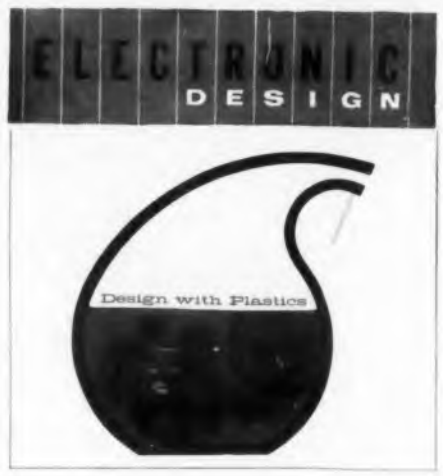
ELECTRONIC DESIGN

Design with Plastics

HIGHLIGHTS OF ISSUE



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Number

18

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NBP BPA

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ENGINEERING REVIEW

For more information on developments, described in "Engineering Review," write to the address given in the individual item.

Omnipresent Horizon

Hazards of flying through fog will be minimized by a pilot display projector developed by Autonetics, Downey, Calif. With this device, simulated images of the horizon, the outline of obstacles, and the earth below are projected in a luminous pattern and in proper perspective in the pilot's forward view. The system uses a contact analog generator which interprets information received from gyroscopes and other flight control instruments. This information is presented as a pattern on the face of a cathode ray tube and directed toward a reflector in front of the pilot.

Device May Ease Air Traffic Control

Control of air traffic may be made simpler by a new device which automatically identifies flying aircraft by number or letter.

Known as a Visual Decoder, the device eliminates errors in radar "blip" identification of aircraft in a crowded airport traffic pattern. The unit, which uses a high-speed switching tube and a "Nixie" numerical indicator tube, works in conjunction with conventional radar. Employing a full 360 deg, search and recognition radar systems establish contact with all aircraft within range and altitude of the systems.

Search radar pulses are displayed on a Plan Position Indicator (PPI) scope. The recognition radar interrogates aircraft radar beacons. Triggered by the interrogation signal, the beacon automatically transmits a binary-coded pulse train which has been pre-assigned to the aircraft. Received by the recognition radar, the pulse train is routed to the decoder.

To enable the controller to accept one binary-coded pulse train while rejecting all others, an electronic-eye is placed against the face of the

(Continued on page 6)

Visual Decoder is expected to ease handling of air traffic flow.

ENGINEERING REVIEW

PPI scope over the target "blip." This opens the circuit to the decoder. An aircraft is thereby singled out by the controller, fed to the decoder, and displayed on the "Nixie."

The beam switching tube that unscrambles the transponder signal into proper sequence for the "Nixie" operates within 1 μsec. Capable of operating at ten positions, the vacuum tube can be switched from one position to another in 1 μsec. The "Nixie" lights up to within 20 to 50 μsec.

Developed at the Burroughs Corp., Electronic Tube Div., Plainfield, N.J., the device is currently undergoing final testing at Wright Air Development Center. It has been found suitable by the Air Force and the CAA.

We Were Carried Away . . .

We were so intrigued by the possibilities offered by magnetic latching relays when we wrote about one in our June 25th issue, that we forgot to note that others have been intrigued by these devices, too.

Sigma Instruments, Inc., 91 Pearl St., So. Braintree, Mass., has been making them for some years now. Sigma makes models to handle load currents from 1.5 to 20 amperes. They are available with SPDT, DPDT, and 4PDT contact arrangements, and feature sensitivities to 0.3 mw.

Polaris Checkout

Test missile in Polaris development program undergoes system checkout at Lockheed's Sunnyvale, Calif. plant. This small-but-rugged unit will fit in the missile to transmit vital data on the test flight to ground receivers. After checkout, missile will be shipped to the Lockheed-operated Polaris test facility at the Air Force Missile Test Center, Cape Canaveral, Fla. This is the first released photograph of any hardware in the development program of the Navy's 1500-mile-range ballistic missile.

Operator checks transistor waveforms on television screen as part of production line inspection.

Traveling Wave Scope Solves Inspection Problem

The EG&G Traveling Wave Oscilloscope (Edgerton, Germeschausen & Grier, Inc., Boston, Mass.) an old friend to research teams for its accurate display of transient and repetitive waveforms in the μsec region, has found a new application. Lansdale Tube Co., Lansdale, Pa., is manufacturing a new ultra-high speed switching transistor (type 2N501) with rise times on the order of ten μsec and switching potentials of about 10 v. In the usual solid deflection plate type of cathode-ray tubes a 10 v potential is too low to deflect the beam without first amplifying the signal, and the long rise time of available amplifiers precludes their use with ultrahigh speed switching devices.

The EG&G TW Scope is capable of producing full scale deflection with a 10 v input, and its rise time of 0.1 μsec ensures that the observed rise times originate in the transistors and not in the test instrument itself.

Lansdale developed a closed circuit TV system to display the transistor waveforms on a 17-in. television screen. The transistors were connected to the TW Scope's deflection system. Mounted over the oscilloscope's screen was the EG&G type 710 camera which has a 5X magnifying glass for visual observation of the screen. The TV camera was focused on the screen through this magnifying glass, and the transistor waveforms were displayed on the TV Monitor.

Transistor Chart Correction

Our 1958 listing did not include many Texas Instruments Inc. and General Electric Co. types that originally appeared in our 1957 chart.

A complete listing of the missing transistors along with their characteristics will appear in the October 1st issue.

ENGINEERING REVIEW

In the Light of Hot Air

Here a powerful stream of dissociated, ultra-hot air is discharged as a plasma stream from largest plasma-jet generator in the U.S. Able to produce temperatures over twice the surface temperature of the sun, this three-phase ac arc will allow testing of comparatively large space flight models while simulating the heat and chemistry of atmospheric re-entry. The large, air-stabilized arc, enclosed by a chamber 18 in. through and three feet high has been run at the rate of 15000 kw. The plasma jet generator is part of the General Electric family of Space Technology tools.

Mobile Flight Operations Center Aids Army Tactical Aircraft

Army aircraft traffic in any combat area will be controlled by a highly mobile Flight Operations Center. The flight control system, developed by the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey, is mounted in military vans and trailers. It is for tactical use in battle zones.

FOCs differ from familiar air control towers since they are designed to regulate Army aircraft enroute between points, rather than at landing and takeoff. In its primary role as a service to aviators, the FOC clears a pilot's flight plan before takeoff and then provides him with in-flight assistance from origin to destination.

Nucleus of the control caravan is a 30-foot operations van. Other vehicle units include a radio equipment shelter and two trailer-mounted

CIRCLE 524 ON READER-SERVICE CARD ➤

GENERAL ELECTRIC

TUBE DESIGN NEWS

FROM THE RECEIVING TUBE DEPARTMENT OF GENERAL ELECTRIC COMPANY

Deadly Hughes GAR-2A Falcon Missile Employs Six G-E 5-Star Subminiatures in Vital Control Sockets!

General Electric 5-Star high-reliability subminiature tubes help give dependable striking power to Hughes Aircraft Company's GAR-2A air-to-air missile, which seeks out its target by means of infra-red guidance.

Six 5-Star subminiatures are employed: Types 5899, 5902, 6021, 6111, 6112, and 6205. The Hughes Type GAR-2A missile complements the GAR-1D Falcon, which relies on radar guidance. Eight 5-Star subminiatures are used in the GAR-1D.

Tubes and other electronic components in Falcon missiles are compactly mounted on plug-in etched circuit boards. Miniaturization has been carried to a point roughly equivalent to compressing two television sets into a space no larger than a football.

Cold, Heat, Acceleration, Vibration—All Are Environmental Hazards

The tiny 5-Star Tubes that guide Falcons to their explosive destinations, must withstand the extreme cold of high altitudes, the heat of skin friction, the acceleration and vibration of launching and flight.

Dependable service under these conditions calls for special rugged qualities which General Electric has designed into all 5-Star subminiatures. These tubes, moreover, are built with extra care in a lint-free, dust-free factory, and undergo 100% tests that accurately reflect airborne and missile operating requirements.

On the next page will be found suggestions on how to conserve tube life and obtain top performance, when applying high-reliability tubes in compact circuits where temperatures may run high, as with missiles.

7077 UHF Triode Tests Prove Tube's Versatility, Show Low Noise Figure at 30–60 MC

Recent tests have confirmed that General Electric's new 7077 ceramic UHF-amplifier triode has an extremely low noise figure in the 30–60 megacycle region, and is well suited to IF-amplifier applications.

For receivers operating at microwave frequencies, 30–60 megacycles is an area of prime importance in the IF-amplifier circuit. Minimum noise here is essential, if the full potentialities of a low-noise microwave crystal mixer are to be realized.

Low shot-noise resistance and negligible transit-time loading help make Type 7077 an ideal choice for the cascode input stage of an IF-amplifier circuit. Besides the tube's electrical advantages, its physical features—small size, ruggedness, and high heat resistance—add to the 7077's value in military applications.

Complete data on IF-amplifier tests of the 7077 at varying band widths, may be obtained from any G-E office listed on the next page. Also, ask for information about sockets for the tube, already developed and available, and for noise, gain, and other performance characteristics at frequencies from 30 to 1000 megacycles.

Tear off and keep this sheet for reference. It contains useful tube-application data.

FOR MAXIMUM TUBE LIFE, AVOID HIGHER-THAN-RATED TEMPERATURES!

Promote Dependable Performance by Keeping Bulb Temperatures And Dissipation Levels within Published Tube Limits!

Sharp penalties in shortened life can result from tube operation which is in excess of rated limits for bulb temperature and dissipation. See life-test curves at right for evidence that high temperatures and high dissipation levels cut the number of operative tubes—the percentages dropping rapidly as heat and dissipation go up.

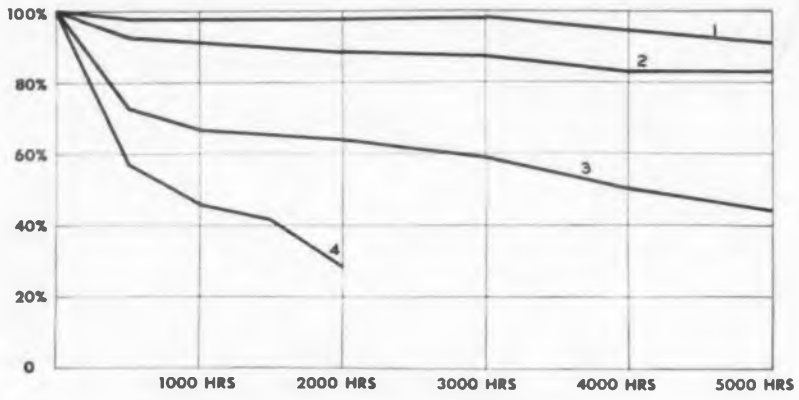
Excessive temperatures in tubes can cause reverse grid currents, loss of emission, shorted elements, glass-envelope failures, and other faults.

Ambient Heat Level, Internal Element Dissipation, Both Influence Tube Temperature

How hot a tube will run, is a joint result of the ambient temperature and the dissipation of the internal elements of the tube. Designers can reduce bulb temperatures mechanically, by using improved tube shields which permit the heat to flow by conduction to a heat sink—have good radiation efficiency—and allow free air circulation.

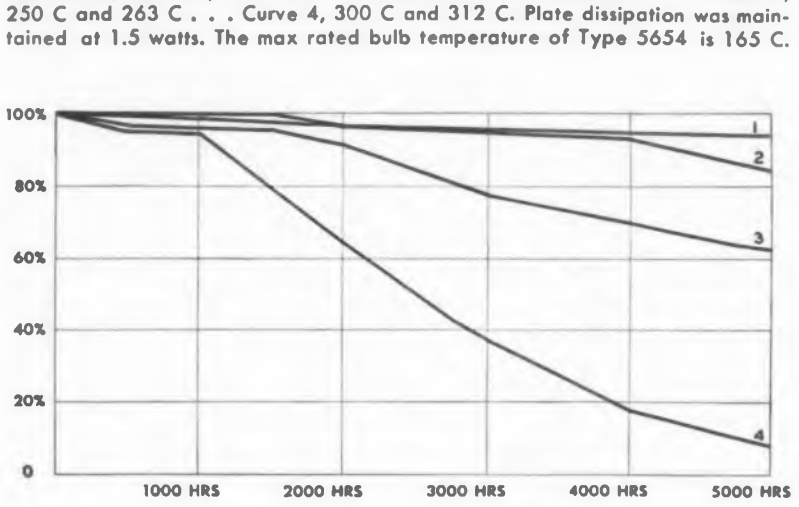
Normally, however, tube shields do not significantly lower the temperature of the internal tube elements. Here the circuit designer's control must be electrical—i.e., he should strive to avoid dissipation levels in excess of rated limits.

Observing these limits will increase tube reliability and greatly extend the span of tube life. More specific and detailed facts about tube operating temperatures can be obtained from any General Electric office at the bottom of this page.



TYPE 5654 HIGH-RELIABILITY MINIATURE

Life test results at varying temperatures. (Vertical scale shows percentage operative* tubes remaining. Horizontal scale, time.) Ambient temp for Curve 1 was 100 C, bulb temp was 125 C . . . Curve 2, 175 C and 192 C . . . Curve 3, 250 C and 263 C . . . Curve 4, 300 C and 312 C. Plate dissipation was maintained at 1.5 watts. The max rated bulb temperature of Type 5654 is 165 C.



TYPE 6005 HIGH-RELIABILITY MINIATURE

Life test results at varying dissipation levels. (Vertical scale shows percentage operative* tubes remaining. Horizontal scale, time.) Dissipation level, $P_p + P_c 2$, for Curve 1 was 10.0 w. . . . Curve 2, 13.5 w. . . . Curve 3, 15.4 w. . . . Curve 4, 20.0 w. Bulb temperature was allowed to increase with dissipation. The max rated dissipation of Type 6005 is 13.2 w.

**By "operative tubes remaining" is meant tubes without any short, open, air leak, or heater-cathode leakage in excess of 100 microamperes.*

Tubes for the above tests were taken in lots of 200 or more from the production of all manufacturers with qualification approval. Accordingly, results are a composite for the industry.

For further information, phone nearest office of the G-E Receiving Tube Department below:

EASTERN REGION
200 Main Avenue, Clifton, New Jersey
Phones: (Clifton) GRegory 3-6387
(N.Y.C.) WIsconsin 7-4065, 6, 7, 8

CENTRAL REGION
3800 North Milwaukee Avenue
Chicago 41, Illinois
Phone: SPring 7-1600

WESTERN REGION
11840 West Olympic Boulevard
Los Angeles 64, California
Phones: GRanite 9-7765; BRadshaw 2-8566

Progress Is Our Most Important Product

GENERAL ELECTRIC

12-11-205

Mobile van, with a 10-foot communications and flight-charting console, keeps the tangles out of the complex moving web of fixed-wing aircraft and helicopters.

Diesel generators to permit uninterrupted operation while one is serviced or repaired.

Four radio sets are used, including FM, vhf and uhf for ground-to-air contact. Two teletypewriters are set in an equipment compartment separated from the control room of the van.

The van is supplied with heat and air conditioning so effective that men and equipment can function efficiently at 60 below zero in arctic weather or 140 above in the desert.

A Beaming Test

Navigational antennas are now being checked out and aligned with a new test station consisting of receiving and transmitting unit developed by Raytheon Manufacturing Co., Waltham, Mass. Telescopes attached to the test unit make it possible to position the antenna beam at an exact angle and to take extremely fine optical measurements within 0.0001 in. Transmitter and receiver are housed in two separate buildings 100 feet apart to meet test specifications of system. Transmitter house, shown above, is designed to hold a mock-up of installation for which the antenna assemblies are intended. Environmental test conditions subject antennas to extremes of heat and cold while beam alignment measurements are being taken.

CIRCLE 524 ON READER-SERVICE CARD

ENGINEERING REVIEW

Analyzer Tells Chemical Composition in Minutes

Within a few minutes chemical analysis of products to a degree of accuracy that could previously only be obtained in a matter of hours, is possible with an electronic analyzer.

The Argon Irrigation Detector, made by W. G. Pye and Co., Cambridge, England, records the chemical composition of complex mixtures and indicates the quality of each component of the mixture. It requires a very small sample of the material for testing.

Designed for use in the chemical and oil industries, the device is also expected to be of considerable value to the pharmaceutical and perfume industries, and in the atomic energy field.

TV-Type Camera May Disclose Unseen Details of Planets

Previously unseen details of the planets and distant nebulae may be determined with an advanced type of camera tube known as the Intensifier Orthicon. The new device developed at RCA's David Sarnoff Research Center, Princeton, N. J., will also permit visual reconnaissance in almost complete darkness. The new Intensifier Orthicon is reportably 100 times more sensitive than the fastest known photographic film for the same exposure time at extremely low levels of light. Operating on principles employed in the Image Orthicon used in present television pickup functions, it can view surroundings which appear completely dark to the human eye, achieving a sensitivity "which approaches the fundamental limit set by photon statistics." Its value in astronomy as a viewing system coupled with a telescope to overcome the effects of the earth's atmospheric turbulence in viewing planets and nebulae was emphasized. At present

◀ CIRCLE 7 ON READER-SERVICE CARD

disturbances in our atmosphere obscure many details during the exposure time required for even the fastest film. As a result, it has been impossible for astronomers to resolve clearly the surface features of Mars and other planets, or the structure of many nebulae and star clusters. By cutting down substantially the exposure time, it should be possible to reduce correspondingly the effects of atmospheric turbulence.

Largest Waveguide Rotary Joint Delivered To Air Force

Largest waveguide rotary joint ever made has been delivered to the Air Force. The aluminum joint, six ft high and four ft in diam. will transmit 80 megawatts in the uhf range. Built by ITE Circuit Breaker Co., Philadelphia, Pa., the rotating joint will sweep at rates up to 40 rpm. The VSWR of the rotary joint is 1.2 over the 10 per cent bandwidth. Variation with rotation of equipment is 0.4 db through 360 deg.

The complete unit is constructed so that the rotary joint has, as an integral part of the system, its own support casting and bearing. The support casting and the 4-point contact bearing-gear make the wave guide rotary joint self-supporting and usable in any orientation. It was built for installation in a prototype warning system.

Closed Circuit TV To Aid English Advertising

Planning, engineering and installation of the most comprehensive system of closed-circuit television and telecine of its type in England and possibly the world, have been entrusted to Marconi's Wireless Telegraph Co. Ltd. Forty-three offices, including 3 conference rooms, will be wired to use the facilities provided.

Enlightened Alignment

Two electronic gaging and testing machines, one for each set of head lamps, insure proper dual headlight system installation at Oldsmobile Division of General Motors Corp. Beams from the head lamps pass through the 18 in. lens to a series of hermetically sealed photocells which transmit readings to the four large dials at the top of the instrument. These dials indicate any error in direction or power of each of the four head lamps. After necessary adjustments are made, a built-in searching circuit rechecks accuracy. If accuracy does not fall within specified limits, colored soap is automatically sprayed on the windshield. This action indicates that the lights must be readjusted. The machines were developed by Performance Measurements Co., Detroit, Mich.

