examples of how characteristic is designated in Paper, Electrolytic and Mica capacitor nomenclature. This article will explain the term as it is used for a specific type of capacitor . . . the mica dielectric capacitor.

Under discussion will be a Sangamo fixed, mica dielectric, button style capacitor . . . the CB86PE102G. It has been stated previously that the characteristic letter "E" defines the capacitance stability of the unit during one "round trip" excursion from room temperature (+25°C) to minimum and maximum temperatures specified for the capacitor. Capacitance stability is evidenced by two capabilities of the product: (1) Temperature Coefficient. This is the dynamic change in capacitance as a function of temperature. (2) Capacitance Drift. This is a static change in the room temperature capacitance after the temperature excursion. It represents the ability of the capacitor to retrace its "temperature coefficient" curve. Let's further investigate these two capabilities of mica capacitors.

FIGURE 1



Test Step	Temperature Check Point	Calculated T. C. In P/Million/°C
1	−55°C	15.3
2	−40°C	12.5
4	+45°C	4.9
5	+65°C	2.4
6	+85°C	17.0
7	+106°C	2.6
8	+125°C	2.0

FIGURE 2

	Designator	Temperature Coefficient Parts/million/°C	Capacitance Drift
CHARACTERISTIC	B	Not specified	Not specified
	D	−100 to +100	0.3% or 0.3 mmf; whichever is greater
	E	− 20 to +100	±.1% + 0.1 mmf

Temperature Coefficient (T. C.) is defined as the parts per million change in capacitance for every degree change in temperature. In equation form, it is defined as:

$$T.C. = \frac{(C_2 - C_1) \times 10^6}{(T_2 - T_1)\, C_1}$$

Where: T. C. = Temperature Coefficient in parts per million per degree C.
C_1 = Capacitance at reference temperature (+25°C) in mmf
C_2 = Capacitance at test temperature in mmf
T_1 = Reference temperature (+25°C).
T_2 = Test temperature in degrees C.

Figure 2 shows a table setting forth values for three characteristic designators. If the T. C. and Drift of a mica capacitor fall within the limits of those values shown in Figure 2, then the capacitor can be said to have a B, D or E characteristic. However, the temperature range of the capacitor must be specified.

Now let's look at Figure 1 again. The primary objective of the test is to find the maximum value of T. C. throughout the specified temperature range of the capacitor. In this case the temperature range of the CB86PE102G is —55°C to +125°C. The ideal test would determine all instantaneous values of capacitance from —55°C to +125°C but, until recently, time has been the prohibiting factor in this test procedure. The capacitance is therefore measured at selected temperature test points throughout the specified range. Today, through the utilization of the latest equipment and procedures, Sangamo can obtain these ""in-between" values in a fraction of the previous time. This approach means significantly better-tested components for customer equipment. For the purpose of this article, only the selected test points will be used for checking maximum T. C. throughout the temperature range.

Notice that in Figure 1 there are 10 capacitance readings . . . Start, Steps 1, 2, 3, 4, 5, 6, 7, 8 and Finish. The T. C. is calculated for each temperature check point other than 25°C using the above equation. These points are Steps 1, 2, 4, 5, 6, 7 and 8. The test results have been computed and are tabulated in Figure 1. If, after having computed the value of T. C. for all seven points, the maximum plus and minus values lie in-between the limits of any one designator, then the capacitor is said to meet that "characteristic".

Capacitance Drift is simply the element that defines capacitance stability of the unit during *one* "round trip" temperature excursion as shown in Figure 1. It is expressed as a percentage and is computed by dividing the greatest single difference between any two of the three values recorded at +25°C by the second value recorded at +25°C (Reference Temperature) multiplied by 100. It can also be expressed in mmfds. by subtracting the smallest capacitance value recorded from the largest of the three values recorded at +25°C. If this value is then compared with those values of Drift shown in Figure 2, the characteristic of the capacitor can then be determined.

Temperature Coefficient of capacitance is usually the parameter of greatest interest to design engineers. Drift is often of secondary importance. Sangamo feels that these two parameters should be stated separately in specifications and encourages its customers to state their requirements quantitatively and separately for T. C. and Drift. Further, a precision capacitance tolerance does not insure or indicate capacitance stability.

SC-60-2

SANGAMO ELECTRIC COMPANY, Springfield, Illinois

-designing toward the promise of tomorrow

CIRCLE 13 ON READER-SERVICE CARD

Biggest IRE Show Ends On High Competitive Note

Exhibitors Do Little Over-the-Counter Selling, But Call Response Good for Future Business

AWARBLE from Pioneer V traveled a million and a half miles through space to open the biggest trade show in the world. By the time the satellite itself had voyaged another half a million miles farther from earth, the 1960 International IRE Show and Convention had come to a successful conclusion.

The object of the show was not, and never has been, to take orders for merchandise at the booths. There was no "hard sell." But exhibitors were pleased with the turnout and the contacts they made. "We didn't actually do business at the show, but we got a lot of definite inquiries—the kind that lead to sales," said Howard A. Smith, New England sales manager for Emerson & Cuming. "It was a *good* attendance: lots of engineers, not so many curious passersby as last year."

One transistor manufacturer gave out 8,000 brochures listing his transistors. Last year only 2,500 were picked up. Other comments overheard by ELECTRONIC DESIGN editors confirmed the impression that the show was more successful this year than last:

- Philip Broad of Union Switch and Signal effused: "It's great this year, really great. The booth is more heavily trafficked. We're not making any business deals, but we've certainly made a lot of contacts and leads."
- Wallace Green, Kurman Electric Co.: "I'd say we were doing about half again as good as we did last year—just in terms of quality of interest. People are looking more. They're asking questions—not as many catalog collectors."
- Gertrude P. Hinkle, Pyrofilm Resistor Co.: "Engineers are coming with more specific problems this year—much more than in the past. They've got requirements, and they want answers."
- C. Tuttle, Vitramon, Inc.: "We had more interest expressed in our stuff the first day here than the whole four days of last year's show put together—and have had more than five times as many of our business cards filled out."

Engineer Opinions Mixed

That was one side of the coin. What did engineers think? Opinions were mixed. Visitors who

Large figures were a mark of the 1960 International IRE Show and Convention. Some of these figures, as of show's end: total attendance, 69,760; exhibitors, 856 ranged along two and a half miles of corridors, taking up seven acres of booth space with over 1,000 exhibits; products on display, more than 20,000; papers given, 258 at 54 technical sessions, organized by IRE's 28 professional groups (information content, according to a wag, about 10 million bits). Exhibitors represented about 80 per cent of the electronics production capacity of the United States.

From overseas came about 1,000 registrants, representing 38 different countries. Total foreign IRE membership is 6,000, with 22 sections in 84 countries.

Last year's attendance total was topped this year by almost 10,000.

One way to get fresh air at IRE was to register late.

Retiring IRE president Ernst Weber (left) presented gavel to incoming president Ronald L. McFarlan at opening meeting of 48th IRE convention. Medical electronics, space systems and electronics in classrooms were called "challenges" by Mr. McFarlan, new energy sources, "key to future."

had come to learn about specific products often were annoyed and disappointed with the salesmen at many booths, particularly at the larger companies. From one disgruntled engineer who couldn't get the information he was looking for: "I am damn disgusted with the pitchmen sent to represent companies."

One very clear trend noted during the show was that there was more competition in every field of endeavor than last year. Few, if any, companies had the field to themselves. Sales pitches were on the order of "We are the experts in the field" rather than "See the good performance of our product." Products themselves were pushed

An army of personnel directors waited inside the out-of-Coliseum recruiting center, as Career, Inc., president William A. Dougass cut opening tape.

hard: the educational pitch was thought unnecessary.

Recruiting Big, as Usual

No show round-up would be complete without mention of the job recruiting. Activity was higher again this year. But this time there was very little hiring under the immediate jurisdiction of the IRE. Two bulletin boards in the Coliseum was the extent of "recruiting" on the show floor. Across the street at the Henry Hudson Hotel, however, it was a different story.

Career Publications, Inc., had set up shop on the second floor. By week's end it had accounted for 15,000 separate interviews between personnel directors from 27 manufacturing concerns and over 1,200 job-hunting engineers and technicians. In addition, 50 more companies were represented at the center through literature. Edward P. Dear, representative of Careers, Inc., reported that most engineers—60 per cent—were seeking salaries of $9,000 to $11,000. About 10 per cent were asking $15,000 and up—some up to $30,000.

Both job seekers and manufacturers seemed pleased with the centralized recruiting set-up, Mr. Dear reported. More than 3,000 engineers and scientists visited the center to "look things over," he said.

Less Military in Papers

Commercial rather than military, theory rather than hardware were emphasized in this year's papers at the Waldorf-Astoria Hotel. A rough tabulation of IRE papers delivered during the last four years shows a definite trend in choice of subject toward the analytical aspects of electronics and toward commercial application of military hardware.

The number of hardware-oriented papers read at IRE conventions decreased more than 30 per cent between 1957 and 1960, while theoretically-oriented papers increased about the same percentage. The military electronics average: a decrease of almost 50 per cent. Commercial systems and components papers have increased fourfold.

Conspicuous by their absence this year were the many announcements at technical sessions of novel gadgets having relatively limited application. New products were unveiled instead at the display booths.

Disclosures of new work, too, were noticeably absent. A number of good survey papers were given, as well as "blue-sky" reports, like D. J. Blattner's (RCA Labs) description of radio relaying by reflection from the sun. But to engineers attending the technical sessions, it seemed the cream of new development papers was being skimmed off by specialty conferences, such as Joint Computer, Solid State, Reliability and Microwave Theory and Techniques.

While most sessions were well-attended, one weary engineer in the Coliseum observed cynically that the only place you could get a chair was at a technical session.

Private seminars like this Litton Industries "Omnibus" presentation were common in rented hotel salons during the show.

Solid Circuit vs. Micro Component Assembly

While examples of all three approaches to microminiaturization—solid circuits, micromodules and microcomponents soldered together—were on dispaly at the show, the first and last engendered especially strong partisan feeling. Texas Instruments unexpectedly announced marketing of solid-circuit computer devices three years ahead of schedule (p. 106, this issue). Five companies banded together to promote the microminiature parts assembly effort under the name of MICRAM.

The two concepts are not mutually exclusive, of course. The first has always been touted as "for three to ten years from now," and the second as an intermediate substitute. But at the show this year solid circuits took on a certain immediacy in the minds of some engineers. TI's announcement came as a surprise to other companies in the solid-electronics field. Fairchild, Motorola, GE, RCA and Westinghouse are working on solid circuits of their own and may be almost as close to success as TI.

At the same time the proponents of assembled microparts were arguing the advantages of established reliability and commercial availability—not as an intermediate step but as a standard production technique that would be cheaper than solid circuits for many years to come. Many engineers commented that the TI line was limited and that prices were too high; much interest, therefore, appeared centered around the assembled microcomponents.

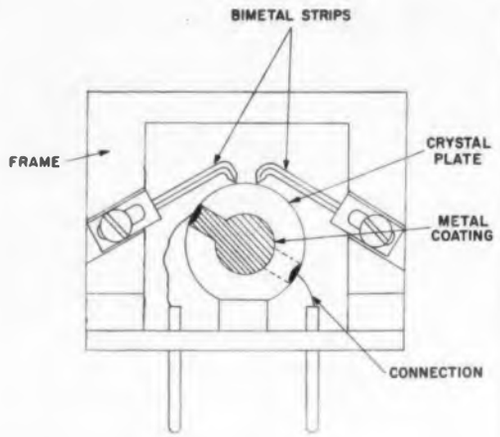
"Time is too important," one engineer said, "We can't wait a month or so while crystals are grown or substrates are processed. By using off-the-shelf items we can have nearly any type of circuit made in a relatively short time."

From other engineers the "numbers game" came under fire. Rating the smallness of an assembly by describing the number of parts that theoretically could be crammed into a cubic foot of space was condemned. Nobody yet has built, it was argued, nor will anybody build for a long time to come a cubic foot of crystal or a micropart assembly that has the equivalent of a million components in it. It seemed senseless to many engineers to use the hypothetical density of parts per cubic foot as a gage of size.

Air Force Urges Moletronics

Component manufacturers were told by an Air Force spokesman that molecular electronics was the coming thing, and they were urged to consider ways of getting into the field. But an ELECTRONIC DESIGN survey indicated that not everyone was rushing to get into the act.

Common table salt and pepper dramatize the smallness of Pacific Semiconductors' "picotransistors."



Use of bimetallic strips by the Army Signal Research and Development Laboratory to control frequency drift induced in radio crystals by temperature changes was revealed at IRE. Strips are so oriented that when temperature increase causes frequency to rise, one of the strips increases its pressure, correcting drift. Downward drift is corrected by the other strip.

The Air Force proponent was Col. William S. Heavener, chief of the Electronic Technology Laboratory, Wright Air Development Div., Dayton, Ohio. He delivered a paper, "Tomorrow's Technology—Functional Electronic Blocks" at the technical session on electronic component parts.

In one year, Colonel Heavener said, the Air Force expects to receive a molecularized computer from Texas Instruments. And in two years, he added, Westinghouse should be coming out with a molecularized vhf receiver for the Air Force. By 1965 the Air Force expects to have a limited selection of molecular electronic field equipment.

Manufacturers Unworried

"Functional electronic blocks—now there's something that's run away from the Air Force." So said Dr. R. Soria, vice president in charge of research and engineering at Amphenol. "This whole molecular bandwagon somehow got into the hands of hucksters who are making a big to-do about it.

"Don't get me wrong—functional electronic blocks are a step in the right direction. But the talk that surrounds it is loose, greatly exaggerated, somewhat irresponsible. The implication is that it's all going to happen overnight, tomorrow."

Comments from other component manufacturers:

"Functional electronic blocks are coming," said George E. Gausell, sales manager for Southern Electronics. "But we're not worried about going out of business at the moment. I suppose, though,

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we're going to have to get into molecular electronics sooner or later. You know, learn to swim with the fish—or get out of the water."

C. Tuttle, sales manager for Vitramon, said: "We're getting into molecular electronics. It's a growing field. But I guess it won't be feasible with reliability for about another five years."

Edward Redgate, a district manager for De Jur Amsco Corp.: "Worried by functional electronic blocks? Not at all. We're selling more and more connectors every day."

Roy S. Laird, sales manager of Ohmite: "We're not, to my knowledge, getting into functional electronic blocks. And we're not worried. Those blocks are a little too far away to worry about."

MICRAM—Lions Lie Down Together

Five major companies teamed up during the show to demonstrate that microminiaturization is here, commercially available with off-the-shelf parts. The MICRAM program—Microminiature Individual Component Reliable Assembled Modules (*ED,* March 16, p. 8)—of temporary cooperation was strictly for promotion of the hand-assembled micropart concept. There was no financial connection between the five companies, according to a spokesman.

Raytheon Semiconductor Div.: Pacific Semiconductors, Inc.: Aerovox Hi-Q Div., and Sylvania Electric Products Lighting Div. showed samples of assemblies with densities of one to three million parts per cu ft (if it were possible to build a cubic foot of assemblies). Al Gross, chief engineer for Cleveland Metal Specialties, who assembled the modules, was on hand to expound on MICRAM with enthusiasm.

"Fairly recently," Mr. Gross said, "somebody said densities of 800,000 components per cu ft could be packaged in certain configurations . . . and that packages of one million or more parts per cu ft were something which would be achieved in the future. Raytheon, Sylvania, Pacific Semiconductors and Aerovox have made it possible to do today what was to be achieved in three or four years."

What about interconnection reliability? Mr. Gross insisted that the use of conscientious, patient people skilled in watchmaking techniques invariably gave a high production yield. "In that sense, there isn't any inter-connection reliability problem," he said.

In line with the MICRAM concept of microminiaturization was Engineered Electronics Co.'s display of Miniweld circuit modules. The company's high-density packaging results from welding the junction points of a wire mesh, then clipping out the wire lengths that are not needed for

interconnection. All the inter-connected wiring is in a miniature encapsulated "hard" matrix.

"Welding," a company spokesman said, "lets you weld-connect a component at a point close to its body, eliminating the space and weight of long leads on heat sensitive components."

'Flyspeck' Parts Merchandised

"Flyspeck" components are already off-the-shelf items in many cases. Pacific Semiconductors, which announced its microdiode at last year's WESCON, was taking orders for production quantities at IRE. A mechanical and electrical companion, the microtransistor, was being shown for evaluation by PSI, with production expected in June. Allen-Bradley had a commercially available flyspeck resistor. Filmohm showed a wafer resistor. GE and Sylvania were marketing micro-light bulbs.

Lt. Col. Jeremy K. Schloss, an Air Force R & D man, reminded printed-circuit manufacturers at the Waldorf that there would always be a use for printed-circuit boards no matter what solid-state components were used. But he urged the manufacturers to "devise new techniques which will be more compatible with new concepts." (Story on p. 11.)

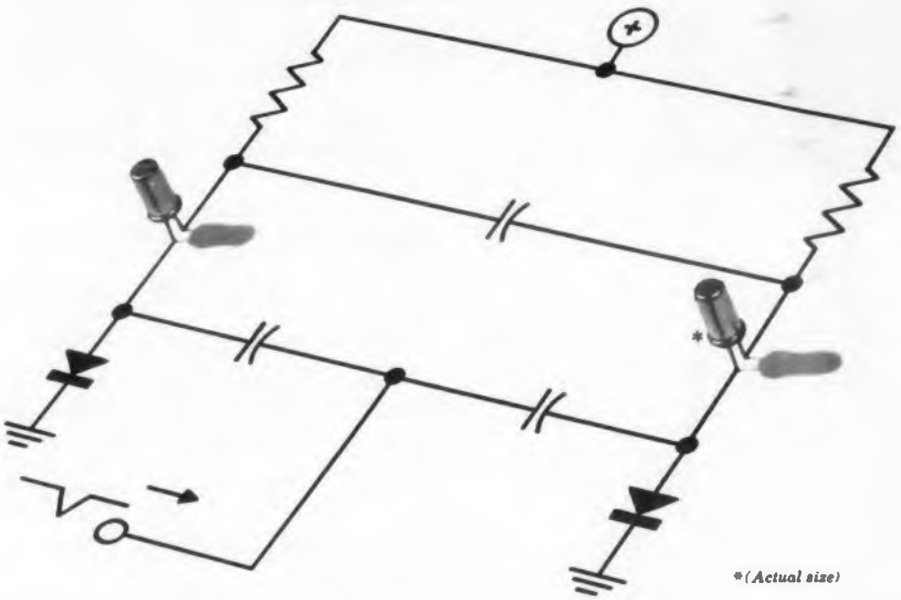
Nine Companies Enter Tunnel-Diode Derby

Companies in the tunnel-diode derby were off and running on the Coliseum floor. Ever since Hughes Semiconductors announcement at WESCON last year of its Esaki diode, one company after another has dashed into the starting lineup.

They were displaying diodes of germanium, gallium arsenide and silicon in a variety of packages. Some cans were newly developed; others adapted from standard transistor designs. Manufacturers were saying the final form of package will depend on the applications found for their devices.

What applications? Manufacturers were not sure. Some interest was exhibited in their booths, but so far few equipment companies have come up with a solid, commercial (or even military) application for the new tunnel diodes. The tunnel diodes shown, moreover, were in the main sample devices. Controlled production runs have not been made.

Gallium arsenide, at week's end, seemed destined to take a leading spot as technology improves. Many manufacturers cited the greater peak-to-valley current ratios promised by tunnel diodes made with this material and the high-



*(Actual size)

*SHOCKLEY 4-LAYER DIODES *used in simple and inexpensive multivibrator circuit for high speed operation over a wide range of temperatures.*

IRE NEWS

temperature operation already accomplished. However, germanium units now available seemed to be holding their own with the gallium arsenide types on display.

Silicon Useful

Silicon also has the advantage of high-temperature operation, according to a spokesman for Hoffman Electronics Corp.'s Semiconductor Div. Hoffman, the only supplier of silicon Esaki diodes, had one operating at 200 deg C in an oven.

Packaged in TO-5 transistor cases, the Hoffman devices are priced at $25 each. Up to 100 are available from stock. Peak currents range from 1.0 to 5.6 ma, with 65-mv peak voltage and 420-mv valley voltage. Peak-to-valley current ratios are 3.5:1 minimum.

Philco Corp. was also using transistor cases, specifically a shortened TO-18 package. These germanium units, for operation at frequencies up to 1 kmc, are said to have junction capacities down to 5 μμf. Price is now less than $10 each in sample quantities, according to a Philco spokesman.

TI Had GaAs Diodes

Gallium arsenide tunnel diodes were displayed by Texas Instruments, Inc., at show-time. The GaAs devices were available from distributors' stocks at prices ranging from $9 to $36 each. The devices, in TO-18 cases, operate to 500 mc.

Maximum peak-to-valley current ratio for the IN650 to IN653 types is 15:1 said TI.

General Electric Co. showed germanium tunnel diodes in TO-18 cases. These units have maximum peak-to-valley ratios up to 10:1. Prices are $8.50 for type IN2941, $10 for type IN2940, and $12.50 for type IN2939, which are now available. Typical peak-to-valley currents of 15:1 were reported by GE for gallium arsenide devices which were available only in sample quantities. The price is $75 each for these units, which were said to have a one μsec rise-time.

Germanium tunnel diodes in sample quantities were also available from Sperry Rand Corp.'s Semiconductor Division. Priced from $10 to $75 each, Sperry's T101 through T105 units were said to operate at frequencies up to 500 mc.

G. T. Offered GaAs Diodes

General Transistor Corp. displayed a gallium arsenide tunnel diode in sample quantities. Prices and peak-to-valley current ratios for the devices are: $8 for 3:1; $10 for 5:1; and $15 for 7:1. The devices, packaged in TO-9 cases, operate to about 40 to 50 mc.

RCA Designed New Case

A special package for high-speed applications was designed by Radio Corp. of America for tunnel diodes on display. The peak-to-valley ratios for RCA's germanium devices range from 4.5:1 to 10:1.

These diodes, priced from $12.50 to $18 each, are now available from stock according to Marty Klein, field engineer for RCA's Semiconductor Div.

The germanium material is placed in a cylindrical ceramic sleeve 0.125 in. OD and 0.250 in. high. Ribbon leads are fastened to each end of the cylinder so the device can be connected into a circuit.

RCA is also developing gallium arsenide devices.

Sony Corp. of Japan also displayed germanium alloy junction Esaki diodes. The devices are now available at $10 each in sample quantities, according to Keiichi Nakamura, physicist in Sony's research laboratories where Dr. Leo Esaki developed the diode. ■ ■

The klystron being fondled by Eitel-McCullough's H. C. Warner was used to power a radar signal to Venus and back—a distance of 56 million miles. Eimac displayed it at the show.

WASHINGTON REPORT

Ephraim Kahn

FREQUENCY ALLOCATION through international treaty will be necessary for exploration of outer space. The Senate's Committee on Astronautical and Space Science urges worldwide agreement, so reliable and uncluttered communications between ground stations and space vehicles can be maintained and radio-astronomy can advance. For most effective future operations, particularly in space, the radio spectrum must be utilized as if it were a scarce natural resource.

BROADER LEGISLATION to outlaw kickbacks on negotiated contracts has been requested of Congress. The General Accounting Office points out, for example, that under present law the widely used "price redeterminable" contract is exempt from the Anti-Kickback Act. A violation of the law in this type of contract "would be actionable only if such contracts are considered to be on a cost reimbursable basis." General Accounting Office wants to make all negotiated contracts subject to the act, including fixed-price pacts. It adds that weapon system contracts "by reason of the enormous extent of sub-contracting involved, appear to be particularly susceptible to kickback abuses."

UNIFIED STRATEGIC COMMUNICATIONS set-up proposed by the Defense Department has been reluctantly accepted by the Air Force. The service has informed commanders in the field that unification of long-haul communications will be slow in coming. At the same time it indicated that official Air Force policy favored "gradual integration." In contrast with previous inter-service disagreement, the military services now concur in the view that gradual assumption of control of strategic communications by the Joint Chiefs of Staff is not only inevitable but desirable. No specific recommendations on unification can be expected until late this year.

AIR FORCE SPENDING for missiles and aircraft will total nearly $7 billion if Congress votes what has been asked for fiscal 1961. Request for aircraft spending dipped to $3,910 million--for 633 planes--from the preceding year's $4,078 million. But missile needs jumped sharply, from $2,604 million last fiscal year to $3,024 million in the coming one. R & D is pegged at $970 million and ground-support equipment, including much electronics, at $899 million. The Navy, by the way, wants to put its air fleet on a five-year turnover basis. This would involve doubling airplane purchases--to about 1,200 a year-- in each of the next five years.

A MILITARY SYSTEMS COMMAND to coordinate Army effort in R & D has been proposed by consulting scientists. Object is to create a policy-planning board that would guide efforts to shave lead-times and see to it that a balanced program is maintained. A new priority list for Army R & D --figured over the next dozen years--is believed to stress communications, logistics and mobility. Its adoption would signal a change in emphasis from increasing the Army's firepower to making it more effective and accurate.

AN OPEN MIND on research project shifts is maintained by the office of the Defense Department's Director of Research and Engineering. Dr. Herbert York's office reviews all projects that are expected to cost $10 million or more over a three-year period and any changes in existing projects that will involve as much as $2 million up or down. Review is particularly intensive in the calendar quarters immediately preceding budget-making and funds apportionment. But Dr. York hopes to "bring into the open for top-level decisions" as soon as possible "any major shifts in emphasis, as well as the initiation of costly programs which have a profound effect on program planning and budgeting in the near future."

SCOPE OF MILITARY R & D has been outlined by Dr. York. There are some 2,000 projects covering about 15,000 "tasks." All in all, research, development, test and evaluation accounts for about $5.3 billion in the fiscal 1961 budget request, down from about $5.8 billion in the current year. Basic research, however, has been hiked by 10 per cent. Over three-fourths of the work is in the hands of industrial concerns.

DUPLICATION OF PROGRAMS is not necessarily evil, notes the Air Force's Chief of R & D, Lt. Gen. Bernard E. Schriever. "I think we go overboard sometimes to reduce duplication," he says, noting that military and civilian uses of space, for example, are dissimilar. The urgency of military space systems requires "a bolder approach," he says, than that of a civilian agency--particularly for such items as early-warning, surveillance, communications and intelligence.

HIGHER TERMINATION CEILING for prime contractors is being considered at the Defense Department and probably will be adopted. When it is, prime contractors will be able to settle subcontractors' claims up to $25,000. The ceiling now is $10,000. The top limit on the so-called short-form settlement procedure has already been boosted from $1,000 to $2,500.

PATENT POLICY BLOW-UP, sure to come eventually, probably will not reach a climax this year. Congressional adjournment, planned for early July, will almost undoubtedly forestall passage of a policy revision for patents that stem from Government-financed research. The Controller General, commenting on bills to permit the Government to share in profits from commercial applications of discoveries made under R & D contracts, finds merit on both sides.

Buddy, Can You Spare A Dec. 24, 1958, ED?

We met a sad reader at the IRE show. He has a complete file of ELECTRONIC DESIGN—well, nearly. He has a copy of every issue since the first one of November-December, 1952—all but one. He's missing the last issue of 1958.

Can any of our readers spare a copy of the Dec. 24, 1958, issue for Ivan I. Bezugloff Jr.? He's vice-president of Metronix, Inc., in Chesterland, Ohio.

CHANGES IN PRICES AND AVAILABILITY

SILICON ZENER DIODES have been reduced in price up to 40 per cent by Motorola, Inc. In quantities of 100 and up, new prices on 50-w diodes range from $5.30 to $20, reduced from $7.50 to $23.60. Prices on 10-w diodes now range from $4.80 to $14.40.

PRODUCTION DEVICES at U. S. Semiconductor Products of Phoenix, a division of United Industrial Corp., have been reduced in price from 15 to 45 per cent. Major cuts were announced in the line of silicon reference elements, in addition to the Zener diode line, tantalum capacitors and other semiconductor devices.

SCOTCH BRAND VIDEO TAPE No. 179 has been reduced 8 per cent in price by Minnesota Mining and Manufacturing Co. The cut drops the net price of a standard hour-long reel from $248.95 to $228.41, when bought in lots of 48 or more. New tapes and their cost per reel in quantities of 48 or more are: 400-ft reel, $24.50; 800-ft, $42.50; 2,600-ft, $135.42, and 3,600-ft, $175.40.

GERMANIUM ALLOYED JUNCTION TRANSISTORS have been reduced in price up to 20 per cent by U. S. Transistor of Syosset, L.I.

160 - MU - MOLY - PERMALLOY POWDER CORES have been reduced in price as follows: 55204-A2 (55206), was 47 cents, now 37 cents; 55252-A2 (55254), was $1.15, now 97 cents; 55928-A2 (55930), was 71 cents, now 49 cents.

Is your company making changes in prices or availability of its products? Send the details to *ELECTRONIC DESIGN*, 830 Third Ave., New York 22, N.Y.

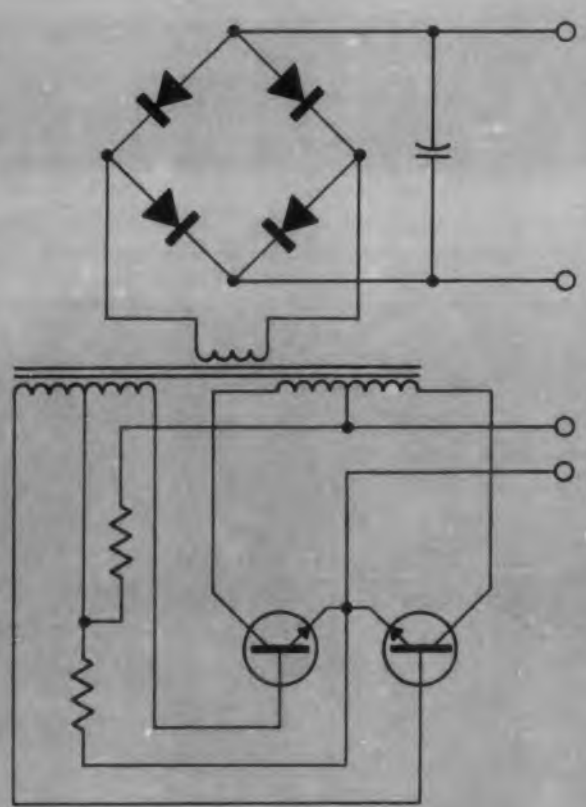
CIRCLE 780-799 ON READER-SERVICE CARD ➤

ELECTRONICS

ENGINEERS' GUIDE TO SILICONES

Use Reader Service Card for more information on specific products mentioned in this guide.

For additional copies of this guide circle No. 780



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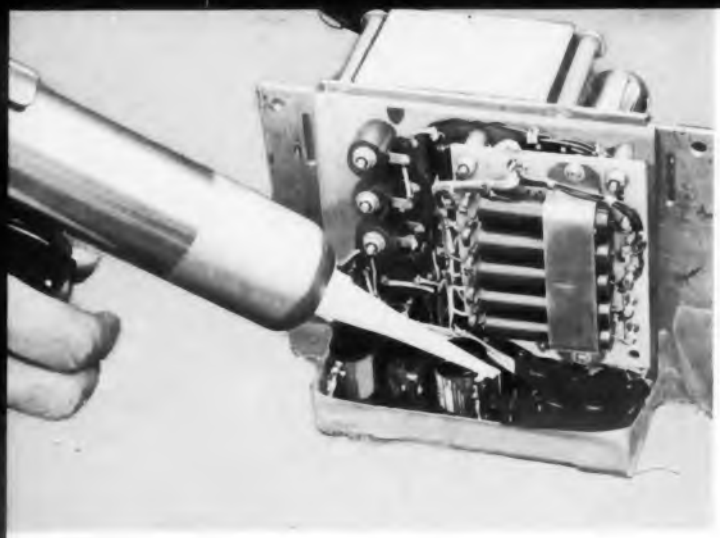


Reliability

Engineers at Northrup Aviation take no chances on the performance of intricate high impedance circuits in the Snark guided missile, the F-89 Interceptor and other Northrop projects. They virtually "seal in" top performance by completely encapsulating the brains of these units in Silastic® RTV to protect the circuit and components against moisture, vibration and shock at temperature extremes. Silastic RTV is easy to apply . . . vulcanizes at room temperature . . . can be easily cut away and then repaired.

Miniaturization

An excellent example of the way silicones can be used to miniaturize electronic equipment is the 600 va aircraft transformer designed by Air Arm Division of Westinghouse Electric Corporation. Both size and weight of this miniature power transformer for airborne electronic equipment were cut in half by switching to heat stable Dow Corning silicone dielectrics. Actually four pounds, eight ounces were slashed from the original eight pound 14 ounce transformer without sacrificing either efficiency or capacity.

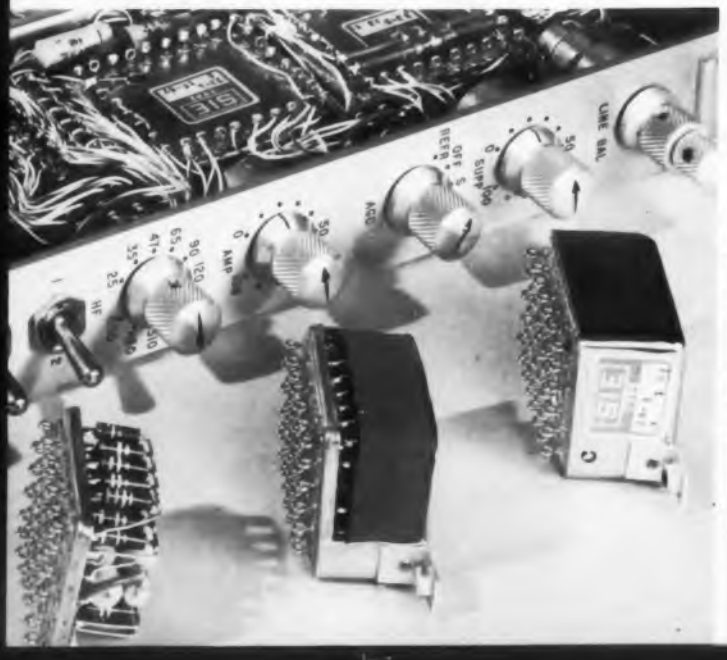
Dow Corning Silicones mee

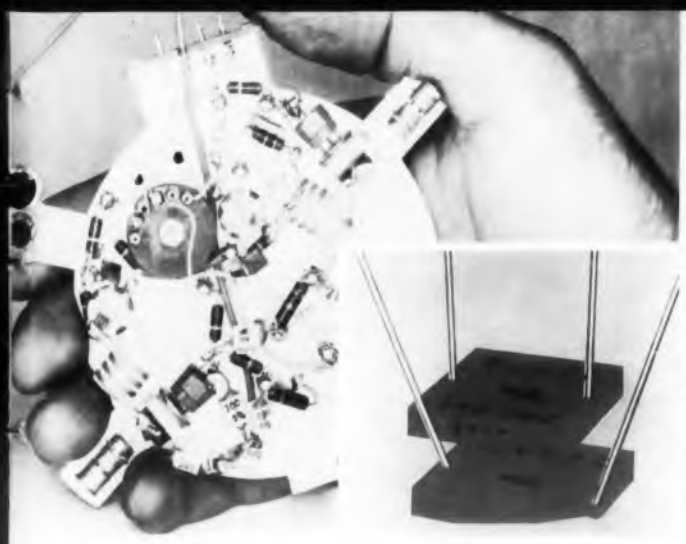
Modularization

Potted with Silastic RTV, a component module (center) is ready for use in Southwestern Industrial Electronics' geophysical amplifier. Silastic protects and seals circuits against many hazards. Potted modular construction assures a constant environment for electronic components, protects components from damage during assembly, facilitates field type replacement service. Modules can be stored safely . . . danger of condensation forming on enclosed components due to changes in ambient temperature is eliminated.

Value Engineering

A single tube from the line of Beam Switching Tubes developed by the Electronic Tube Division of Burroughs Corporation can replace as many as 90 transistors, diodes and resistors in switching and counting circuits. Positioning of the magnet is critical to proper operation. A cushion of Silastic assures proper alignment, bonds the glass envelope and magnet, provides greater shock resistance than any other material tested. In addition, Silastic is used to bond the magnet shield to the assembly.





Environmental Protection

Capacitors made by Vitramon Incorporated, Bridgeport, Conn., have porcelain bodies impervious to moisture penetration, but surface condensation can form a conductive film permitting lead-to-lead shorts. Easily applied Dow Corning silicone fluid produces a thin, nonoily coating that causes condensation to bead, eliminates the possibility of shorts . . . protects the capacitors during handling and storage . . . assures reliability of capacitors in missile guidance, tracking and computing units.

Temperature Extremes

Schlumberger Well Surveying Corporation, makers and operators of geophysical well-logging instruments, found terminal boards of silicone-glass laminate more reliable in service and easier to fabricate. The instrument shown has a working range up to 194 C in high humidity environments. In Schlumberger's evaluation tests, silicone glass laminates proved more uniform in dielectric properties, low in moisture absorption, easier and less expensive to fabricate and install.

oday's electronic needs!

Silicones are semi-organic materials closely related to quartz and mica in chemical structure. They are available in a wide variety of forms including potting, filling, encapsulating and impregnating materials. They are also available as rigid structural parts — mounting panels, coil bobbin, terminal strips — fabricated from silicone glass laminate or silicone molding compound. Pin connector seals and other resilient parts fabricated from Silastic®, the Dow Corning silicone rubber, are widely used because of their unique combination of physical and electrical properties.

Regardless of physical form, Dow Corning Silicones give long, reliable service when exposed to:

HEAT—Silicones resist the effects of temperature from —65 to 275 C, (—82 to 525 F) — higher temperatures for shorter times. They meet all requirements for 180 C and 220 C materials, as defined by AIEE Publication Number 1.

CORONA—Silicones exhibit little deterioration from the effects of corona.

VOLTAGE STRESS—Because of their low electric losses and good corona resistance, silicone dielectrics can be operated at high voltage stresses.

MECHANICAL STRESS—Because of their good thermal stability, silicones retain their original properties even after long time aging at extremely low and high temperatures.

CHEMICAL ATTACK—Chemically inert; they resist the effects of most corrosive atmospheres.

MOISTURE—Silicones are inherently moisture resistant at both intermediate and extreme temperatures and retain this property after long exposure to high temperature.

FUNGUS—Silicones are not nutrients for fungus or microorganisms and will not support growth.

FIRE—Some silicones are self-extinguishing, others will barely support combustion.

For your convenience, this Electronic Engineer's Guide to Silicones has been divided into seven parts:

1—Potting, Filling, Impregnating and Coating Materials; including components for Class H systems as a miniaturization tool.

2—Encapsulants

3—Rubbery Molded Parts

4—Silicone Insulated Wire and Cable

5—Rigid Structural Parts and Components

6—Silicones as Process Aids

7—Miscellaneous Silicones including Fluid Coolants

For Semiconductor and Optical Silicon see back cover.

Additional information on the silicone products described in this guide is available from Dow Corning Corporation.

Thermal stability of Dow Corning silicone resin-bonded glass laminates and polyester-bonded glass laminates is compared by heating both to 800 F (426 C). After five minutes, the organic bonded control piece is charred and smoking . . . after 15 minutes, the bonding resin burns away almost entirely. The silicone laminate remains unchanged.

In Quality Control of Dow Corning silicone fluids, dissipation factor and dielectric constant are determined using a General Radio Schering Bridge and Balsbaugh 2TN25 Electrical Measuring Cell to assure accuracy. Stringent quality control testing assures product purity, low electrical losses and high performance of Dow Corning Silicones.

Applied as liquid . . . cures to gel

DIELECTRIC GEL

...resilient, transparent protection

Dielectric Gel offers a new concept in potting, and filling materials . . . permits visual and instrument inspection and testing of protected components and circuitry.

Easily applied as a water white liquid of medium viscosity, this material readily surrounds components. Designated as Dow Corning Dielectric Gel, it cures in place to form a resilient mass that combines outstanding dielectric properties with thermal stability and moisture resistance.

No damaging stresses are exerted on delicate parts by this material either during or after cure. Curing time can be varied from approximately 30 minutes to nearly 48 hours. Curing temperatures range from 40 to 150 C.

Since Dielectric Gel is transparent, potted circuits can be traced visually — test probes can be inserted through the gel for instrument checking of circuits and components. Having an excellent memory, Dielectric Gel "heals" itself immediately when test probes are removed.

Resilient, this material protects potted parts from shock and vibration. It develops virtually no stresses throughout its wide operational temperature span. Parts potted in Dielectric Gel are not damaged by fluctuating temperatures — a problem with rigid potting materials. In addition to filling and potting applications, Dielectric Gel can be used as an impregnant for capacitors, magnetic amplifiers and similar devices.

For detailed physical and electrical properties, see Item IV in the chart on pages 6 and 7 of this bulletin.

For further information, use card and circle No. 781.

Dow Corning Dielectric Gel allows high voltage components to be spaced less than 1/4 inch apart in this CBS Laboratories 25-kv power supply. Used for airborne reconnaissance equipment, the unit meets stringent reliability requirements despite heat, vibration . . . size and weight restrictions.

SILICONE FLUIDS

...to decrease dielectric losses

Heat-stable, nonvolatile and nonsludging, Dow Corning silicone fluids show little change in dielectric properties over a wide range of frequencies and temperatures . . . viscosity also remains virtually unchanged from —65 to 250 C. They exhibit negligible vapor pressure and high flash point. Electrical grade Dow Corning silicone fluid is available in viscosities of 20, 50, 100, 200, 350, 500 and 1000 centistokes.

Filling and impregnating transformers, capacitors, magnatrons and other electronic components with Dow Corning silicone fluids increases electrical strength and reliability at high altitudes and elevated temperatures. Miniature paper capacitors are impregnated with silicone fluid to decrease dielectric losses and allow operation at higher temperature . . . assure uniform capacitance over a wider temperature range.

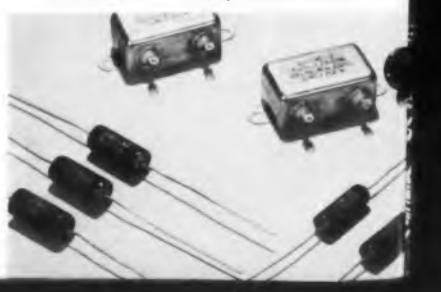
As a surface coating, silicone fluids impart a high degree of surface resistivity to nearly any material. After heat curing, this protection is permanent and is not affected by moisture or a wide variety of oils.

Physical and electrical characteristics are given under Item VI in the chart on pages 6 and 7.

For further information, use card and circle No. 782.

Produced to meet military specifications, this 40-kv pulse capacitor is filled with a Dow Corning silicone fluid to assure extremely low dielectric losses and high volume resistivity at high operating temperatures.

To assure almost constant capacitance vs. temperature relationship for their specialty capacitors — and the lowest possible power factor for their RF interference filters — the Filtron Co., Inc., Flushing, N. Y., impregnates them with Dow Corning silicone fluid. Silicone fluids boost the performance of the paper dielectrics . . . increase permissible operating temperatures, decrease dielectric losses. They add greatly to reliability . . . often eliminate costly compensating circuits. Aerovox capacitors below also use Dow Corning silicone fluid.



SILICONE COMPOUNDS

...for transistor potting

Dow Corning silicone compounds are ideal for potting transistors. They improve reliability by sealing out moisture . . . improve heat dissipation because of their good thermal conductivity. In addition, they reduce rejection rates by preventing metal splatter from reaching the transistor wafers when caps are welded in place. These silicone compounds don't melt, don't thicken, and retain their excellent dielectric properties from —70 to 200 C. Transistor manufacturers use this grease-like transistor potting material to help build a new degree of reliability into their products. See upper righthand illustration.

Transistors manufactured by Industro Transistor Corporation.

...for general purpose use

Tape wound toroidal cores, in both miniature and large sizes, are cushioned with silicone compound between core and outer box by Magnetics, Inc. Dow Corning compounds are nongumming, nonmelting, maintain a stable viscosity from —70 to 200 C. They have excellent dielectric, damping and heat-dissipating qualities and are superior barriers to moisture. Other firms use Dow Corning silicone compounds for heat-sinks, sealants and similar applications, both mechanical and electrical. The connector shown at the bottom right is being sealed using Dow Corning compound which provides a waterproof, continuous dielectric around all leads.

For physical and electrical properties, see Item V in the chart on pages 6 and 7.

For further information, use card and circle No. 783.

IMPREGNATING VARNISHES

...and high temperature insulation systems

Dow Corning silicone varnishes are suitable for use in electronic components and equipment designed for continuous operating temperatures to 250 C . . . higher temperature for shorter times.

Impregnated with silicone varnish, the insulating components of miniature coils, servo motors, transformers and other assemblies are bonded into moisture resistant insulation systems having high dielectric strength. Combined with other silicone components, Dow Corning silicone varnishes assure maximum reliability . . . help reduce size and weight by as much as 50%.

For further information, use card and circle No. 784.

Sylkyd®-enameled magnet wire is equal in diameter, size for size, with Class A magnet wire. Heat stable, it aids miniaturization in 180 C insulation systems when combined with Class H insulating component and impregnated with Dow Corning silicone varnish.

Dow Corning silicone varnishes make good bonding cements. They can take fairly high loadings of inorganic fillers without loss of properties . . . appropriately filled, they are excellent for sealing wire wound resistors — and other electronic devices.

For further information, use card and circle No. 785.

1

2

3

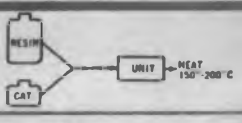
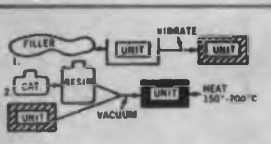
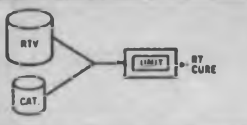
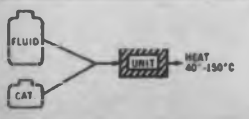
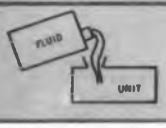
4

5

1. These miniature coils, produced by American Machine and Manufacturing Co., are insulated with Dow Corning Silicones to save weight and space . . . assure reliability at ambients of 350 F.
2. Milro Controls Co. combines maximum output with minimum weight and ample overload protection by impregnating these power transformers with silicone varnish.
3. United Airlines extended service life of autopilot servo-motors from 1000 hours to five years by using Class H components and Dow Corning silicone varnish.
4. Filled silicone varnish is used as a resistor coating by Tru-Ohm Division of Model Engineering and Mfg. Co.
5. AiResearch miniature motor combines Sylkyd enameled wire and silicone varnish for maximum reliability and minimum weight.

Dow Corning silicone potting, encaps

PROCESSING INFORMATION

DOW CORNING PRODUCT AND USE	BASIC SYSTEM	APPLICATION METHODS	TYPICAL CURING CONDITIONS	SHELF LIFE	EST. SERVICE TEM (degrees for 1000-hr life)
DOW CORNING SOLVENTLESS SILICONE RESINS **I Rigid Impregnant** (See page 8) a. Resin only		(1) vacuum-impregnate (std procedures)	4-6 hr @ 150°C final cure 8 hr at or above use temperature	>1 yr @ 70° F (catalyzed) unlimited (uncatalyzed)	−40 to +200 (−40 to +400
II Rigid Encapsulants (See page 8) a. Resin plus silica flour filler		(1) pressure gun (2) as coil filler, may be extruded on wire while winding	4-6 hr @ 150°C final cure 8 hr at or above use temperature	>1 yr @ 70° F (catalyzed) unlimited (uncatalyzed)	−40 to +250 (−40 to +480
b. Resin plus zirconium ortho-silicate		(1) surround unit with granular filler, then vacuum-impregnate sand and unit with solventless silicone resin; requires mold or form	4-6 hr @ 150°C final cure 8 hr at or above use temperature	>1 yr @ 70° F (catalyzed) unlimited (uncatalyzed)	−55 to +300 (−70 to +570
SILASTIC RTV **III Rubbery Encapsulant** (See page 8) Fluid grade silicone rubber that vulcanizes in place . . . also used for potting and filling		(1) dip and flow (2) pour (3) spatula or pressure gun	set-up in 24 hr @ 70° F; full properties developed after 4-7 days	4 hr @ 70° F (catalyzed) 4 mo @ 70° F (uncatalyzed)	−60 to +250 (−70 to +480
DOW CORNING DIELECTRIC GEL **IV Transparent Potting Material** (See page 4) Gel-in-place silicone fluid . . . also used for filling and impregnating		pour, using std potting techniques	48 hr @ 40° C or 6 hr @ 75° C or 1 hr @ 150° C	24 hr @ 70° F (catalyzed) unlimited (uncatalyzed)	−60 to +200 (−70 to +400
DOW CORNING COMPOUNDS **V Grease-like Potting Material** (See page 5) . . . also used for filling and coating		(1) insert with gun (2) hand or spatula (3) aerosol spray can	Needs no cure	unlimited	−70 to +200 (−95 to +400
DOW CORNING SILICONE FLUIDS **VI Potting — Filling Impregnating Fluids** (See page 4)		fill, using std liquid dielectrics processing procedures	Needs no cure	unlimited	−65 to +200 (−80 to +400

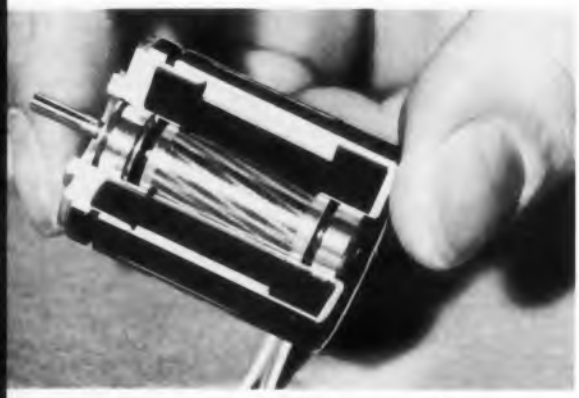
DOW CORNING SILICONES PROVIDE PHYSICAL, ELECTRICAL PROTECTION

ENGINEERING DATA

ERMAL. EMP. eg C)	ENDURANCE TIME (hr)	GAMMA RADIATION RESISTANCE (megarad, @ 23° C)	TYPICAL PHYSICAL PROPERTIES			TYPICAL ELECTRIC PROPERTIES							REMARKS
			SPECIFIC GRAVITY	COEF. OF THERM. EXP.	THERMAL CONDUCTIVITY cal (sec/cm²/deg C/cm)	ELECTRIC STRENGTH (V/mil, ASTM D149)	VOLUME RESISTIVITY (ohm-cm)	DIELECTRIC CONSTANT (ASTM D150) DEG C	400 CPS	0.1 MC	DISSIPATION FACTOR (ASTM D150) DEG C	400 CPS	0.1 MC	
00 50	500 5000	1000	1.11	125x10⁻⁶ (linear)	0.36x10⁻³ (100° C)	350-0.125" (¼" elect)	5x10¹⁵	23 150 200	2.82	2.80 2.80 2.75	23 150 200	0.002	0.001 0.003 0.002	high temperature solventless capacitor or transformer impregnant
00 50	500-1000 5000-10,000	>2000	1.70	80x10⁻⁶ (linear)	2x10⁻³ (100° C)	350-0.125" (¼" elect)	4x10¹⁵	23 150 200	3.62	3.60 3.60 3.53	23 150 200	0.007	0.002 0.002 0.002	useful as coil filling compound or rigid sealant
00 50	1000 10,000	>2000	3.3	13x10⁻⁶ (linear)	2.7x10⁻³ (100° C)	240-0.125" (¼" elect)	4x10¹⁵	23 150 200 300	7.30	7.10 7.20 7.10 7.10	23 150 200 300	0.008	0.007 0.007 0.01 0.02	outstanding resistance to degrading effects of heat & radiation
50 00	500-1000 >5000	100	1.12	770x10⁻⁶ (volume)	0.5x10⁻³ (100° C)	400-0.063" (¼" elect)	0.5x10¹⁴	23 150	3.14	3.03 3.28	23 150	0.01	0.004 0.06	general-purpose dielectric protects against vibration, moisture, ozone & other damaging environments
00 0	1000 >6000	10	0.970	960x10⁻⁶ (volume)	0.7x10⁻³ (150° C)	1000-0.10" (½" ball elect)	5x10¹⁴	23 150 200	3.00	3.00 2.51 2.34	23 150 200	0.00008	0.00002 0.0003 0.0006	excellent for potting delicate electronic components; develops no internal stresses; good confined heat stability
50 00	20 1000	30	1.0	960x10⁻⁶ (volume)	0.75x10⁻³ (150° C)	500-0.010" (½" ball elect)	10¹⁴	23	2.85	2.85	23	0.0001	0.0009	general-purpose sealant for electric connectors
00 00	>5000 >10,000	200	0.955	1070x10⁻⁶ (volume)	0.34x10⁻³ (77° F)	350-0.100" (1" elect)	10¹⁴	23 150 200	2.68	2.68 2.30 2.15	23 150 200	0.0001	0.00002 0.0001 0.0003	excellent electric properties over wide range of temperature & frequency; useful as dielectric coolant

Silastic RTV protects General Instrument Corporation's Radio Sondes against high potential arcing and corona at 60,000 feet, as well as against launching shock and vibration at 565 knots.

To protect this airborne transistorized oscillator against shock, Delta-f, Inc., Geneva, Ill., used a flow-on blanket of Silastic RTV. It supplies needed cushioning, and is unaffected by the built-in heating element.



Analysis of the problems of size, weight, reliability and environment convinced engineers at G-M Laboratories Inc., Chicago, that a silicone insulating system would provide the best design for their servo motor. The stator is vacuum impregnated with solventless resins which fill the coil interstices. The void-free results achieved are clearly shown below by the bisected encapsulated capacitor.

SILASTIC RTV

...cures at room temperature

Silastic® RTV is a liquid silicone rubber that vulcanizes at room temperature to form a rubbery solid with good dielectric and physical properties. Cured Silastic RTV remains operable from —60 to 250 C and is highly resistant to ozone, corona, weathering, and oxidation.

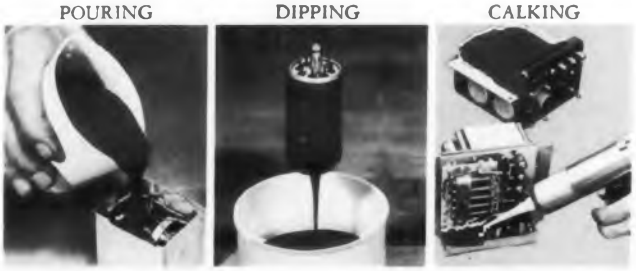
Silastic RTV has proved ideal for encapsulating, potting, sealing, and void filling electronic components and equipment . . . it dampens vibration and ages well. This liquid silicone rubber can be formed in place or shaped in improvised forms made of paper, metal foil, plastic or wood. It vulcanizes without heat or pressure. Cured jackets made from Silastic RTV can be slit open and resealed to facilitate repair of encapsulated parts.

Supplied in several different fluid grades, Silastic RTV and its catalyst are easily mixed and ready for use . . . are available with set-up times ranging from about two minutes to several hours. Optimum physical properties are attained in four to seven days . . . parts can be handled in less than 24 hours. No specialized equipment is needed for mixing, forming or curing.

For physical and electrical properties, refer to Item III of the chart on pages 6 and 7.

For further information, use card and circle No. 786.

POURING DIPPING CALKING



SOLVENTLESS RESINS

...with high heat stability

These thermosetting silicone resins form tough, rigid materials. They retain their physical and electrical properties at temperatures as high as 300 C.

Dow Corning solventless silicone resins are used alone as impregnants and with inorganic fillers as encapsulants. After curing, solventless resin forms a solid void-free mass that is impervious to moisture and unaffected by heat, chemicals or nuclear radiation. When the filled-in-place technique is used (see item II, page 6) this material is used in components designed to meet military thermal shock tests. With no solvent to evaporate, resins set up without voids . . . curing system is nontoxic.

Cured Dow Corning solventless resins retain excellent physical and electrical properties after aging 8000 hours at 500 F. They show no evidence of electrical degradation after thousands of hours of alternate exposure to water and 300 F temperatures.

Properties of filled and unfilled solventless resins are given under Items I and II in the chart on pages 6 and 7.

For further information, use card and circle No. 787.

SILASTIC

. . . the Dow Corning Silicone Rubber

Rubbery parts made of Silastic® retain their physical and dielectric properties over the wide temperature span of —90 to 250 C. Silastic is virtually unaffected by ozone, corona or corrosive atmospheres . . . initial properties are unchanged despite rapid thermal cycling or long term storage.

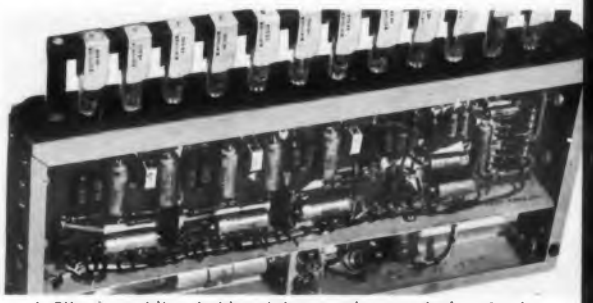
Parts made of Silastic have found many uses in electronic components and assemblies. It is used for flexible bushing gaskets on liquid filled capacitors because of its non-tracking surface and its ability to maintain a constant seal of capacitor fluids. Molded corona boots on color television "fly-back" transformers are made of Silastic because of its heat resistance and high electric strength.

Gaskets made of Silastic are used extensively to provide environmental seals for packaged electronic gear. Silastic molded parts are also used for the shock mounting of electronic assemblies . . . resilient inserts made of Silastic are used in cable connectors.

Parts manufactured from Silastic and designed for your application are available from rubber companies throughout the country. A list of these companies is available from Dow Corning.

For further information, use card and circle No. 788.

This Varian Associates klystron tube for airborne radar uses Silastic molded connectors and lead wire to minimize frequency drift and resist the damaging effects of corona.



A Silastic molding holds miniature tubes gently but firmly to protect them from vibration and shock in this fire control system built by Emerson Electric Manufacturing Co.

SILICONE INSULATED WIRE AND CABLE

Wire and Cable insulated with Silastic is easy to solder, speeds production because it is not affected by soldering heat — and it is flexible for quick and convenient hookup of electronic components. Wire, cable and flexible tubing made from Silastic and from silicone resin impregnated glass braid is available. Contact Dow Corning for a list of these manufacturers.

For further information, use card and circle No. 789.

Glass-Served Magnet Wire bonded with Dow Corning silicone resin is comparable to organic-bonded glass served wire in smoothness and abrasion resistance. Considerably more heat stable, it is suitable for use in 220 C insulation systems.

Sylkyd®-Enameled Magnet Wire is suitable for use in systems designed to operate at limiting temperatures as high as 180 C. It has the same space factor as Class A enameled wires, is resistant to a wide variety of chemicals, will not craze or lose flexibility on shelf aging.

For further information, use card and circle No. 790.

Co-Operative Industries uses a molded-on Silastic jacket to protect the corrugated brass core of its WR-112 wave guide from damage . . . to help control flexing during preforming and installation.

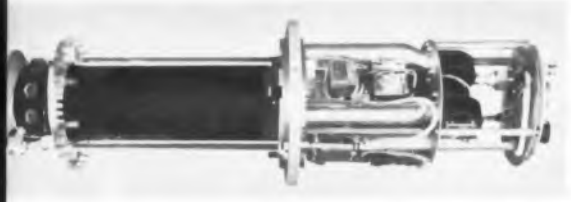
Silastic gaskets are used to hermetically seal this packaged General Precision Laboratory air navigational system.

Stretch Wire Corporation produces wire that elongates to 165% of its original length . . . then springs back. Silastic insulated, this wire is used in missile and ordnance electronics.

Silastic insulated lead wire being connected to a high voltage transformer for RCA TV sets.

West Coast Electrical Manufacturing Corporation uses Sylkyd-enameled magnet wire in construction of this miniature solenoid for aircraft and missiles. It weighs only 2.5 ounces, exerts a 3.5 pound pull on a 1/16 inch stroke.

Terminal boards for Jupiter missile control system built by Chrysler Corp. Missile Div. fabricated from glass laminate made with Dow Corning Silicones.



ITT Laboratories specify silicone-glass laminates as main coil form in their AN/SRT-14, 15, 16, radio transmitters for low loss factor at high frequencies.

GLASS LAMINATES

. . . for maximun reliability

Glass laminates made with Dow Corning silicone resins have good mechanical strength in addition to low loss factor, low moisture absorption, superior resistance to arcing, corona, corrosive atmospheres, fungus and contaminants. They retain their excellent dielectric properties despite storage, environmental aging, rapidly changing ambients, vibratory shock.

Silicone-glass laminates have exceptional resistance to heat . . . up to 250 C continuous for years, substantially higher for short times. They can be laminated in very thin sections; have fine machinability and resist creep under pressure of terminal fasteners.

A list of sources for silicone-glass laminates is available from Dow Corning.

Low pressure laminating resins for use in wet lay-up fabricating techniques are available from Dow Corning.

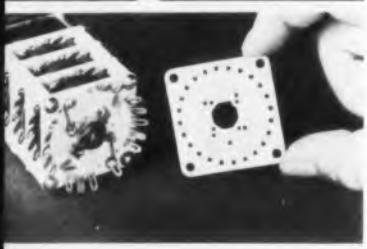
For further information, use card and circle No. 791.

TYPICAL PROPERTIES OF SILICONE-GLASS LAMINATES*

Flexural Strength, psi at:		Electrical Strength, volts/mil	
25 C	24,000	initial	310
260 C after 100 hr at 260 C	4,600	after 200 hr at 260 C	327
Water Absorption, percent	0.05	after 5000 hr at 260 C	180
Dissipation Factor at 10^6 cycles		Dielectric Constant at 10^6 cycles	
Condition A[1]	.002	Condition A[1]	3.67
Condition D[2]	.004	Condition D[2]	3.68

* As measured on samples 1/8 inch thick.
[1] As received. [2] After 24 hr immersion in water at 23 C.

One-piece core and flange construction is used to make these coil bobbins.



Rotary switch decks made by Shallcross Manufacturing Co., are laminates made of silicone-glass.

Osborne Electronic Corporation uses wet lay-up technique to make bobbins of special sizes and shapes for their custom transformers.

MOLDING COMPOUND

Dow Corning molding compounds are composed of inorganic fillers in combination with heat stable silicone resins. Parts formed from these silicone molding compounds have good arc resistance, good wet electrical properties. They are mechanically strong, resistant to moisture, corrosion and fungus.

Electronic parts made from silicone molding compound retain their physical and electrical properties under continuous exposure to temperatures as high as 300 C, short time exposure to temperatures as high as 500 C. They are lightweight, yet have good mechanical and electrical strength. When exposed to direct flame, they are self-extinguishing.

For further information, use card and circle No. 792.

Manufactured by the Aeronautical Division of Minneapolis-Honeywell, this golf-ball-size servo motor operates at controlled speeds from 0 to 11,000 rpm and develops a stall-torque of 0.75 ounce-inches. Silicone molding compound helped make the design possible.

Dow Corning Diffusion Pump Fluids permit faster, more efficient production. They develop vacua in the range of 10^{-5} to 10^{-7} mm of mercury, offer quick pumpdown and rapid recovery. Chemically inert, noncorrosive and nontoxic, they resist oxidation even when exposed to air at operating temperatures. Dow Corning diffusion pump fluids do not decompose into gums or tars . . . save replacement costs and production time. Tested in a CVC type G-4 pump, a Dow Corning fluid was unchanged in properties after more than 2,000 cycles of 12 minute pump operation followed by three minutes exposure to atmosphere at operating temperature.

For further information, use card and circle No. 793.

TV tube evacuation with Dow Corning diffusion pump fluid.

Used for Molds. Silastic RTV is easily poured over any pattern . . . simple or complex. In a matter of minutes or hours—your choice—it sets up to a firm, flexible rubber that will tolerate hot casting materials up to 500 F without damage. Molds are re-usable, give fine detail, seldom need a parting agent. When a release agent is necessary, a solution of household detergent generally does the job.

For further information, use card and circle No. 794.

Pour RTV over pattern . . . encapsulant into mold . . . remove part.

OTHER SILICONES

Dielectric Coolants are used for rapid dissipation of heat. Because of their excellent thermal stability and relatively flat viscosity-temperature curves, Dow Corning silicone fluids make excellent heat exchange media. They can be pumped at high speed without breakdown due to shear, remain in consistency over a range of —65 to 250 C, and will not oxidize or act as corrosives to metals even at high temperatures.

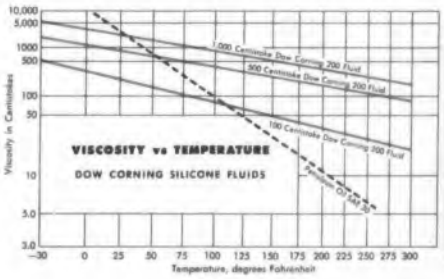
For further information, use card and circle No. 795.

Foam Resins provide a new tool for environmental engineering where a heat stable, low density dielectric is desired to cushion components. When introduced into a canned component or assembly, foaming resin fills voids . . . provide good mechanical bonding with high dielectric strength and low thermal conductivity.

For further information, use card and circle No. 796.

Printed Circuit Overcoatings that combine good dielectric properties with a high degree of water repellency in coatings as thin as one or two mils can be brush, spray or dip applied. Silicone resins are also used as solder masks . . . resist both molten solder and liquid flux.

For further information, use card and circle No. 797.



Halicrafters Company uses Dow Corning fluid as cooling medium in heat exchangers for electronic equipment rated up to 7,000 watts dissipation.

Other Dow Corning Silicones for use in mechanical, hydraulic and electrical devices of interest to engineers designing systems for control and other uses are described in other literature. One example is the use of damping fluid in the radar antenna buffer built by Houdaille Industries, shown below.

For further information, use card and circle No. 798.

Consolidated Electrodynamics Corporation uses foaming resin to simplify production of a Process Moisture Monitor.

Infrared Optical Materials

are produced by Dow Corning and supplied as unpolished optical blanks of various sizes and shapes —domes, flat plates, prisms—to meet the needs of guidance and surveillance systems.

Dow Corning Optical Silicon offers a unique combination of properties that assure the highest degree of reliability and versatility. Ground, polished and coated by an optical supplier, Dow Corning Optical Silicon provides more than 95% transmission of any desired wavelength between 1.3 and 6.7 microns . . . high transmission efficiency at other wavelengths is also obtained by selective coatings.

Semiconductor Materials

are also produced by the Hyper-Pure Silicon Division of Dow Corning Corporation.

For further information, use card and circle No. 799.

For Detailed Information...

Additional information on the products mentioned in this Electronic Engineers' Guide to Silicones is available from Dow Corning. Circle the appropriate numbers on the magazine's reader service card, or write direct mentioning the appropriate card reference numbers, or contact the Dow Corning Regional Office nearest you.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

PRINTED IN U. S. A.

FORM No. 59/6

Standardization Headaches Plaguing Russians, Too

Electronic standardization problems, not unknown to design engineers in this country, apparently are raising hob in the Soviet Union, too.

A Russian engineer, V. S. Kiskachi, writing to the editor of the Soviet periodical *Standartizatsiya*, pointed out that a lack of interchangeability between electrical components manufactured by different organizations was "often due to non-uniformity in coupling devices."

"For instance," he said, "the seven and nine-pin miniature tubes manufactured by the Russian aviation industry have a 23-mm base coupling, while similar tubes manufactured by the radio industry have a 25-mm coupling.

"Such a lack of interchangeability hinders the repair of radio engineering equipment and makes procurement of spare parts difficult. In standardizing radio components, it would not be necessary to try to standardize all the components at once. It would be sufficient at the beginning to standardize the most widely used components—contact and contactless selsyns, plugs and sockets, various switches, push-button devices, microswitches, variable and fixed resistors, relays, tube bases, tube sockets and signal lamps."

Mr. Kiskachi suggested that the standardization adio equipment be under the direction of the te Committee for Radio Electronics and the ommittee for Standards, Measures and Measuring Instruments.

Communications Chief Assails Snail's Pace in Russian R&D

Delays in R&D are another reason for complaint in the Soviet Union. From N. D. Psurtsev, Soviet Minister of Communications, comes this lament:

"In many instances [industry workers and scientific research institutes] design equipment and subsequently introduce it to industry at an exceedingly slow pace."

Writing in *Radio* on the topic "Along the Road to Technical Progress," Mr. Psurtsev complained that an automatic short-wave transmitter called Molniya has been in the design stage since 1956 but the prototype was not scheduled for completion until 1961.

At the same time Mr. Psurtsev said that microwave receivers had been on the drawing boards for three years, a new television transmitting station was just being installed for a test run after being in the research stage for the same length of time, and the design of TV transmitters and receivers "has not yet been properly organized."