High Speed Teletype Revealed by Army

Messages at the rate of 750 words a minute are being printed by a new message printer and code puncher, the first in a new family of superspeed combat teletypewriter units.

The new device, reportedly the world's fastest, was developed for the U. S. Army Signal Research and Development Lab., Fort Monmouth, N.J., by Kleinschmidt Laboratories, Inc., a subsidiary of Smith-Corona. The device has no ordinary typing keys. Instead, a whirling wheel rimmed with letters prints the high-speed messages. It spins at 3,750 rpm. At the precise instant the correct letter comes into position, a tiny hammer strikes the paper against the type wheel.

Messages are types out on 7/8 in. paper tape. At the same time coded holes are punched out. Tape rate is more than seven and one-half inches per second. These tape messages can be relayed rapidly to other points or they can be printed on the spot in page form by automatic typewriters. The printer mounts on a jeep or

Dow Corning Silicone Dielectrics

Trop-Arctic temperature-test chamber

SILICONE-GLASS LAMINATES SURVIVE DEEP FREEZE, OVEN HEAT

Virtually unaffected by temperatures as high as 250 C, silicone-glass laminates are ideal insulating and structural materials. They are lightweight, strong, moisture and arc resistant . . . have low loss factor, low moisture absorption. Can be drilled, machined, sanded, sawed. Supplied in various finished shapes by leading laminators.

Circle 530 on Reader Service Card

West Coast Electrical Manufacturing Corporation solenoid

SYLKYD ENAMELED WIRE AIDS MINIATURIZATION

Heat-stable Sylkyd® enameled magnet wire makes it possible to design smaller and more reliable electronic equipment. Equal in diameter to Class A wire, Sylkyd enameled wire is suitable for use in 180 C insulation systems; resists moisture, corona, most chemicals; has good shelf life and handling properties. Write for new illustrated brochure.

Circle 531 on Reader Service Card

SILICONE VARNISH GIVES LONG LIFE IN HIGH AMBIENTS

Impregnated with Dow Corning Silicone Varnish, the insulating components of miniature coils, servos, motors, transformers and other assemblies are bonded into moisture resistant insulation systems having high dielectric strength. Combined with other silicone components, silicone varnishes assure maximum reliability, permit operating temperatures up to 250 C . . . aid miniaturization . . . increase life while protecting against many chemicals, corrosive atmospheres, other environments.

Circle 532 on Reader Service Card

American Machine and Manufacturing Co. miniature coils

For further information on these products, write Dept. 169

Super-speed printing reperforator which prints out messages at 750 words per minute will play a part in tomorrow's tactical communication system.

truck teamed to a mobile forward area communications center. The printer-puncher could also be used to feed battle information into a new mobile combat computer now under development.

In future commercial use, the device could speed the transmission of telegrams, stock market quotations, and weather reports. It is also seen to have applications in the field of integrated data processing.

Space Filler

Although Lear, Inc., Grand Rapids, has been awarded a Wright Air Development Center contract for the development of a crew capsule for a space vehicle, preliminary studies would have to determine design, mission, and capabilities of the entire ship and some characteristics of the space station. Wheel-shaped station would be placed in orbit at an altitude of about 22,000 miles above the equator. Station, artist's model shown here, would accommodate space ships in its mooring nests.

MEETINGS

Sept. 12: Regional Technical Conference, Society of Plastics Engineers

St. Clair Inn, St. Clair, Mich. Sponsored by Detroit Section of SPE. Arrangements have been made for papers on injection molding, compression molding, thermoforming, reinforced plastics, automotive lighting, and vacuum metalizing. For information write J. D. Young, E. I. du Pont de Nemours & Co., 13119 W. Seven Mile Rd., Detroit 35, Mich.

Sept. 12-14: 7th Annual High Fidelity Show

Palmer House, Chicago, Ill. Write to International Sight and Sound Exposition, Inc., 1 N. La Salle St., Chicago 2, Ill., for further details.

Sept. 15-19: 13th Annual Instrument-Automation Conference and Exhibit

Philadelphia Convention Hall, Philadelphia, Pa. Sponsored by ISA. Two technical sessions on the use of instruments in the nuclear field will highlight the 5-day conference. Ask Fred J. Tabery, Conference and Exhibit Manager, 3443 S. Hill St., Los Angeles, Calif., for further information.

Sept. 22-24: National Symposium on Telemetering

Americana Hotel, Miami Beach, Fla. Sponsored by PGTRC of IRE. Ken West, 1345 Indian River Dr., Eau Gallie, Fla., has additional information about the symposium.

Sept. 24-25: 7th Annual Symposium on Industrial Electronics

Rackham Memorial Auditorium, Detroit, Mich. Sponsored by PGIE and AIEE. Address queries to William R. Thurston, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Sept. 29-Oct. 3: ASTE Semi-Annual Meeting and Western Tool Show

Shine Exposition Hall, Los Angeles, Calif. Sponsored by American Society of Tool Engineers. Theme will be "Tooling for the Space Age." For more information write ASTE, 10700 Puritan Ave., Detroit, Mich.

Sept. 29-Oct. 3: Audio Engineering Society Trade Exhibit

Hotel New Yorker, New York, N.Y. Sponsored

by the Society at its tenth Annual Convention. New devices and methods for the use of professional sound equipment under proper conditions for engineering appraisal. For more information get in touch with Sumner Hall, Amityville, N.Y.

Oct. 1-2: 2nd Annual Symposium on Engineering Writing and Speech

New York City. Sponsored by the IRE, PGEW.

Oct. 8-10: Canadian IRE 1958 Convention and Exposition

Toronto, Ont. Twenty-five sessions covering medical electronics and education, cosmic rays and microwave systems. Exhibits featuring nucleonic and electronic projects, products, and components will be displayed.

Oct. 13-15: National Electronics Conference

Hotel Sherman, Chicago, Ill. Tentative program includes sessions on transistors, servomechanisms, antennas, audio, filter design, solid state, microwaves, instrumentation, network theory, engineering writing and speech, computers, radar and radio navigation, magnetic amplifiers, engineering management, industrial electronics, television and communications. More information can be obtained from National Electronics Conference, Inc., 84 East Randolph St., Chicago 1, Ill.

Oct. 16-18: 5th Annual Meeting Institute of Management Sciences

Sheraton Hotel, Philadelphia, Pa. Technical and semi-technical sessions on the subject: Modern Tools for Today's Executives. Fields covered will include: programming, automata theory, systems engineering, communications, and networks. Contact Kurt Hesdoerffer, TIMS, 250 North Street, White Plains, N.Y.

Oct. 20-21: 4th National Aero-Com Symposium

Hotel Utica, Utica, N.Y. Sponsored by the IRE Professional Group on Communications Systems. It will stress the requirements, progress and challenge of communications in all its phases.

Oct. 20-22: URSI Fall Meeting

Pennsylvania State University, University Park, Pa. Co-sponsors are IRE professional groups on information theory and antennas and propagation. Write U.S.A. National Committee, URSI, 2101 Constitution Ave., N. W., Washington 25, D.C., for more information.

MEETINGS

Oct. 22-24: Fifth National Symposium on Vacuum Technology

Sir Francis Drake Hotel, San Francisco, Calif. Sponsored by American Vacuum Society. For more information write American Vacuum Society, Box 1282, Boston, Mass.

Oct. 22-25: National Society of Professional Engineers Fall Meeting

St. Francis Hotel, San Francisco, Calif. Sessions will be devoted to hearing committee reports on such issues as the effect of the accelerated activity in space travel on the future of the engineering profession; effective utilization of present engineering manpower; encouraging capable high school students to consider careers in engineering; and the role of the Federal government in engineering education. J. A. Sontheimer, Secretary, California Society of Professional Engineers, c/o St. Francis Hotel, San Francisco, Calif., has more information.

Oct. 27-28: East Coast Conference on Aeronautical and Navigational Electronics

Lord Baltimore Hotel, Baltimore, Md. Sponsored by IRE Professional Group on Aeronautical and Navigational Electronics and the Baltimore Section. Technical papers to be presented will concern such things as new techniques in air navigation, news systems for air traffic control and radar. There will also be exhibits of navigational systems and test equipment and components. For additional information contact Harry S. Rutstein, Publicity Chairman, Eastern Associates, Inc., Baltimore, Md.

Nov. 17-21: 8th National Plastics Exposition

International Amphitheatre, Chicago, Ill. To be held concurrently with the API Annual Conference at the Hotel Morrison. Sponsored by the Society of the Plastics Industry, Inc. Theme to be stressed: Plastics for Profits. Will cover new plastics materials, methods, machines, and techniques.

Dec. 2-4: 3rd EIA Conference on Reliable Electrical Connections

Dallas, Tex. For information, write W. O. Richards, 224 Cedar St., Syracuse 3, N.Y.

EDITORIAL

If You Use It, Use It Right

Objective of our feature report in this issue is to convince electronics designers that plastics can make life easier for them in many ways. But it won't be easier unless they learn to use these materials intelligently.

Plastics has earned, in some quarters, a very poor reputation—based on its misapplication in the hands of uninformed designers. For example, one of the first replies to our survey questionnaire said, "Plastics—that's the thermally unstable, deformable stuff that scratches easily, isn't it?"

This electronics engineer had probably tried to wash a plastic spoon in hot water and watched it curl up. Or he noticed how fast a decorative plastic piece on his TV set or auto radio turned yellow and cracked with age. Or became annoyed when a plastic knob or pushbutton loosened and fell off a piece of equipment in the lab.

Plastics engineers say that this doesn't have to happen. Now how do you avoid this trouble? First, early in the design stage, decide which parts you'd like made of plastic.

Then, before you walk into the Model Shop and pick a piece of plastic out of the scrap bin to have machined, call in a good plastics molder or manufacturer for consultation. He appreciates being called in early enough to do you some good. And you get the benefit of his early guidance.

At that time, you pick the electrical and mechanical characteristics. Your consultant will pick a material that will do the job without costing you a fortune. He'll also show you how to specify holes, grooves, etc. so the piece can be made in the first place.

Result—a perfectly satisfactory application of plastics. Another result—add one word to the title of our staff report. It now reads, "Using Plastics in Electronics—Intelligently."

James D. Shelpi

USING PLASTICS IN ELECTRONICS

Plastics, if properly applied, offer the electronics designer many money-saving advantages. But the emphasis is on "proper application." And the greatest obstacle the designer faces in this respect is learning how to apply literally hundreds of types of plastics. Many handbooks, including the monumental *Modern Plastics Encyclopedia* are available for detailed information. But the electronics designer, usually lacking basic plastics knowledge, throws up his hands when first meeting the vast chemical complex called "Plastics." In this Staff Report, we have highlighted the materials most commonly used today. Our exclusive ELECTRONIC DESIGN "Simplified Plastics Reference Chart" for electronic designers gives important characteristics of these materials. Applications for most of these materials are shown in the accompanying report. After making an initial choice, the designer may then consult plastics handbooks or preferably a good plastics molder or plastics manufacturer's literature for more details. Molders and manufacturers may even advise of a new and exotic formulation about to be announced. It may be worthy of consideration for your application. Because the subject of potting is a special and very important application of plastics, it will be covered by itself in a future issue of ELECTRONIC DESIGN.

Laurence D. Shergalis
Associate Editor

PLASTICS MATERIALS fall into two categories: thermosetting and thermoplastic. Thermosetting plastics are those that, once formed, will not soften or change shape upon application of heat. Thermoplastic materials can be softened at elevated temperatures and will become deformed.

Thermosetting Plastics

Probably the most common electronics application today for thermosetting materials is in the fabrication of laminates for printed-wiring boards. Laminates are made up of layers of resin-impregnated paper, cloth, glass fiber or other material, formed under high pressure and high heat. Each combination has its unique characteristics and special applications. Other thermosetting plastics include:

- Phenolics
- Ureas
- Melamines
- Epoxies
- Alkyds
- Polyesters
- Silicones
- Diallyl Phthalates

Phenolics are excellent electrical insulators and are extremely chemically resistant. Common uses include radio tube bases and switch parts.

Urea and melamine have extremely high electrical resistance and high heat resistance. Melamine is the material found in the latest tableware. Electronics applications include cases and cabinets. Urea is also commonly used as radio cabinet material, knobs and handles.

Epoxies are available as molding compounds, resins, foamed blocks, adhesives and coating. Most common uses of epoxies are in potting and laminating.

Excellent dielectric strength is the most important feature of alkyd molding materials. Applications include television tuners, motor insulators, cases, and switch parts.

Polyester resins can be reinforced with glass fibers resulting in light weight, high strength, and excellent weather resistant qualities. They have good dielectric qualities and can be made in a range of colors varying from opaque to transparent.

Silicone insulation is highly stable up to about 600 F depending upon its filler material. They have good dielectric properties including a low power factor over a wide frequency range. They have their greatest application as insulators.

Recent Development

Diallyl Phthalate (DAP) is a fairly new material which exhibits excellent dielectric strength, good heat resistance, and excellent dimensional stability. They have very low moisture absorbing characteristics. DAP compound can be molded around metal without cracking. Various fillers including glass-fibers, Orlon, and Dacron may be used to adjust its properties to meet particular requirements. Dielectric strength of glass-fiber DAP is superior to Orlon which in turn is superior to Dacron filler material. However, the strength of Dacron-filled DAP is superior to the other two.

These materials may be molded—with suitable filler material to give them strength.
Common fillers include:

- Wood Flour
- Mica
- Asbestos
- Glass fiber
- Orlon
- Dacron
- Nylon
- Conductive compounds

Wood flour is the most common and least expensive filler, but it merely adds body to the resin. Conductive compounds may be used as fillers to produce an electrically-conducting plastic part. Characteristics imparted to plastics by the other fillers may be found in plastics reference material.

Thermoplastic Materials

Among the common thermoplastic materials are:

- Styrenes
- Polyethylenes
- Fluorocarbons
- Polypropylene
- Vinyls
- Acrylics
- Cellulosics
- Nylon

Styrene, or Polyethylene, is very tough and has high heat resistance. Dielectric properties are good and water absorbtion is low. Common applications include portable radio cabinets and instrument panels.

Recommended for outdoor use, polyethylene can withstand temperatures down to −100 F without becoming brittle. It has excellent electrical resistance. Applications include chemically resistant containers including the familiar "squeeze bottle", and protective covers.

Among the fluorocarbons are Teflon, and Kel-F. Both noted for their excellent electrical qualities. Fluorocarbons are extremely hard with high impact strength. They have zero water absorption and are stable over a wide temperature range.

New Promising Plastic

Excellent resistance to heat is the most outstanding property of polypropylene. Polypropylene parts will not deform at temperatures up to about 300 F. Being a very new material, polypropylene has not yet been thoroughly tested in a wide variety of applications. It shows promise however, for applications which can take advantage of its hard surface, and low coefficient of friction and light weight.

Vinyls are commonly found as wire and cable insulators, electrical connector material, and phonograph records. It has extremely good abrasion resistance and very low rate of water absorbtion. Vinyls are not generally recommended for outdoor use.

Where exceptional transparency is desired acrylics are excellent. They find applications in protective windows, and edge-lighted dials. Acrylics have the ability to pipe light. They also are excellent insulators.

Cellulosic parts do not break under normally rough use. They have good electrical properties and are used as a medium-voltage insulator. Telephone sets and some transistor radio cabinets are made of cellulosic compounds.

Nylon for Mechanical Parts

Nylon's hard, glossy surface resists abrasion. Its low coefficient of friction permits its use as gears and cams. It also finds some application as low capacity bearings.

Foamed plastics are one of the special variations of plastics material. They are used mainly in packaging applications where shock resistance is necessary and in microwave applications. Their light weight and exceptional dielectric properties make them suitable for microwave applications.

Potting materials are important to electronic designers. Because the subject of potting is very broad, material on potting is not included in this staff report. However, a special series on the subject will appear in a future issue of ELECTRONIC DESIGN.

For a reprint of this Staff Report, turn to the Reader-Service card and circle **101.**

Thermosetting Materials

Materials	Dielectric Constant @ 10^6 cps	Vol. Res. (50% rh, 23C) Ohm-cm	Moisture Resistance	Practical Temperature Limit F	Resistance to Weathering	Dimensional Stability	Machining Characteristics	Typical Applications	Remarks
Alkyds	2.8-6.0	1.0^{14}	Good	325	Good	Excellent	Good	Connectors, tube sockets, mountings, cases, high-voltage equipment, tough surface coatings	Good chemical resistance and arc resistance. Good mechanical strength
Allylics	3.6-4.5	Greater Than 4×10^{14}	Excellent	212 +	Excellent	Excellent	Good	Knobs, connectors, handles	Attacked by oxidizing acids. Can be colored
Epoxies	0.03-0.05	10^{17}	Excellent	600 +	Excellent	Excellent	Good	Switches, insulators, corrosion resistant joints, potting, surface coatings	Good flexibility. Available in a variety of forms
Melamines[1]	6.9-7.2	7.0×10^{11}	Excellent	400	Excellent	Good	Good	Connectors, circuit breakers, ignition parts	Almost unbreakable, scratch and and heat resistant
Phenolics[2]	4.5-6.5	7.0×10^{12}	Fair	450	Good	Excellent	Poor	Depends upon filler used. Dials, tube sockets, knobs, speaker diaphragms	Can be made to resist high impact. Poor heat conductors. Available in a wide variety of forms
Polyesters	2.8-5.5	10^{14}	Good	300	Good	Fair	Good	Radomes, battery cases, chemical containers	Huge class of materials. Used as reinforced plastics for structural applications. Excellent surface hardness
Silicones[3]	3.5-4.6	10^7-10^{13}	Excellent	590[4]	Good	Excellent	Fair	Wire and cable insulation, coil forms	High heat stability, excellent insulator
Urea	6.4-7.0	10^{12}	Good	250	Excellent	Excellent	Fair	Radio cabinets, pushbuttons, baked enamel coatings	Very hard, scratch resistant. Unaffected by carbon tetronchloride and gasoline

1, 2, 3. Glass-fiber filled only as a typical example. Other fillers offer similar characteristics.

4. Depends on filler used.

Thermoplastic Materials

Materials	Dielectric Constant @10^6 cps	Vol. Res. (50% rh, 23C) Ohm-cm	Moisture Resistance	Practical Temperature Limit F	Resistance to Weathering	Dimensional Stability[3]	Machining Characteristics	Typical Applications	Remarks
Acrylics	2.3-3.0	10^{15}	Excellent	196	Excellent	Good	Fair	Transparent covers, lenses, edge-lighted dials, nameplates.	Exceptional optical clarity. Used for decorative purposes also.
Cellulosics[1]	2.8-6.4	10^{10}-10^{14}	Fair	110-220	Fair-Poor	Good	Good	Telephone sets, radio cases, insulator parts	Retain lustrous finish under rough usage
Fluorocarbons	2.1	10^{19}	Excellent	500	Excellent	Good	Good	High voltage insulation, microwave insulation	Stable over wide temperature ranges
Nylon	3.5	10^9-10^{13}	Good	400	Fair	Good	Excellent	Mechanical parts in electronics assemblies, such as light bearings, gears, cams	Resilient, can be colored
Polyethylene	2.3	10^{15}	Excellent	250	Good	Good	Good	Protective covers, chemical containers	Available as rod, tube, filament or sheet
Polypropalene	2.1	8×10^{15}	Excellent	280	Good	Fair	Excellent	Lightweight cabinets, high frequency structural material	Very low density material makes it applicable to li... weight uses
Styrene	2.4-3.8	10^{12}-10^{17}	Fair	200	Poor	Fair	Good	Battery cases, portable radio cases, instrument panels	Not recommended for uses where subject to severe impact or bending[4]. Avoid abrasives
Vinyl[2]	3.5-4.5	10^6	Good	175	Poor	Poor	Excellent	Wire and cable insulation, protection coverings	Wide range of materials. High resistance to acids

1. Covers ranges of five common types: cellulose acetate, cellulose acetate butyrate, cellulose propionate, ethyl cellulose, cellulose nitrate.
2. Polyvinyl chloride used as a typical example. Many other forms are available.
3. Dimensional stability of all thermoplastic materials is considerably less than that of the thermosetting.
4. Except when glass fiber reinforced.

Simplified Plastics Reference Chart

Because of the many varieties of some of these materials, a listing including all would defeat the usefulness of an easy-to-read chart. Therefore, the sixteen plastics chosen represent basic materials. In two instances, as noted, a particular formulation was chosen to represent the entire family.

Laminates, including vulcanized fiber are important plastics materials. Because a very recent comprehensive listing of these materials appears in the June 11, 1958 issue of ELECTRONIC DESIGN, page 36, they are not listed.

Applications include those generally found in the electronics industry. The designer should explore further applications based upon the characteristics of the materials.

Because of the large number of companies in plastics, and the even greater number of materials, it was impossible to compile a complete trade name list within space limits of this chart.

The Editors of ELECTRONIC DESIGN wish to thank John L. Hull, Hull-Standard Corp,. Hatboro, Pa., for his assistance in organizing this staff report. In addition, the following companies also supplied information useful in preparing these articles:

Aacon Industries Inc.
Acme Resin Corp., Polyfluoron Div.
Adams Fiberglass Co.
Aircraft Armaments Inc.
Alpha Wire Corp.
American Cyanamid Co.
American Machine & Foundry Co.
American Petrochemical Corp., Mel-Rez Div.
Assembly Products Inc.
Autonetics, Div., North American Aviation, Inc.
Bakelite Co., Div. of Union Carbide & Carbon Corp.
Barden Corp.
Beckman Instruments Inc., Scientific Instruments Div.
Bendix Aviation Corp., Pacific Div.
Boeing Airplane Co.
David Bogen Co.
Budscraft Inc.
Burndy Corp.
Cleveland Cap Screw Co.
Collins Radio Co.
Continental-Diamond Fibre Corp., Sub. Budd Co.
Dictaphone Corp.
E. I. duPont de Nemours & Co., Inc.
Duramic Products Inc.
Dynamics Research Corp.
Electric Storage Battery Co., Exide Industrial Div.
Electronic Plastics Corp.
Electro Engineering Works
Electro Products Lab.
Electrovert Inc.
Emerson & Cuming Inc.
Farley & Loetscher Mfg. Co.
Flurocarbon Products Inc., Div. U.S. Gasket Co.
General Electric Co.
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Grace & Co., W. R.
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Hercules Power Co.
Hi-Temp Wires Inc.
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Kennedy & Co., D. S.
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Rubber & Asbestos Corp.
Sanders Associates
Sandia Corp.
Scientific Atlanta Inc.
Shure Bros. Inc.
Swenson Co., Inc., V. H.
Sylvania Electric Prod. Inc.
Synthane Corp.
Technicraft Co.
Tensolite Insulated Wire Co.
Tri-Point Plastics Inc.
Varian Associates
Zippertubing Co.

Some Trade Names and Manufacturers

Plaskon: Barrett Div., Allied,
Dyal: Sherwin-Williams

Dapon: FMC Organic Chem., Div., **Durez:** Hooker, **Di-All:** Mesa Plastics

Epon: Shell, **Epiphen:** Borden, **Araldite:** Ciba, **Epi-Rez:** Jones-Dabney, **Bakelite:** Div., Union Carbide

Cymel: American Cyanamid, **Fiberite:** Fiberite, **Plaskon:** Barrett Div., Allied, **Catalin:** Catalin, **Diaron:** Reichhold, **Permalite:** Melamine Plastics

Alycylite: Loven, **Arochem:** Archer-Daniels-Midland, **Bakelite:** Union Carbide, **GE Phenolic:** General Electric, **Resinox:** Monsanto

Hetron: Hooker, **Atlac:** Atlas, **GE Polyester:** General Electric, **Glipol:** Glidden, **Marco:** Celanese Corp.

Bakelite Div.: Union Carbide, **Dow Corning:** Dow Corning, **GE Silicones:** General Electric, **Novabestos, Pyrotex:** Raybestos-Manhattan, Inc.

Beetle: American Cyanamid, **Rhonite:** Rohm & Haas, **Sylplast:** Sylvan Plastics

Some Trade Names and Manufacturers

Lucite: Dupont, **Paulite:** Luminous Resins, **Plexiglas:** Rohm & Haas, **Pulyco:** Borden

Hercocel: Hercules, **Ethocel:** Dow, **Pyralin:** Dupont, **Tenite Butyrate:** Tennessee Eastman

Bakelite Fluorothene: Union Carbide, **Exon 461:** Firestone, **Kel-F:** Minnesota Mining, **Teflon:** Dupont

BCI Nylon: Bolding Cartelli, **Catalin Nylon:** Catalin, **Fosta Nylon:** Foster Grant, **Spencer:** Spencer Chemical, **Zytel:** Dupont

Alathon, Rulon: Dupont, **Bakelite:** Union Carbide, **Dylan:** Koppers, **Grex:** W. R. Grace

Moplen: Montecatini

Ampacet: American Molding, **Bakelite:** Union Carbide, **Cycolac:** Borg-Warner, **Kralastic:** U.S. Rubber, **Plio-Tuf:** Goodyear

Blacar: Cary Chemical, **Crestfoam:** Crest, **Diamond PVC:** Diamond Alkali, **Geon:** B. F. Goodrich, **Marvinol:** Naugatuck

Design with Plastics

Plastics For The Electronics Industry

Ralph L. Mondano

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Basic economics have forced industry and government to unite in many joint study programs to find suitable materials to meet environmental conditions such as temperature, speed, shock, radiation, etc. The electronics industry is one such industry, and its material problems are many. This article concentrates on plastics in the electronics industry.

PLASTICS materials used by the electronics industry are divided into two basic categories, those primarily concerned with electrical properties and those primarily concerned with structural properties. On several occasions it is necessary to design plastic components to meet both rigid electrical and structural specifications. Where this occurs, an optimum point in design is selected. Then the overall general project is reevaluated as to feasibility and the general specifications usually relaxed to the limitations of presently available plastics.

1. Thermosetting Resins

Phenolics

Such common phenolic items as tube bases, radio cabinets and resistor and capacitor jackets are well-known in the electronics industry and need no introduction. Phenolics have serious limitations as concerns electrical loss and insulation as compared to some of the newer materials available today.

Polyesters

One of the first applications of polyesters was in combination with glass fabrics to make laminated radomes. This was a very significant contribution. Our air-borne radar systems were trying to use laminated plywood radomes and the transmission problems were severe. The polyesters have good electrical properties. They have low loss, acceptable dielectric constants and have a temperature range of operation from —55 to 400 F. By compromising on mechanical properties, triallyl cyanurate cross-linked polyesters are available and are capable of operation up to 500 F.

Serious delamination problems have been en-

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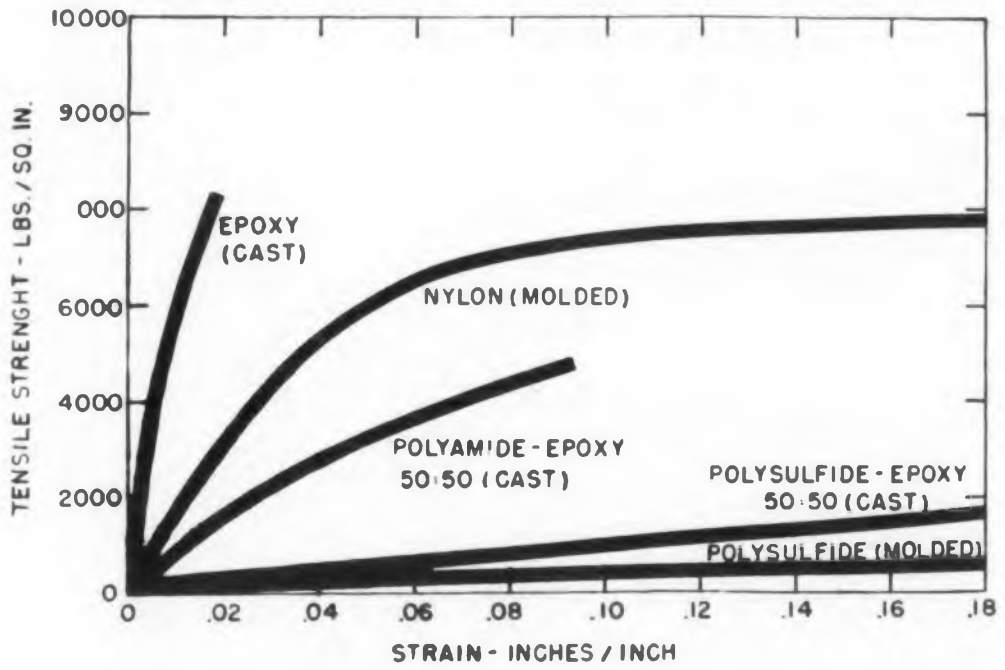

Fig. 1. Typical tensile stress-strain curves for epoxy cast resins, alloyed epoxies, molded nylon and polysulfide.

countered in the use of TAC (triallyl cyanurate) resins in laminates. For the most part, in the electronics industry, polyesters are reinforced with glass fibers or fabrics. The glass constituent does not appreciably affect the overall electrical loss.

Polyesters are presently replacing the wax that has been used in transformers in the past. Military system reliability is mainly responsible for accelerating the use of these resins in many radar and missile electronic component applications.

Manufacturers of polyesters such as Pittsburgh Plate Glass, Rohm and Haas, H. H. Robertson, and Celanese Corp., have advanced the technology of these resins to give the engineer good handling control and a fair degree of reproducibility. Manufacturers are in a position to supply two basic resins—flexible and rigid. A combination of these can give any degree of hardness between "rubbery" and "peanut-brittle" hardness.

An unlimited number of fillers has been tried with polyester resins in attempts to improve physical properties such as lowering the shrinkage, lowering the coefficient of thermal expansion, improving the impact resistance, raising the heat distortion point, improving the dielectric strength properties, and, at the same time, reducing costs. Some successful fillers have been mica for good electrical insulation; glass fibers and talc to improve mechanical strength; ceramic for lowering the coefficient of thermal expansion and increasing the dielectric constant.

Polymerized Styrene Monomers

Polymerized styrene monomer or polystyrene is one of the lowest electrical loss plastics available to the electronics industry. Its biggest drawback is its low heat distortion point. But a cross-linked polymer with an added degree of heat resistance has been developed.

Operating temperatures of approximately 225 F are permissible as compared to 190 F for some of the best non-cross-linked injection molding polystyrene. Finished parts must be machined from rods and sheets, as casting techniques similar to those utilized for polyesters are not practical. It is difficult to obtain a finished casting.

Epoxies

The arrival of epoxies on the scene was most timely. Studies conducted by the electronic engineers on reliability and reproducibility of electronic components displayed quite clearly that the high shrinkages of the polyester resins and poor adhesion were creating serious limitations. At first, attempts were made to fill these resins with inert fillers. The filled polyester resins created several problems as concerns reproducibility.

Epoxy resins gave immediate promise of assisting in these areas. They inherently have low volumetric shrinkages on the order of 1 to 2 per cent, unfilled, and excellent adhesive properties to most surfaces. The shrinkages and adhesion have been proven reasonably reproducible. Their electrical loss is slightly higher than that of the polyesters, but for potting, encapsulation, and impregnating of components, they have proven satisfactory with minor exceptions. This resin can be poured, puddled, and shaped to desired configurations and hardened to a structural material with a minimum of physical distortion. Epoxy resins are the only known material that can be used to accomplish the above tasks.

Thermosetting Epoxy Alloys

The epoxy resins are presently being alloyed with polyamides, polysulfides, polyurethanes, and glycols. The term "alloying" is used in the same sense that metals are alloyed. This alloying provides resins with very excellent mechanical properties and, in most cases, less desirable electrical properties. For example, Fig. 1 shows the range of mechanical properties that can be obtained. Unfortunately, not all properties can be obtained from one magic alloy.

To obtain resistance to high temperature, say, continuous operation at 400 F, the alloy would ideally have to be a very tight molecular structure which would not make it suitable for application where mechanical shock was involved. If the alloy were designed for mechanical shock, it would not be able to operate at high temperatures. The area under the stress-strain diagram is an indication of the toughness of an engineering material.

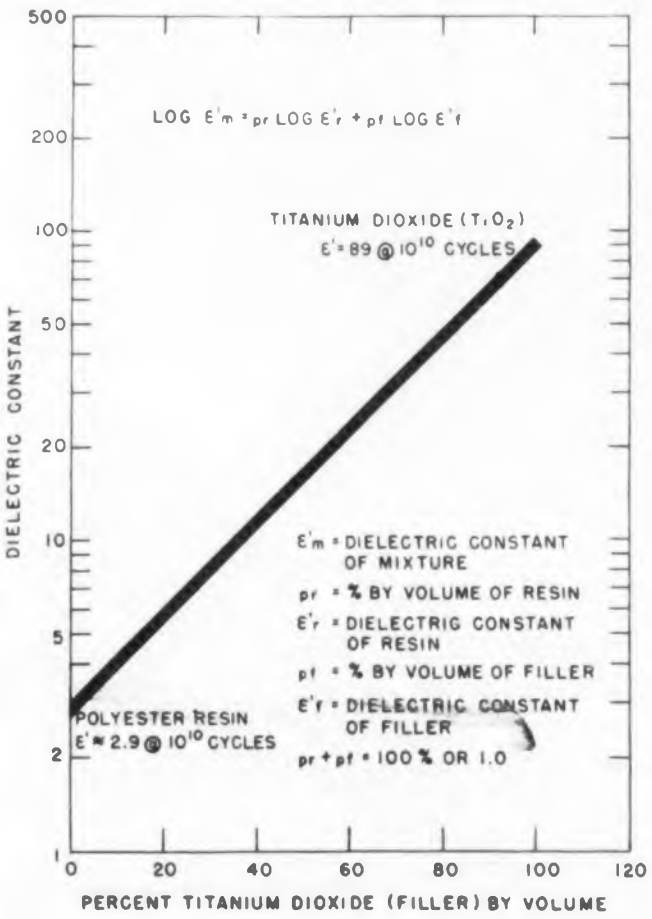

Fig. 2. Variation of dielectric constant for various amounts of titanium dioxide filler.

Fig. 1 makes evident the very significant differences in toughness of different resins cited. The resins are unreinforced, and alloys composed of these resins have a small range of ultimate strength properties. As an example, the ultimate strength in tension at standard atmospheric conditions varies from approximately 3000 to 7000 psi. These resins have found use in all types of potting and encapsulating. The degree of alloying is a function of the electrical and mechanical design requirements.

Polyamide-Epoxy Alloys

Polyamides add toughness and good adhesion to the basic resin. The polyamides are hydroscopic in nature. This moisture absorbing effect can cause a change in the electrical and mechanical properties over a period of time. It could result in a serious reliability problem in any finished electronic component design for the military.

Polysulfide-Epoxy Alloys

Polysulfides can provide an epoxy compound with a great degree of flexibility (Fig. 1), but the resulting compounds have poor dielectric strength properties. With the addition of large percentages of polysulfide to an epoxy resin, the resulting dielectric strength of the epoxy alloy can be as much as 50 per cent less than the dielectric strength of the unmodified epoxy resin.

There is no straight-line relationship between the thickness of an insulation material and its dielectric strength. Thin plastic films carefully prepared have displayed dielectric strengths as high as 1000 v per mil. This is by far the exception and close design values should be set approximately 25 per cent below the average of a reasonably larger number of samples of any one material in the range of thicknesses being considered. This is a good engineering approach, but has limitations as concerns economics.

Artificial Dielectrics

Both epoxies and the polyester resins can be combined with certain fillers of high dielectric constant such as titanium dioxide to obtain higher dielectric constants. An example of its use is a radome. The desirable dielectric values of radomes are dependent upon the frequencies utilized and the system requirements. At higher frequencies, dielectric constants of radome walls of a value equalling approximately 6 have been

Plastics in the Electronics Industry (cont.)

found desirable. To obtain these dielectrics, relationships (Fig. 2) have been worked out and found to be correct within tolerances of ±0.1 of the dielectric constant. Similar relationships can be set up for any number of resins and fillers. Dielectric constants have been obtained from 2.8 to approximately 20 with loss tangents as low as 0.010 at frequencies of 10^{10} cps. For the most part, in radome design the resins used with the ceramic powders have been polyesters because of their low electrical loss.

Coefficient of Expansion

Mechanical measurements made on ceramic and resin combinations display interesting phenomena concerning expansion properties. Ceramic powders such as lithium alumino silicate combined with epoxy resins in a 50-50 ratio by weight provide a coefficient of thermal expansion equalling that of aluminum (Fig. 3). This is a good design point when considering casting resins in or around aluminum sections. Larger percentages of lithium alumino silicate added to epoxy resins can give the finished casting a lower coefficient of thermal expansion.

This, theoretically, is the result of a volume shrinkage in the lithium alumino silicate based on a crystal structure change with increasing temperature. The electronics industry has utilized this particular physical phenomenon in designing high tolerance air gaps between rotors and stators impregnated and encapsulated with thermosetting resins. A typical example is the miniaturized gyro.

Electrical Loads

Another application and use of the thermosetting resins in combination with fillers is the electrical load or rf absorbing plastic material. Combinations of iron powder and thermosetting resins have produced excellent attenuating properties. One of the most important features of an rf load is that it have a low standing wave ratio. In the design of dummy load materials, other factors such as maximum absorption per unit volume, adequate power handling capacity, adequate heat resistance, low moisture absorption, suitable physical strength, and reasonable ease of fabrication are important.

These materials have found use as absorbing barriers or shields to prevent resonances, substitute as an antenna to prevent radiation during tests and adjustments, as directional couplers and many other applications.

Silicone Resins

Silicone resins have until recently been supplied only in a solvent system. High pressure techniques were utilized for molding, mainly to obtain silicone-glass laminates. At present, there are glass-filled silicone molding resins and 100 per cent solids casting and low-pressure laminating resins. The electronics industry has taken advantage of the high temperature and good electrical properties of silicone resins, typical examples of which are the high temperature insulation in motors and transformers.

One of the greatest attributes of the silicone resins is their non-carbon-tracking property. If any arcs or flashovers occur, a carbon track is not left on the silicone laminate. The major drawbacks of silicone resins are their brittleness and poor adhesion.