Moreover, Mr. Psurtsev said, many electronic vacuum-tube and semiconductor instruments "are rather expensive and are designed for an inadmissibly short period of service."

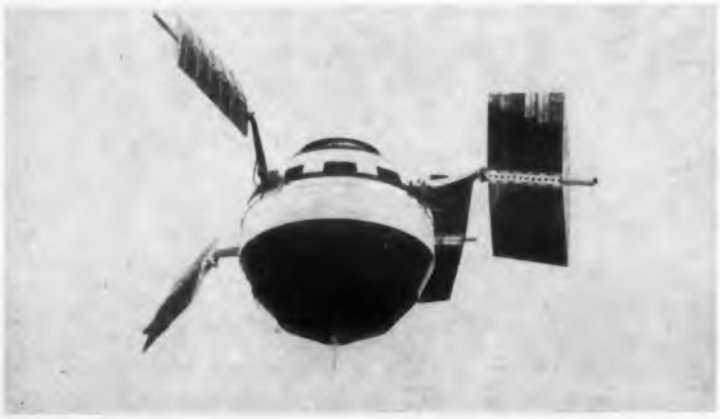
◀ CIRCLE 780 TO 799 ON READER-SERVICE CARD

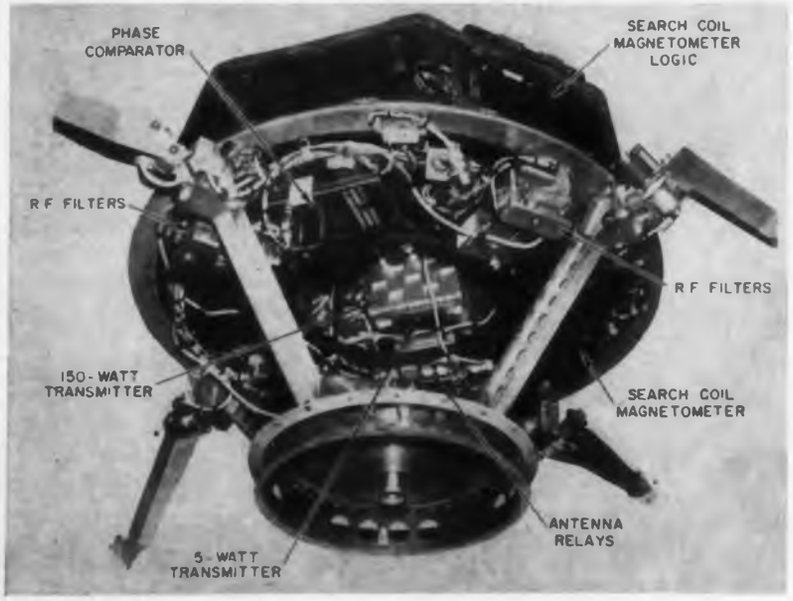
Pioneer V, as it was being readied last month for its journey into orbit between the earth and Venus. Solar-cell paddles are still to be fastened down inside of the third-stage shell. After launching, a command signal from earth caused the paddles to spring into the proper position.

Pioneer V Blazing Trail For NASA Exploration

94.8-Lb Planetoid Collecting First Data In 10-Year Probe of the Solar System

Blasting off into orbit, Pioneer V, packed inside of the third stage of a Thor-Able booster rocket, leaves the pad at Cape Canaveral. The 150-w transmitter carried by the planetoid is about 30 times more powerful than any other previous U. S. space transmitter.





In flight, Pioneer V appears as above. Solar cells of 8 per cent efficiency gather energy from the sun to recharge the nickel cadmium batteries inside the instrument package. Painted on the skin is an absorptive-emittive design that should keep instrument temperature within 55 and 80 deg F throughout the orbit. **At left** is a view of some of the instrument packaging. Combined weight of the transmitting and measurement equipment is about 40 lb. Data gathered by the instruments can be stored in a digital memory between periods when the vehicle is transmitting to the earth. Transmission occurs upon command from ground stations.

PIONEER V, the sun satellite now millions of miles from the earth, is leading the way in an ambitious space exploration program of the National Aeronautics and Space Administration.

NASA plans call for charting of space within the solar system and unmanned investigations of nearby planets within the present decade.

Pioneer V, 94.8-lb forerunner of future, heavier space explorers, is highly limited in the amount of data it can collect and return to earth because of its size. It carries no TV-like scanning equipment, because it will not be close enough to bodies in space to photograph them. Even the limited instrumentation carried by this planetoid, however, shows the possibilities for future probes.

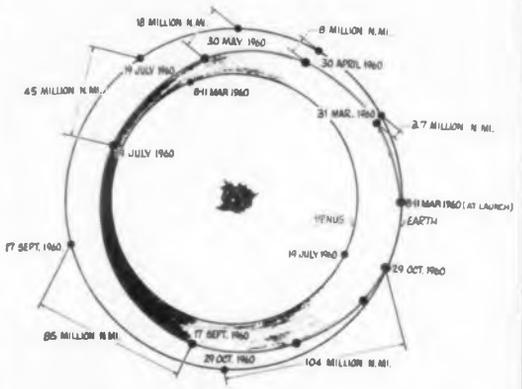
Magnetic and Temperature Measurements Among Others

Magnetic field strengths are measured by a half-pound search coil magnetometer designed by Space Technology Laboratories, Inc., which provided over-all system integration and payload packaging for the experiment. A photoelectric cell aspect detector triggers an electrical impulse when the cell faces the sun, providing information on the direction of magnetic fields encountered.

Five thermistors, two carried on the solar-cell paddles and three inside the instrument package, give temperature data.

Micrometeorites striking the planetoid are counted, and their momentum indicated by a counter designed by the Air Force's Cambridge Research Center. A diaphragm mounted on the planetoid's skin and a microphone mounted inside make up this instrument, which weighs less than a pound.

Total radiation flux measurements are made by



Orbiting of Pioneer V is illustrated by the black spots. Shaded area separates the orbits of Venus and the man-made planetoid. Distances listed show how far the space vehicle is from earth—about 6 million mi. now. Pioneer V will make its closest approach to the sun in July.

an ion chamber and Geiger-Mueller tube package, designed by the University of Minnesota. The ion chamber provides particle energy data, and the tube counts the number of medium energy electrons and protons passing through.

5-Lb Radiation Counter Responds to High Energies

High-energy radiation is measured by a 5-lb radiation counter developed by the University of Chicago. This package has six argon gas-filled cylinders surrounding a seventh cylinder. Particles ionize the gas in the cylinders that they penetrate, so that the number of cylinders penetrated gives a measure of particle energy.

Three static converter power supplies provide multiple-regulated dc outputs and a 3-kc, square-wave output. These units were supplied by Gulton Industries' Engineered Magnetics Div. Gulton's Alkaline Battery Div. supplied nickel cadmium batteries for the experiment.

The sun satellite will have an orbit cycle of about 311 days, coming about 18 million miles closer to the sun than the earth does in its yearly orbit.

NASA assigned responsibility for the launch to the Air Force Ballistic Missile Div., which subcontracted the satellite portion of the project to Space Technology Laboratories. About 50 industrial subcontractors and universities joined in the Pioneer V effort. ■ ■

NEWS

'Satellite Computer System' Gives Extra Flexibility

A "satellite computer system" that provides for direct transfer of data between small computers and a larger, more centralized one is said to add flexibility to all types of data processing.

Originated by Control Data Corp., the system uses the desk-size 160 computer and the large-scale 1604 computer. The 160 units are used in small, independently directed data-processing centers that have direct access to the 1604.

The system is said to increase the efficiency of the small computers by giving them a means of using the large capacity and high speed of the 1604 computer. Data may be transferred without hooking up any black boxes. At any time the 160 can interrupt the 1604 and transmit data to it at the rate of 160,000 characters per sec. Data can be transmitted back at the same rate.

The 1604 reportedly can process other data while simultaneously accepting data from several 160 centers. The satellite system processes data to punched card units, line printers, paper tape units, electric typewriters and magnetic tape units.

Antennas "Flown" in Ground Test

Antenna research for high-altitude, supersonic aircraft is being conducted at a range that uses "flying" model aircraft. Above, observer plots antenna pattern as rotating 350-lb model of Boeing jetliner transmits signals. Suitable for low to super-high frequency testing, the range permits pattern measurement in any attitude. The study is being made at the Wichita (Kans.) Div. of Boeing Aircraft Co. Ferrite, slow-wave and exponential-current-distribution antennas, as well as new materials and techniques, are under test.

Portable Lab Studies Machines

Miniaturization techniques have made possible a table-top laboratory kit that enables study of electric machine characteristics both as units and in a system. The kit has 1/15-hp machines, including these types: dc, wound-rotor ac, and squirrel-cage ac. Miniature torque sensors are used.

All components are tapped for thumb-screw attachment to a grid plate, supplied with the kit. Power is supplied with available dc and 60- and 400-cps power packs. Power can also be supplied from existent sources.

The kits, made by Lebow Associates, Oak Park, Mich., are intended for use in small-budget engineering colleges or trade schools. They are available on a standard or custom basis, with components selected to meet curriculum requirements.

Students study characteristics of electric machines with this new table-top laboratory kit. The kit, which includes ac and dc machines, has miniature torque sensors.

Pyrotechnic Missile Gyro Uses July 4th Pin-Wheel Principle

A pyrotechnic gyroscope based on the principle of a Fourth of July pinwheel may soon replace conventional spring-driven gyros in American short-range missiles. The new gyro, now being used in the British Royal Navy Seacat missile, is said to have alleviated problems of reliability, bulk and cost.

The pyrotechnic gyro uses a small explosive charge to accelerate its rotor. Springs and clutches are eliminated.

Donald H. Putnam, president of Giannini Controls Corp., Pasadena, Calif., says the pyrotechnic gyro meets the specifications for almost every American short-range missile. His company has been licensed by Short Bros. & Harland, Ltd., Belfast, Ireland, to make a gyro that can attain rotor speeds of 36,000 rpm in one-tenth of a second.

Optical Fingerprinting Unde

INKLESS fingerprinting is accomplished with an optical system being developed by the Electronics Div. of Chance Vought Aircraft, Inc., Dallas, Tex.

To operate the system, invented by Wyman White, a division engineer, the finger is placed on a small glass area without exerting pressure and without rocking. The print pattern is projected onto a screen or ground glass for observation or photography. Prints can also be transmitted over standard telephone circuits.

The optical sensing system does not include electrical circuitry, a company spokesman said; however, electronic methods have been developed for automatic identification and for fingerprint transmission.

Various automatic identification methods are being studied by the company. One senses the converts into mathematical ratios the transmission and reflection of light from areas of a print pattern. The ratios are combined to provide an identification code.

Other equipment converts print patterns into characteristic curves displayed on recording devices.

Optical fingerprinting without ink, using a TV-monitor to show the sharpness of the print pattern. Finger is rested against a small glass area at left without pressure and without rocking. Automatic fingerprint identification and transmission equipment has been designed for the system, under development by Chance Vought Aircraft, Inc., Dallas, Tex.

evelopment

The telephonic sending and receiving units developed include a frequency-monitoring system to prevent interference that might cause distortion in print transmission.

Electronic scanning of fingerprint patterns for automatic comparison is also being studied, the company says.

Aside from use in police work, optical fingerprinting might become an acceptable method of normal business identification, Chance Vought says, because it would be more reliable than signature comparison. ■ ■

CIRCLE 29 ON READER-SERVICE CARD ➤

NEWS

Thin-Film, Aluminized CRT's For 2 to 5 Kv Acceleration

Aluminizing of many oscilloscope cathode-ray tubes, with accelerating voltages as low as 2 to 5 kv, is now said to be economically feasible with a process developed by Thomas Electronics, Inc., Passaic, N.J.

Previously, tubes with accelerating potentials below about 5 kv were not aluminized because economical processing techniques were not developed, according to Peter Seats, director of the company's research and development division. Lower voltages require thinner aluminum coatings, so that an electron beam can penetrate the metal film, he explained, but it has been difficult to achieve uniform thin films to rest against a rough phosphor surface.

Increased Brightness Achieved

Chief advantage of aluminizing is increased brightness. Thomas' aluminized tube with 3-kv acceleration is said to be about 50 per cent brighter than an equivalent non-aluminized crt.

Beam current can be lowered because of this brightness advantage, giving better resolution because of narrow line widths.

Instrument designers might achieve equivalent brightness with lower operating voltages where fine resolution is not crucial.

Other advantages claimed for the aluminized tubes include:

- Elimination of cathode glow and infrared radiation, which cause film fogging during scope photography.
- Prevention of ion burns, because the low operating voltages do not accelerate ions enough to penetrate the aluminum layer.
- Removal of spurious charges from the screen through the conductive aluminum film.

Existing Circuits Can Be Used

Prototypes of aluminized 5ADP and 5AQP tubes are being produced by Thomas. Existing circuit designs can be used with the new tubes, according to Mr. Seats.

Details on the Thomas aluminizing process were not disclosed. However, Mr. Seats said that new materials, as well as new processes and production techniques, were involved.

Below an accelerating voltage known as the cross-over potential, an aluminized tube is not as bright as a non-aluminized crt, because the electron beam is impeded by the metal film. Beyond the cross-over potential, which is about 2 kv in the Thomas tube, the aluminized tube becomes brighter because of the reflection of light by the

aluminum film just behind the screen phosphors.

Ordinarily the tubes developed by Thomas will be operated at 500 to 1,000 v above this cross-over accelerating potential, according to Mr. Seats.

The tubes will first be used in oscilloscopes to be produced by Analab Instrument Corp., Cedar Grove, N.J. Analab worked with Thomas in the development of the aluminized crt's.

$270,000 Wall St. Fraud Laid To Juggling With Computer

Electronic hanky-panky in a Wall Street brokerage house has resulted in a $270,000 short-circuit of the firm's accounts. Charged with embezzlement through data-processing manipulation is Frank B. Haderer, a vice-president of Walston & Co., who reportedly fast-shuffled the IBM cards for almost eight years.

Having random access to the computer, Haderer is said to have punched cards to show withdrawals from one stock account and a corresponding addition to his own. The shortage was revealed by an audit of the books, but it took several weeks to point the accusing digit at Haderer. The prosecutor explained:

"When books and records are manipulated, it's possible to identify handwriting, but when electronic computers are used, it's hard to tell who pushed the button."

Push-Button 'Craftsman' Developed

With the push of a button on a panel, the operator in charge of this boring operation starts a numerical control system working. Pre-punched tapes automatically control the operation. The system can be adapted to a variety of tasks—such as positioning, drilling, reaming or tapping. Developer by Sperry Gyroscope Co. of Canada, it will be made for U.S. distribution by Wheeler Electronic Corp.

NEWS

Instrument Society Sets Up $1,000 Achievement Award

The Instrument Society of America has established an annual award to the member making the most important contribution to new principles of instrument design, development or application.

Consisting of a citation and a cash award of $1,000, the award is to be known as the Arnold O. Beckman Award, in honor of the former president of the society and now one of its honorary members. Dr. Beckman, of Altadena, Calif., is the founder-president of Beckman Instruments, Inc., of Fullerton, Calif.

Conference to Discuss Future Miniaturization of Components

Experts will probe ten years into the future at the opening session of the 1960 Electronic Components Conference. The session—called "Quo Vadis, 1970"—will stress future needs in systems, components, and research.

The conference, which will be held May 10-12 in Washington, D.C., will also devote two sessions to miniaturization, microelectronics and molecular circuitry.

Conference headquarters will be the Washington Hotel, 15th and F Sts., N.W. For the tenth year, the sponsor will be the American Institute of Electrical Engineers, Electronic Industries Association, Institute of Radio Engineers, and the Western Electronic Manufacturers Association.

New Computer Rejects Errors by Operator

A new computer "controls" the operator by detecting human error and rejecting improper data as soon as they are entered. Called the Monrobot XI, the computer processes and understands both alphabetical and numerical information.

The machine can handle all kinds of available input or output codes, according to Walter K. Clifford, vice president of Monroe Calculating Machine Co., Inc., Orange, N.J. Storage is contained on a magnetic drum divided into 1,024 storage registers. Each register can hold one number or word, or two program instructions. The magnetic drum revolves 5,200 times per min, and data flows to and from the drum in the form of electronic impulses at the rate of 160,000 per sec.

The versatility and performance of the machine equals that of machines costing three times as much, Mr. Clifford said. He added that the Monrobot XI would be priced at $24,500.

Networks and Feedback Systems To Be Analyzed at Symposium

Circuit properties and recent developments in active networks and feedback systems will be covered in a symposium April 19-21 in New York City. The program, to be held in the auditorium of the Engineering Societies Building, will include three papers on design for maximum gain in bandwidth from tunnel diodes.

The symposium, organized by the Microwave Research Institute of Polytechnic Institute of Brooklyn, is the tenth in a series of international ones planned by the institute. Dr. H. J. Carlin of Polytech is the program chairman.

First Army Technical Net Announces May Schedule

The First Army MARS SSB Technical Net, whose mission is to disseminate technical knowledge by radio communication, announces the following schedule for May:

May 4—"Antenna Panel," W. Offutt, engineering manager, and B. Woodward, engineer, Airborne Instrument Laboratories, Melville, L. I., N.Y.

May 11—"Frequency Control," Dr. G. Winkler, scientist, USARDL, Fort Monmouth, N. J.

May 18—"Communication Electronic Needs of the Future," Dr. J. V. Harrington, division head, and Dr. B. Lax, MIT Lincoln Laboratory, Lexington, Mass.

May 25—"Fundamentals of Oscillator Operation," R. W. Gunderson, editor, Braille Technical Press, New York, N.Y.

The net meets on 4030 kc each Wednesday at 9:00 pm.

Terrain-Avoidance System Developed for Low Flying

An electronic terrain-avoidance system for low-flying aircraft has been developed for the Air Force.

The system, developed by Cornell Aeronautical Laboratory, Buffalo, N.Y., will be tested soon in a B-57B bomber. The project has been under development for three years, and is an outgrowth of research begun in 1953.

The laboratory also has announced development of a ground-based simulator of low-level flights. During simulated "flights," the pilot, in an F-84 cockpit, controls the "aircraft" in accordance with terrain conditions that are made to appear on his radar.

NEWS

Ultrasonic Flowmeter Reads Through Pipe Walls

An ultrasonic flowmeter that transmits through the walls of pipes to measure quantity and rate of flow has been demonstrated. The unit uses no mechanical devices inside the pipe. It consists of an insert pipe of the same diameter as the pipe to be measured, two transducers mounted on the insert, a portable amplifier, and the readout.

The meter operates by sending an ultrasonic beam across the stream and measuring the beam shift caused by the flowing liquid. The sound from the transmitting transducer echoes inside the pipe. Because of the shift, only a fraction of it is picked up by the transducer in the opposite wall of the pipe. Made by Gulton Industries, Inc., Metuchen, N.J., the flowmeter is available with meter readout and direct writing recorder, or integrator and mechanical totalizer.

Portable ultrasonic flowmeter uses transducers mounted on opposite sides of pipe insert to measure quantity and rate of flow. The unit above, a meter readout and direct writing recorder, checks a water meter

2 Educational TV Bills Go Before Congress

Two amendments to the Communications Act of 1934 have been introduced into the current session of Congress.

One deals with the reservation of television channels for educational broadcast services. As of February, 259 channels are reserved. These include 88 vhf and 171 uhf channels. Total educational TV stations now on the air include 34 vhf and 11 uhf channels. Of this number, three stations are on non-reserved channels.

The other, perhaps more comprehensive, bill proposes to establish minimum standards of public service programing for broadcasting stations.

This bill covers licensing, a code of ethics, etc.

Both bills are now before the Committee on Interstate and Foreign Commerce.

Probe Detects Minute Corrosion By Measuring Electrical Resistance

A probe reported able to detect corrosion in metal, atom by atom, has been developed.

It detects by measuring the resistance of a metal exposed to corrosive elements and comparing it to the resistance of the same metal when it has been protected from corrosion. Corrosion increases a metal's electrical resistance.

The metal is used in the form of a vacuum-deposited film, 2 to 50 millionths of an in. thick. Half the surface is exposed to the corrosive agent, and the other half is covered with a protective coating. The instrument connected to the probe is said to detect 5 billionths of an in. of metal loss.

Developed by Thompson Ramo Wooldridge, Inc., of Canoga Park, Calif., the probe can measure minute changes in the concentration of contaminants ordinarily difficult to detect. For example, it can measure the concentration of water in a non-aqueous liquid.

The probe has been used to determine the water content of hydrocarbons, a normally difficult measurement. It is being adapted to the measurement of corrosive conditions in missile systems.

Beryllium Oxide Facilities Expanded

Technician inspects beryllium oxide micromodule wafer at National Beryllia Corp.'s Haskell, N. J., plant. Production and research facilities of the plant have been tripled.

NEWS

Mass Spectrometer Tested For Use in Space Satellite

A miniature mass spectrometer to be carried in a space satellite is under prototype test by Consolidated Systems Corp.

The spectrometer, which weighs less than 12 lb, is designed to operate for more than a year between 150 and 600 mi above the earth. It will distinguish six types of particles—hydrogen atoms, nitrogen atoms and molecules, oxygen atoms and molecules, and water vapor. Neutral particles will be ionized outside the satellite shell by an electron beam from a rhenium filament.

Information on the particle composition of the upper atmosphere will be telemetered to receiving stations on the ground by an electrometer amplifier.

A binary solid-state logic system about the size of a cigarette pack will program the operation of the spectrometer. The device will have two permanent magnets to assure that a magnetic field for deflecting the particles is available regardless of the satellite's orientation in space.

Automatic Weather Observation Under Test by the Air Force

An automatic weather-observation network that can detect lightning 2,000 miles away is being tested by the Air Force.

The network consists of a central station at Kansas City and six subsidiary stations scattered throughout the central United States.

Each station detects static generated by lightning, records its time of detection and the compass direction and transmits the data to Kansas City. There, within a tenth of a second, the data are sorted and the lightning's position is plotted electronically on a special map of North America.

The weather-observation system was developed for the Air Force by the Army Signal Research and Development Laboratory, Fort Monmouth, N.J., and the Stavid Div. of Lockheed Electronics, Plainfield, N.J.

When the system becomes operational, it will be used for weather research by the military and will assist the Air Force Severe Weather Warning Center and the United States Weather Bureau in preparing forecasts.

U. S. Scientists Developing Systems Reliability Tests

Two scientists at the National Bureau of Standards are building mathematical models that

can be used to predict the reliability of systems.

The scientists, J. R. Rosenblatt and M. Zelen, of the bureau's Statistical Engineering Laboratory, are attempting to develop a variety of mathematical probability approaches.

Some aspects of system performance fall into the area of probability because unknown and uncontrollable factors influence their performances.

The two scientists have defined reliability, for their purposes, as the probability of a system's satisfactory performance under specified conditions, including the time of operation.

Concurrent with the scientists' work the bureau is developing statistical methods for predicting the reliability of the components that go into systems.

Electronics Concern Making Distributors Its 'Warehouse'

A new plan of International Resistance Co., Philadelphia, makes local independent distributors the company "warehouse." Complete stocks of all components normally required by electronic manufacturers in the area are to be carried by the distributors.

"There will be a saving of days in delivery time," according to Robert Bailey, sales manager of the company, "yet the goods will be sold at factory prices."

Radio Telescope Positioning System

This precision angle digitizing system will be used to supply visual and printed records of position of a radio telescope at the Air Force Cambridge Research Center. The equipment, using an optical-type punched-tape reader, compares computer-prepared desired positions with actual antenna positions. Datex Corp. built the system.

NEWS

Changing Management View On Automatic Control Systems Cited

Top management is paying more attention to automatic control, according to George M. Muschamp, engineering vice-president, Minneapolis-Honeywell's Industrial Products Group.

Top management throughout industry is becoming involved in decisions on automatic controls as the scope of control problems increase, Mr. Muschamp told a recent meeting of the New York section of the Instrument Society of America. The costs of solving control problems and the effects of control systems on existing organization were also cited by Mr. Muschamp as factors requiring top management's attention.

Effectiveness of control systems in the plant, office and laboratory have been demonstrated, he said, and labor opposition has decreased greatly. This means that some programs once difficult to justify, are becoming more readily acceptable to management.

On-The-Job Movies Instructing Assemblers at Electronic Plant

Step-by-step training films of complex wiring and mechanical assembly operations are credited with saving more than $3 million last year in the manufacture of electronic computers and instruments for the F-105 fighter-bomber. This was reported by the Eclipse-Pioneer Div. of Bendix Aviation, Teterboro, N. J., at a cost reduction conference of Air Force subcontractors held at the plant.

The motion pictures, with sound, largely replace the usual "lead" man, or instructor. They show the exact procedure to the worker while he is assembling the item. Progress of the film is treadle-controlled by the operator from his assembly station.

In one instance, the use of these films is said to have reduced the assembly time of precision gyro components 25 per cent by reducing wasted effort and lost motion by assemblers.

Army Radio Network to Offer Four Technical Talks in April

Four speakers will deliver talks in April over the First United States Army Single Sideband Technical Net.

The net operates on Wednesdays at 9 pm, E.S.T., on 4030 kc upper sideband. It can be

heard within a 1,000-mi radius of New York City.

Arrangements for a similar net centered on Washington, D.C., are being made.

The talks scheduled for April are as follows:

April 6—"Filter Design and Applications," by James L. Prather of the Radio Div. of the Signal Corps, Ft. Monmouth, N.J.

April 13—"New Semi-Conductors For High Frequency Circuits," by W. A. McCarthy, chief applications engineers, Semiconductor Div., Raytheon Co., Boston.

April 20—"Modern Trends in Electronic Instrumentation," by Walter A. Knoop Jr., a partner in Gawler-Knoop Co., Roselle, N.J.

April 27—"Tacan and Similar Aircraft Navigation Systems," by William Loebel, project engineer, Olympic Radio & TV Div. of the Siegler Corp., Long Island City, N.Y.

Beacon Simulator Tests TACAN in Aircraft

A new test set is said to be capable of checking the TACAN navigation equipment in up to 25 aircraft at once.

Called the TACAN Radio Beacon Simulator Test Set, the unit transmits simulated bearing, range and identity signals comparable to ones normally transmitted by a ground-beacon station.

The set simulates ranges of up to 180 mi with an accuracy estimated at 1 per cent or better. It can select one of two pre-set azimuths from any of 18 bearings. Bearing accuracy is put at one-quarter degree. In addition to testing aircraft within a radius of two miles, the 170-lb unit is said to be suitable for bench testing and calibration.

Developed by Stromberg-Carlson-San Diego for the Hughes Aircraft Co. of Los Angeles, the unit is a component of MART (Mobile Automatic Radiation Tester), aircraft ground-test equipment being built for the Air Force.

New beacon simulator set checks TACAN navigation equipment in aircraft within a radius of 2 mi. Stromberg-Carlson-San Diego unit is also suitable for bench testing and calibration. It weighs 170 lb.

NEWS

Panel Trend Stressed In Solar-Cell Market

Introduction of a 26-sq-ft silicon solar-cell panel by International Rectifier Corp., El Segundo, Calif., accents a trend toward panel marketing in the solar-cell branch of electronics.

A significant cost saving to customers buying panels rather than individual cells is said to be the main reason for the trend.

The International Rectifier prototype panel contains 10,640 silicon solar cells and develops about 100 w. Production units will develop over 200 w, using 12 per cent efficient cells, according to the company.

Dr. Charles A. Escoffery, technical assistant to the president of International Rectifier, estimates that if large quantities are ordered, the price of the panel, currently $15,000, will drop to $2,000 to $3,000.

This is many dollars-per-watt less than when buying cells singly.

The panel was demonstrated by International Rectifier at the recent *IRE* show as the charging source for batteries of a 1912 Baker electric automobile.

Hoffman Electronics Corp. in Los Angeles is also selling solar-cell panels. The first applications were power modules for transistor radios in early 1956. Five and 10-w modules for combining into power panels of any size are being sold. Typical applications include use in telephone-relay-station equipment and in radio communication gear for forest-ranger stations.

High-Speed, Transistorized G-20 Computer Now in Production

Production has begun on the Bendix G-20 Computer at the company's Computer Div. in Los Angeles. The new entry into the medium-size computer field offers all-semiconductor circuitry and expandable random-access storage. Five thousand transistors and 30,000 diodes are employed and the magnetic core memory can consist of from one to eight modules of 135,000 cores each.

The computer is capable of 45,000 operations per sec and features parallel processing for input-output activities independent of the arithmetic unit.

A complete G-20 system for scientific applications is expected to lease for under $10,000. Demand is reported brisk and a new plant under construction will provide a 70-per-cent increase in production facilities.

Battle TV-Map System

Tactical information transmitted from front-line areas is displayed automatically on a TV-like battlefield map at combat headquarters in a system being developed for the Marine Corps.

The equipment includes hand-held, push-button generators, a portable data-processing unit, the map display unit, and a portable electric typewriter for recording data from the front.

To send tactical information to a central command post, observers first set a series of rotary switches on a hand-carried generator. Then in a short burst over standard field communications sets, they transmit the message they have set up.

Symbols and alphanumeric characters selected and displayed by the system identify targets and indicate position. Other information displayed on the military map, which is optically registered to a cathode-ray-tube face, includes target number, direction of movement, time of observation and observer identity.

Data on up to 50 targets can be displayed on the map, according to Stromberg-Carlson-San Diego, a division of General Dynamics Corp., developer of the system.

1959 Miniaturization Award To McLean of Bell Labs

David A. McLean, component development engineer of the Bell Telephone Laboratories, Murray Hill, N.J., was named winner of the 1959 Miniaturization Award. He was selected from a field of 107 nominees for his new method of forming printed circuit patterns containing passive circuit components. Horace D. Gilbert, chairman of the awards committee and president of Miniature Precision Bearings, Inc., presented McLean with the award at a dinner held at the Waldorf-Astoria Hotel, March 20.

Certificates of Excellence were also awarded for developments of: a tunnel diode for practical applications; solid circuits using single crystal semiconductor wafers; a micro-diode; a miniature mercury battery; a compact digital computer; a miniature 150 watt bulb; a four-stage amplifier, and a one inch hydraulic cam motor. An award was also presented for contributions to the acceptance and success of the molecular electronic concept.

Those attending the dinner heard from Lieutenant General Arthur G. Trudeau, chief of research and development of the Department of the Army. As guest speaker, his theme was "New Dimensions for the Future." He told of some of the Army's plans and problems in the field of miniaturization.

NEWS

Automatic Weather Device Designed in Sweden

An instrument to register and transmit meteorological data automatically and continuously has been designed by a Swedish inventor, F. O. Nilsson.

An electronic program device controls observation instruments for humidity, direction and force of the wind. These data are radioed to a remote receiver, where they are automatically plotted on a recording chart.

The Andrée Silver Plaque has been awarded to Mr. Nilsson for his invention by the Association of Swedish Inventors.

CHANGES IN PRICES & AVAILABILITY

ZENER SILICON DIODES have been reduced in price ranging up to 40 per cent by Motorola, Inc. The reductions affect 70 per cent of the company's Zener silicon diode line.

SILICON MESA TRANSISTORS and silicon diodes are now available through Rheem Semiconductor Corp.'s first distributors. Transistors and diodes are available in the following quantities: diodes 1-4,999; transistors 1-999. The silicon mesa transistor line features types and prices in the 1-99 and 100-999 brackets as follows: 2N497, \$19.30, \$12.85; 2N498, \$26.65, \$17.75; 2N656, \$21.55, \$14.35; 2N657, \$27.40, \$18.25; 2N696, \$21.75, \$14.50; 2N697, \$22.70, \$15.15.

MICROPHONE CALIBRATION services have been increased in price by Shure Bros., Inc. Primary microphone calibration now costs \$175, an increase of \$50. Secondary calibration costs \$50, an increase of \$10. An additional charge of \$15 is made if a polar-response (pick-up pattern) curve is desired.

AN INCREASED TRANSISTOR quantity break, announced by Landsdale Tube Div. of Philco Corp., makes Philco transistors available in quantities 1 to 999 at factory prices to industrial distributors.

ACRYLIC MOLDING POWDER (Implex) has been reduced in price by Rohm & Haas Co. The new truck-load is 46-1/2 cents per lb for material in the natural color and 48-1/2 cents per lb for pigmented grades.

NEWS BRIEFS . . .

BUILDORAMA, an exhibition of the products of Slater Electric and Manufacturing Co., Inc., is being held at the Architects International Bureau of Building Products, Miami, Fla.

MICROWAVE COMMUNICATION SYSTEM will be installed in Italy as a "package" by Westinghouse Electric International Co., Pittsburgh, Pa., under a $1-million contract from the Air Force. Operating in the 2000-mc band, the system will use frequencies between 1700 mc and 2300 mc.

POWER SUPPLIES to activate ground-support equipment for the Bomarc ground-to-air missile, will be designed, engineered and manufactured by Transval Electronics Corp., Seattle, Wash., under a $600,000 contract from Boeing Airplane Co.

RADIO AND ELECTRONICS expert H. A. Wheeler, president of Wheeler Laboratories, Inc., has received the 1960 Distinguished Engineer Alumnus Award from George Washington University.

A TELEMETERING SYSTEM to insure more efficient operation of flood and reservoir control will be installed in the Canal Zone by United Electrodynamics of Pasadena, Calif.

HIGH-SPEED DIGITAL JET TRAINER developed by Sylvania's Electronic Systems Div. has been accepted by the Navy.

EXTENSION of Martin Co.'s contract with the Atomic Energy Commission for work on isotopic power totals $2,300,000.

PROTOTYPE POWER AMPLIFIER will be designed and developed by Southwestern Industrial Electronics Co., Houston, Tex., under a $14,610 subcontract to Summers Gyroscope Co. The amplifier will be used with a new rate-of-climb meter for missiles and aircraft.

NEW RESEARCH GROUP has been formed by the Systems Div. of Beckman Instruments, Inc., to study advanced information-handling techniques.

LICENSING AGREEMENT between Eitel-McCullough, Inc., of San Carlos, Calif., and English Electric Valve Co. of Chelmsford, England, has been arranged for the exchange of manufacturing rights and technical information in electron tubes.

NEWS BRIEFS . . .

HIGH FREQUENCY (point-to-point) communications equipment for Project Mercury network will be supplied by the Technical Materiel Corp. of Mamaroneck, N.Y., under a contract from Western Electric Co.

CERAMIC CAPACITORS, the VK series, will be made at a new plant being built for Vitramon, Inc., of Bridgeport, Conn.

COOLED STRUCTURES for space vehicles designed for re-entry will be made by Bell Aircraft Corp. for the Air Force under a $1.4-million contract.

NETWORK ANALYZER, a desk-top computer, now can be leased from General Electric's Computer Dept. on a five-year plan.

AERIAL RECONNAISSANCE testing equipment will be produced by Chicago Aerial Industries, Inc., of Melrose Park, Ill., under Air Force contracts totaling $500,000. One of the contracts will cover the design and development of an image velocity simulator.

200 ENGINEERS AND TECHNICIANS from Sylvania Electric Products, Inc., and Radio Corp. of America will be trained for installation, operation and maintenance of the data-processing phase of the Air Force Ballistic Missile Early Warning System (BMEWS).

CLOSED-CIRCUIT TV enables busy advertising executives to see a complete video commercial, merely by looking up from their desks. McCann-Erickson is now equipped with an EMI Electronics closed-circuit TV and sound system throughout its six-story building. Camera angles, movement and color can all be carefully considered in advance of filming.

A PLAN FOR COMBINING Electronic Communications, Inc., of St. Petersburg, Fla., and the W. L. Maxson Corp. of New York on the basis of exchanging one share of ECI common stock for each 1 3/4 shares of Maxson capital stock has been approved by the boards of directors of both companies.

TWO NEW DIVISIONS—Subsystems and Components—have been formed by Alto Scientific Co. The Subsystems Div. will be engaged in subcontract work covering console checkout equipment and "black box" design and manufacture. The Components Div. will design and manufacture electronic components.

AIRBORNE VHF communication and navigation equipment will be produced by Collins Radio Co. of Cedar Rapids, Iowa, under a $1,100,000 contract from the Air Force.

AN ULTRASONIC INSTRUMENT for diagnosing internal diseases has been developed by Dr. C. H. Hertz and Dr. I. Edler, both of Lund University, Sweden. The new method, which reportedly has been used with success in some 1,000 cases, furnishes information about the shape and movements of the heart chambers and parts of the stomach not accessible to such techniques as X-rays.

FORMATION of a new company, Pressure Elements, Inc., has been announced by C. H. Colvin, president of Colvin Laboratories, Inc. The new organization will design, manufacture and market pressure diaphragms and capsules.

THE ACQUISITION of Midland Manufacturing Co. and Wright Electronics, Inc., Kansas City, by Pacific Industries, Inc., San Francisco, has been announced. Midland and Wright are large producers of quartz crystals for the electronics industry.

SINGLE CRYSTAL germanium and silicon will be processed in a new $500,000 facility at Sylvania Electric Products, Inc.

WESTINGHOUSE ELECTRIC CORP. plans a new building that is expected to expand facilities for the company's Semiconductor Dept. at Youngwood, Pa., by 30 per cent.

THEME OF THE AIEE Great Lakes District Meeting, to be held April 27-29, will be "Pearl Street to Cape Canaveral." Papers will cover advances in transmission and distribution, computers and data processing in control systems, industrial controls, electronic instrumentation, rotating machinery, feedback controls, missiles and guidance, education and machine tools.

DOPPLER NAVIGATION units will be produced by Ryan Electronics, a division of Ryan Aeronautical Co., San Diego, Calif., under a $1.5-million contract from the British Royal Navy.

TELEPRINTER EXCHANGE service (Telex) now links the U.S. with Nigeria, says RCA Communications, Inc.

COMPUTING SYSTEM for handling airline reservations is being tested by International Telephone and Telegraph Corp. Called AIRS, the system was developed by two European affiliates of ITT for Air France.

NEWS BRIEFS...

MATERIALS RESEARCH CORP. has formed a wholly owned subsidiary, NRC Manufacturing Corp. It will manufacture zone-melting apparatus, high-vacuum furnaces and other equipment designed by the parent company.

BORG-WARNER CORP. has formed a new Controls Div. The new operation, at Santa Ana, Calif., will take over the personnel, products and existing facilities of the BJ Electronics plant of Borg-Warner.

A GROUND COUNTERMEASURES receiving system will be made by Sylvania's Mountain View (Calif.) Div. A $7-million contract has been awarded by the Air Force.

A DEVELOPMENT-PRODUCTION contract, totaling $100,000 for integrally-lit accelerometers, has been awarded to the Burton Manufacturing Co., Santa Monica, Calif., by the Air Force.

A CLOSED CIRCUIT TELEVISION system has been installed at London Airport by Marconi Wireless Telegraph Co. Ltd. The experimental system is expected to enable authorities to determine whether the control of aircraft parking can be improved.

ALL ASSETS of Clemco Aero Products of Compton, Calif., have been purchased by Hathaway Instruments, Inc. of Denver, for a price in excess of $500,000. Formerly a division of J. W. Clement Co., it will operate under the name of Clemco Aero Products, Inc.

TELEMETER MAGNETICS, INC. has announced the merger of two of its subsidiaries, Invar Electronics Corp. and Digital Instrument Laboratories. The consolidated organization will be known as Invar Electronics Corp.

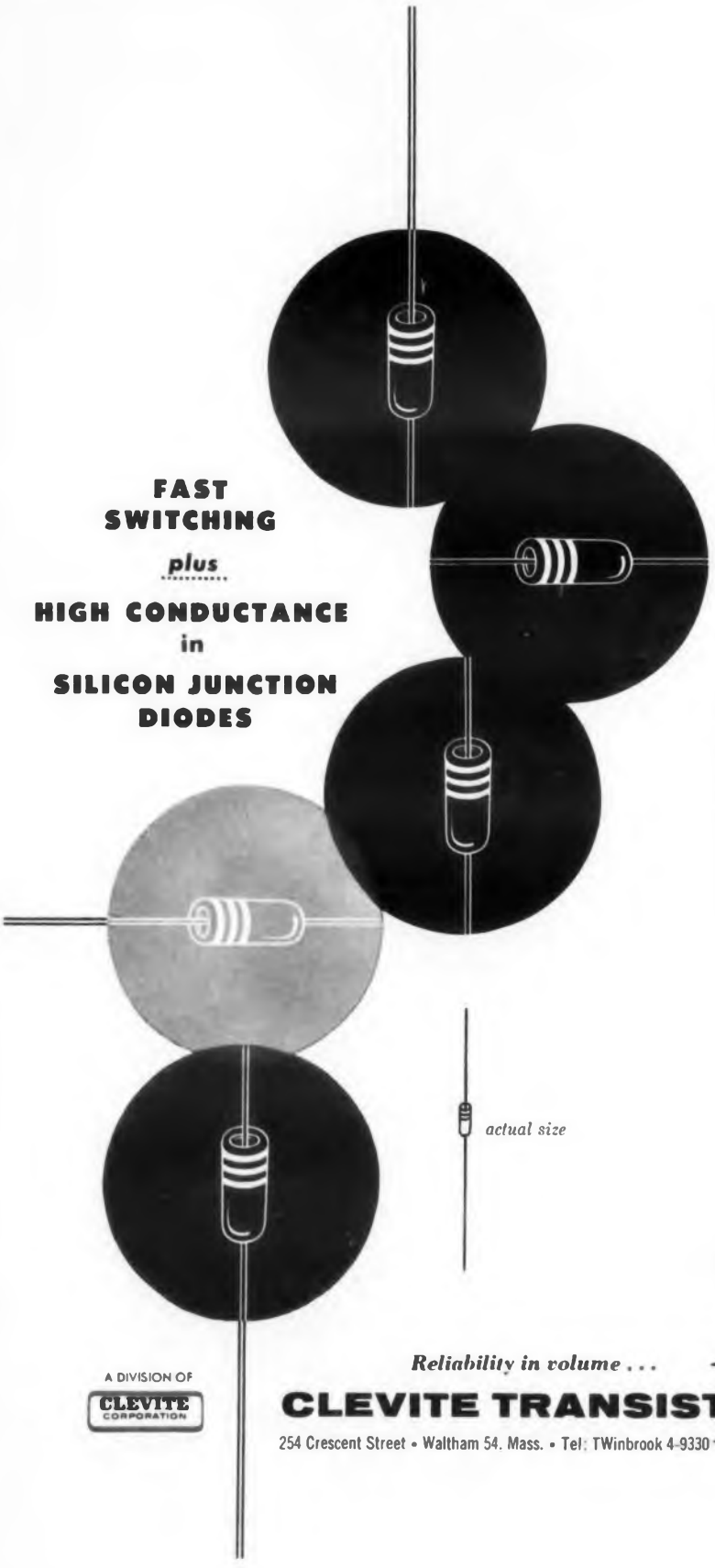
AC SPARK PLUG, a division of General Motors, has opened its Advanced Concepts R&D laboratories in El Segundo. Efforts at the new facility will be devoted to advanced system analysis for ballistic missiles and future space vehicles.

IMPROVED RECORD COMMUNICATIONS between the United States and Puerto Rico will be undertaken by the American Cable & Radio System. Plans call for the inauguration of 36 duplex telegraph channels in the underseas telephone cable which extends from West Palm Beach, Fla., to San Juan.

FAST SWITCHING

plus

HIGH CONDUCTANCE in SILICON JUNCTION DIODES



actual size

SWITCHING TYPES

New circuit possibilities for low impedance, high current applications are opened up by Clevite's switching diodes. Type CSD-2542, for example, switches from 30 ma to −35v. in 0.5 microseconds in a modified IBM Y circuit and has a forward conductance of 100 ma minimum at 1 volt.

Combining high reverse voltage, high forward conductance, fast switching and high temperature operation, these diodes approach the ideal multi-purpose device sought by designers.

GENERAL PURPOSE TYPES

Optimum rectification efficiency rather than rate of switching has been built into these silicon diodes. They feature very high forward conductance and low reverse current. These diodes find their principal use in various instrumentation applications where the accuracy or reproduceability of performance of the circuit requires a diode of negligible reverse current. In this line of general purpose types Clevite has available, in addition to the JAN types listed below, commercial diodes of the 1N482 series.

MILITARY TYPES

JAN

1N457	**MIL-E-1/1026**
1N458	**MIL-E-1/1027**
1N459	**MIL-E-1/1028**

Signal Corps

1N662	**MIL-E-1/1139**
1N663	**MIL-E-1/1140**
1N658	**MIL-E-1/1160**
1N643	**MIL-E-1/1171**

All these diodes are available for immediate delivery. Write now for Bulletins B217A-1, B217A-2 and B217-4.

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Phone-Line Data Transmission Improved with IBM Terminal

Improved equipment for digital communication over regular telephone lines has been announced by IBM's Data Processing Div., White Plains, N.Y.

Transmission of up to 150 characters per sec is reported achieved with the IBM 7701 magnetic-tape transmission terminal. The terminal is compatible with the 200-character-per-in. tapes of the IBM 727 and 729 tape handlers.

Data are transmitted from the 7701 through a modulating sub-set provided by the telephone company, through the communication lines to a demodulating sub-set at the other end, and into a receiving 7701. Tape reading and writing errors, as well as transmission errors, are automatically detected and corrected. In the event of persistent errors, the machine stops and signals the operator.

The equipment is fully transistorized and does not require special air conditioning.

$1 Million Lab Completed in West For Space and Weapons Studies

A $1 million research and development laboratory has been completed by Electro-Optical Systems, Inc., Pasadena, Calif., for space and military weapon projects.

The new facility will house development of an ion-propulsion engine for space vehicles and satellite-control mechanisms. Other technical programs will include molecular electronics, exploding wires, optical homing and guidance systems, high-speed switching techniques, solid-state transducer development, and space defense systems.

Already in operation is a high-temperature (3000 C), high-pressure (5000 psi) furnace for material studies under environmental extremes and an optical laboratory providing an uninterrupted optical path of 250 ft.

2 Minneapolis Concerns Merge Computer and Control Operations

A merger of the Control Data Corp. and the Control Corp. has been approved by stockholders of the two Minneapolis companies.

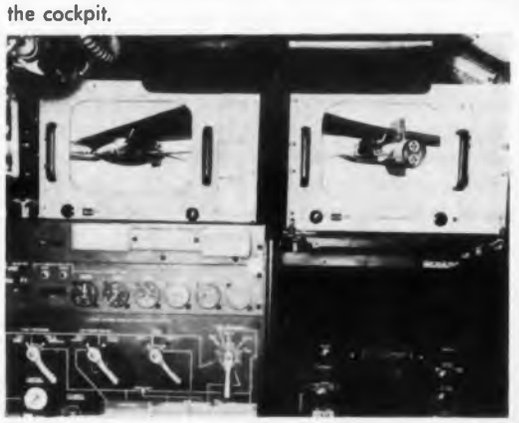
The merged organization plans to combine Control Data's digital computers with the industrial and public-utility control systems manufactured by Control Corp. The two companies have been collaborating on proposals and engineering for over a year.

The merger will cover both commercial and Government markets. Control Corp.'s electronics business has been primarily commercial, while Control Data's has been mostly with the Government.

TV Zeros

Closed-Circuit Systems Keeping Watchful Eyes on Rocket 'Baby' Under Wing of Mother Aircraft And Room Where Tires Tire

North American X-15 rocket plane is carried aloft under the wing of a B-52 mother ship (right) for launching. During the ride up, the rocket craft is kept under constant surveillance by closed-circuit TV, which displays on the pilot's instrument panel (below). The TV system, developed by Kin Tel Div. of Cohu Electronics, San Diego, Calif., uses cameras mounted in aluminum cylinders and attached to the B-52 fuselage near the cockpit.



$1 Million Contract Awarded For Project Mercury Display

Monitor and control display systems for Project Mercury, the man in space program, will be produced by Stromberg-Carlson-San Diego under a subcontract of over $1 million from Bell Telephone Laboratories.

Data inputs from the space capsule, such as heart rate, blood pressure and body temperature of the astronaut; and the capsule's oxygen pressure, acceleration rate, attitude and route determination will be visually displayed at a Cape Canaveral control center.

In On Blind Spots

Using closed-circuit television, technicians of Goodyear Tire and Rubber Co., Akron, Ohio, monitor endurance tests of tires. Auto and aircraft tires are accelerated to as high as 500 mph. Such speeds can be risky for direct observation (see start of blow-out above). Hence, TV, which permits safe viewing in another room (below).

Computers Exchange Data Via Translating System

An electronic system has been developed to permit exchange of data between the IBM 704 and the Remington Rand Univac computers. Called the ZA-100 Computer Language Translator, the system can interchange data between computers or process raw data into either of the computer formats.

Electronic Engineering Co. of California, developer of the system, says it performs 13 electronic data translations. The system is being used by the Navy.

NEWS

Computer Control Planned To Produce 'Best' Product

An electronic computer-control system being designed for factories is calculated to set production controls to turn out the "best" product. Thomas R. Jones, president of Daystrom, Inc., told the Northern New Jersey Chapter of the Society for the Advancement of Management that his company was designing the system.

Outlining the operation of the system, Mr. Jones said: "The computer will start at a certain point, move a valve a little distance, determine what effect that has had in the final product, and, if the result is good, will move the valve, switch or whatever a little farther, until it has passed the optimum point."

After determining the optimum point in the system, the computer will lock itself on positions that produce the best products, he added.

Mr. Jones predicted that electronic computer control of plants would make possible the manufacture of many products that cannot now be produced in man-operated factories.

System Sends TV Data Over Telephone Lines

A newly developed television system transmits maps, charts and pictures over long-distance telephone lines. The International Telephone and Telegraph system, called the AN/FXC (1), uses scan-conversion storage tubes to compress 525-line video from an 8-mc to a 2.5-kc bandwidth before transmission. Narrow-band transmission is restored to wide band at the receiving end for fast video-rate scan.

Equipment at the transmitting end of ITT's television communications system includes a digital rack, industrial video (ITV) cameras and a briefing console.

Before transmission, the slow-scan video is digitalized and mixed with a pointer-position code generated by the transmitter. At the receiver, the pointer appears on the screen as an arrow. Audio transmitted simultaneously over a separate line permits two-way conversations.

The television transmission takes anywhere from 10 to 120 sec a frame, depending on the picture detail required. Bit rates of 1667 per sec and 2500 per sec can be provided. The system, built by ITT of Fort Wayne, Ind., consists of six major units: a transmitter console, digital rack and briefing monitor, and a receiver console, digital rack and audience monitor.

Engineers at the Rome (N.Y.) Air Development Center, where a test demonstration of the equipment was recently conducted, say the system may be used at Air Force bases for the rapid assembly of command-decision data.

The system can use Air Force security equipment to scramble information at the sending station and decode it before it appears on the receiving screens. In this way, it is said, classified military briefings can be conducted from coast-to-coast.

Pocket-Sized TV Receivers Are Forecast by Sarnoff

TV receivers "small enough in size to be carried inside your pocket" are predicted by David Sarnoff, chairman of Radio Corp. of America. He said advances in basic circuitry and miniaturization would make this possible.

Speaking to the Radio and Television Society in New York, Mr. Sarnoff declared that "the promises of TV technology are infinite." He cited three examples of how technology could influence the caliber, range and reception of TV programing in the years ahead:

- "Man-made satellites will soon serve as mirror-in-the-sky relays for global TV."
- "Automatic and instantaneous electronic translation techniques are being devised, which will enable people of all nations to converse across the barriers of language."
- "Improvements in broadcast transmitting techniques and the practical use of extremely high frequencies will enable maximum utilization of the spectrum."

Mr. Sarnoff received the society's first Gold Medal Award for "outstanding achievement in broadcasting."

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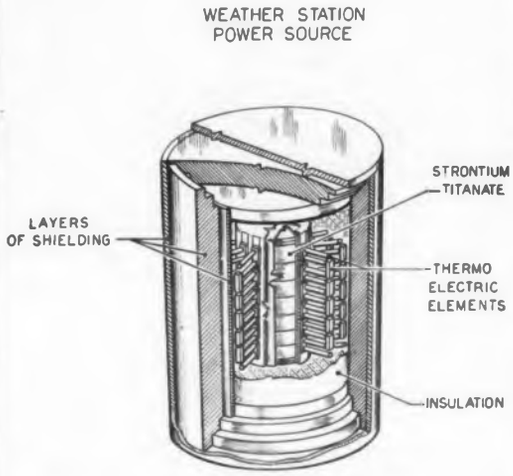
NEWS



5-W Generator Uses Nuclear Energy

Heat from a compound containing strontium 90 is converted into electrical energy by 72 thermocouples in the power source shown above. The unit, which generates 5 w, also is shown, in an artist's conception, as the power source for an automatic weather station. The device, 8 ft. high by 32 in. in diameter, has been designed by the Nuclear Div. of the Martin Co., Baltimore.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

WESCON Chairman Aims For Lively Meeting

Policies intended to provide pace and interest in the next WESCON meeting have been announced by Richard G. Leitner of System Development Corp., chairman of the show's technical program committee. In an attempt to by-pass traditional technical-meeting formats, Mr. Leitner plans to:

- Place the emphasis on the quality of technical contributions when considering papers to be read.
- Inject the element of showmanship into authors. Efforts will be made to set up clinics to help authors prepare their material.
- Encourage oral presentation and arrange for assistance in preparing visual aids that authors may need in giving their talks.
- Include a number of debates on the program.

Space and Re-entry Test Facility Under Construction in Maryland

Plans for a new laboratory to simulate outer space and atmospheric re-entry have been announced by the National Aeronautics and Space Administration. The facility will be part of NASA's new $18-million Goddard Space Flight Center, now under construction at Greenbelt, Md.

Functional and reliability tests are planned of satellites, space probes and vehicles, tracking communications, and data-reduction systems.

The new facility will be "omni-environmental" —capable of simulating extremes of temperature and altitude, acceleration, mechanical vibration and shock. Instrumentation will record the test results.

Design of the laboratory is being handled by MB Electronics of New Haven, Conn.

Miniature Hi-Fi Tape Operates at 1-7/8 IPS

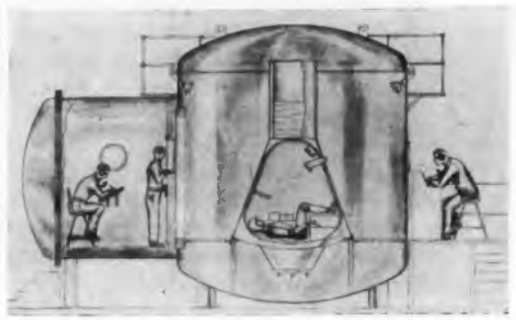
A new tape-cartridge system is said to provide high fidelity at a speed of 1-7/8 in. per sec. Described by Dr. P. C. Goldmark, president of CBS Laboratories, in a paper at the New York IRE meeting, the system includes a one-reel cartridge no larger than a folded handkerchief and an automatic tape-cartridge changer.

The equipment uses 150-mil-wide tape. Despite the slow speed, the frequency response curve is said to be essentially flat, from 50 to 15,000 cycles. A one-micron record-playback head is used to sense the short-wave lengths associated with slow tape speeds.

Developed by CBS for the Minnesota Mining & Mfg. Co., the system is expected to find use in the home recorded-music market. Zenith Radio Corp. plans to develop the first commercial machine for the system.

NEWS

Off into Space—in a Simulator



Astronauts in Project Mercury, the United States' man-in-space program, are scheduled to sample high-altitude conditions first in a tank 15 ft high by 12 ft diam. The tank, drawn above, will simulate altitudes up to 225,000 ft, with dive rates that an astronaut can expect to encounter on returning to earth. The astronaut on his back in the chamber will be linked to the outside by an oxygen and intercom system, port holes for observation, and a myriad of test-control signal conductors. The simulator is being built by Tenney Engineering, Inc., of Union, N.J., for the National Aeronautics and Space Administration.

Laboratory Test for Components Rougher Than a Rocket Blast

Diodes and transistors for the Atlas-Titan missile program are said to be treated rougher in a new reliability laboratory than in a huge rocket.

The components are reportedly subjected to shock, vibration and stresses greater than experienced at rocket blast-off or re-entry. During other tests, components are baked, frozen, soaked and exposed to corrosive chemicals.

Established by Clevite Transistor Products of

Progress of a baking test on 2,500 diodes is checked at the Clevite Reliability Laboratory. The ruggedness of diodes and transistors destined for use in missiles and space vehicles is tested in the laboratory.

Waltham, Mass., the laboratory tests components individually from two weeks to a month and records a complete history for each. Ultimately it is expected that data-processing equipment will analyze the individual histories and predict life potentials under various uses.

James Peterman, Clevite quality control manager, reported the laboratory was screening components to be used in space stations, an Air Force interglobal communications system and various missile programs. He added that test data were being gathered to contribute to the Minute Man missile program.

Extra-Galactic Radio Sources Traced With New Interferometer

A new twin-radio telescope has made outstanding progress in identifying radio sources from outer space, according to a recent Navy announcement. Nine extra-galactic radio sources, ranging to one billion light years from the earth have been identified in the two months that the instrument has been in full operation.

The instrument consists of two 90-ft parabolic antennas mounted on a 1600-ft length of track oriented east-west. Working in tandem as a radio interferometer, the twin dishes are said to have a resolving power greater than any radio telescope in operation. A north-south track will soon be added to increase resolving power further.

The telescopes are a part of the radio astronomy program of the Office of Naval Research and are operated by the California Institute of Technology under the direction of Prof. John G. Bolton.

Professor Bolton hopes to identify more than 100 extra-galactic radio sources. Investigation of other planets for radiation belts is also planned.

Thermoelectric Power Plant Generates 5 w

A thermoelectric power plant that can produce 5 w for a year on $10-worth of propane gas has been placed on the market.

Currently, sample units cost about $5000 each, but production units are expected to cost $500 at most, according to the developer, the General Instrument Corp.

The power plant is 1 ft in diameter by 1 ft high, and weighs 10 lb. Propane gas is burned in the center, and the resultant heat is converted into electrical energy by thermopiles in the walls of the combustion chamber. The thermopiles are of semiconductor material.

The device will operate unattended as long as fuel is available. It consumes about 50 gal of propane a year. The units could be used to power unattended navigational beacons, automatic weather stations or communications equipment in remote areas.

NEWS BRIEFS . . .

. . . **COMPUTERS, CONTROLS, COMMUNICATIONS** and color TV will spur an electronic boom in the Sixties, according to David Sarnoff, chairman of RCA. He predicted a $25-billion electronic market by 1965 (present value is $14 billion). More than $10 billion is expected to come from defense outlays, with 20 cents of every defense dollar going to electronics. "There is simply no ultimate in sight . . . for electronics," Mr. Sarnoff said.

. . . **A RESEARCH PROJECT** to determine whether or not the size of atomic flaws in metals can be measured will be conducted by Dr. C. T. Tomizuka, University of Arizona physicist. A $93,181 grant has been awarded to him by the Air Force for a three-year study of "Imperfections in Metal."

. . . **U.S. ROCKETS** to be used in a meteorological research program will be bought by Sweden. The rockets will be used primarily in a high-altitude research program planned by the International Meteorological Institute in Stockholm. Swedish rocket and electronic experts will study the rockets here. Sweden will be the first country outside the United States to obtain American space rockets and launching devices for scientific research.

. . . **AN AGREEMENT** aimed at increasing the sale of British-designed electronic equipment in the United States is underway. Fairbanks Whitney Corp. of New York will market most of the range of electronic equipment designed and manufactured by EMI Electronics Ltd., London.

. . . **INSTALLATION** of an IBM 650 electronic data processing machine, for civil engineering students at Massachusetts Institute of Technology, will be the first of its type in the nation, according to Institute officials.

. . . **ENGINEERING DEVELOPMENT** and production representing nearly 1/3 of the Airborne Long Range Input defense program has been awarded to Electronic Communications, Inc. of St. Petersburg, Fla., under a $9.5-million contract from the Air Force.

. . . **"PACKAGE WITH A MEMORY,"** an advanced design nose cone recently used aboard a Titan missile, was successfully retrieved from the South Atlantic. Called a "data cassette," the package returned the technical story of what happens to a long-range missile nose cone as it re-enters the earth's atmosphere at 12,000 mi per hr and withstanding heat of 12,000F. The "memory package" was designed by Avco's R&D Div. of Wilmington, Mass.

. . . **MISSILE STORAGE** and maintenance will be a permanent responsibility at Norton Air Force Base, Calif. The first Thor arrived from Douglas Aircraft Co.'s testing facility. Eventually there will be a steady flow of Thors to the base. They will be shipped as replacements as the missiles are fired by training squadrons at Vandenberg Air Force Base and at launching sites in Great Britain. The Thor guidance system will be stored separately in a thermostatically controlled environment.

. . . **HERMES ELECTRONICS CO.** and Marconi's Wireless Telegraph Co., Ltd., of England intend to collaborate in planning and supplying complete systems. Hermes will also become agent and licensee for Marconi point-to-point radio communications equipment in the United States. Under the agreement, it is also intended that the Marconi Co. will become licensee and agent for certain Hermes specialized components and equipment.

. . . **A CONTRACT** for 246 airborne dc amplifiers has been awarded to Southwestern Industrial Electronics Co., Div. of Dresser Industries, Inc., by Grumman Aircraft Corp., Bethpage, N.Y.

. . . **COMPONENTS APPLICATION** to space and air vehicles was the subject of a recent seminar held by the Leach Corp. Attending were 55 sales engineers from various parts of the U.S.

. . . **SPACE VEHICLE** tracking facilities at Cal Tech's Jet Propulsion Lab will be increased with the addition of a second 85-ft-diam tracking antenna, a type I.B azimuth elevation unit.

. . . **THE FCC** has granted RCA authority to operate commercial telegraph channels in the U.S.-Puerto Rico coaxial telephone cable. RCA will use cable and radio facilities to provide telegraph, telex, and leased channel services.

. . . **BENDIX WILL CHANGE** its name in June from Bendix Aviation Corp. to the Bendix Corp.

. . . **A 186-MI** over-the-horizon radio communications link between the U.S. and the Bahamas is now in operation. Three ITT companies carried out the project.

. . . **75 PER CENT MORE ENGINEERS** will be needed during the next 10 years to meet the growing demands of American industry, Harry R. Wege, vice president and general manager of RCA Missile and Surface Radar, told the Engineering Society of Southern New Jersey.

EDITORIAL

Whence Springs A Good Design Idea?

Frequently really creative ideas spring from the subconscious. A designer may be stumped for days over a particular problem. He mulls over the problem time and time again, only to have the solution elude him until—presto!—at a moment when he isn't looking, thinking, pondering, the answer is revealed to him. Somehow his subconscious, through permutations of associations earlier impressed, yields the new concept.

ELECTRONIC DESIGN, we hope, is an instrument to supply fertile sense data to both the conscious and subconscious mind. We hope there are ideas on our pages that you can use now or later.

With this issue, we announce the expansion of our coverage of designs conceived by engineers. When you turn to our Design Decisions department, the name we have picked for this editorial feature—we hope you will see decisions that evoke, "Hey, that's darn clever!"

We hope to show you regularly fresh examples of unusual decisions that have been applied in product development. Design that is out-of-the-ordinary will be the fare. Occasionally we will report on trends in contemporary design.

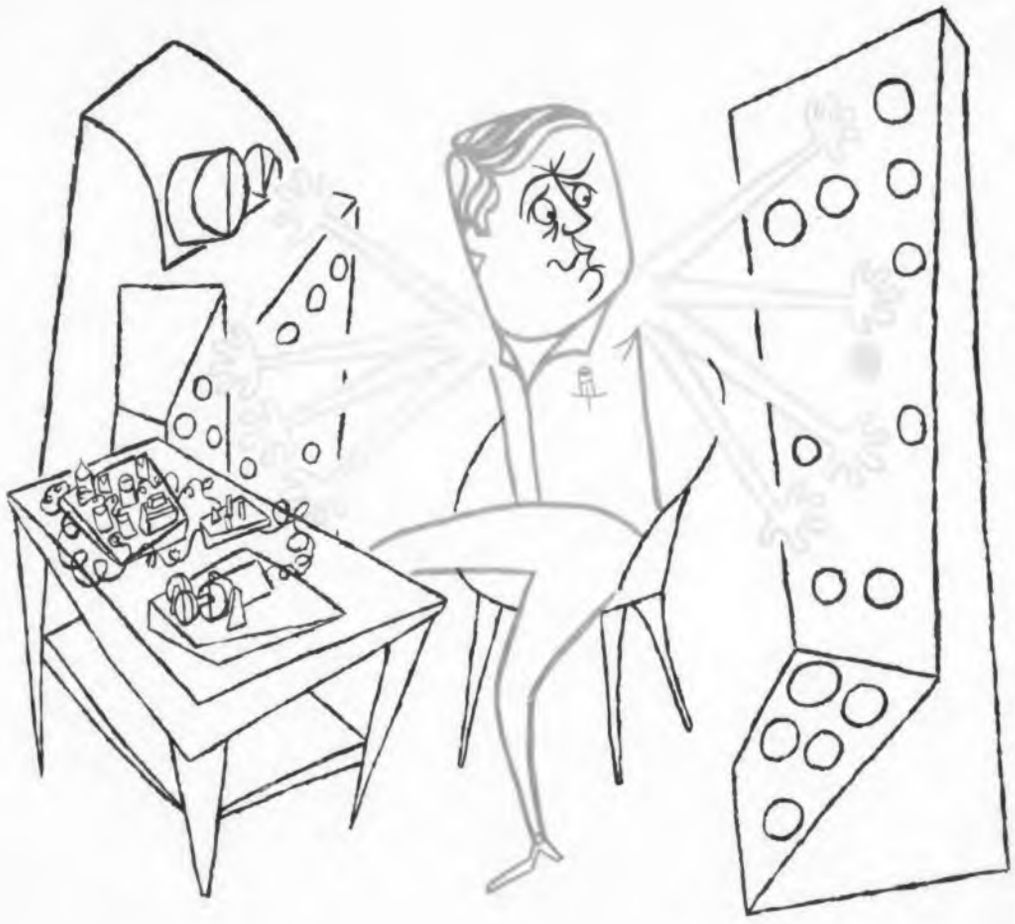
This new department will complement our popular Ideas for Design feature. The chief difference will be that Design Decisions will examine the design philosophy behind a finished product. Ideas for Design will report clever solutions to isolated problems, principally circuit or electromechanical. We encourage our readers to submit both isolated ideas and decisions. As in the past, we will credit innovating designers and send them a small honorarium.

With your help, creative solutions can spring from both ELECTRONIC DESIGN and the subconscious.

Test Dynamic Response of Low-Frequency Servos

Sampling Switch Circuit Breaks the Bottleneck

David J. Salonimer
Missile Electronics Laboratory
Ordnance Missile Labs, ARGMA
Redstone Arsenal, Ala.



Need a fast, fool-proof dynamic test for low-frequency servo components? Missile engineer Dave Salonimer presents a technique for sine-wave testing components at frequencies as low as 1/4 cps. Test-time for one component of the Army's Jupiter missile was cut from one hour to 1-1/4 minutes.

THREE COMMON methods exist for determining the dynamic characteristics of servo components. These are based on response to a step, a ramp and a sine-wave input, respectively. While each has its drawbacks and limitations, the sine-wave method has gained favor over its two competitors. The reason is simple—where it can be used, the sine-wave method possesses advantages that outweigh its drawbacks.

The techniques described here overcome the disadvantages of sine-wave testing that have often prevented its use in testing very low-frequency servo components. Using these techniques, repeatable measurements have been achieved at frequencies as low as 1/4 cps, in the presence of considerable noise.

Dynamic Testing Uses Step, Ramp or Sine-Wave Method; Each Has Drawbacks

The dynamic characteristics of servo components can be determined from their response to a step input. This method requires the measurement of the "settling time" (the time required for the system to reach a prescribed minimum deviation from the steady value), following the sudden application of an error signal or an increase or decrease of load. The results of this measurement are frequently displayed as a strip chart record. The inconvenience of this form is one serious disadvantage of the method.

A second method for measuring dynamic characteristics utilizes the determination of the system response to a "ramp function." When a steadily increasing signal is applied, a system with time lag will follow with an error dependent upon the system gain, time constants, and the slope of the driving signal. With a fixed-slope ramp signal generator driving the system, a measure of the time required for the output to reach a specified level, from the instant of application of the ramp, will be indicative of the system's dynamics.

Tests using a ramp-function input signal generally require only very simple test equipment and are easily automated. This type of testing is most often used on components or subloops which have relatively long time constants, perhaps 1/5 sec or more.

Unfortunately, the technique may prove to be impractical if the component output tends to be

noisy. When the measurement is that of the time from the start of the input ramp until the output reaches a certain value, noise may cause premature termination of the timing interval, and readings become correspondingly unreliable. Moreover, the ramp function tests do not permit discrimination between the influence of the system gain and that of system time constants on the error. Additional tests must be made to determine any necessary adjustments.