2. Elastomers

Polyurethanes

Some thermosetting resins are referred to as elastomers because of their elastomeric appearance and behavior. Adiprene L (duPont), a 100 per cent solids liquid polyurethane resin, falls into this category. It is a very tough resin with good electrical properties. It has a heat resistance of approximately 300 F, low compression set, good adhesive properties and high dielectric strength. The electronics industry is presently experimenting with high voltage connectors made from this resin.

Silicone Rubbers

Silicone rubber has found wide use in the electronics industry for shock mounting of electrical components. It has proved successful in ranges of −90 to 500 F. One of its drawbacks is its poor mechanical properties such as poor tensile strength and tear resistance. Until recently, silicone rubber compounds failed completely in the presence of hydraulic oils. Compounds are now available that provide acceptable resistance to environments of hydraulic oils.

Silicone rubbers are supplied in many forms. They can be put into solution in a solvent and brushed on, or they can be transfer molded. They have good dielectric strength properties.

Polysulfides

Polysulfide resin is a synthetic rubber with very good adhesive properties. Where the dielectric strength requirements are not too rigid, it has found excellent use as a potting and encapsulating media. Good adhesion results in the fact that moisture or other undesirable foreign matter cannot creep in along the interface of the resin and bonding surface. As a result of this good adhesion, all types of connectors are being successfully molded with polysulfide by the use of an air pressure injection gun. Basic polysulfides are available from the Thiokol Corp.

There are at present so many compounds on the market that physical data can be found indicating temperature ranges anywhere from −65 to 400 F for indefinite periods of time. The user is cautioned to evaluate any application approaching the above referred to extremes.

3. Foamed Plastics

Hycar

One of the first electrical grades of foamed resin was "Hycar." It is supplied in hard, expanded board form and has low dielectric loss

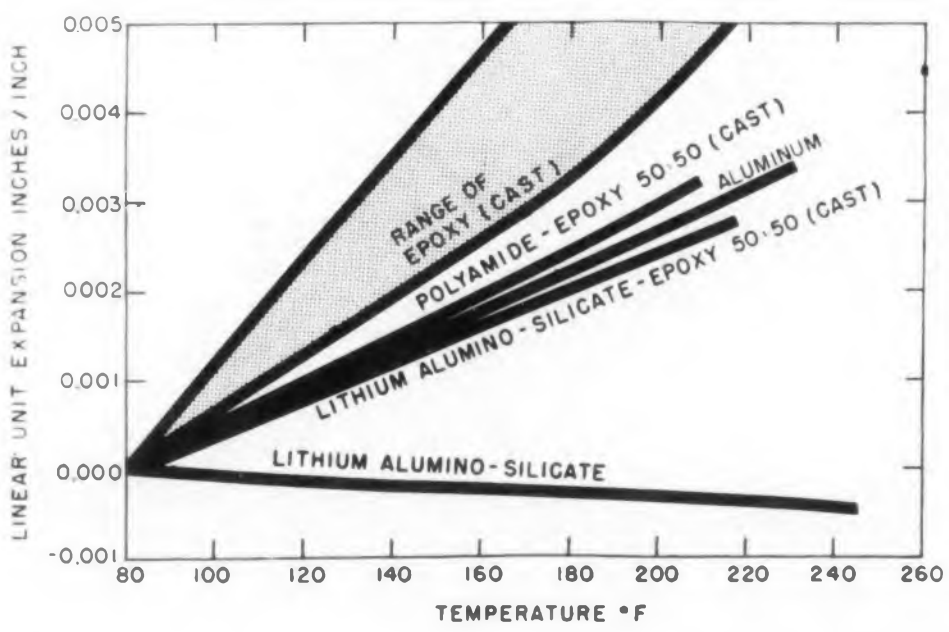

Fig. 3. Coefficient of thermal expansion of unfilled epoxy, epoxy alloy, filler, and filled epoxy.

(0.003) and dielectric constant of 1.2 as measured at X band. Its major drawbacks are that it must be machined to shape and that it has a low operating temperature (175 F).

Isocyanate Foams

The classification includes the presently available polyurethane and polyether type foams. Polyurethane foam has good electrical properties and a temperature operating limit of approximately 300 F. Rigid and flexible type foams are available. They are very easily handled and require a minimum of equipment for most operations.

Electronic engineers held high hopes for this type foam in the early stages of its development. Foamed-in-place radomes and electronic component packaging were evaluated. The cost of the radomes was high and the high temperature operating range unsuitable for high speed aircraft and missiles. Its major drawbacks in electronic packaging have been its poor heat conductivity and moisture absorption.

Polyethers are available in the flexible variety. They have a lower operating temperature limit; however, they offer promise in the shock mounting of electrical components because of their low temperature flexibility and their exceptional ease of handling. Both of these foams can be processed to obtain a wide range of densities.

Foamed Silicone Resins

Several different types of foamed silicones are available, and there are a variety of rigid silicone foamed resins which are still in an experimental stage. Various techniques are being evaluated as concerns foaming and matalyzing mechanisms. Not too many applications have been made in the electronics industry because of the processing requirements of the foamed components, in order to realize the full electrical and high heat resistant properties. The high temperature cure required to obtain optimum properties of the silicone materials precludes its use in many electronic applications. These materials have good thermal insulation properties.

Foams evaluated as substitute medias for air where high power transmission in wave guides is required have proven unsuccessful. The silicone foams do not have the exceptionally low loss that one would expect in view of the basically low electrical loss of the basic resin.

Foamed Silicone Rubber

Foamed silicone rubber is known for its wide temperature range and shock mount properties. It has poor tensile strength and tear resistance. The most recent development in this field is a foamed-in-place type which expands at room

temperature. The user is cautioned to the fact that these foams are not basically unicellular and consequently when exposed to moisture, will exhibit low dielectric strength. Molding techniques that result in the formation of a skinned surface provide a greater degree of protection against moisture entrapment in the open cells of the foam.

Epoxy Foams

Epoxy resins ar foamed by utilizing gas-liberating additives to the basic epoxies. It is a mechanical process. Foams produced to date are rigid, diffcult to reproduce, and possess electrical properties less desirable than the isocyanate foams. By comparison, the polyurethane foams are more desirable.

Polystyrene Foams

Expanded polystyrene foam is well known in the electronics industry. The earlier foams were derived from the reaction of methyl chloride and polystyrene. This foam has excellent electrical properties, i.e., it more closely resembles dry air as concerns dielectric strength, electrical loss and dielectrical constant, than any other known dielectric material. Its major drawbacks are low heat resistance (150 F) and poor solvent resistance.

The more recent expandable styrene beads can produce foamed-in-place shapes as compared to the earlier variety which is available in bulk form. Processing techniques recommended utilize high pressure steam to expand the styrene beads. This has resulted in an undesirable situation from an electronics standpoint.

Cellular Cellulose Acetate

Cellular cellulose acetate has good heat resistance, good mechanical properties, and good electrical properties. Cellular cellulose acetate foams have proved moisture-absorbent, thereby limiting their use in many electrical applications where moisture is a problem. Cellular cellulose acetate cannot be used as a foamed-in-place resin. The foam boards are available in densities ranging from 4 to 8 lb per cu ft.

Foamed Phenolics and P.V.C.

Foamed phenolics and P.V.C. are available but are undesirable for electrical applications.

Foams—General

Glass beads, phenolic spheres, ceramic spheres, and styrene beads have been used in combination with casting resins and foams to obtain low density foam-like structures. Advantages have been decreased weight, lowered dielectric constants, and higher heat resistant values except in the styrene bead type.

Adhesives

The choice of an adhesive for electrical application can offer a challenge. Almost all of the thermosetting resins have been used in various combinations to obtain suitable adhesives. When very thin adhesive films are used, on the order of 0.0015 to 0.003 in., problems centered around dielectric constant and electrical loss are not serious. Adhesive layers used as electrical insulation should be chosen very carefully. The best adhesives electrically would be styrene-based but they would have poor adhesion and low heat resistance. Where high heat resistance and good adhesion are required, a mica-filled epoxy adhesive should be used. It is important to remember that the basic electrical properties of the resin carry through into the properties of the adhesive.

4. Thermoplastic Resins

Fluorocarbons

The arrival of the fluorocarbons was hailed by the electronics industry. They gave immediate promise because of their good electrical properties and high temperature performance. Problems such as cold flow, corona, fabrication, and cost have forced the electronics industry in time to look every other way first before settling for these compounds. Parts machined from compression molded rods and discs have exhibited good mechanical properties. But with minor exceptions, these materials do not lend themselves to mass production techniques.

Surface etches presently available for fluorocarbons have solved the problem of bonding fluorocarbons to itself and other materials. The treating process is dangerous.

In general, the remainder of the thermoplastics, with the exception of polystyrene, receive the same general scrutiny as concerns their application in any field, such as automobiles and appliances. If they can meet the physical requirements such as strength and wearability and are more economical, they are utilized. Some examples are knobs using cellulose acetate butyrate, and radio cabinets utilizing rubber phenolics and injection molding compounds such as styrene-butadiene acrylonitrile copolymers.

New thermoplastic polymers such as acetal resins (duPont), polycarbonate resin (General Electric), methylstyrene copolymers, and the new polyolefins are being evaluated for electrical applications. Most of these new materials have higher heat resistant properties than the presently available thermoplastic materials other than the fluorocarbons. They can be molded as the normal thermoplastic materials.

Silicone Insulation Adds Reliability

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and
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Dow Corning Corporation
Midland, Mich.

One of the most important considerations, when designing components and assemblies for the wide range of service conditions demanded of today's electronic systems, is materials selection. Components and materials that retain their initial characteristics over wide ranges in temperature and other environmental conditions are necessary to assure system reliability. Silicones, discussed in this article, fulfill many of these requirements.

SILICONE dielectric materials, because of their unique properties, are used to improve reliability of electronic components and assemblies where:

- temperatures up to 250 C are continuously encountered;
- transient temperatures up to 400 or 500 C are encountered;
- temperatures down to —70 C are encountered;
- size and weight must be reduced;
- dielectric losses at frequencies from dc to 1.0 kmcs must be reduced;
- components and assemblies must be protected from moisture;
- components and assemblies must be protected from environmental materials;
- corona is encountered;
- nuclear radiation is encountered.

Although the general chemical structure of silicones is related to that of quartz, silicone insulating materials are available in a wide variety of physical forms including fluids, grease-like compounds, elastomers, greases, and resins. These dielectric materials are sometimes reinforced with inorganic materials such as glass fibers and cloth, mica splittings, and asbestos to improve their physical characteristics. Because of their unique combination of properties, silicone materials often provide the most economical solution to design and application problems.

Good Dielectric Properties

Dielectric properties of most silicones are comparable with those of the best insulating materials available. The dielectric constant is usually between 2.6 and 3.3 and the dissipation factor of silicone elastomers and resins is usually less than 0.005 at all frequencies from 10 cps to 1000 megacycles. Dissipation factor of silicone fluids is even less (Fig. 1). The volume resistivity of silicones is normally between 10^{13} and 10^{15} ohm-cm. These dielectric properties are usually

ABOUT THE AUTHORS

As Supervisor of the Electrical Laboratory, Product Engineering Laboratories at Dow Corning Corp., Donald F. Christensen (top) is responsible for the direction of tests to evaluate dielectric materials. Continuing this interest he is a member of ASTM committee D 9 and Chairman of its section of "Thermal Stability of Varnished Fabrics." He is also a member of AIEE. Mr. Christensen was graduated from the University of Michigan with a BS degree in electrical engineering.

Cedric G. Currin (bottom) is a Project Leader in the Electrical Laboratory, Product Engineering Laboratories and is responsible for evaluating the dielectric properties of silicone insulating materials. He is a member of the AIEE and of the ASTM, and has presented papers to both societies. Mr. Currin was graduated from Iowa State College and has an MS degree in electrical engineering. He has an avid interest in electronics.

Fig. 1. High dissipation ratings are obtained by filling transistors with electrical grade silicone compounds.

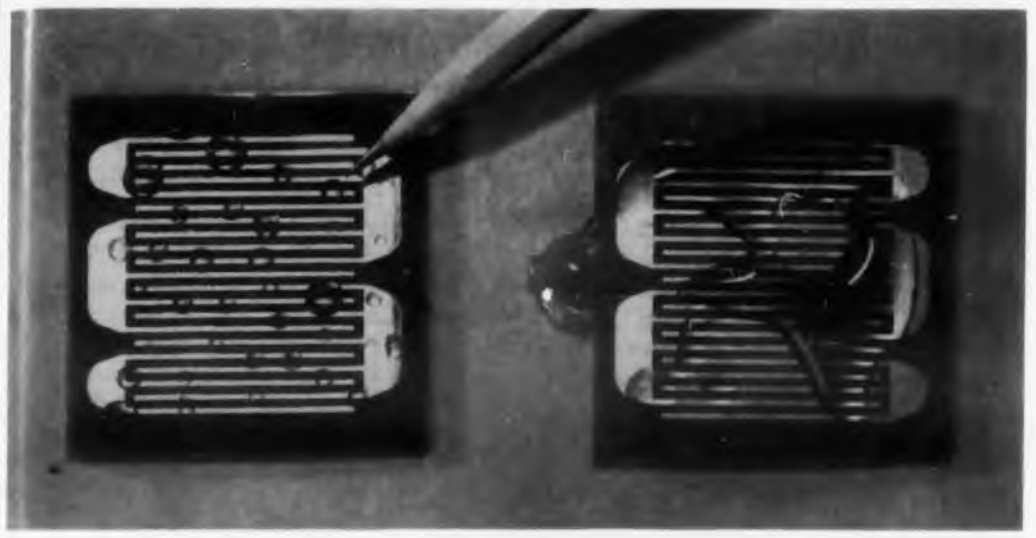

Fig. 2. Water repellency is imparted to printed-wiring boards by spray application of modified silicone resin.

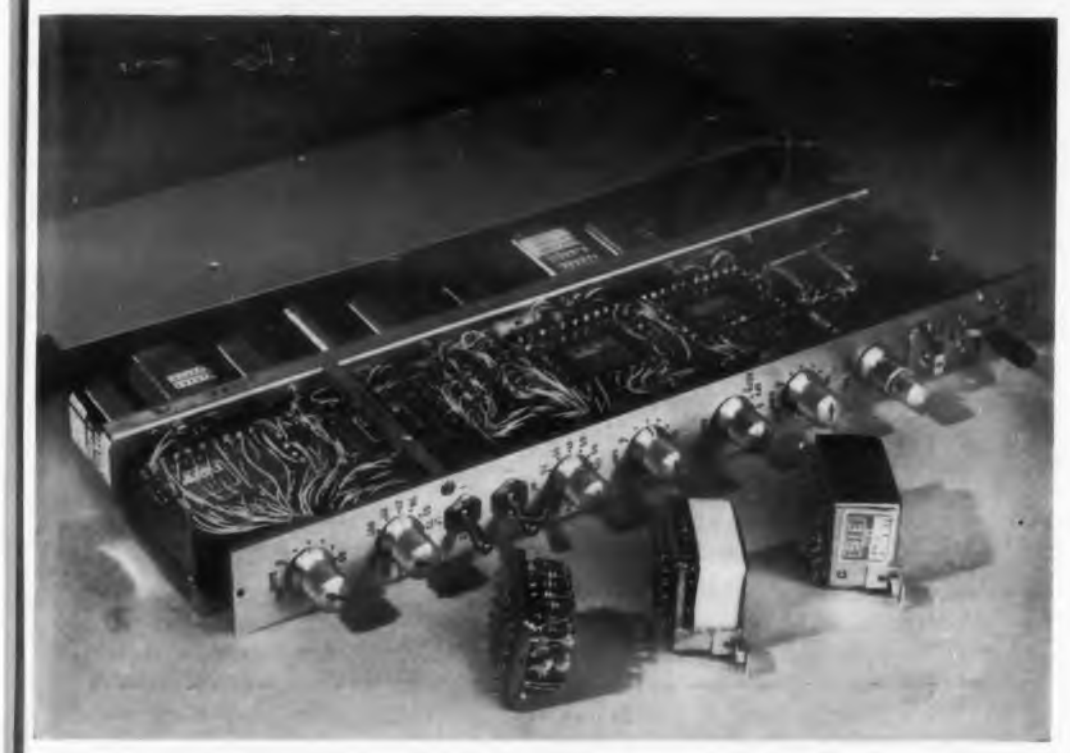

Fig. 3. Protection of electronic subassemblies from shock and extreme moisture is assured by potting with room temperature vulcanizing silicone rubber.

Fig. 4. Klystrons operate better at high altitudes when equipped with Silastic insulated high voltage terminals and leads.

little affected by temperatures over the range from —55 C to 200 C.

While higher temperatures affect some dielectric properties, the properties at temperatures above 200 C are superior to those of almost all synthetic insulating materials. This permits short time operation at temperatures up to 400 C and even higher.

Thermally Stable

As insulating materials, silicones are well known for thermal stability and moisture resistance (Fig. 2). These materials may be used continuously at temperatures from below —55 C to above 200 C. Silicones also have markedly superior resistance to effects of corona and many are resistant to various types of nuclear radiation.

Not only are there analogous silicones for most previously mentioned types of insulation, but there are silicones in forms which are new to the insulation field. One such type which has found wide acceptance in the electronic industry is Silastic RTV (Figs. 3 and 4), a room temperature vulcanizing silicone rubber. These elastomers are available as thick liquids which are easily catalyzed prior to usage. The liquid is applied as a coating, encapsulant, or sealant, simply by dipping, spreading with a spatula, or by using a caulking gun. Then, after a few hours at room temperature, the liquid turns into an elastomeric solid suitable for operation over wide ranges of environmental conditions.

Most electronic applications of silicones take advantage of two major characteristics of these insulating materials:

1. Ability to withstand repeated exposures to extreme temperatures and moisture conditions;
2. Excellent dielectric properties.

For example, Boeing Airplane Co. has reported excellent results with a solventless silicone resin filled with levigated alumina. After the addition of catalyst and application of a suitable cure, this material has a heat distortion temperature greater than 300 C and the electric strength of a 0.040 in. thick sample is more than 800 volts per mil at 315 C. From their tests, Boeing concluded that this alumina filled silicone resin is satisfactory for potting equipment for continuous use at 315 C.

Many Applications Possible

Table I shows a number of typical applications now being made by the electronics industry of the various types of silicone insulating materials. In many instances the use of silicones permits the use of simpler electronic and mechanical designs to achieve reliable performance under adverse operating conditions.

TABLE I. HOW SILICONES IMPROVE RELIABILITY

PROBLEM	SOLUTION	WHY	HOW
Protect components and entire assemblies from atmospheric conditions.	Fill entire unit with electrical grade silicone fluid.	Excellent dielectric properties over wide frequency and temperature ranges permit use as replacement for air. Since electric strength of silicone fluids is much greater than air at atmospheric pressures, units can usually be reduced in size substantially. Silicone fluids serve as effective heat transfer media.	To improve heat transfer, 20 centistoke viscosity silicone fluid is recommended. This fluid may be pumped to a cold sink to further cool the assembly. Provisions must usually be made for thermal expansion of the fluid.
	Encapsulate entire unit with RTV silicone rubber.	Good dielectric properties over wide frequency and moderate temperature ranges permit use as an encapsulant. The elastic characteristic damps vibration of components. Silicone rubber is moisture resistant.	RTV silicone rubber is easy to apply by pouring or by using a caulking gun. Cure does not require heating which might damage temperature sensitive components. Cure may be varied from a few minutes to a few days.
	Encapsulate entire unit with filled solventless silicone resin.	Good dielectric properties over wide frequency and temperature ranges permit use as an encapsulant. Fillers impart additional heat stability and physical strength and low cost. Solventless silicone resins have outstanding radiation resistance.	Unit must be heated to 125 C to cure solventless silicone resins. Pot life at 100 F of catalyzed resin is many weeks. If 140 mesh zirconium ortho silicate is used as a filler, filler may be placed in cavity first, agitated, and then resin introduced after application of vacuum.
Decrease size and weight of filament, plate pulse transformer, servo and aircraft actuator motors, other magnetic devices.	Use silicone (rubber and resin) insulation throughout unit.	Suitable dielectric properties and ability to withstand temperatures of 200 C and above permit higher hot-spot temperatures resulting from miniaturization. Often size and weight can be reduced 40 to 60 percent. High thermal conductivity reduces thermal gradients.	Silicone resins and elastomers are available in forms analogous to more conventional insulating materials. For optimum performance at high temperatures, silicones must be cured at 200 C or higher temperatures.
Eliminate effects of moisture on point-to-point circuitry.	Use silicone glass laminate for terminal strips, mounting boards for components. Use silicone rubber insulated hook-up wire.	Silicone glass laminate and elastomers are water repellent and have low moisture absorption. Dielectric properties are little affected by moisture exposure.	Silicone materials are not affected by soldering temperatures; assembly causes no damage to insulation.
Reduce moisture effects on printed circuitry.	Treat circuit board with modified silicone resin.	Modified silicone resin has low water vapor permeability.	Modified silicone resin may be applied as a spray, withstands solder bath temperatures, is not wet by solder.
Maintain constant electrical characteristics of paper capacitors for —55 to 125 C.	Use capacitors impregnated with silicone fluids.	Excellent dielectric properties of silicone are relatively constant from —55 C to 200 C and from dc to 1000 Mcs.	Silicone impregnated capacitors are usually hermetically sealed and are available in usual wide ranges of ratings, sizes, and mountings.

TABLE I. HOW SILICONES IMPROVE RELIABILITY

PROBLEM	SOLUTION	WHY	HOW
Protect components and sub-assemblies from vibration.	Pot components in RTV silicone rubber.	Elastic characteristic damps vibration of components. This characteristic is retained over a temperature range from —55 C to 200 C.	RTV silicone rubber may be easily applied without costly process equipment or techniques.
	Apply silicone "wax."	Silicone "wax" provides more dampening action than even RTV silicone rubber, also is highly water repellent.	Material may be dip or spray applied; little heat treatment necessary. Maximum operating temperature limited to approximately 125 C.
Improve flexibility of cables at extreme low temperatures.	Use silicone rubber insulated wires and cables.	Elastic as well as other physical and dielectric properties are relatively constant from —55 C to over 200 C.	Silicone rubber insulated wire is easy to strip; insulation is not affected by soldering temperatures.
Provide magnetic devices such as transformers, chokes with radiation resistance.	Use silicone bonded glass served magnet wire impregnate coil with filled solventless silicone resin.	Physical and dielectric properties are essentially unaffected by radiation doses as great as 2000 megarads.	Vacuum impregnation must be used to eliminate voids in coil; otherwise gas in voids would ionize in radiation field.
Protect glass envelopes of tubes, capacitors from excessive stresses during and after encapsulation.	Coat glass with silicone rubber.	Resilient silicone rubber relieves stresses caused by cure of encapsulating material, withstands cure temperatures, does not inhibit cure of common encapsulating resins.	Either RTV or heat vulcanizing silicone elastomers may be used.
Provide cables and terminals reliable under high voltage and high altitude (corona) conditions.	Insulate cables and terminals with silicone rubber.	Silicone rubber has exceptional resistance to effects of corona. Low dielectric constant of silicone rubber increases corona starting voltage.	Terminals should be designed to reduce electric field surrounding conductor and insulation.
Provide low loss tank coil forms for dielectric heaters.	Make coil forms from tubular silicone glass laminate.	Silicone glass laminate has low loss factor up to 100 Mcs at temperatures from —55 C to 300 C. Loss factor is little affected by moisture exposure.	Silicone glass laminate can be easily machined.
Improve reliability of cable connectors under adverse atmospheric conditions.	Seal connector with a suitable silicone electrical compound (of grease consistency).	Silicone compounds have low losses over wide ranges of frequency and temperature, highly water repellent, retain physical consistency from —55 C to over 250 C.	Silicone compounds may be applied with spatula or caulking gun.
	Use connector insert, made of silicone molding compound.	Silicone molding compound retains dimensional stability from —55 C to above 300 C, is physically strong, has good dielectric properties.	Material may be compression or transfer molded; after bake improves high temperature properties.

PLASTICS AS Microwave Dielectrics

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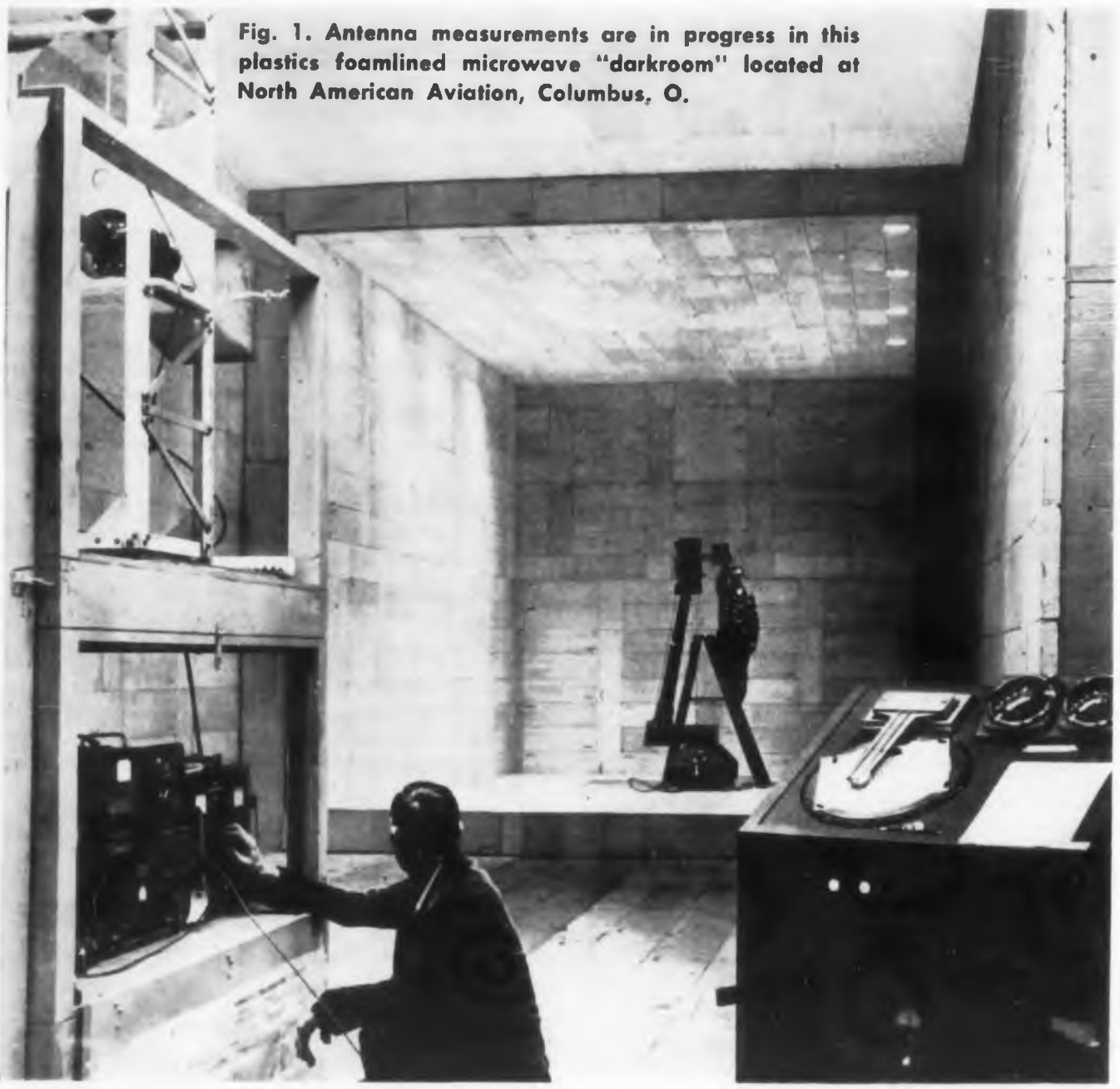


Fig. 1. Antenna measurements are in progress in this plastics foamlined microwave "darkroom" located at North American Aviation, Columbus, O.

Many plastics materials are used in microwave applications. These include absorbers, foams, solid rod and sheet, casting resins, and fiberglass-resin laminates. In some instances the particular virtue of the plastics substance is that it is low loss; in others, highly dissipative. Certain foams, for example, can have dielectric constants below 1.1 and loss tangents below 0.0002; some solid plastics rod stock, on the other hand, has a dielectric constant above 100 and loss tangent in excess of 2.0. Filling in the gap between these extremes is a whole series of materials of adjusted electrical properties useful to the microwave design engineer. A selection is presented in this article.

Absorbers

For Anechoic Chambers

Absorbers for free space or anechoic chambers are usually made from plastics foam in which is distributed dissipative material. Distribution in the foam is in such a manner that a good match to the electrical properties of air at the front surface is made; dissipation increases with depth. Absorbers for anechoic chambers are usually supplied in sheet form; they are cemented to the interior of a room to present a continuous nonreflecting surface. The range of frequencies covered extends from 50 mc to 35,000 mc. Fig. 1 shows a typical installation. Table 1 lists the important properties of one series of free space absorbers, namely, Eccosorb FR. In addition, there are many other types including flexible foam absorbers for antenna nacelles and for caps to cover radiating antennas for test purposes.

For Waveguide and Coaxial Line

Several other types of plastics material absorbers are of interest. Conductive particles can be

ABOUT THE AUTHOR

William R. Cuming is vice president and chief engineer of Emerson & Cuming. He received his ME degree from Stevens Institute of Technology in 1942, and his MBA from Harvard. He has been with Monsanto Chemical Co., MIT as a staff member, and with the Naval Research Laboratory.

distributed throughout a machineable solid substance. The amount of conductive material, as well as the manner in which the particles contact one another largely determines electrical properties. Resulting composition is bulk resistive. Materials of this type have dielectric constants ranging from about 3 to over 100. Dissipation factor is deliberately high, ranging from 0.1 to 2.0 at microwave frequencies. Permeability is unity. These plastics are used for waveguide or coaxial terminations. Typical properties are given in Table 2. Fig. 2 shows some machined pieces.

Similarly, magnetic particles can be incorporated in plastics to again produce a series of materials of extreme interest to microwave designers. These are featured by high magnetic dissipation factors. Usage also is for terminations and loads. Fig. 3 is a series of tapered loads.

Moldable and Castable Absorbers

Both the bulk resistive and the high magnetic loss materials are supplied in forms which are moldable by the user. The bulk resistive material (in several values) is available in a form resembling damp sand. It is packed or tamped into a mold or cavity and subsequently cured to accurate dimensions and accurate electrical properties. The high loss magnetic plastics composition is available as a casting resin. Pieces can be cast to proper size and shape.

Casting Resins

Conventional casting resins of the epoxide or polyester types are of only limited interest to microwave engineers. Losses are rather higher. A few casting resins, however, based on nonpolar compounds, are worth consideration. The resins are used for embedment in waveguide, coax and antenna systems. Ruggedization and hermetic sealing are two of the impoortant advantages. Microwave dielectric constant is relatively low. Some recent casting resins when fully cured can be used at 600 F.

Foams

Plastics foams are widely used in microwave applications. Owing to low dielectric constant and low loss, a foam can be safely interposed as a dielectric in an electromagnetic energy field. Foams are used in such applications as (1) a support for the center conductor in coaxial cables; (2) windows in waveguides; and (3) as the core material in the sandwich structure of airborne radomes.

Foams are available in many different forms: prefoamed shapes, liquid foam-in-place resins, powders, expandable beads, casting resins, and "pack-in-place" foams. Both flexible and rigid foams are available.

Foams are used in microwave lenses. The lens may have a uniform or a variable dielectric constant. The Luneberg Lens is an excellent example of the latter type. This lens is a sphere of dielectric material in which the dielectric constant varies from 2.0 at the center to 1.0 at the outer edge. It is made by molding and assembling a series of concentric hemispherical shells of polystyrene foam. Each shell is of a different density and, therefore, of a different dielectric constant.

Artificial Dielectric Foams

Artificial dielectrics based on foams are made by distributing throughout a foam matrix a

Table 1—Absorber for Free Space Rooms (Eccosorb FR Series)

Type	Frequency Range	Bands Covered	Maximum Power Reflection (percent)	Size ft	Thickness in.	Weight per sq ft
330	2300 mc. and above	S, C, A, B X, G, K	1	1 x 3	2	10 oz
340	940 mc. and above	L and S, C, A, B X, G, K	1	1 x 3	4	1 lb 4 oz
350	455 mc. and above	U. h. f. and L, S, C, A, B, X, G, K	1	1 x 3	8	2 lb 8 oz.

finely divided metallic powder. The metallic particles are insulated from one another. For example, an epoxy foam of 20 lb per cu ft. has been made with a dielectric constant of 7.0 and a dissipation factor of 0.03. The overall effect is to significantly raise the dielectric constant of the foam with practically no increase in weight. Dissipation factor remains at a low level. Aluminum flake has been used with success. A variety of resins have also been used as the matrix. Pack-in-place techniques may be used.

Applications for artificial dielectric foams include lenses and radomes. Undoubtedly, other microwave uses will be found as engineers become familiar with the properties and availability.

A special form of an artificial dielectric foam is one in which the metallic particles are in contact with one another. The effect is to raise the dielectric constant, also the dissipation factor. The material thus becomes an electromagnetic energy absorber. Fig. 4 indicates a unique lens construction using both artificial dielectrics and a foam-in-place resin.

Table 2—Bulk Resistive Waveguide Absorber (Eccosorb HF 853)

Tensile Strength, psi	3500
Izod Impact—ft lb/in. of notch	11
Coefficient of Linear Expansion—cm/cm/C	50×10^{-6}
Thermal Conductivity—BTU/sq-ft/hr/F/in.	1.5
Water Resistance—per cent gain in 24 hrs at 25 C	0.25
Dielectric Constant at 8600 mc	25.0
Dissipation Factor at 8600 mc	0.40
Resistivity—ohm-cm	1000

Table 3—Low Loss Adjusted Dielectric Constant Rod and Sheet (Stycast Hi K 500 F)

Dielectric Constant	3 to 25 in steps of 1.0
Volume Resistivity	above 10^{14} ohm-cm
Dielectric Strength	above 300 v/mil
Dissipation Factor, 10^8 to 10^{10} cps	below 0.0008
These will vary dependent upon the dielectric constant:	
Specific Gravity	1.8
Flexural Strength psi	10,000
Modulus of Elasticity	2×10^5
Izod Impact—ft lb/in. of notch	0.3
Coefficient of Linear Expansion—cm/cm/C	25×10^{-6}
Thermal Conductivity—Cal/sec/cm²/C/cm	4×10^{-4}
Water Absorption—per cent gain in 24 hrs at 25 C	0.1
Temperature Range for Use	—70 to 500 F

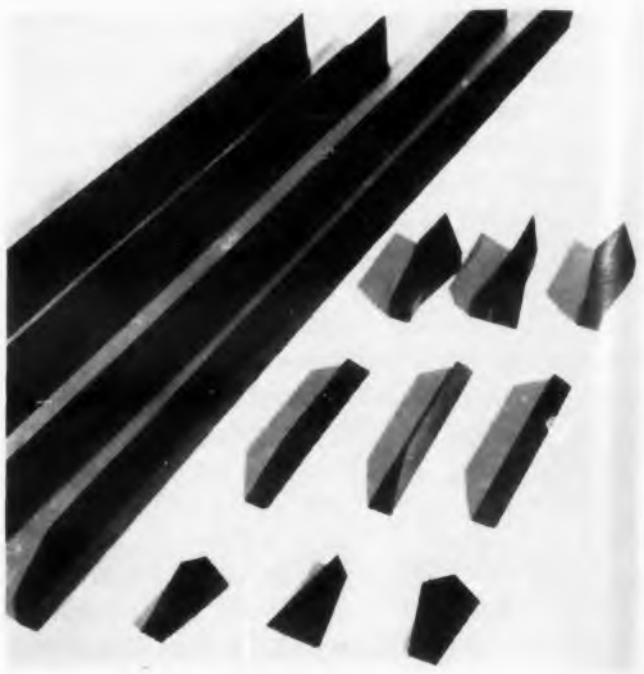


Fig. 2. Waveguide terminations molded from a bulk resistive plastic composition with high dielectric dissipation factor and, therefore, high attenuation per unit length.

Rod and Sheet

Low loss machined solid plastics parts are used throughout microwave equipment for mechanical support and as electrical elements. In many instances, it is desirable that the dielectric constant be low. At times, however, a specific value of dielectric constant is required. This would occur, for example, when using the dielectric as a matching device or when the size of a waveguide is to be shrunk in dimensions.

There is an extensive series of materials available to the designer. The range of dielectric constant is from 3 to 25. Temperature capability is −70 F to 500 F. These materials are made by incorporating titanates in low loss plastics. Table 3 gives some details.

Below dielectric constant 3 other materials are available. (Foams have been mentioned.) Rigid, rugged rod stock of dielectric constant 1.7, 2.2 and 2.5 are also available.

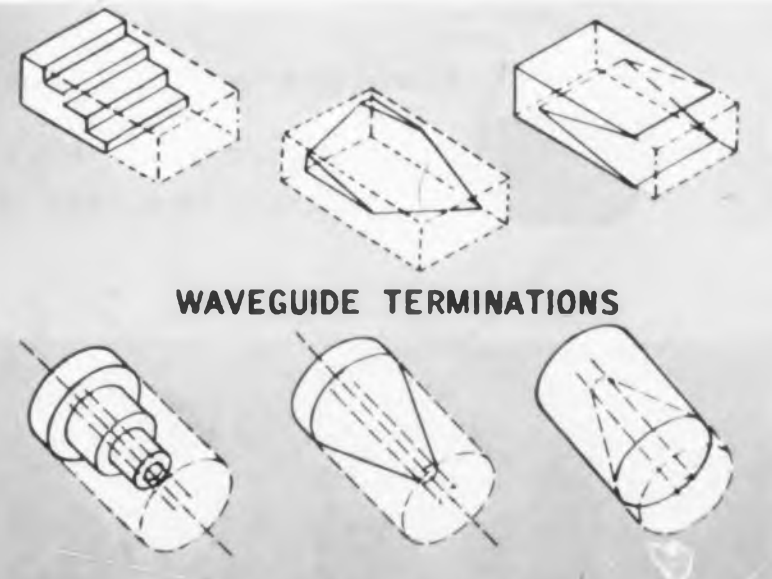
Glass Fiber Resin Laminates

No discussion of plastics in microwaves would be complete without mention of plastics laminates. These are made by molding a plastics material which is reinforced with glass fibers in mat or fabric foam. Resultant structures are strong and light weight. They are used extensively by the microwave engineer for radomes, dielectric supports and for microwave transparent windows. An interesting application for a fiberglass laminate structure is the microwave focusing lens shown in Fig. 5.