The third method considered is the determination of the system response to a sine wave. With sine-wave excitation of a servo system, two measurements may be made:

1. The phase shift between input and output,
2. The ratio of the amplitudes of input and output.

The first measurement reveals effects of time constants, natural frequencies, or damping ratios. The second makes possible calculation of the variation in gain.*

For components of which time constants are less than 0.008 sec (less than 45 deg phase shift at a frequency of 20 cps) and for which the input signals are electrical rather than mechanical, relatively simple test equipment can be employed and automatic testing is possible. At frequencies below 10 cps, the problem becomes more complex, particularly in the presence of component output noise and waveform distortion. Several laboratory-type instruments for making these low-frequency measurements are presently on the market. However, these instruments are complex and are not easily adaptable to automatic testing techniques. Moreover, if the sinusoidal input must be generated mechanically (for example, an accelerometer mounted upon an oscillating table), synchronization of the test equipment to the input may prove to be a difficult problem. Both these problems can be licked by a test set-up of proper design. Consider first the mechanically cycled components.

Sinusoidal Motion Is Applied, Sampling Switch Compares It With Component's Response, Yielding Phase Shift

The design of apparatus for exciting a component mechanically to measure its dynamic characteristics depends upon the mechanical nature of the component itself. An integrating accelerometer might be clamped to an oscillating table; a local angle of attack meter might be mounted with its probe in a wind tunnel and the driving oscillation applied to its body. The basic test method in each case is the same.

*Strictly speaking, where the device under test is not linear, that is, the dynamics cannot be described by a linear differential equation, use of the term phase shift requires qualification. However, the dynamic performance of such a device can often be satisfactorily described by its performance relative to another, selected as a standard.

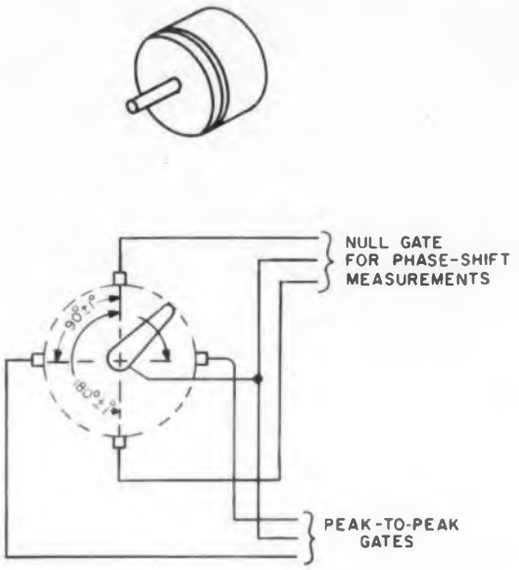


Fig. 1. Rotary sampling switch permits low-frequency phase shift and peak-to-peak measurements.

The input, a sinusoidal motion, is applied to the component mechanically. The response of the component is obtained as an electrical signal from the output terminals of the device. When the input sinusoidal motion is compared simultaneously with the output signal, a phase shift is always evident. The phase shift is, in general, a function of the driven frequency and the dynamics of the component. The measuring technique to be described requires electrical signals for both the input and the output. A potentiometer mounted in the mechanical oscillating apparatus will convert the mechanical driving motion to an electrical signal.

Time Between Null Points On The Input and Output Waveforms Is A Measure In Relation Of Phase Shift

The measuring system proper incorporates a single-pole, four-contact rotary sample switch* depicted in Fig. 1. Contact dwell may be 4 deg to 6 deg of rotation. For direct measurements in mechanical apparatus, the rotor (wiper) is driven by the cycling apparatus. In such a configuration the wiper of the sampling switch must be rotated one revolution for each cycle of the tested device. The potentiometer of the driving apparatus (reference potentiometer) serves to generate an electrical signal representative of the motion of the driving mechanism. The body of the sampling switch (which supports the contacts) is mounted in a way that allows rotation with respect to its mount through an arc of approximately 270 deg.

To establish a reference, the sine wave output from the reference potentiometer is connected to capacitors through the sampling switch as in Fig. 2. The body of the sampling switch is rotated

*A suitable sampling switch may be obtained from Electro Miniatures Corp., 1060 Elm Ave., Ridgefield. N. J. (Their part number 9510-12-147.)

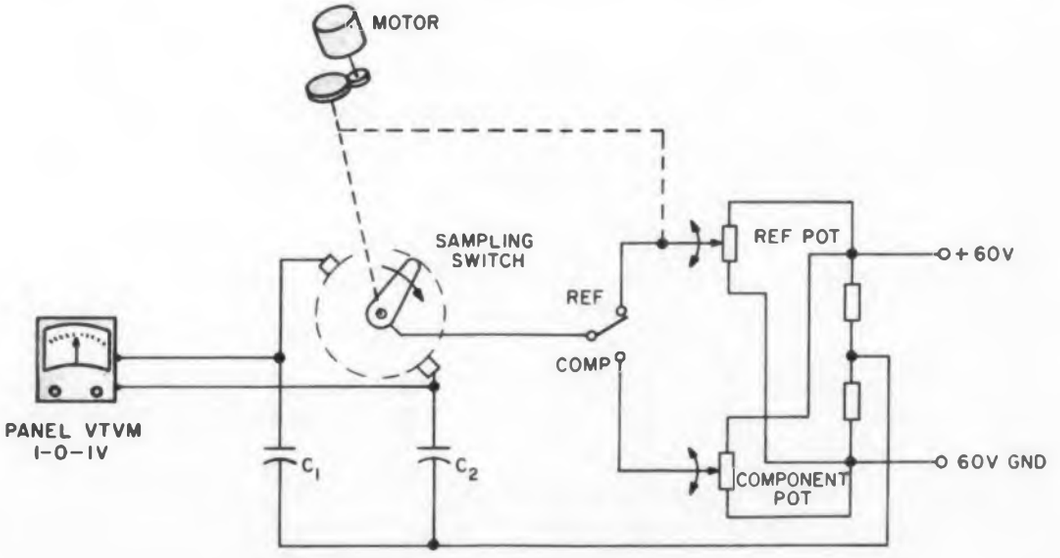


Fig. 2. Low-frequency phase-shift measuring circuit.

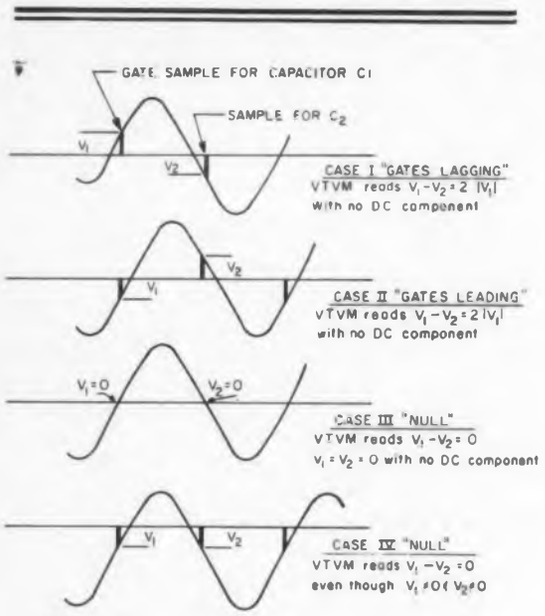


Fig. 3. Sampling input and output waveforms to find "null."

until a null reading of the vacuum tube voltmeter, vtvm, is obtained. This procedure is repeated with the output of the potentiometer of the component. The angular displacement between the two null positions of the sampling switch body is the phase shift.

Fig. 3 illustrates the sampling process for "gates lagging," Case I; "gates leading," Case II; and "null," Case III. If the effective time constant of the potentiometer-capacitor combination is short compared with a gate closure interval, the indications will be obtained quickly. This is because the capacitors will charge to nearly the full sample amplitude for any single gate closure. If the capacitor voltage exceeds that of the sample when the corresponding gate closes, it will be discharged to the potentiometer until the proper value is reached. Fig. 3, Case IV, illustrates the fact that dc in the output does not affect the location of "null." Since the vtvm reads difference voltage, any "offset" which charges both capacitors equally is not indicated.

Six Advantages Gained By Switch Method Of Phase Measurement

A number of unique features of this method of measuring phase shift are evident:

1. Only wave "zeros" are used in determining phase shift, and hence the shape of the remainder of the wave has no influence.

2. The "reference" switch body position, once found, does not have to be re-established for each reading.

3. The polarity of the vtvm deflection indicates the direction in which the switch body should be turned to "null."

4. The effect of potentiometer noise is minimized since the voltage measured will represent an average over the period of gate closure. Readings repeatable within ±1/2 deg have been obtained with the device for cases in which so small a portion of the component potentiometer was in use that each potentiometer wire represented more than one electrical degree. With severe noise, wider gates and larger capacitors are suggested.

5. If the test specification is written so that a high boundary of phase shift is the only restriction, the sample switch may be clamped at this value, and "go" or "no-go" readings are available. The polarity of the vtvm reading is the determining factor.

6. A possible modification of the device incorporates a differential gear assembly interposed in the mechanical connection to the sampling switch rotor and thus permits the introduction of a relative angular displacement without motion of the sampling switch body.

Dynamic Gain Measured By A Second Peak-Reading Voltmeter Displaced 90 Deg On Switch

The peaks of a pure sinusoidal wave are displaced by 90 deg from the null points. A second vtvm, Fig. 4, a second set of capacitors, and the second set of gates provide for a peak-to-peak reading. A zero-left vtvm is employed for this measurement. If the wave to be measured is badly distorted so that its maximums are flattened or peaked, a peak-to-peak measurement may not provide significant dynamic data. However, if the distortion is characteristic of the equipment under test, the measured peak-to-peak voltage may be useful where two similar devices are being compared.

If a component under test does not respond symmetrically (that is, if it deflects more in one direction than the other,) the wave form seen by the sampling switch will contain a dc component. Although, as shown by Case IV in Fig. 3, this component will not affect either the phase shift or the peak-to-peak measurement, the "null" capacitors will each be charged to the dc potential. Switching the vtvm across one of the capacitors to read this voltage gives a measure of this dynamic unbalance.

Choice of capacitors is governed by the duration of the gate closure, the nose content of the wave to be sampled and the resistance values of the potentiometers. For measurements at 1/2 cps, with 6-deg contact dwell and 5 K-10 K potentiometers, 3-μf (nonpolarized) capacitors have been found satisfactory. Very small capacitors do not smooth the noise content of the signal satisfactorily, and

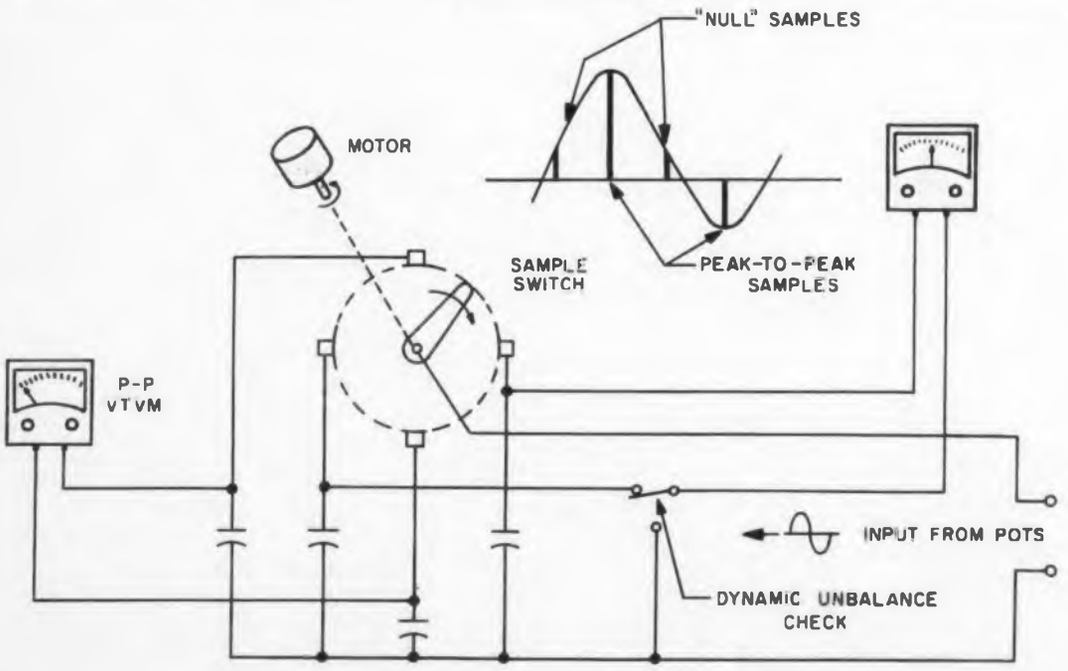


Fig. 4. Simultaneous peak-to-peak and phase-shift measurements.

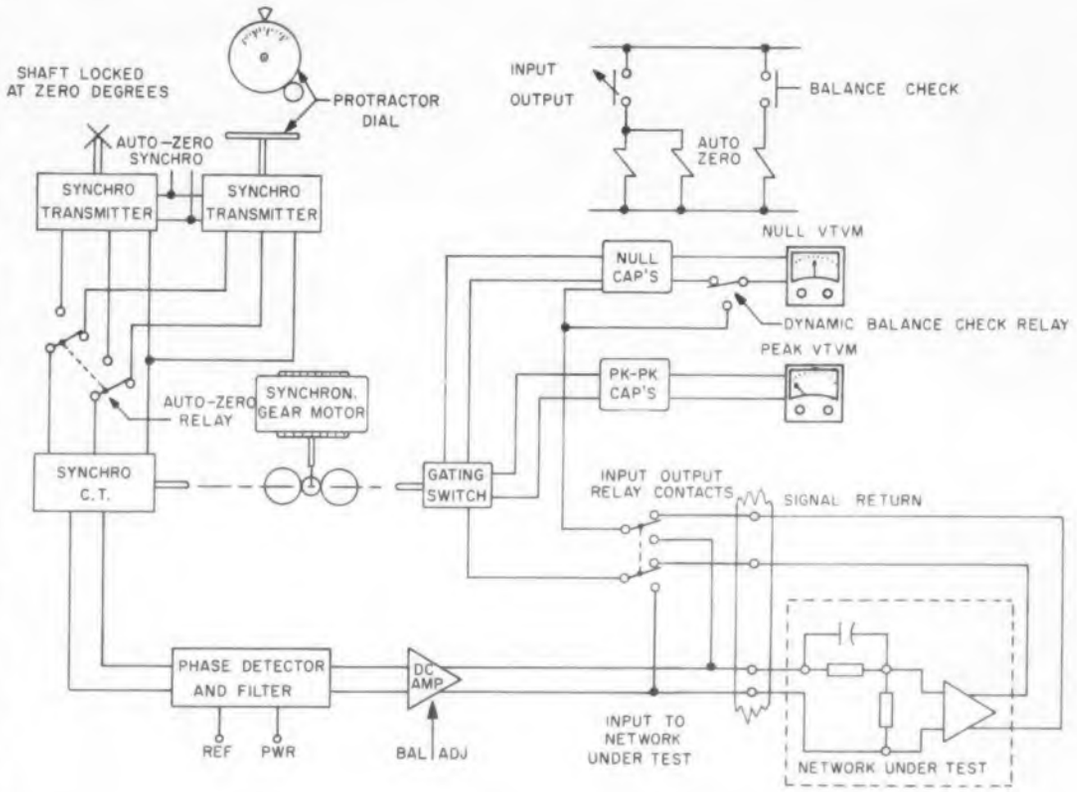


Fig. 5. Low-frequency phase-shift and amplitude-measuring circuit.

the vtvm will not settle. On the other hand, large capacitance requires many cycles to reach equilibrium and makes the search for the "null" tedious and unnecessarily time-consuming. Both potentiometers should present the same resistance to the capacitors.

Sampling Switch Technique Can Also Test Low-Frequency Electrical Components

For large guided missiles of which control systems are characterized by low natural frequencies, perhaps under 2 cps, stabilization of "lead networks" or even whole control loops must often be tested at very low frequencies. Simple checkout equipment, easily operated and requiring little maintenance, is essential. Automatic checkout with "go, no-go" dynamic tests may be desirable. The gating-switch phase-shift and peak-to-peak measuring techniques are readily adaptable to this somewhat specialized task.

The instrument, Fig. 5, for measuring both phase shift and dynamic gain generates the test signal. This signal is compared with the return from the network under test by means of the sampling switch. In this application, however, the sampling switch is not manipulated as in testing mechanically driven components. Instead, it serves to indicate the relative phase shift by comparison of the positions of the null points of the gated capacitor circuit.

The synchronous gear motor drives the sampling switch and a synchro transmitter. The two synchros with the demodulator and filter constitute a sine-wave generator. This generator's frequency in cps is equal to the speed of the driven synchro in rps. Turning the rotor of the dial synchro phase-shifts the output wave relative to the motor shaft and, consequently, relative to the sampling switch orientation. This output wave is fed through an impedance transforming amplifier (100 K input, 20-ohm output) with a voltage gain variable from 0 to 0.9.

To reference the dial to 0 deg, a portion of this output is fed to the gating circuitry. The dial is turned to obtain a zero reading of the null vtvm. The dial is then positioned on the synchro shaft so that it reads 0 deg. To read phase shift, the signal out of the test network is now fed to the sampling circuits and the dial turned to obtain a zero reading of the null vtvm. The dial indicates the phase shift, directly, while the peak-reading vtvm indicates the peak-to-peak amplitude.

Low-Frequency Dynamic Gain and Unbalance Testing Incorporate Automatic Zero and Go, No-Go Testing

A dynamic gain measurement can be easily made if the instrument output and test network output are measured sequentially. An automatic zero feature can be built in if a third synchro, the same type as the dial synchro, with rotor locked at 0 deg, is switched into substitution for the dial synchro by a relay. By incorporating this relay with the "input-output" selector switch, the operator is spared the effort of zeroing the protractor dial any time he wishes to measure the amplitude of the instrument output.

Dynamic unbalance can be measured by reading the voltage on either of the gate condensers after adjusting to the phase-shift "null." This voltage will be the dc "offset." The same type of indication can be obtained for the instrument output alone, to indicate amplifier unbalance. Inclusion of the "automatic zero" feature here, also, is another possible simplification. "Go, no-go" automatic dynamic testing can be achieved in a manner similar to the technique for automatic zero. The ampl :de and phase-shift of the instrument output be preset to match the networks or apparatus to be tested. Separate synchros and gain potentiometers can be sequenced with relays along with the test program selectors so that all amplitude readings from the test circuits would be the same, when correct, and the null meter would read close around zero. Vacuum tube voltmeter relays with two sets of contacts will serve to indicate the performance limits.

The importance of an undistorted instrument output wave from a very low impedance final stage cannot be overemphasized. While not difficult to obtain with transistor emitter-follower amplifiers, this condition is essential. Distortion originating at the instrument, phase-shifted through the test network may produce a wave distorted in such a way that its zeros are shifted leading or lagging by several degrees, and readings would become meaningless. If the apparatus under test exhibits nonlinear characteristics, they must be taken into account when the test specification is established.

Broad Improvements In Low-Frequency Testing Can Result

- The extension of frequency response testing into the very low frequency range simplifies testing techniques on systems with very low natural frequencies or long time constants.
- Performance specifications are easily prepared and readily understood.
- Variations in dynamic response from assembly to assembly are revealed and sources of trouble isolated.
- Changes in performance due to changes in internal dynamic parameters are readily predicted.
- Added to these advantages, which are characteristic of frequency-response testing, the possibility of automated readings makes the sampling switch technique an effective method for production testing of low-frequency servo systems and components. ■ ■

Typical high-pass filter, showing internal construction.

Design Procedure for Coaxial, High-Pass Filters

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Microwave Components: Coaxial vs Waveguide

Blinded by some obvious advantages of rectangular waveguides, many engineers have been overlooking the benefits offered by coaxial lines. Certainly, waveguides have lower attenuation, higher power-handling capacity, and simpler construction. But many coaxial components—terminations, filters, wavemeters, directional couplers—are more convenient to use.

In many laboratory applications, the higher power capability and lower attenuation of the waveguide are seldom used. In these cases, the simpler construction is offset by the larger size and weight. A 3-kmc, 10-db waveguide attenuator, for example, would weigh about 4 lb; it would be about 8 in. long by 3 in. by 1½ in. A comparable coaxial attenuator would weigh only about 6 oz, and would be about 3 in. long and ¾ in. in diameter.

Glyn Bostick, chief engineer of Radar Design Corp., prepared this design procedure to solve a problem. He often needs a high-pass filter in a hurry. Conventional design methods are formidable analytically; they require cut-and-try refinement after initial construction, and they often call for a variety of machining skills in their construction.

The design procedure shown here is simple. Construction requires only lathe work with readily available materials.

WITH A FEW simple equations, an engineer can design high-pass, coaxial filters rapidly and reliably. These filters, suitable for cut-off frequencies between approximately 1000 mc and 6000 mc, yield several benefits.

- Their design is rapid and reliable.
- They are rugged and have long life expectancy.
- Their construction requires only lathe work with readily available materials.
- The center conductor is self-supporting.
- The pass band is clean with less than 1-db attenuation.
- Attenuation per section at a given frequency below the cut-off frequency is predictable within about 5 per cent in db. This permits accurate choice of number of required sections.
- All sections are identical except for a slight variation in one dimension for two end sections.

Design Procedure and Equations

In designing a coaxial, high-pass, microwave filter, it is merely necessary to determine the diameter and length dimensions shown in Figs. 1 and 2, and to determine the required number of sections.

The characteristic impedance, Z_o, is normally chosen equal to the terminating resistance. The type of connector to be used is also normally known. The connector determines the outer diameter of the tubing to be used, and with standard tubing, this sets the inner diameter, b.

The outer diameter, a, of the brass which houses a filter section is easily obtained from

$$Z_o = 60 \ln \frac{b}{a}$$

The outer diameter of the filter dielectric, b' for the end capacitors and b'' for the middle capacitors, is determined by subtracting twice the wall thickness of the brass cylinder from its outer diameter, a.

The inner diameters of the dielectric, a' and a'' are obtained from

$$Z_o' = 0.173\ Z_o = \frac{60}{\sqrt{e}} \ln \frac{b'}{a'}$$

for the end capacitors, and

$$Z_o'' = 0.346\ Z_o = \frac{60}{\sqrt{e}} \ln \frac{b''}{a''}$$

for the middle capacitors, and e is the dielectric constant.

The free-space wavelength, λ_{oc}, at the cut-off frequency f_c is

$$\lambda_{oc} = \frac{11.8}{f_c}$$

where the wavelength is in inches and the cut-off frequency is in kilomegacycles.

The distance, L_1, between the sections, and the length, L_2, of each section are given by

$$L_1 = \frac{\lambda_{oc}}{16}$$

$$L_2 = \frac{L_1}{\sqrt{e}}$$

Finally, the number of sections required is

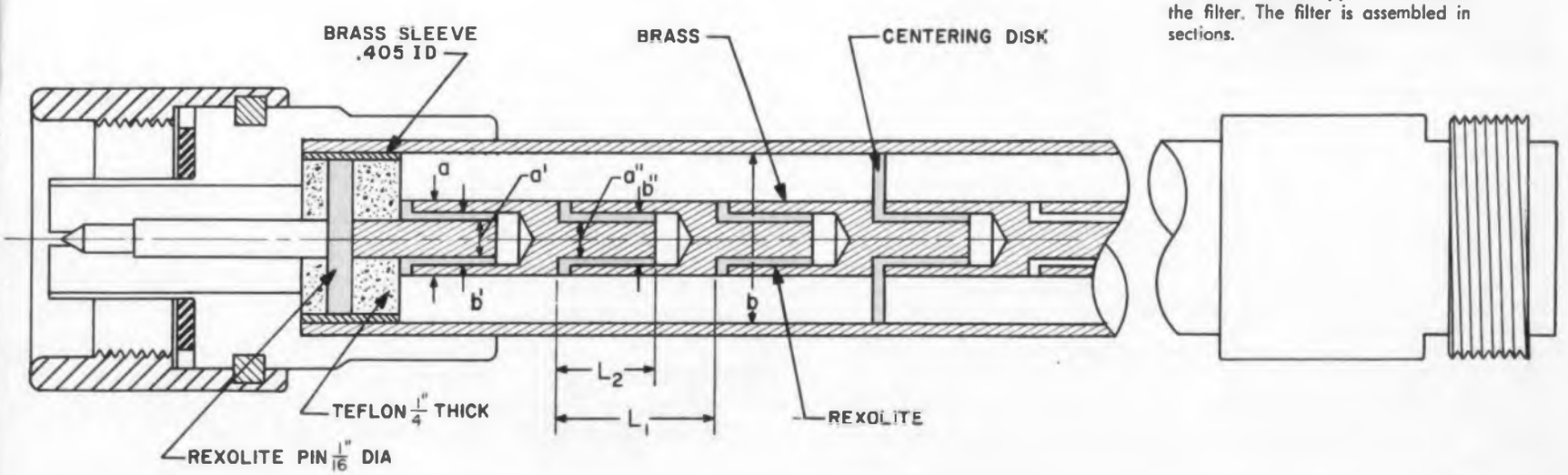

Fig. 1. Construction of coaxial, high-pass filter, for use with an *N* connector. The Rexolite pin prevents the center pin of the connector from floating. The Teflon bead supports the end of the filter. The filter is assembled in sections.

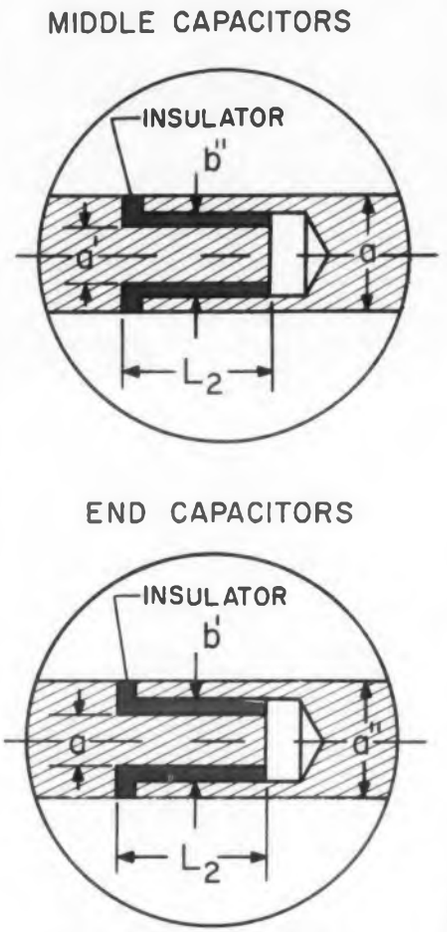

Fig. 2. Details of filter construction.

taken from the expression for the attenuation in the stop band, α.

$$\alpha = \frac{144\,NL_1}{\lambda_{oc}}\left(1 - \frac{f}{f_c}\right)$$

where f is the frequency of maximum attenuation, f_c is the cut-off frequency, and $f < f_c$.

Sample Design

Design a high pass filter using type N connectors with:

$f_c = 2575$ mc
$\alpha \geq 45$ db at 2000 mc
$\alpha < 1.5$ db from 2600 to 10,000 mc
$Z_o = 50$ ohms.

Choose $b = 0.430$ in. (ID of standard tubing convenient for use with N connectors). Then

$$Z_o = 60\,ln\,\frac{b}{a}$$

$$50 = 60\,ln\left(\frac{0.430}{a}\right)$$

$$a = 0.187 \text{ in.}$$

Allow 0.020 metal-wall thickness. Then $b' = b'' = 0.187 - 0.040 = 0.147$ in.

Determine the dielectric to be used as insulator. Rexolite 1422 is a good choice as it has good mechanical characteristics and it is easy to machine. Rexolite 1422 has a dielectric constant of 2.54. Then

$$Z_o' = 0.173\, Z_o = \frac{60}{\sqrt{e}}\, ln\, \frac{b'}{a'}$$

$$= 0.173 \times 50 = \frac{60}{\sqrt{2.54}}\, ln\, \frac{0.147}{a'}$$

$$a' = 0.117 \text{ in.}$$

$$Z_o'' = 0.346\, Z_o = \frac{60}{\sqrt{e}}\, ln\, \frac{b''}{a''}$$

$$a'' = 0.093 \text{ in.}$$

Solve for L_1 and L_2

$$\lambda_{oc} = \frac{11.8}{f_c} = \frac{11.8}{2.575} = 4.6 \text{ in.}$$

$$L_1 = \frac{\lambda_{oc}}{16} = \frac{4.6}{16} = 0.287 \text{ in.}$$

$$L_2 = \frac{L_1}{\sqrt{e}} = \frac{0.287}{\sqrt{2.54}} = 0.180 \text{ in.}$$

Finally, solve for the number of sections

$$\alpha = \frac{144\, NL_1}{\lambda_{oc}} \left(1 - \frac{f}{f_c}\right)$$

$$45 = \frac{144 \times N \times 0.287}{4.6} \left(1 - \frac{2000}{2575}\right)$$

$N = 22.5$ or 23 sections

Add one section, making 24 sections. The attenuation can be predicted to within 5 per cent.

Notes On Fabrication

- Since there will be some fringing capacitance associated with the internal lines (Z_o' and Z_o''), cut-off will be slightly lower than predicted. This is generally desirable. If not, L_2 can be trimmed until desired cut-off is obtained.
- Centering disks should be used to provide mechanical rigidity. A very small number may be used and they may be made very thin, provided that their number and thickness yield adequate strength.
- Extra sections should be fabricated so an inspection-selection process can yield a set of highly uniform sections.
- All concentric fits must be snug to exclude "air film." ■ ■

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Measuring Power Supply Impedance

Author Jim DelGuercio discovered that few engineers are familiar with power supply measurements. Therefore, he wrote this article describing two methods of determining power supply impedances. One method is primarily for checking tube supplies; an alternate method is especially applicable to transistor supplies. A quick check to determine stability and recovery is also given.

PRESENT-day electronic equipment design dictates rather stringent demands on the power supply. Where 1-per-cent regulated supplies were more than adequate years ago, 0.1 per cent is common today in military and commercial equipment with the trend that better regulation will be needed in the future. One aspect of power supply design that has not been stressed in the past is the dynamic impedance of the unit. All too often the testing of the power supply stops with the checks of changes in line voltage and load variations along with the environmental conditions. In actual use the system will sometimes yield less than expected results or perhaps even malfunctions because not enough thought has gone into the power supply design and testing. One may believe that the supply impedance may be in the order of 1 to 2 ohms and in actual use may appear considerably larger, thereby harming the performance of the equipment. It is that impedance the power supply presents to the alternating load conditions that we also need to know if we are to be honest to the equipment.

Because the power supply is the common element to the electronic circuit its impedance can be the element coupling one circuit to another. Clearly, if this impedance is made zero, interference between circuits could be eliminated. Of course, the design should employ adequate decoupling circuits to ease the power supply requirements. Occasions do arise which prevent this attainment. When such a condition occurs, it is essential that this power supply impedance be obtained for the spectrum needed. The procedure is simple and the equipment needed can be easily built. Two common methods of testing will be shown.

Impedance Test Set-Up

Power supply impedance measurements can be made by a simple use of Ohms' Law. In Fig. 1, the supply is represented by a battery *Ebb* which has zero ohms and a series impedance *Rps*. A load, R_L, is applied to the supply, and the load current frequency is varied with a signal generator. The power supply impedance can be obtained at the frequency desired by measuring the ac voltage v across the supply and dividing this by the load ac current I.

The impedance measurement should reflect that impedance which is obtained in normal operation. This condition requires that R_L load be adjusted so that the normal current flows. The changing or dynamic load currents which flow due to a varying load is also required. This range in currents may be obtained by analyzing the load circuitry to determine current extreme and rate of change of load.

For example, an oscillator operating at 20 kc may be turned on for a brief time. The impedance of the supply should remain small when this load is applied. A convenient dynamic load will be described. The design procedure can be extended to other load ranges.

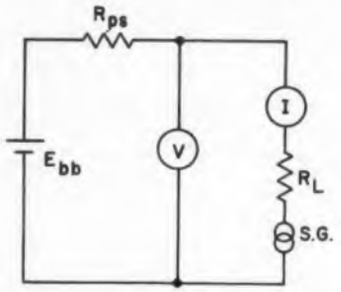

Fig. 1. Impedance measurement set-up.

Dynamic Load Consideration

The dynamic load must be capable of dissipating the power developed across it and must be able to supply a reasonably undistorted sine wave. Fig. 2 shows a typical dynamic load. The ac current through the supply will be essentially the current flowing through this dynamic load and can be measured by noting voltage drop across a small-value calibrated non-inductive resistor in the cathode circuit. (The load current will be the same in the dynamic load and supply if no shunting load resistors are used.) The volt meter can be a Ballantine or equivalent and can be switched from point (*1*) to point (*2*).

Assume that we have a power supply rated at 300 v, 600 ma and the dynamic load varies ±50 ma peak-to-peak. The 6L6 (triode connected) has the following ratings: 19-w plate dissipation; plate voltage is +360 maximum; and plate current at bias of −22.5 v is 62 ma. A signal of 15 v peak-to-peak will vary current ±50 ma. As a safety factor the load current can be varied ±100 ma. Therefore, two 6L6 tubes are needed. At no signal input conditions, the tubes draw 124 ma leaving 476 ma to be by-passed through load resistors. A precision 10-ohm resistor is placed in the cathode for current measurement.

The input signal may be obtained directly from a signal generator or a simple amplifier added to increase the signal generator level. Of

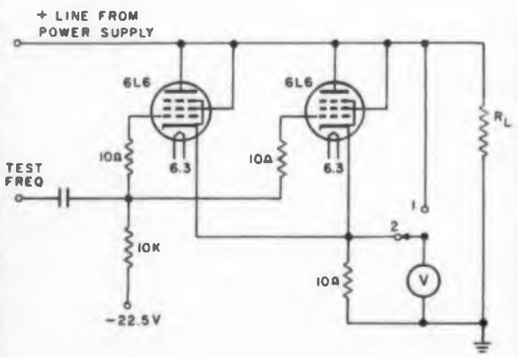

Fig. 2. A dynamic load.

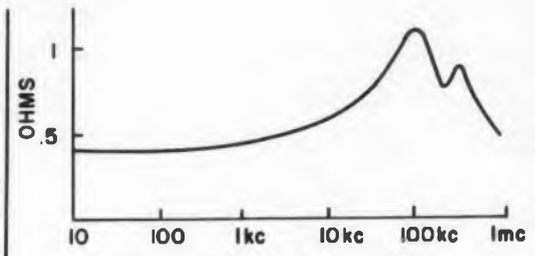

Fig. 3. Typical impedance curve.

course the added amplifier should have a flat response to the high frequency limit desired.

Impedance Curve vs. Frequency

To obtain the impedance vs. frequency curve, start with perhaps 20 cps and adjust the signal input to vary load current by 35 ma rms. Divide the voltage measured across the power supply by the current through the cathode resistor to obtain the impedance of the supply at that frequency. This procedure is continued in steps to 200 kc or to the frequency required. The resultant curve will appear similar to Fig. 3.

Two peaks in the curve will be obtained as a rule. The first peak of the curve is the result of two conditions: (1) the gain of the regulator decreasing at the higher frequencies which accounts for the increasing impedance and (2) if an output filter capacitor is used, its impedance at the higher frequency will become smaller to reduce the output impedance to a lower value. The second peak is the result of resonance of the output capacitor. A small capacitor is usually placed in parallel with the filter capacitor to eliminate this effect.

Alternate

A second method which may be used is shown in Fig. 4. The coupling capacitor has a reactance at the low-frequency end which is negligible compared to the load. The load, R_1, draws nominally current from the supply. The signal generator can supply sufficient power to vary the load current to the desired value. The resistor, R, is calibrated non-inductive and is in the 100- to 200-ohm value

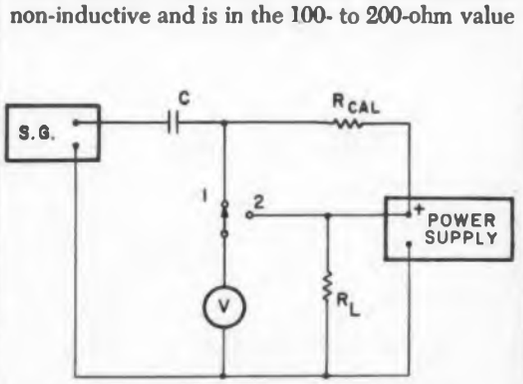

Fig. 4. Alternate method for checking impedance.

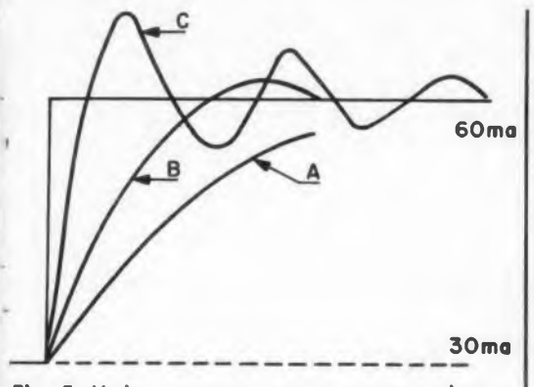

Fig. 5. Various responses to a step current change.

for convenience. The volt meter is used to measure the ac voltage at points *1* and *2*.

Since $$V_2 = V_1 \frac{Rps}{R \,\&\, Rps}$$

Then $$Rps = \frac{V_2 R}{V_1 - V_2}$$

Again this can be plotted as in Fig. 3.

One excellent feature of this method is that it is very adaptable to production needs. If V_1 is constant, V_2 can be calibrated for impedance. If any unit under production test exceeds this voltage level it can be noted easily by non-technical personnel and be rejected. This method is ideal for checking transistorized regulators. The disadvantage is the large capacitor required and the signal generator power requirements. However, these conditions are not serious ones.

Where one transformer is used to provide power for several supplies, further checks should be made. The impedance of one regulated supply should be measured when the other regulators are also functioning in the normal capacities. This check is useful to indicate the degree of isolation between supplies. Any coupling between supplies will tend to increase the effective power supply impedance. Of course, curves should be taken at minimum line and load conditions.

Finally, a check on the recovery of the power supply of pulsed loads should be made. Again using the dynamic load, but this time using square-wave input signals instead of sine-wave signals, the power supply output voltage should be observed with the aid of a scope. The pulse rate should be adjusted to allow the transient time to settle down. The curve observed will be similar to one curve of Fig. 5. This test is very useful in determining the recovery time of the power supply and also gives an indication of the system stability. Curve *A* indicates a sluggish response whereas Curve *C* is approaching instability. Very little overshoot is the desired response with the Curve *B* usually being the optimum result desired. ■ ■

In this second and last part, the author covers performance characteristics, mounting systems, shaft and housing fits. The first part of this article appeared in March 30 ELECTRONIC DESIGN.

Instrument Precision Ball Bearings: How to Select and Apply Them

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TORQUE of instrument precision ball bearings has interested designers more as component performance requirements rise. Torque, as used here, refers to restraining torque or resistance to rotation. It consists of three ingredients: rolling friction, which varies directly with applied loads but is notably reduced by a high degree of geometrical accuracy and surface finish of the balls and raceways; retainer drag, which is dependent on retainer design, accuracy, and size; and viscous friction, a factor of lubricant viscosity, quantity.

In the lightly loaded region of 0.5 to 3 lb, and at speeds below 100 rpm, slight imperfections in geometry and surface finish affect torque adversely. As speeds and loads increase, these effects tend to smooth-out and become less apparent. At high speeds, viscous friction becomes the major factor; at a few thousand rpm, it may amount to several times the basic torque value at low speeds. Grease generally exerts a greater drag than oil; too under starting conditions it may cause very high torque peaks compared to oil.

Torque Testers. Two basic types are used today: the starting type and the running type. With the former, a specified weight is applied to exert a thrust load on a bearing with its inner ring held stationary on a vertical test spindle. Air jet pressure or an electric drive rotates the outer ring of the bearing. From measurement of the force required to start the outer ring rotating, a value for starting torque is established. The main advantages of the starting type tester are simplicity and lowest cost; its disadvantages include the need to take a large number of readings to find maximum peak-torque values, particularly on bearings of lesser quality, and a tendency to "ride over" high torque areas.

The running torque tester, as most recently evolved in the MIL-STD-206A "referee" instrument, is more costly, but it has advantages of low inertia, good dynamic-response and a continuous printed-record of torque variations through several revolutions of the bearing, if desired. While some earlier versions functioned principally as Go/No-Go devices, more recent designs equipped with recorders allow more exacting laboratory study of torque variations and constitute excellent tools for assessing the most meaningful torque measurements. A tester of this type is shown in Fig. 6.

Intensive study of torque by bearing manufacturers has resulted in considerable improvement of the basic torque quality of instrument bearings. This, in turn, has simplified the torque measurement and quality control problem. Also, there is much data on levels of torque that can be expected under various load and speed conditions, and the effects of grease and oil over a wide range of operating temperatures. As a result, designers who meet situations where torque is critical, can get reliable guidance from bearing producers on bearing selection and lubricant, and on mounting design and installation techniques.

Load Capacity. The load capacity of precision ball bearings for instrument use is more realistic when based on static (rather than dynamic) load ratings. Static load ratings involve hardness of the

Table 1. Guide To Selection Of Lubricants

Typical applications	Recommended temperature range	Type	Basic specifications	Limitations and precautions
Gyro gimbals, synchro repeaters and sensitive very low speed, low torque applications	—67° to 250° F.	Oil	Synthetic (MIL-L-6085)	For low speed only
Gyro rotors, small motors, generators, synchro transmitters, etc.	—67° to 250° F.	Grease	Synthetic oil base (MIL-G-3278)	400,000 DN* maximum
Small motors, generators and other devices at moderate speeds and low temperatures	—100° to 350° F.	Grease	Silicone oil base (DC 33 light type)	200,000 DN* maximum
Motors, generators and other moderate speed applications at higher temperatures	—40° to 450° F.	Grease	Silicone oil base (Shell ETR-B type)	Applied load should not exceed 1/3 of bearing load rating at operating speed

* Product of bore of bearing in millimeters and speed in RPM

bearing ball and race material, the number and size of balls, and race curvatures—all affecting the ability of the bearing to stand permanent deformations at the ball-to-raceway contacts. Since some permanent deformation can occur even under very light loadings, and since heavy "g" loadings are often encountered in airborne devices, the usual static load-capacities required for bearings used in heavily-loaded aircraft control uses are excessive for sensitive instrument devices.

To supply reliable load ratings, this company defines static load capacity as the maximum that can be withstood by bearings without an appreciable increase in torque, as measured on a sensitive, continuous-rotation torque tester.

The designer determining the static rating required for an instrument where there is light, normal loading should carefully review in terms of "g" load, the shock and vibration conditions to be met in his use. This figure, multiplied by the dead weight of parts supported by the bearings, gives an estimate of peak static-loads to be accommodated.

Dynamic Load Ratings. The dynamic load ratings of instrument bearings, when required, are determined on a completely different basis: that of the estimated number-of-revolutions or length-of-time at a specific speed at which the first evidence of fatigue spalling or flaking takes places on raceway or balls. Because of the light and transient nature of loads applied, this condition rarely develops in electronic instrumentation work.

Speed Capability. The speed capability of ball bearings has always been difficult to define because of the large number of factors involved, including: load, speed, type of lubricant, and operating temperature. The size of the bearing plays a prominent part also, with the smallest bearings having the highest speed possibilities. Another important factor (one under the designer's control) is choice of the correct ball retainer.

Spring separators should be considered only for speeds below a few hundred rpm. Bearings with these retainers are intended only for negligible speed and should be lubricated only with oil.

Pressed steel retainers are capable of speeds well above the average electronic application requirements under conditions of light loading and with grease lubrication. Conservative limits for the smallest bearing are speeds up to 50,000 rpm; for the largest, at least 25,000 rpm. Life of the lubricant is usually the limiting factor when temperatures exceed 250 F.

Phenolic retainers will run at even higher speeds since the material has the advantage of absorbing oil or some of the oil content of grease if used. Where reliable and continuous operation is involved (gyro rotors and other high speed devices), this retainer is almost universally used because it definitely simplifies the lubrication problem.

Lubricant. Lubricant effect on performance in electronic instrumentation can be stated in these general terms: for lowest torque at low speed, use oil; for longest life at high speed, use grease.

Since air-oil mist or jet-spray systems usually cannot be tolerated in instrument applications because of space, weight, and other complications, the designer's choice is limited largely to prelubricated bearings. Thus, oils are used on gyro gimbals, synchros, computer gear trains, and other mechanisms where rotational speeds are low or of short duration and slight seepage or dissipation is no problem, yet the extra drag of grease would be objectionable. Grease is the best choice for continuously-rotating, high-speed applications (motors, generators and most gyros).

Temperature is a serious limitation for both oils and grease; generally, better resistance to oxidation at high temperatures is offered by the silicones. Although silicone fluids have superior viscosity-change characteristics over wide temperature ranges, they are generally poor lubricants under high-speed and heavy-load conditions. Table 1, a general guide, shows characteristics and selection criteria for several commonly used oils and greases.

Mounting Systems: Good Alignment And Relief of Thermal Restraint Important.

To get full advantage of the operating characteristics of instrument precision ball bearings, use good mounting design practices. Two factors often overlooked are the need for good alignment and provision for relief of thermal constraint.

Misalignment results in high torque peaks at low speeds; it also can cause ball retainer wear and breakage at moderate and high speeds. A good, general rule on alignment is: hold total accumulated errors below 0.001 in. per in. When bearings are closely restrained or axially preloaded, it is advisable to reduce the total accumulated errors to 0.0005 in. per in. or lower.

Thermal constraint of ball bearings falls into two general types: radial and axial. Either or both may develop when chrome or stainless-steel bearings are mounted in housings of aluminum or magnesium. Unless bearing seats are steel-bushed to resist the contraction of the higher expansion coefficient housings material, constraints may occur at low temperatures.

Two simple mountings which avoid end thrust constraint are shown in Figs. 1 and 2. These "fixed and floating" mountings are achieved by locking both inner and outer ring on one bearing and the inner ring only on the other. Fig. 1 shows the use of two conventional unflanged bearings. Fig. 2 shows a flanged bearing used at the fixed end to avoid machining a shoulder in the housing. Both designs provide accurate running-alignment of inner rings, provided, of course, that the shaft shoulder is machined or ground square with the shaft seat. In Fig. 2, best co-axial alignment of the outer rings is provided by the simply machined through-bored housing.

Two simple low-cost mountings are shown in the opposed bearing arrangements of Figs. 3

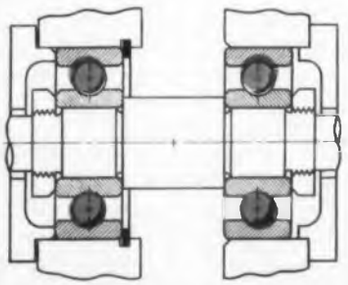


Fig. 1. "Fixed and floating" mounting uses unflanged bearings, one with both inner and outer rings locked, the other with inner ring only locked. Use of snap wire in housing at left allows through bore for good alignment.

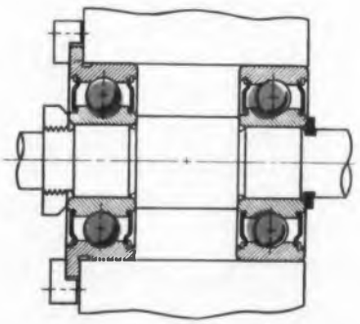


Fig. 2. "Fixed and floating" mounting uses flanged bearing at one end, unflanged at other, permitting through-bored housing and avoiding machining of shoulder in housing.

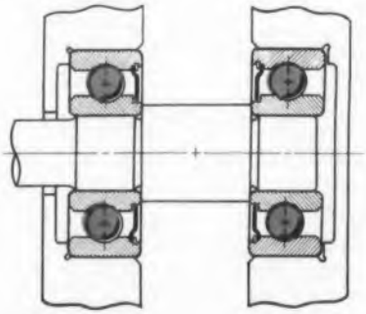


Fig. 3. Opposed mounting with unflanged bearings with positive axial clearance in housing avoids thermal thrust constraint. Shaft locknuts are not needed for light loads.

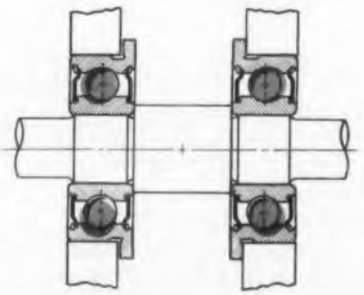


Fig. 4. Opposed mounting with flanged bearings permits through-boring. Flange to housing clearance at right avoids end thrust constraint.

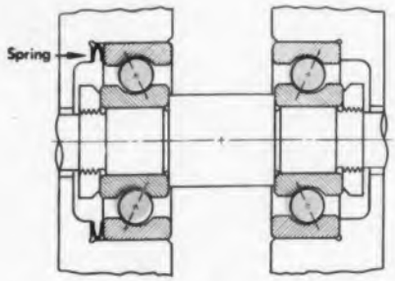


Fig. 5. Spring loading method for axial adjustment removes unwanted axial and radial movement and is simple and fool-proof.

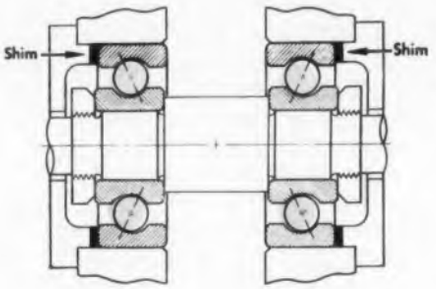


Fig. 6. Precision shims minimize misalignment and permit close axial adjustment for high precision applications.

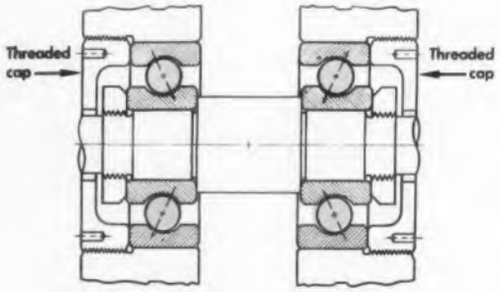


Fig. 7. Threaded nut axial adjustment removes axial and radial play but is potentially troublesome unless faces of adjusting caps are held square with threads.

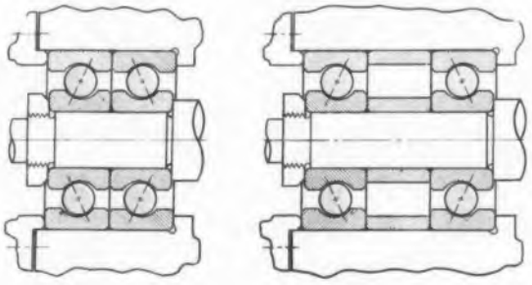


Fig. 8. Back-to-back preloaded duplex pair may be mounted contiguously, left, or with spacers, right. It provides high moment rigidity and is preferred when shaft runs hotter than housing. If bearing or pair is used at opposite end of shaft, it must have axial clearance to avoid thrust constraint.

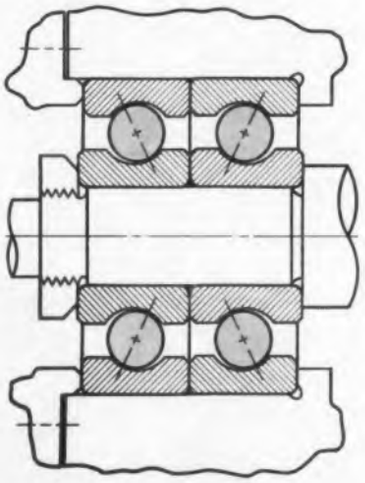


Fig. 9. Face-to-face pair also provides rigidity but is less sensitive to misalignment. It is used when housing runs hotter than shaft. As in DB mounting, bearing at opposite end, if used, must have axial clearance to avoid thrust constraint.

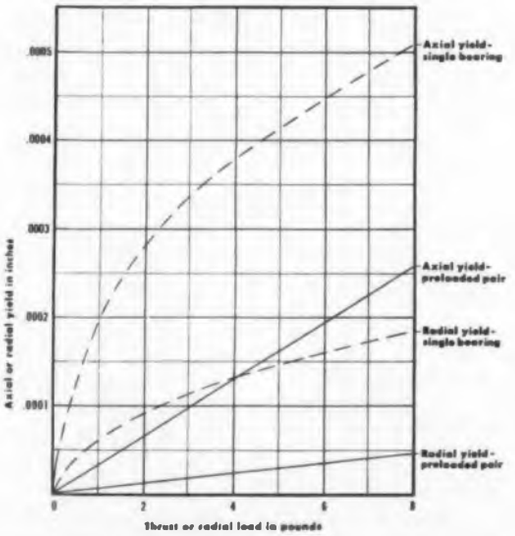


Fig. 10. Axial and radial yields of preloaded pairs are substantially less than those of single bearings and rates are essentially linear because of preload effect.

and 4. Fig. 3 shows unflanged bearings as would be used in small motor and similar mountings, and Fig. 4 shows flanged bearings which avoid the cost of the end caps required in the Fig. 3 mounting. Both mountings feature positive end-clearance to avoid thermal-contraction end-thrust constraint and, since each bearing takes only one directional thrust, no shaft locknuts (or other holding devices) are needed as are required by the mountings in Figs. 7 and 8. Good co-axial alignment can be secured with two-piece housings by use of rabetted joints with pilot surfaces and bearing bores machined in one setting.

Figs. 5, 6 and 7 show mounting variants of Figs. 3 and 4 and, principally feature ways and means of securing axial adjustment to remove unwanted axial and radial movement.

The most foolproof mounting is the spring loading arrangement of Fig. 5. This is a tried and true system and can cause trouble only if springs are badly out-of-parallel or develop thrust loads sufficient to cause high torque or excessive heating. Figs. 6 and 7 show shimmed and threaded nut adjusting systems. Here again, precautions are in order. For high precision applications where zero free-play is desired, shims should be ground and preferably lapped to low errors-of-parallelism to hold down misalignment effects. The average user can get into more trouble with the screw thread adjustment system than with precision shims, since faces of adjusting caps are difficult to hold square with threads; unless precautions are taken, this can develop serious misalignment errors.

Duplex pairs for axial preloading are used principally on gyro rotors, computer magnetic-storage-drum units, and in certain types of rolling contact integrating drives. They are available in two basic types, *DB* (back to back) shown in Fig. 8 and *DF* (face to face) shown in Fig. 9. Because of the radically different characteristics of preloaded pairs as compared with single bearings, designers should always check with the bearing manufacturer before specifying.

The choice between *DB* or *DF* pairs depends on many factors, chief of which are:

Select DB pairs

1. When loading is cantilevered or overhung;

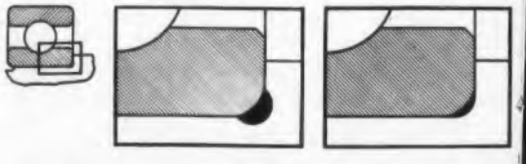


Fig. 11. Approved methods of obtaining corner clearance are, left, undercut or, right, shoulder fillet radius less than maximum listed by manufacturer for bearing used.

particularly when only a single pair is used. *DB* pairs provide better angular or moment loading rigidity. Space bearings apart with equal length spacers to secure greatest moment rigidity, as in Fig. 8, right.

2. When alignment conditions can be controlled closely. Even small imposed misalignments can impose serious parasitic loadings. Rule of thumb for total misalignment maximum: not over 0.0002 in. per in.

3. When preload can be established along the shaft. Locknut or similar clamping device is required.

4. For the axially floating pair of two separated duplex pairs. This is required to relieve thermal constraint on relatively long spindle type mountings.

5. When shaft tends to run hotter than housing. With DB pairs, differential expansions radially and axially tend to compensate; more so when equal spacer mounting is used.

Select DF pairs

1. When alignment cannot be as closely controlled as for *DB* pairs.

2. When preload can be established by housing locknut or cap. Note that *DF* pair cannot be used where axial float in housing is necessary.

3. When housing runs hotter than shaft, a rare case. With *DF* pairs, relatively greater expansion of outer rings both radially and axially tend to relieve rather than increase preload.

Typical radial and axial yield values of single and preloaded pairs, either *DB* or *DF* mounted, are indicated in Fig. 10 which shows the virtual linearity of preloaded pair yield rates.

Remember that duplex bearings inherently develop higher torques than single bearings. Also, they are sensitive to misalignment errors and thermal differentials. Preload specifications should be carefully set by consultation with bearing suppliers after careful consideration of all design factors.

Shaft And Housing Fits: The Key to Avoiding Unwanted Radial and Axial Constraints.

Shaft and housing fits are important details that should not be overlooked since proper fitting constitutes an important key to the avoidance of unwanted radial and axial constraints.

Press fits, generally, should be avoided in lightly-loaded electronic applications. If, however, a press fit is required, it should never be used on both outer and inner rings. A press fit is almost never needed for light loads and moderate speeds, as the principal reason for using it is to prevent relative rotation between the rotating bearing ring and its seating. Some relative rotation can be tolerated under light loads; also, a stationary bearing ring will rarely rotate on its seating unless heavy rotational-unbalance develops or the bearing itself becomes excessively tight radially. Typical examples of proper shaft and housing fits are shown in Table 2.

Table 2. Examples Of Shaft And Housing Fits.

Shaft fits	Conditions and typical applications	Type of fit	Desired average fit	Shaft diameter	Bearing bore	Resulting fit extremes
	Light radial loads Low speeds Gyro gimbals, synchros, computers, servos, recording devices	Close clearance	.0001" loose	.2499"-.2497"	.2500"-.2498"	.0001" tight-.0003" loose
	Light to moderate radial loads Low to high speeds Gyro rotors, small motors, generators	Light Interference	.0001" tight	.2501"-.2499"	.2500"-.2498"	.0003" tight-.0001" loose
Housing fits	**Conditions and typical applications**	**Type of fit**	**Desired average fit**	**Housing bore**	**Bearing O.D.**	**Resulting fit extremes**
	Light to moderate radial loads Moderate to high speeds Gyros, small motors, generators, synchros, computers, servos, recording devices	Moderate clearance	.0002" loose	.6252"-.6250"	.6250"-.6248"	.0000"-.0004" loose

Selective assembly is used to control shaft and housing fits to closer ranges than is possible with random assembly within the tolerance ranges of bearing, shaft and housing. "Classified" or "calibrated" bearings are supplied by manufacturers with bore and outside diameter sizes grouped and identified with suitable identification symbols. These are matched with similarly classified shafts and housings to obtain optimum fits.

The following size groupings and identification symbols, which have been standardized by ASA for Instrument Precision Ball Bearings, apply to classified bearings with 0.002 in. tolerance ranges on bore and OD. The size determinations are based on the smallest measured bore and the largest measured outside diameter:

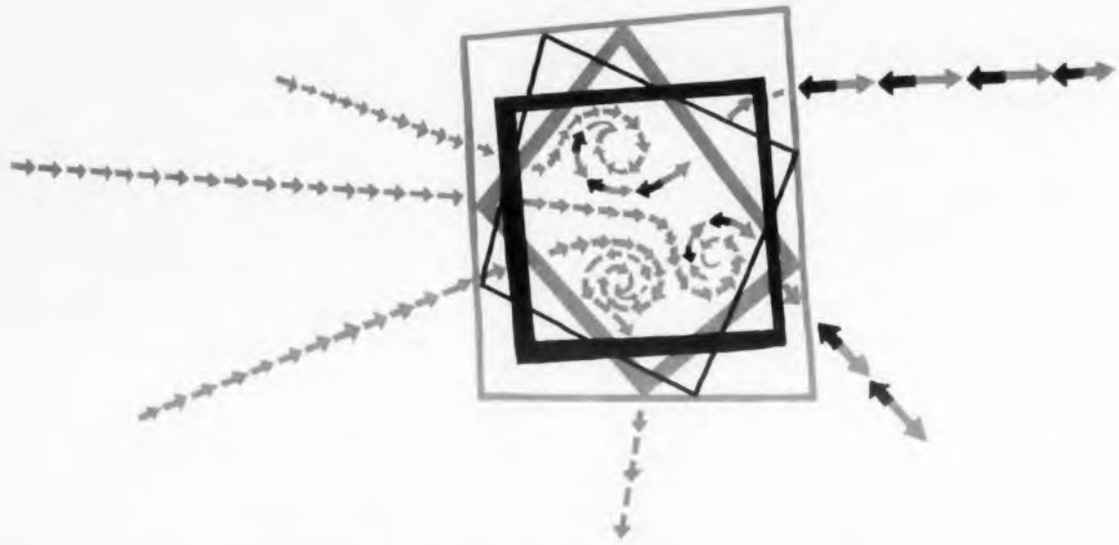
Bore size	Identification Symbol
+0.0000 to —0.0001 in.	Bore 1
—0.0001 to —0.0002 in.	Bore 2
Outside diameter size	
+0.0000 to —0.0001 in.	OD 1
—0.0001 to —0.0002 in.	OD 2

Shaft And Housing Shoulders

Shaft and housing shoulders are required to hold bearings in position against axial movement arising from thrust loads and to promote accurate alignment. Bearings which are predominantly radially loaded can be shouldered against housing snap rings or circlips; but, for most accurate alignment under thrust loads or axial preloads, the solid housing shoulder or machined cap is preferred. When using flanged bearings, the side face of the housing must be accurately machined, a simpler and less costly operation than boring and facing a solid internal housing shoulder.

Although all bearings are chamfered or corner radiused, it is necessary to provide a flat seating area beyond the maximum extent of the corner break on the bearing ring. Best practice is to undercut the shaft or housing fillet to facilitate grinding or machining shoulders flat and automatically avoid bearing corner interference that otherwise may develop with oversize shaft or housing fillets.

Fig. 11 shows two methods of obtaining corner clearance. If undercuts are not used, the shoulder fillet radius must be less than the stipulated maximum values listed in bearing manufacturer's catalogs. Minimum recommended shoulder heights can also be determined from bearing catalog tables. It is also advisable to avoid extending the shoulder beyond the face of either inner or outer ring. This is important in dismounting the bearing without damage and, in many cases where loosely fitted shielded bearings are thrust loaded, to prevent rubbing interference between the shaft shoulder and the bearing shield. ■ ■



Mr. Wasserman's pet component interest for the past seven years has been the design and application of square loop magnetic materials for analog and digital devices. He stresses that uses for square loop materials are numerous and their reliability is extremely high.

Self-Excited Transistor DC-AC Converter Design

Reuben Wasserman
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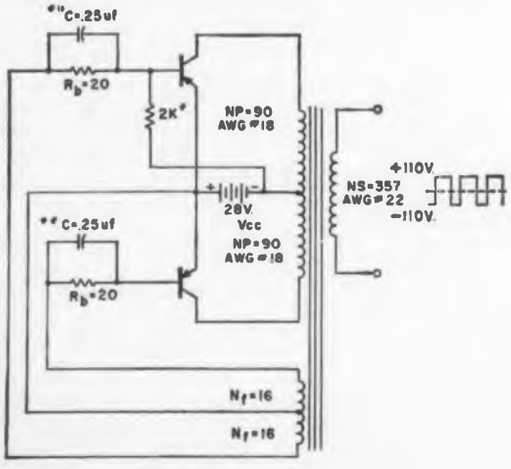
By making use of several nomographs, considerable time and effort can be saved during the design of transistor dc-to-dc and dc-to-ac converters.

CALCULATION required to design a self-excited transistor converter can be simplified by several nomographs and a few handy equations. The converter is essentially a transistor multivibrator whose free running period is established by energy stored in inductance. The low voltage drop of the full "on" operation of the transistor makes it an ideal power switch.



NOTE
*2K=SELF-STARTING RESISTOR.
**C=SPEED UP CAPACITOR.

Fig. 1. Schematic of a self-excited transistor-magnetic converter.

Calculating the Voltage

In designing the converter shown in Fig. 1, it is desirable to use square-loop material in the transformer for higher operating efficiency. The voltage drop in the "on" transistor is negligible compared with the dc supply V_{cc} so that V_{cc} appears across N_p for one half-cycle of the oscillator. During this period

$$V_{cc} = N_p \frac{d\phi}{dt}.$$

The polarity of the feedback winding holds one transistor in the "on" state, the other in the "off" state. The transformer core saturates, then falls to zero, which in turn reduces the feedback to zero. The transistor that was originally cut off starts to conduct, reversing the direction of $d\phi/dt$ which induces a voltage of opposite polarity in the transformer. This voltage reverses the state of the transistors.

The equation for calculating the voltage is,

$$V = 4fNB_mA \times 10^{-8}$$

where

f = frequency in cps
N = number of turns
B_m = flux density in gausses
A = core area in cm²

Table 1. Typical Core Characteristics.

Core Material (Trade Name)	H_c	B_m
Orthonol	0.2	14,700
Deltamax 50 per cent NiFe		
Hipernik	0.03	7,100
Square HyMu 79 per cent NiFe	1.5	12,000
Hipersil		
Tape Thickness Above 1 kc = 1 mil; above 400 cps = 2 mil; above 60 cps = 4 mil		

Criteria to Remember

- Select core material that has low coercive force (Hc) to minimize core loss, high saturation flux density to reduce core size, square hysteresis loop to increase switching speed, and thin tape size to keep eddy current losses at a minimum at the oscillating frequency. See Table 1.
- The dc voltage input to the transistor should be as high as possible for a given power output requirement to obtain maximum efficiency.

Maximum permissible emitter-to-collector reverse voltage must be at least 2.5 times the dc input voltage since the cut-off transistor has across it the sum of the dc input plus the induced voltage of the other primary plus transient peaks (which can be minimized).

■ Frequency cut-off characteristics of the transistor should be a minimum of five times the oscillating frequency to minimize transistor power dissipation.

■ Select maximum current gain transistors for the given inverse voltage and power requirement.

■ Power dissipation of transistor is approximately equal to

$$\frac{I_c \times V_{ce}\,(\text{on})}{2} + \frac{V_{ce} \times I_c}{4}\left(\frac{t_r + t_f}{T}\right)$$

$$+ \frac{V_{ce(inv)} \times \beta I_{co}}{2}$$

where t_r = rise time; t_f = fall time; $V_{ce\ (inv)}$ = inverse peak voltage; β = current gain for grounded emitter; and I_{co} = reverse leakage current.

Design Example

Step 1. If the core type material, frequency, power output requirements and transistors are known, design of the converter can be easily accomplished by using nomographs. Assume desired output = 110 v ac, 70 w at 400 cps; dc input voltage = 28 v.

Assume power efficiency is 80 per cent, which is a conservative estimate. The power input would then be

$$70\ \text{w}/0.80 = 87.5\ \text{w}$$

The dc current input is then

$$87.5\ \text{w}/28\ \text{v} = 3.1\ \text{amp}$$

Step 2. The material selected can be either Orthonol, Deltamax, or Hipernik which are composed of 50 per cent NiFe, having a maximum flux density of $B_m = 14{,}700$. For power conversion applications, it is desired to use as high a flux density material (50 per cent NiFe) as possible.

If the converter design calls for a voltage at low power design levels or where high efficiencies are desired under light load conditions, then HyMu80 material is most suitable.

Step 3. Select wire size from AWG wire size table (Table 2). For primary N_p (duty cycle 50 per cent),

$$I_{dc}/2 = 3.1/2 = 1.55\ \text{amp}$$

The proper wire size is then #18. For secondary N_s,

$$I_s = 70\ \text{w}/110\ \text{v ac} = 0.630\ \text{amp}$$

The wire size is #22.

Step 4. Refer to the nomograph shown in Fig. 2 to find $N_pAB_m \times 10^{-8}$ for given input voltage of 28 v at 400 cps. Set ruler on 28 v, frequency at 400 cps and read $N_pAB_m\,10^{-8} = 0.17$.

Step 5. To find N_pA for given B_m of 14,700 gausses, refer to Fig. 3. Set ruler on $NAB_m\,10^{-8} = 0.17$ and $B_m = 14{,}700$ gausses and read $N_pA = 120$.

Step 6. Assume for good practice 1/2 core wind-

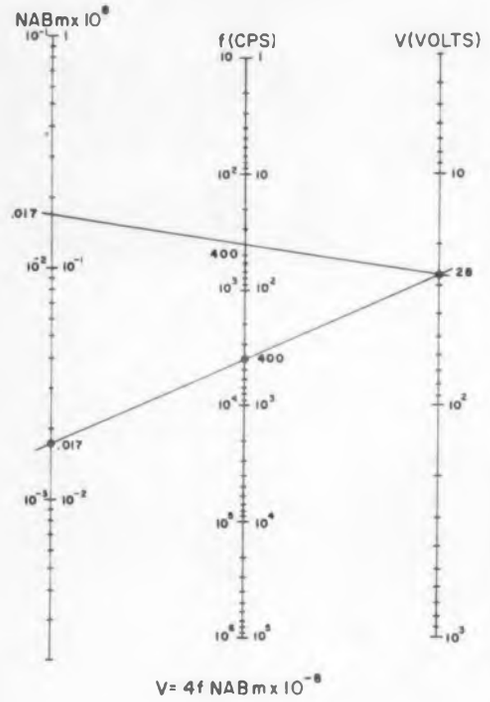


Fig. 2

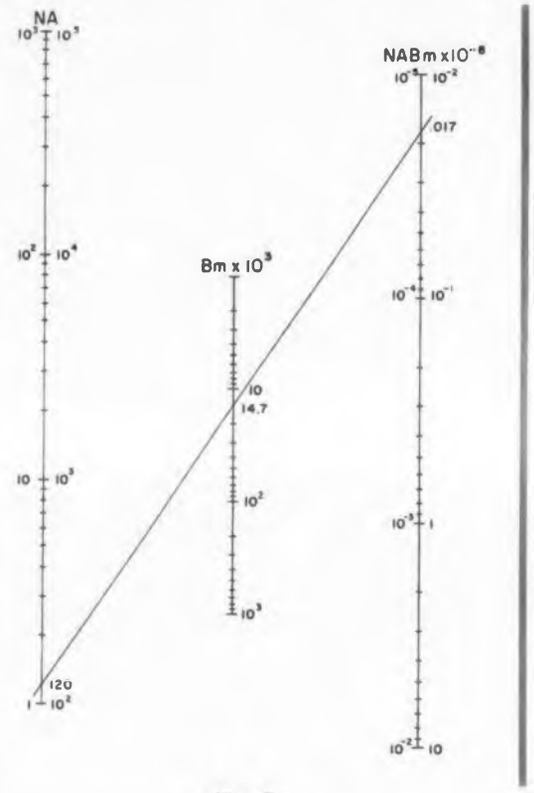


Fig. 3

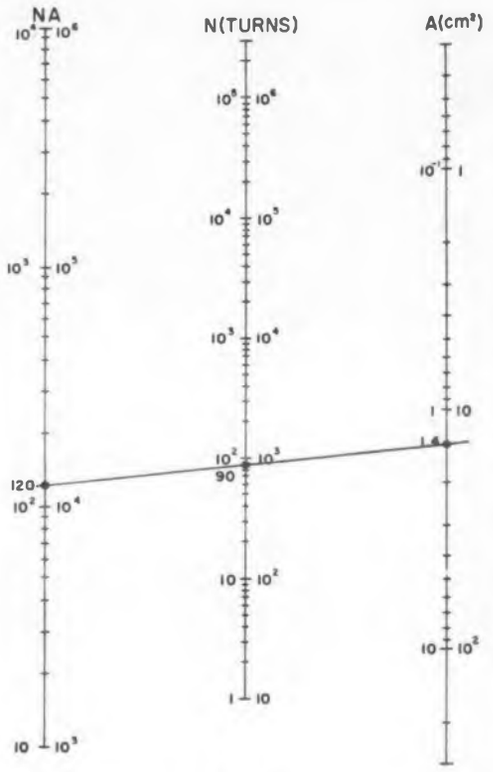


Fig. 4

Nomographs permit rapid determination of key design values.

Table II. American Wire Gage

Gage Number	Cross Sectional Area*	Ohms 1000 ft	Current Capacity (ma)**	Nominal Cross Section with Formvar Insulation	Gage Number	Cross Sectional Area*	Ohms 1000 ft	Current Capacity (ma)**	Nominal Cross Section with Formvar
1	83,700	.126	83,700	—	21	810	13.1	810	961
2	66,400	.159	66,400	—	22	642	16.5	642	767
3	52,600	.201	52,600	—	23	509	20.8	509	620
4	41,700	.253	41,700	—	24	404	26.2	404	497
5	33,100	.319	33,100	—	25	320	33.0	320	400
6	26,300	.403	26,300	—	26	254	41.6	254	320
7	20,800	.508	20,800	—	27	202	52.5	202	259
8	16,500	.641	16,500	17,530	28	160	66.2	160	207
9	13,100	.808	13,100	13,950	29	127	83.4	127	169
10	10,400	1.02	10,400	11,130	30	101	105.0	101	134
11	8,230	1.28	8,230	8,873	31	79	133	79	108
12	6,530	1.62	6,530	7,088	32	63	167	63	88
13	5,180	2.04	5,180	5,670	33	50	211	50	70
14	4,110	2.58	4,110	4,529	34	39	266	39	56
15	3,260	3.25	3,260	3,624	35	31	335	31	45
16	2,580	4.09	2,580	2,894	36	25	423	25	36
17	2,050	5.16	2,050	2,323	37	19	533	19	29
18	1,620	6.51	1,620	1,808	38	15	673	15	23
19	1,290	8.21	1,290	1,489	39	12.5	848	13	17.6
20	1,020	10.40	1,020	1,197	40	9.9	1070	10	14.4

* Cross Sectional Area of Solid Bare Wire (cir mils)
** Current Capacity based on 1000 cir mils per amp

ing for primary ($2N_p + 2N_f$) winding and 1/2 core winding area for secondary (N_s). N_pAw = 1/4 core winding area (N_f negligible). Assume useful core winding area = 1/2 window area of core (W),

$$N_pAw = 1/8W$$
$$0.125 = N_pAw/W$$

Step 7. From core manufacturers' data sheets select a 2 mil core. The window area is 1.96; ID = 1.5 in.; OD = 2.0 in.; A (cross sectional core area) = 1.370 cm².

Step 8. To find N_p for given A, refer to nomograph shown in Fig. 4. Set ruler on $N_pA = 120$ and $A = 1.37$, and read $N_p = 90$.

Step 9. Select transistor with the following characteristics: $V_{ce\ (max)} = 70$ v; $I_{c\ (max)} = 5$ amp; $P_{o\ (max)} = 25$ w; h_{FE} (current gain at $I_c = 3$) = 15; $V_{ce\ (on)} = 1$ v at $I_c = 3$ amp; $I_b = 0.2$ amp at $I_c = 3$ amp; $t_r = 15$ μsec; and $t_f = 35$ μsec.

Step 10. The input impedance of grounded emitter, R_{in}, is 1 v/0.2 amp = 5 ohms. Add R_b for current limiting. Let $R_b = 4R_{in} = 20$ ohms. Then,

$$V_f = (R_{in}/R_b)I_b$$
$$= 25 \times 0.2 = 5 \text{ v}$$
$$N_f = N_p \times 5/28 = 16 \text{ turns}$$
N_f wire size (duty cycle 50 per cent)
$I_b/2 = 0.2/2 = 0.1$ amp #30

Step 11. Calculate the number of turns of the secondary, N_s.

$$N_s = N_p\ (110)/28 = 357 \text{ turns}$$
N_s wire size #22.

Step 12. Check window area.

376 turns #22 (760 cir mils)	$= 285000 \times 10^{-6}$
2×17 turns #30 (130 cir mils)	$= 4000 \times 10^{-6}$
2×96 turns #18 (1800 cir mils)	$= 350000 \times 10^{-6}$
	639000×10^{-6}

Copper area = 0.639
$W = 1.96$

Core size is more than adequate.

Step 13. Calculate transistor dissipation.

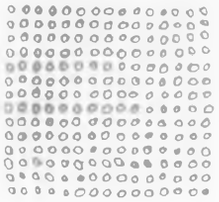
$$P_c = \frac{I_c \times V_{ce}\,(\text{on})}{2} + \frac{V_{ce} \times I_c\,(t_r + t_f)}{4 \quad T} + \frac{V_{ce} \times I_{ceo}}{2}$$

$$= \frac{3 \times 1}{2} + \frac{28 \times 3\ (0.015 + 0.035)}{4 \qquad 0.125} + \frac{56 \times 0.030}{2}$$

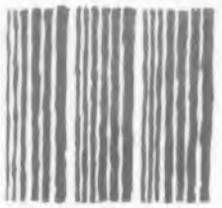
$$P_c = 1.5 + \frac{21}{25} + 0.84 = 3.2 \text{ w}$$

Total transistor dissipation = 2 x 3.2 = 6.4 w thus, it can be seen that the core loss is negligible. Power input = power output + power dissipation = 70 w + 6.4 w.

$$\text{Efficiency} = \frac{70}{76.4} = 91 \text{ per cent} \blacksquare\blacksquare$$



How to Insure . . .



Reliable Printed Circuit Materials

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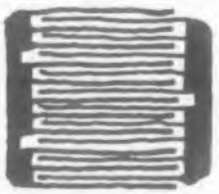
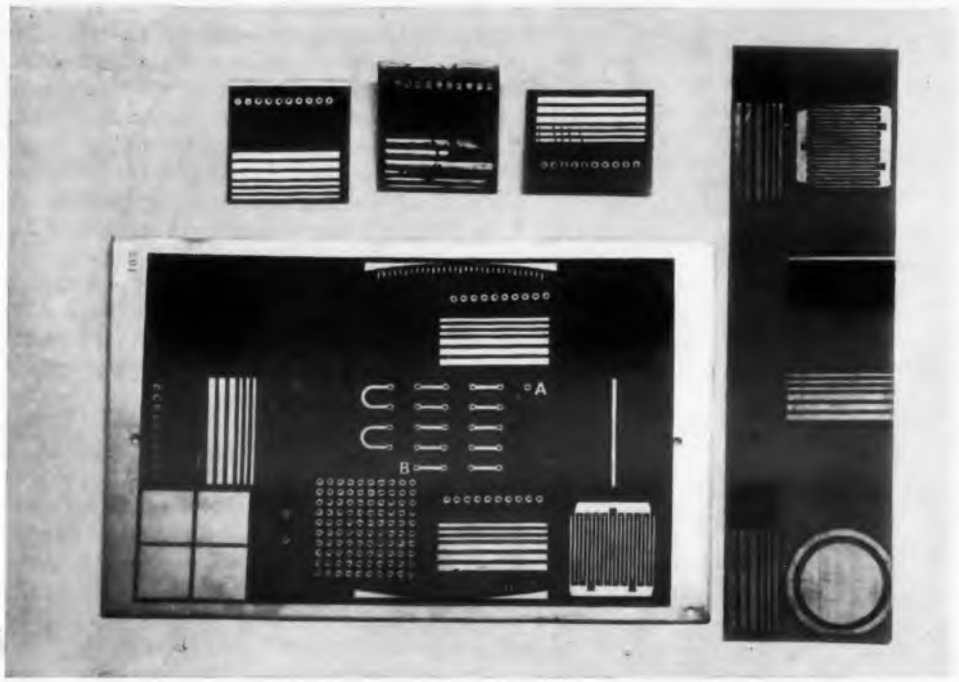
Cost of rejects of the basic printed wiring board is relatively insignificant compared to the cost of scrapping a complete assembly. Therefore, rigid controls are necessary to insure quality before and during processing. This article discusses various types of controls and what they accomplish.



IN THE AREA of printed circuit materials and processes our approach to reliability is through the use of controls. These controls primarily consist of:

- Design standards based on reliable criteria
- Accurate material specifications
- Qualified vendors
- Rigid incoming inspection, and in-line inspection where required
- Alert and compentent quality control

In addition to providing a basis for reliability, these same controls can provide other important advantages. For example, these controls will provide substantial economies in labor, materials, parts, machine load, etc. Briefly stated, these economies result from the "do it right—do it once" philosophy. Disregard for this concept results in rework, waste, modifications and associated expenses.



Test specimens that are cut from each sheet of material. The large rectangular test specimen is used to evaluate both material and processing. The three specimens shown above it are for bond strength tests. At the right, the long piece is used by the fabricator for his own acceptance tests.

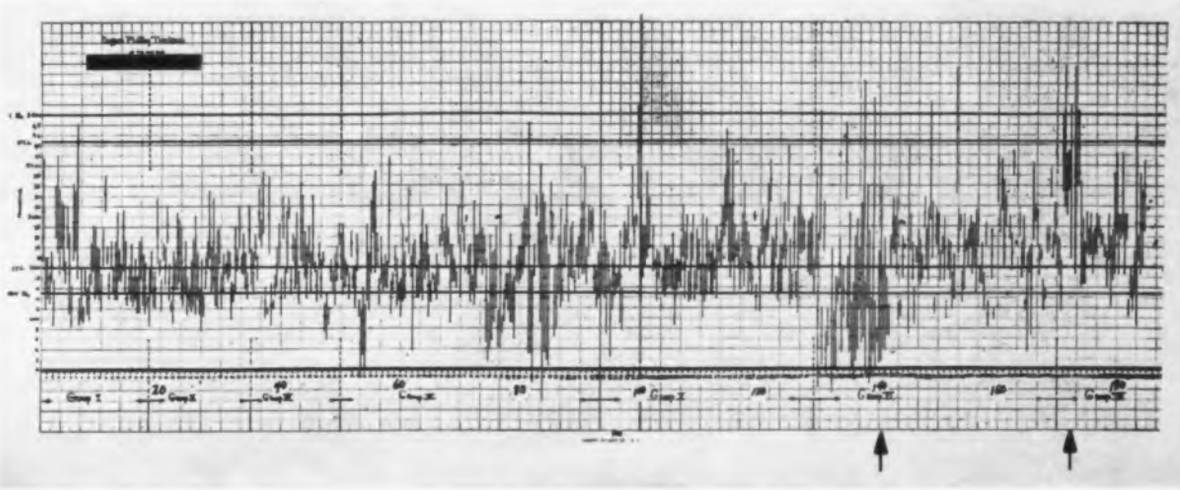
New type test pattern, lower left. Small pieces above, are specimens of cross-sectioned, plated-through holes used for measuring plating thickness. Area of the large test pattern above a line drawn through the sets of numbers is equal to the square inches of copper material. Using this, the fabricator can watch the test pattern current density to that of the particular board he is making.

How To Start

Controls should be established on all of the raw materials which comprise the product. These controls may be either directly applied or indirectly applied through vendors or sub-contractors. A study of the end product and the manufacturing processes involved indicates that the initial area of control is on the fabricated printed-circuit board. It is of paramount importance that printed-circuit boards released to manufacturing for assembly be capable of withstanding the manufacturing environment with few rejects, and then be capable of meeting the military environment on demand with no failures.

In general, controls are established by discussions between laminator, fabricator and the company design engineers. Individual problems and areas of needed control are discussed. It is of the greatest importance to the fabricator that the material be able to go through every step of his processing without degradation of physical and mechanical properties, and without requiring special processing techniques.

It is important to the laminator that control tests be uniform and standardized, insofar as possible, and that the required material fall within the laminator's own standard processing tech-



Typical quality control chart prepared from data from incoming inspection. This chart is a statistical average of copper plating thickness in plated-through holes. Note the two "out-of-control" areas indicated by the arrows.

niques. The company's objective is that appropriate tests be instituted to insure a uniformly higher reliable product. The implementation of these discussions is the preparation of specifications in which test controls are established, allocated to and accepted by the various participants.

A basic criterion, solderability, is used as a prime control test. It is generally agreed that this test is the only one that can expose a range of defects in the base material. In order to raise the discrimination level sufficiently high to reflect high reliability, a temperature of 500 F, which is 20 F over the processing limit, for 15 sec, that is 10 sec over the limit of use, is selected. Every sheet of material produced by the laminator is tested through this condition. A further imposition of 4 days of humidity conditioning is made on the sample prior to the soldering.

In addition, the test is to be made on a sample which had been etched into a pattern, so that the copper, the base material and the adhesive are all exposed to the humidity condition prior to the thermal shock of soldering. It is also required that bond strength be tested after soldering and that it meet a minimum value.

This control is designed to indicate such intrinsic weaknesses in the material as inter-laminar blistering resulting from excessive moisture absorption, resin starved areas, poor glass impregnation or improperly cured resin. Also it indicates surface blistering of the copper resulting from poor adhesion or attack by the etchant, surface discoloration of the base laminate as a result of adhesive degradation or "dry" spots in the glass base, lifting of the copper resulting from adhesive degradation, or copper to laminate bond through heat shock or relief of laminating stresses caused by improper lay-up of the base glass. Performed by the laminator, this test is in addition to his standard quality control checks.

Fabricator's Duties

It is incumbent on the fabricator, as the purchaser of the laminate to see that the laminator performed the tests previously described. He should be called upon to produce for company review the data provided by the laminator.

The fabricator performs acceptance tests on all the material received. These tests are specified against tabulated requirements and on specified samples. The fabricator's acceptance test sample was a print and etch pattern. Duplicate samples were specified to be submitted by the fabricator to the company for quality control tests.

An additional test sample from the center area of each sheet is processed in accordance with the entire manufacturing procedure. It is a representation of a final product with plated through holes, etch wedges and other test patterns. In this way the overall uniformity of each sheet was com-

pletely controlled—corners, edges and center.

Testing and material control are correlated by the use of material coding. Each sheet of material submitted is marked by the laminator with the sheet number, press number, and press load number. This number is marked on each part cut from the sheet by the fabricator. Each part is also marked with a wet processing number by the fabricator which identified the center pattern with the batch. Therefore it is a simple matter to relate all boards from a single sheet and to an acceptance test sample in the event of a material or processing defect.

Data gathered as a result of these controls are statistically analyzed to determine the relative importance of each control area. The results of this analysis indicate that many areas previously considered critical are so well controlled that they can safely be relegated to a lower inspection level.

For example, flexural strength, volume resistivity, heat resistance and solvent resistance which were previously considered to be critical control points and were on a 100 per cent test basis, are now on a periodic control basis. Other test parameters of a more critical nature such as surface resistance and water absorption are also on a broader sampling basis.

Certain tests such as bond strength after dip soldering and insulation resistance before and after moisture cycling have been retained on a tight inspection level in view of their descriptive characteristics of material integrity and ability to withstand assembly operations.

Results of Controls

Establishment of controls, the costs of testing and close surveillance could be expected to have had a pronounced effect on the cost of the printed circuit board. Initially, this was the case as a result of the lack of familiarity by everyone (laminator, fabricator, Arma) with the controls imposed. The resulting cost increases to Arma were in the neighborhood of 100 per cent. However, at least the fabricators were willing to hedge against this unfamiliarity by basing part of their price on a reject rate. This hedge took the form of a renegotiable contract.

Rejects by Arma to the fabricator have been negligible. In one case only eight rejects were recorded out of a quantity of 1500 pieces shipped. The price of the printed circuit board has dropped to a reasonable competitive level

Many of the tests have been adopted by the laminators and fabricators and are presently part of their own quality control procedure. Disputes over test data have been minimized and test data corroboration has been excellent due to the standardization test methods. The net result has been an over-all cost saving with high quality. ■■

Stepped-Index Luneburg Lenses:

- **Theory**
- **Construction**
- **Characteristics**
- **Uses**

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LUNEBERG lenses are most commonly used in lens antennas and passive reflectors (Fig. 1). For example, if a small and broadbeamed feed antenna is placed with its effective phase center at the focal radius of the lens, an efficient lens antenna results because all energy radiated into the forward hemisphere is theoretically collimated. The feed can be lightweight so that it can be moved quickly over the surface of the ball to provide a convenient means of scanning a radiation beam whose characteristics are determined primarily by an aperture equal in diameter to the lens. There is no limitation on scanning angle imposed by the lens itself. The lens can remain stationary while the lightweight feed only is moved over its surface.

A metallic reflector, on the other hand, can be used to cover a portion of the surface of the lens, and the combination of lens and cap then serves as a passive reflector of microwave energy throughout a solid angle equal to that subtended by the cap. If a lossless lens were realizable, all of the energy of an impinging plane wavefront that actually entered the lens would be returned in the direction from which it came so long as the focal point fell within the boundaries of the surface reflector.

Theory

The focusing properties of the spherically symmetric general Luneberg lens can be achieved by infinite different relationships between dielectric constant and radius. The general solution is quite involved.[1] Fig. 2 illustrates the most common and one of the more practicable solutions for the case where one focal point is on the sphere's surface and the other is at infinity.[2]

In any spherically symmetric medium, each ray path lies in a plane and, therefore, attention can be confined to any plane which passes through the center of the sphere. The plane-wave-to-point focusing properties are then obtained by requiring that all parallel incoming ray paths have the same electrical length from the incident tangent or phase-front line to the diametrically opposite point on the surface of the sphere. Solution of this problem yields elliptical ray paths within the lens as shown in Fig. 2. The relationship between relative dielectric constant and fractional radius is:

$$k = 2 - r^2,$$

in the range $0 \leq r \leq 1$. The required variation of relative dielectric constant lies between 1 at the surface of the lens and 2 at the center.

Practical Luneberg Lens

Several schemes have been attempted in a spherical lens to satisfactorily approximate the variation of dielectric constant required by $k = 2 - r^2$. No practicable scheme for smoothly varying the relative dielectric constant from 2 at the center to 1 at the surface has been achieved.

Lenses have been and are being made with void-type dielectrics in which a series of flat circular plates of different radii are stacked on one another to approximate a sphere. These plates have a relative dielectric constant of 2 or greater. Holes, 1/8 to 1/2 in. in diameter, are drilled in each plate to reduce the "effective" dielectric constant to more or less the correct value at each point in the sphere. Such dielectrics are neither homogeneous nor isotropic, however. The resulting lenses may be severely sensitive to polarization unless very small holes in very thin plates are employed.

Artificial dielectrics, in which conducting particles are dispersed uniformly in a low-k medium, offer distinct possibilities. However, these dielectrics are frequency-sensitive, unless the dimensions of the loading elements are either very small with respect to wavelength or on the order of magnitude of a wavelength. In most cases, adequate polarizability requires other than spherical loading elements. With the larger elements of the order of one wavelength, isotropicity then requires complicated and expensive shapes such as jacks. The most reasonable artificial dielectrics appear to be those in which very tiny (micron dimensioned) conducting flakes of a metal such as aluminum are randomly dispersed in a low-k, low-density, foam base. Isotropicity and homogeneity are fair to good, but the dissipation factor is too great for many applications in the microwave region. There exists considerable interest in metal-loaded dielectrics for use in the vhf and uhf ranges where losses are less troublesome.

Mixture dielectrics are possible in which a

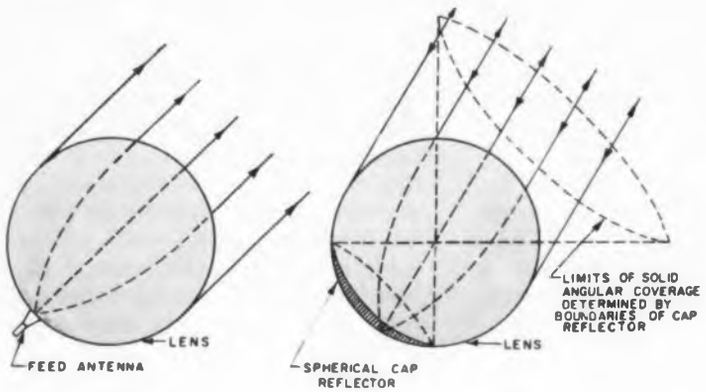


Fig. 1. Applications of the spherical microwave Luneberg lens.

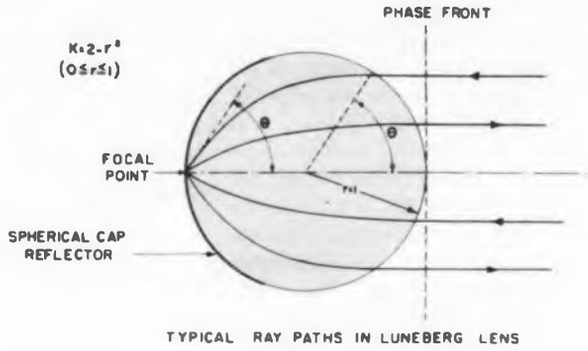


Fig. 2. Typical ray paths in a Luneberg lens.

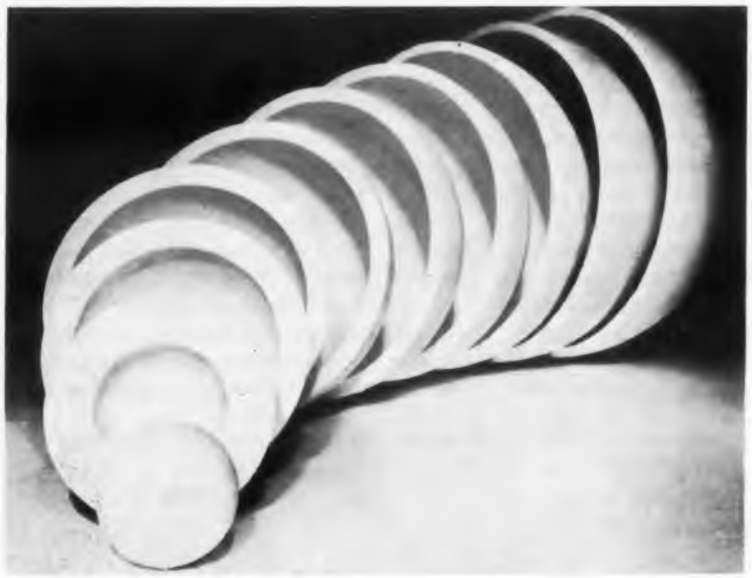


Fig. 3. Hemispherical half-shell construction of stepped-index Luneberg lens.

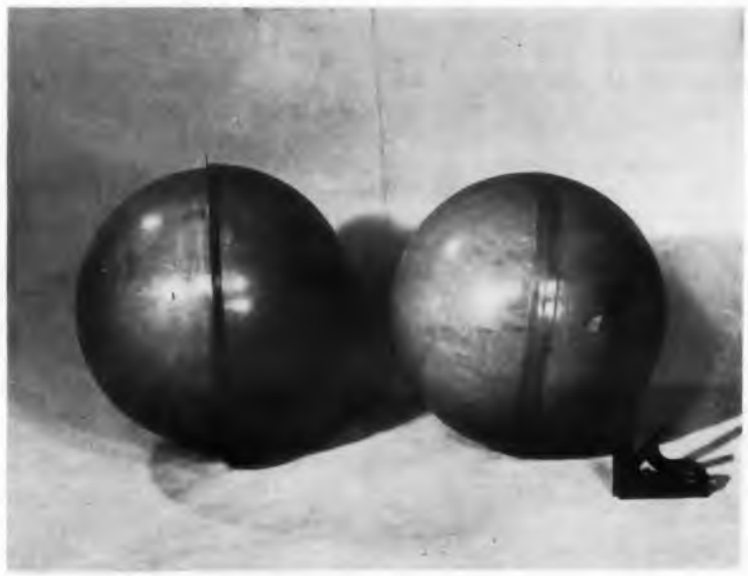


Fig. 4. Lenses enclosed in thin protective fiberglass radomes.

high-k material, such as powdered titanium dioxide, is dispersed in a low-k form. But these materials have not been widely employed in Luneberg lenses.

The most practicable dielectrics for use in Luneberg lenses of k up to 2 are adjustable density foam materials in which the relative dielectric constant can be held within a tolerance of about ± 0.02 for k's between 1 and 2. In the strictest sense, these foams are void-type dielectrics. But the voids are very small and random in both size and shape so the isotropicity is quite good. The dissipation factor can be kept to less than 0.0005.

It is still not possible to achieve a smooth variation of dielectric constant with radius, but a satisfactory step-wise approximation to the curve of k versus r can be made. The type of hemispherical-shell construction that has been very successful is shown in Fig. 3. Production techniques have been developed to the point that these reflectors and Luneberg lenses are available essentially "off the shelf" in more than a dozen standard diameters from 3 in. up.

Ten steps are shown in the 18 in. diameter lens of Fig. 3. The best approximation to the theoretical smooth curve of k versus r requires a maximum number of steps. Economy of fabrication dictates a minimum number. Some Luneberg lenses never have fewer than 10 steps even in units as small as 3 in. in diameter.

These factors influence the choice of the actual number of steps in any particular case:

1. The maximum required frequency of operation places a limitation on maximum shell thickness of the order of $\lambda/2$. If shells are much thicker than $\lambda/2$, a type of wave-trapping phenomenon appears to be possible. It tends to reduce the transmission of energy from one shell to the next.
2. The degree of production-line control over k (± 0.02) makes the efficacy of more than about 25 steps somewhat doubtful in a production item. But 30 to 35 steps are very frequently used. 50 steps are possible with very careful controls.
3. Individual shells cannot be made arbitrarily thin because of molding difficulties and the relatively fragile nature of very low-density, low-k foams. At the outside of a large lens ($k \approx 1$), it is not feasible to make shells much less than 1/8 in. thick.

The step-wise approximation of the smooth k versus r curve permits the use of an outermost

step which is actually air, and the focal point can be located just outside the surface of the ball. This, in turn, permits optimum adjustment of the position of the feed antenna or the cap reflector. Two finished lenses enclosed in fiberglass radomes are shown in Fig. 4. The lens on the right is for use with a horn or other feed antenna and the focal point is just outside of the tight-fitting radome surface. The lens on the left is a passive reflector with a built-in conducting film on the inside of the rear half of the radome. This half is slightly larger than the front half as required in order that the conducting film can be mounted at the focal radius. Foam spacers of very low density and $K \approx 1.03$ are used between the rear half of the radome and the outermost dielectric shell.

Stepped-index Luneberg lenses are being made easily in practically any diameter from 3 to 36 in. and a 48 in. prototype is now in process. The number of steps varies from a minimum of 10 in even the smallest sizes to as many as 30 in a 9 in. lens and up to 50 in the larger units.

Electrical Characteristics

Various factors place minor limitations on electrical performance:

1. Dielectric materials are not entirely lossless. Even though the dissipation factor of polystyrene foams is less than 0.0005, some energy is dissipated as purely dielectric loss.
2. Of at least equal importance to dielectric losses are interface losses due to discontinuities of k in the stepped-index construction and to small but sometimes unavoidable air spaces between adjacent shells. These inevitably cause some scattering and defocusing.
3. Wave trapping within the shells can possibly reduce transmission efficiency at the higher frequencies.
4. Radome losses exist at X-band and higher frequencies on account of interface reflections at the surfaces of the fiberglass radome whose $k \approx 4$.

While each of these losses may be minor in itself, the sum of all losses may be far from negligible.

Lens As A Passive Reflector

The majority of lenses in use today are employed as passive reflectors in conjunction with appropriate cap reflecting surfaces. They are widely used as radar cross section enhancement devices in target drones or other test vehicles. And they are applicable as tow targets, runway markers and seaway channel markers, and in test installations for radar equipment.

The quality of a Luneberg lens itself is most easily judged when it operates as a passive reflector since, under these circumstances, energy traverses the lens twice and all the above losses are influential during both passes. Electrical measurements are easily made to compare the reflectivity with that of a flat smooth metallic plate of the same projected area. This is literally a comparative measurement of radar cross section. It can be accomplished rapidly with adequate instrumentation. A good lens will show a cross section within less than 2 db of the theoretical value for a uniformly illuminated perfect reflector of the same diameter [$\sigma = (4\pi^3 r^4)/\lambda^2$ square meters, where r = lens radius in meters and λ = wavelength in meters] over a frequency range of several octaves. A 2 in. diameter, 10-step lens, for example, which measures 1.5 db down from a 12 in. diameter flat plate at 10 kmc and lower frequencies.

There are two major advantages of the Luneberg lens reflector over the triple-bounce corner reflector as a passive radar cross-section enchantment device. These are:

1. The theoretical cross section is about 9 db above that of a circular corner reflector of the same radius.
2. The solid angular coverage of the lens is far superior to that of the corner. Fig. 5, for example, is the reflectivity pattern of a 7 in. diameter lens with a spherical cap reflector that subtends approximately 90 deg at the center of the sphere. The pattern is for rotation about any diameter normal to the radial line through the center of the cap and shows essentially theoretical reflectivity over a range of about 70 deg in aspect angle with 3 db points about 80 deg apart. The associated cap reflector can cover the entire rear half of the lens but considerable shadowing of the aperture then occurs at aspect angles above about 45 deg. A reflector angle of about 140 deg provides about optimum flattop response.

The major disadvantage of the lens reflector over a corner reflector is its considerably greater

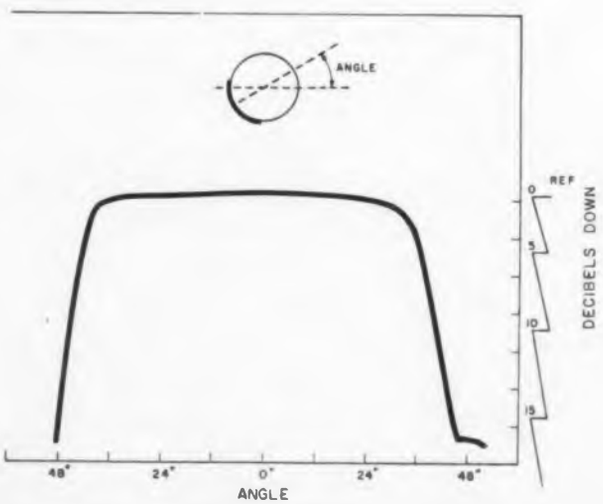


Fig. 5. Reflectivity pattern of 7 in. diameter Ecco Luneberg lens with 90 deg spherical cap reflector. Frequency is 9.34 kmc. Calibration reference is 7 in. diameter flat conducting plate.

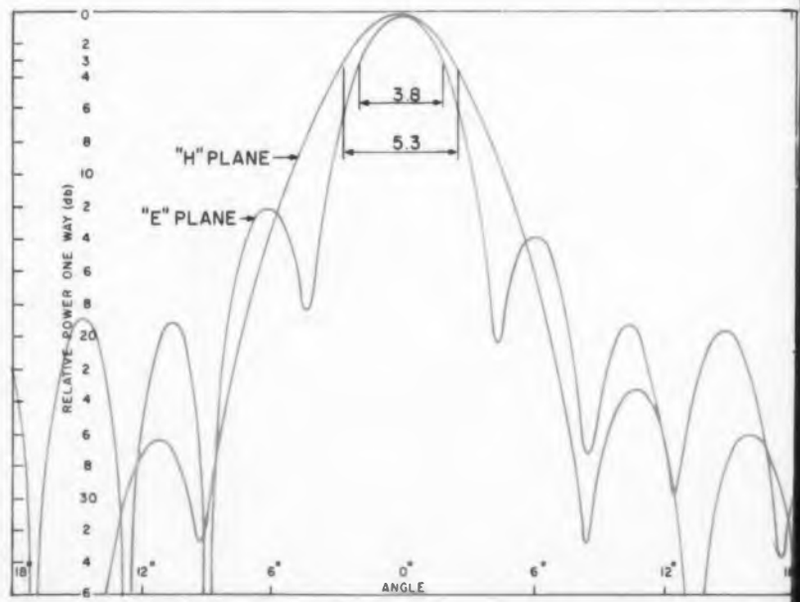


Fig. 6. Typical beam patterns for 18 in. standard Ecco Luneberg lens with 1/2" 1" open-end waveguide feed spaced 1/2" from surface of lens. Frequency = 9 km

weight. A 12 in. polystyrene foam lens weighs about 10 lb. The average density is about 19 lb per ft³. Lightweight lenses of density about one quarter of these values are available but may be too lossy for effective use as reflectors (several db reduction in cross-section) unless space is available for larger units.

Defocused lenses have been studied for use as bistatic reflectors in target-drone vehicles, for example, but thus far have been found only moderately effective even at small bistatic angles. However, investigations have been far from thorough.

The Lens Antenna

The second major use of the Luneberg lens is in a broadband lens antenna where an appropriate waveguide or horn feed is employed as the active element. As mentioned, a relatively lightweight feed can be rapidly moved over the surface of the lens for rapid scanning purposes. A series of fixed feeds, electrically switched, is also a possibility for scanning. Different feeds operating at different frequencies are entirely feasible.

Typical feed devices are small-aperture waveguide horns, open-end waveguides or dielectric-loaded waveguides, the prime requirement being a satisfactory approximation to a point source. The directivity, beamwidth and side-lobe level of the resulting feed-plus-lens antenna system can be controlled to some extent by modifying the illumination taper and by radial adjustment of the effective phase center of the feed with respect to the focal point.

Representative beam patterns for a 14-step 18 in. diameter lens with open-end waveguide feed at 9 kmc is shown in Fig. 6. Beamwidth is computed as $(58\ \lambda)/D = 4.2$ deg. The theoretical directivity (gain) is $(4\ \pi\ A)/\lambda^2$ which equals 33 db, and the value measured by comparison with a standard gain horn is as high as 31 db. This corresponds to an aperture efficiency of about 0.63 which includes not only the efficiency of illumination but all of the losses previously mentioned.

The spherical symmetry of the lens is illustrated by Fig. 7. It compares beam patterns taken with the feed antenna at various positions on the surface of the lens. The effect of radial adjustment of the feed antenna with respect to the focal radius is shown in Fig. 8.

The dielectric loss tangent is usually not more than 0.0004 in any of the shells. But an exact computation of dielectric loss is very difficult to make due to the variations of loss factor with radius. A very rough estimate of the dielectric loss can be made by assuming these "average" values: $k = 1.5$; $tan = 0.0003$; and path length equal to diameter. Attenuation is then about 0.0032 db per cm at 3.33 cm or 0.15 db in 18 in. Therefore, the major portion of the difference between theoretical and measured gain is accounted for by focusing inaccuracies, radome losses, wave trapping effects and illumination taper.

The 18 in. lens referred to above (2 db down at 9 kmc) may be 6 db below the theoretical value at 17 kmc with an open-end Ku-band waveguide feed. This combination will yield an H-plane beam width of about 2.5 deg as compared with the theoretical 2.3 deg.

Power Handling Capabilities

Attenuation in an 18 in. lens was estimated above as 0.15 db at 9 kmc. This corresponds to a power less of about 3.3%. Proportionately greater losses in larger diameter lenses, and because it is often desirable to transmit power levels of several kilowatts, mean that the amount of heat generated within the lens may be far from insignificant. The problem is further aggravated by the very low thermal conductivity of some materials and their relatively low softening temperature (about 170 F). Very limited experimental work has shown that the core temperature of an 18 in. standard lens may reach 150 F after about one hour's continuous transmission of 400 at X-band, and the core is almost certainly not the hot spot when the lens and the feed antenna are stationary with respect to each other. To improve power-handling capabilities, various schemes of ventilation and cooling have been proposed, and high-temperature materials of adjustable dielectric constant are under active development. ■ ■

References

1. Samuel P. Morgan, "General Solution of the Luneberg Lens Problem", J. A. P., 29 (September 1958) pp. 1358-1368

2. R. K. Luneberg, "Mathematical Theory of Optics", Brown University Press, 1944, pp 189-212

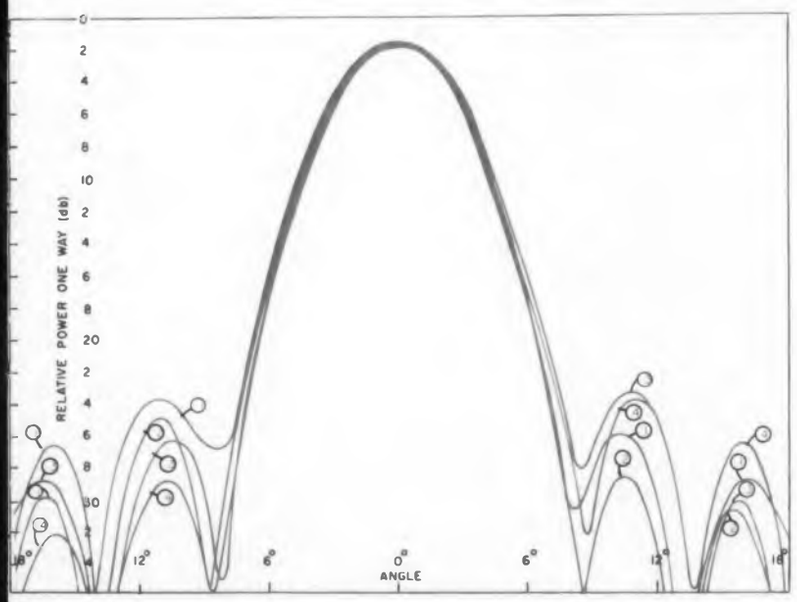


Fig. 7. H-plane beam patterns of 18 in. standard Ecco Luneberg lens with 1/2 x 1 in. open-end waveguide feed 1/2 in. from lens surface at four different positions on sphere. Frequency is 9 kmc.

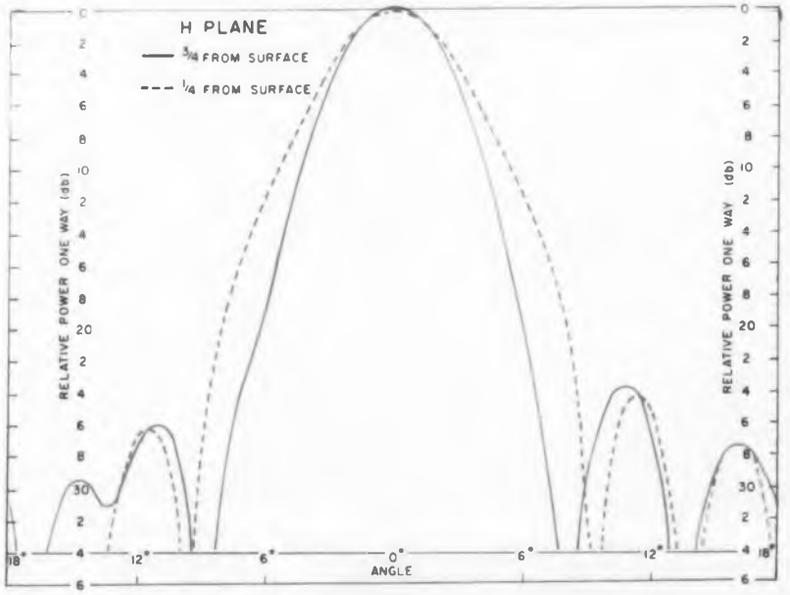


Fig. 8. H-plane beam patterns of 18 in. standard Ecco Luneberg lens with 1/2 x 1 in. open-end waveguide feed at different distances from surface of lens. Frequency is 9 kmc.

William F. Nielsen
Sandia Corporation
Albuquerque, N. M.

How to Design an Adjustable Pulse Integrator

Bill Nielsen presents here a straightforward design procedure for a simple pulse integrating circuit with some rather novel features.

THE PULSE integrator of Fig. 1 offers three distinct advantages over conventional pulse integrating circuits.

1. Its integration time can be varied to an essentially unlimited degree without any effect on the steady state gain or output voltage.
2. Its effective integration time is greater than the physical *RC* time constant by a calculable gain factor. Hence, smaller capacitors can be used for a given integration time.
3. Although it multiplies the physical integration time constant by using positive feedback, the circuit is rendered highly stable by including negative feedback.

In the usual case, a designer will know the characteristics of the pulse train to be integrated, the desired pulse-to-dc gain of the integrator, and the desired integration time. The most useful design equations, obtained from a mathematical analysis of the circuit, are then:

$$\text{Gain} = \frac{\Delta E_o}{E_p} = G_1 \times G_2$$

$$= \frac{T_d}{T} \frac{(1 - \epsilon^{-\delta/T_c})\,(1 - \epsilon^{-T/T_d})}{|1 - \epsilon^{-(\delta/T_c + T/T_d)}|} \qquad (1)$$

$$\times \frac{\mu R_2}{(\mu R_1 + r_p)}$$

Effective Integration Time

$$RC_{eff} = \left[\frac{\mu (R_1 + R_g) + r_p}{\mu R_1 + r_p}\right] R_3 C_2 \qquad (2)$$

where $T_c = (R_g + R_f)\, C_1$

$T_d = R_d C_1$

r_p = dynamic plate resistance of $V1$

In these equations, and in Fig. 1, E_p is the peak pulse amplitude of the input voltage E_{in}, δ is the pulse width, T is the pulse period, and R_g is the pulse source resistance. We assume that $\delta << T$, $C_2 >> C_1$, and $(\mu + 1) \cong \mu$, which is the usual case.

The overall pulse-to-dc gain is expressed as the product of two individual gain terms, G_1 and G_2, for practical design convenience. The first gain term G_1 represents the pulse-to-dc conversion of the diode-*RC* pulse stretcher at the grid input of the integrator-amplifier. The second gain term

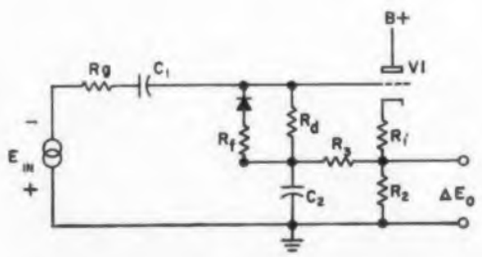


Fig. 1. Integration time can be varied over a wide range with this novel and simple pulse integrator.

G_2 represents the dc gain of the integrator-amplifier.

Knowing the characteristics of the input pulse train (E_p, δ, T); and the charging resistance, $R_g + R_f$; the first step in the design of the circuit is the determination of C_1 and R_d. As a practical matter, the designer, in most cases, can immediately choose R_d as 1 meg since he knows that maximum pulse-to-dc conversion efficiency is achieved with the greatest possible ratio of R_d to $(R_g + R_f)$.

The largest value of R_d permissible is limited by most tube specifications to about 1 meg. Actually, the only component value to be determined in the G_1 term is C_1.

Here again, in a practical circuit, the designer is usually interested in only one of two possible cases. He is either interested in the maximum pulse-to-dc conversion, or he is interested in preserving the pulse-to-pulse amplitude relationship of an input pulse train which has a random pulse-amplitude variation. The latter case requires a stretcher discharge-time constant of about one-fifth of the pulse repetition period.

For maximum pulse-to-dc conversion:

$$C_{1\ optimum} = \frac{\delta}{(R_g + R_f)}$$

For following random amplitude fluctuations of the input pulse train with high fidelity:

$$C_1 \cong \frac{T}{5\ R_d}$$

The designer may in some cases choose a value of C_1 between these two extremes as a system compromise.

Having determined R_d and C_1, the first gain term, G_1, may be evaluated. Knowing the overall gain desired, the required value of G_2 may then be found. The tube and operating point chosen will then determine μ, r_p, and R_1. The required value of R_2 may then be found by rearranging Eq. 1 to yield:

$$R_2 = \left(\frac{\mu R_1 + r_p}{\mu}\right) G_2 \qquad (3)$$

Eq. 2 shows that the physical integration time constant, R_3C_2, is multiplied by the factor

$$\frac{\mu (R_1 + R_2) + r_p}{\mu R_1 + r_p}$$

This multiplying factor may now be determined since R_2 is known. Values for R_3 and C_2 may then be chosen to give the desired integration time. The designer has great latitude in the choice of R_3 and C_2 for a given integration time, allowing consideration of component physical size as an important factor.

Either R_3 or C_2 may be varied to change the integration time without affecting the circuit

gain. This leads to the possibility of replacing fixed resistor R_3 with a variable resistance, providing a constant gain circuit with variable integration time.

Sample Design Procedure

To illustrate the application of this design procedure, one may consider the specific case of a pulse train input with the following characteristics:

Peak pulse amplitude $E_p = -10$ v

Pulse width $\delta = 1 \times 10^{-6}$ sec

Pulse repetition period $T = 100 \times 10^{-6}$ sec

Pulse source resistance $R_g = 10{,}000$ ohms

The input pulse stretcher is to be designed for maximum pulse-to-dc conversion. An overall pulse-to-dc circuit gain of unity is desired to produce a 10-v increase in the dc level at the integrator output due to the specified pulse train input. The desired integration time is 100×10^{-3} seconds.

The first step in the design of the circuit is the determination of the values of R_d and C_1 in the input pulse stretcher. Since maximum pulse-to-dc conversion in the stretcher is desired, R_d is chosen to be as large as tube specification will permit which is 1 x 10^6 ohms. Then

$$C_{1\ optimum} = \frac{\delta}{R_g + R_f}$$

Since in this case the 10,000-ohm source resistance R_g is two orders of magnitude greater than the estimated 100-ohm diode forward resistance R_f, the calculation of $C_{1\ optimum}$ is simply

$$C_{1\ opt} \cong \frac{\delta}{R_g} = \frac{1 \times 10^{-6}}{1 \times 10^4} = 100 \times 10^{-12}\ \text{f}$$

The first gain term G_1 may now be evaluated,

$$G_1 = \frac{T_d}{T} \frac{(1 - \epsilon^{-\delta/T_c})\ (1 - \epsilon^{-T/T_d})}{[1 - \epsilon^{-(\delta/T_c + T/T_d)}]}$$

where

$T_c = (R_g + R_f)\ C_1 \cong (10^4)\ 100\ (10^{-12}) = 10^{-6}$ sec

$T_d = R_d C_1 = 10^6\ (100)\ 10^{-12} = 100 \times 10^{-6}$ sec

Then

$$G_1 = \frac{\overline{100 \times 10^{-6}}}{100 \times 10^{-6}} \times \frac{(1 - \epsilon^{-10^{-6}/10^{-6}})\ (1 - \epsilon^{-100\times10^{-6}/100\times10^{-6}})}{[1 - \epsilon^{-(10^{-6}/10^{-6} + 100\times10^{-6}/100\times10^{-6})}]}$$

$$= 0.46$$

Since the overall pulse-to-dc gain desired is unity

$$G_2 = \frac{1}{G_1} = \frac{1}{0.46} = 2.2$$

Having determined the required value of G_2, the designer must next select a specific tube and

approximate operating point. This selection will determine μ, r_p, and R_1.

For one section of a type 6111 dual triode, with an operating point of 150 v on the plate, 2 ma plate current, and grid bias of -6 v:

$$\mu \cong 20$$

$$r_p = 7500 \text{ ohms}$$

$$R_1 = 3000 \text{ ohms}$$

Eq. 3 may now be used to determine

$$R_2 = \left(\frac{\mu R_1 + r_p}{\mu}\right) G_2$$

$$= \left[\frac{20\,(3000) + 7500}{20}\right] 2.2$$

$$= 7500 \text{ ohms}$$

The integration-time multiplying factor may now be determined.

$$\left[\frac{\mu\,(R_1 + R_2) + r_p}{\mu R_1 + r_p}\right]$$

$$= \frac{20\,(3000 + 7500) + 7500}{20\,(3000) + 7500} = 3.2$$

Since the desired integration time is 100 x 10^{-6} sec

$$R_3 C_2 = \frac{100 \times 10^{-6}}{3.2} \text{ sec}$$

$$= 31.2 \times 10^{-6} \text{ sec}$$

If R_3 is chosen to be 62 x 10^3 ohms, then

$$C_2 = \frac{31.2 \times 10^{-6}}{62 \times 10^3} = 0.5 \times 10^{-6} \text{ f}$$

The completed design is shown in Fig. 2.

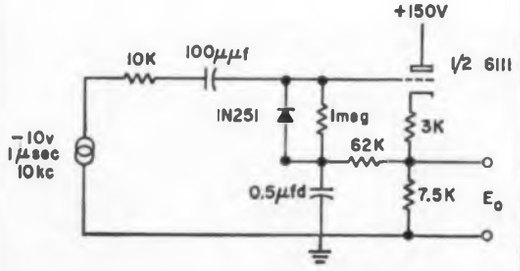


Fig. 2. A unity-gain pulse integrator with a 100-msec integration time. The peak pulse amplitude is —10 v, the pulse is one μsec wide, and its repetition period is 100 μsec.

Upon application of the specified input pulse train, E_o in Fig. 2 rises from a static level of +15 v to a level of +25 v ($\Delta E_o = 10$ v), with a time constant of 100 msec. ■ ■

Acknowledgments

The development of this circuit was based on an original design suggestion by G. W. Rodgers, Sandia Corp., Albuquerque, N. Mex.

Null-Readout, Precision Scope Syncs Complex Waves

A NULL-BALANCE technique, used for the first time in a commercial oscilloscope, yields hard-to-beat accuracies in scope measurements of voltage and time. Though null readout is enough to make any scope "different," the Analab 1100 has a profusion of unusual features. They include:

- Variable sweep length in addition to variable sweep rate.
- A "beam finder" which automatically locates off-screen traces and gives "notch" positioning on expanded sweeps.
- A 5AQPB aluminized monoaccelerator crt which, with 3-kv acceleration potential, offers as much light output as conventional post-accelerator tubes with 6 or 7 kv; better resolution and linearity; more uniform spot size; longer screen life; elimination of spurious screen charges and cathode glow; and elimination of post-deflection distortion.
- Anti-parallax graticule, equivalent to a mirror-backed scale on a meter, which enhances the null-readout accuracy.
- Safe, off-ground operation to 500 vdc.
- Functional color-grouping of controls on front panel.
- A scale-illumination control with f/stop markings for use in scope-trace photography.
- Sync and trigger-shaping circuits so stable that front-panel stability control is not needed.

This scope marks a departure from the megacycle race for higher and higher frequency scopes. Its development stems from the concept of its manufacturer, Analab Instrument Corp., 30 Canfield Road, Cedar Grove, N.J., that the low-frequency scope field has been too long neglected and that there's much room for improvement.

Null Readout Cuts Many Errors

The null readout offers a dramatic example of a change in low-frequency scope philosophy. The readout controls, accurate to 1 per cent of full scale, allow the user to position different parts of a waveform at the horizontal or vertical axis and allow him to read the voltage or time directly from the readout dials.

This procedure avoids nonlinearities inherent in the crt and the deflection amplifiers and, with the anti-parallax graticule scribed on the front and rear of the face plate, it allows the operator to eliminate parallax errors.

Variable Length Sweep Supplements Variable Rate

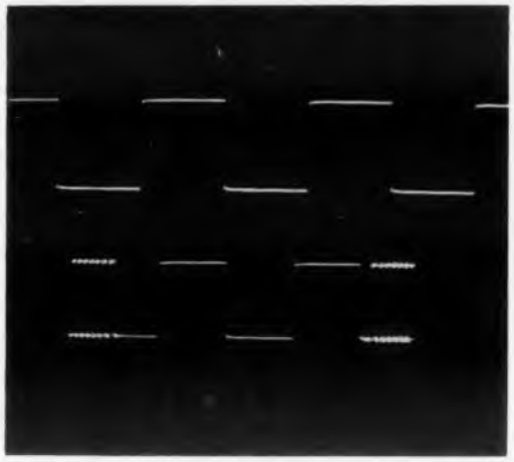
The variable-length sweep constitutes another innovation in low-frequency scopes. It provides a gate whose length is calibrated from 1 μsec to 50 sec. Uncalibrated, the gate can be used to 150 sec. This gate can be used to synchronize the sweep to almost any part of almost any waveform.

It can be used, for example, to trigger the sweep from the second cycle of a damped oscillation though the first cycle had a higher amplitude. The trigger can start a sweep on another scope so one can simultaneously view an expanded part of a complex wave. Or the trigger can delay the sweep of another scope or of a separate plug-in, soon to be made available. Or it can start and stop an external counter.

The Analab type 1100 main frame with the

Null-readout, dual-channel scope gives voltage and time on 1-per-cent-accurate readout controls.

Calibrated sweep length pinpoints a desired time interval of digital decade counter and feeds start and stop triggers to Berkely Time Interval Meter. Scope shows number of counts per decade while Interval Meter displays duration in digital form.

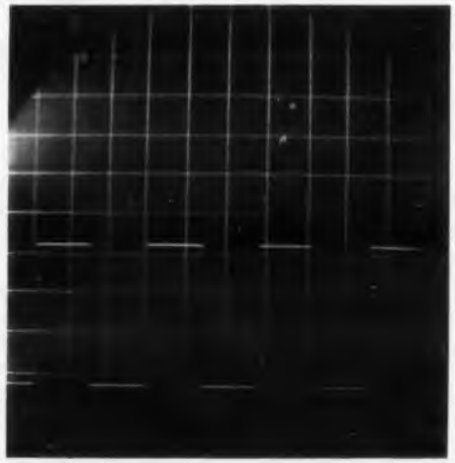


"Beam finder," used with expanded sweep, tags a particular cycle of interest. With beam finder on (lower trace), observer centers expanded part of trace with horizontal positioning control. He can still see its location with respect to total display. When beam finder is released, desired expanded portion is centered on screen.

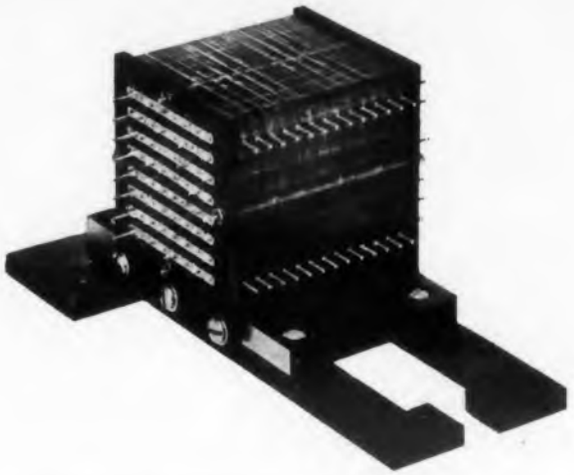
dual-channel type 700 plug-in sells for $695. It will be on 30-day delivery after the end of May. Both channels of the plug-in have a sensitivity of 100 μv per cm over their full dc-to-150-kc bandpass.

The scope features full 10-cm deflection in both *X* and *Y* directions. It has been thermally designed to the extent that no forced ventilation is required. This obviates filter cleaning and, of course, avoids the noise of fans.

For more information on this oscilloscope, turn to the Reader-Service Card and circle **100.**



Grid pattern made by multiple exposure of a vertical and horizontal line, positioned incrementally by null-readout dials, permits precise photographic scaling. Distortions in camera lens or crt appear in grid pattern as well as waveform. Graticule shadow on the crt screen helps emphasize distortion due to curvature of the tube face.



Rod memory without circuitry. Rods are the small "lines" protruding from left end (not the solder terminals.)

Magnetic Rod Computer Elements Made Commercially Available

MAGNETIC rod computer memories are now commercially available—one as an off-the-shelf item—to design engineers from the National Cash Register Co.'s Electronics Div. The rod is a high-speed magnetic device that reverses its state in about 50 mμsec.

Only the rod memory made for a U. S. Navy application is available as an off-the-shelf item. The Navy's 1000-bit memory required its own power supply and switching circuits necessary to provide integration with associated equipment. This unit was made for ground equipment operating in a normal environment, and limited emphasis was placed on size, weight, and unique packaging.

Other rod memories will be made and sold according to customer requirements —which includes memory size, power, speed, total size, weight, environment, etc. There are no limitations on memory size other than economic considerations. Like cores, the rod module can be organized into small planes and arrays, or larger ones with the added flexibility of a building-block concept.

Price and delivery (which depend on the parameters mentioned above) are "comparable to cores at this time," reports the manufacturer (located at 1401 E. El Segundo Blvd., Hawthorne, Calif.). However, it adds, "improved manufacturing techniques which are presently underway, will undoubtedly reduce the cost of the rod significantly below that of present day cores, on a per-bit basis."

Besides its large-scale memory applications, there are other applications—high-speed scratch pad memories, index registers, small memories within an existing slower core memory, or buffers for intercomputer synchronization. The present rod memory can be "accessed" three or four times during a core memory cycle, and a more sophisticated rod unit can be "accessed" six to eight times during the same period.

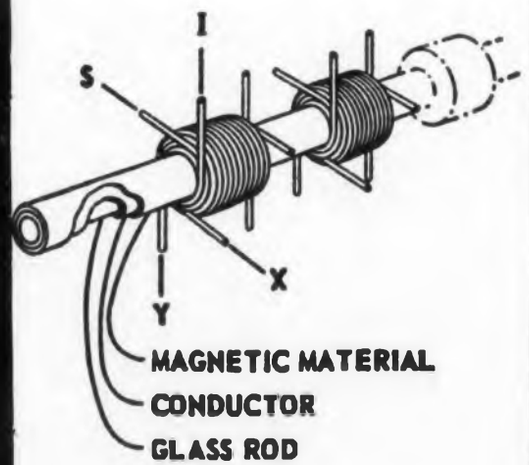
The rod is constructed by silver-coating a 10-mil glass rod and electroplating that

with a very thin coating of iron-nickel alloy, about 3000 angstroms thick. The rod is plated in continuous lengths so that it has the advantage of a continuous magnetic element in which many (10 per linear inch) bits can be handled and tested as a single unit.

Organized into a memory system, the rod is threaded through previously wound and stacked solenoid matrices which are machine-wound for uniformity and economy. At each bit position three or four superimposed solenoids are required: two inputs, a sense and inhibit for coincident-current operation; one input, a sense, a bias, and an "enable" for word-ordered operation.

In a coincident-current operational mode, the rod has performed satisfactorily over the temperature range of −100 to +200 C, the manufacturer reports. It adds that, because of its high-speed switching characteristics and its use of multiple sense turns (typically 10), large memory sense output voltages are developed (greater than 100 mv). This, the manufacturer says, greatly simplifies circuitry design and signal detection.

For more information on this memory unit, turn to the Reader Service Card and circle number 101.



I – INHIBIT (FIRST WINDING)
S – SENSE (SECOND WINDING)
Y – Y DRIVE (THIRD WINDING)
X – X DRIVE (FOURTH WINDING)

Magnetic rod with solenoid bundles wound in coincident-current memory mode.

New Directions in Tube Design Unveiled at IRE Exhibits

Show displays feature crt's for transistor circuits, Higher power microwave tubes and magnetron revival, More reliability and uniformity in receiving types.

STEPPED-UP design activity in many segments of the tube industry was indicated by the many developments shown at the 1960 International Convention of the Institute of Radio Engineers in New York.

Military requirements for new and specialized tube types have been responsible for much of the pick up.

Display tubes suitable for transistorized circuits appear to be the major design effort in the crt industry. Competition is also developing in high-resolution crt's, printing and character-forming tubes.

Microwave activity is also at high pitch as manufacturers aim toward higher and higher power levels. Magnetrons are making a comeback with the importation of extremely high frequency types and the development of voltage-tunable maggies. Many PPM-focused traveling-wave tubes were shown but few electrostatically focused types.

The efforts of receiving-tube manufacturers are being directed at increasing reliability and uniformity to meet the combined threat of transistors and foreign imports.

Crt's Developed For Transistor Circuits, High Resolution Needs

IRE show exhibits indicated that activity was being stepped up in cathode-ray tube design, with particular emphasis on tubes for transistorized circuitry. Several developments in both TV tubes and industrial crt's illustrated this trend.

Thin-film aluminized oscilloscope tubes with accelerating potentials in the 2-to-5-kv range, shown by Thomas Electronics, Inc., Passaic, N. J., are one step in this direction. (See p. 32, this issue.)

Previously instrument tubes with accelerating potentials below about 5 or 6 kv were not aluminized. Aluminizing increases brightness about 50 per cent at accelerating voltage levels suitable for transistorized equipment. This permits beam current to be reduced so that better resolution can be achieved.

Crt's specially designed for transistorized oscilloscopes, using the low-voltage aluminizing process, are now being developed in Thomas' laboratories, according to Peter Seats, director of the company's Research and Development Div.

Move to Electrostatic Deflection

IRE exhibitors indicated that crt designers were turning to electrostatic deflection to meet the requirements of transistorized circuitry and battery operation. This method considerably lowers deflection power, but it also gives poorer linearity that can be achieved with electromagnetic deflection. Various schemes to overcome the inherent disadvantages of electrostatic deflection are being tried.

The chief drawback to putting deflection plates inside the tube instead of an electromagnetic yoke around the neck is that a uniform field is much harder to achieve. Ideally deflecting field lines should be perpendicular to beam motion at all points within the tube.

Curved deflection plates, which flare out like a speaker horn, are being used by Allen B. DuMont Laboratories, Inc., Clifton, N. J., to help solve this problem, according to Dr. A. E. Beckers, director of tube engineering for the company.

DuMont has developed a 3-in. electrostatically deflected tube, type 3BFP, priced at $150. The tube offers transistorized-equipment designers a 1.5-kv accelerating potential, with vertical deflection sensitivity of 9 to 12 v/in. and horizontal deflection sensitivity of 12 to 15 v/in.

Electronic Tube Corp., Philadelphia, is using extra-wide horizontal deflection plates in a transistorized oscilloscope crt it is developing under Navy contract. The tube will be used in the Navy's AN/USM-117 fully transistorized 5-mc oscilloscope, according to Kenneth G. Meinken, executive vice president. Engineering samples of a commercial version of the tube will be available at about $100 each by mid-May, Mr. Meinken said.

The 31BSP2 operates at 3.5-kv accelerating potential, with 12.5 v/in. vertical deflection sensitivity, and 26 v/in. horizontal deflection sensitivity. It is a spiral-banded, post-accelerator type with a 3-1/4 x 2-3/4 in. rectangular faceplate. The usable scan is 2-1/2 in. horizontally and 2-1/4 in. vertically.

When in production, probably by late July, unit prices in the $45 to $65 range are expected for the tube.

Transistorized oscilloscope crt developed by Electronic Tube Corp. rests against a scope camera. The rectangular-face tube is about 13½-in. long. Electrostatic horizontal tapered deflection plates are almost as wide as the tube's inner diameter.

TV Tube Makers Also Active

Sylvania's experimental scan-magnification tube was another indication of the transistorization trend in crt design. In this scheme an electrostatic deflecting mesh is added to an electromagnetic deflection tube, providing two-times linear magnification or four times the viewing area for equivalent deflection power. This is accomplished, Sylvania says, in a 17-in., 110-deg tube with an anode voltage of 10 kv and a mesh voltage of 5 kv.

This is an optimum choice, according to Ralph R. Shields, manager of electronics products sales for Sylvania's Television Picture Tube Div., because a lower anode to mesh ratio would result in neck shadow. The mesh, or diverging lens assembly, is placed 0.4 in. behind the yoke reference line in Sylvania's tube.

This development is being evaluated by set makers, Mr. Shields said, as Sylvania continues work on several other schemes to maximize deflection efficiency while retaining picture quality and linearity.

Low heater power for battery operation was another feature of some of the tubes at the Sylvania exhibit. Filament operation is at 1.5 v and 140 ma, rather than the standard 6.3 v, 600 ma. This power reduction of nearly 20 times is achieved through a highly efficient heater-cathode arrangement.

Philco Has Low Heater Power

Philco's Lansdale Div. has also developed low heater power tubes that will soon be introduced. The filament operates at 1.9 to 2 v at about 100 ma, according to J. William Snyder, engineer in charge of cathode ray-tube development.

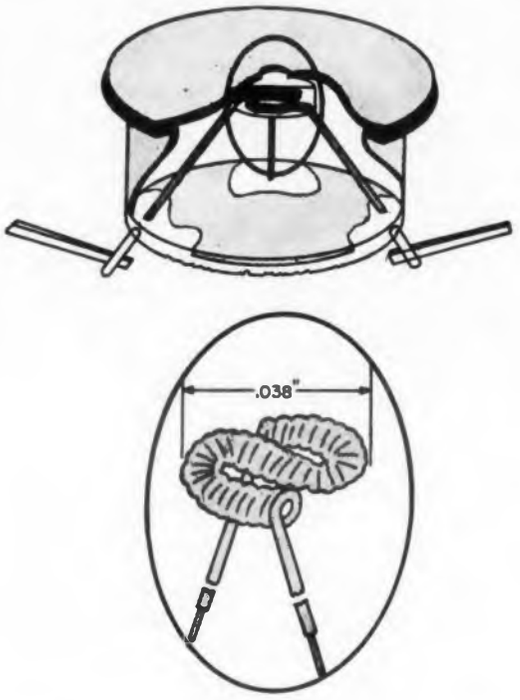
An S-shaped filament coil is placed in a small nickel cylinder, 0.050 in. diam and 0.018 in. long. This cathode cap is filled with a liquid aluminum oxide preparation to insulate the filament from the nickel.

The cathode cap is then fixed in a grid cylinder, with the filament connections and a 0.002-in. cathode tab set in Sauereisen cement so proper positioning is maintained. Emissive cathode material is sprayed onto the top of the cathode cap through the grid aperture after the cathode is firmly in place.

Cathode glow is almost eliminated with this highly efficient configuration. Measurement with an optical pyrometer indicates a temperature of about 760 C on the emissive surface, about equal to that achieved by the conventional 3.78-w heater, Mr. Snyder said.

Military Needs Bring New Tubes

Military radar requirements have also brought cathode-ray tube design activity. High-resolution tubes, said to be particularly useful for side-looking radar, were shown by Litton Industries, Sylvania, and DuMont.



Exploded view shows how Philco's S-shaped filament fits into the 0.050-in.-diam. cathode cap in the company's low heater power design. This configuration permits filament operation at 1.9 to 2 v and 100 ma rather than the conventional 6.3 v at 600 ma, a power reduction of nearly 20 times wothout reducing temperature of the cathode emissive surface.