Fig. 4. (above) At the left are discs of an artificial dielectric foam, Eccofoam Hi K 625 D, which have been drilled to produce a radial variation in effective dielectric constant. Discs have been assembled to produce a microwave lens (center). Lens right, has been encapsulated in a low density foam-in-place resin for protection and ruggedization. The unit was made for Melpar, Inc.

Fig. 3. (left) Magnetic particles distributed throughout a high temperature resistant plastic produce a material suitable for loads in circular waveguide.

Fig. 5. Fiberglass laminate construction has been used in producing the lens which is at the focus of the parabolic telemetry antenna.



Designing Waveguide And Coaxial Terminations With Bulk Resistive And High Magnetic Loss Materials

Terminations are either step tapered or uniformly tapered. Step tapered terminations are recommended only where space is at a premium; they are narrow band, and highly critical dimensionally. Reflections from the various discontinuities cancel to produce a low overall reflection from the termination. Step tapered terminations are difficult to reproduce due to the dimensional problem and slight variations in materials.

Uniformly tapered terminations are generally preferred. They are relatively broadband, noncritical dimensionally and reproducible. Once a design is established, it is possible to mold them to final size and shape. In general, the more gradual the taper, the lower the vswr. Termination length may be as low as one-half to as high as ten times the free space wavelength. For waveguide, tapering is often done in both the E and H plane.

The E plane is the most important. Sufficient attenuation must occur in the material so that a reflection does not occur at the far end of the termination. At least 30 db of attenuation in the material is desirable. Once the impedance match has been satisfactorily accomplished, by means of the taper, the absorptive material may completely fill the waveguide or coax.

18 Uses of PLASTICS In Batteries

Silver-zinc batteries are especially adapted to aircraft use because of their inherently light weight. To further decrease weight, Yardney designers have utilized plastics in their 14xHR 15V battery. This article discusses the way in which these various types of plastics have been used.

Fig. 1. Typical silver-zinc battery for aircraft use.

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ONE OF THE main factors responsible for the unprecedented high specific energy and power capabilities of silver-zinc batteries has been the systematic application of plastics as structural and functional components—components selected on the basis of light weight, mechanical properties, resistance to thermal conditions, electrical insulation properties, ease of fabrication and resistance to the chemicals used in the batteries.

All Yardney silver-zinc cells are constructed in plastic cases. These are injection molded of any of several plastics, depending on the specific cell model. Among the plastics used for this purpose are

- Methylstyrene-acrylonitrile copolymer
- Polystyrene-acrylonitrile copolymer
- Nylon
- Polyethylene

In the Yardney 14xHR15V (Fig. 1), used as an aircraft battery in Bell Helicopter Corporation's 47H Helicopter (Navy HYL-1) eighteen different applications of plastics can be found. The uses of plastics in this battery are typical of their application in a great variety of batteries.

Fig. 2 shows the location of the several applications of plastics. Weighing 11.5 lb, this 24 v-15 amp-hr battery has a volume of 166 cu in., as compared to 34 lb and 452 cu in. for the 24 v-11 amp-hr lead-acid battery it replaced.

Fourteen 15-amp-hr cells are connected in series. Each cell is housed in an injection-molded case of methylstyrene-acrylonitrile copolymer and uses an injection-molded cover of the same material. Specifically, these parts which weigh 43 grams, are molded from Cymac 201 thermoplastic molding compound. The injection moldings of Cymac were selected on the following bases:

- Low specific gravity (1.06)
- Exceptional combination of high ultimate tensile strength (9700 psi—ASTM Test Method D638-52T) and high flexural strength (16,100 psi—ASTM Test Method D790, with one inch per minute crosshead speed)
- Resistance to heat (heat distortion point: 207 deg F when tested in accordance with ASTM test method D648-45T)

ABOUT THE AUTHOR

After coming to Yardney Electric Corp. in 1953 as a research engineer, Ivan Blake quickly rose to the post of Assistant Head of the Engineering Division, then to Head of the Engineering Division.

Mr. Blake, however, is much more than a top administrator—he holds several patents on such items as a sea water battery; a cuprous chloride-magnesium battery; a magnesium dry battery; and a persulphate, water-activated battery.

He is a graduate of Maryville College in Tennessee, where he received his degree in Chemistry. Starting as a chemist with the Electro-Manganese Corp. he has been with Procter & Gamble Co. and the Burgess Battery Co.

- Good resistance to crazing
- Complete resistance to battery electrolyte (concentrated solution of potassium hydroxide)
- Excellent injection molding characteristics
- Ease of sealing cover to case, using solvent sealing techniques on a complete battery basis

the cell cases and covers constitute 11.75 per cent of the total weight.

Three Plastics in Vent Plugs

Each cell has a vent plug, of which the body is injection molded from polyethylene, the cap from nylon and the inside packed with tetrafluoroethylene felt. Each of the three plastics was selected on the basis of a particular design function.

The vent plug, which is molded with an outside diameter of 0.2660-0.2670 in., fits into a vent opening that has a diameter in the range of 0.2635-0.2655 in. Polyethylene was selected for this part because it was sufficiently elastic to allow a compression fit into the smaller vent opening.

The vent plug cap, on the other hand, was molded of the more rigid nylon in order to get a tight fit in the undersized opening in the top of the softer polyethylene vent plug body.

Tetrafluoroethylene felt was chosen as packing material for the vent plug because it is not wetted by the potassium hydroxide electrolyte. This property minimizes the possibility of establishing, by capillarity, continuous electrolyte paths through the vent plug. Yet it allows the packing to be done in such a way as to permit each cell to breathe.

Sealed Metal to Plastic

One of the most formidable problems in the design of the cell used in the battery, was the method of sealing the metal cell terminal posts into the injection-molded plastic cover.

This seal required a material that bonded perfectly to both the plastic cover and the steel terminals and possessed complete chemical inertness to the potassium hydroxide electrolyte. The selected material was a modified thixotropic, room temperature-curing, epoxy resin.

This material, after curing at room temperature, has the following desirable properties:

- Complete chemical resistance to potassium hydroxide electrolyte
- Excellent resistance to mechanical impact or shock
- Excellent thermal stability and thermal shock resistance
- Superb bonding between metal and plastic
- Excellent electrical insulation properties
- Convenient handling and application
- Exceptional dimensional stability

The total weight of this sealing formulation re-

Fig. 3. Polyester-bonded glass-fiber case is 4-7/8 x 4-7/8 x 6-23/32 in.

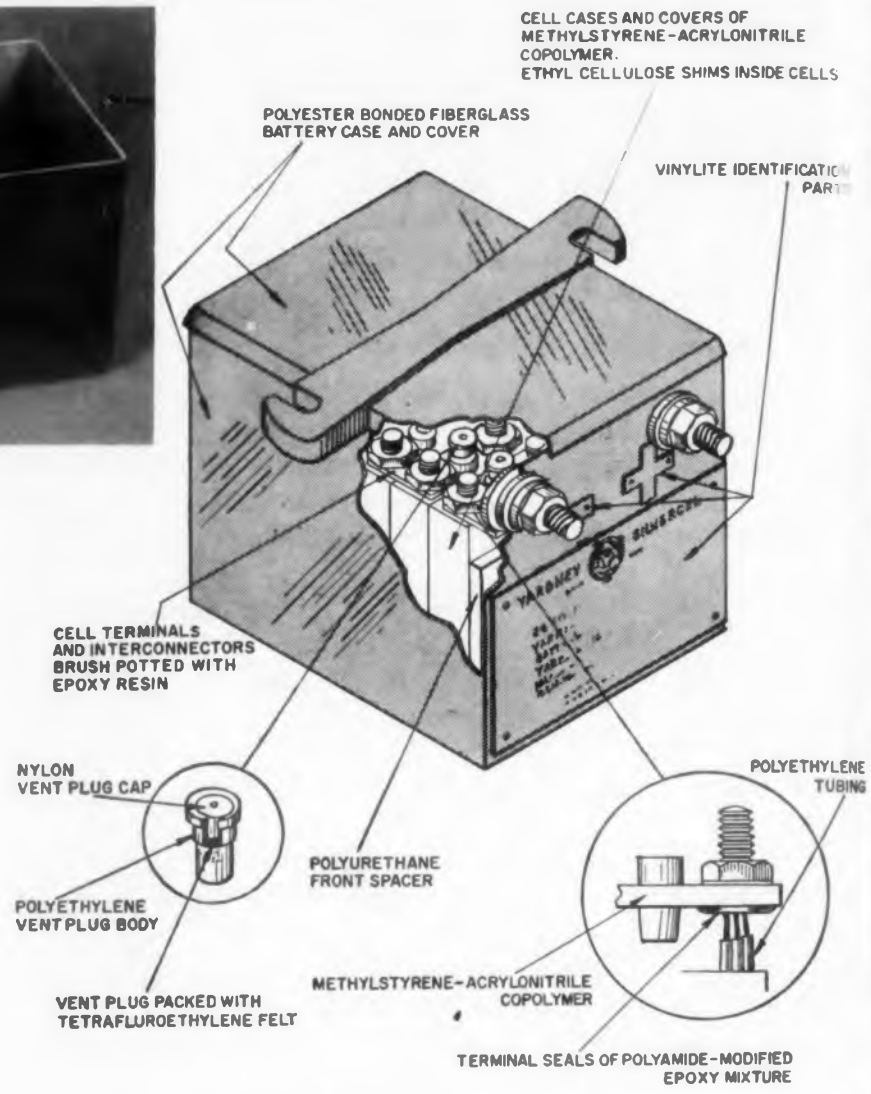


Fig. 2. Where plastics are used in Yardney's silver-zinc battery.

quired for the 14 cells of the battery makes up 7 grams out of the battery weight of 11.5 lb.

In each cell, the connecting lead wires from the electrodes to the cell terminals, are enclosed in extruded polyethylene tubing. The tubing is black for the negative electrode leads and red for the positives. These colors permit easy visual inspection for correct electrode orientation during manufacture. Also, the polyethylene is completely resistant to attack by the cell electrolyte.

Ethyl-cellulose shims are used to obtain correct internal spacings within the cell. Ethyl-cellulose was selected because of its excellent resistance to electrolyte, heat stability and availability in thin sheets.

Battery Cases Molded

The external housing for the complete battery consists of a compression-molded polyester resin-bonded glass fiber case and cover (Fig. 3).

The case weighs 300 grams and has a uniform wall thickness of 0.093 in. ±0.005 in., with all internal radii less than 1/16 in. It is made by laying alternate layers of 0.010 in.-0.12 in. glass fiber mat and polyester resin onto a steel mold maintained at about 250 F.

The battery box cover, which weighs 132 grams, is molded from the same material as the case.

Polyester resin-bonded glass fiber was selected because of its:

- Low weight
- Excellent resistance to mechanical stresses
- Excellent resistance to thermal stresses and shock
- Chemical inertness
- Good electrical insulation properties
- Its capability of being fabricated economically to close tolerances
- Low cost

Other materials—such as magnesium, aluminum and stainless steel—were considered, but none possessed the excellent combination of properties exhibited by the polyester bonded glass fiber.

Positive and negative polarity markers on the external surfaces of the case, as well as the nameplate, are made from Vinylite. The positive polarity marker is made of red Vinylite; the negative marker and the nameplate, of black Vinylite. Here the selection was dictated by:

- Low cost

- Resistance to electrolyte attack
- Ease of heat stamping lettering on the Vinylite
- Good appearance and finish

Epoxy Protective Coating

All exposed cell terminals and intercell connectors are "brush-potted," at room temperature, with an epoxy resin. This resin provides a continuous epoxy surface over the entire top surface of the unit cells, preventing any external damage to the metallic conductors that might be caused by moisture, salt atmosphere, and the like. The epoxy brush-potting has good mechanical properties and excellent resistance to the battery electrolyte.

The battery uses a front spacer of polyurethane plastic foam, with a density of 17-21 lb per cu ft, which serves as a structural component as well as filler. This spacer holds the battery cells under compression within the battery case and also serves to correct dimensional variations due to manufacturing tolerances on other components.

Plastics Used in Packaging

Electrolyte for each cell is packaged and sealed in polyethylene bottles. Also provided to the customer is a special injection-molded polyethylene filler cap. In filling each battery cell, he removes the cap from the polyethylene electrolyte bottle and screws on, in its place, the special filler cap. One end of this special filler cap is a threaded cap; the other, a tube of dimensions to make a tight pressure fit into the 0.2635-0.2655 in. diam opening in the cell vent.

The tube end of the special filler cap is pressed into the cell vent and the electrolyte pumped from the bottle into the cell by alternately squeezing and releasing the walls of the polyethylene bottle. In packaging, the final battery assembly is sealed in polyethylene bag.

18 Uses of Plastics in Electronics

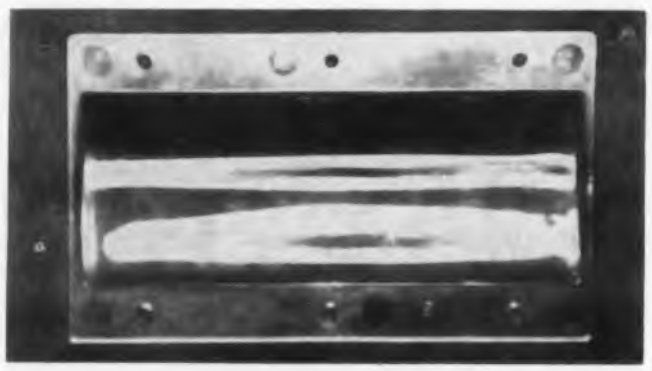
1. Cell cases
2. Cell covers
3. Cell terminal seal
4. Cell terminal seal
5. Extruded tubing
6. Vent plug body
7. Electrolyte bottles
8. Electrolyte filler caps
9. Internal cell shims
10. Battery case
11. Battery cover
12. Positive and negative polarity markers
13. Nameplate
14. Vent plug cap
15. Vent plug packing
16. Front spacer
17. "Brush potting" of terminals and connections
18. Final packing

Design with Plastics

Applications Of Plastics in Electronics

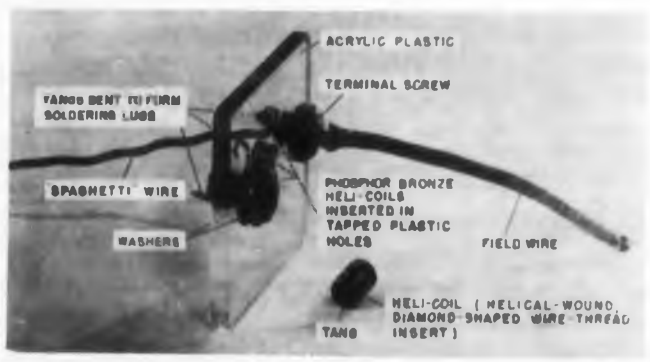
Here are a selected number of applications showing how plastics materials can be successfully applied to electronics products. These uses may suggest solutions to other difficult design problems.

Acrylics



Methyl methacrylate possesses exceptional optical properties that enable it to be made into lenses of good quality. A plexiglass lens is made by Sylvania as a magnifier for a non-electronic part, but it may be used as an instrument dial magnifier as well. Flat surface is controlled to within 0.02-in. total indicator reading.

•



Acrylic terminal strips with tapped holes use phosphor-bronze thread inserts to strengthen the plastic threads. Made by Heli-Coil Corp., the inserts also provide an electrical connection through the panel board.

Acrylic instrument panels for aircraft are made by a bonding process developed by Kerrco Products. They can be edge-lighted or back lighted, and feature a clear acrylic panel with a dull surface with numerals in white. They exhibit good readability in daylight, and in the dark, only the wording on the panel is illuminated. The material is scratch and chemical resistant.

•

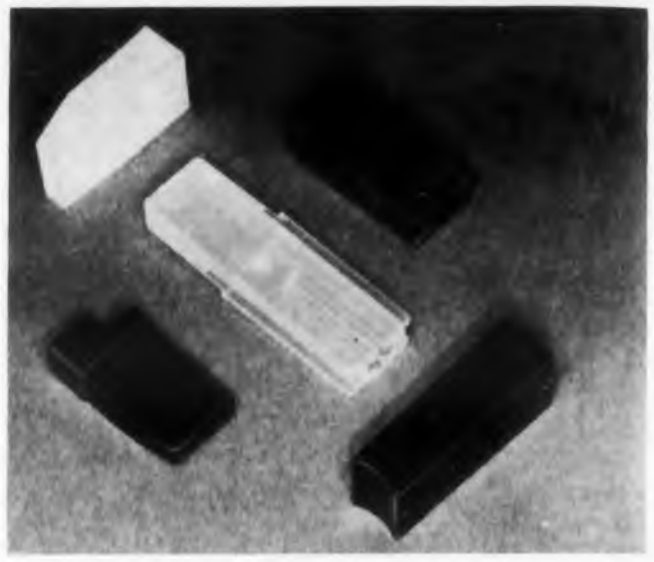
Alkyd

Alkyd, glass filled, houses a permissive make relay made by IBM. This plastic was chosen because of its high strength, electrical stability and fast molding cycle. Alkyd also can be colored, and IBM took advantage of this property to color-code all their parts. Previously they had lost several thousand parts by not having color-coding. Black parts are hard to keep separated in production when different metal inserts are used.

•

Cellulosics

Cellulose acetate butyrate is the case material for one of Assembly Product's ruggedized meters. The plastic was chosen because of its flexibility and non-brittle characteristics. A special liquid compound was used to prevent static electricity.



Cellulose acetate butyrate, used as pushbutton material in an auto radio, has high surface luster, high impact strength, and can be made in 19,000 colors. Outside surfaces are smooth and are free from flow marks and flash. Sylvania makes these buttons and is able to hold tolerances to within 0.002-in.

•

Cellulose acetate was chosen by Dictaphone Corp. from which to mold their new hand microphone. Parts molded are the microphone housing, connector body, start-stop slider, and push buttons.

•

Diallyl Phthalate

Diallyl phthalate compounds, because of their superior dielectric characteristics, have been put to use as molded insulation on precision synchro lamination

...acks. Lear Inc. had the problem of holding the ...dividual laminations together. Riveting and ...cementing are not suitable. Molding the insulation ...n the motor and stator laminations eliminates many ...and operations. Thickness is about 0.01 in. OD and ...D are held to tolerances of 0.0002 to 0.0003 in.