Litton showed its Micropix crt with 0.8-mil spot size, designed for operation to altitudes of 70,000 ft. Fine-grain phosphor is deposited on the face of this tube before the face is joined to the tube body, according to Donald R. Cone, assistant to the manager of the Display Devices Dept. in Litton's Electron Tube Div.

The 5,000-line, 5-in. model of this tube, operating at 27.5 kv accelerating potential, is priced at about $990.

Sylvania showed its SC-2782 tube with 1-mil spot size, and its SC-2809 crt with 0.8-mil spot size. Both are 5-in., 50-deg deflection tubes, with about 23.5-kv accelerating potential. OEM price of the SC-2782 is about $250. Price of the 0.8-mil tube was not learned.

DuMont is producing 3-in. tubes with 0.7-mil spot size; 5-in. with 1-mil spot size, and 7-in. tubes with 1.5-mil spot size, all with 25 μamps beam current.

Efforts toward higher resolution are continuing, according to DuMont and Litton spokesmen, who said that laboratory tubes with 1/2-mil spot size have been produced.

Resolution of this order is also useful for electrostatic type printing tubes, which have been developed by all three companies.

Character-Display Tubes Shown

Litton also showed a character-display tube, the Composipix, which uses electromagnetic deflection to position a character on the tube's face and electrostatic deflection to form characters. This tube is capable of displaying a radar or oscilloscope pattern, with characters placed at desired positions, according to a company spokesman. The type L-4010 5-in. tube, with 4,000 line resolution, is priced at about $1,180.

The Charactron display tube developed by Stromberg-Carlson-San Diego, Div. of General Dynamics Corp., uses a selection plate to form letters. The electron beam is directed at a particular aperture in the selection plate matrix. Each aperture is shaped like a symbol, number or letter, so that the beam forms that character.

After the character is formed, electrostatic deflection plates align the beam on the axis of the tube. Then it is magnetically focused and deflected to its display position.

Several other character-generation schemes are being studied by tube manufacturers, it was learned. Among these is a technique for selecting particular portions of a lissajous figure and deflecting them to desired positions on a tube face. The disadvantage of the character matrix technique, sources commented, is that beam current is considerably reduced in the selection process.

Small Crt Monitors Displayed

Waterman Products Co., Inc., showed 2-in. tubes designed to monitor crucial circuits. Requests for these small tubes were brought on by the Russian equipment displayed in the Coliseum last year, according to Joseph Boyle, field engineering manager for the company. Small monitoring display tubes were used extensively in Russian-designed systems.

Waterman's VC-118 2-in., flat-face tubes are priced in the $12 to $15 range. Deflection sensitivities are 34 v/in. vertical and 60 v/in. horizontal.

The automotive test equipment market is currently the biggest outlet for low-priced, electrostatically focused and deflected tube types, according to Mr. Boyle.

Sylvania also showed small tubes in its Stack mounting concept. Three small monitoring tubes were stacked one on top of the other in the Sylvania display, next to a large three-gun tube. The use of the three separate monitors avoids the catastrophic failures possible with a multi-gun tube, according to a company spokesman. In addition the cost of the three small tubes will probably be smaller than that for the multi-gun tube.

Klystrons March To Higher Power, Other Tubes Join Parade

SEVERAL PULSE and cw klystrons of the very highest ratings were announced by the big three of the field—Eitel McCullough, Litton and Varian.

The Eimac X-626 was announced for the first time during the IRE show, although it has been in production under wraps for about a year. The klystron delivers 1.25 megawatts peak and 75 kw average power at 450 mc, with pulse-length up to 2 msec. The tube has been selected for duty in BMEWS (Ballistic Missile Early Warning System) because of its high reliability, according to George Chamber of Research and Development Marketing. At the same time, Varian made public its VA-842 klystron, designed to the same peak, average and pulse-length specs.

The interesting difference in approach is that while the three-cavity X-626 uses external cavity design, characteristic of Eimac tubes, the four-cavity VA-842 incorporates internal cavities. Advantages are cited for both approaches—broader tuning and lower replacement cost for the former, simplicity of operation and non-critical focus structure for the latter.

Litton announced its type L3387 pulsed amplifier klystron which can produce the enormous peak power of 30 megawatts. A low duty cycle (0.0033) drops the average power to 100 kw, still a respectable figure. Operating at 1250 to 1350 mc, the tube provides a gain of 36 db. Three integral cavities are mechanically tuned over this frequency range. Company representatives stated that this is the highest powered integral-cavity tube ever produced at these frequencies.

Four-cavity X-band klystron amplifier handles 5-kw cw power in a 6-lb package.

Varian announced two other high-power tubes, the 11.5-kw VA-833 Band and the 11.0-kw VA-833 C, which are cw amplifiers covering the 0.47-to-0.985-kmc band, suitable for color TV or multichannel phone carriers. In the X-band, Varian announced a 6-lb marvel of liquid and air cooling, the VA-823 series, which delivers 5 kw of cw power in the 8-to-10-kmc range. The external electromagnet used with this four-cavity tube weighs 200 lbs. Just coming out of development was Raytheon's QK680, an Amplitron capable of delivering 8 kw of cw X-band power at efficiencies of 60 per cent higher.

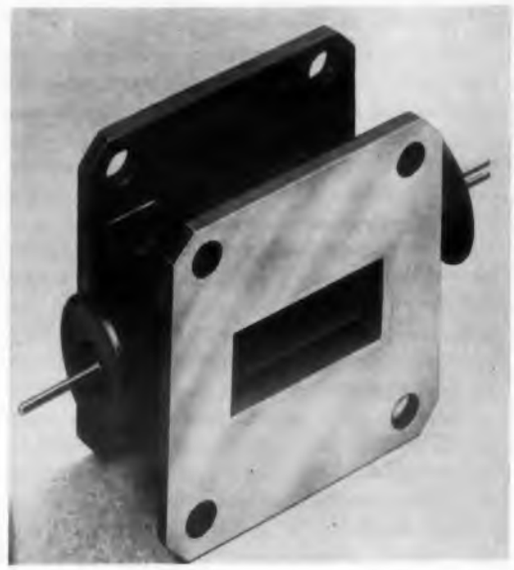
No End In Sight For Super Power

Other tubes still in development, but described at show time by the manufacturers, indicate that the drive toward greater power will continue. Varian representatives said the company is working on the VA-849, a 20-kw cw X-band klystron series, and on the VA-850, a pulse klystron providing 25 megawatts peak and 25 kw average power at S-band for radar and linear accelerators. Eimac tubes coming down the development pipe soon are the X 632, a metal-ceramic four-cavity pulse klystron at S-band, delivering 10 megawatts peak and about 16.7 kw average power, and the X 700 high-duty-cycle klystron of 20 kw peak and 1 kw average power.

About IRE Show time, RCA announced its developmental type A-2346, a 5-megawatt peak, 300-kw average power triode, claimed to be the most powerful in its 450-mc frequency range. A water-cooled 5-megawatt magnetron, delivering 12.5-kw average power and operating in the 1250-to-1365-mc frequency range was announced by English Electric Valve at about the same time. Several high-powered magnetrons from Raytheon indicate that this tube type is very much a contender in the megawatt field. The liquid-cooled RK 7528, delivering 2 megawatts of peak and 2.4 kw average power, is tuneable over the 1250-to-1350-mc range. Expected life is 250 hrs, objective is 500 hrs. The RK 7484 is a forced-air equivalent, delivering 2-kw average power, with life expectancy upped to 300-1000 hrs. The liquid-cooled RK-7529 delivers 3.5 megawatts peak and 2.5 kw average (in the 2700-2850) mc range. The liquid-cooled QK 665 and QK 666 deliver 5 megawatts peak, 9 kw average power in the 1250-1350 mc range.

Klystrons—High, Wide And Then Some

Among lower power klystrons, the new look featured higher frequency, wider tuning range, lighter weight, longer life. Raytheon's QK 673 reflex klystron is pushing the frequency frontier to a range of 88-92 kmc. The tube is mechanically tuneable through this range via a micrometer control, and produces a minimum of 3 mw



External trigger fires this Sylvania ST 4199 X-band switch tube, eliminating spike leakage.

over the tuning range. In addition electronic tuning is possible over a 90-mc range. The tube was used with a frequency doubler in the working demonstration of FXR's 2-mm waveguide setup.

At IRE Show-time, Polarad announced work on a series of higher-frequency broadband Velocitrons, which will enhance the performance of their signal generators. The ZV 1009 now covers the range of 1.5 to 6.0 kmc in three modes of oscillation, while the ZV 1011 covers 4 to 11 kmc in two modes, producing 50 mw minimum. Work is in progress to attain the wide-tuning range at much higher frequencies. All these tubes are of high-temperature metal-ceramic construction.

A metal-ceramic klystron introduced by Sylvania for the new civilian band of 12.1 to 12.8 kmc attracted a great deal of interest at the show. Life expectancy for this tube is 10,000 hours. An integral tuning cavity is external to the vacuum chamber.

Raytheon entered the power klystron field with a new broadband medium power klystron. The 5-ft, 65-lb. tube incorporates a high perveance gun allowing operation at lower voltage than comparable klystrons.

Maggie Here to Stay

That the magnetron is very much alive in the midst of contending tube types could be seen from the many new maggies at the show, medium-power as well as high-power already mentioned. Two 8-mm magnetrons are currently being imported. One, a 25-kw import from Holland (*ED* March 2, 1960 p. 36), type 7093, is

being distributed by Amperes Electronics. The other, a 100-kw heavyweight, type MG 16T1 is imported from France by ITT.

Sylvania exhibited ruggedized K-band M 4154, Ka-band M 4155 and Ka-band M 4063 magnetrons. These tubes can withstand 30 g's from 20 to 2000 cps in all three planes according to William Dowden, product sales manager. The three tubes are rated at 45-65 kw, 32 kw and 40 kw peak, respectively.

Considerable interest was exhibited in General Electric's voltage tuneable magnetrons, demonstrated at the Essex House during the IRE show. The high efficiency inherent in magnetrons coupled with the relatively flat (less than 1.6 db) characteristic over a tuning range of greater than 2:1 has already led to incorporation of these tubes in forthcoming signal generators, according to Robert I. Reed, application engineer. In addition to the 1-w, 1-to-2.3-kmc Z 5405 announced last year, a 4-w 2.9-to-3.1-kmc Z 5337 was shown. This pound and a half of microwave source is equipped with a magnetically shielded integral magnet. Among the many other new magnetrons of medium power were six introduced by Raytheon.

TWT's Advance in Low Power Applications

New traveling-wave tubes exhibited advances in almost every characteristic—lower-noise, lighter-weight, wider-band. In the area of power, however, nothing new was seen that approached Varian's 2-megawatt peak, 4-kw average VA-125, A,B tubes.

Sperry exhibited a family of high-gain PPM traveling wave tubes covering the complete spectrum from P-to-X-band. As with most new tubes this year, metal and ceramic construction is used to improve shock and temperature characteristics.

Watkins-Johnson Co. announced two TWT's of the PPM type. The WJ-206, providing 10 kw peak power at X-band, features a magnetic focusing that is integral with the rf slow wave structure. This ungridded version will soon be joined with a high-mu gridded version. The WJ-211 has a lower noise figure (2.7 db) than ever before obtained with a microwave tube, according to H. Richard Johnson, vice president. Noise figure is said to be below 5 db over the full 2-to-4-mc octave.

Eimac's entry to the TWT field is represented by the X778, a ceramic-and-metal PPM type operating in the 5-to-11-kmc range. This tube is capable of 1-w output, and a small signal gain of 60 db. For C-band operation, Raytheon announced the QKW 825, a 3-w broad band power amplifying TWT for pulsed or cw operation.

In the S-band, Varian announced a 5-kw peak, 15-w average power PPM type TWT, the

TUBE ADVANCES

VA-128. Because this is a gridded tube, lower-modulating voltage is required. The tube operates in the 2.7-to-3.5-kmc range, and provides 800 mc of electronic bandwidth. The VA-131 TWT handles a husky 50-kw peak output, 200-watt average power in the 1.15-to-1.55-kmc range. Gain of this PPM tube is 45 db. Down at uhf, the new VA-132 periodic permanent magnet TWT handles 200 w cw power in the 0.5-to-1.0-kmc range.

Three electrostatic-focused TWT's were announced by Huggins labs. The HA-58 operates from 0.5 to 0.9 kmc, the HA-52 operates from 0.5 to 1.0 kmc, and the HA-27 operates from 1.0 to 2.0 kmc. In these tubes, all beam-focusing is accomplished by means of the electrostatic field set up between two helixes. The absence of any focusing magnet considerably reduces the size and weight of the tubes relative to the power handled. The HA-58, for example, handles 1 w, has a small signal gain of 30 db, and weighs 2 lbs. The only other electrostatically focused TWT mentioned at the show time is the X333 of ITT. This tube is designed to handle 5 w of cw power at the 1-2 kmc frequency range, and provide 30 db small signal gain.

BWO's Still Permanent Magnetic

In spite of many indications recently that electrostatic BWO's are just around the corner, only permanent magnet types were noticed at the IRE Show. Varian recently announced a new line of small, low voltage tubes covering from 3.1 kmc to 18 kmc with five tubes. The VA-163, covering from 18 to 26.5 kmc was announced at the show. Another type, the VA-164, covering the range 26.5 to 40 kmc will soon be available. Bendix exhibited a BWO line covering the 40 to 75 kmc range in four tubes. Raytheon exhibited a ruggedized BWO line covering the 1-to-12.4-kmc range with four tubes.

Odds and Ends of Microwave Tubes

The Barratron, "Big Noise From San Carlos" in last year's ads, was apparently silenced for security reasons this year. It was missed from Litton's display. Sylvania showed a unique microwave gas switch the ST 4199 that has virtually no spike leakage and less flat leakage than a TR, according to David Simon, advertising & merchandising manager. The gas is fired by an external source prior to the arrival of the high-power. Thus spike leakage is eliminated in this X-band tube, and 10 μsec switching is achieved.

Sperry announced a new "electric gun" that company representatives claim is five times more

powerful than earlier beam devices. The gun makes possible the development of 200-megowatt klystrons. Oxide coating is deposited on a concave button of special nickel material, 1-1/2 inch in diameter, from which electrons converge into a high-density beam.

Increased Reliability Uniformity Trend In Receiving Tubes

The receiving-tube industry revealed several new design features that, coupled with advanced automation techniques, will improve performance and reliability.

In conventional tube structures, such as shown in Fig. 1a, the side rods depend on the grid wires for support; in the "frame-grid" construction, shown in Fig. 1b, the four-sided frame is rigid and does not depend on the grid wires for support. Advantages of this construction over conventional types include less microphony, more uniform characteristics, lower equivalent noise resistance and higher slope.

New Ampliframes shown by Amperex Electronic Corp., Hicksville, L. I., N. Y., provide sufficiently high gain-bandwidth products to enable TV manufacturers to use two- rather than three-stage video intermediate-frequency sections without noticeable sacrifice in performance. A 6EH7

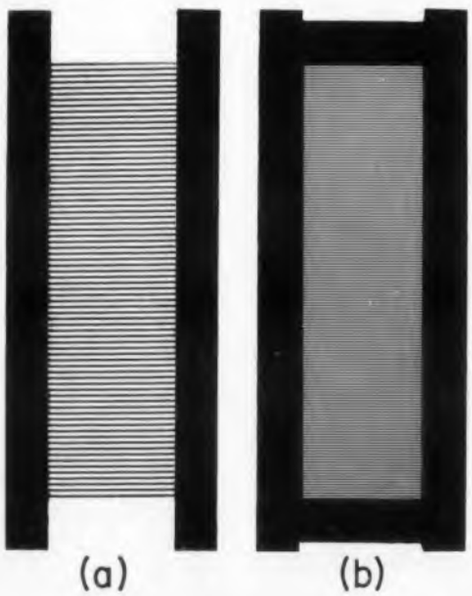


Fig. 1. Comparison between conventional grid (a) and frame grid (b) as they appear on a projection microscope screen. In (a) the side rods depend on the wires for support; in (b), the frame supports the grid wires.

TUBE ADVANCES

remote cutoff pentode and 6EJ7 sharp cutoff pentode offer g_m figures of 12,500 and 15,000 respectively. Thus a two-stage Ampliframe video if strip, with a 2.5-mc bandpass, is capable of a gain of 1,200 compared with 350 with two conventional tubes. A 6FY5 high-frequency triode for rf amplifier service offers 2 db higher gain and 1 db lower noise than previously available frame grid tubes.

GE Introduces 'Shadow Grid'

Another approach to low noise figures in vhf amplifiers has been labeled the "shadow grid" construction, shown at the IRE by GE's Receiving Tube Dept., Owensboro, Ky.

As seen in Fig. 2, an extra grid is precisely aligned and mounted in front of the screen grid of a 6FG5 pentode. The shadow grid, connected to the low potential cathode, tends to divert electrons around the screen grid and thus effectively shields each screen grid wire from the electron stream. Plate-to-screen current ratios as high as 60 to 1 have been achieved, with the 6FG5 screen dissipation rated as low as 150 mw. The screen may be tied to the plate supply directly, eliminating the need for a dropping resistor and bypass capacitor. The g_m of the 6FG5 is listed at 9,500 at plate and screen voltages of 250 v.

Sylvania's 9-T9 Series for Printeds

Octal base power output tubes for audio and TV deflection service are being re-packaged in straight-sided T-9 bantam bulbs by Sylvania

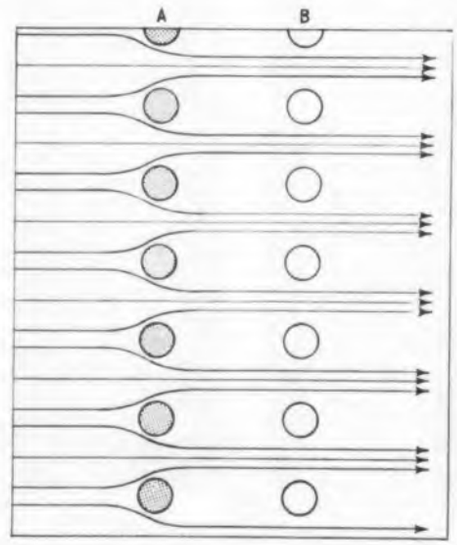


Fig. 2. Shadow grid *A* diverts electron flow around screen grid *B*, thus reducing screen current. Screen dissipation for the GE 6FG5 is only 150 mw.

Electric Products Co., Emporium, Pa. This permits the use of high plate dissipation devices in the space allocation previously restricted to lower rated tubes. Conventional nine-pin printed circuit sockets are used. A triode-pentode, 6HC8 and 17HC8, for 110-deg vertical deflection and a 4.5-w beam power pentode for audio, type 7695, were displayed at the IRE convention.

Multi-multi Tubes?

Perhaps the radio of the future will contain but one tube. If CBS and Tung Sol schemes are accepted by industry, there will be fewer tubes installed in equipment without sacrifice in performance. How? By incorporating multi-section tubes in a single envelope.

Tung Sol demonstrated at the IRE show developmental models of (1) a duo-diode twin triode; (2) dual pentode; (3) dual pentode-triode, and (4) a duo diode-triode-pentode. CBS, it was learned, is completing work on several triple triodes. Both CBS and Tung Sol devices will have 12-pin bases.

Crowds gathered around the RCA exhibit at the IRE show to examine the "Nuvistorized" TV portable on display. Developmental triode and tetrode types were used throughout, except for the deflection, power and high-voltage sections. However, RCA spokesman indicated that sampling and production of other than triode types were in the not-too-near future.

New Image Orthicons Displayed

General Electric Co. featured its GL-7629 thin-film image orthicon in its IRE booth. This recently developed tube (*ED*, Jan. 6, p. 58) has an aluminum oxide target 2 x 10^{-6} in. thick. It gives usable brightness in picking up a scene down to about 10^{-4} ft-L, according to a GE spokesman.

The tube, for both black-and-white and color TV, is priced at about $2,275. Military versions of the tube were also shown.

RCA showed its 4-1/2-in. black-and-white image orthicon, designed to replace standard 3-in. types where better definition is required. The 4-1/2-in. RCA-7389-A is OEM priced at about $1,400 compared with about $1,000 for the 3-in. model.

In the vidicon field, RCA is working on a 1-1/2-in. high-quality tube, and a 1/2-in. vidicon for small cameras, like those that might be used in a satellite.

Machlett Laboratories, Inc., Springdale, Conn., exhibited its ML-7038A vidicon. The G_3 electrode is an evaporated film on the side of the tube. The mesh-assembly support is fused into the glass tubing to provide increased ruggedness. After construction, the tube's face plate is bonded to the side by a cold seal. The price is $265 for the 1-in. vidicon. ■ ■

Solid Circuits are thinner than a thin dime.

Solid Circuits For Sale

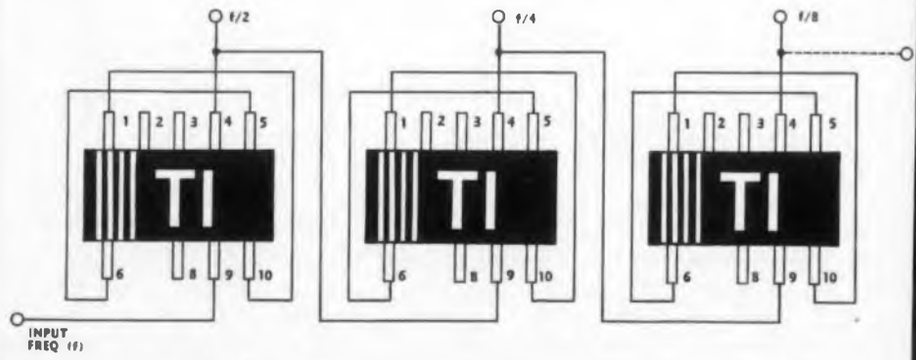
SOLID CIRCUITS are here—for sale! Only two years ago these minuscule circuits could be found only in the blue-sky writings of imaginative trade-magazine editors. Or they'd appear in the inspirational, after-dinner addresses of generals and admirals who were called upon to discuss—"the future."

For many who remember the days when a 6SN7 was the heart of a multivibrator, the match-head sized multi available from Texas Instruments, Inc.'s Semiconductor Components Div. in Dallas may fire the imagination with a mixture of astonishment and incredulity.

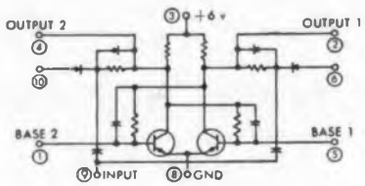
Yet this multivibrator, the TI type 502, is so real it carries a price tag; $450 per circuit in quantities less than 100, $300 each for larger quantities.

For applications in counter circuits, shift registers, and set-reset flip-flops it can be triggered at repetition rates up to 200 kc and can operate over a temperature range from −40 to +85 C.

With a 6-v supply, the multi can deliver at least 4 v to a 10 K load (con-



Solid-Circuit multivibrators can be interconnected to form many circuit configurations as exemplified by this binary counter.



Equivalent circuit of TI's off-the-shelf Solid-Circuit multivibrator.

nected to ground) when it is flipped off.

It can deliver a pulse as narrow as 1 μsec and can be triggered by as little as 1.5 v. Its maximum rise time is 1 μsec.

The Solid-Circuit diffused-silicon bistable multivibrator replaces the equivalent of 16 conventional components. Its dimensions, 0.250 x 0.125 x 0.031 in., are so tiny they can lead the unwary to assume packing densities that border on the absurd—to millions of parts per cubic foot.

Of course, interconnected Solid Circuits occupy small fractions of a cubic inch—not cubic feet.

Though TI's type 502 is the only Solid Circuit available off the shelf, many other circuits or combinations of circuits are available on a custom-designed basis. These can include logic gating configurations, oscillators, inverters, binary counters, amplifiers and others.

Interconnecting Solid Circuits is, of course, a rather delicate operation. Since lead spacing is 47 mils center-to-center, one doesn't wire these circuits into a system with a 100-w soldering iron. TI has developed some practical inter-connection schemes which will be available to users.

For much information on these little circuits, turn to the Reader-Service Card and circle **104**.

Solid-Circuit multivibrator is dwarfed by its king-size "miniature" counterpart.

Shaft Encoder's Performance Improved With New Magnetic Technique

HIGHER rotational speeds, increased reliability, and longer life--these are the advantages claimed for shaft position-to-digital encoders designed with a new magnetic technique. The noncontact technique generates digital signals representing input shaft position by altering the magnetic state of ferrite readout cores in accordance with a coded pattern cut into the surface of a ferrite disk driven by the input shaft.

Developed by the Librascope Div. of General Precision, Inc. (Glendale, Calif.) the magnetic encoders have a potential life exceeding 20,000 hr. The noncontact, magnetic technique eliminates any need for mechanical adjustment of encoder elements during the entire operational life.

The technique has been successfully applied, the company reports, to 7, 13, 17, and 19-bit encoders capable of 128 counts per input shaft revolution. Input shaft speeds as high as 10,000 rpm can be accommodated by the 7-bit encoder. Speeds of 3000 rpm are possible with the higher capacity units.

A wide range of digital codes including true binary, Gray, and binary coded decimal can be supplied in the encoders.

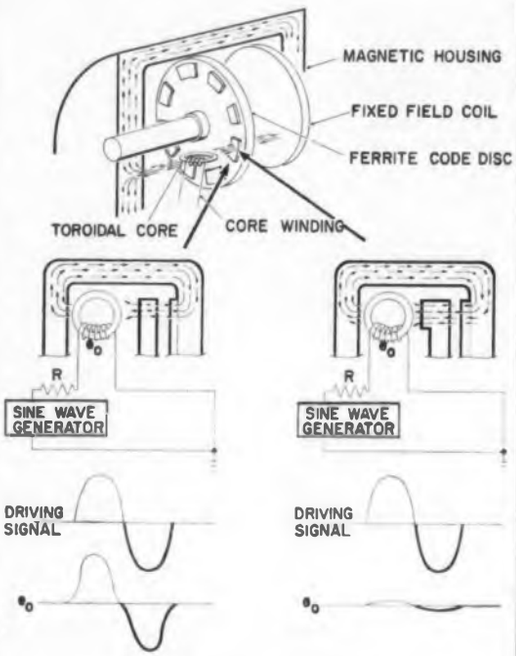
Operating Principles

The magnetic technique uses changes in the magnetic induction of toroidal cores to generate two-level voltage signals that can arbitrarily be designated as binary "ones" or "zeros". The signals are generated in response to the rotation past the readout cores of raised and depressed portions of a ferrite disk driven by the input shaft. The raised and depressed portions of the ferrite disk form a coded pattern that is a binary representation of the angular position of the disk.

The basic operating principles of the magnetic encoder are shown in the drawing. The ferrite readout cores and the ferrite code disk occupy the air gap between the ends of the magnetic housing. The field is generated by a field coil to one end of the magnetic housing. The total flux density within the readout core results from the flux generated by its own excitation current and the flux of the core-encompassing magnetic circuit. And the polarities of the two fields are arranged so that the action of the fixed field magneto-motive force opposes the core's excitation field's magneto-motive force.

When a depressed portion of the code disk track, corresponding to a binary "one", shares the air gap with the core, the fixed field flux density is decreased because of the increase in magnetic circuit reluctance. This results in an increased magnetic induction in the core and an increased impedance. The voltage

The left photo shows a complete unit; the right, the magnetic encoder disk.



The magnetic technique uses changes in the magnetic induction of toroidal ferrite readout cores to generate two-level voltage signals that can be arbitrarily designated as binary "ones" or "zeros."

drop across the core is increased so that the output voltage is high corresponding to a binary "one".

Conversely, when a raised portion of the code disk shares the air gap with the core, the fixed field flux density is increased because of the decrease in magnetic circuit reluctance. The resultant magnetic induction in the core is decreased and the core impedance decreased. The voltage drop across the core is decreased so that the output voltage is low corresponding to a binary "zero".

The technique provides "one" to "zero" voltage ratios of 20:1 or more, which permits a wide range of readout circuits to be used with the encoders. Operating temperature range for the encoders is −20 to +100 C.

Magnetic encoders may be used singly or in multiplexed combinations, and readout may be in serial or parallel form. Up to 20 encoders may be linked by a single-harness transmission system and excited by a single ac source. Sequential or random interrogation by a single set of decoding circuits is thus possible.

For more information on these encoders using the noncontact, magnetic technique, turn to the Reader-Service card and circle number **102.**

Fig. 1. Front and side view of the sealed contact reed relay. Two magnetically operated contacts are hermetically sealed in a glass capsule in an atmosphere of inert gas.

Reed Relay Provides Hundreds Of Millions Of Operations

THE CLAREED sealed-contact reed relay gives literally hundreds of millions of perfect operations, according to the manufacturer, because the contacts are virtually free from contamination. Magnetically operated, the contacts are enclosed with an inert atmosphere inside a hermetically-sealed glass capsule.

Suited for transistor drive applications as well as computers, data processing and automation equipment, the relay is made by C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill. Single capsule relays with individual coils or combinations of many capsules surrounded by a common coil are available to meet designers' requirements.

The nickel-iron alloy reeds are gold plated at the contact surface. And the shaft of each reed is mounted cantilever style in either end of the glass capsule and positioned within "extremely precise tolerances," according to the manufacturer. The switch can be made to close with as little as 0.25 w applied to the magnetic coil; it can operate in as little as 0.8 msec, and it can release in 0.25 msec.

Only 3.25 in. long, the capsule offers space savings, especially when mounted in groups with a common coil or on printed circuit boards. Able to withstand a shock of 40 g, the capsule can be operated in any position.

Contact arrangement is: normally, form A; biased, form B; by combination of A and B, form C. The contact rating is: to 1 amp; to 250 v; 15 v-amp max, non-inductive. Contact resistance is rated at 25 to 40 milliohms.

At 1/2 amp and 28 v dc, the life expectancy is 20,000,000 operations; at 1/4 amp and 28 v dc, it is over 100,000,000 operations. Minimum breakdown voltage at 60 cps is 500 v rms and the insulation resistance is a minimum of 500,000 meg.

The unit can stand a minimum vibration of 0.08 in. or 20 g, whichever is lesser, in the frequency range of 10 to 750 cps. Natural resonance of a single reed is 900 to 950 cps.

The switches per coil and the watts required to just operate the typical coils are, respectively: 1, 0.25; 2, 0.3; 3, 0.35; 4, 0.42; 5, 0.52; 6, 0.8; 12, 1.5; and 20, 3.5.

For more information on these sealed contact reed relays, turn to the Reader-Service Card and circle number **201**.

Fig. 2. Ten switches mounted in line, five on each side of a printed-circuit board, with five magnetic coils. This assembly may be mounted directly into a rack, or it may be enclosed in a flat, rectangular container.

Diode's Typical Switching Speed Rated At 0.3 Musec

THE TYPE D-4121 silicon diode can perform up to 500,000,000 logic functions in a fraction of a second. It has a guaranteed maximum speed of 0.8 mμsec, and a typical rating of 0.3 mμsec. It was designed for use in high speed military computers such as missile guidance and tracking systems and in commercial equipment.

Made by Sylvania Electric Products Inc. (Semiconductor Div., 100 Sylvan Road, Woburn, Mass.), the unit can "outrace any existing diode," according to Dr. William J. Pietenpol, vice-president and general manager of the company's Semiconductor Div. He said that as other components of comparable speed are developed, "it will be possible, for the first time, for logic circuits to process ideas in less than a billionth of a second."

The diode is hermetically sealed and capable of operating at 150 C. It offers "superior performance despite extreme conditions of vibration, shock, temperature change, and moisture," according to Dr. Pietenpol. The unit can operate in the microwave region—1000 mc and up.

At 25 C, the forward voltage drop (V_F) is 1.5 v when the forward current (I_F) is 40 ma; it is 0.6 v when the forward current is 10 ma.

Reverse current (I_R) is 200 μa when the reverse voltage (V_R) is 4 v. This rating is also applicable at 25 C.

For more information on this fast switching diode, turn to the Reader-Service Card and circle number **200**.

Capable of performing 500,000,000 logic functions in a fraction of a second, the D-4121 diode can operate at 150 C.

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

Center-To-Center Distance Between Cable's Conductors Measures 125 Microns 583

This microminiature cable has 20 conductors with a center-to-center distance of 125 microns. Designed for computer and satellite applications, the cable has a density of 40,000 conductors per square inch of cross section. Cable thickness is 100 microns. Weight of the cable is 620 mg per meter or 2400 ft per lb. And the tensile strength is 4 lb.

Tape Cable Corp., Dept. ED, 790 Linden Ave., Rochester 10, N. Y.

Price & Availability: *$1 per ft. Delivery is from stock to two weeks.*

Tunnel Diodes Made OF Gallium Arsenide 582

Made of gallium arsenide, the 1N650 series of tunnel diodes are designed for applications in high-speed computer circuitry. The diodes are packaged in a standard JEDEC TO-18 case and provide guaranteed peak currents up to 10 ma ±2%. Peak to valley ratios are greater than 15 to 1. Guaranteed forward voltages are up to 1.1 v ±5%; the units operate in temperatures to 150 C.

Texas Instruments Inc., Semiconductor-Components Div., Dept. ED, P.O. Box 312, Dallas, Tex.

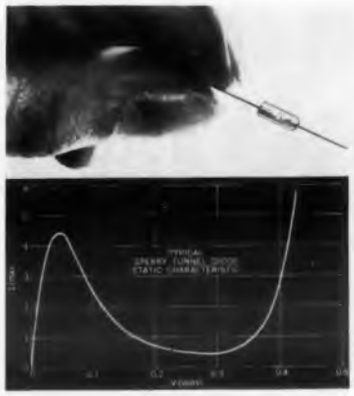
Price & Availability: *Available immediately with distributors handling orders up to only 999 units. Price is $27.30 per unit in quantities to 99; 1N653 priced at $8.10 when 1000 or more ordered.*

Incandescent Lamp Measures 0.015 In. In Diameter 601

Called the Pinlite, this incandescent lamp measures 0.015 in. in diameter and 0.062 in. in length. It is furnished with axial platinum leads 0.003 in. in diameter. The unit operates on 1.5 v dc and draws 15 ma. Typical applications include: computer read-out, meter pointer visual aid, and high frequency indicator to 3000 mc. The unit has a resistance of 15 ohms, when cold, and 100 ohms, when 1.5 v is applied.

Kay Electric Co., Dept. ED, Pine Brook, N. J.

Price & Availability: *Price is $4.75 per unit; it is available immediately.*

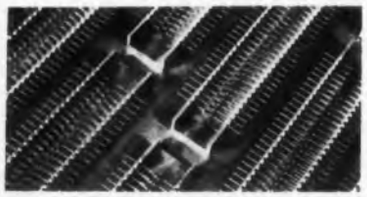


Tunnel Diodes' Peak Currents Range from 0.8 to 20 Ma 590

Peak currents of the types T101 to T105 tunnel diodes range from 0.8 to 20 ma. Peak to valley current ratios on all types are above 5 to 1, typically 8 to 1. The units have a typical peak point voltage of 50 mv and typical valley point voltage of 250 mv.

Sperry Rand Corp., Sperry Semiconductor Div., Dept. ED. South Norwalk, Conn.

Availability: *Sample quantities immediately.*



Silicon Computer Diodes Have 4-Musec Recovery Time 589

These glass silicon diodes have a maximum recovery time of 4 musec and a capacitance that is typically less than 1 μμf. Type numbers are 1N903 through 1N908, 1N914, and 1N916. They have voltage ratings up to 100 v and average rectified currents up to 75 ma.

Rheem Semiconductor Corp., Dept. ED, 350 Ellis St., Mountain View, Calif.

Price & Availability: *Immediately available. Average price is $4.25 at the 100-piece quantity level.*

CIRCLE 91 ON READER-SERVICE CARD ▶

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 2, No. 1

RAYTHEON "M"-TYPE BACKWARD WAVE OSCILLATORS

Electronically tunable at high power levels for a wide range of microwave applications

Where extensive frequency mobility is required, the efficient crossed-field, "M"-type backward wave oscillator is highly versatile. Introduced more than eight years ago, it has been perfected by Raytheon and is now being economically mass produced. Hobbing of the slow-wave structure, a Raytheon-developed technique, assures precision construction necessary for consistently reproducible performance from tube to tube.

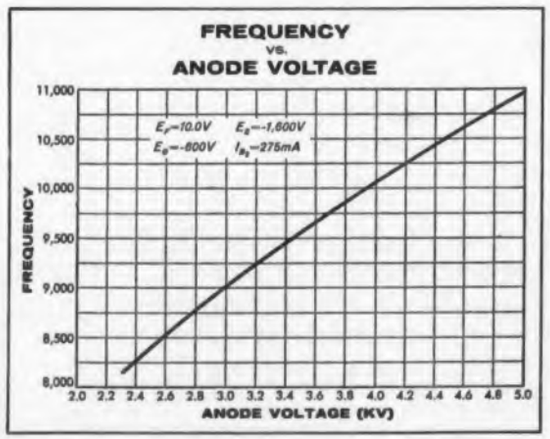
Typical of the "M"-type BWO's available from Raytheon is the QK-634A, an X-band tube which features all ceramic-and-metal construction for reliable operation under extreme environmental conditions.

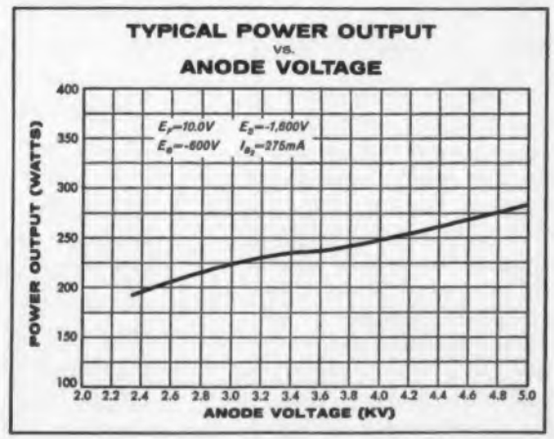
The QK-634A has a nominal power output of 200 to 250 watts and is electronically tunable over its entire frequency range. Precise determination of the radiated spectrum is accomplished by adjusting the voltage applied to either the anode or the sole. Amplitude modulation is also accomplished electronically. Small and compact, the QK-634A can be mounted in any position.

QK-634A Backward Wave Oscillator

Typical Operating Characteristics--QK-634A

Frequency Range	8,150 to 11,000 Mc
Power Output	150 watts (min.)
	200 to 250 watts (nom.)
Output Flange	Mates with UG40A/U modified for clearance holes
Tuning Sensitivity	1.0 Mc/V





Other unclassified BWO's in this series include the QK-625 and QK-659, which cover the 2,500-4,450 Mc band.

Excellence in Electronics

RAYTHEON

You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts

A LEADER IN CREATIVE MICROWAVE TECHNOLOGY

NEW PRODUCTS

Potentiometer 409

For transmitting and receiving equipment

Having no shaft or bushing, the Cap-Pot potentiometer is a moisture-proof unit suitable for use in portable transmitting and receiving equipment, as well as trimmer applications where high resolution is needed. It is constructed of nylon with the knob as an integral part of the unit. The diameter measures 0.5 in. and the behind-panel-depth is 5/16 in. Power rating is 0.5 w at 40 C, derated linearly to zero at 105 C. Dielectric strength is 900 v rms at sea level for 1 min. Type A offers a resistance to 5000 ohms max and has a tolerance of ±5%. Type B, trimmer, offers 10,000 ohms and has a tolerance of ±10%.

Clarostat Mfg. Co., Inc., Dept. ED, Dover, N.H.

Ultrasonic Cleaner 598

Has a half-gallon capacity

The System Forty, a half-gal capacity ultrasonic cleaner, includes a 40-w generator with an output of 90,000 cps, and a heavy gage stainless steel cleaning tank. The working compartment of the tank measures 4-3/4 × 5-1/4 × 4 in. The generator cabinet measures 10 × 8 × 5-3/4 in., and has a push-pull activity regulation throttle, which is the system's only control knob. More than fifty distinct classes of soils and contaminants can be disintegrated by this system.

Ultrasonic Industries, Inc., Dept. ED, 141 Albertson Ave., Albertson, Long Island, N.Y.

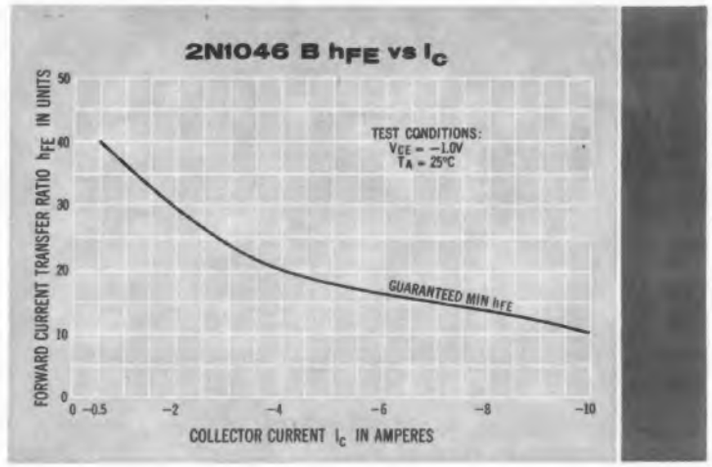
Price & Availability: *Available from stock. Can be delivered immediately. Price is $99.95 per unit.*

MANIUM POWER TRANSISTORS

New high current 2N1046-A-B give you high frequency/dissipation/voltage with high beta!

New TI 2N1046B germanium power transistors give you 10 amp I_C with typical 18 mc f_T* . . . 130 volt BV_{CBO} . . . guaranteed beta of 10 at 10 amp I_C . . . 30 watt dissipation . . . high frequency/high current operating characteristics. The 2N1046 series alloy-diffused P-N-P transistors provides maximum reliability for your core driving, hi-fi amplification, and other high frequency power applications.

f_T Frequency at which common base current gain of the device is unity.*



Call on your nearest TI distributor or sales office for immediate delivery of TI germanium power transistors including the 1-amp 2N1038 series and the 3-amp 2N1042 series power transistors.

TI GERMANIUM POWER TRANSISTOR CHARACTERISTICS AT 25°C

Type	Dissipation at 25°C watts	Collector to Base Voltage-v max	Collector to Emitter Voltage min BV_{CEO}	Emitter to Base Voltage-v min BV_{EBO}	Collector Current Amps max	h_{FE} @ I_C min	h_{FE} @ I_C max	Collector Reverse Current I_{CO} max ma	Collector Reverse Current I_{CO} max v	Typ R_{CS} @ I_C ohms	Internal Cutoff Frequency avg f_T
2N456A	50	−40	−20	−20	−7	30 @ 5a	90	−0.5	−20	0.040 @ 5a	430 kc
2N457A	50	−60	−30	−20	−7	30 @ 5a	90	−0.5	−30	0.040 @ 5a	430 kc
2N458A	50	−80	−40	−20	−7	30 @ 5a	90	−0.5	−40	0.040 @ 5a	430 kc
2N1021	50	−100	−50	−20	−7	30 @ 5a	90	−0.5	−50	0.040 @ 5a	430 kc
2N1022	50	−120	−50	−20	−7	30 @ 5a	90	−0.5	−60	0.040 @ 5a	430 kc
2N511	80	−40	−20	−30	−25	20 @ 10a	60	−2	−20	0.025 @ 10a	260 kc
2N511A	80	−60	−30	−30	−25	20 @ 10a	60	−2	−30	0.025 @ 10a	260 kc
2N511B	80	−80	−40	−30	−25	20 @ 10a	60	−2	−40	0.025 @ 10a	260 kc
2N512	80	−40	−20	−30	−25	20 @ 15a	60	−2	−20	0.033 @ 15a	280 kc
2N512A	80	−60	−30	−30	−25	20 @ 15a	60	−2	−30	0.033 @ 15a	280 kc
2N512B	80	−80	−40	−30	−25	20 @ 15a	60	−2	−40	0.033 @ 15a	280 kc
2N513	80	−40	−20	−30	−25	20 @ 20a	60	−2	−20	0.038 @ 20a	300 kc
2N513A	80	−60	−30	−30	−25	20 @ 20a	60	−2	−30	0.038 @ 20a	300 kc
2N513B	80	−80	−40	−30	−25	20 @ 20a	60	−2	−40	0.038 @ 20a	300 kc
2N514	80	−40	−20	−30	−25	20 @ 25a	60	−2	−20	0.040 @ 25a	350 kc
2N514A	80	−60	−30	−30	−25	20 @ 25a	60	−2	−30	0.040 @ 25a	350 kc
2N514B	80	−80	−40	−30	−25	20 @ 25a	60	−2	−40	0.040 @ 25a	350 kc
2N1038	20	−40	−30	−20	−3	20 @ 1a	60	−125μa	−20	0.150 @ 1a	8.0 kc $f_{\alpha e}$ min
2N1039	20	−60	−40	−20	−3	20 @ 1a	60	−125μa	−30	0.150 @ 1a	8.0 kc $f_{\alpha e}$ min
2N1040	20	−80	−50	−20	−3	20 @ 1a	60	−125μa	−40	0.150 @ 1a	8.0 kc $f_{\alpha e}$ min
2N1041	20	−100	−60	−20	−3	20 @ 1a	60	−125μa	−50	0.150 @ 1a	8.0 kc $f_{\alpha e}$ min
2N1042	20	−40	−30	−20	−3	20 @ 3a	60	−125μa	−20	0.167 @ 3a	8.0 kc $f_{\alpha e}$ min
2N1043	20	−60	−40	−20	−3	20 @ 3a	60	−125μa	−30	0.167 @ 3a	8.0 kc $f_{\alpha e}$ min
2N1044	20	−80	−50	−20	−3	20 @ 3a	60	−125μa	−40	0.167 @ 3a	8.0 kc $f_{\alpha e}$ min
2N1045	20	−100	−60	−20	−3	20 @ 3a	60	−125μa	−50	0.167 @ 3a	8.0 kc $f_{\alpha e}$ min
2N1046	30	−100	−50	− 1.5	−10	40 @ 0.5a		−1	−40	0.500 @ 1a	15 mc min
2N1046A	30	−140	−50	− 1.5	−10	20 @ 4a		−1	−40	0.125 @ 4a	15 mc min
2N1046B	30	−140	−50	− 1.5	−10	10 @ 10a		−1	−40	0.050 @ 10a	15 mc min

Microwave Diodes 599

For S and X bands

The temperature capabilities of the full line of S and X band microwave diodes have been increased. As a result, standard heat capabilities up to 150 C are now available. Among the diodes are Micro-Min types IN830, IN830A, IN831, and IN832. Also included are the IN21 and IN23 series, and the IN21WE, IN416, and IN415 series.

Sylvania Electric Products Inc., Semiconductor Div., Dept. ED, 730 Third Ave., New York 17, N.Y.

Price & Availability: *Following types available from stock: IN830, 31, 32, 33, 30A, 31A; IN21B, C, D, E, F, 23B, C, D, E; IN21 and 23WE, IN416B, C, D, E; IN415B, C, D, E.*

Antenna Slip Rings 615

Provide more than 500 circuits

These antenna slip-ring assemblies provide from 50 to over 500 circuits, and have a current capacity to 2000 amp. Available in both shaft and flange type mountings, the units are ball-bearing mounted and come with hermetically-sealed housings. They are designed for the rf or uhf frequency ranges. Environment requirements of MIL-5400C are met. The units measure from 12 to 72 in. in length; bore diameter, if applicable, is from 1 to 12 in.

Slip Ring Co. of America, Dept. ED. 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

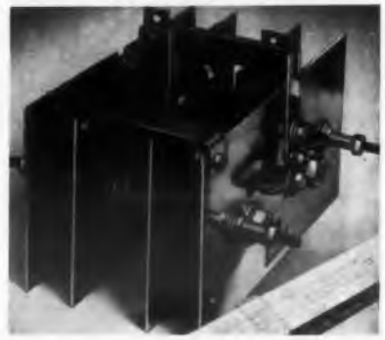
Price & Availability: *Made on order only and delivered 30 to 120 days after order received. Price varies from $1500 to $30,000.*

◀ CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Rectifier Stacks 481

With ratings to 750 amp



With ratings to 750 amp and a piv of 50 to 600 v, these silicon rectifier stacks have built-in paralleling reactors for equal current distribution through parallel circuit branches. A standard building block is a doubler module with an integral paralleling reactor and four 70-amp silicon junction rectifiers mounted on copper cooling fins. Two of these may be mounted to form a single-phase bridge rated at up to 550 amp. rectified dc output. Three modules form a three-phase bridge rated to 750 amp. Other configurations can be furnished.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Electronic Counter 483

Has ranges from 50 to 500,000 cpm

Model LM-1 laboratory monitor has five counting rate ranges from 50 to 500,000 cpm. The count rate meter portion can display full-scale counting rates of 50, 500, 5000, 50,000, or 500,000 cpm. A probable error switch permits the operator to select 2, 6 or 25% counting rate probable errors. Factory calibrated to ±2%, the unit normally needs no additional calibration, though a 3600-cpm output is located on the rear apron for calibration checking. The unit measures 19-1/2 x 10 x 5-1/2 in.

Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

Price & Availability: *Delivered from stock in 30 to 60 days. Price is $470.*

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CIRCLE 94 ON READER-SERVICE CARD
CIRCLE 600 ON READER-SERVICE CARD

NEW ... FROM INDUSTRY'S BROADEST RECTIFIER LINE

SILICON CARBIDE RECTIFIERS

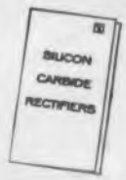
FEATURES

- **IMPROVED RELIABILITY AT ELEVATED TEMPERATURES**
- **HIGHER TEMPERATURE PERFORMANCE TO 500°C**
- **EXCELLENT RADIATION RESISTANCE**

Silicon carbide rectifiers are now available for production requirements. Their inherent higher temperature capabilities (to 500°C) provide greater reliability in existing circuitry subject to high ambient temperatures. Resistance to radiation is up to 100 times greater than previously available in any semiconductor rectifiers.

	SPECIFICATIONS @ 500°C			RATINGS @ 500°C	
Type	Peak Inverse Voltage (volts)	Maximum Inverse Current I_R (μA)	Maximum Forward Voltage @ Specified Current (volts @ mA)	Maximum Average Forward Current I_0 (mA)	Maximum Peak Inverse Voltage (volts)
TCS10	100	500	6 @ 100	100	100
TCS5	50	500	4 @ 100	100	50

	SPECIFICATIONS @ 25°C		
Type	Peak Inverse Voltage (volts)	Maximum Inverse Current I_R (μA)	Maximum Forward Voltage @ Specified Current (volts @ mA)
TCS10	100	10	12 @ 100
TCS5	50	10	8 @ 100



Write for Bulletin PB-70

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"Leadership in Semiconductors" SEE YOUR LOCAL AUTHORIZED TRANSITRON DISTRIBUTOR FOR QUANTITIES FROM 1-999

NEW PRODUCTS

DC Power Supply 534

Delivers 120 kv at 5 ma

Model PSC 120-5-2 power supply, made for insulation testing, industrial, experimental, and research applications, delivers 120 kv dc at 5 ma. Input is 115 v at 60 cps. Ripple is less than 2% rms. Either positive or negative polarity may be obtained by changing plug-in connectors. Polyethylene cable is used for the output. Instrumentation consists of 4.5-in., three-range kv and ma meters mounted on the front panel. Overload relays are adjustable from 5% to 115%. Housed in a steel cabinet, the unit measures 32 x 21.5 x 59 in.

Del Electronics Corp., Dept. ED, 521 Homestead Ave., Mount Vernon, N.Y.

Price & Availability: *Price is $2500. Units are in stock.*

Subcarrier Oscillators 535

Record ac or dc sginals on magnetic tape

Series FO 5A voltage-sensing, frequency-modulating subcarrier oscillators record ac or dc signals on magnetic tape. The output is a square wave for directly feeding recording heads without an amplifier. A sine-wave output version can also be furnished. Center frequency can be customer specified from 500 cps to 54 kc. The frequency deviation is ±40% of the center frequency, with sensitivity stability within ±1% of total bandwidth throughout the temperature range. Silicon solid-state devices are used for minimum power dissipation. Suited for missile and space telemetry applications, the units operate under environmental extremes and weigh only 3 oz.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

Availability: *from stock; delivery time is 30 days.*

Frequency Converters 536

Convert 60 to 400 cps

Models FC6415, FC6410, and FC645 transistorized frequency converters convert an input of 60 cps to 400 cps at power ratings of 150, 100, and 50 va, respectively. The outputs are compensated against both input and load variations. The units are suitable for powering gyros and servomechanisms, magnetic amplifiers, and other ac equipment in both laboratory and industrial applications.

ERA Pacific, Inc., Dept. ED, 1760 Stanford St., Santa Monica, Calif.

Price & Availability: *Models FC6415, FC6410, and FC645 are priced at $395, $345, and $295.*

Silicon Rectifier Stacks 537

Medium-power type

These medium-power, silicon rectifier stacks are offered in over 125 types. Designated models 1N2638 through 1N2764, the stacks consist of glass-to-metal, hermetically sealed, silicon diodes mounted on 1.56-in. copper cooling fins. Mounting dimensions are 3.48 to 7.53 in. Circuit configurations are single-phase, 1/2-wave, center-tap, bridge and magnetic amplifier bridge; three-phase and bridge; and 6-phase star.

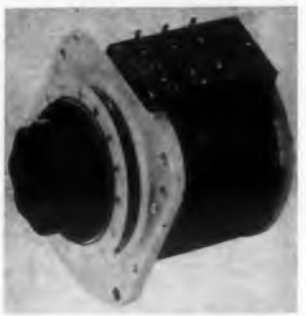
International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Price & Availability: *Price ranges from $2.80 to $45 ea for quantities of 1 to 9. Delivery is in two weeks.*

NEW PRODUCTS

Variable Transformers 502

Operate from 240 v



Operating from a single-phase, 240-v line, model VT8H variable transformer is rated at 3 amp and delivers a line voltage of 240 v or an overvoltage of 280 v; model VT8HN is a no-overvoltage unit rated at 4 amp. Operating from an input of 120 v, model VT8H is able to provide 280 v and model VT8HN, 240 v. Used in ganged assemblies, the units provide three-phase operation.

Ohmite Manufacturing Co., Dept. ED, 3696 Howard St., Skokie, Ill.

Price & Availability: *Units are in stock. Type VT8H is priced at $20; type VT8HN, $21.*

Shaft-Rotation Digitizing System 504

Resolution is 2000 counts per revolution

This transistorized, shaft-rotation digitizing system records rotating shaft position and has a visual display using six Nixie readouts. A load-driving memory provides digital signals to electrical readouts such as summary punch, parallel input printer, tape perforator, or keypunch. The complete system consists of an angle pulse generator and a counter-accummulator. Digitizing rate is 20,000 counts per sec. Maximum rotational velocity is 10,000 rpm and maximum storage of the six-digit readout is ±999,999. Input required is 115 v at 60 cps with 15 va max.

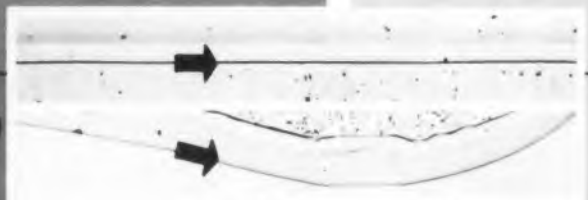
Telecomputing Corp., Data Instruments Div., Dept. ED, 12838 Saticoy St., N. Hollywood, Calif.

Price & Availability: *Units will be in stock by May 15, 1960. Price is $4300.*

CIRCLE 109 ON READER-SERVICE CARD ➤

LOW POWER. Consider the high-efficiency Raytheon 1N536 series.

MEDIUM POWER. Look into the Raytheon 1N253 and the new 1N2512 series.



Raytheon diffused junction (upper photo) gives utmost uniformity, highest performance, greatest reliability. Compare with irregular fusion junction (below).

HIGH POWER. Note the all-new Raytheon 1N248A, 1N1191A and 1N1195 series.

For reliable power . . .
Depend on diffused junction rectifiers!

Here are reliable Raytheon diffused junction silicon rectifiers spanning the complete semiconductor power spectrum!

Raytheon manufacturing success in diffused junction rectifiers has long provided fast recovery, low forward voltage drop and extreme uniformity of device characteristics. Outstanding mechanical design and production under stringent quality control result in rectifiers with excellent ratings and characteristics. Utmost reliability is assured by constant life and environmental testing beyond the most stringent requirements of Mil 19500B, over the guaranteed temperature range of −65°C. to +165°C.

Of special interest in low current applications of the 1N536 series are the excellent reverse recovery, fast start and fast rise of Raytheon diffused junction rectifiers.

In the four amp range, the Raytheon 1N2512 series features low reverse current and is available in three package styles: with insulated stud, stud connected to anode, or stud connected to cathode.

In the higher current range, the new Raytheon diffused junction silicon rectifiers offer ratings up to 22 amps (at 150°C.)—plus the important advantages of low forward voltage drop and high efficiency, for exceptional regulation in power applications.

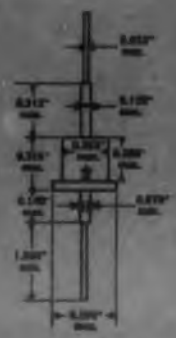
Further information on all these reliable Raytheon rectifiers is given on the following page. Semiconductor Division, Raytheon Company, 215 First Avenue, Needham Heights 94, Massachusetts.

RAYTHEON

RAYTHEON SEMICONDUCTORS

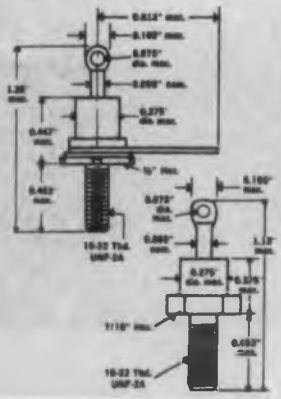
Raytheon diffused junction silicon rectifiers

LOW CURRENT SERIES. The fast reverse recovery, low current Raytheon rectifiers. Feature both fast start and fast rise. Temperature range —65°C. to +165°C.



Type	P.I.V.	Ave. Rectified Current 25°C mA	Ave. Rectified Current 100°C mA	Reverse Current (Max.) in μA at rated P.I.V. 25°C	Reverse Current (Max.) in μA at rated P.I.V. 100°C
1N536	50	750	250	2	400
1N537	100	750	250	2	400
1N538	200	750	250	2	300
1N539	300	750	250	2	300
1N540	400	750	250	2	300
1N1095	500	750	250	2	300
1N547	600	750	250	2	300

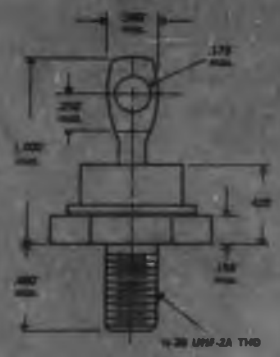
MEDIUM CURRENT SERIES. Workhorse of the Raytheon rectifier line. High efficiency and stability. Insulated or non-insulated stud, standard or reverse polarity. Temperature range —65°C. to +165°C.



Cathode to Stud	Anode to Stud	INSULATED Stud	P.I.V. Volts	Ave. Rectified Current 30°C amps.	Ave. Rectified Current 150°C amps.	Reverse Current (max.) μA at rated P.I.V. 25°C	Reverse Current (max.) μA at rated P.I.V. 150°C
1N2512	1N2512R	1N2518	100	4.0	1.0	2.0	250
1N2513	1N2513R	1N2519	200	4.0	1.0	2.0	250
1N2514	1N2514R	1N2520	300	4.0	1.0	2.0	300
1N2515	1N2515R	1N2521	400	4.0	1.0	2.0	300
1N2516	1N2516R	1N2522	500	4.0	1.0	2.0	350
1N2517	1N2517R	1N2523	600	4.0	1.0	2.0	400
1N253			95		1.0*		100*
1N254			190		0.4*		100*
1N255			380		0.4*		150*
1N256			570		0.2*		150*

*At 135° C.

HIGH CURRENT SERIES. The heavy current family of reliable Raytheon rectifiers. Features low forward voltage drop, high efficiency, exceptional regulation. Temperature range—65°C. to +175°C.



Type	P.I.V.	Ave. Rectified Current, Amps @ 150°C.	Reverse Current (Max.) at Rated P.I.V., mA @ 150°C.
1N248A	50	20	5
1N249A	100	20	5
1N250A	200	20	5
1N1191A	50	22	5
1N1192A	100	22	5
1N1193A	150	22	5
1N1194A	200	22	5
1N1195	300	18	10
1N1196	400	18	10
1N1197	500	18	10
1N1198	600	18	10

J-6949

Your local authorized Raytheon Distributors carry in-stock inventories for immediate delivery.

RAYTHEON **SEMICONDUCTOR DIVISION** RAYTHEON COMPANY

SILICON AND GERMANIUM DIODES AND TRANSISTORS • SILICON RECTIFIERS • CIRCUIT-PAKS

ENGLEWOOD CLIFFS, N. J., LOwell 7-4911 (Manhattan Phone, Wisconsin 7-6400) • **BOSTON, MASS.**, Hillcrest 4-6700 • **CHICAGO, ILL.**, NAtional 5-4000 • **LOS ANGELES, CAL.**, NOrmandy 5-4221 • **ORLANDO, FLA.**, GArden 3-0518 • **SYRACUSE, N. Y.**, GRanite 2-7751 • **BALTIMORE, MD.**, SOuthfield 1-0450 • **CLEVELAND, O.**, Winton 1-7716 **SAN FRANCISCO, CAL.**, Fireside 1-7711 • **CANADA:** Waterloo, Ont., SHerwood 5-6831 • **GOVERNMENT RELATIONS:** Washington, D.C., MEtropolitan 8-5205

Digital Switch Assembly 517

Contains up to 16 switches

Series TSD modular digital switch assembly contains 1 to 16 thumbwheel switches in 8, 10 or 12 positions with numerical readout. Switches are manually operated by a 0.25-in. thumbwheel. The unit is furnished with easily replaceable printed circuit wafers or with fixed wafers. It may be positioned horizontally or vertically.

Chicago Dynamic Industries, Inc., Precision Products Div., Dept. ED, 1725 Diversey Blvd., Chicago 14, Ill.

Price & Availability: *Price range is $2.27 to $5.58 per module. Standard units are available for immediate delivery.*

DC Power Supplies 404

Deliver up to 17 kv at 2 ma

These dc power supplies deliver up to 17 kv at an output current of 2 ma, regulated against line and load changes to 1%. Model RG-5 has a variable output of 4 to 6 kv, model RG-10 has an output of 8 to 12 kv, and model RG-15 has an output of 13 to 17 kv. All units have current and volt meters.

Spellman High Voltage Co., Dept. ED, 3029 Webster Ave., Bronx 67, N.Y.

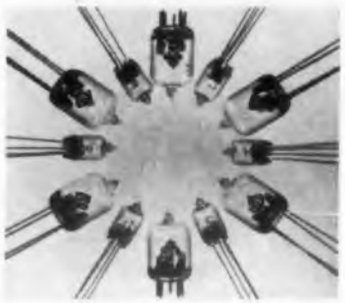
Price & Availability: *Model RG-5 is priced at $250; model RG-10, $260; and model RG-15, $275. Units are in stock for immediate delivery.*

Don't miss an issue of ELECTRONIC DESIGN; return your renewal card today.

NEW PRODUCTS

Krytrons 480

Come in 12 types



Included in this line of krytrons are six miniature and six subminiature types. The tubes, which are cold cathode devices for triggers, timers, regulators, and pulsers, have anode hold-off voltages up to 6 kv, anode delay times down to 0.15 μsec, and anode currents up to 500 amp. They provide conservative safety margins for temperature conditions from −55 to +85 C, and withstand 2000 to 2800 g shock and 10 g at 0 to 500 cps vibration.

CBS Electronics, Dept. ED, 100 Endicott St., Danvers, Mass.

Potentiometer 514

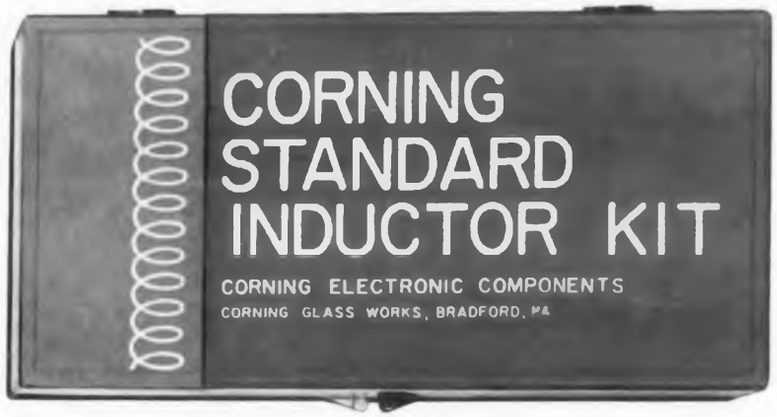
Is 1/2 in. wide and 0.2 in. thick

Called WeeTrim, this trimming potentiometer is 1/2 in. wide and 0.2 in. thick. Its aluminum housing is made in a square configuration and weighs less than 2 g. Other characteristics include: standard resistance values from 10 to 50,000 ohms; continuous rotation of wiper; operating temperature range of −55 to ±200 C; vibration 30 g, 10 to 200 cps; shock 50 g, 11-msec duration. The component meets the requirements of MIL-E-5272A. Various adjustment lead screws are available.

Handley, Inc., Dept. ED, 12960 Panama St., Los Angeles, Calif.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

Ten standard value metallized glass inductances ranging from .05 uh. to 1.30 uh. Unexcelled for high frequency tuning applications requiring temperature stability and low loss. Operating temperature range −55°C to +125°C. Temperature coefficient zero to plus 20ppm/°C. Tolerance ±10%.



Now . . . low cost inductors off-the-shelf from distributors

Determine the exact inductance values you need quickly and inexpensively with this handy new test kit available only from Corning distributors. The kit consists of 10 standard value glass inductors which you can modify to specific odd values with four different types of cores.

These glass inductors are ruggedly built to take repeated handling in test labs or on production lines. The only inductors made without wires, the coil consists of a silver oxide film fired to the glass, then copper-plated and tin-dipped. It can't shift or work loose.

See your Corning distributor now for this new cost-cutting, time-saving Standard Inductor Kit. Low price is only $24.95 (net) including mounting hardware and complete technical data book.

Two each of these four different types of cores: 1) red dot, 5.0 permeability; 2) blue dot, 9.2 permeability; 3) ¼" brass; 4) 3/16" brass.

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ELECTRONIC COMPONENTS
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CIRCLE 106 ON READER-SERVICE CARD

CORNING STANDARD INDUCTOR KIT

Immediate delivery from these distributors

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MARYLAND, Baltimore 1
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300-310 West Redwood Street

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Cramer Electronics, Inc.
811 Boylston Street

MASSACHUSETTS, Boston 17
Radio Shack Corporation
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Federated Purchaser, Inc.
1021 U. S. Route 22

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NEW YORK, Hempstead
Davis Electronics Corporation
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Hudson Radio & TV Corp.
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Terminal Electronics, Inc.
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OHIO, Akron 8
The Sun Radio Company
110 East Market Street

OHIO, Cincinnati 10
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Hughes Peters Inc
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NEW PRODUCTS

Power Control Units 407

For ac or dc

These universal power control units use magnetic amplifier control modules to gate silicon-controlled rectifiers. They control ac or dc power. Both 60- and 400-cps models are offered. Applications include dc motor speed and position control, ac servo motor control, temperature control, and voltage-current regulation.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

Variable Speed Drives 406

For 1/100- to 1-1/2-hp motors

These variable speed drives are manufactured in three power ratings: for 1/100- to 1/8-hp motors, for 1/4-, 1/3-, and 1/2-hp motors, and for 3/4-, 1-, and 1-1/2-hp motors. Operating from 115 v, 60 cps, single-phase, they provide adjustable voltages for dc shunt motors. The units incorporate silicon rectifiers. Optional features are: remote control, dynamic braking, and reversing.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

Synchronous Motor 510

Speed is 8000 rpm

Type R172 size 11 synchronous motor has a speed of 8000 rpm and a pull-out torque of 0.48 oz-in. A 6-pole motor, it is suitable for use in ground support equipment, in devices for testing accelerometer functions, in timing devices and recorders, and wherever constant speed is required in military or industrial applications. For phases I and II, voltage is 26 v, frequency is 400 cps, power is 3.4 w, and power factor is 0.38. Units can have a plain or pinion shaft and are constructed to stand environmental extremes.

Kearfott, Div. of General Precision, Dept. ED, 1150 McBride Ave., Little Falls, N.J.