•

Epoxies

Epoxy resin reinforced with glass fiber is the coating ...er this foamed-plastic antenna test tower. Use of ...tal was avoided by its builder, Scientific-Atlanta ...c., since the designers wanted to simulate free ...ace. A glass fiber reinforced torque tube drives the ...odel from a motor in the base. Phenolic and nylon ...ur and bevel gears drive the head. Glass balls in a ...henolic raceway provide the bearings.

•

Epoxy finishes can be applied by the dry powder ...chni ...que to give thicker and more uniform protec... ...on of rotating metal parts. National Polymer Prod... ...cts Inc. supplies the powdered resins.

•

Epoxies will adhere to metals or ceramics with equal ...affinity and require no metallized surface. Duramic ...Produ...cts Inc. takes advantage of this property in the ...sealin... of metals to ceramics. They get up to a 90 ...per cent cost saving over solder sealing.

Applications of Plastics (cont.)

Fluorocarbons

Tetrafluorethylene fluorocarbon resin, duPont's Teflon, has application in miniature electrical connectors. Made by Sealectro Corp., these units will withstand temperatures up to 550 F.

•

Polymer trifluorochloroethylene can be applied as insulation from an Aerosol container. Called "Polyfluoron" by Acme Resin Corp., the material has been used as coating on Amphenol 21-273 and 21-274 coaxial cables used on jet aircraft. Liquidometer Corp. devised the use of the coating, which is resistant to aviation fuels.

•

Polychlorotrifluorethylene, Kel-F made by M. W. Kellogg Co., is used by Burndy Corp. as insulating material for high-temperature connectors. They meet higher temperature standards than nylon insulated connectors.

•

Tetrafluoroethylene, Teflon, is used as brusholder supports by General Electric on railroad-type generators. The insulators withstand repeated flashovers and give relatively long service life. Teflon has a short time dielectric strength ranging from 1000 to 2000 volts per mil.

Tetrafluoroethylene turnings made by Kidwell Inc. hold tolerances to 0.00025-in. on diameters. Concentricity can be held to 0.002-in. T.I.R. in holes 20 or more diameters deep. Material is duPont's Teflon.

•

Laminates

Phenolic paper-base laminate used in a control panel being made for IBM requires excellent dimensional stability. They drill 748 holes, 0.156 in. diameter with tolerances of plus 0.003 in., minus nothing. The material, Richardson Co. Insurok T-889, also must withstand a severe milling operation without distorting.

•

Modified phenolic resin, hard paper base laminate has been designed for strong flame retardance. Made by Synthane Corp., FR-1 has the properties of Grade XX.

•

Epoxy-resin, Alpha paper base laminate EP-22 made by Synthane, has similar characteristics to glass-base laminates. It has application where good electrical characteristics must be maintained under adverse environmental conditions.

•

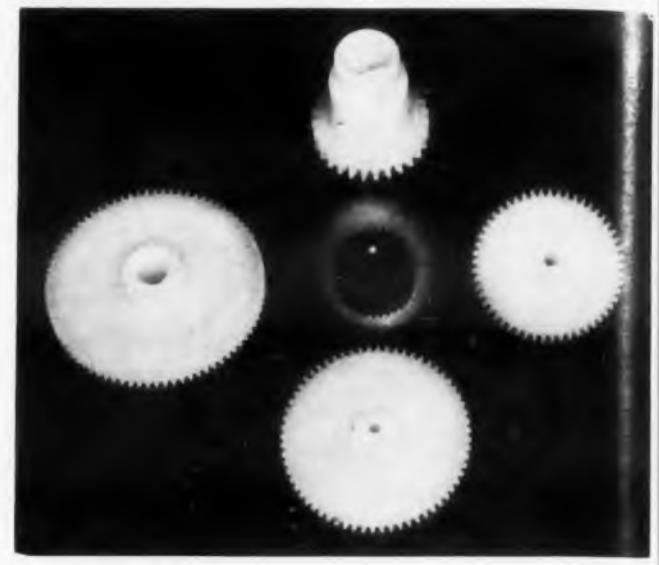
Glass-supported Teflon laminate, Continental-Diamond Fibre Grade GB-108T is used where low dielectric losses are desired. It may be used for flexible printed wiring applications. It has an exceptionally smooth surface.

•

Paper-base laminate, Continental Diamond Fiber's Dilecto, is used as a timer switch base by International Register Co. Its use as a support plate combines both its electrical and mechanical properties. The material has excellent dielectric properties and is dimensionally stable.

Applications of Plastics (cont.)

Nylon



Nylon has excellent bearing characteristics and is used by Sylvania as radio and TV control pinions and drive wheels. Nylon can be molded into intricate shapes while holding tolerances to within 0.002-in. These parts replaced die cast gears.

Nylon blocks, molded by Gries Reproducer Corp. for AMP Inc. make up a patch board. High degree of dimensional uniformity is necessary. Designers have taken advantage of nylon's ability to retain its shape.

Nylon head self-tapping screws are used in portable TV receivers to avoid having a metal contact on the outside of the case. Made by Gries Reproducer Corp., the self-insulating fasteners can be used in high-voltage equipment. Dielectric strength (short time) is 385 volts per mil.

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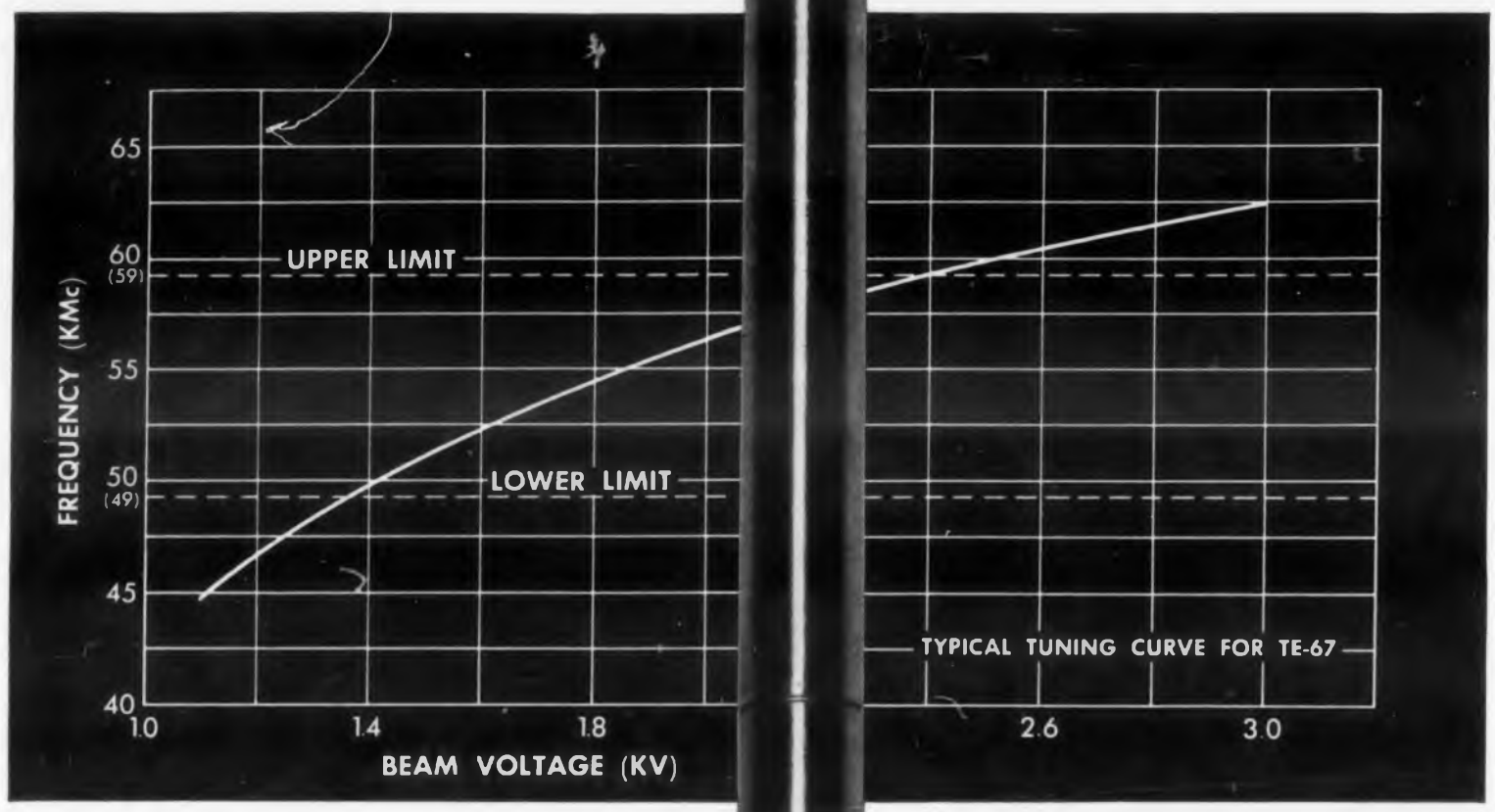
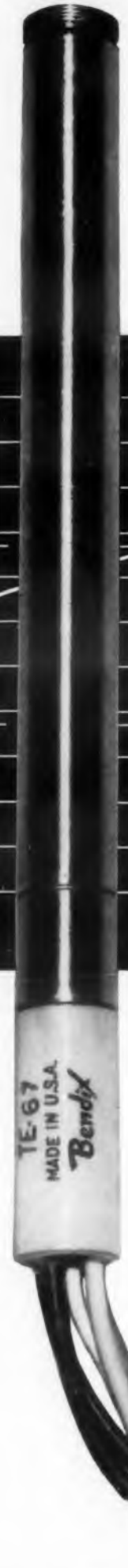




An exclusive Bendix Red Bank product, the Type TE-67 Backward-Wave Oscillator Tube generates microwave energy at extremely high frequencies never before available.

This new tube provides a wide range of usable frequencies for applications in: advanced types of multichannel telephone and television systems, high definition short-range radar, highly directive communications, microwave spectroscopy and other fields where low power, voltage-tuned millimeter wavelength radio frequency energy is required. As the backward-wave tube is voltage tuned, frequency is automatically changed by varying the voltage input. No mechanical tuning adjustment is required.

For more detailed information on the tubes described here, write to: RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

ELECTRICAL DATA

Frequency Range	49kmc—59kmc
Anode Voltage	1000—3000 volts
Power Output	5mw average
Beam Current	5ma
Magnetic Field	1300 gauss (minimum)
Heater Voltage	6.3±10%

MECHANICAL DATA

Output Flange	Special adapter to RG-98/U
Maximum Diameter	0.625"
Length	8"
Mounting Position	Any
Weight	5 oz.*

*Without magnet (tube only). Magnets are available.

Additional tubes are under development to extend the frequency range to 75 kmc.

THE TRAVELING-WAVE AMPLIFIER TUBE, also available from Bendix Red Bank, is designed for operation in the 4.0 to 8.0 kmc frequency range with approximately 40 db gain and 200 milliwatts output power. The tube utilizes a helical slow-wave structure with coupled helix attenuator section. The mechanical design minimizes the effects of vibration upon the tube operation.

West Coast Sales & Service: 117 E. Providencia Ave., Burbank, Calif. • Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. Canadian Distributor: Computing Devices of Canada, Ltd., P.O. Box 508, Ottawa 4, Ontario

Red Bank Division

Bendix
AVIATION CORPORATION

Nylon **powder** is molded into a ball bearing retainer by Barden Corp. Using this finely-divided nylon powder developed by Polymer Corp., Barden has designed a retainer through which oil spreads evenly.

•

Molded nylon cradle with a duPont neoprene "buckle" make up this cable clamp. These clamps, made by Electrovert Inc., hold well at temperatures ranging from —76 to 212 F.

•

Nylon provides tough insulation for these Harvey Hubbell test prods. Made of duPont Zytel, the devices will not crack or chip and have excellent electrical resistance.

o

Nylon pellet inserted into the threaded section of socket screws presents their shaking loose under severe vibration. Cleveland Cap Screw Co., makers of the screws report that locking action is retained at temperatures from —70 to 250 F.

•

Phenolic

Phenolic replaces metal as the numeral type at the tip of a printing sector. Used in the IBM Proof machine, the phenolic tips are made from Monsanto's Resinox 3700. IBM reports considerable cost reduction over metal type.

◄ CIRCLE 528 ON READER-SERVICE CARD

Applications of Plastics (cont.)

Phenolic (cont.)

Phenolic, nylon filled, has good resistance to wear, is low in cost and has good dimensional tolerance. When employed as helical gears in IBM's punched card sorter, it reduces operating noise.

•

Phenolic, nylon filled, was found by IBM to possess the high strength and dimensional stability necessary for service as a high-speed cam. About 1 in. in diameter, the cam is subject to extremely high pressure. It is molded, not machined, for use in IBM's 24 and 56 punched-card accounting machines.

•

Phenolic, mineral filled, is dimensionally stable, has good heat resistance and electrical resistance. IBM found these characteristics ideally suited to production of a magnetic memory core frame. Made in one piece, the frame holds 16,000 cores. They are used in IBM's 700 Series systems.

•

Phenolic, made static-free, replaces metal as a bed plate in IBM's 24 and 26 punched card systems. Static would cause poor feeding of cards over the bed plate. According to IBM, this is the only application of this material to date.

Polyester

Polyester film, Mylar, laminated with vinyl and reflective aluminum is one of the materials used by Zippertubing Co. in the fabrication of their electrical cable closures. Zippers are electronically welded to flat tape. They can be used many times and can be made chemically resistant.

•

Polyester film of excellent dimensional stability is used by J. Frank Motson Co. for radio dials. Called Mylar by duPont, the film permits printing to be held to a tolerance of 0.2 mil.

•

Polyethylene

Polyethylene is the material used in this wire splice protective cover. Made of duPont's Alathon by Plastic Engineering Sales Corp., the two piece fitting provides a moisture-proof seal.

•

Polyethylene resin extruded, is used in the tubes of this Exide battery. Using duPont's Alathon, Exide engineers expect a 20 per cent increase in life over former batteries using rubber tubes. Alathon doesn't corrode and maintains its strength and flexibility under low temperatures.

Applications of Plastics (cont.)

Polyester (cont.)

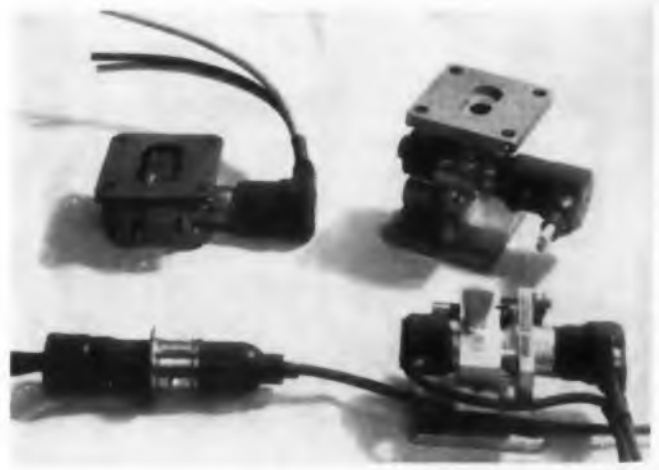
Polyethylene derivative, duPont Rulan combines the advantages of polyethylene plus high resistance. It finds application as high-voltage lead wires in RCA TV receivers.

•

Polyethylene is used as a shock mount by Sylvania. It also clamps electronic components firmly into position. It was used because of its resiliency, ease of processing, and high tensile strength.

•

Silicone



Molded Silicone insulation is used by Varian Associates to ruggedize and moistureproof their klystrons. Molding process also produces a hermetic seal and permits the tubes to operate at temperature extremes and high altitude without pressurization.

•

Silicone-impregnated synthetic mica is processed by General Laboratory Associates. The resulting material, Isomica, is used in making high-temperature capacitors. Capacitors ranging from 0.001 to 10 uf. 1600 to 600 v work well to temperatures of 400 F.

Styrene

Foamed polystyrene packages designed by Motorola, Inc. protect their transistors from shock and crushing damage during shipment. Their extremely light weight adds little to shipping costs. Aeroplastics Corp. and Ambassador Plastics have been supplying these packages.

•

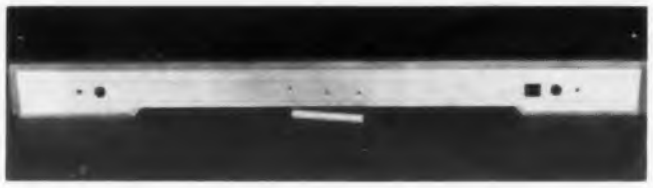
High **heat styrene** gives color, finish, and excellent dimensional stability to these IBM magnetic tape reels. Container material is clear styrene; knob is copolymer styrene. Great cost reductions were achieved using this material over the former metal parts.

•

High impact styrene is used by Sylvania as part of a plastic-metal TV flexible coupling. This material can be molded around a metal insert without crazing. Diameter of the groove is ±0.002-in.

High impact styrene makes up a vertical chassis mount for a TV receiver. Made by Sylvania Plastics Div., the part is lightweight and can stand rough usage without chipping or cracking, and is fire retardent. Hole diameter tolerance is within 0.002-in.; mounting surface limits are plus nothing, minus 0.005-in. Previously, combination metal and rubber shock mounts were used.

•



Medium impact styrene was used as a plate escutcheon for a TV control panel. Made by Sylvania Electric Prod. Inc., Plastics Div., the part is required to have good electrical and mechanical properties, excellent dimensional stability, and must withstand 142 F for 72 hours. Allowable twist end to end is less than ± 1 deg. Normal dimensional tolerance is ± 0.005 in.; bow is less than 1/32 in. It replaced wood and metal.

•

Vinyl

Vinyl plastic sleeve, made by Alpha Wire Corp., is extruded from Bakelite resins. This zippered sleeving permits completely enclosing the wire.

•

Vinyl is the least expensive of several materials that Sanders Associates Inc. uses as base material for its Flexprint printed wiring. These flexible printed wiring cables and harnesses also utilize insulating films of polyethylene, polyester, silicone, "Kel-F", and Teflon. Choice of material depends upon its application.

Richard L. White
Hoffman Semiconductor Div.
Evanston, Ill.

How To Design Pulse Magnetic Amplifiers

Part 2 Logic Circuits

Magnetic core logic is here to stay. Circuit improvements, better zero to one ratios, more efficient designs, and higher operating frequencies are in the offing.

This article presents the foundation stones for all magnetic logical circuitry.

ALMOST an unlimited number of logical configurations can be designed, once the basic logic is understood. Using a basic circuit, shift registers, counters, frequency dividers, full adders and many other logical circuits can be designed.

Basic Circuit

The basic logic circuit, its symbol, and waveshapes are shown in Fig. 1. The circuit is complementary. With a "0" input at A, the proceeding output at C is a "1" and vice versa. If A is connected to Φ_1 of the power oscillator and B is used as the input terminal, the output follows the input.

The amplifier has a half cycle delay. The input (at A or B) must be in phase Φ_1, and the output will be in phase Φ_2. These phases are obtained from the transistor oscillator shown in the first part of this article.