Pentode 553

Is a semi-remote cut-off type

Designed for use in gain-controlled picture if stages of TV receivers, type 6GM6 is a semi-remote cut-off pentode, 7-pin miniature tube. It has a transconductance of 13,000 μmhos. Class A_1 maximum ratings include a plate voltage of 330 v, plate dissipation of 3.1 w, and a peak heater-cathode voltage of 200 v. The tube comes with separate base pins for grid No. 3 and the cathode.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Molding Compound 505

Type 786 polyurethane-based compound operates from —65 F to +350 F, exhibiting good physical and electrical properties. It is furnished in kits or in frozen tubes.

Coast Pro-Seal & Mfg. Co., Dept. ED, 2235 Beverly Blvd., Los Angeles 57, Calif.

Availability: Delivery time is five days.

Silicone Rubber 506

Designated as RTV-11, this silicone rubber material contains no solvent and has a typical viscosity of 120 poises. Its uses include potting, encapsulating and impregnating, and protective coatings for printed-circuit boards.

General Electric Co., Silicone Products Dept., Dept. ED, Waterford, N.Y.

Capacitor Substitution Box 507

Model CDE electrolytic capacitor substitution box offers 15 combinations of capacitance from 10 to 150 μf, in steps of 10 μf, at voltages up to 450 wvdc.

Cornell-Dubilier Electric Corp., Dept. ED, S. Plainfield, N.J.

Sweeping Oscillator 508

The Ligna-Sweep SKV, designed for audio, video, and vhf coverage, now has a range of 200 cps and sweep repetition rates from 0.2 to 60 cps. It provides linear and logarithmic sweeps.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N.J.

Price & Availability: $995 per unit plus $17 for the marker. For orders of 10 or more, the unit is priced at $895. Delivery is in 30 to 40 days.

Jumper Strips 498

Types RJ and RJS jumper strips are single piece units made of brass and available either nickel plated or cadmium plated. Type RJ has closed type connecting lugs with holes sized to accept 6-32 screws. Type RJS has spade type connecting lugs requiring loosening of terminal screw to insert. Both are available with up to 23 connecting lugs.

Kulka Electric Corp., Dept. ED, 633-643 Fulton Ave., Mount Vernon, N.Y.

Analog Computer Accessory 499

High speed repetitive operation is available as an accessory for all Pace 231 R analog computers. With repetitive operation, the solution appears as a continuous plot on a 17-in. display screen. A computer equipped with this accessory can be operated either repetitively or as a real time simulator at the throw of a switch without degradation of its real time accuracy.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

NEW PRODUCTS

Full-Wave Rectifier 554

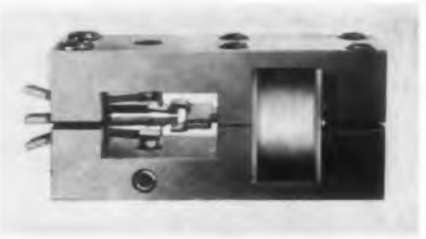
Uses an indirectly heated cathode

Full-wave vacuum rectifier type 6CA4 uses an indirectly heated cathode. It is intended for use in hi-fi audio equipment. In rectifier service, maximum ratings are: peak inverse plate voltage, 1000 v; ac plate-supply voltage per plate, with capacitor-input to filter, 350 v; peak plate current per plate, 450 ma; and dc output current, 150 ma. The 6.3-v heater of the 6CA4 eliminates the need for an extra winding on the power transformer.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Subminiature Choppers 401

Meet Mil specs



This series of spdt, center-pivoted, instrument choppers is designed to meet Mil specs for shock, vibration, and temperature. They have residual noise in the sub-microvolt range. Subminiature in size, they are made to fit standard 7-pin miniature plug-in receptacles with leads for wiring in or with a printed circuit mount. A variety of operating frequencies and contact closure configurations are offered.

James Electronics Inc., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

Price & Availability: *Immediate delivery on sample quantities priced from $30 to $42 ea.*

Transducers 560

Are variable permeance types

Type LD variable permeance transducers come in seven models ranging from 3-1/2 to 19-1/8 in. in length, with a housing diameter of 0.375 in. on all models. The units sense linear position and provide a proportional ac output. Carrier frequencies of 1 to 20 kc may be used. Maximum input voltage is 20 v rms; the output is 1/2 input for full stroke displacement over the rated range of 0.2 in. for the smallest model to 12.8 in. for the longest.

Crescent Engineering & Research Co., Dept. ED, 5440-L N. Peck Road, El Monte, Calif.

DC to AC Inverters 446

For aircraft and missile applications, these units operate from 28 v dc and provide 115 v, 400 cps, single-phase or three-phase output. Power ratings are 30 to 1500 va.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

Static Time Sequencer 447

This unit shows the functioning of static programmer equipment which provides power-control signals for automatic test operations such as missile count down.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

Memory Systems 450

Ranging from word-select ferrite cores to complete memory systems, this line of products provides operating speeds up to 1 mc.

Telemeter Magnetics Inc., Dept. ED, P.O. Box 329, Culver City, Calif.

Availability: *Units are made to order; delivery time is kept to a minimum.*

Flip-flop and Clock 451

Model 1202 flip-flop and model 1403 clock are packaged as plug-in units for use in digital computers and computer type systems.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

Price & Availability: *Each unit is priced at $160 ea and can be delivered in about two weeks.*

Nickel Cadmium Batteries 487

The Nicad line of cells and batteries comes in a wide range of types and sizes with capacities starting at 20 ma-hr and continuing up through 23 amp-hr. The units are miniature, hermetically sealed, and rechargeable.

Gould-National Batteries, Inc., Dept. ED, 831 N. Vandalia St., St. Paul, Minn.

Time Delay Relay 489

This miniature transistorized time delay relay has been qualified to meet MIL-E-5272C, Procedure XII. The device has an accuracy of ±2% over a range from −65 to +125 C, and a voltage variation from 18 to 30 v dc.

Natel Engineering Co., Inc., Dept. ED, 15922 Strathern St., Van Nuys, Calif.

Price & Availability: *Individual units available from stock. For larger quantities, 10 to 14 days delivery should be allowed. Price range is $80 to $125; quantity discounts available.*

This is the time of our annual subscription renewal.

NEW PRODUCTS

Frequency Meter 402

Range is 25 to 2500 cps

The series M vibrating-reed frequency meter has standard frequencies of 50, 60, and 400 cps; any frequency from 25 to 2500 cps can be furnished on special order. Nominal input voltage ratings of 30, 115, 230, and 480 v rms are standard, from 30 to 1000 v can be supplied. Frequency indication is independent over a $\pm 20\%$ variation and over a form-factor range of 1.5 to 1. The reeds are gold-plated and are calibrated to within $\pm 0.3\%$ absolute. For any center frequency, 9 and 17-reed models are standard; units can be furnished with any number of reeds to 72. Frequency spacing can be linear or nonlinear.

The Winslow Co., Dept. ED, 701 Lehigh Ave., Union, N.J.

Price & Availability: *Price ranges from $9 to $40 for quantities of 1 to 1000. Delivery time is 15 to 45 days.*

Rate Turntable 475

Can provide multiple rates

Model T-844 rate turntable is a compact portable test unit for mounting rate gyros, antennas, guidance assemblies, and other components requiring imposition of constant rates of turn for spot checks of performance. The basic unit provides for a single rate about a vertical axis, but modified units can provide multiple rates, tilting to polar or horizontal axes, or come furnished with servo drive.

Sterling Precision Corp., Instrument Div., Dept. ED, 17 Matinecock Ave., Port Washington, L. I., N.Y.

BOURNS

TRIMPOT®

Schweber

FOR IMMEDIATE LARGE QUANTITY DELIVERY AT FACTORY PRICES

2000

Yes! Schweber can sell up to 2000 pieces of any model of BOURNS TRIMPOT® at factory prices. Sizeable quantities are available for immediate shipment from stock from Schweber's warehouse.

Schweber

ELECTRONICS

80 HERRICKS ROAD, MINEOLA, L.I., N.Y.
PIONEER 6-6520 TWX G-CY-NY-580

CIRCLE 111 ON READER-SERVICE CARD

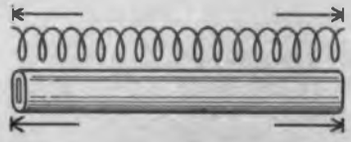
NUMBER 4
RELIABILITY SERIES

BOURNS TRIMPOT® WITH BUILT-IN TEMPERATURE STABILITY

Stable settings under extreme temperature conditions is an outstanding feature of the Trimpot® potentiometer. This thermal stability is built-in through all phases of design and production—

MATCHED COEFFICIENTS OF THERMAL EXPANSION

Resistance wire and mandrels have matched coefficients of thermal expansion to reduce the "strain gage effect." Linear expansion rates for the mandrel and wire match so closely that the temperature coefficient value for the entire wirewound element approximates that of the wire itself.

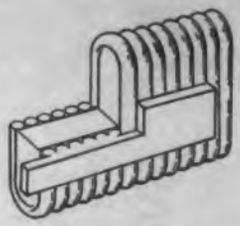


THERMALLY STABLE CERAMIC MANDRELS

Bourns takes advantage of high thermal stability of ceramic materials for element mandrels. Today, all Bourns Trimpot potentiometers provide the improved performance and reliability afforded by ceramic materials.

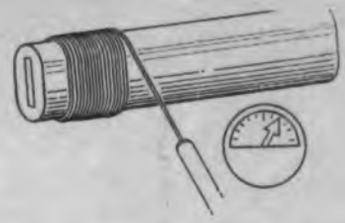
EXCLUSIVE SILVERWELD® TERMINATION

Silverweld is an actual metal-to-metal fusion of element wire and external terminal. In doing away with mechanical or soft-solder joints, Bourns eliminates potential hot spots thus extending the potentiometer's temperature range. The fusion of the Silverweld terminal to many turns of wire on the resistance element avoids the problem of single wire termination. Silverweld is virtually indestructible under thermal stresses.



EXCLUSIVE TENSION CONTROL EQUIPMENT

Bourns has developed specialized winding equipment that provides constant and precise control of wire tension during winding operations. "Necking" of the wire or resistance-altering stresses never occur. Instead the wire remains uniform—well able to withstand temperature variations with no appreciable change in resistance.



Specify Trimpot — the original leadscrew-actuated potentiometer with reliability on which you can depend. 20 basic models — 4 terminal types — 3 mounting styles.

BOURNS

BOURNS, INC., TRIMPOT DIVISION
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PLANTS: RIVERSIDE, CALIF. AND AMES, IOWA

Write for new Trimpot summary brochure and list of stocking distributors.

Exclusive manufacturers of Trimpot®, Trimit® and E-Z-Trim®. Pioneers in transducers for position, pressure and acceleration.

CIRCLE 112 ON READER-SERVICE CARD

IDEAS FOR DESIGN—*ENTRY BLANK*

To the *Ideas-For-Design* Editor of ELECTRONIC DESIGN —
830 3rd Ave., New York 22, N.Y. • PLaza 1-5530

Here is my design idea for possible publications in your *Ideas For Design* department. I can expect $10 for this idea if accepted for publication.

(Ideas suitable include: *1.* new circuits or circuit modifications, *2.* new design techniques, *3.* designs for new production methods, *4.* clever use of new materials or new components in design, *5.* design or drafting aids, *6.* new methods of packaging, *7.* design short cuts, or *8.* cost saving tips)

STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY—(Please be explicit. Include sketches or photos that will help the idea across)

Name_____

Title_____

Company_____

Address_____

(Place illustrations on separate sheet if necessary)

Looking for New Ideas? Stumped by a Design Problem?

ELECTRONIC DESIGN's Ideas for Design section contains current ideas contributed by other engineers to help you solve a problem, do your job more easily, rapidly and efficiently. You will find unusual applications of components, clever and original solutions to circuit and other problems, simpler or better ways of measuring, exceptional breadboarding techniques or legal advice relating to your work.

Use Ideas for Design as your source for new approaches and solutions to your design problems. Every idea is immediately applicable, ready to work for you.

Why not help others by contributing your ideas to this section? This convenient form makes it easy. Tear it out, jot down your idea and mail it to us. If we run your idea you will receive a check for $10.00. If not, it will be returned to you.

In 1959 ELECTRONIC DESIGN carried over 200 original Ideas for Design, the equivalent of 250 regulation text book pages of information for you. This is one more example of ELECTRONIC DESIGN's continued service to the working design engineer, providing information which will make your job easier by keeping you better informed.

NEW PRODUCTS

Potentiometers 584

Come in 1/2, 3/4, 1 in. diameters

Designated types 5000, 7500, and 1000, these potentiometers are 1/2, 3/4, and 1 in. in diameter, respectively. Their resistive values range from 50 to 350 K, with linearity tolerances down to 0.075%. All units have housings of nickel-plated brass, terminal headers of molded diallyl phthalate, and O-ring shaft seals.

International Resistance Co., Circuit Instruments Div., Dept. ED, Box 11628, St. Petersburg, Fla.

Price & Availability: *Available in sample quantities only. Special values delivered in 28 days. Standard values will be in stock by March 15. Contact company for price.*

Data Interpreters 416

Three units offered

This series of data interpreters includes type 312-5 selective interpreter, type 312-6 selective posting interpreter, and type 312-7 selective posting interpreter with dual card receiver. After sensing information is punched in a card, the interpreter prints out the information on the same or on other cards. Any one of 13 lines can be printed; selection is made by means of a control dial, and the card to be sensed is selected by a dial setting corresponding to control-hole punching in the card or in the cards following. Cards containing specified control holes can be automatically suppressed.

Sperry Rand Corp., Remington Rand Div., Dept. ED, 315 Park Ave. South, New York 10, N.Y.

Price & Availability: *Type 312-5 can be rented for $190 per month; type 312-6, $205; and type 312-7, $215.*

CIRCLE 113 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Strain Gage Adapter 527

Has all circuitry needed for read-out

Model SGA-100B strain gage adapter contains all necessary circuitry for read-out of flow, pressure, weight, or force transducers. Readout is on dc, mv potentiometers or recording oscillographs. A Zener-regulated bridge supply is used with excitation adjustable between 2.5 and 10 v dc nominal. Calibration resistors are contained in plug-in modules for use with four-arm resistive bridge of 120 ohms or greater. The unit requires 105 to 125 v, 60 cps. Power output is 0 to 10 and 0 to 30 mv dc, depending on the transducer.

Ramapo Instrument Co., Inc., Dept. ED, 8 First St., Bloomingdale, N.J.

Price & Availability: *Available from stock. Price is $125.*

Heat Sink Coolers 457

For high-power waveguide loads

Designed for high-power waveguide loads, model RDL-13-200 cooler has a maximum vswr of 1.1. It can be used with a waveguide having a range of 7.05 to 10 kmc and measuring 1-1/4 x 5/8 in. Units in the same series cover waveguide loads of 2.6 to 18 kmc and handle 100 to 400 w avg.

Radar Design Corp., Dept. ED, 1005 Pickard Drive, Syracuse 11, N.Y.

Price & Availability: *$95 to $190 ea; immediate delivery from stock.*

for immediate delivery of

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semiconductors

at factory prices

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240 Wythe Avenue
Brooklyn 11, N.Y.

CIRCLE 115 ON READER-SERVICE CARD

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION

JAN TYPE

GENERAL INSTRUMENT SILICON DIODES

1N457
1N458
1N459

When JAN type diodes are required, you can be certain that General Instrument's engineering skills and manufacturing facilities will enable us to deliver them at prices that reflect years of volume production experience.

The General Instrument line of silicon *and* germanium diodes is the most complete available to the industry, with the widest possible range of characteristics. We also make a complete line of medium and high power silicon rectifiers, including all JAN types. Complete information and data sheets are available upon request.

Code No.	Min. Fwd. DC Cur. @ +1V	Max. Rev. DC Cur. @ Test V. 25° C.	Max. Rev. DC Cur. @ Test V. 150° C.	Test Voltage	Max. Inv. Voltage	Min. Breakdown Voltage*	Avg. Fwd. DC Cur. (Max.)
1N457	20 mA	.025 μA	5 μA	60V	60V	70V	75 mA
1N458	7 mA	.025 μA	5 μA	125V	125V	150V	55 mA
1N459	3 mA	.025 μA	5 μA	175V	175V	200V	40 mA

*Reverse voltage at which a reverse current of 100 uA flows.
All ratings and characteristics are at 25° C. unless otherwise noted.
Operating temperature range −80° C. to +200° C.

Semiconductor Division
GENERAL INSTRUMENT CORPORATION
65 Gouverneur Street, Newark 4, N. J.
Midwest office 5249 West Diversey Ave., Chicago 39
Western office 11982 Wilshire Blvd., Los Angeles 25

GENERAL INSTRUMENT CORPORATION INCLUDES THE SICKLES DIVISION, AUTOMATIC MANUFACTURING DIVISION, SEMICONDUCTOR DIVISION, RADIO RECEPTOR COMPANY, INC., THE HARRIS TRANSDUCER CORPORATION, MICAMOLD ELECTRONICS MANUFACTURING CORPORATION AND GENERAL INSTRUMENT (CANADA) LTD., SUBSIDIARIES

CIRCLE 878 ON READER-SERVICE CARD

NEW PRODUCTS

Coaxial Relay 461

Transfer time is 10 msec max

Used for remote switching of 3-1/8-in. coaxial lines, type RC21FA-1 spdt vacuum coaxial relay has a total transfer time of 10 msec max at a maximum repetition rate of 33-1/3 transfers per sec. Its power rating is 3-mw peak, 20 kw average to 600 mc. The relay has a characteristic impedance of 50 ohms and a frequency range of 0 to 600 mc. Crosstalk is 37.5 db down at 600 mc; vswr is 1.05 max to 400 mc.

Jennings Radio Manufacturing Corp., Dept. ED, Box 1278, San Jose, Calif.

***Price & Availability:** Can be delivered 120 days after order received.*

Pressure Transducer 532

Static error band down to ±1%

Designed for missile and aircraft instrumentation, model 720 absolute pressure transducer has a static error band, including linearity, friction, hysteresis, resolution, and repeatability, as low as ±1%. There is no calibration shift as a result of pressures up to 150% of rated range. Other specifications for typical pressure ranges of 0 to 350 and 0 to 3500 psia are: power rating of 1-1/2 w at 165 F, and operating temperature of —100 to +200 F. Model 720 measures 1.34 in. diam x 1.35 in. exclusive of connectors.

Bourns, Inc., Dept. ED, Box 2112, Riverside, Calif.

Beam Power Tube 465

For linear amplifier use

For use in linear amplifiers at frequencies up to 500 mc, type 7580 beam power tube has a maximum plate dissipation rating of 250 w. In single sideband, suppressed carrier service with two-tone modulation, it can deliver a peak envelope power output of about 400 w at 30 mc or 360 w at 500 mc. Input and output circuits are isolated at high frequencies by a ring terminal for grid No. 2. A separate base pin for this grid is available for operation at lower frequencies.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

DC Amplifier 522

Frequency response is over —3 db at 200 kc

Model DCA-1-B solid state dc amplifier has a frequency response exceeding —3 db at 200 kc, a gain accuracy of ±0.03%, linearity and stability at ±0.02%, and drive 500 μv referred to the input. A solid-state chopper is used. The unit is of modular, plug-in design and measures 4.75 x 3.5 x 4.25 in.

Packard Bell Computer Corp., Div. of Packard Bell Electronic Corp., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

Price & Availability: *Price is $945 ea for up to 9 units. Delivery time is 60 days.*

B & W Associates built in a Sola regulated plate-filament power transformer as an integral component in their portable lie-detection apparatus.

Portable lie detector operates accurately with Sola-regulated plate and filament voltages

This sensitive polygraph operates by picking up and immensely amplifying tiny electrodermal responses. It's small wonder that line voltage variations encountered in field operation must be corrected if the responses of the witness are to be measured accurately.

The lie detector's built-in power supply transformer is a Sola Constant Voltage Plate-Filament Transformer which performs this dual function: (1) it supplies plate and filament voltages just as an ordinary power supply transformer would do; (2) it regulates these supply voltages within ±3% even when the line voltage varies over a 100 to 130-volt range.

Besides providing regulation which assures accurate polygraph operation, the Sola transformer protects tubes and components from cold inrush current and from fault currents.

This simple, reliable component costs little more than ordinary, non-regulating transformers. And compared to other types of regulating circuitry used with conventional power transformers, it is considerably cheaper.

The plate-filament regulator is only one of the complete family of Sola Constant Voltage Transformers including such special types as filament and adjustable-output units. More than 40 models are available from stock, and Sola manufactures custom-designed units in production quantities to meet special needs.

For additional information write for Bulletin 31D-CVE

SOLA

B P C

A DIVISION OF BASIC PRODUCTS CORPORATION

SOLA ELECTRIC CO., 4633 W. 16th St., Chicago 50, Ill., Bishop 2-1414 • In Canada, Sola Electric (Canada) Ltd., 377 Evans Ave., Toronto 18, Ont.

CIRCLE 121 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Rectifier 466

Is rated at 17 amp average at 25 C

Style 31 double-diffused silicon rectifier is rated at 17 amp average at 25 C ambient on a 5 x 5 x 1/16 in. copper heat sink. The peak inverse voltages of the component range from 50 to 400 v, in 50 v steps. A typical forward dynamic resistance of 0.009 ohms is achieved by diffused junction techniques.

Syntron Co., Dept. ED, 283 Lexington Ave., Homer City, Pa.

Oscillograph 639

Records up to 14 traces

Model 621 direct-recording oscillograph can record up to 14 data traces on paper 6-in. wide. The record is displayed on a horizontal table before being wound on the take-up roll. The record transport can be operated at speeds of 0.2 to 60 in. per sec, in three ranges. The galvanometers used have a natural response from dc to 10,000 cps and a flat response of 6000 cps. These galvanometers also allow information traces to cross. The recorder is a lightweight, compact unit and is portable. It incorporates modular plug-in components.

Midwestern Instruments, Dept. ED, P.O. Box 7186, Tulsa, Okla.

Availability: *Delivery time is 30 days.*

For Immediate Delivery Of MOTOROLA TRANSISTORS

Contact These DISTRIBUTORS

ALAMOGORDO
Radio Specialties,
209 Penn Ave.
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Ack Radio Supply Co.,
3101 Fourth Ave., So.
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811 Boylston St.
COpley 7-4700

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STate 2-2944

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NAtional 2-6860

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1260 E. 38th St.
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MOTOROLA
Semiconductor Products Division

CIRCLE 881 ON READER-SERVICE CARD

CIRCLE 122 ON READER-SERVICE CARD

FROM MOTOROLA

NEW 5 AMP POWER TRANSISTORS

... offer Wider Selection of Gain / Voltage Combinations

This new Motorola 5 amp power transistor series offers significant advantages to designers of high-quality industrial and military equipment. Outstanding features include:

- All voltages are specified including BV_{CBO}, BV_{CEX}, BV_{CES} and BV_{CEO}.
- Twenty gain/voltage combinations.
- Guaranteed maximum thermal resistance of .8°C/W.
- Less driving power required because of higher gain.
- Maximum 2 to 1 beta range specified.
- 90 watts dissipation.
- 100°C maximum junction temperature.
- Hermetically sealed TO-3 package.

Units are designed for switching and amplifier applications from DC through the audio frequency range. High voltage and current ratings permit switching operation at power levels of up to 500 watts. High transconductance and low saturation make high beta units ideal for converter applications.

IMMEDIATELY AVAILABLE from your Motorola Semiconductor Distributor. For complete technical information, contact your Motorola Semiconductor district office:

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CHICAGO 51, 5234 West Diversey Avenue — AVenue 2-4300
DETROIT 27, 13131 Lyndon Avenue — BRoadway 3-7171
LOS ANGELES 1741 Ivar Avenue, Hollywood 28 — HOllywood 2-0821
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SAN FRANCISCO 1299 Bayshore Highway, Burlingame — Wisconsin 7-2980 / Diamond 2-3228

MOTOROLA
Semiconductor Products Division

NEW PRODUCTS

CR Tube 403

Operates at 90,000 ft

The Rayonic Type 3ATP1 cathode-ray tube is designed for frequencies in the 100-mc range at altitudes up to 90,000 ft without the use of potted bases or special containers. The second anode and all deflection plates are brought out through the bulb to reduce input capacitance and allow high-voltage operation. It has a 1.5 x 3 in. flat face; sensitivity is 33 v per in. vertical at 2000 v anode potential. Measuring 9-in. long, its overall height is 1.5 in.

Waterman Products Co., Dept. ED, Philadelphia 25, Pa.

Price & Availability: *Sample quantities now available; estimated OEM price is under $30.*

DC Power Supply 482

Gives 4 to 32 v at 0 to 15 amp

Model TR40 transistor regulated dc power supply is designed to operate from 105 to 125 v dc, 50 to 60 cps, and furnishes 4 to 32 v at 0 to 15 amp. Regulation is held to within ±1/2% for the stated line voltage and load current changes. Maximum rms ripple does not exceed 3 mv. Terminals for remote sensing and ac input are located on the rear terminal board. The unit is intended for rack mount, and occcupies 8-3/4 in. of vertical panel height. A dust cover is furnished with the unit.

Opad Electric Co., Dept. ED, 43 Walker St., New York 13, N.Y.

Price & Availability: *Available from stock. Price is $415.*

Static Inverter 476

Can supply 60-w output

Capable of supplying 60-w power at an efficiency of 95%, model P303 static inverter changes dc to a square-wave ac. It can drive motors directly without the need of an output transformer. A frequency stability of ±1% over a wide temperature range makes this unit suitable for the operation of gyro and recorder motors. It weighs 3 oz with a total volume of just over 2-1/2 cu in. The basic unit operates from 28 v dc with an output frequency of 400 cps.

Westamp, Inc., Dept. ED, 11277 Massachusetts Ave., Los Angeles 25, Calif.

Commutator 405

Life is 10,000 hr

For aircraft and missile multiplex telemetering systems, this electronic commutator has a life of 10,000 hr or more. Operating temperature is from −60 to +125 C, load resistance is 5000 ohms to 2.5 meg, and contact resistance is 5 to 10 ohms. Leakage currents are less than 0.005 μa at 5-v signal levels. Sampling rates are as high as 50,000 samples per sec. The unit is completely solid state, has short rise and fall times, and has no built-in amplifiers to affect the signal. Of modular design, it occupies 0.4 to 0.5 cu in. per channel.

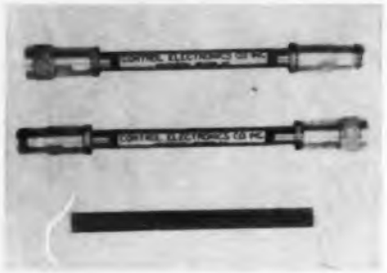
Kinetics Corp., Dept. ED, 410 S. Cedros Ave., Solana Beach, Calif.

Availability: Standard 30-channel, high level units are furnished from stock. Other units are made on order.

NEW PRODUCTS

Acceleration Switch 453

Input-output impedance is 50 ohms



Model 216 miniature, spdt, acceleration switch operates over the temperature range of −65 to +250 F. A bi-directional, single-axis switch, it is capable of closing electrical circuits in response to a preset acceleration level and resetting when the acceleration drops below the preset value. It consists of a gas-damped seismic system with a range of ±10 to ±30 g, an accuracy of ±5%, repeatability of ±0.5 g, and a damping ratio of 0.8 of critical. It is normally open with contact ratings of 100 ma for each contact. Particularly suitable for use in aircraft and missile control, measuring, and indicating devices, the unit is hermetically sealed, weighs 1 oz, and measures 1-11/16 x 7/16 in.

W. L. Maxson Corp., Instruments Div., Dept. ED, 475 Tenth Ave., New York 18, N.Y.

Price & Availability: *For 1 to 10 units, $125 ea. Delivery is 30 days after receipt of order.*

Relays 463

Are aircraft-missile type

Series RA and SA miniature relays are hermetically sealed, aircraft-missile types for ac applications. Either half-wave or full-wave silicon diode rectifiers are in the case to provide for using up to 125 v ac on the coil. Units come with shock and vibration resistances of 30 and 50 g, respectively. They are available in standard mounting arrangements, including AN type connector mounting.

Hart Manufacturing Co., Dept. ED, 210P Bartholomew Ave., Hartford, Conn.

SILICON DIFFUSION COMPUTER DIODES

Military Types

IN643-662-663

TYPE NO.	VOLTAGE* @ 100 μa (volts)	MIN. FWD. CUR. @ +1.0 volt (mA)	MAX. REVERSE CURRENT (μa)		REVERSE RECOVERY CHARACTERISTICS	
			25°C	100°C	REVERSE RESIST. (Ohms)	MAX. RECOV. TIME (μs)
1N643†	200	10	.025 (10v) 1 (100v)	5 (10v) 15 (100v)	200K	0.3
1N662‡	100	10	1 (10v) 20 (50v)	20 (10v) 100 (50v)	100K	0.5
1N663*	100	100	5 (75v),	50 (75v)	200K	0.5

†Mil-E-1/1171 (SigC) ‡Mil-E-1/1139 (SigC) *Mil-E-1/1140 (SigC)

Extremely Fast Low Capacitance Types

IN925 thru IN928

TYPE NO.	MIN. SAT. VOLTAGE @ 100 μa (volts)	MIN. FWD. CUR. 1.0 volt (mA)	MAX. REVERSE CURRENT (μa)		REVERSE RECOVERY CHARACTERISTICS			MAX. CAP. @ ZERO VOLTS (μμf)
			25°C	100°C	REVERSE RESIST. (Ohms)	MAX. RECOV. TIME* (μs)	TYPICAL RECOV. TIME** (Mμs)	
1N925	40	5	1.0 (10v)	20 (10v)	20K	0.15	5.0	4.0
1N926	40	5	0.1 (10v)	10 (10v)	20K	0.15	5.0	4.0
1N927	65	10	0.1 (10v) 5.0 (50v)	10 (10v) 25 (50v)	20K	0.15	5.0	4.0
1N928	120	10	0.1 (10v) 5.0 (50v)	10 (10v) 25 (50v)	20K	0.15	5.0	4.0

*Switching from 5mA to − 10 volts ($R_L = 1K$, $C_L - 10\mu\mu f$)
**Switching from 5mA to − 10 volts
($R_{Trap} = 100$ ohms, $C_L = 8\mu\mu f$ including diode capacitance)
†Maximum DC working inverse voltage is 85% of minimum saturation voltage
OTHER SPECIFICATIONS:
Peak Pulse Current, 1 μsec, 1% duty cycle: 3.0 Amps
Storage and Operating Temperature Range −65°C to 200°C

New High Conductance Types

IN789 thru IN804

TYPE NO.	MIN. SAT. VOLTAGE* @ 100 μa (volts)	MIN. FWD. CUR. @ +1.0 volt (mA)	MAX. REVERSE CURRENT (μa)		REVERSE RECOVERY CHARACTERISTICS	
			25°C	100°C	REVERSE RESIST. (Ohms)	MAX. RECOV. TIME (μs)
1N789	30	10	1 (20v)	30 (20v)	200K	0.5
1N790	30	10	5 (20v)	30 (20v)	200K	0.25
1N791	30	50	5 (20v)	30 (20v)	200K	0.5
1N792	30	100	5 (20v)	30 (20v)	100K	0.5
1N793	60	10	1 (50v)	30 (50v)	200K	0.5
1N794	60	10	5 (50v)	30 (50v)	200K	0.25
1N795	60	50	5 (50v)	30 (50v)	200K	0.5
1N796	60	100	5 (50v)	30 (50v)	100K	0.5
1N797	120	10	1 (100v)	30 (100v)	200K	0.5
1N798	120	10	5 (100v)	30 (100v)	200K	0.25
1N799	120	50	5 (100v)	30 (100v)	200K	0.5
1N800	120	100	5 (100v)	30 (100v)	100K	0.5
1N801	150	10	1 (125v)	30 (125v)	200K	0.5
1N802	150	50	5 (125v)	50 (125v)	200K	0.5
1N803	200	10	5 (175v)	50 (175v)	200K	0.5
1N804	200	50	10 (175v)	50 (175v)	200K	0.5

Study these specifications! You'll find a decided dollar advantage because you can select exactly the specifications you require... and have the added assurance of reliability standards unsurpassed in the industry!

Pacific Semiconductors, Inc.

12955 CHADRON AVENUE, HAWTHORNE, CALIFORNIA
(A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE, INC.)

CIRCLE 879 ON READER-SERVICE CARD

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ACK SEMICONDUCTORS, INC.
Birmingham, Alabama

ACK RADIO SUPPLY OF GEORGIA, INC.
Atlanta, Georgia

ALLIED RADIO CORPORATION
Chicago 80, Illinois

ALMO RADIO CORPORATION
Philadelphia 7, Pennsylvania

CRAMER ELECTRONICS, INC.
Boston 16, Massachusetts

DENVER ELECTRONIC SUPPLY CO.
Denver 4, Colorado

ELECTRO SONIC SUPPLY CO., LTD.
Toronto 5, Ontario, Canada

ELECTRONIC SUPPLY
Melbourne, Florida

ELECTRONIC SUPPLY CORP.
Pasadena, California

ELECTRONIC WHOLESALERS, INC.
Washington 1, D.C.

ELMAR ELECTRONICS, INC.
Oakland, California

FERGUSON ELECTRONIC SUPPLY CO.
Detroit 38, Michigan

GENESEE RADIO & PARTS CO., INC.
Buffalo 16, New York

GRAHAM ELECTRONIC SUPPLY, INC.
Indianapolis 25, Indiana

KIERULFF ELECTRONICS, INC.
Los Angeles, California

LEW BONN COMPANY
Minneapolis, Minn.

OIL CAPITOL ELECTRONICS
Tulsa 16, Oklahoma

PEERLESS RADIO DISTRIBUTORS, INC.
Jamaica 33, New York

PIONEER ELECTRONIC SUPPLY CO.
Cleveland 15, Ohio

RADIO SPECIALTIES COMPANY, INC.
Alamogordo, New Mexico

RADIO SPECIALTIES CORP.
Phoenix, Arizona

RADIO SPECIALTIES, INC.
Albuquerque, New Mexico

ROCHESTER RADIO SUPPLY CO., INC.
Rochester 5, N.Y.

SEATTLE RADIO SUPPLY, INC.
Seattle, Washington

SREPCO, INC.
Dayton 4, Ohio

STANDARD RADIO PARTS, INC.
Tucson, Arizona

STANDARD SUPPLY COMPANY
Salt Lake City 10, Utah

STERLING RADIO PRODUCT, INC.
Houston 1, Texas

SYRACUSE RADIO SUPPLY CO.
Syracuse, New York

TERMINAL ELECTRONICS INC.
New York 11, N.Y.

WHOLESALE ELECTRONIC SUPPLY
Dallas, Texas

WHOLESALE RADIO PARTS COMPANY
Baltimore, Maryland

CIRCLE 880 ON READER-SERVICE CARD

NEW PRODUCTS

Photoelectric Switch 585

Single lens type

Using a single lens for the exit and return of the light beam, the LS series photoelectric switch measures 3-3/8 × 2-9/16 × 5-1/8 in. The light source, photocell, and transistorized amplifier are housed in one package. Focused and parallel beams are available for operating as close as 1 in. or as far as 80 ft. Objects smaller than 0.05 in. in diameter can be detected.

Presin Co., Dept. ED, 2014 Broadway, Santa Monica, Calif.

Price & Availability: *Units are available from stock; price is $137.50 ea.*

Spectrum Analyzer 428

Range is 5 to 1000 cps

Model 51 spectrum analyzer covers the frequency range of 5 to 1000 cps without the use of contiguous filters. It operates in real time, has a 3-db resolution of 6.5 cps and a 40-db bandwidth of 60 cps. All the frequency components of the input signal in the frequency range are displayed every 200 msec. A complete frequency spectrum of the input signal is displayed on a 5-in. oscilloscope every 1/5-sec. The instrument is a delay-line synthesized Fourier analyzer operating at a maximum information extraction rate.

Federal Scientific Corp., Dept. ED, 615 W. 131st St., New York 27, N.Y.

Price & Availability: *Price is $39,400 for one unit, $32,600 ea for two, and $25,000 ea for three. Delivery requires 200 days.*

◀ CIRCLE 123 ON READER-SERVICE CARD

DC Power Source 670

Delivers 6 v

Replacing primary-type, dry-cell batteries for dc power, model 6CAD450 power supply delivers 6 v. By removing cells, outputs of 4.8, 3.6, 2.4, and 1.2 v dc can also be provided. The total capacity is 450 ma-hr at a 10-hr rate without ac. For severe load conditions, it will supply 4 amp for short periods. The dc power input rate for charging purposes is adjustable to 0.006, 0.012, and 0.018 amp. The unit, including cells, weighs 18 oz.

American-Monarch Corp., Dept. ED, 2801-37th Ave., N.E., Minneapolis 18, Minn.

Price & Availability: *Price is between $6.25 and $50. Delivery is in 60 days.*

Toroidal Inductors 606

Used in wired and printed circuits

Capable of being used in wired and printed circuits, these toroidal inductors are encased in epoxy filled bakelite cases in sizes from 11/16 in. in diameter and 3/8 in. high, to 2 in. in diameter and 1 in. high. Values of Toroiductors range from 100 μh to 20 h. They come with standard core materials and cover a range from low audio frequencies to about 100 kc.

Forbes & Wagner, Inc., Dept. ED, 345 Central Ave., Silver Creek, N.Y.

Price & Availability: *Are now made on order only and delivered 20 to 30 days after receipt of order. Available from stock by May 1. Prices on request.*

Foot-Switch 429

Rating is 0.8 amp at 125 v ac or dc

No. 90 foot switch, designed to change speeds in variable-speed equipment, is rated at 0.8 amp at 125 v ac or dc. The variable resistor has a maximum resistance of 350 ohms.

Linemaster Switch Corp., Dept. ED, 432 Woodstock Terrace, Woodstock, Conn.

Price & Availability: *Units are available from stock. List price is $6.75 ea, including cord-set.*

CIRCLE 124 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Counter 637

For continuous operation at 500 rpm

Able to operate continuously at 500 rpm and intermittently at 1280 rpm, type 10519 mil counter provides readings from 0000 to 6399. One revolution provides 10 mils of indication. The counter is reversible at any point in its cycle. Applications include use in radar indicators, computers, fire control devices and missile tracking devices. Designed to meet MIL-E-5272A, the counter is corrosion resistant with black anodized aluminum housing and drums. The input shaft is stainless steel and other parts are hardened, specially treated steel. Other materials may be specified.

Bowmar Instrument Corp., Dept. ED, 8000 Bluffton Road, Fort Wayne, Ind.

Availability: *The unit is made on order.*

Pressure Switch 642

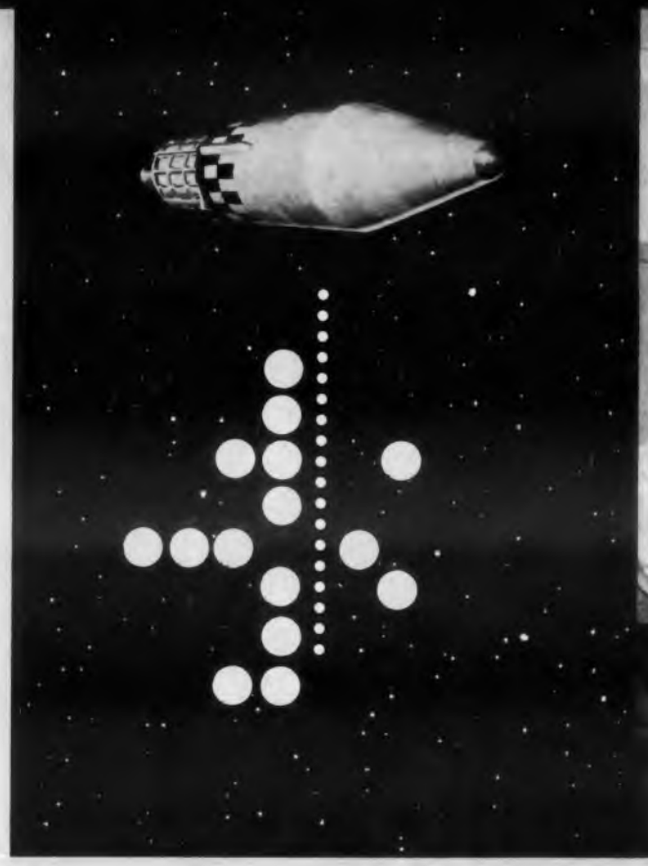
Barometric range is 700 to 25,000 ft

The predetermined pressure range of the 1707 barometric pressure switch is 700 to 25,000 ft. decreasing altitude, ±10%. The unit weighs 4 oz and measures 2-1/4 in. in diameter by 2-1/4 in. The assembly contains a standard 5300 series subminiature snap-action switch that withstands 10 g vibration to 500 cps. The 1707 is one of several series 1700 switches. They can be designed for other altitude settings, and with 1 to 3 pole circuitry.

Haydon Switch, Inc., Dept. ED, Waterbury 20, Conn.

Availability: *Made on order only. Can be delivered 45 days after order is received.*

CIRCLE 921 ON CAREER INQUIRY FORM, PAGE 219 ➤



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY IN

ELECTRONICS

Lockheed Missiles and Space Division has made significant contributions in electronics in such areas as: computer development; telemetry; radar and data links; transducers and instrumentation; antennas and electromagnetic propagation and radiation; ferrite and MASER research; data reduction and analysis; solid state electronics, including photovoltaic devices, electrochemistry, infrared optics; FM-FM data systems; PAM-PCM data links; and logical design.

Special emphasis is being attached to the research, design and development of improved military electronics systems for communications, including new methods of data transmission, reception and storage. Pioneering work is also being conducted in space vehicle borne computers, DC-AC inverters, non-gyro guidance systems. Studies in oceanography include underwater communication and navigation, and natural phenomena and military aspects of the deep sea.

Lockheed's programs reach far into the future and deal with unknown environments. It is a rewarding future and one that outstanding scientists and engineers are invited to share. If you are experienced in any of the above areas, or in related work, we invite your inquiry. Please write: Research and Development Staff, Dept. D-21, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER, MIDAS and SAMOS Programs; Air Force X-7; and Army KINGFISHER.

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA · CAPE CANAVERAL, FLORIDA · ALAMOGORDO, NEW MEXICO · HAWAII

NEW PRODUCTS

Sampling Switch 477

Is a 2-pole, 60-position type

Designed for application to an area-defense, missile-guidance, radar system, this switch is a 2-pole, 60-position, motor-driven, low-level type. It occupies 43.7 cu in., weighs less than 2.5 lb, and consumes 7 w of power at 100 v, 400 cps, single phase. The switch is said to have performed satisfactorily while undergoing missile vibration testing of 20 to 3000 cps at 35 g for 35 min per axis.

Instrument Development Laboratories, Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.

Film Capacitors 641

Insulation resistance is greater than 10^{13} ohms

The CR Process precision film capacitors, designed for operation from −55 to +125 C, have an insulation resistance greater than 10^{13} ohms. Capacitance change is less than 1% for the entire range. From 25 to 125 C, the capacitance change is less than ±0.3% and the temperature coefficient is 0 ±30 ppm per deg C, which remains stable with repeated temperature cycling. Dielectric absorption is less than 0.0003 when measured with a charging voltage of 44 v for 30 sec. Dissipation factor is 0.0003 over the temperature range and over a wide range of frequencies. Standard tolerance of the units is 2%.

Component Research Co., Inc., Dept. ED, 3019 S. Orange Drive, Los Angeles 16, Calif.

***Price & Availability:** Price ranges from $5.50 to $40 ea for 1 to 24 units. Delivery time is one week.*

General Purpose Recorder 588

For use with up to six sensing elements

This general purpose laboratory recorder is for use with up to six resistance-type sensing elements or transducers. Six self-contained temperature controlled bridge circuits are designed for sensor resistances of 85 to 350 ohms. The output of the sensors is recorded every 5 to 30 sec. The full scale range is continually variable from 0.6 to 60 ohms with an accuracy of ±0.5% of full scale. When pure nickel sensors are used, temperature changes of 0.01 F in the range of 100 to 160 F are continuously monitored and recorded.

The Sippican Corp., Dept. ED, P.O. Box 537, Marion, Mass.

Price & Availability: *Prices are quoted on request. Delivery is in 90 days after receipt of order.*

Recorder-Reproducer 432

Has five modes of recording and playback

Model 5-752A recorder-reproducer permits selection from five modes of recording and playback: analog, fm, PDM, compound modulation, and digital. Change-over is made by plugging in the appropriate signal amplifier. The automatic ready circuit is energized when the tape is correctly threaded and the machine is ready for operation. Having an all-welded steel cabinet, the unit is suitable for mobile installations.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Price & Availability: *Information is provided on request.*

CIRCLE 130 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Gyro 471

Withstands 40 g acceleration and shock

Capable of withstanding 40 g acceleration and shock, model 3417 gyro has an outer gimbal range of 360 deg, and an inner gimbal range of ±80 deg from the caged position. Mechanical caging is actuated by a push-rod plunger extending through the gyro base. Both gimbals can be uncaged simultaneously in less than 0.1 sec when a 24 to 30 v dc input is applied. Operating temperature range is from —54 to +71 C.

Giannini Controls Corp., Dept. ED, 918 E. Green St., Pasadena, Calif.

Connector Adapter 638

One-piece construction

Made to conserve space in communications equipment, this 75-ohm, rf, T-adapter is for use with Conhex rf connectors. The one-piece construction provides unusual strength. The contact assembly provides excellent electrical characteristics. The unit is preassembled and gold-plated for long shelf life.

Sealectro Corp., Dept. ED, 139 Hoyt St., Mamaroneck, N.Y.

Availability: from stock.

Klystrons 464

Have a 50-mc bandwidth

Type L-3283 klystrons have flat gain and power characteristics over the minimum bandwidth of 50 mc. At band edges, minimum peak power output is 2 mw. The tubes' linear phase shift vs. frequency characteristic qualifies them for use in radar systems requiring electronic tuning and pulse shaping.

Litton Industries, Electron Tube Div., Dept. ED, 960 Industrial Road, San Carlos, Calif.

Microwave Attenuators 452

Temperature coefficient is 280 ppm

These microwave attenuators use vacuum-evaporated, metal-film resistors with a temperature coefficient of 280 ppm. These units are stable over the temperature range of −55 to +125 C. Available in sizes of 3, 6, 10, and 20 db, they have type N fittings and cover the range of 1 to 10 kmc with a low vswr.

Microwave Control Corp., Dept. ED, 250 W. 57th St., New York 19, N.Y.

***Price & Availability:** $37; delivery is two weeks after receipt of order.*

Teflon Terminal 478

Used in heavy gage chassis assemblies

Designed for use on chassis bases up to 0.187 in. thick, type ST-250L4-C2 press-fit Teflon terminal is of the double turret type. Two termination positions are provided, each with a holding collar for extra mechanical strength in the wire termination. Terminal stud diameter is 0.062 in. with holding collar diameters of 0.125 in. Overall height above chassis is 0.406 in.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

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ELECTRONIC DESIGNERS CATALOG EDC

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NEW PRODUCTS

Ceramic Elements 472

Hold properties up to 350 C

Compounded from a modified lead zirconium titanium material which maintains its piezoelectric properties at temperatures approaching 350 C, these ceramic elements are suitable for use in sonar systems, ultrasonic cleaners, accelerometers, and similar electro-acoustical devices. They come in hollow spheres and cylinders up to 6 in. in diameter, bars up to a foot long, discs, and blocks. Ends are silver coated for easier attachment of leads which can be furnished upon request.

Universal Dynamics Corp., Dept. ED, 130 Los Aguajes Ave., Santa Barbara, Calif.

Stepping Switch 635

Is 22-pole, 2-position type

Type D-9082-M-28 stepping switch is hermetically sealed and has a 22-pole, 2-position design. Current at rated coil voltage is 3.5 amp, normal rated voltage is 28 v dc, approximate switching rate is under 30 msec, and contact rating is 1/2 amp resistive at 110 v ac and 2-1/2 amp resistive at 28 v dc. The dielectric switch rating is 500 v rms. The unit stands vibration of 2000 cps at 10 g, shock of 30 g for 11 ±1 msec, 50 hr of salt spray, and 95% ±5% RH at 49 C for 48 hr. The operating temperature range is −55 to +80 C.

G. H. Leland, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.

Price & Availability: *Price ranges from $178.35, for quantities of 1 to 9, to $108.95, for quantities of 100. Delivery of 1 to 9 units takes two weeks.*

Vol. 2, No. 3

Nickelonic News

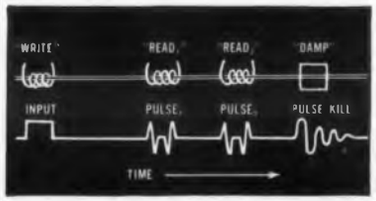
DEVELOPMENTS IN INCO NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS

Magnetostriction of Nickel drives Deltime data storage unit. With these units some 15 million bits of data could be handled in a 3x7x7 foot space, engineers estimate.

Shock waves in Nickel "store" 1500 bits of information

MAMARONECK, N. Y.: Magnetostriction produces shock waves in Nickel that travel one foot in about 63 microseconds. Deltime, Inc. uses this property of Nickel to build electronic delay lines. Their latest is a data storage unit that packs eleven 300-microsecond delays in a small space. Ten lines "store" 150 bits of data each, the other "clocks."

Center rod of unit (shown with plastic cover to reveal detail) is structural. Nickel delay lines are concentrically located around rod. Diagram below shows schematic of a single line with associated pulses.



Delay lines are Inco Electronic-Grade "A"* Nickel, drawn fine and stranded to reduce eddy currents. Deltime engineers say Nickel combines large and efficient magnetostrictive response, minimum corrosion, excellent mechanical properties.

Pertinent Literature: Write for Inco Bulletin 127B: "Magnetostriction".

Circle 837 on Reader-Service Card

5 new Inconel-protected instruments retain accuracy at missile speeds, heats

. . . point the way to more reliable high temperature parts design

CHICAGO, ILL.: Streaking through the air on mile-a-second missile nose cones . . . fixed in hot, corrosive fluid streams . . . the five new instruments described below operate reliably at glowing temperatures. Aero Research standardizes on Inconel* nickel-chromium alloy for parts of these instruments that bear the brunt of this demanding service.

(1) Total temperature probe – withstands 1740° F generated by friction during flight on missile nose cones. (See photos below.) For maximum reliability, its Inconel sheathing also withstands oxidation and thermal shock.

(2) Wide-range thermocouple – measures temperatures from as low as −320° up to +1900° F in high-velocity fluids. Inconel sheathing effectively resists these severe erosive-corrosive conditions.

(3) High-accuracy, high-temperature probe—measures temperatures between 0° and 1800° F. Again, Inconel sheathing assures reliability, protecting its accuracy in supersonic jet exhausts, high-temperature furnaces.

(4) Jet thrust measuring rake, water-cooled – operates in 3500° F jet afterburner gases. Inconel alloy construction provides essential high strength at high temperature, plus corrosion resistance.

(5) Sonic-speed, 4430° F, wind tunnel, water-cooled – Inconel alloy forms all major components, gives tunnel the backbone needed to stand up under terrific velocity and heat.

You, too, can give parts high temperature stamina with Inconel alloy. It retains useful strength through 2000° F, and can be easily welded and formed into intricate shapes.

Pertinent Literature: Write for Bulletin T-7: "Engineering Properties of Inconel and Inconel X", and "Inco Nickel Alloys for Electronic Uses".

Circle 838 on Reader-Service Card

Inconel-sheathed total temperature probe mounted on Redstone missile nose cone – assures high strength at high temperatures and readily withstands oxidation, erosion and thermal shock at extreme velocities. Probe (shown at right) is product of Aero Research Instrument Company, Inc., Chicago, Illinois.

Sensitive transducer measures minute changes of pressure in human body

. . . Monel fluid chambers withstand corrosion, do not affect saline purity

WALTHAM, MASS.: This sensitive pressure transducer measures a wide range of physiological pressures – from 400 mm Hg down to less than 1 mm Hg.

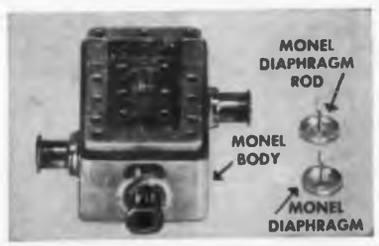
Absolute and differential pressures travel from source (needle or catheter) through a saline-filled tube to actuate two small Monel* nickel-copper alloy diaphragms. Monel diaphragm rods pivot a tiny differential transformer core, producing a signal which is fed to amplifiers for quick reading.

Monel alloy was chosen for the parts above because it withstands corrosive attack from all common saline and sterilizing solutions. As a result, Monel alloy does not affect saline purity. In addition, Monel alloy is easy to form, machine, to braze, solder and weld.

Pertinent Literature: Write for Bulletin T-5; "Engineering Properties of Monel and R Monel".

Circle 839 on Reader-Service Card

*Trademark The International Nickel Company, Inc.



Monel transducer body and diaphragms resist corrosive saline solutions for long, reliable service. Transducer is made by Sanborn Company, 175 Wyman St., Waltham, Mass.

INCO NICKEL

ALLOY PRODUCTS

CIRCLE 137 ON READER-SERVICE CARD

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company
67 Wall Street New York 5, N.Y.

NEW PRODUCTS

DC Power Supply 640

For ground radar applications

Designed for ground radar applications, model M-1324 dc power supply measures 19 x 17 x 22 in. It meets MIL-T-24A, MIL-E-5272, MIL-M-10304, MIL-C-5015, and JAN-C-62. It has an output of 26.5 v at 100 amp, adjustable to ±10%. Static line regulation is 0.1% for ±10% line variation and dynamic load transients are minimized to 3 v for a 30% load change. Ripple is 1% rms max. The input is 208 v ac ±10%, 60 ±5 cps, three-phase. The unit uses magnetic amplifier circuitry and a transistorized preamplifier.

Perkin Engineering Corp., Dept. ED, EL Segundo, Calif.

Price & Availability: *$2900 per unit, $2000 in quantities of 30, and $2500 in quantities of 10. Delivery time is 60 days.*

Data Collector 455

Is compact, self-contained

Model 180 data collector, a self-contained unit about the size of a typewriter, collects and records in computer-intelligible form. It assembles variable data, identification data from prepunched cards, fixed data, and time to the nearest 0.01 hr into punched paper tape. The output is recorded at a rate of 15 characters per sec.

Control Data Corp., Dept. ED, 501 Park Ave., Minneapolis 15, Minn.

Price & Availability: *Price is $2995 ea. The unit will be ready for delivery in the summer of 1960.*

Photoelectric Pickup 441

Reflecting type

Model RFU-7, reflecting type photoelectric pickup can be adjusted as to the angle and reflection of spot distance. The IRC series of relays contain the controls for adjusting both the light and photo sensitivities in the unit. With these controls, the relay can be triggered to act at any desired threshold of reflected light. The unit measures 1-3/4 x 2-1/2 x 2-3/4 in.

Photomation, Inc., Dept. ED, 96 S. Washington Ave., Bergenfield, N.J.

Price & Availability: *Available from stock and delivered in 1 week. Price is $77.50; quantity discounts available.*

Potentiometer 672

Short stroke linear motion type

Designed primarily for missile applications, model 157 is a short-stroke, linear-motion potentiometer. The self-aligning shaft permits measurement of linear displacement even when perfect alignment with an actuating member is impossible.

Bourns, Inc., Instrument Div., Dept. ED, Box 2112, Riverside, Calif.

Limit Switch 442

Controls 4 isolated circuits

This switch contains 2 two-circuit, double break switches which can control four isolated circuits. An aluminum actuator arm operates one of the basic switches when rotated to the left; it operates the other when rotated to the right. Each basic switch has ratings of 120, 240, and 460 v ac at 10 amp. Switches and terminals are mounted in die-cast aluminum housings.

Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. ED, Freeport, Ill.

Price & Availability: *Available from stock. Prices are: $20.65 per unit; $19.62 when ordered in quantities of 25 to 49; $18.59 when ordered in quantities of 50 to 499.*

CIRCLE 141 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Calibration Console 395

Accuracy is 0.05%

Designed for fast calibration of ac and dc instruments, model 61 laboratory calibration console provides an accuracy of 0.05%. Any dc range can be automatically divided into as many as 15,000 steps; ac ranges may be divided into 30 parts. The unit can be used for design, development, and service calibration of all types of portable, panel, switchboard, and recording instruments. It measures 5 x 7 x 2 in.

Weston Instruments, Daystrom, Inc., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N.J.

Power Supplies 420

Output is ±300 v

Models R-500, R-300, and R-100B power supplies have tracking, dual outputs of ±300 v dc at 500, 300, and 100 ma. Low dissipation is provided by silicon junction diodes. Power transformers have a 30 C rise at 25% overload. Circuit breakers have thermal sensing elements in the secondary which open the primary. The output ripple is about 200 mv ac. Designed specifically for energizing analog computers and components, these units have a variety of laboratory and industrial applications.

George A. Philbrick Researches, Inc., Dept. ED, 285 Columbus Ave., Boston 16, Mass.

Beryllium Oxide Ceramic 419

For vacuum tube applications

This beryllium oxide ceramic, designated Berlox EM, is specially processed for vacuum tube applications. It is also suitable for electrical insulating at high frequencies and at elevated temperatures. It has a low coefficient of expansion and excellent thermal shock resistance. Rods, tubes, cylinders, and bulk shapes are available.

National Beryllia Corp., Dept. ED, N. Bergen, N.J.

Magnetic Amplifier 586

Gives Power Gains up to 20,000

Model 615 magnetic instrumentation amplifier is designed to give power gains of up to 20,000 in a single stage. It is suited for amplifying low-level dc signals from thermistors, resistance thermometers, null detectors, and other low level dc transducers. The two input circuits and the output circuit are fully isolated from the 115-v supply as well as from each other. The unit requires 4 w of 115 v, 60 cps power. The outside case, hermetically sealed, is tin-coated steel. Life expectancy, without adjustment or maintenance, exceeds 10 yr.

Acromag, Inc., Dept. ED, 22519 Telegraph Road, Southfield (Detroit), Mich.

***Price & Availability:** Sample quantities are available beginning April 1st, 1960. Delivery time is 45 days. Price is $225 ea for quantities of 1 to 5 units; other prices will be quoted.*

Slip Ring Assemblies 430

Ring envelope sizes have 1 to 10.5 in. diam

This line of standard slip ring assemblies includes the following sizes of ring envelope diameters: 1, 1-3/4, 2-5/8, 4-7/8, 7-1/4, 9-9/16, and 10-1/2 in. These assemblies are of fabricated construction to provide maximum resistance to shock, vibration, and other environmental conditions and to permit the use of additional rings. The rings are made of hard silver and the brushes are silver graphite. Assemblies may be stacked on a common shaft forming a multiple unit.

Breeze Corp., Inc., Dept. ED, 700 Liberty Ave., Union, N.J.

◀ CIRCLE 142 ON READER-SERVICE CARD

NEW PRODUCTS

Electronic Counter 473

Accurate to better than ±1 part per million

Using a count-down time base requiring no adjustment and an oven-regulated crystal reference, model MFM-831 timer-counter has an absolute accuracy of better than ±1 part per million ±1 count. Frequency range is 10 cps to 1 mc; timer range is 3 μsec to 1 million sec. Data output is 6 decimal digits of 8-4-2-1 parallel binary decimal code. The unit complies with the requirements of MIL-E-4158B and has complete freedom from operating adjustments.

Epsco, Inc., Equipment Div., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.

Encapsulating Machines 408

Two types available

Two different kinds of encapsulating machines are offered. Model 1 portable resin dispenser can be used with foam, epoxies, and polyesters. Model 359D encapsulating machine is for use with thermosetting molding compounds such as epoxies, diallyl phthalates, alkyds, and silicons.

Hull Corp., Dept. ED, Hatboro, Pa.

Price: *The portable resin dispenser is priced at $2059 fob Hatboro. Model 359D is priced at $4780 with manual controls and $6780 for semi-automatic operation.*

Plug-In Modules 467

Are 3 x 4 in. printed circuit boards

These standard module packages are 3 x 4 in. printed circuit boards designed to plug into a standard printed circuit connector having 2 to 15 contacts. The boards are developed from 1/16 in. thick copper clad fibreglass board. Module systems are also available. They include: audio preamplifiers, muted noise amplifiers, monostable, astable, bistable multivibrators and trigger circuits, logic circuits, and emitter follower amplifiers.

Solar Manufacturing Corp., Dept. ED, 4553 Seville Ave., Los Angeles 58, Calif.

Silicon Rectifiers 479

Have peak inverse voltages from 100 to 1000 v

This line of silicon rectifiers is hermetically encapsulated in metallized ceramic. They are available with peak inverse voltages of 200, 400, 600, 800, and 1000 v at 750 ma. Units with lower peak inverse voltages can be supplied to customer specifications. Also available for the radio and phonograph industries are rectifiers with 400 v peak inverse voltage at 150 ma. The units measure 0.3 in. long x 0.2 in. OD.

Solitron Devices, Inc., Dept. ED, 67 S. Lexington Ave., White Plains, N.Y.

Tetrode 511

Used as a grounded-cathode rf-amplifier

Semiremote cut-off tetrode, type 6FH5, is a 7-pin miniature tube designed for use as a grounded-cathode rf-amplifier in vhf tuners of TV receivers. When connected as a triode, transconductance is 9000 μmhos, and the amplification factor is 50. Maximum ratings include 150-v plate voltage, 22-ma cathode current, and 2.2-w plate dissipation.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

RF Connectors 474

Used with air dielectric coaxial cables

These rf connectors are designed for use with semi-flexible, aluminum-sheathed, air dielectric coaxial cables. They are aluminum versions of the standard types N, C, LC, LT, EIA flange, and couplings for Styroflex, Foamflex, and Spirafil cable. Heat treated beryllium copper inner contacts allow for thermal differential expansion of the cable. A connection that is equal in strength to the tensile strength of the sheath itself is possible with these connectors.

Tamar Electronics, Inc., Dept. ED, 1805 Colorado Ave., Santa Monica, Calif.

NEW PRODUCTS

Delay Lines 470

Come in hermetically sealed casings

Designed for maximum delay-rise time ratio, these distributed-constant delay lines are hermetically sealed in drawn steel casings. Each unit consists of six ceramic rods coated with a silver capacitive element. They operate over a temperature range of −55 to +105 C; temperature stability is 0.15% C delay. Impedance is 1000 ohms 10%; attenuation tolerance is 20% max.

IMC Magnetics Corp., Gray & Kuhn Div., Dept. ED, 570 Main St., Westbury, N.Y.

Coaxial Terminations 634

Have low vswr

The DRL-3 series of coaxial terminations are compact, low-power units, offering a low vswr over a broad frequency range. Model RDL-3N, shown, covers 0 to 4000 mc with a vswr of 1.05:1 or less. Standard HN, N, TNC, BNC, LC, and LT connectors are offered. Units have precious metal resistors on a rugged ceramic base and can be used with up to 2 w.

Radar Design Corp., Dept. ED, 1004 Pickard Drive, Syracuse 11, N.Y.

Price & Availability: *Price ranges from $30 to $75, depending on connector. Units are available for immediate delivery.*

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

RFI Tester 636

Frequency range is 375 to 1000 mc

Model NM-52A tester, consisting of a selective-sensitive calibrated uhf microvoltmeter and a receiver, is designed to investigate, analyze, monitor and measure conducted energy or radiated electromagnetic energy over the range of 375 to 1000 mc. It has a sensitivity 20 to 40 db greater than required by Mil specs. The oscillator radiation is less than 8 μμw.

Stoddart Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif.

Price & Availability: *The unit is available for immediate delivery at a price of $3250.*

Potentiometers 456

Have 5/8-in diameter

Having a 5/8-in. diameter, series 200 miniature, composition potentiometers have a resistance range of 250 ohms to 2.5 meg linear taper. The units can be furnished with an attached switch, or without, in standard bushing-mounted construction or in an ear-mounting configuration. Power rating is 1/4 w up to 100,000 ohms and 1/5 w over 100,000 ohms at 55 C, derated to no load at 85 C. Voltage rating is 750 v ac, bushing to terminals for a 1-min high pot test; 500 v dc, operating maximum; and 350 v dc, across end terminals. Rotation is 280 deg without the switch, 315 deg with the switch. The units are designed for commercial applications.

Chicago Telephone Supply Corp., Dept. ED, Elkhart, Ind.

Price & Availability: *For quantities of 3000 to 9999, price starts at $160.42 per 1000 without switch, $316.93 per 1000 with switch. Delivery is four to five weeks after sample approval.*

NEW PRODUCTS

Cable Tester 587

For coaxial and multiple-conductor cable

By measuring elapsed time between a transmitted pulse and any resulting reflections, model 722 cable tester locates shorts, opens, mismatches, or intermittents in coaxial or multiple-conductor cable from 10 to 200 ft long. A cathode-ray tube shows the cable being tested. Faults appear as deflections along the horizontal trace across the screen. Location of the fault is marked by the relation of the deflection to graticule lines checked by an internally calibrated standard cable giving range marks 50 ft apart.

Smith-Florence, Inc., Dept. ED, 4228-23rd Ave., W. Seattle 99, Wash.

Price & Availability: *The unit can be delivered in 14 to 28 days after receipt of order. Price is $375.*

Ferrite Isolator 469

Isolation is greater than 17 db

Model V-FL 1 ferrite isolator is used to isolate the generator from the load. A compact unit, it operates as a non-reciprocal 45-deg rotator with a permanent magnet supplying the bias field. Isolation provided is greater than 17 db over a 3% band with an insertion loss of less than 0.6 db.

T.R.G., Inc., Microwave Component and Antenna Dept., Dept. ED, 9 Union Square, Somerville 43, Mass.

Price & Availability: *Price is $350 ea. The unit is made on order and can be delivered in 20 to 30 days.*

Shock Test Set 390

Produces 100 g for 6 msec

Able to duplicate the shock wave forms found in missiles and jet aircraft, the variable pulse shock machine produces a saw-tooth wave-shape up to 100 g with a duration of 6 msec, 1/2 or 1/4 sine waves, and a trapezoid wave-shape. Model ST-40 has a 12-in. work table and loads up to 40 lb of specimens. Model ST-100, able to load up to 100 lb, has a 15-in. diam. Both machines require 50 psi of plant or bottled air for raising the table after each drop. This equipment includes a built-in scope-triggering circuit and a safety release circuit.

Associated Testing Laboratories, Inc., Dept. ED, Caldwell, N.J.

Photoelectric Scanner 613

Contains light source and photocell

With energy source and detector combined in a single unit measuring 2-1/4 in. in length by 1-1/8 in. in diameter, type SA-IR infrared photoelectric scanner responds to metallic and nonmetallic objects at distances up to 2 in. The infrared source is rated at a 60,000-hr life when operated on 5 v ac. The anodized-aluminum housing, in which source and detector are contained, has provisions for mounting in a single 3/4-in. hole. A standard four-prong base permits a plug-in connection to the control circuit.

Farmer Electric Products Co., Inc., Dept. ED, 2300 Washington St., Newton Lower Falls, Mass.

Price & Availability: *Delivery is 2 weeks. Price is $29.*

REMEMBER!

For immediate information on "SCOTCH" BRAND Instrumentation Tapes, contact your nearest 3M branch office:

ATLANTA, GA. — 732 Ashby Street, N.W. Telephone: TRinity 6-4401

BEDFORD PARK, ILL. (Chicago Office)—6850 South Harlem Avenue, Argo Post Office. Telephone: GLobe 8-2200 (Chicago—LUdlow 5-7800)

BUFFALO, N.Y.—330 Greene Street (P. O. Box 2012, Zone 5), Telephone: BAiley 5214

CINCINNATI, OHIO—4835 Para Drive, Telephone: ELmhurst 1-2313

CLEVELAND, OHIO—12200 Brookpark Road, Telephone: CLearwater 2-4300

DALLAS, TEXAS—2121 Santa Anna Avenue (P. O. Box 28158), Telephone DAvis 7-7311

DETROIT, MICH.—411 Piquette Avenue, Telephone: TRinity 5-7111

HIGH POINT, N. C. — 2401 Brevard Street (P. O. Box 151), Telephone: 3496

HONOLULU, HAWAII—1410 Kapiolani Boulevard, Telephone: 996-483

LOS ANGELES, CALIFORNIA—6023 South Garfield Avenue, Telephone: RAymond 3-6641

NEWTON CENTER, MASS. (Boston)—1330 Centre Street, Telephone: DEcatur 2-9810

PHILADELPHIA, PENN. — 5698 Rising Sun Avenue, Telephone: PIlgrim 2-0200

RIDGEFIELD, NEW JERSEY (New York)—700 Grand Avenue, Telephone: WHitney 3-6700 (N.Y.—OXford 5-5520)

ST. LOUIS, MISSOURI—10725 Baur Boulevard, Telephone: WYdown 1-1320

ST. PAUL, MINNESOTA—367 Grove Street, Telephone: PRospect 6-8511

SEATTLE, WASHINGTON—3663 First Avenue South, Telephone: MUtual 2-5550

SOUTH SAN FRANCISCO, CALIFORNIA—320 Shaw Road, Telephone: PLaza 6-0800

MINNESOTA MINING AND MANUFACTURING COMPANY ...WHERE RESEARCH IS THE KEY TO TOMORROW 3M

CIRCLE 149 ON READER-SERVICE CARD

A GOOD RESOLUTION ON TAPE—

Tape high frequencies, whip the dropout problem with "SCOTCH" BRAND High Resolution Tapes

RIGHT HANDS UP, GENTLEMEN? Then repeat this phrase: "We resolve to get the tape that gets all the high frequencies—'SCOTCH' BRAND High Resolution Tape."

All levity aside, there's no need to settle for second-best. With "SCOTCH" BRAND Tapes 158 and 159 you get sharp resolution in high frequencies, good low frequency response—plus the consistent performance of a uniform tape.

Since "SCOTCH" BRAND high potency oxides are more efficient than ordinary oxides, a thinner coating can be applied to the polyester backing, and the sensitivity at short (1 mil) wave lengths is still about 3½ db greater than that of ordinary oxides. This thinner coating means a more flexible tape, permitting the intimate tape-to-head contact so necessary to sharp resolution in the higher frequencies. Thanks to "SCOTCH" BRAND silicone-lubricated binder system, backing and oxide are locked together as a *system*. Tape passes over heads friction-free, with even motion, minimizing phase and frequency shift distortion.

You can pack more pulses per inch, and get either standard or extra playing time with "SCOTCH" BRAND High Resolution Tapes. Your dropout count is lower because uniformity is higher. Only "SCOTCH" BRAND can draw on 3M's more than 50 years of experience in precision coating techniques. The result is a consistent tape with a uniform coating you can depend on for reliable performance.

"SCOTCH" BRAND High Resolution Tapes meet your need for top high-frequency response even in pulse code modulation (PCM) and pre-detection (video) applications; so switch now from tapes that may well be made obsolete by new instruments.

Whatever your application—data acquisition, reduction, or control programming—experienced "SCOTCH" BRAND technology has a dependable tape for the job. Sandwich Tapes 188 and 189 cut headwear, eliminate oxide rub-off, last 10 times longer than ordinary tapes. New Heavy Duty Tapes 198 and 199 give long wear, minimize static charge build-up. High Output Tape 128 gives top output in low frequencies, even at temperature extremes. And "SCOTCH" BRAND Standard Tapes 108 and 109 remain the standard for instrumentation.

Your nearby 3M Representative serves as a convenient source in all major cities. For details consult him or write Magnetic Products Div., 3M Company, Dept. MBQ-100, St. Paul 6, Minn.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY ...WHERE RESEARCH IS THE KEY TO TOMORROW 3M COMPANY

CIRCLE 150 ON READER-SERVICE CARD

NEW PRODUCTS

Bushings 486

For low voltage applications

These solder-seal bushings are designed for low voltage applications on hermetically sealed capacitors, test transformers, and similar types of electrical equipment. The bushings are completely leak-proof, and come in a variety of shapes, sizes, and ratings to fit a wide range of applications. Bushings consist of a porcelain unit with a thin metal coating to which metal caps, flanges, or rings can be attached by soft solder techniques.

Lapp Insulator Co., Inc., Dept. ED, Le Roy, N. Y.

Availability: Delivery from stock is 6 to 8 weeks.

Ribbon Indicator 462

Fits 1-1/8 x 5 in. panel opening

Model A22M electronic ribbon indicator measures 2 x 5-3/16 in. and can be mounted vertically or in a left or right horizontal position. It is a null-balance device that operates on the common 0 to 0.5 v ac signal with an accuracy of ±1% of full signal input. The amplifier assembly is a self contained unit that may be removed in its entirety if replacement is necessary. It can be supplied with one or two alarm contacts.

Crane Co., Swartwout Div., Dept. ED, 18511 Euclid Ave., Cleveland 12, Ohio.

Price & Availability: Available from stock by July 1. Can be delivered in 12 to 14 weeks. Prices range from $107.50 to $152.50.

Have you sent us your subscription renewal form?

Silicon Diodes 512

Come in three types

General purpose types 1N457, 1N458, and 1N459 silicon diodes have 0.025 μa reverse leakage and reverse voltages ranging up to 200 v. The devices are hermetically sealed in the standard glass package measuring 0.265 in. long, with a body diameter of 0.108 in. max. The requirements of MIL-E-1/1026, MIL-E-1/1027, and MIL-E-1/1028 are complied with.

Rheem Semiconductor Corp., Dept. ED, Box 1327, Mountain View, Calif.

DC-DC Amplifier 509

Gain is 25,000

Type A3700-01 dc-dc amplifier assembly, consisting of an input mechanical modulator, a high-gain ac amplifier, and an electrical demodulator output, has a gain of 25,000. The power input is +28 v dc ±2% at 10 ma max, −28 v dc ±2% at 35 ma max, and 6.3 v ac ±10% at 100 ma max. Signal frequency is 400 ±2.5 cps and output voltage is 10 v dc max. The unit operates at temperatures from 4 to 60 C. It weighs 25 oz.

Kearfott, Div. of General Precision Inc., Dept. ED, Little Falls, N.J.

Microwave Bandpass Filters 454

Temperature range is −65 to +250 F

These microwave bandpass filters have input-output impedances of 50 ohms. Model MWF-102 has a bandwidth of 7 to 11 kmc and model MWF-103 has a bandwidth of 8.65 to 11 kmc. Both units have a maximum insertion loss of 2 db in the pass band. At 5% and 15% at either end of the pass-band, the attenuation is 30 db down and 60 db down, respectively. The filters are aluminum-cased with an iridite finish. The inner conductors are silver-plated brass. Connector pins are silver-plated beryllium copper. Type N connectors are supplied with male and female type connections at each end.

Control Electronics Co., Inc., Filter Div., Dept. ED, 10 Stepar Place, Huntington, L.I., N.Y.

***Price & Availability:** $260 ea; two to three weeks.*

NEW PRODUCTS

Delay Line 515

Has 50 to 500 μsec delays

Type 5811 is a torsional mode delay line designed to meet the environmental requirements of MIL-E-5272A. Delays are available from 50 to 500 μsec, and digit rates are up to 1 mc. This line has a steel, hermetically-sealed case with provisions for external delay adjustment. Signal-to-noise ratio is at least 15 to 1; insertion loss is from 35 to 50 db. Maximum storage capacity is 500 binary digits.

Ferranti Electric Inc., Electronics Div., Dept. ED, 95 Madison Ave., Hempstead, Long Island, N.Y.

Availability: Made on order only. Delivered in 45 days.

Transistor Tester 468

Measures frequency response

Model F-20, a transistor frequency response meter, covers the frequency range between 50 to 750 mc. The instrument is self-contained, comes complete with batteries, and is adaptable for external power supply operation. It is small, lightweight, and portable. An accurate indication of the tested transistor's high frequency capabilities is possible with this unit. Lower frequency range models are also available.

Molecular Electronics, Inc., Dept. ED, 443 W. 50th St., New York 19, N.Y.

This is the time of our annual subscription renewal.

Crystal Controlled Oscillator 516

Comes in silicon or germanium

Available in either silicon or germanium, the LTO-NP series low-frequency, crystal-controlled oscillator has a frequency range of 3 through 100 kc. Frequency tolerance from 3 to 16 kc is ±0.03%; from 16 to 100 kc, ±0.02%. Total harmonic distortion is better than 5%. The unit has a 0.95 in. diam and a 2.25 in. seated height; weight is 1-3/4 oz.

Monitor Products Co., Dept. ED, 815 Fremont, S. Pasadena Calif.

Availability: *Made on order only. Can be delivered 28 days after order received.*

Triode-Pentode 552

Is a 9-pin miniature tube

The 6GH8 is a multi-unit tube of the 9-pin miniature type containing a medium-mu triode and a sharp cut-off pentode in one envelope. Characteristics include plate voltages of 125 v for both units, and transconductance of 8500 μmhos for the triode unit and 7500 μmhos for the pentode unit. The tube is intended for use in multivibrator-type horizontal-deflection oscillator circuits in TV receivers. It is also suitable for use as an agc-amplifier or sync-separator tube in TV receivers.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Buffer Amplifier 551

Signal frequency is 400 ±20 cps

Model S3105-01 dual-channel buffer amplifier, designed to drive any of the firm's resolvers with a tuned primary impedance over 2000 ohms and a primary resistance of less than 1000 ohms, has a signal frequency of 400 ±20 cps. Input impedance is 800,000 ohms, voltage gain is 1 ±0.15%, maximum signal output is 26 v, and phase shift is less than 30 min. Input is 60 ±2 v dc at 20 ma. The unit operates over the temperature range of −55 to +75 C. It is hermetically sealed and weighs 5 oz max.

Kearfott, Div. of General Precision Inc., Dept. ED, Little Falls, N.J.

DESIGN DECISION

Quadrature Error Designed Out of . . .

Complex Ratio Bridge

Too often, the spark of genius, or the universally admired "sneaky-clever" design is concealed behind an instrument's front panel. An engineer responsible for these gems, these clever or unusual designs in a piece of equipment, receives the unspoken admiration of only his immediate colleagues.

To remove the veil from unusual circuitry, packaging, and functional appearance design, and to give their designers the recognition they deserve, **ELECTRONIC DESIGN** *offers* **Design Decisions,** *an expansion of the former* **Design Forum** *department.*

We welcome contributions by our engineer-readers and will send a ten-dollar honorarium for all contributions accepted for publication.

Complex ratio bridge gives six-place resolution by bucking out quadrature voltage to achieve a sharp null.

WHEN a voltage of the form $i(R_x \pm jR_y)$ is introduced into a ratio bridge, the "j" component may obscure the in-phase null. By canceling this effect the in-phase reading can be made very sensitive. Shifting the bridge reference signal 90 degrees does the trick. Measuring the amount of reference needed to "buck" the quadrature signal gives the quadrature ratio information.

This solution to a design problem faced by engineer Carl Anderson of Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles 16, Calif., resulted in a versatile and accurate complex ratio bridge. The instrument, first described in *ED,* Nov. 11, 1959, was designed to test networks, transformers, synchros, resolvers, gyros and transducers. Models CRB-1B and CRB-2B measure both in-phase and quadrature ratio with a maximum 0.001 per cent accuracy, tangent of phase angle, phase-shift angles from 0-1 deg and 0-10 deg. Frequency ranges are (CRB-1B) 30-1000 cps and (CRB-2B) 50-3000 cps.

A block diagram of the instrument is shown in Fig. 1. The circuit consists of a pair of ratio transformers operating to balance out the unknown complex voltage. These transformers provide the basic accuracy of the instrument—which must be preserved by a null reading of good resolution.

Off-null voltage obtained during balancing is fed into a high gain null amplifier having high input impedance. A phase-sensitive detector give zero-center null readout, while ratio is read from the ratio transformers in the rectangular form $R_x + jR_y$ or $R_x + \tan(y/x)$ and R_x/ϕ deg.

Since a quadrature voltage will diminish the slope of the pure-resistance null, per-

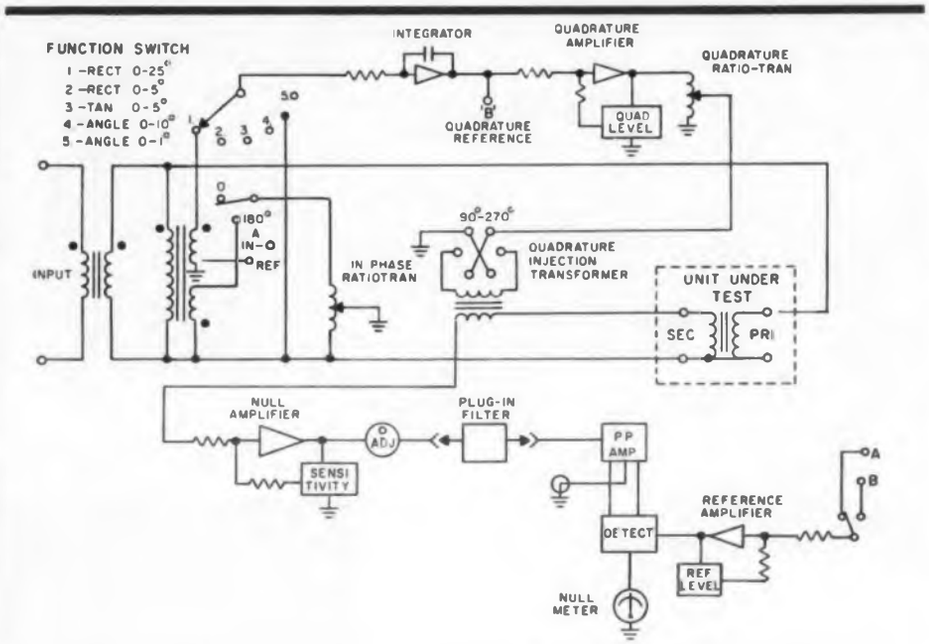


Fig. 1. A pair of accurate ratio transformers give in-phase and quadrature ratios. A portion of the in-phase reference voltage turned 90 deg is used to cancel quadrature effects when trying for an in-phase null.

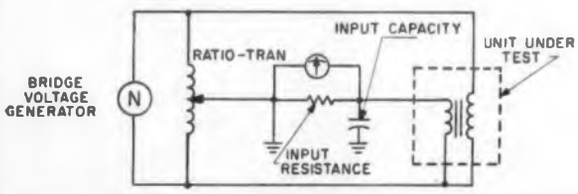


Fig. 2. This is the basic bridge circuit. Note that the bridge float: at null test units output is at ground potential.

haps obscure it altogether, a portion of the bridge reference voltage is shifted through 90 deg and fed into the balancing circuit through the quadrature ratio transformer. By calibrating the magnitude of this injected quadrature voltage with respect to the reference, the amount of quadrature component of the transformation ratio can be read directly as a rectangular coordinate, a tangent of the phase angle or directly in degrees.

The quadrature generator is an operational amplifier, as are all critical amplifiers in the instrument, connected as a differentiator with a closed-loop gain of 5 x 10^{-2} and an open-loop gain of more than 10^4.

To increase the sharpness of the null even further, a narrow band-pass filter rejects harmonics and noise. A possible phase shift in the null amplifier due to a frequency difference between the bridge-energizing frequency and the design center of the filter, is compensated by a phase shift corrector.

Switching and phase inverting is provided to permit measurements to be made in any quadrant. A basic bridge is shown in Fig. 2. The bridge floats: at null the output of the unit under test is at ground potential and no loading from the null amplifier input resistance or capacitance exists.

An isolation transformer lets the operator use a single-ended–unbalanced–bridge energizing source. It can be switched out of the circuit when used with a balanced source.

Price of the CRB-1B and CRB-2B is $1995 and $1695 respectively; 60-day delivery on orders.

For further information on these complex ratio bridges turn to the Reader-Service Card and circle **103**.

DESIGN DECISIONS

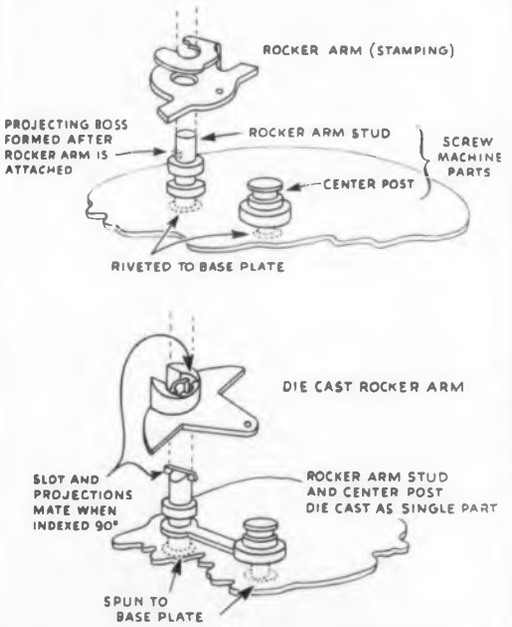
Die Casting Shrinks Switch Cost, Ups Performance

By combining the rocker-arm stud and center post of a potentiometer switch into a single die casting, Clarostat Manufacturing Co., Inc. of Dover, N. H., sliced 53 per cent off the cost of the stud and center post.

Using an automatic, single-cavity, die-casting technique developed by Gries Reproducer Corp. of New Rochelle, N. Y., Clarostat uncovered hidden advantages in switching from the screw-machined stud and center post and from the stamped rocker arm to die casting.

In addition to the direct cost-savings, Clarostat found:

- The dimensional uniformity from part to part



Single-piece casting (below) of rocker-arm stud and center post eliminated manufacturing problems encountered with screw-machined parts.

Precision die castings, designed and produced by Gries Reproducer Corp., helped Clarostat cut costs in this on—off switch while improving quality.

which resulted from their being cast in the same cavity made for a high degree of interchangeability. This allowed automatic assembly of the finished switch.

- The precise dimensioning attained in die casting led to improved switch performance.
- Replacement of two screw-machined parts by one die casting lowered parts inventory and cut inspection time.
- Die casting gave Clarostat designers added flexibility in making rigid parts. A designer could put metal where he needed it; he could beef up stressed areas or use lighter sections in low-stress parts.

Scope Features Single Plug-Ins For All Variable Circuitry

Unlike most commercial oscilloscopes which have Y, X, or time-base plug-ins, ETC's K-160 has all signal generating and processing circuitry in the plug-ins. This includes preamplification, switching, time-base generation, and crt modulation. Four independent plug-ins are intended to cover almost any requirement for a low-frequency scope.

The 1-mc main frame, which should satisfy any future requirement, contains the 5-in. crt, beam controls, independent X and Y main amplifiers, and a power supply. As a result, the main frame, one of the most expensive sections, need never be replaced as application needs grow.

Main frame serves all low-frequency needs on Electronic Tube Corp.'s K-160 oscilloscope.

SERVICES FOR DESIGNERS

Translations of Soviet Journals 222

English language versions of leading Soviet physics journals are now made available within five to seven months after publication in the Soviet Union. The translations cover work in electro-acoustics, radio physics, ion and electron optics, solid state physics and other fields of concern to electron physicists and engineers.

This program offers complete cover-to-cover translations, not merely abstracts or selected articles. According to Edward P. Tober, Production and Distribution Manager, the recent expansion of this program, undertaken with the cooperation of the National Science Foundation, has won quick support from large numbers of individuals and organizations alert to the importance of keeping abreast of the Soviet output.

American Institute of Physics, Dept. ED, 335 E. 45th St., New York 17, N.Y.

Computer Designs Packages 223

Mechanical design of electronic assemblies for problem environments is done by computer at Computer Engineering Associates, Pasadena, Calif. When an electronic package has to withstand unusual environments, there are a large number of parameters to be optimized.

CEA's approach is to use the company's direct-analog computer. Finite difference models of the assembly are transformed into electrical analogs and run through the computer at high speed.

Electrical elements are used to represent analogous elements in the physical system, and both currents and voltages in the computer assume physical significance. Voltages become equivalent to mechanical displacements, velocities or temperatures, and currents to mechanical forces, moments or heat flows.

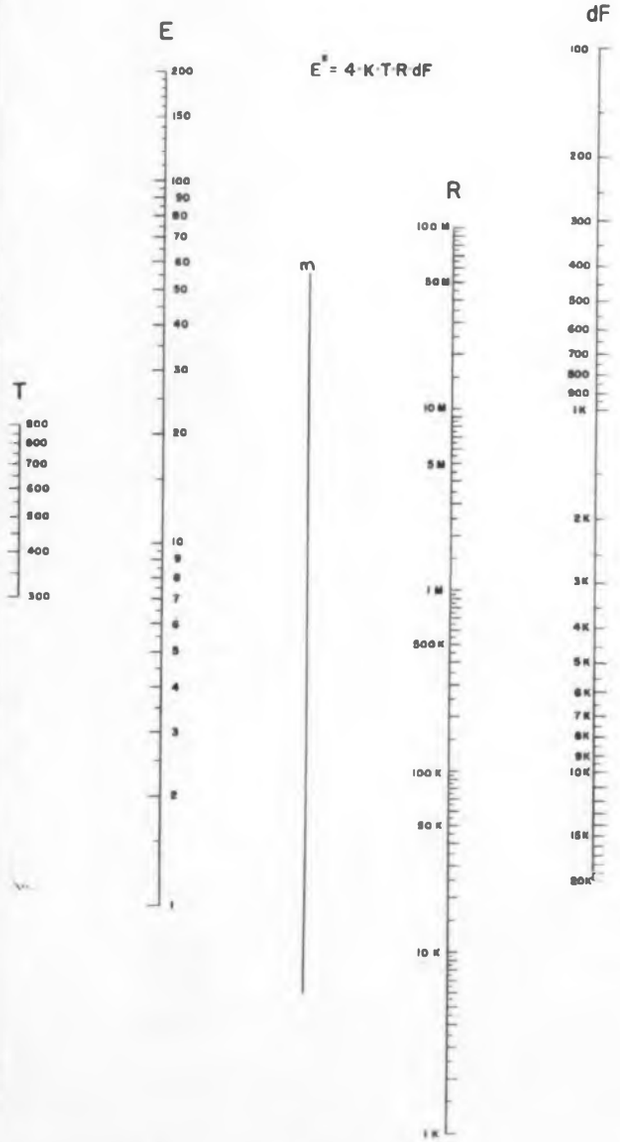
CEA gives attention to shock and impulse response, temperature distribution, heat flow, acoustics and noise level in electronic assemblies, as well as aircraft or missile designs. Special problems that arise after an assembly is built can be solved on the spot and basic changes made in the computer room.

For plants where the volume of work calls for the purchase of a computer, CEA will design and install special and general purpose direct analog computers. Training in their use is available for the engineers and technicians in customer plants.

Computer Engineering Assoc., Dept. ED, 350 N. Halstead, Pasadena, Calif.

Noise Voltage Nomogram

David P. Costa
Naval Material Laboratory
N. Y. Naval Shipyard
Brooklyn, N. Y.



FREQUENTLY encountered in the design of electronic circuitry and in the measurement of noise figure components is the determination of noise voltage given by Nyquist's equation

$$E = (4\,K\,T\,R\,dF)^{1/2}$$

where:

E = noise voltage of resistive element, μv
K = Boltzmann Constant (1.38×10^{-23}) joules/K
T = temperature of resistive element, K
R = resistance of element, ohms
dF = frequency bands, cps

The nomogram provides a quick means for solving the above equation if any three of the four variables are known.

Example: What would be the noise voltage produced by an af amplifier at room temperature (about 300 K) over a frequency band of 20 kc if its impedance is 10 megohms?

1. Connect T and R, intersect m.
2. Connect m and dF, find $E = 57.5$ μv. ■ ■

NEW LITERATURE

Insulation Materials 165

This folder contains data sheets on the following high temperature insulation materials: a refrasil fiber; quartz fiber; fiberglass reinforced phenolic molding compound; zirconium oxide, carbon, and quartz fiber reinforced phenolic molding compound; and a chopped silica fabric reinforced phenolic molding compound. In addition to the data sheets, the folder contains a table covering basic material formulations. The Fiberite Corp., 512-528 W. Fourth St., Winona, Minn.

Latching Relay 166

Bulletin No. BR-7A contains performance characteristics, dimensions, mounting and terminal data for five models of an electrical latching relay. Included are schematic drawings showing typical applications of the component for time delay and sequencing circuitry. The relay is said to have a life of over 200,000 operations at the extremes of contact load and temperature. Babcock Relays, Inc., 1640 Monrovia Ave., Costa Mesa, Calif.

Infrared Interference Filters 167

This four-page brochure discusses performance characteristics of four basic types of infrared interference filters: long-pass, short-pass, band-pass, and spike. Coating services are also described. Infrared Industries, Inc. P. O. Box 42, Waltham 54, Mass.

Voltage Digitizers 168

A line of transistorized voltage digitizers is described in short-form catalog G-1D, six pages. Eight different types of Voldicon semiconductor digitizers are covered. Standard input-output options currently available and Voldicon logic are discussed; prices are included. Adage Inc., 292 Main St., Cambridge 42, Mass.

Components Catalog 169

Two-color, 32-page catalog No. 30A gives complete specifications, technical data and prices on all the firm's products available from stock. This catalog includes complete tables of technical data, photos and dimensional drawings for each type of resistor, attenuator, relay, switch, capacitor and variable transformer covered. Also described are the Model E miniature power rheostats, molded composition resistor sizes, metal film and molded wirewound resistors. The stock lists of tantalum capacitors in all three types, wire, slug and foil, have been increased considerably. Ohmite Manufacturing Co., 3695 Howard St., Skokie, Ill.

Reusable Containers 175

Dimensioning and construction details of modular reusable shipping and storage container systems appear in catalog No. E-59, 16 pages. The catalog deals with the modular concept, custom design, methods of assembly, interior modifications and shock isolation, exterior modifications and closures, and gives detail specifications of closure and corner members. Zero Manufacturing Co., 1121 Chestnut St., Burbank, Calif.

Solid Insulating Materials

The International Electrotechnical Commission has published the first edition of publication No. 112, "Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions." The test method described in the publication is intended to indicate the relative behavior of solid insulating materials with regard to their susceptibility to surface tracking when exposed, under electric stress, to water and other contaminants from the surroundings. *It is available at $2.40 a copy from the American Standards Assoc., Dept. ED, 70 E. 45th St., New York 17, N.Y.*

Electric Furnance Brazing 176

Bulletin GEA-3193C, 50 pages, covers such topics as the where and why of furnace brazing, how to remove copper from steel after brazing, application and selection of brazing metal, selection of flux, strength of furnace-brazed parts, how to furnace-braze cast iron, and remedies for furnace-brazing ailments. The publication is a re-release of a booklet that was compiled and published several years ago. General Electric Co., Schenectady 5, N.Y.

Copper Furnace Brazing 177

This handbook is called "Design for Controlled Atmosphere Copper Furnace Brazing—a Handbook for Designers, Engineers, and Manufacturers." The 24-page book contains chapters on what the brazing process is, where brazing is used, inspection methods, and charts and tables of engineering data. George Getz Corp., Fabriform Metal Products Div., 7720 Maie Ave., Los Angeles 1, Calif.

Fabricated Silicone Rubber 178

This six-page bulletin describes custom engineered fabricated silicone rubber, including precision molded parts, extruded parts, and seals for electronic applications. A table of special purpose compounds appears in the illustrated bullet. Haveg Industries, Inc., Taunton Div., 336 Weir St., Taunton, Mass.

NEW PRODUCTS

TV Tape Recording

"Television Tape Recording" is a 48-page booklet that describes and illustrates basic principles and components related to video tape recording and playback. Control systems, special techniques, editing, splicing, and duplicating of video tapes are covered. The booklet also describes the Videotape machine and method of operation. *Price of the booklet is $1.00. Robins Industries Corp., Dept. ED, 36-27 Prince St., Flushing 54 N.Y.*

Silicone Rectifier Handbook 185

This silicon rectifier handbook has seven chapters that cover such topics as semiconductor theory, manufacturing methods, rectifier characteristics, rectifier circuits, test circuits, rectifier and filter circuit design, and application techniques. A supplementary section of the 64-page book lists ratings and dimensions of the firm's silicon rectifiers. Sarkes Tarzian, Inc., Semiconductor Div., Section 3002A, Bloomington, Ind.

Potentiometers 186

Data sheet No. 60150 describes a series of 7/8" diameter, ten-turn precision potentiometers for servo mounting. Included are complete preliminary specifications, environmental characteristics, coil data, dimensional drawings, and photographs. Beckman Instruments, Inc., Helipot Technical Information Service, 2500 Fullerton Road, Fullerton, Calif.

Thermal Insulation 187

This bulletin contains product descriptions covering chemical, physical, and structural properties of santocel A, a silica aerogel used for thermal insulation. This product gains a low thermal conductivity which is less than the theoretical value for "still" air. Shipping and handling notes, and suggestions as to use, included. Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Mo.

Fasteners 188

This brochure depicts a variety of assembly-cost savings case histories. A total of 17 case histories in this illustrated brochure describe assembly savings achieved in industries through the use of fasteners from a selection of more than 9000 variations. The basic idea of the front-mounting speed clip is incorporated into the sockets of GE germanium rectifiers for industrial electronics

applications. The corrosion-resistant, vibration-proof fasteners hold power resistors under live spring tension to avoid mechanical shock. Photographs are included. Tinnerman Products, Inc., Box 6688, Cleveland 1, Ohio.

Fasteners 195

32-page design manual No. 5930 illustrates the ESNA developed equa-stress modified UNF-3 thread form which, installed in a series of elastic stop nuts, will at least double the fatigue endurance of a standard high tensile bolt. The manual includes 17 pages of findings related to the basic nature and causes of fastener fatique; six detailed drawings of the double/durability self-locking nuts; and applicable fatigue performance test results. Photoelastic comparisons between standard and improved nuts provide a visual explanation and verification of the drastic load redistribution accomplished by the equa-stress thread form. Elastic Nut Corporation of America, 2330 Vauxhall Rd., Union, New Jersey.

Voltage Dividers 196

This first issue of ESI (vol. 1, no. 1) is devoted to voltage divider accuracy and calibration. If you would like your pet questions about the firm's products discussed, let them know and they will try to work them in. If you have any comments on applications you would like to pass on, these will also be welcome. Included in this bulletin are garphs, diagrams, and photographs. Electro Scientific Industries, 7524 S.W. Macadam, Portland

Ceramic Fiber 197

Fiberfrax ceramic fiber that withstands operating temperatures up to 2300 F is treated in an eight-page multi-colored brochure that gives the properties, available forms, and current uses of this high temperature material. Typical uses discussed include linings for induction furnaces, brazing metallic honeycomb sandwich panels in airframe industry, general furnace insulation, and critical applications in missile and space programs. Charts, diagrams, graphs, and photographs are included. The Carborandum Co., Buffalo Ave., Niagara Falls, N.Y.

Electronic Packaging 198

This folder, six pages, illustrates the firm's capability in the electronic control packaging field by citing specific projects. Included are data on an automatic control for the operation of an air-turbine drive alternator; and IC and fire control switchboard for complete weapons system test of a submarine missile launcher and a control package for the operation of an aircraft gas-turbine afterburner. Breeze Corporations, Inc., 700 Liberty Ave., Union, N.J.

NEW LITERATURE

FM Station Guide 205

This six-page booklet contains a complete listing of the nation's fm and fm-am radio stations and their frequencies. Canadian stations are included. Blonder-Tongue Labs, Inc., 9 Alling St., Newark 2, N.J.

Miniature Cavities 206

A series of six uhf-vhf miniature cavities offering 36 combinations of size, power, and function are listed in table form in this one-page data sheet, No. TF 164. Resdel Engineering Corp., 330 S. Fair Oaks Ave., Pasadena, Calif.

Rectifier Bulbs 207

Ratings, design data, weights, dimensions, and typical applications of the firm's rectifier bulbs appear in this eight-page brochure, entitled "Tungar Bulb Data Manual." Power handling capability of the ten types of bulbs now available range from 20 amp at 25 v to 6 amp at 250 v. The brochure also contains descriptive and theoretical data on the use of the bulbs in rectifier circuits to provide noise-free power supplies with low voltage drop and high efficiency. General Electric Co., Electronic Components Div., Owensboro, Ky.

Variable Resistor 208

Dimensional drawings, electrical specifications, and a description of the series M250 variable resistor appear in this one-page data sheet. The unit is a 9/32 in. in diameter microminiature composition resistor. CTS of Asheville, Inc., Skyland, N.C.

Timing Relays 209

Characteristics of the firm's timing relays are discussed in this six-page bulletin, No. 131. Use of the Red Line relays at various companies is also discussed. G-V Controls, Inc., Okner Parkway, Livingston, N.J.

Receiver Input System 210

A vhf-uhf receiver input system that provides a passband of 200 mc without tuning is described in this four-page bulletin, No. TF165. The system offers a decreased noise factor and eliminates the need for more than one antenna. A specification table permits selection of components required for multi-receiver installations. Resdel Engineering Corp., 330 S. Fair Oaks Ave., Pasadena, Calif.

Tuning Devices 215

This four-page article gives the principle of operation of permeability tuned devices for use at frequencies up to 45 mc. The devices themselves are variable inductors suitable for use in if amplifiers and rf tuners. Dimension drawings, performance curves, and typical characteristics are included in the article. Ferrotran Electronics Co., Inc., 693 Broadway, New York 12, N.Y.

Magnetic Particle Clutch 216

Data sheet No. 110-7, two-pages, describes the series 878 magnetic particle clutch. The unit is an electro-magnetic proportional valve suitable for such applications as low-inertia absorption dynameters, variable torque-limiting devices, and tension devices. Specifications and an installation drawing are included. Lear, Inc., ElectroMechanical Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

Analog Computers 217

A four-page brochure describes the company's line of general and special purpose analog computers and accessories. Models MC-5800 and 5900 master analog computers are included along with an electronic multiplier, X-Y data plotting boards, linear programming computers, and missile-range instrumentation computers. The brochure contains specifications and photographs. Computer Systems, Inc., 611 Broadway, New York 12, N.Y.

Transducers 218

High temperature variable permeance transducers constructed of boron free materials throughout are described in a one-page data sheet. Included are construction data, and electrical and mechanical specifications. Technical Industries Corp., 389 N. Fair Oaks Ave., Pasadena, Calif.

Strain Gage Monitor 219

Mechanical and electrical specifications of the model 213 digital strain gage monitor appear in this three-page bulletin. The unit measures one, two, or four active arm strain gage elements with individual resistance arm values of 50 to 1500 ohms with 0.1% accuracy. Technical Industries Corp., 389 N. Fair Oaks Ave., Pasadena, Calif.

Snap Switch 220

Model SS101 snap switch is described in this two-page data sheet. The switch has solenoid-operated, multiple-contact snap action. Specifications and dimension drawings are included in the bulletin. Warco Industries, Inc., 6625 Delmar Blvd., St. Louis 30, Mo.

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE DIV. OF ALCOA, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

STILL A MAN'S WORLD. More attention by designers of electronic equipment to the human factor is being called for by the people handling human engineering for the Air Force. Both operation and maintenance are involved. Typical deficiencies that may unnecessarily complicate maintenance, for example, are: insufficient or inadequate check points, extensive calibration requirements and the placing of high-failure-rate components in inaccessible spots. Ultimate goal is equipment designed so that required maintenance can be conveniently handled by those with a minimum of training in electronics.

UP TWENTY PER CENT. Though not completely clarified, the Defense Department's budget for 1961 in terms of military electronics looks like it will hit $5.5 billion. This is an increase of some 20 per cent over the 1960 figure.

SUN NEVER SETS. True to the traditions of the Empire yesteryear, the British will soon find another means of linking the members of the Commonwealth. This time it will be an undersea cable network that can carry slow-scan TV as well as telephony. The first link, between Britain and Canada, is scheduled for completion in 1961. By 1964 the second leg, tying Canada to Australia, will be ready. And so on.

TERA, GIGA, NANO AND PICO. These are the four prefixes that the National Bureau of Standards has picked following recommendation of the International Committee on Weights and Measures. These four join the already-in-use: mega, kilo, hecto, deka, deci, centi, milli and micro. Tera is 10^{12}; giga, 10^{9}; nano, 10^{-9}; and pico, 10^{-12}. Symbols for these new prefixes are, respectively, T, G, n and p. For example, 10^{-12} farad is a picofarad and is written in abbreviated form thusly: 1 pf.

JURY-SIZED SUB? The Navy is deep into a program (along with nine private firms and research groups) to put into the brine a fully automated sub that will need a crew of only 12. Automated and integrated will be the five fundamental control areas, or "loops": ship control, communications, engineering, weapons and environmental.

CABLEMAN'S CORNER. The old adage "Don't put the cart before the horse" was never so true as it is in these days of automation and instrumentation. With all the intricate pieces of equipment being designed these days, it is important that careful consideration be given to the wire and cable that may be employed in any system. Often forgotten is the unromantic aspect of the connecting links of the system. Cables are the arteries through which must flow the power and informational pulses necessary for reliable performance.

Don't take a chance on being able to obtain a cable that will fit into what is left. Many times, important characteristics such as conductor size, insulating walls, protective sheaths, flexibility and flex-life have to be sacrificed. Don't sacrifice reliability in your cables for an existing space or connector fittings.

For 100% reliability in multi-conductor cables, call on a cable specialist—and call on him as soon as possible. Phone Rome 3000, or write: Rome Cable Division of Alcoa, Dept. 1140, Rome, New York.

These news items represent a digest of information found in many of the publications and periodicals of the electronics industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

CIRCLE 221 ON READER-SERVICE CARD

NEW LITERATURE

Electromicrometer 225

A digital readout electromicrometer with ±0.1% accuracy is described in this one-page data sheet. The unit operates in conjunction with a variable permeance transducer located at the point of desired measurement. Specifications and an operational description are included in the illustrated bulletin. Technical Industries Corp., 389 N. Fair Oaks Ave., Pasadena, Calif.

Oscillograph Paper 226

Pamphlet No. P-40 describes direct print paper which provides an immediately visible record of oscillograph tracings. Made for use in moving-mirror galvanometer oscillographs which employ an ultraviolet light source, the paper yields an image without chemical processing. Procedures for the second exposure, permanizing, and automatic processing are also described. Eastman Kodak Co., Photo Recording Methods Sales Div., Rochester 4, N.Y.

Telemetry Components 227

A new line of airborne fm/fm telemetry components is described in a 24-page brochure, No. 936. Transistorized voltage-controlled subcarrier oscillators for conventional signal voltage ranges, fractional-volt ranges, and millivolt ranges are included. The brochure contains detailed electrical, environmental, and physical characteristics in addition to outline drawings. Tele-Dynamics, Inc., 5000 Parkside Ave., Philadelphia 31, Pa.

Environmental Test Equipment 228

Thirteen types of environmental test equipment are illustrated and described in a two-page data sheet, No. C-14. An acoustic-noise test system, auxiliary vibration tables, and saw-tooth shock machines are also included. Associated Testing Labs, Inc., Manufacturing Div., 401 Clinton Road, Caldwell, N.J.

Microwave Components 229

Principal electrical characteristics for more than 150 microwave tubes and special purpose devices are listed in this four-page catalog. The microwave components include traveling-wave tubes, ferrite devices, magnetrons, and microwave diodes. Some of the special purpose devices listed are decade counter tubes, and trigger tubes. Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y.

Servo Data 235

Entitled "The Second Order Linear Servo," this 10-page article presents a history of servo terminology, offers practical working formulae and values, and includes vellum-chart sheets of factors conveniently used for servo design which may be removed from the pamphlet for ozalid reproduction. Giannini Controls Corp., 918 E. Green St., Pasadena, Calif.

Relay and Switch Enclosures 236

This 32-page catalog describes a complete line of hermetically sealed and protective enclosures for relays, switches, and control packages. One, two-, or three-header enclosures with plug-in or hook terminals are included in the catalog. Wiring diagrams and mounting layouts also appear. Automatic Electric Co., Northlake, Ill.

Precision Instruments 237

Over 12,000 stock items are listed in this 416-page catalog, No. 21. Technical details, MIL specifications, and complete drawings are included for such items as: precision gears, shafts, speed reducers, magnetic clutches, differentials, instrument plates, tool parts, and many other associated components. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L.I., N.Y.

Servo Actuator 238

Series 3107 servo actuator, an electromechanical linear device for use in closed-loop positioning systems, is described in data sheet No. 111-12, two-pages. Specifications, an installation drawing, and a performance curve are included. Lear, Inc., ElectroMechanical Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

Microwave Components 239

Catalog No. 160A covers a line of microwave components and antennas for the V and W bands. The illustrated 12-page booklet contains complete specifications for components such as isolators, attenuators, circulators, and switches, as well as hybrid-ring mixers and millimeter-wave antennas. TGR, Inc., Microwave Component and Antenna Dept., 9 Union Square, Somerville 43, Mass.

Single-Phase Regulators 240

How to use single-phase ac line-voltage regulators to accomplish effective voltage regulation in three-phase circuits is the subject of this application bulletin, No. AC610. Sorensen & Co., South Norwalk, Conn.

NEW LITERATURE

Silicon Rectifiers 245

This six-page catalog describes a complete line of hermetically-sealed, silicon Zener diodes. A listing of 152 standard types and instructions on selection from 1584 standard and special voltage tolerance types is provided. Performance characteristics, current limits, and derating curves are included. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Aircraft and Missile Equipment 246

Electromechanical, mechanical, and electronic equipment available for aircraft, missile, and related fields is listed and described in this 25-page catalog, No. GC-60. Photographs, performance curves, schematics and general engineering data are included for actuators, control systems, filters, capacitors, inverters, and electric motors. Airborne Accessories Corp., 414 Chestnut Ave., Hillside 5, N.J.

Switches 247

A line of switches, relays, and gravity sensing potentiometers is presented in the firm's 1960 catalog. The following types are listed: sensitive-tilt mercury switches, dry-reed switches and relays, magnetically actuated mercury switches, switches with mercury-wetted contacts, and gravity-sensing electrolytic potentiometers. Hamlin, Inc., Lake and Grove St., Lake Mills, Wis.

Capacitors 248

Bulletin No. GEA-6789A, four pages, provides detailed information on general-purpose ac capacitors designed for a wide range of industrial applications. Graphs, outline drawings, terminal, bracket, case data, and a list of available ratings are contained in the booklet. General Electric Co., Schenectady 5, N.Y.

Magnetic Performance 249

Extensive design data, test data, and magnetization curves for centricores (toroidal cores wound from thin magnetic tapes), stamped ring cores (made from laminations), and precision die-cut DU laminated cores appear in bulletin No. C-5, 24 pages. Also included is data on Super Squaremu 79 centricores for magnetic amplifier applications. Test methods outlined follow recommended procedures standardized by industry committees and include circuit diagrams. Magnetic Metals Co., Hayes Ave. at 21st St., Camden 1, N.J.

Switches 255

Electrical and mechanical data on the firm's line of subminiature switches appear in this four-page catalog. All switches are designed to meet the requirements of MIL-S-6743. Outline drawings for models CE-100, 200, and 300 are included in the catalog. Crown Electric Products Co., Box 171, Orange, N.J.

Circuit Breakers 256

This 20-page bulletin contains photographs, diagrams, graphs and charts showing specifications, operating characteristics, dimensions, and ratings for a complete line of low-voltage power circuit breakers. Both manual and electrical stored energy closing mechanisms are described. General Electric Co., Schenectady 5, N.Y.

Subminiature Connectors 257

Detailed information on the miniature K and D subminiature connectors appears in this two-color, four-page folder. Also included is information on appropriate hardware and accessories. Schweber Electronics, 60 Herricks Road, Mineola, Long Island, N.Y.

Zirconium Fact File 258

This zirconium fact file contains technical data, application and available forms of the metal as developed and compiled by manufacturers and fabricators. Zirconium, a prominent construction material in atomic reactors, has many applications in electronics, missiles, and other fields. *Write on company letterhead to Zirconium Association, Dept. ED, 2130 Keith Bldg., Cleveland 15, Ohio.*

Ultrasonic Solvent Cleaner 259

This data sheet describes ultrasonic solvent cleaner No. 6, used for removal of rosin flux residues as well as other types of flux residues. Oily deposits and organic contaminants are also removed. The bulletin contains description, uses, physical property, and packaging data. Hi-Grade Alloy Corp., 3034 E. 95th St., Chicago 17, Ill.

Limit Switch 260

Two-page data sheet No. 168 describes a center neutral plug-in limit switch, model 301LS1. The switch is capable of doing the work of two separate limit switches in many situations. Photos, dimension drawings, operating details and ordering information are included in the bulletin. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

NEW LITERATURE

Electric Motors 265

Catalog No. 258, 36 pages, contains a listing of the company's line of electric power drives. Included are: ac squirrel cage motors; slo-speed gear motors; right angle worm gears; multimount speed reducers; Speed-Trol variable speed drives, and right angle Speed-Trols. Inllustrations, dimension prints, and tables of specifications appear in the catalog. Sterling Electric Motors, 5401 Telegraph Road, Los Angeles 22, Calif.

Shaft Position Encoders 266

This four-page bulletin, No. 316-A, contains data on 1000, 1024, 2000, and 2048 position encoders which can be incorporated into geared assemblies to provide positional information up to 10^6 or 2^{20} positions. Available models and principles of operation are described. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Thermistors and Varistors

This 39-page data book covers thermistors and varistors, thermal conductivity cells, electronic controls and thermal, electronic and physical-sensing devices. Thermistor data includes operating characteristics and applications, temperature-resistance characteristics, voltage-current characteristics, and current-time characteristics. Typical curves are given for thermistors and varistors. *Send $1.00 to Victory Engineering Corp., Dept. ED, 519 Springfield Road, Union, N.J.*

Power Supplies 267

General purpose dc power supplies are listed in bulletin No. 178A, two pages. Units with unfiltered outputs ranging from 6 to 230 v dc and 0.6 to 150 amp are covered. A table gives specifications and cabinet dimensions for 22 models. Opad Electric Co., 43 Walker St., New York 13, N.Y.

Welded Fasteners and Parts 268

In addition to complete dimensional data on stock weld nuts, weld screws, special purpose weld parts, and leg levelers, this catalog, No. 60, includes welding information, electrode data and designs and weld setups for welding individual parts. The 50-page booklet also contains an engineering section with detailed explanations on how to get optimum welds under various conditions. The Ohio Nut & Bolt Co., Sales Dept., 33 First Ave., Berea, Ohio.

Transformer Ratio-Arm Bridge 275

Bulletin WK-B-601, two pages, gives information on the features, specifications, principle of operation, performance and applications of rf bridge type B-601. Wayne-Kerr Corp., 1633 Race St., Philadelphia 3, Pa.

Miniature Bearing Manual

This 140-page "Design and Purchasing Manual" on miniature and instrument ball bearings contains essential information on testing, packaging, marking and correct procedures for ordering. Data on radial play, runout and other technical considerations are included. There is also a listing of reasons for specifying ABEC Class 7 tolerances for bearings going into instruments. A load nomograph will help in selecting bearings of suitable life and load requirements. Additional information covers lubrication, storage and materials. The catalog supplies information on plain, flagged, shielded, extended inner retainer and special wafer bearings. *Write on company letterhead to: New Hampshire Ball Bearings, Inc., Dept. ED, Route 202, Peterborough, N.H.*

Miniature Relay 276

Type BR-1SZ miniature relay is described in this bulletin, two pages. The hermetically sealed 1-1/4 oz relay was developed for airborne and ground applications, and operates from −65 to +125 C. Specifications, dimension, mounting types, and terminal styles are included. Babcock Relays, Inc., 1640 Monrovia Ave., Costa Mesa, Calif.

Hi-Pot Testing 277

This 12-page application bulletin, titled "Practical Hi-Pot Testing," covers ac and dc breakdown testing, with a discussion on nondestructive tests of dielectric strength in wiring harnesses, motors, cables, solenoids, thermostats and similar equipment. Mobile and bench type test units are described in the booklet. Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.

Data Processing Component 278

An electronic component for data processing and data handling systems, called the Codewriter, is covered in this four-page brochure. The input model, output model, and the combination input-output model are described. A circuit diagram and a keyboard chart are included in the brochure. Royal McBee Corp., Industrial Products Div., 740 N. Main St., W. Hartford 17, Conn.

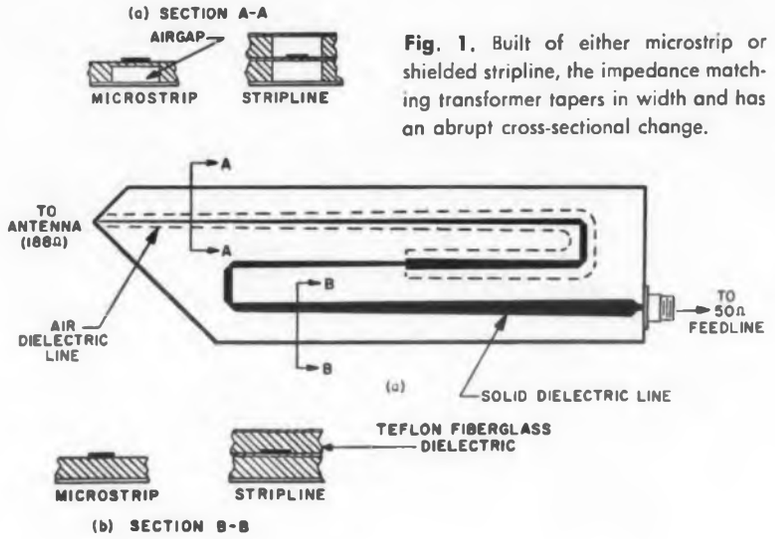


Fig. 1. Built of either microstrip or shielded stripline, the impedance matching transformer tapers in width and has an abrupt cross-sectional change.

Antenna-Matching Transformer Keeps VSWR Low Over Wide Band

USING a microstrip and/or a shielded stripline transmission system, a tapered, impedance matching transformer was designed to match a wide-band antenna to a 50-ohm line. With the low frequency limit at about 200 mc, the 188-ohm antenna was matched over a 40 to 1 frequency bandwidth. Over the entire range the vswr was less than 2 to 1.

Because it is tapered in width, the transformer, Fig 1, has characteristics impedance, Z_o, gradually changed from 50 ohms at the feed-line to 188 ohms at the antenna terminals. This impedance change occurs with either a microstrip line–a wide, flat conductor separated from a narrow conductor by a dielectric–or a shielded stripline. The solid dielectric used was Teflon fiberglass.

About halfway along its length, the transformer has an abrupt change in its cross section. At this point, the solid dielectric strip, Fig. 1b, is replaced by an initially wider strip. The dielectric of this new section is part solid and part air. In this "air" strip, Fig. 1a, almost 90 per cent of the Teflon between the conductors is removed. This transition is made because, for a given strip width, the air dielectric section has a higher characteristic impedance, Fig. 2. The lower impedance of the solid section makes it a more practical choice at the 50-ohm termination. At this impedance, its strip width could be narrower than if an air section were used. However, at the higher impedance end, the solid section would have to be far too narrow. For this reason, the transformer cross-section is changed from the solid to a solid and air dielectric. This change also allows a longer electrical length of line to be obtained.

The tapered transformers were mounted on a 24-in. planar, equi-angular, spiral antenna. The antenna's apex height was 12.4 in. For the vswr, at 200 mc to be within 2 to 1, the transformer length had to be 30 in.

The measured vswr for the microstrip transformer-antenna combination, Fig. 3a, was less than 2 to 1 from 175 mc to 4000 mc.

With the stripline transformer feeding the antenna, and with the upper test frequency limit extended, the vswr, Fig. 4, was less than 2 to 1 up to about 8000 mc.

Low vswr values were also obtained with a shielded stripline matching transformer connected to a fin antenna.

Howard E. King, Space Technology Laboratories, Inc., Los Angeles, Calif.

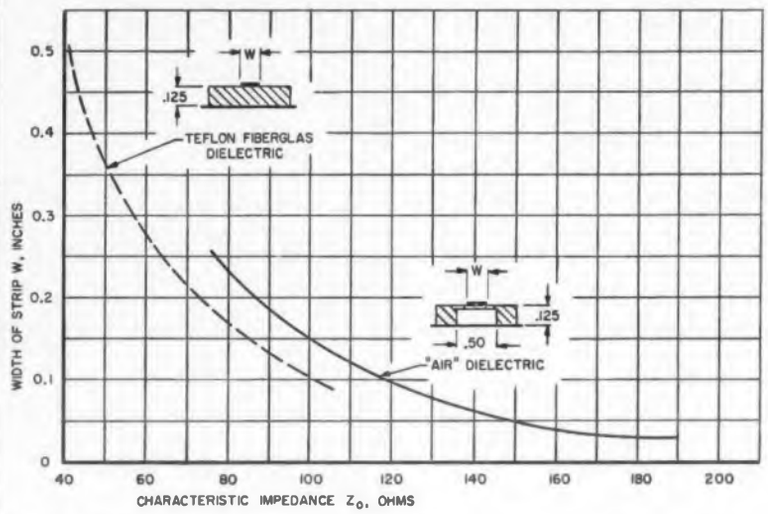


Fig. 2. The characteristic impedance variation with strip width is shown for a microstrip-line. One curve is for a sold dielectric cross section; the other for an "air" dielectric cross section.

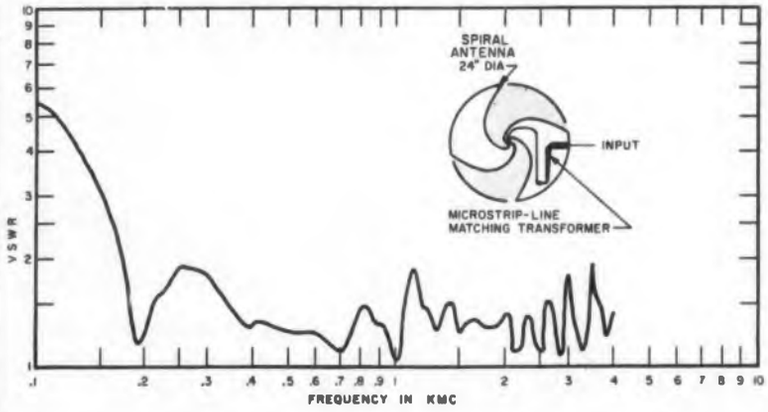


Fig. 3. (a) For an equiangular spiral antenna matched with a microstrip impedance matching transformer, the vswr is less than 2 to 1 from 175 mc to 4000 mc. (b) Inset shows the placement of the transformer within the antenna boundary.

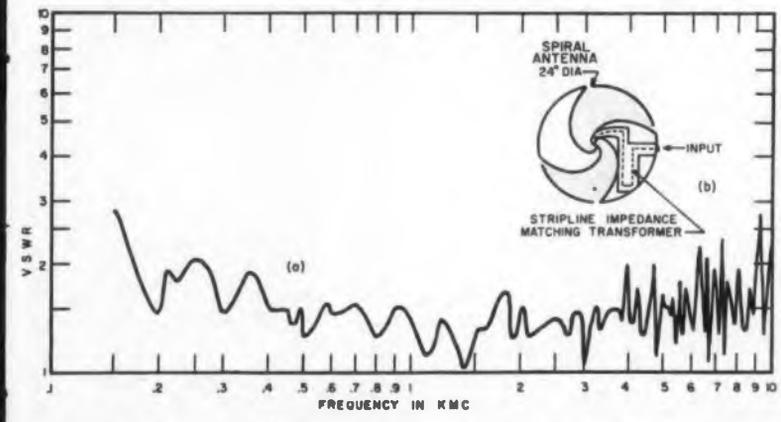


Fig. 4. (a) Matching the spiral antenna with a shielded stripline transformer yields vswr's less than 2 to 1 from 180 mc up to 8000 mc. (b) Again, the transformer was placed entirely within the antenna boundary.

IDEAS FOR DESIGN

Detected AM Chopped for Per-Cent Modulation Measurement

An inexpensive oscilloscope, one without a dc amplifier or wide bandwidth, can be used when measuring the per-cent modulation of a transmitter output.

Ordinarily, the circuit shown in Fig. 1 would be used in making the modulation measurement. An envelope detector removes the high-frequency signal, leaving only the modulating wave. However, the oscilloscope must have a dc amplifier so that the average carrier level is known when the display is observed. The expression for the per-cent modulation is given in the figure.

The arrangement of Fig. 2a, which chops the detected signal before it is passed on to the scope, allows the zero reference to appear but does not require a dc amplifier. Also, it isn't necessary to

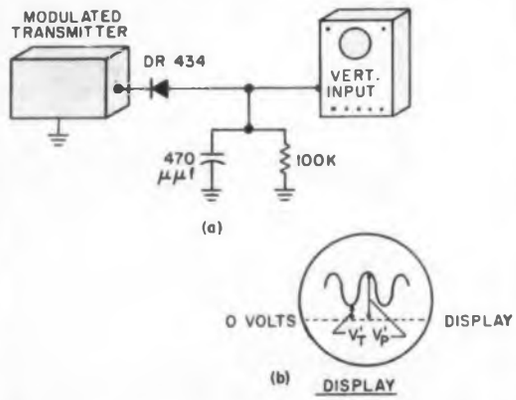


Fig. 1. (a) Conventional arrangement for measuring per-cent modulation requires oscilloscopes with a dc amplifier. (b) The per-cent modulation is found from the scope display.

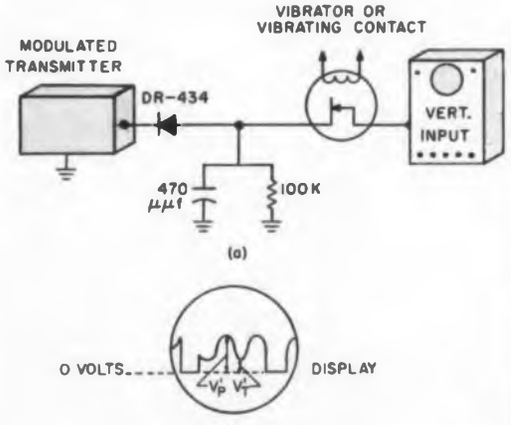


Fig. 2. (a) A dc amplifier is no longer required when the detected signal is first chopped and then applied to the scope's vertical input terminals. (b) The scope display still provides the peak, trough and zero reference points.

sync the chopper and modulating signal, since all that is desired are readings of the peak, trough, and zero reference points. The resultant display is shown in Fig. 2b.

Measurements made on a Dumont 208 scope with the chopping arrangement, were found to be within 5 per cent when checked with both a Tektronix 545 scope and the calibrated meter on a Boonton Signal Generator. However, the method was more inaccurate when the rf voltage was very low, or the modulation trough was very deep.

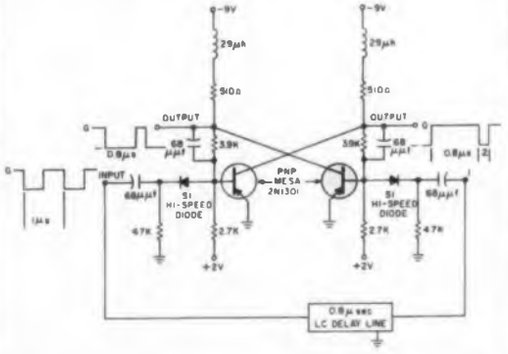
Matthew C. Baum, Solid-State Circuits Generalist, New York, N.Y.

High-Speed Pulse-Stretcher Depends Upon Delay Line Time

An accurate, high-speed pulse-stretcher was required of which output pulse width could be accurately controlled and would be independent of the width of the input pulse. Due to the input pulse's high duty cycle (50 per cent) one-shot and blocking oscillators could not be used because of their long recovery time.

The pulse-stretching circuit devised uses a high-speed mesa transistor flip-flop. An LC delay line stretches the pulse to any length provided it is less than the total square-wave input. The length of the output pulse is a function only of the delay line. Since the length of delay can be made accurate to ±1 per cent, the output pulse will be equally accurate.

The figure shows a 1-mc square-wave (0.5 μsec on; 0.5 μsec off). The leading edge of the pulse switches the flip-flop output. This same edge is sent through the delay line, 0.8 μsec long in this case, and resets the flip-flop from the other side. The output pulse is seen to be 0.8 μsec wide. This



Pulse-stretcher uses a mesa transistor flip-flop. The length of the output pulse depends only upon the delay line.

allows 0.2 μsec for the flip-flop recovery, a time which is quite sufficient for the mesa transistor.

Jack Shirman, Design Engineer, Stromberg-Carlson, Rochester, N.Y.

IDEAS FOR DESIGN

Transistor Replaces Common Emitter Resistor in Difference Amplifier

In transistor differential amplifiers, Fig. 1, the common-mode rejection suffers badly if resistor R is made small enough to give good amplifier stabilization. A technique permitting reasonably high-operating current and high-rejection ratio, but low supply voltage was required.

Substituting a third transistor for the emitter

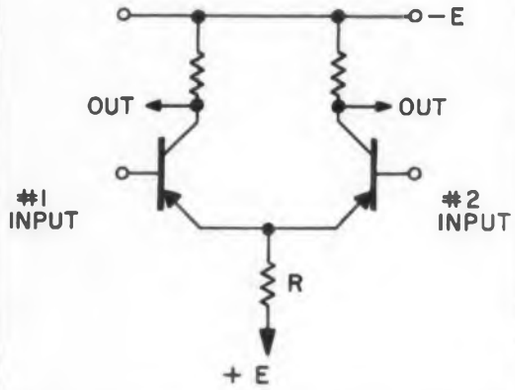


Fig. 1. Conventional differential amplifier circuit has poor common-made rejection if R is small enough for good stabilization.

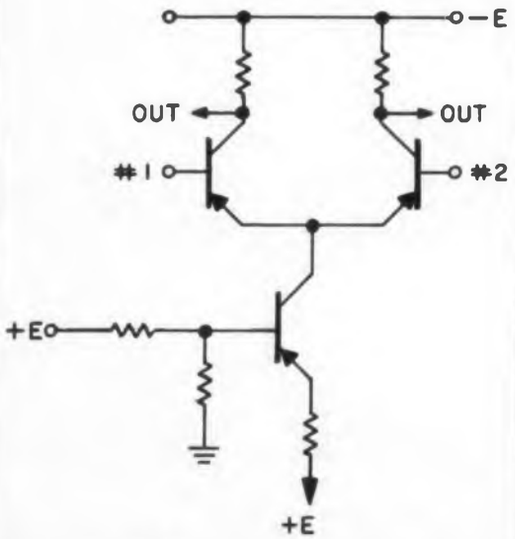


Fig. 2. Substituting a transistor for R allows high-current operation with an effectively large emitter resistance.

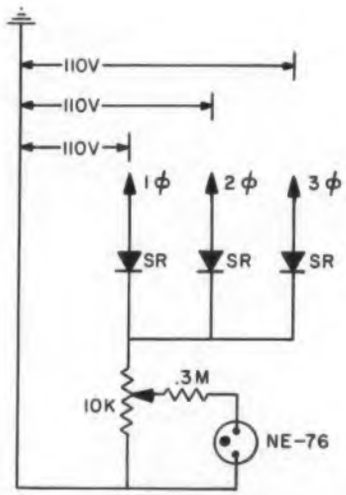
resistor of the conventional circuit, as shown in Fig. 2, permits operation at fairly high currents. Also, it has the effect of a very large emitter resistor, since the collector characteristics of a transistor present a very high impedance to any collector load. For example, if a stage current of 5 ma is required and the emitter resistance is desired around 100 K, the conventional circuit would require a 500-v supply. Using the third transistor, it is quite easy to get the same results with a 10-v, or less, supply.

Roy P. Foerster, Group Engineer, The Martin Co., Baltimore, Md.

Neon Bulb Detects Phase Failure

At an unmanned fire station, the fire siren was powered by a three-phase motor. Occasionally, one phase of the supply line would fail and the motor become inoperative. The failure would be detected only when an emergency attempt was made to blow the siren or during the weekly test run.

To determine whether any of the phases had failed, sampling currents from each of the three phases were summed in a tapped resistor. An NE-76 neon bulb is driven by the voltage across



this resistor. The tap is set so that the bulb just fires when all three phases are energized. If a phase fails, the voltage available to the bulb is only two-thirds as great. The close tolerance NE-76 then extinguishes.

The pilot light containing the neon bulb was mounted on the outside of the building where it was checked by a guard on his regular rounds.

Louis E. Owen, Laboratory Supervisor, Goodyear Atomic Corp., Portsmouth, Ohio.

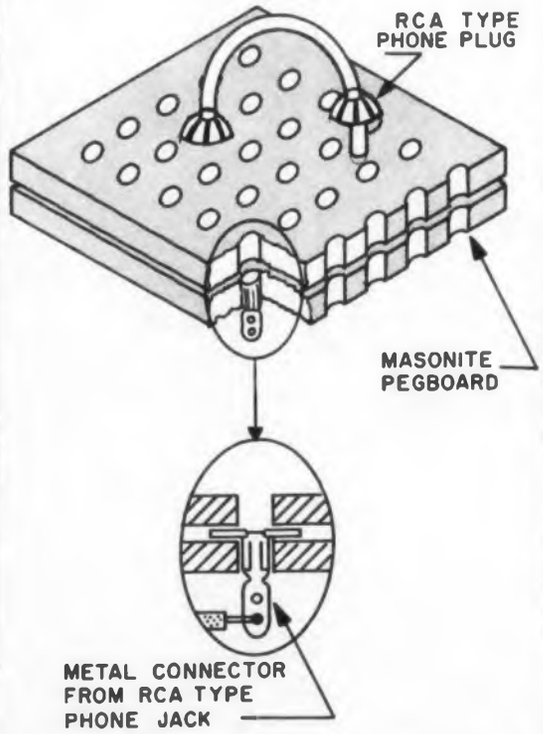
IDEAS FOR DESIGN

Masonite Sheets + Phono Jacks + Holes Equal Patch Board

A low-cost patch board, suitable for laboratory set-ups or for breadboard work, was easily built from common, readily available materials.

The patch board consisted of two pieces of tempered hard-board with holes at half-inch intervals. Connector jacks are sandwiched between the two boards, bolted together as shown in the figure. The board material is masonite pegboard, 1/8 in. thick, tempered on both sides, with 7/32 in. diam holes on a 1/2 in. grid pattern. This material can be bought at a neighborhood lumberyard. The temper is desirable for appearance, as well as to prevent erosion of hole edges from contact wear.

The female connector sandwiched between the two boards is the contact device used in the RCA type phono jack. The connectors are held in place between the two boards by the overhanging lip of the connector. A thin spacer, such as a plain



A laboratory patch board can be easily built from two pieces of masonite pegboard and phono jacks. The female connectors are sandwiched between the boards and connections are made with phono plugs.

washer, should be used on the bolts which hold the two boards together. This spacer insures that the boards will not bind the jacks and hamper their spring action. Patch-cords are made from RCA type phono plugs. In bread-board use, components are mounted on small plug-in strips.

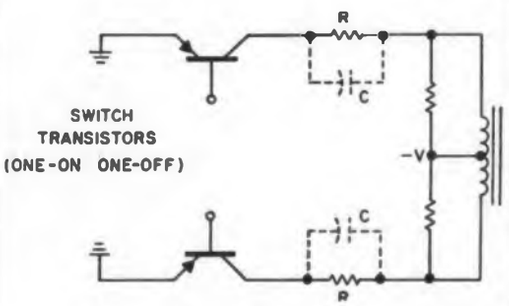
If desired, a simple "L" shaped extruded aluminum frame can be made for the unit, although adequate support for laboratory use can be provided with long bolts in the four corners. Larger-than-normal components can be mounted on banana plugs for mechanical support, with flexible leads tipped with phono plugs for electrical contact.

Using the banana plug and a single pegboard, displays of small assemblies and units can be readily set up. Mounting of the units with banana plugs allows easy removal of the assemblies for closer inspection.

M. I. Arbogast, Projects Engineer, RCA, Camden, N. J.

Capacitors Halve Reverse-Voltage In Flux-Switching Circuit

A large amount of flux had to be switched into a magnetic circuit in a short time interval. The high-frequency transistors that would do the job were limited to a relatively low back-voltage swing. Without the dotted capacitors, the voltage



at the switched-off transistor jumps to −2 v while the other transistor is being switched on.

With the capacitors added, as shown, and their value chosen to present the proper RC time constant, the voltage at the transistor switch will not go more negative than the supply voltage *V*. Thus, the voltage the transistor must stand decreases by a factor of one-half. This idea made the use of the desired high-frequency transistors possible. Though the device here was a magnetic head, the same arrangement could be useful in any circuit built to supply a rapid flux build-up.

Richard S. Muller, Technical Staff, Hughes Aircraft Co., Culver City, Calif.

IDEAS FOR DESIGN

Transistor Chain Forms High Voltage Amplifier

The comparatively low collector to emitter voltage ratings of transistors limit their maximum output voltage swing. However, the transistor amplifier shown here can operate with an output voltage swing of 300-400 v.

Fig. 1 shows the basic series arrangement with which the high output is obtained.

A current injected at the base of the top transistor must flow down the series string, increasing the drop across R_L and decreasing the drop across each transistor in the string. The decreased drop across each transistor is accompanied by an increase in each base current through the series base resistors. If the series base resistors are chosen so that all base current are always equal, then the expression for the output collector current is $i_L = (\beta - n)\, i_{bo}$,

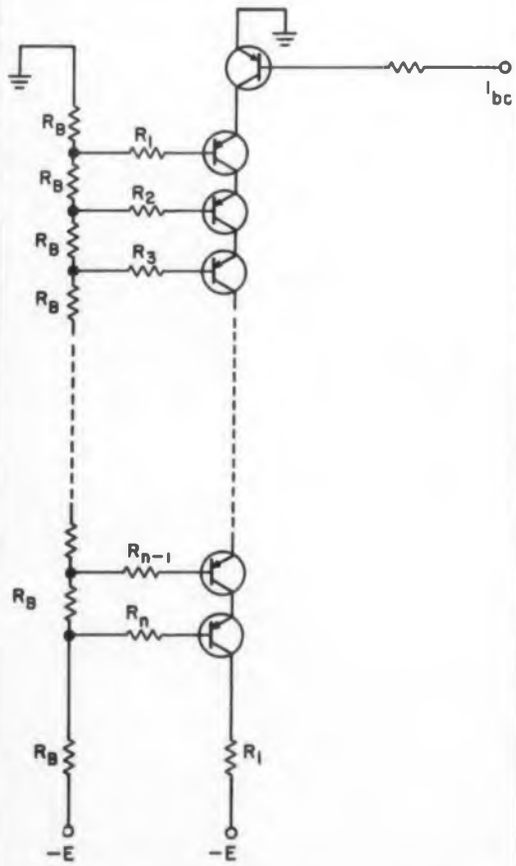


Fig. 1. This series transistor chain is equivalent to single transistor of nv_{CEmax} collector-emitter rating with a current gain of $(\beta\text{-}n)$.

where i_L = current through R_L
β = current gain of each transistor
n = number of transistors in the series string
i_{bo} = base current at input

If the injected current is removed, then each transistor is cut off and the drop across each is determined by the bleeder chain, R_B. The circuit of Fig. 1 is therefore equivalent to one transistor of nV_{CEmax} collector-emitter rating with a current gain of $(\beta - n)$.

For purposes of experiment, a 300-v supply was chosen and ten transistors (type 2N247, 35-v collector-emitter rating, $\beta = 60$) were connected in series, Fig. 2. With R_f open, this circuit is equivalent to one transistor with a 350-v collector rating and an opimum β equal to 50. R_f was added for stabilization. With R_f in the circuit the amplifier had a gain of ten, a useful output

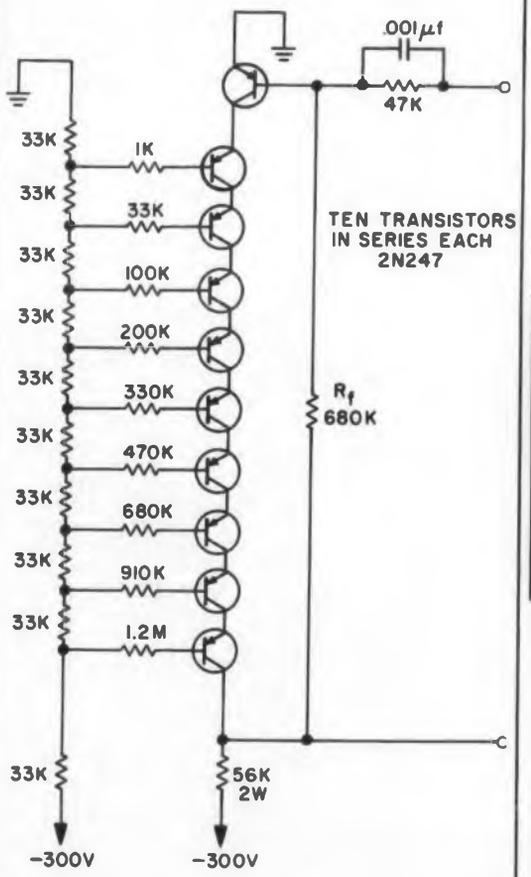


Fig. 2. Experimental circuit equivalent to one transistor with a 350-v collector rating and a β of 50.

voltage swing approaching 300 v, and a frequency response flat from dc to 0.5 mc.

Linton S. Kypta, University of Illinois, Urbana, Ill.

BOOKS

Atomic Radiation, Part II

Prepared by RCA Service Company, Radio Corp. of America, Camden 8, N. J., 117 pp.

Intended primarily as a practical guide for industrial, military, and research installation engaged in nuclear energy activities, this manual examines the practical aspects of radiation protection. It discusses such topics as: monitoring instruments and techniques, radiation exposure control and permissible exposure levels, protective devices, decontamination, handling and shipping of radioactive material, and radioactive waste disposal.

This book is useful as a text for scientific schools and colleges and for civil defense training.

Plastics Engineering Handbook

The Society of the Plastics Industry, Inc., Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 565 pp, $15.00.

This standard reference on plastics materials, methods and fabrication has been revised, expanded and completely updated. The Handbook contains several new chapters, and almost all of the others have been rewritten to reflect the advances made since the second edition appeared in 1954. There is much new material on nomenclature, cellular plastics, welding, decorating and plastics used as adhesives. Chapter headings include: Classification of Rigid Molding Materials, Compression Molding Fabrication of Articles from Thermoplastic sheets, Embedding and Potting, Injection Molding of Thermoplastics, and Vinyl

Dispersions.

The text is fully illustrated, with hundreds of photographs, tables and charts.

Progress In Dielectrics, Volume I

Edited by J. B. Birks and J. H. Schulman, John Wiley & Sons, Inc., 440 Fourth Ave., 312 pp, $11.00.

This volume aims to provide "a common meeting-point" for all interested in dielectrics. It presents much of the current knowledge of dielectric phenomena, materials, and techniques and reviews recent progress in the subject. Subsequent volumes will be published annually.

The first four chapters deal with dielectric breakdown and the insulating properties of solid, liquid, and gaseous dielectrics. Included is a comprehensive review of the several mechanisms of dielectric breakdown in solid insulation and the question of insulation-testing procedures. Also, electric strength, breakdown time-lag and high field conductivity of dielectric liquids, and the practical aspects of the use of gaseous insulation are discussed. Chapter headings include Fer-

The Electronic Guide

References for Research Division, Electronic Guide Publishing Co., Burbank, Calif., 191 pp, $7.50.

Designed to help the electronic engineer locate articles of interest, the Guide lists many of the electronic articles which appeared during 1959. Close to fifty leading English-language periodicals, published in seven nations, were used in compiling this bibliography. The articles are listed by title and arranged under appropriate category headings. Electronic fields represented vary from basic instructional theory, audio, radio and television design, to ultrasonics, computers, automation, radar, and instrumentation design. All levels of electronic technology are represented among the indexed articles. Included also, is a bibliographic section, listing the names, addresses, and subscription prices of all the periodicals surveyed.

(Incidentally, the Guide lists a total of 368 of ELECTRONIC DESIGN's 1959 articles and the name of our magazine is featured over 81 times.)

J. George Adashko

Low Frequency Varicaps

SEVERAL experimental models of low-frequency varicaps (pn junctions having a nonlinear capacitance) were developed and investigated. These devices have applications in electronic frequency retuning of RC generators, electronically tuned filters, balanced modulators and dielectric amplifiers.

Single-crystal silicon varactors were made in the form of discs, 3 to 5 cm in diameter, armored with an aluminum mount. The contacts were insulated from the housing by oxidizing the aluminum and using a layer of epoxy resin.

In the absence of an external voltage, the magnitude of the capacitance per unit area of the pn junction ranges from 0.02 to 0.03 μf per square centimeter. The area S of the pn junction ranges from 7 to 18 sq cm.

It is easy to show that the lower and upper working frequencies of the varicap are determined from the approximate equations:

$$f_l \approx \frac{Q_{min}}{2\pi C_b R_{sh}} \quad (1)$$

$$f_h \approx \frac{1}{2\pi Q_{min} C_p R_u} \quad (2)$$

where f_l, f_h are the lower and upper working frequencies respectively, Q_{min} is the minimum per-

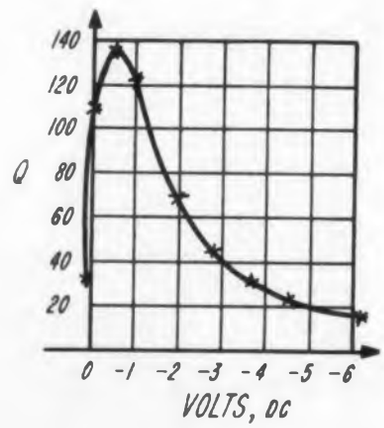


Fig. 1. The variation of Q with frequency for an inverse voltage of 2 and an ambient temperature of 20 C.

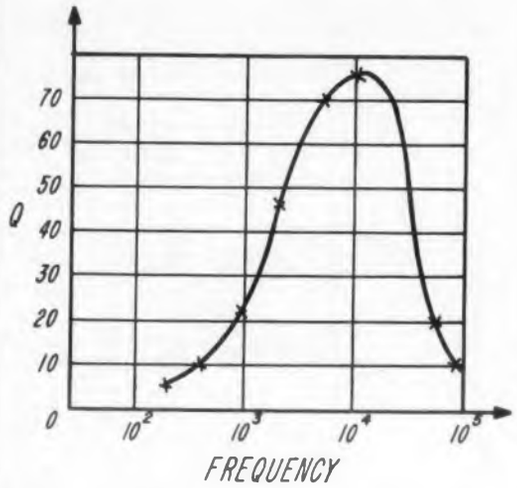


Fig. 2. The variation of Q with applied dc voltage. Frequency is constant at 5 kc and the ambient temperature is 20 C.

missible Q of the varicap, C_b is the barrier capacitance of the pn junction, R_{sh} is the equivalent resistance of the pn junction and its shunting leakage conductance, and R_n is the resistance of the diode and contact material, in series with the pn junction.

If we specify $Q_{min} = 10$, f_l is on the order of several hundred cycles (at inverse voltages on the order of 1 v), and f_h is several hundred kilocycles. We note that for germanium varicaps f_l is on the order of tens of kilocycles.

Fig. 1 shows the variation of Q with frequency for one of the samples, at an inverse voltage of 2 v and an ambient temperature of 20 C.

Fig. 2 shows the dependence of Q on the applied dc voltage for the same sample ($f = 5$ kc, $T = +20$ C.)

The barrier capacitance of the pn junction is almost independent of the temperature. For the specimens described, at $V = 0$, the temperature coefficient of capacitance ranges from $+0.12$ to $+0.20$ per cent per deg C. At negative voltages this coefficient is less than at $V = 0$.

For one of the specimens, the temperature coefficient of capacitance was found to vary as follows:

(a) $V = 0V$, Temp. Coeff. $= +0.12$ per cent/deg C.

(b) $V = 1.0V$, Temp. Coeff. $= +0.05$ per cent/deg C.

(c) $V = 2.0V$, Temp. Coeff. $= +0.03$ per cent/deg C.

Various circuits in which low frequency varicaps are used have also been investigated. However these circuits will be described in the future.

Translated from Low Frequency Varicaps appearing in Radiotekhnika, *No. 12, 1959, pp. 69-70.*

GERMAN ABSTRACTS

E. Brenner

Magnetic Ring Modulator

A SPECIFIC advantage of a magnetic ring modulator over the corresponding diode circuit lies in the gain between signal input and sideband output. Using an idealized induction curve, Fig. 1, an equivalent circuit can be deduced. While the idealization only approximates actual core behavior, this circuit can serve as the starting point for a modulator design.

The magnetic ring modulator using four identical cores, Fig. 2, is treated as a three-port network with carrier and signal inputs, and sideband output. The linear equivalent circuit shown in Fig. 3 is obtained by assuming superimposed sinusoidal winding currents and calculating the induced fundamental frequency voltages in each path.

In this lossless equivalent circuit the following core properties are used (MKS-units):

n_1 = turns of each of the four carrier windings
n_2 = turns of each of the two signal windings
n_3 = turns of the output winding
A = cross-sectional area of each core
d = mean length of flux path in each core
$\mu\mu_0 = dB/dH$ for $H = 0$, Fig. 1
$L_k = 2n_k^2\ \mu\mu_0\ A/d$; $k = 1$ or 2 or 3
$M = (L_2L_3)^{\frac{1}{2}}$

Denoting the carrier and signal frequencies by ω_c and ω_s respectively, the impedances in Fig. 3 are given by

$Z_0 = j\omega_s(4L_2/\pi^2)$; $Z_1 = j\omega_cL_1$
$Z_2 = j\omega_sL_2 - Z_0 + Z_0^*$
Z_L = load impedance
$Z_L' = Z_0Z_L/Z_3$; $Z_3 = j\omega L_3$

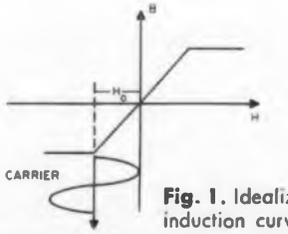


Fig. 1. Idealized normal induction curve.

*Denotes the complex conjugate.

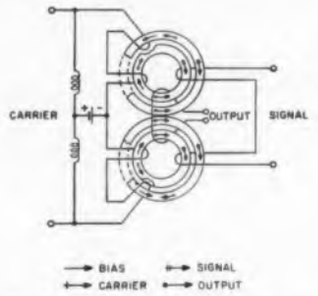


Fig. 2. This magnetic ring modulator has identical cores. The arrows show the magnetomotive force and flux contributions at an instant when the upper two cores present maximum impedance and the lowest two cores minimum impedance.

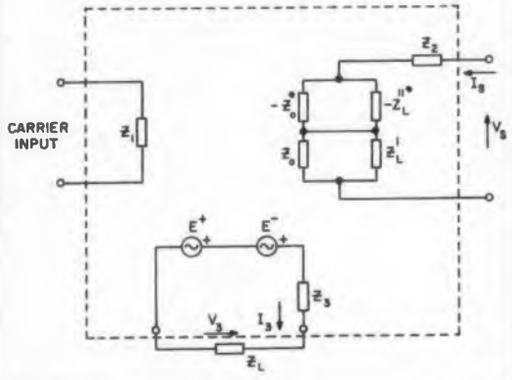


Fig. 3. Linear equivalent circuit of the magnetic modulator considered as a three-port network.

For calculating Z_L and Z_3, either sideband frequency ($\omega_c \pm \omega_s$) is used, depending on the component treated. For Z_L' the upper sideband frequency applies. For Z_L'', the lower. The "sideband generators" (induced rms voltages) are denoted by E^+ and E^- and are related to the rms signal current, I_s, by

$$E^{\pm} = 2M(\omega_c \pm \omega_s)I_s/\pi$$

If losses were to be included, each inductance would be replaced by a series RL circuit with resistance proportional to frequency.

Using the lossless equivalent circuit for inductive load ($Z_L = j\omega L_3$), the approximate volt-ampere ratio:

$$\frac{V_3 I_3}{V_s I_s} \approx \frac{\omega_c}{3\omega_s}$$

shows that the gain is limited by the core losses. These losses limit the choice of carrier frequency. The circuit shows substantial attenuation when used as a demodulator and is, in that respect, distinctly inferior to the diode circuit.

When used as a low loss modulator, the circuit is always stable when the upper sideband is obtained by filtering. Terminated through a band-

GERMAN ABSTRACT

pass filter into a resistance $Z_L = (\omega_c + \omega_s)L_s$, the sideband to signal power ratio is in excess of unity. That is:

$$\frac{P(\omega_c + \omega_s)}{P(\omega_s)} = \frac{\omega_c + \omega_s}{\omega_s}$$

When the lower sideband is filtered out, the possibility of negative reflected resistance exists. Parametric excitation or amplification may result.

To avoid excessive storage (reactive power) each of the three circuits is generally tuned. In this procedure it is useful to tune the signal and output circuits to corresponding upper and lower band limits. Thus, reasonably uniform frequency characteristics are obtained.

Abstracted from an article by R. Elsner, Archiv der Elektrischen Übertragung, *Vol. 13, No. 11, November 1959, pp 486-494.*

Transistor Noise

FOR GERMANIUM transistors in the common base or common emitter configuration, a noise figure, F, for small current densities is given by:

$$4\,kTR_0F = A - B \qquad (1)$$

$$A = 2eI_C \left| \frac{R_b + Z_o + 1/y_{11}}{\alpha} \right|^2$$

$$B = 2eI_E \mid R_b + Z_o \mid^2$$

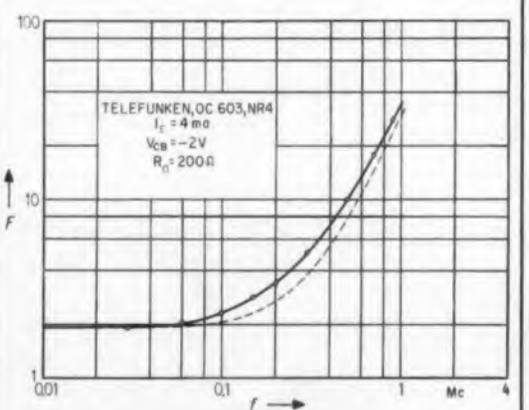


Fig. 1. Noise figure as a function of frequency for a germanium transistor (solid line) and predicted noise curve for a low-current density (dotted line).

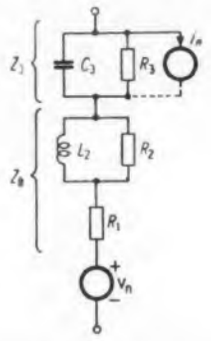


Fig. 2. Equivalent circuit for noise calculation of an unsymmetrical *pn* diode with a high-current density.

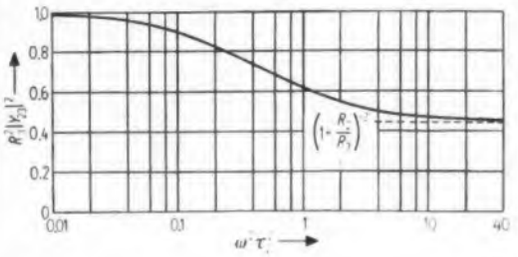


Fig. 3. Frequency dependence of the factor given in Eq. 2.

where R_0 = Source Resistance = $Re(Z_0)$
R_b = base resistance
α = ac current amplification in common base configuration
y_{ij} = admittance parameters of intrinsic transistor in common base configuration

Eq. 1 is applicable to silicon transistors if B is divided by a factor m that accounts for recombination of carriers in the depletion layer. ("Noise In Silicon Diodes And Transistors," ELECTRONIC DESIGN, March 18, 1959). For large current densities, a deviation from the behavior predicted by Eq. 1 is observed with increasing frequency, Fig. 1.

By using an equivalent circuit for *pn* junctions, which includes inductance as well as resistances and capacitances, Fig. 2, a noise figure can be calculated from Eq. 1 if B is multiplied by the factor:

$$R_3^2 \mid Y_{23} \mid^2 = \frac{1 + w^2\tau_2^2}{1 + w^2\tau_1^2\,(1 + R_2/R_3)^2} \qquad (2)$$

where $\tau_2 = L_2/R_2$. The frequency dependence of this factor is shown in Fig. 3. This formula has been verified experimentally.

Abstracted from an article by B. Schneider and M. J. O. Strutt, Archiv der Elektrischen Übertragung, *Vol. 13, No. 12, December 1959, pp 495-502.*

ELECTRONIC DESIGN

DIGEST

of recent papers and literature

New 8-mm Radar Has High Resolution, Short-Range Application

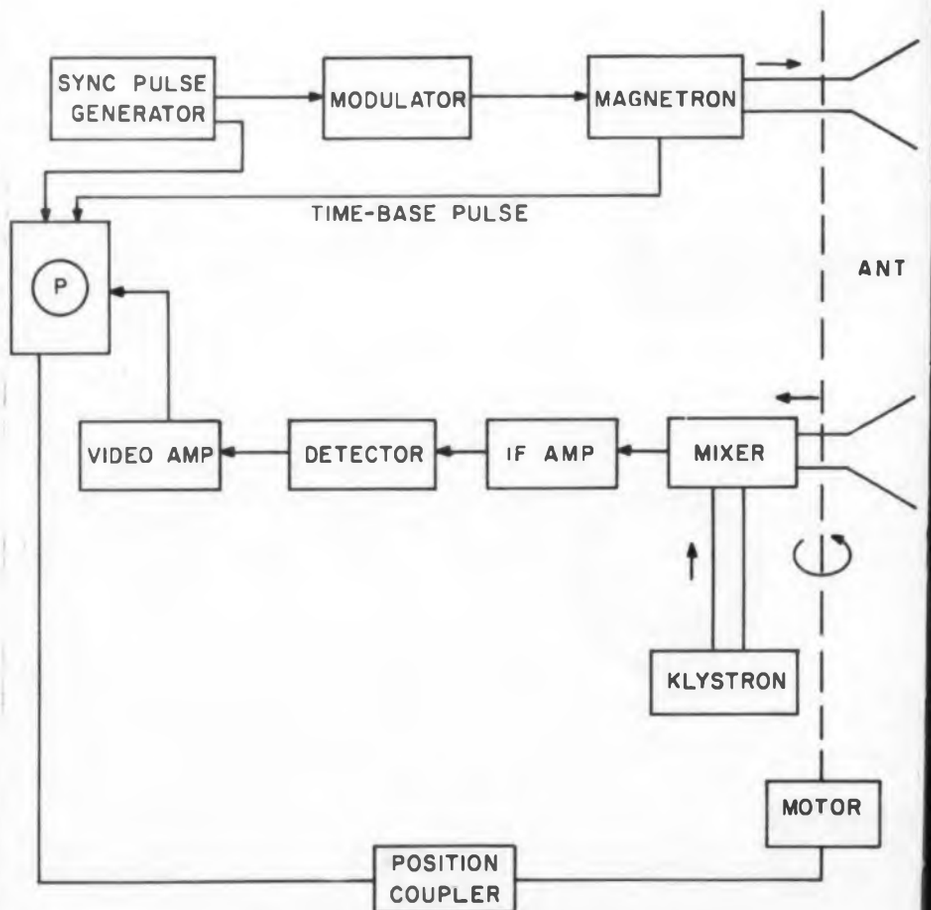


Fig. 1. Block diagram of the 8 mm radar installation. The starting pulse is delivered by the magnetron to the time base circuit.

A very high resolution, radar installation operating in the 8-mm wave region, has recently been designed by the N. V. Philips Telecommunicatie Industrie of Hilversum, the Netherlands. Called the 8 GR 250, the new radar is extremely useful for ships navigating in busy waterways and for controlling traffic on airport runways and aprons. ELECTRONIC DESIGN ***has previously reported on the magnetron used with this new radar development (Feb. 3, 1960, p 11; March 2, 1960, p 36). Presented here are aspects of the radar's circuitry, physical installation, and performance.****

THE 3-cm and 10-cm wavelengths have long been used for navigational radar with excellent results where fairly long ranges were concerned. However, for navigation and surveillance within a restricted area, the radar must have a very high resolution, and a very small dead zone at the PPI center. This is extremely difficult to achieve at these relatively long wavelengths. Thus, the much shorter wavelength of 8.6 mm. It has a pulse length of 0.02 μsec. With a specially designed 25-kw magnetron the pulse rise time is 600 kv per microsec. The principal operating data for the radar installation is summarized in the Table.

Two Separate Antennas Transmit and Receive Radar Signals.

An interesting design feature is immediately apparent from the radar installation's block diagram, Fig. 1. To operate with the short pulse length, two separate antennas are required—one to transmit

*Material extracted from An 8 mm High-Resolution Radar Installation, J. M. G. Seppen and J. Verstraten, *Philips Technical Review*, Vol. 21, No. 3, Dec. 1959, p 92-103.

the high energy ranging pulses, the other to receive the reflected signals. The duplexer, necessarily present in radars having only a single antenna, is eliminated.

A duplexer consists of two gas-filled tubes mounted in a special waveguide circuit. These open the transmitter channel, close the receiver channel while the pulse is being sent out, and reverse the process in the period between the transmitted pulses. The extinction time of these tubes is too long, however, to allow objects at very short distances to be observed. The reception channel will still be closed when such early reflections arrive at the antenna. The two antennas had to be designed into the system because of this operating limitation.

Atmospheric Attenuation Window Occurs at 8.6-mm Wavelength

Not every wavelength in the millimeter range is suitable for radar purposes. This is because the atmospheric absorption makes the attenuation in this range much greater than in the centimeter band. The waves are absorbed by oxygen and water vapor, and attenuated by particles of water in the form of rain, mist and clouds. The relation between the attenuation suffered by radio waves in the atmosphere and wavelength, Fig. 2, is a very complicated one. However, the total attenuation, curve 3, Fig. 2, has a minimum, or window, at 8.6 mm. This is the reason for designing the radar for this wavelength. The fact that the attenuation is greater than in the centimeter range is not a serious objection. The radar installation is intended for short distances where the total attenuation is relatively small.

Frequency band	34 512 - 35 208 Mc/s
Pulse length	0.02 μsec
Peak pulse power	25 kW
Pulse repetition frequency	5000 c/s
Intermediate frequency	90 Mc/s
IF bandwidth	50. Mc/s
Beam width ⟨ horizontal	0.3°
of antenna ⟨ vertical	17°
Speed of antenna rotation	40 r.p.m.
PPI	30 cm diameter
Radii of areas displayed on screen: A.S.M.I. type 8 GR 250/00	0.5 - 1 - 1.5 - 3 - 5 - 10 km (550 - 1100 - 1650 - 3300 - 5500 - 11000 yds approx.)
"Ship-shape" type 8 GR 250/01	0.3 - 0.5 - 1 - 2 - 3 - 5 nautical miles
Supply voltage and frequency	120 V, 400 c/s

The operating characteristics of the 8-mm radar installation are summarized in this Table.

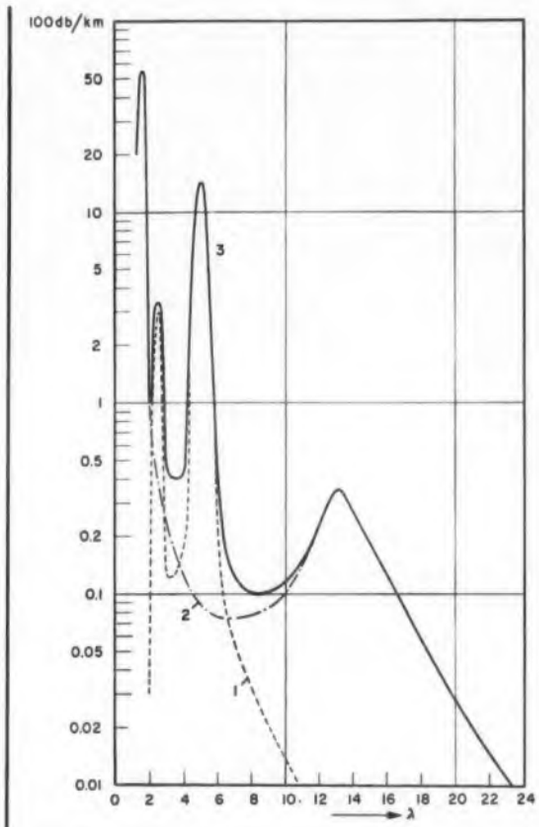


Fig. 2. Attenuation of radio waves by oxygen and water vapour in the atmosphere, as a function of wavelength. 1 = oxygen, 2 = water vapour, 3 = total attenuation (sum of 1 and 2). Curve 3 has a window at a wavelength of 8.6 mm.

Operating Characteristics: Radial Resolution

The radial resolution of a radar is determined by the pulse length. The transit time of the pulse from the antenna to an object at a distance R and back is given by $T = 2R/c$, where c is the velocity of light. Two objects, separated radially by a distance ΔR, can only be distinguished if the difference in the transit time to the two objects, $2\Delta R/c$, is greater than the pulse length τ. This minimum distance, equal to $c\tau/2$, is the radial resolution of the radar system.

Evidently it is desirable to have the shortest possible pulse length. This, unfortunately, cannot be indefinitely shortened, since the magnetron requires a number of cycles to reach its peak power. This implies that at shorter wavelengths pulses of shorter duration can be generated, improving the radial resolution. With a 0.02-μsec pulse length the radial resolution of the 8 GR 250 is about 10 ft.

Tangential Resolution

Using the millimetric wavelength makes it pos-

sible to produce a very narrow beam of radiation with an antenna of moderate size. The tangential resolution is given by the product of the horizontal beam width and the distance R from the antenna. The 0.3-deg beam width of the radar corresponds to a tangential resolution of about 10 ft at a distance of 600 yd.

CRT Spot Size Limits Radar Resolution

A limitation on the resolution of a radar system is the finite size of the luminous spot on the crt screen. A PPI presentation is useless if the screen images of the objects to be discriminated are smaller than the spot produced on the screen by the electron beam. In practice the image on the PPI is displayed on a scale adjustable in a number of steps. The largest scale corresponds to the smallest area displayed.

In the 8 GR 250, this area is a circle with a radius of about 500 yd. On the next scale the radius is about 1000 yd and so on. The limiting effect of spot size is obviously least for the smallest area. The various parameters have been selected so as to achieve, in the smallest areas, the best possible compromise between the resolution of the radar system and that of the cathode-ray tube.

Pulse Repetition Frequency

The choice of the pulse repetition frequency depends on the radar's wavelength. It also has to be chosen between certain limiting values.

The maximum prf depends upon the range of the radar system and the maximum average power delivered by the magnetron.

The minimum prf is governed by the speed at which the antenna rotates and by the antenna's horizontal beam with v_h. Since there must be at least one transmitted pulse per angular displacement v_h of the antenna, it follows that:

$$prf_{min} = \frac{2\pi N}{60\, v_h}$$

where N is the number of antenna revolutions per minute. To be able to distinguish weak echoes on the screen from random receiver noise fluctuations, the prf is always at least several times higher than the prf_{min}. The antenna then scans each perceptible object with more than one pulse at a time. Where the antenna dimensions are constant, basic antenna beam width and radar range considerations show that prf_{max} is proportional to the wavelength. In choosing the prf, the minimum pulse repetition frequency is more important, however, since the number of pulses per observed

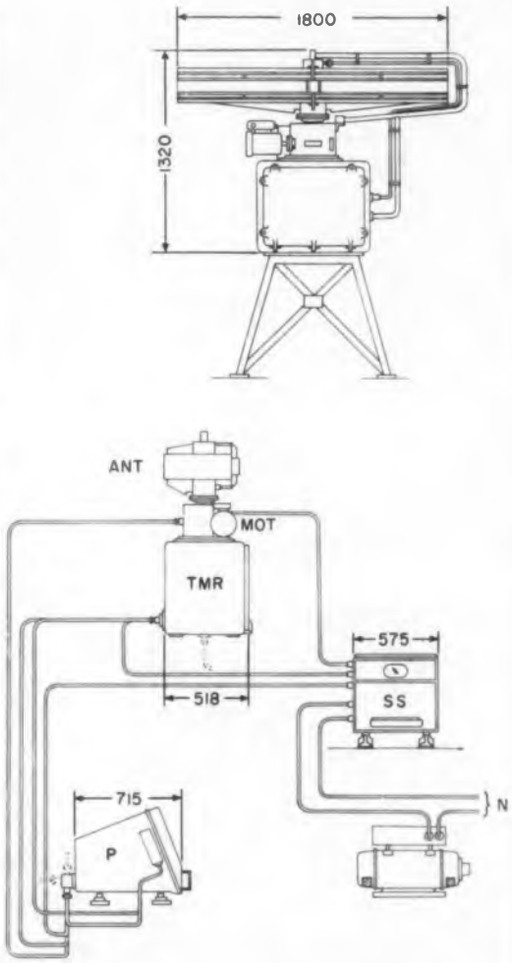


Fig. 3. Schematic layout of Philips 8 GR 250 radar installation. *TMR* is the water-tight case containing transmitter, modulator and receiver. Above the case are the two antennas and the drive motor. *P* is the PPI unit. *SS* contains the supply circuits and the synchronizing pulse generator. A rotary converter supplies 120 v, 400 cps. A front view of the *TMR* is shown in the upper right. Dimensions in millimeters.

object determines the minimum detectable signal.

Since the 8 GR 250 equipment is especially intended for short-range detection of moving objects, a high speed of antenna rotation is desirable. At distances of a few hundred yards the angular velocities at which objects can change their position with respect to the radar antenna can be considerable. For this reason, and also because of the short wavelength used, prf_{min} had to be fairly high. This led to the choice of a 5000-cps pulse repetition frequency.

Physically Compact Unit Can Be Mounted On Ship's Deck

The layout of the installation is illustrated in

DIGEST

Fig. 3. The transmitter, the receiver and the modulator and driver stage are contained in a watertight casing. TMR. On this casing are mounted the transmitting and receiving antennas and their driving mechanism. They are rotated at a speed of 40 rpm.

The antennas are two parabolic reflectors of the pill-box type. Crosstalk is minimized by mounting them at a specific distance apart. The minimum distance at which an object can be seen is very small; one can even see on the PPI the feeder waveguide for the upper antenna (which inevitably comes into the beam because of the antenna's free rotation.)

Main power pack SS also contains the synchronizing-pulse generator that determines the pulse repetition frequency of 5000 cps. Below this is the rotary converter, which provides the supply voltage (120 v, 400 cps).

Fig. 4 is a photograph of the watertight casing in which the transmitter, receiver and modulator are mounted. The unit is shown installed on the upper deck of a ship. Clearly visible above the casing are the antennas' slots.

Circuit Details

The Philips magnetron type 7093 used in the installation is modulated with voltage pulses of approximately 15 kv; the magnetron draws a peak current of about 12 amp. The modulator, Fig. 5, is designed to give the most favorable possible efficiency. The modulator had to:

(1) Produce high voltage, high power rectangular pulses of the right shape and durations.

(2) Store power in a reservoir which could be charged up again in the interval between two pulses.

These requirements were fulfilled by two circuits: the driver stage, which generates the pulses, and the modulator proper, which converts these into pulses of high voltage and power.

Rectangular Pulse Obtained From Charged Coaxial Cable

A good rectangular pulse can be achieved by taking a transmission line of specific length, charging it to a certain voltage and discharging it through a resistor. If the line is lossless and terminated by its characteristic impedance, this discharge will cause a constant current to flow through the resistor for a time that depends on the length of the line. This is the way in which the pulses are generated in the driver stage. The transmission line K is in this case a simple coaxial cable. This is possible because the pulse length is so short. If the pulse length were longer, use would preferably be made of an artificial line for

Fig. 4. The TMR case and antennas are mounted here on a ship's deck. The loop around the antenna is the feeder waveguide for the upper (transmitting) antenna.

which the velocity of propagation of electromagnetic waves is smaller.

In the intervals between pulses, the line K, Fig. 5, is charged up gradually via the choke L_c. At the appropriate moment, the synchronizing-pulse generator, Fig. 1, which determines the pulse repetition frequency, turns thyratron Th on and K discharges through R_c. The tetrode T in the modulator circuit then conducts strongly and its anode voltage drops by about 15 kv. This voltage pulse applied by the magnetron M, triggers it into oscillation. The output rise time of the magnetron is 200 kv per μsec.

Stray Capacitances Kept Small To Insure Fast Rise Time

A particular feature of the modulator stage, which is basically of conventional design, is that the stray capacitances are kept as small as possible. The losses in the modulator occur in the tetrode T, because of the repeated charging and discharging of the stray capacitances C_{p1} and C_{p2}. Since the pulse length is so short (0.02 μsec) the latter losses are extremely important.

Capacitor C_t is the reservoir which supplies the pulse current to the magnetron. Its value is such

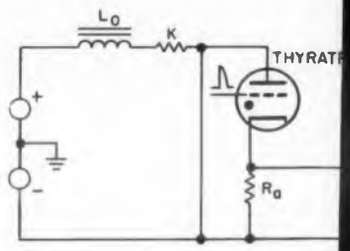


Fig. 5. Simplified schematic diagram of modulator and driver stage.

that despite the high current drawn by the magnetron, the voltage across it drops by only a small fraction. However, the larger C_t is, the larger is its capacitance with respect to earth. This earth capacitance contributes to the stray capacitance C_{p1} which includes the output capacitance of T and the wiring capacitance. It also adds to the stray

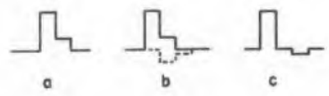


Fig. 6. (a) Echo pulse with (idealized) tail. (b) Delayed and inverted pulse added to (a). (c) Corrected pulse.

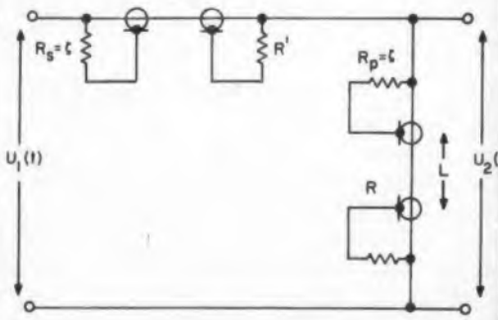
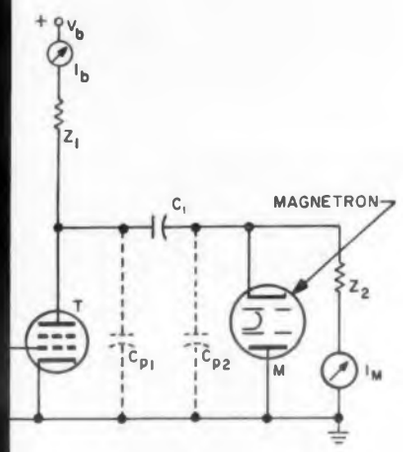


Fig. 7. Pulse-correcting network. Parallel with the series resistor R_s is a coaxial line of length L terminated by R'; parallel with R_p is likewise a coaxial line of length l, terminated by R.



capacitance C_{p2}, which includes the input capacitance of the magnetron and the wiring and earth capacitance of Z_2.

The impedance Z_2, containing a coil and a charging resistor, returns the magnetron side of C_t to earth potential after the pulse.

Pulse Correcting Circuit Reduces Echo Distortion

The echo pulse picked up by the receiving antenna may be unduly elongated, Fig. 6. The smaller the pulse length with respect to the reflecting object, the greater the likelihood of this "tail" formation. This is undesirable since it reduces the resolution of the radar system. The 8 GR 250 contains a pulse-correcting circuit, which adds to the elongated pulse a delayed and inverted pulse of the same shape as the tail. The result is a pulse whose tail is largely eliminated.

The pulse correcting network, Fig. 7, is placed in the coaxial video line of characteristic impedance ζ. The network itself is composed of a series and a parallel resistance also of magnitude ζ. In parallel with each of these two resistors is a coaxial line of characteristic impedance ζ and electrical length $l = c\tau/2$. It is terminated respectively by resistors $R' = \zeta^2/R$ and R. When a voltage $U_1(t)$ is applied to the input terminals, we can write for the output voltage $U^2(t)$:

$$U_2(t) = 1/2\{U_1(t) + kU_1(t - \tau)\}$$

where $k = (R - \zeta)/(R + \zeta)$. A suitable choice of k, that is of R, adds to the original pulse a delayed pulse of the required polarity.

Digested from An 8 mm High-Resolution Radar Installation, J. M. G. Seppen and J. Verstraten, Philips Technical Review, *Vol. 21, No. 3, Dec. 1959, p 92-103.*

Electronic Products NEWS
by CARBORUNDUM®

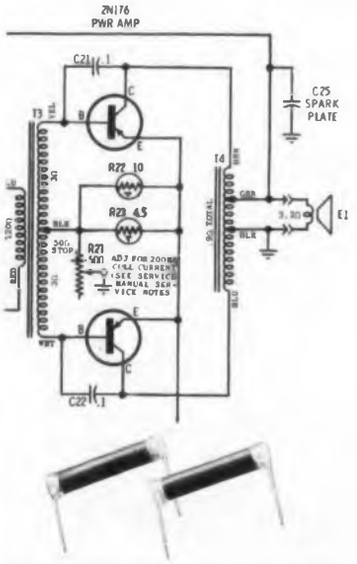
Smallest sub-miniature time delay relay made by Wheaton Engineering Corp. relies on GLOBAR® Thermistors

The ½-ounce postage stamp sized unit shown here is probably the ultimate in miniaturization of electronic time delay relays. It is a product of Wheaton Engineering Corporation, 920 Manchester Rd., Wheaton, Ill.

High precision time delays over a broad range of operating temperatures are produced by utilizing the negative temperature coefficient characteristic offered by GLOBAR Type 997F Thermistors. Contributory factors influencing their use are small size, extreme ruggedness and closely controlled quality and uniformity. "Were it not for your Thermistors," says Wheaton, "many of our precision timing devices would not be as easily or readily available."

If you have any problems involving temperature compensation, temperature sensing and control, time delay or surge current suppression, perhaps GLOBAR silicon carbide Thermistors can help. For more details, write Globar Plant, Refractories Division, Department EDT-40, The Carborundum Company, Niagara Falls, New York.

Transistor current controlled by GLOBAR® Thermistors in Motorola Auto Radios



The latest auto radio produced by Motorola Inc. contains a push-pull transistor output stage and 5 tubes designed to operate directly from the car battery.

Transistors are designed to draw ½ amp. Without control, this current would change with operating temperatures. Normal current must, however, be held within reasonable limits to maintain proper impedance, matching and low audio distortion. Motorola uses GLOBAR Thermistors of correct resistance and temperature coefficients to control the current through the operating range of −20 C to +65 C.

This application is another example of the growing use of Thermistors in transistorized circuits. For information on types and ratings, write Globar Plant, Refractories Div., Dept. EDT-40, Niagara Falls, New York.

Critical requirements met in ceramic-to-metal sealed components

The various units above are typical examples of problems involving ceramic-to-metal assemblies solved by Carborundum's Latrobe Plant.

Of particular interest is the assembly at right center. The threaded monel metal housing is attached to the ceramic by an intermediate KOVAR® flanged eyelet, which compensates for expansion differentials. The center electrode is beryllium copper—brazed to a KOVAR alloy washer which is sealed to the ceramic. The unit on the right is a rectifier housing. The bottom flange and the cap are copper-plated steel bonded to the ceramic. A copper stud is brazed to the cap. Correct design avoided expansion stresses which would damage the ceramic or break the bond.

For assistance in solving similar problems, write Latrobe Plant, Refractories Div., Dept. EDC-40, The Carborundum Co., Latrobe, Pa.

Latest information on ceramic INSULATING TUBING

A new technical bulletin is now available on Carborundum's insulating tubing for thermocouples and other applications. Tubing is offered with single and multiple holes in a wide variety of dimensions and shapes. For your copy of the bulletin, write Latrobe Plant, Refractories Div., Dept. EDB-40, Latrobe, Pa.

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REPORT BRIEFS

Sampled Data Systems

The use of pulse width control for the on-off regulation of systems subject to sampled data is investigated in this paper. The pulse width controller is considered to effect control of a linear n^{th} order plant. During each sampling period it applies to the plant an input signal, selected from the pulse width control signals and based on the state of the plant at the sampling instant. The basic capabilities of this type of control are investigated in relation to relay, and pulse amplitude control. General methods for achieving both stable and optimal control are developed and practical design applications are considered. Examples and experimental evaluation of the design methods are also given. *Pulse Width Control Of Sampled Data Systems, Winston L. Nelson, Columbia University, School of Electrical Engineering, New York, N.Y., July 6, 1959, 157 pp, Microfilm $7.50, Photocopy $24.30. Order PB 143175 from Library of Congress, Washington 25, D.C.*

Magnetic Amplifier Control Systems

Dynamic representation of a control system, which includes a magnetic amplifier as its component, is essentially a problem of incorporating a discrete system (the magnetic amplifier) with a continuous system (the remainder of the control system). The problem is difficult because the magnetic amplifier is a pulse-width modulating system making a direct application of the modified z-transform and the P-transform methods. By applying the technique of "multiple expansion" in electromagnetic theory with proper treatment of Dirac delta-function, however, both a general dynamic representation of such a control system and its linear approximation in terms of the modified z-transform can be obtained. Since in practice the condition for the linear approximation is usually met and the modified z-transform method is readily available, the latter is immediately applicable for the analysis and synthesis of mixed systems which include pulse-width modulators such as the magnetic amplifier. The general representation explicitly gives the criterion for validity of the linear approximation and sets the z-transform theory on a more rigorous mathematical basis. This report presents the detailed derivation of these representations and illustrates their theoretical and practical applications. *Linear Analysis Of Control Systems With Magnetic Amplifiers, T. T. Kadota, Electronics Research Laboratory, University of California, Berkeley, Calif., Nov. 11, 1958, 68 pp, Microfilm $3.90, Photocopy $10.80. Order PB 139062 from Library of Congress, Washington 25, D.C.*

Waveguide Sealing Techniques

Contained here is information regarding all phases of the experimental work undertaken to determine a design criteria for development and application of sealing techniques to be applied to waveguide and coaxial rotary joints. The first part of this report is devoted to the results of experimental and development work performed in producing the final design and construction of sealed RG-52 waveguide rotary joints. The second portion of the report contains five Appendices. The first is devoted to the experimental work on the magnetic mechanical seals. The second appendix is a history with recorded data of the experimental work performed in the development of the final design. Reference is made to the work with the first experimental mechanical seal and continues through to the final development results. The third appendix refers to publications, reports, lectures, and conferences associated with this study. In order to coordinate the design information obtained in this study the fourth appendix of this report presents the developed design criteria with a procedure for designing additional rotary seals with similar requirements to the RG-52 Sealed Rotary Joint developed in this study. The fifth and last appendix presents a major portion of the test data recorded during the final testing of the development models including those required by the technical requirements. *Sealing Techniques For Waveguide and Coaxial Rotary Joints, Milton M. Backman, New York University College of Engineering, New York, N.Y., Aug. 1, 1954-Mar. 31, 1957, 170 pp, Microfilm $7.80, Photocopy $25.80. Order PB 143303 from Library of Congress, Washington 25, D.C.*

Precision Frequency Control Techniques

The individual elements of a short-term frequency measuring system are described and the complete system is evaluated theoretically. Under certain assumptions, a sensitivity of 0.0637 mv/cycle of frequency change is indicated. This represents the available if voltage input to the if amplifier where a maximum additional gain of 140 db is available. Data are presented on the long-term performance of an invar cavity-controlled oscillator immersed in a temperature regulated oven. Construction details of this oscillator are illustrated. Results of measuring the temperature-frequency characteristics of silver-plated Stupalith cavities are given. *Investigations Of Precision Frequency Control Techniques, Samuel E. Meek and Samuel N. Witt, Jr., Georgia Institute of Technology Experiment Sta., Atlanta, Oct. 1-Dec. 31, 1955, 43 pp, Microfilm $2.30, Photocopy $7.80. Order PB 139088 from Library of Congress, Washington 25, D.C.*

REPORT BRIEFS

VLF Radio Propagation

Propagation in the ionosphere is considered as the theoretical form of propagation in a homogeneous gyroelectric medium. The results of this analysis are tabulated in graphical form so that the dispersive qualities of the medium can be readily examined. With the aid of these results, an examination of the natural phenomena of whistlers is presented to determine the feasibility of generating gyroelectric-echoes. Reflection and transmission coefficients are presented for vertical incidence to determine the order of magnitude of such an echo. So far, experiments have not yielded echoes, but with modifications in the transmitting and receiving equipment, echoes may be detected. A complete description of the experimental equipment and a proposal for a more sophisticated receiving system are given. *Experiments In VLF Radio Propagation, Roger M. Golden, California Institute of Technology, Pasadena, Calif., June 26, 1959, 129 pp, Microfilm $6.30, Photocopy $19.80. Order PB 142987 from Library of Congress, Washington 25, D.C.*

Power Transistor Circuitry

Power transformers utilizing various core materials and cross-sectional areas were tested. Two identical transformers fabricated from 1-mil Deltamax failed to oscillate in the converter. Rapid switching was obtained with transformers fabricated from 2 toroidal core materials, grain-oriented silicon steel, and Ferramic H. Experimental results showed that the addition of secondary leakage inductance must be incorporated in the transformer for good switching characteristics. Some transformer core materials require a greater amount of secondary leakage inductance than others to obtain the desired short switching time. The effects of leakage inductance in producing forward and inverse collector currents during switching were studied. Initial current surges in the switching-on transistor could occur when both transistors were conducting at the same instant. Capacitor input load filters produced better switching characteristics than did choke inputs. Determination of transistor output characteristic curves by a pulsing method revealed that the thermal irregularities found in previously determined characteristic curves were reduced by the pulsing method of testing. *Power Transistor Circuitry, John T. Lingle, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., Feb. 15-May 15, 1957, 124 pp, Microfilm $6.30, Photocopy $19.80. Order PB 143304 from Library of Congress, Washington 25, D.C.*

Electronics Maintenance

The symposium covers ways and means of ensuring that electronic equipment is designed initially so that the functions of trouble shooting, maintenance records, calibration, replacement and repair are simplified. In the area of designing for maintenance, much progress has been made in recent years, but still greater progress is required. This report will serve to stimulate further research and application in this field. Contents:

Session 1. What role do you see for human engineering in improving the maintenance problem now?

Session 2. Looking ahead to an era of miniaturization, utilization and automation, what future do you see for human engineering.

Session 3. What engineering techniques and practices are available in designing equipment to reduce the maintenance job?

Session 4. Logistics has become an integral part of the maintenance problem; what do you see as the engineer's problem? The human engineer's problem?

Session 5. How can engineers and human engineers together improve the design for equipment maintenance? *Symposium on Electronics Maintenance No. 2: Design For Ease of Maintenance, Assistant Secretary of Defense, Research and Development, Washington, D.C., May 8-11, 1956, 208 pp, $3.50. Order PB 161107 from OTS, Washington 25, D.C.*

Microwave Detectors

Described are two techniques for achieving a wide video bandwidth in a microwave crystal detector and associated input video amplifier. In each case, forward current bias is used to reduce the crystal video resistance to a reasonably low value. The techniques differ in the manner in which a low effective interstage capacitance is achieved. In the guard-electrode mount, the interstage video capacitance is split into a three-capacitor delta configuration by modification of the detector mount. The additional node thus formed is driven with a near-unity-gain amplifier. Measurements of vswr, video voltage, tangential signal sensitivity and bandwidth are presented for this mount before and after modification. The capacitance-neutralized input circuit may be used with any crystal mount. A feedback amplifier is used to place an effective negative capacitance in parallel with the existing interstage capacitance. One secondary-emission tube is used in the feedback amplifier. *Two Wideband Video Techniques For Microwave Detectors, J. C. de Broekert, Stanford Electronics Laboratories, Stanford University, Palo Alto, Calif., Nov. 27, 1957, 19 pp, Microfilm $2.40, Photocopy $3.30. Order PB 143306 from Library of Congress, Washington 25, D.C.*

LETTERS

Appreciates Design in the 60's

Dear Sir:

I have just finished reading your issue on Design in the 60's (ED, Jan 6) and must offer my hearty thanks and congratulations on an excellent job.

Your issue was well written and presented in one of the most logical formats I have seen to date. Thank you for sparing us having to wade through pages and pages of material. Your presentation was concise and yet informative. Your headlines were a wonderful use of this sort of technique to allow the skimmer to be informed, yet dig where he wanted to.

Again a real fine job, well done without the usual hysteria, a fine presentation.

Howard N. Sachar
Pacific Semiconductors, Inc.
Culver City, California

Tolerance of "Zero" Must Be Defined

Dear Sir:

Comments in your editorial in the December 9, 1959 issue of ELECTRONIC DESIGN regarding measurement standards were appropriate in a field in which electronics deal in microseconds and yet cannot define or standardize on the meaning of "tolerance." The most common laboratory instruments in use today claim plus or minus 1% or less, yet do not reference the zero to which this tolerance was made. In the past, the "zero" was assumed to be the National Bureau of Standards'; however, they, too, have a tolerance which is not "zero."

Your readers working in this field of measurements and standards may be interested in the results of a study for Army Ordnance, started several years ago, which discussed (but did not solve) the problems of build-up of tolerances in modularized equipment, the meaning of "tolerance," the establishment of measurement criteria independent of measurement equipment, etc.

The purpose of the study was to establish the feasibility of modularizing missile test systems and it was in the first phase of the analysis that the "relative" nature of specifying performance of prime equipment having one tolerance with measurement equipment having another tolerance

(which was in turn calibrated with equipment having a third tolerance) was shown to be an obstacle to accurate design.

The study indicated that the industry as a whole disagreed in its interpretation of a tolerance standard. This state of disagreement was particularly troublesome to the R&D scientist who regarded his measurement equipment as absolute but could not produce a specification that would permit a production or field activity to reproduce the lab controlled performance of an item unless the same make and model of the R&D "absolute" measurement equipment were used and the same step-by-step procedures were followed. It was also surprising to find that some testing procedures were used (in spite of their inadequacies) in preference to better ones because "that was the way to do it" or because a great many engineers were apparently taught from the same text books (and who hasn't used Terman).

W. Gonzalez
RCA Service Co.
Alexandria, Va.

▶ The results of the study were published in two "confidential" reports. They are presumed to be available to qualified readers as Task I and Task II Summary Reports of the Standardization Program for Ordnance Corps Guided Missile Electronic Test Equipment Contract DA-36-034-ORD-2062 from Philadelphia Ordnance District or the ARGMA R&D Division of Redstone Arsenal, Huntsville, Ala.

What's Holding Back Reliability

Dear Editor:

In reading your article "What's Holding Back Reliability," it's rather difficult for me to believe that the gentlemen making the statements in your article do not know the answer. Either they are brand new to the industry or are shy in stating the real reason.

The reason is one big bad word "sloppy" management, "sloppy" engineering, and believe me this is prevalent throughout the industry.

Reliability could change IF:

1. The Government tightened up on contracts by elimination of loop-holes in contracts.
2. The contracts contained an incentive inducement to meet specifications.
3. More and experienced Government engineering personnel. Better pay would go a long way in obtaining this goal.
4. Elimination of manufacturers that have a knack of being unable to produce at a reliable level.

M. R. Barton
Derry, N.H.

YOUR CAREER

R&D engineers have been advised by a company president to examine their job attitudes for evidence of "mistaken prevailing beliefs." The executive, W. R. Persons of Emerson Electric, outlined "some fallacies" in an address to the American Society for Engineering Education. He credited Booz, Allen & Hamilton with uncovering the following in a management research study:

Belief: *Scientists and engineers work more effectively when given greater freedom and independence.*

Evidence: Research effectiveness has been injured by a "laissez faire" attitude by management. Tighter direction, planning and control are needed. The scientists and engineers want it.

Belief: *R&D should select the projects on which it works.*

Evidence: R&D plays an important role in project selection, but essentially selection is an integrated, total company effort. Every major area of the enterprise must be represented. This balanced point of view cuts project failures, keys research to desired objectives.

Belief: *R&D effectiveness has been seriously injured by a shortage of engineers.*

Evidence: The supply of engineers has doubled in the last decade. By 1965 engineers will be graduating at twice the rate of 1956. Many laboratories can use more personnel, but the situation is far from critical and is slowly improving. The shortage has been overplayed in the press.

Belief: *R&D accomplishment has been seriously limited by a lack of creativity.*

Evidence: Most laboratories have enough creativity for acceptable performance. Creativity is like money: everybody would like more but enough is present for a comfortable standard of living.

Belief: *R&D training is best accomplished through professional meetings, writings, speeches and additional formal education.*

Evidence: Each of these aids has its place, but the most effective training is on-the-job. Scientists and engineers learn best by doing.

Belief: *Compensation is a major problem in R&D.*

Evidence: Some problems exist, based largely on unequal opportunities for researchers and administrators. Fifty-six per cent of scientists and engineers, for example, prefer incentive compensation to straight-time pay. But on the whole, compensation is not a major problem in the large laboratories. Both management and researchers rank it in eighth place among problems of consequence.

Those are the findings. Any comments?

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ELECTRONIC DESIGN's Confidential Career nquiry Service helps engineers "sell" themelves to employers—*as confidentially and iscreetly as they would do in person.* The ervice is fast. It is the first of its kind in the lectronics field and is receiving high praise rom personnel managers.

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- The "circle number" portion of the form is detached before the application is sent to an mployer, so that no company will know how many numbers you have circled.
- All original applications are placed in confidential files at *ELECTRONIC DESIGN,* and after a reasonable lapse of time, they are destroyed.

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Date of Birth _____ *Place of Birth* _____ *Citizenship* _____

Position Desired _____

Educational History

College	*Dates*	*Degree*	*Major*	*Honors*

Recent Special Training _____

Employment History

Company	*City and State*	*Dates*	*Title*	*Engineering Specialty*

Outstanding Engineering and Administrative Experience _____

Professional Societies _____

Published Articles _____

Minimum Salary Requirements (Optional) _____

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

Circle Career Inquiry numbers of companies that interest you

900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924
925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949

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This company owes its surprising growth (from a handful of brilliant men 8 years ago to a 1200-man organization today) to the originality of its conceptions in diverse electronic fields. (Examples of Sanders' firsts include PANAR® radar, TRI-PLATE® microwave products, FLEXPRINT® flexible printed circuits.)

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Right now opportunities are available at Sanders on a variety of commercial and defense projects, including a very sophisticated seeker system for the U.S. Navy's Eagle Missile, which it is believed will provide superior performance in the face of increasingly effective countermeasure techniques.

ECM ENGINEERS

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INSTRUMENTATION ENGINEERS

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To learn more about opportunities for you at Sanders—and the advantages of our location in the progressive New England community of Nashua, New Hampshire (less than an hour from downtown Boston), send a resume to Lloyd Ware, Staff Engineer, Dept. 920.

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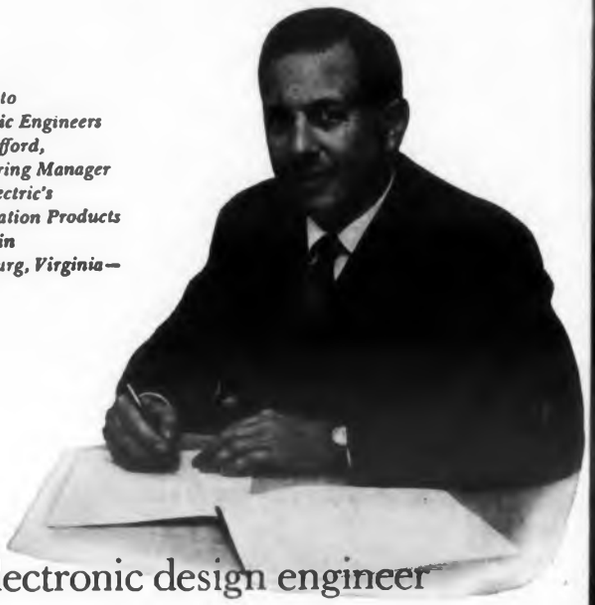
CIRCLE 901 ON CAREER INQUIRY FORM

A message to Electronic Engineers from R. P. Gifford, Engineering Manager of General Electric's Communication Products Department in Lynchburg, Virginia—



"An electronic design engineer earning $10,000 should be a decision-maker *beyond* his project's immediate technical problems."

"I believe that any electronic design engineer earning $10,000 or more welcomes the authority to make a variety of high-level business decisions—in such areas as features versus cost and reliability versus weight—working closely, of course, with his marketing counterparts in Product Planning and also with the Manufacturing Engineers.

"At Communication Products Department we give the experienced engineer the *necessary authority* to do just this. He generally enters the design project early in the development planning phase, so that he can take responsibility for estimating the project expense and schedule—thus contributing to the establishment of bogeys for product cost and delivery.

"Of course our communication systems must do the customer's job, but also they must be *marketable at a profit to the Department;* to make this come true is a vital part of the design engineer's challenge. This means exposure to many management problems and a rare opportunity to grow and move ahead rapidly.

"Our communication products are primarily commercial, including Mobile Radio, Microwave Radio Relay, Terminal Equipment, Telephone Carrier, Multiplex, and Personal Communication Systems. Military contracts also in the house include a 24-channel SSB tropospheric scatter system."

Right now, we have immediate openings for Advance, Development, and Systems Engineers who have significant backgrounds in these areas:

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Multiplex equipment
Microwave systems design
Solid state devices
Microwave plumbing, antennas
Piezoelectric devices
Mobile transmitter, receiver design
Electronic equipment mechanical design
Automatic test equipment D&D
Microminiaturization

For prompt consideration, forward your resume in confidence to Mr. W. J. Kelly, Dept. 76-MD
COMMUNICATION PRODUCTS DEPARTMENT

GENERAL ELECTRIC

Mountain View Road, Lynchburg, Virginia

CIRCLE 902 ON CAREER INQUIRY FORM

CIRCLE 903 ON CAREER INQUIRY FORM

Problem: HYDROSPACE

Hydrospace — concept of space in ocean, motion through an opaque medium — offers a complex of challenge unique in engineering. To solve this tri-dimensional riddle, Raytheon's Submarine Signal offers an equally unique concept — industry's first ASW CENTER.

Now under construction, the Center will be a *single* activity devoted to research, development and production of detection, navigation, communications and fire control equipments.

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SALES & MARKETING MEN

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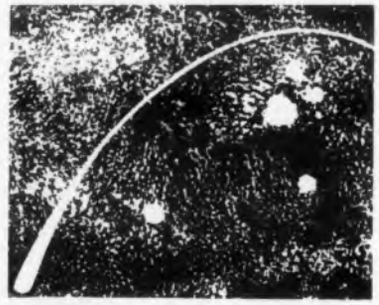

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CIRCLE 905 ON CAREER INQUIRY FORM

CIRCLE 906 ON CAREER INQUIRY FORM ➤

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RCA and SPACE

WEST COAST

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Today he stands squarely on its threshold—eagerness tempered only by ponderous unknowns. Science will probe for the answers and fail, then probe some more—attacking again, again and again. Slowly but surely, question by question, the answers will flow—building man's knowledge and strength. *Man will conquer this new world*, but it will prove his most difficult task.

It will take engineers with rare vision and courage—men who will not accept failure—men of force and determination. This is RCA's brand of engineer.

RCA is preparing now to play a part in this all-out assault with a new, modern electronic center in the San Fernando Valley. There RCA West Coast engineers work on such programs as missile checkout and launch control systems — guidance control — electronic countermeasures — and other high priority projects.

Would you like to be one of this dynamic engineering group? Would you like to grow tall with RCA on the West Coast? If so, let us hear from you very soon.

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CIRCLE 907 ON CAREER INQUIRY FORM

CAREER OPPORTUNITIES BROCHURES

Corning Glass Works

"Opportunities in Glass" is a 28-page guide to the entire operation of the Corning Glass Works. It presents the facts needed to consider a career in glass development and manufacturing. Charts show that careers range from geology to electrical engineering.

A folder supplied with the brochure lists 143 jobs available to college graduates with backgrounds in 23 major areas of study.

Manager of College and Technical Employment, Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 870 ON READER-SERVICE CARD

Systems

An interesting 32-page booklet describing the various systems produced by the Arma Div. of American Bosch Arma Corp. has just been released. It is a useful guide to the whole company. Facts on management, engineering, analysis, manufacturing and product quality are clearly arranged for quick reference, and informations useful to those interested in systems careers are given. Two-color illustrations appear throughout the booklet.

American Bosch Arma Corp., 320 Fulton Ave., Hempstead, N.Y.

CIRCLE 871 ON READER-SERVICE CARD

CIRCLE 908 ON CAREER INQUIRY FORM ➤

Extending existing modulation systems to make more space available in the spectrum, and possibly even broadening the useful spectrum . . . this is a fundamental problem in modern communications. It is the problem to which ITT Laboratories is devoting intensive effort.

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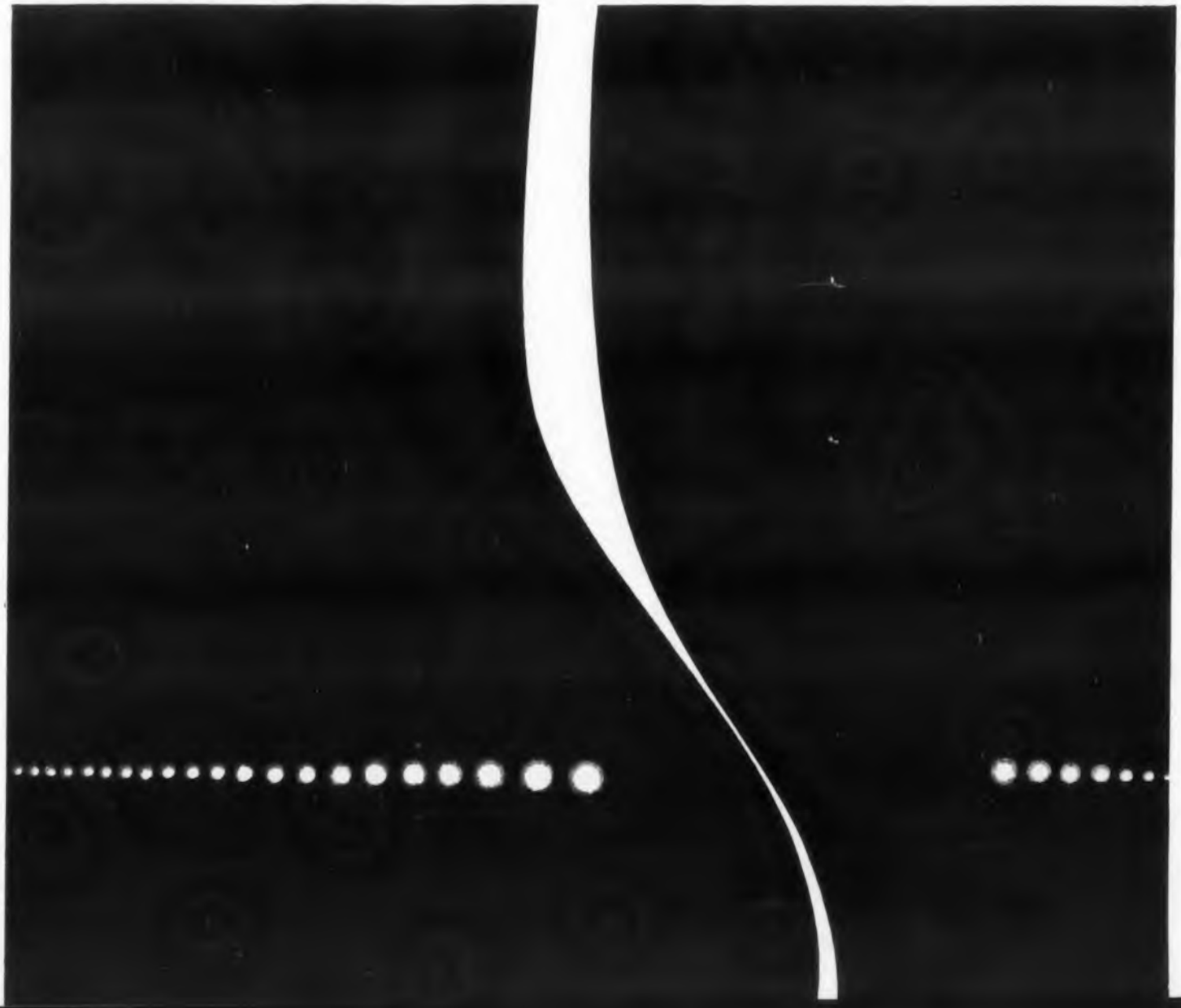

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A feeling of accomplishment, comfortable salary, security, fine home, prestige in the community. Yes, these are the marks of a successful Motorola engineer in Chicagoland. But, what exactly makes a career at Motorola so rewarding—beyond the ordinary realm of material benefits?

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CIRCLE 910 ON CAREER INQUIRY FORM

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Department: Editorial Department

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Qualifications needed by applicant:

Education: EE degree or equivalent educational background

Experience: One or two years as components engineer and/or work in Engineering Standards Department. Some experience in writing evaluation reports.

Date position open: NOW

Salary to be paid: $6,000 to $8,000 depending on qualifications of applicant.

Approved Edward E. Grazda, Editor-in-Chief ELECTRONIC DESIGN

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CIRCLE 911 ON CAREER INQUIRY FORM

ADVERTISERS' INDEX

April 13, 1960

Approximately actual size

This 3 lbs. of transistorized new AC amplifier gives you 20 or 40 db gain, increases scope or VTVM sensitivity 10 or 100!

This new hp 466A AC Amplifier is just 4" high, 6" wide and 6" deep. Yet it can become one of the most helpful instruments on your bench, or in the field. It is ac or battery powered; battery operation gives you hum-free performance and easy portability. Response is flat within approximately ½ db over the broad range of 10 cps to 1 MC, distortion is less than 1%, and gain is stabilized by substantial negative feedback to virtually eliminate effects of transistor characteristics and environment.

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Specifications

Gain:	20 and 40 db, ±0.2 db at 1000 cps.	**Output Impedance:**	Approximately 50 ohms.
Frequency Response:	±0.5 db 10 cps to 1 MC.	**Distortion:**	Less than 1%, 10 to 100,000 cps.
Output Voltage:	1.5 v rms across 1500 ohms.	**Power:**	12 radio type mercury cells; battery life about 160 hours; or ac line power.
Noise:	75 μv rms referred to input, 100,000 ohm source.	**Dimensions:**	6¼" wide, 4" high, 6¼" deep. Weight: approx. 3 lbs.
Input Impedance:	1 megohm shunted by 25 μμf.	**Price:**	$150.00 f.o.b. factory.

Data subject to change without notice.

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