The operation of the basic pulse magnetic amplifier is expressed in Boolean algebra as

$$\overline{A} + B = C \qquad (1)$$

In words this says *NOT* input A *OR* input B equals C.

NOT—AND Circuit

A basic function required for logical operations is the *AND* function, whose circuit, symbol, and waveshapes are shown in Fig. 2. From eq (1) its equation may be written (letting $B = 0$),

$$\overline{A}_1 + \overline{A}_2 + \overline{A}_3 = C \qquad (2)$$

In words eq (2) says: *NOT* (A_1 *OR* A_2 *OR* A_3) equals C. Operating on eq (2) according to the rules of Boolean algebra,

$$\overline{A}_1 \cdot \overline{A}_2 \cdot \overline{A}_3 = C \qquad (3)$$

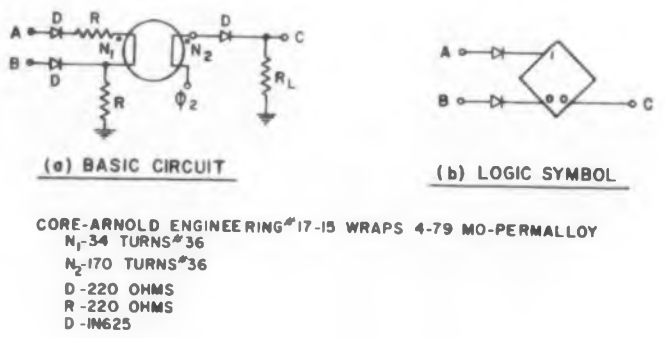


Fig. 1. Basic logical circuitry, symbolism, and waveshapes.

or, in words, *NOT* A_1 *AND NOT* A_2 *AND NOT* A_3 equals C.

OR Circuit

The remaining function required for any logical operation is the *OR* function, shown in Fig. 3. Letting $A = 0$, eq (1) can be written

$$B_1 + B_2 + B_3 = C$$

which says B_1 *OR* B_2 *OR* B_3 equals C.

Bistable Circuit

The bistable circuit is almost as basic to logical functions as the *AND* and *OR*. Composed of two basic modules, with the output of each connected to the input of the other, it is shown in Fig. 4. This circuit has two stable states. An output may be a train of "ones" or a train of "zeros." An output is provided in both power phases. The two outputs are complementary; when one output has "ones" the other has "zeros." Fig. 4 shows provision to "set" or "reset" the bistable circuit with a pulse of either power phase.

Other Circuits

Many logical configurations can be designed with these basic circuits.

"One" Generator. A logical representation of a "one" generator is shown in Fig. 5. It takes a train of power frequency pulses and generates a single pulse corresponding to the first pulse in the train, and delayed by one full cycle (two pulse periods).

As indicated in the figure, a single "zero" output is obtainable from the core preceding the "one" output core. If a single pulse from the trailing edge is desired, the pulse train can be inverted by a single magnetic amplifier, and then fed into the "one" generator.

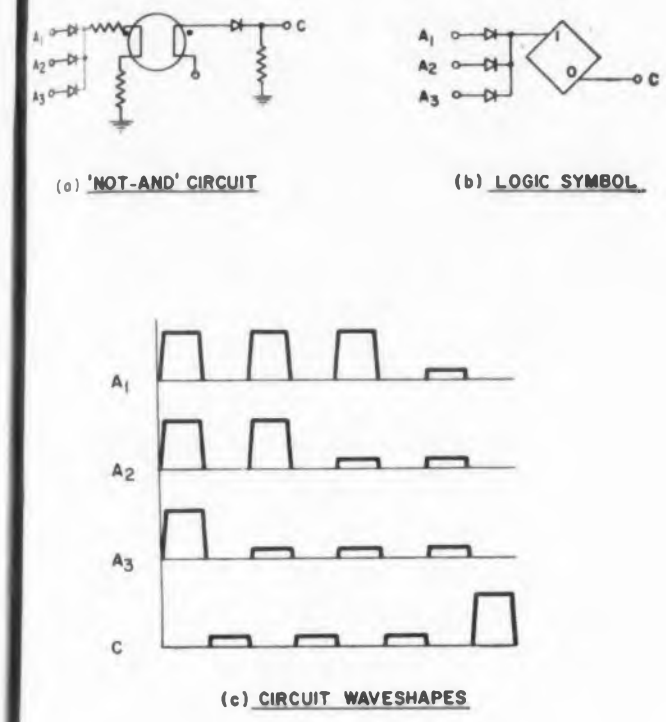


Fig. 2. "NOT-AND" logic.

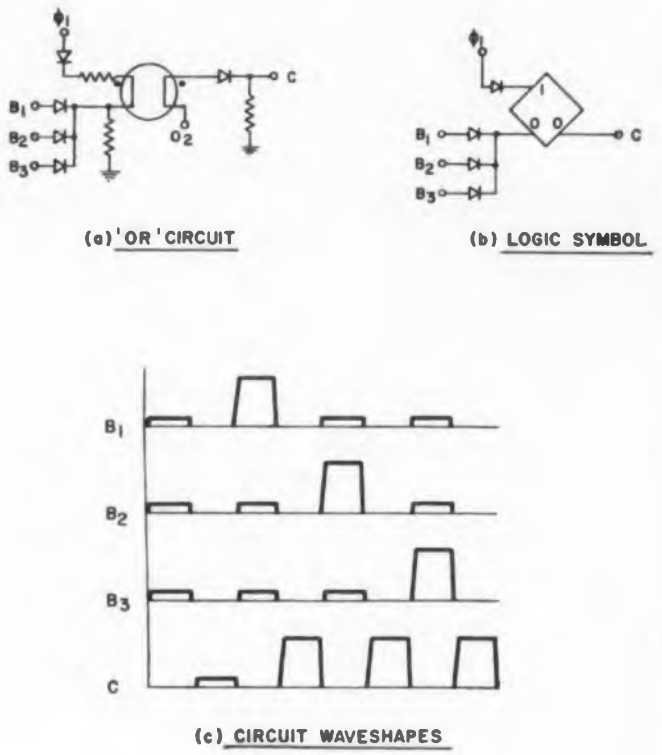


Fig. 3. "OR" logic.

Frequency Divider. Often, a pulse rate lower than the power frequency is required. This is accomplished with the circuit in Fig. 6. The power phase is connected to the input. The output goes back to the inhibit input of every other core. The output pulse rate is the power frequency divided by N. The number of cores necessary to divide by N is $2(N\text{-}1)$.

When division by a larger number is required, several smaller (none multiple) number dividers are used and the outputs are combined in an *AND* gate. As an example, to divide directly by 30 would require 58 cores. But by using dividers of 5 and 6 and one core for an *AND* gate, requires only 19 cores.

Decade Counter. A final example of logical circuitry is the binary coded decade counter. Pulses fed into the input are divided by 10 at the output. The difference between this circuit and the frequency divider is characterized by the input. The frequency divider requires an input at the power frequency. The decade counter accepts pulse input rates from zero to the power frequency.

Any number of decade counters can be cascaded to give a desired count.

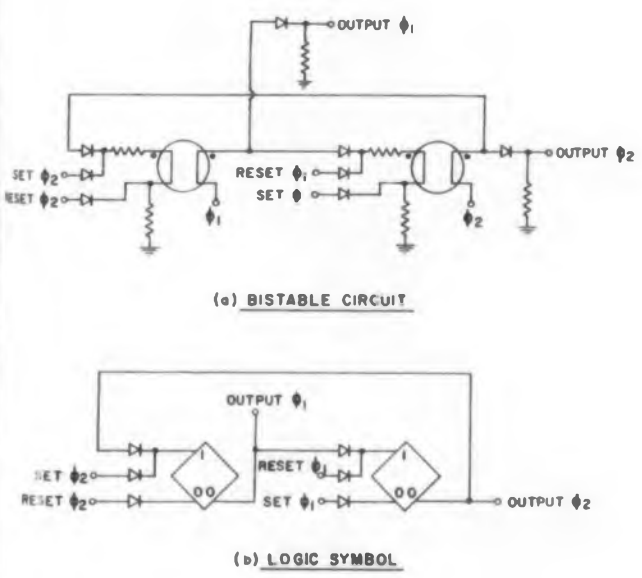


Fig. 4. This bistable circuit can generate a train of "ones" or a train of "zeros."

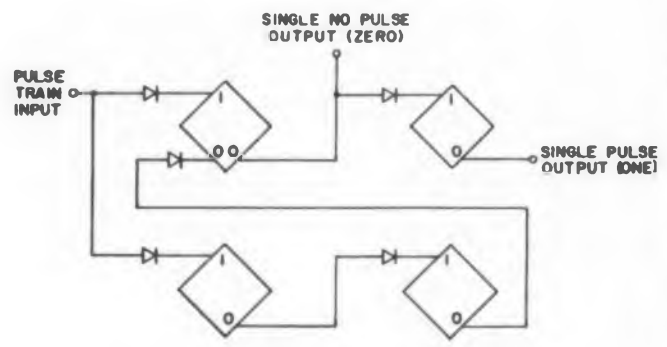


Fig. 5. "One" or "zero" generator.

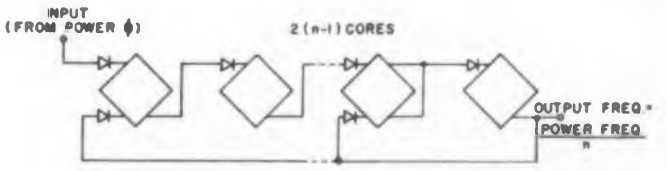


Fig. 6. Divide by n circuit.

Tripole Multimeter

. . . . . will measure 0.001 μa

WITH AN input impedance of 10^{14} ohms, this multimeter permits measurements of 0.001 μa, 2000 v dc, and resistance to 10^{14} ohms. The high input impedance is obtained by a unique connection between a cathode follower and a differential amplifier. One grid of the amplifier is common to one of the cathodes on the follower and is tapped as a terminal. The other amplifier grid and a tap off the other cathode of the follower are two other terminals. These three terminals comprise a so-called tripole which permit unusual measurements.

Uses for the REL-500 precision universal meter include the quick measurement of insulation resistance (very small percentage changes in capacitor charge are detected), measurement of pH, and electrostatic charges up to 20 v dc. Designed by J. LeMouzy of Paris and distributed by Rheem Electronics Division, 7777 Industry Avenue, Rivera, Calif., the instrument uses a unique "tripole" circuit.

Three terminals are used as in Fig. 1—*G′K′* are bussed together physically to establish one terminal. In operation the circuit is balanced so that a voltage appearing from *G* to *K* appears with opposite polarity and equal amplitude from *K* to *K′*.

- Side *GK* offers 10^{14} ohms input impedance with a grid current of 10^{-13} amp.
- *GG′* gives a second input circuit where the potential and the impedance are essentially zero.
- Side *KK′* is the output. Twenty mw power is available to drive a meter, galvanometer, recorder or other indicating device from a low Z (less than one ohm) source.

G and *G′* are inputs to opposite sides of a differential amplifier. Terminals *K* and *K′* are the outputs of the cathode followers. The circuit is so balanced that the potential between *K* and *K′* is zero; any variation in the differential circuit will cause this condition to unbalance. A source of power proportional to the amount of variation is thereby made available.

Assume five v positive applied to *G*. The plate of this stage will go negative. Due to the differential action, the opposite plate goes positive. These voltages will make *K* and *K′* go 5 v negative and positive respectively. In the tripole *K′* and *G′* are connected—the positive rise of *K′* is applied to *G′*, raising it to exactly the same potential as *G*.

The potential across *GK* reappears in the opposite polarity between *KK′*. This maintains the zero potential across *GG′* which, to an external circuit, appears as a zero impedance.

Voltage. With the setup shown in Fig. 2(a) voltage can be measured without loading or shunting the device being measured. The equipment used in this way is suitable for measuring unregulated supplies, grid circuits, potentials across high resistances and back-biased diodes. Impedance is high enough to measure electrostatic charges without discharging the source. This is useful for determining pH, or other quantities which can be measured by using electrostatic potentials.

If a capacitor with a high insulation resistance is connected between *G* and *K* and charged, the capacitor will retain the charge until discharged by the grid current or through its own leakage resistance—a period of several hours.

Consider Fig. 2(b). This setup will read small variations of large voltages. When *SW* is closed, the capacitor will charge to *E* with a polarity as shown. Now open *SW*. Any difference between *E* and the charge on *C* will be indicated.

For the charge to vary *C* must discharge through *GK* or its own leakage resistance. Since both these time constants are large, any detected variation is due to a variation in *E*. A very sensitive scale can be used: the original value of *E* is bucked by the charge on *C*. This setup is useful for measuring voltage variation with time or other parameters, power supply variation with input changes and regulation of voltage sources.

RC measurements are made with the same circuit. Substituting a test capacitor at *C* and using a low drift *e*, small percentage changes can be registered. The greatest leakage occurs within the first few minutes or so, depending on the voltage applied, so the test is shortened considerably.

Current. The zero impedance of *GG′* is valuable when no resistance or time constants can be added into the circuit. The tripole is connected as shown in Fig. 3.

Unbalance caused by the unknown current generated by *E* and R_x causes a voltage to appear across R_o. This is shown by the meter at *KK′*. Since the voltage between *G* and *G′* always remains zero (refer to Fig. 1), the external circuit sees zero impedance. The amount of imbalance shown over *KK′* to maintain this zero is proportional to the current in the external circuit. Cur-

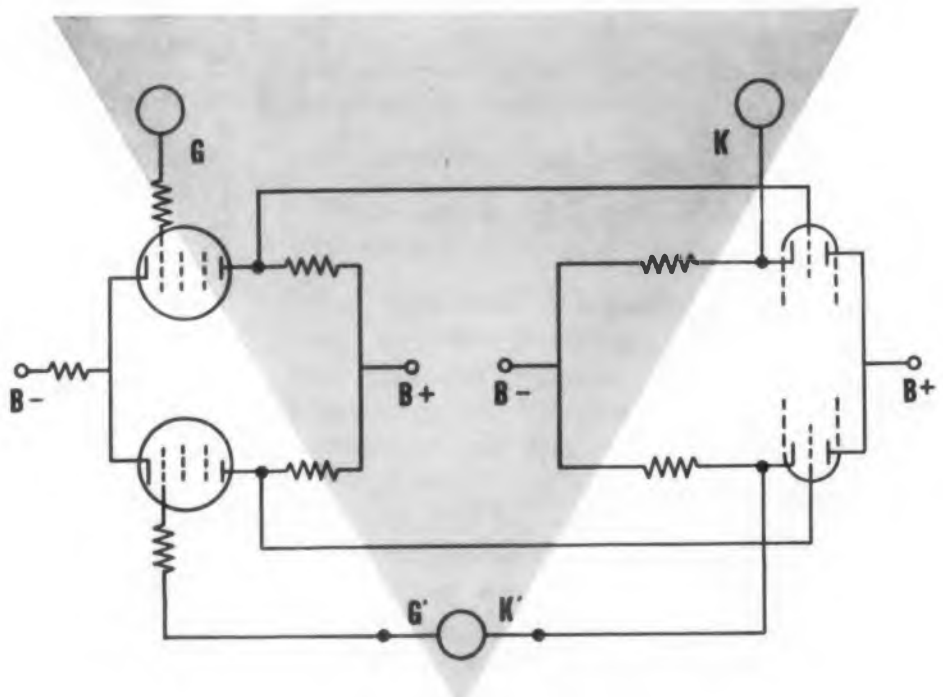


Fig. 1. Simplified schematic of "tripole" circuit. Impedance between terminals G and K is 10^{14} ohms with 10^{-13} a grid current; impedance is zero between G and G′K′. Side K-G′K′ is a low impedance output. G and G′ are inputs to a differential amplifier, K and K′ are outputs of two cathode followers. If differential circuit is unbalanced by an input signal, output power from KK′ will be proportional.

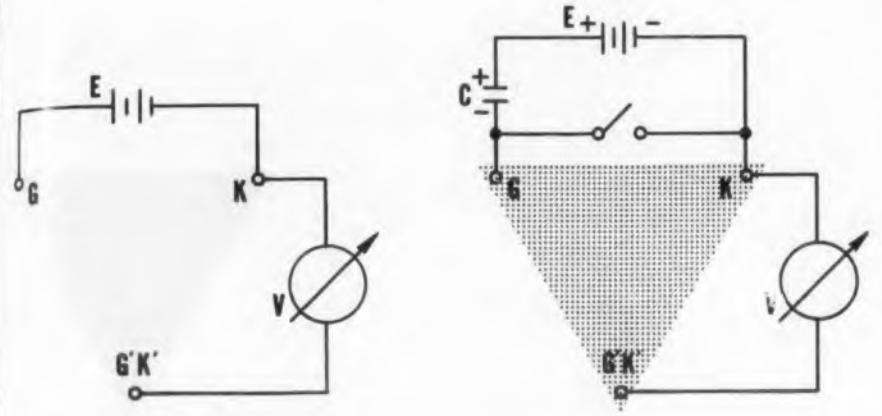


Fig. 2. Set up for voltage measurement as in (a), the multimeter reads up to 2000 v dc without shunting the device being measured. To read small variations in large voltages, a capacitor is charged as in (b). When the switch is opened the capacitor voltage will buck the source; any difference between the two will be registered.

rents in the μμa range are accurately detected.

High Resistance. Clearly, knowing E, I (as shown at V) and R_o, R_x is easily calculated. Since R_o can be 10^3 or so times less than R_x, resistances higher than the 10^{14}-ohm input impedance of the meter can be read with no appreciable loading effects. This is again useful for insulation resistance measurement.

Other applications. By connecting a known capacitor with a high insulation resistance between GK and a known resistor between G and a voltage source as in Fig. 4(a), a good analog integrator is made. GK's high impedance does not load C_o and GG's does not add to R_o. An accurate RC time constant can be constructed; the meter will indicate a voltage which is the integral of e with respect to time, modified by the time constant R_oC_o.

The value of C_x can be found in Fig. 4(b). If C_x is charged to E and discharged into $G'G$, C_o will be charged to a value V proportional to the ratio

$$C_x = C_oV/E.$$

Note that once the tripole has been balanced the accuracy of the reading is almost wholly dependent on the resistors and capacitors used as references, and on the accuracy of the readout device.

For further information on this precision universal meter, turn to the Reader-Service card and circle **100.**

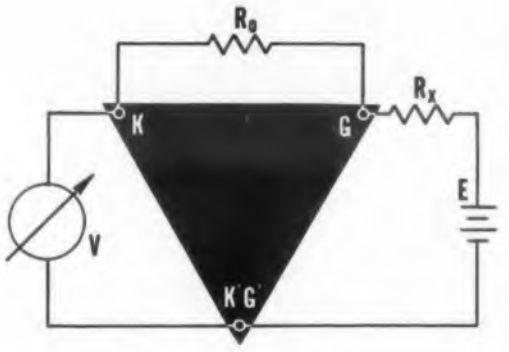


Fig. 3. Effectively, the external circuit—represented by E and R_x—sees no resistance. K and K' are held at the same potential. The amount of energy required to maintain this condition represents the amount of current flowing in the external circuit.

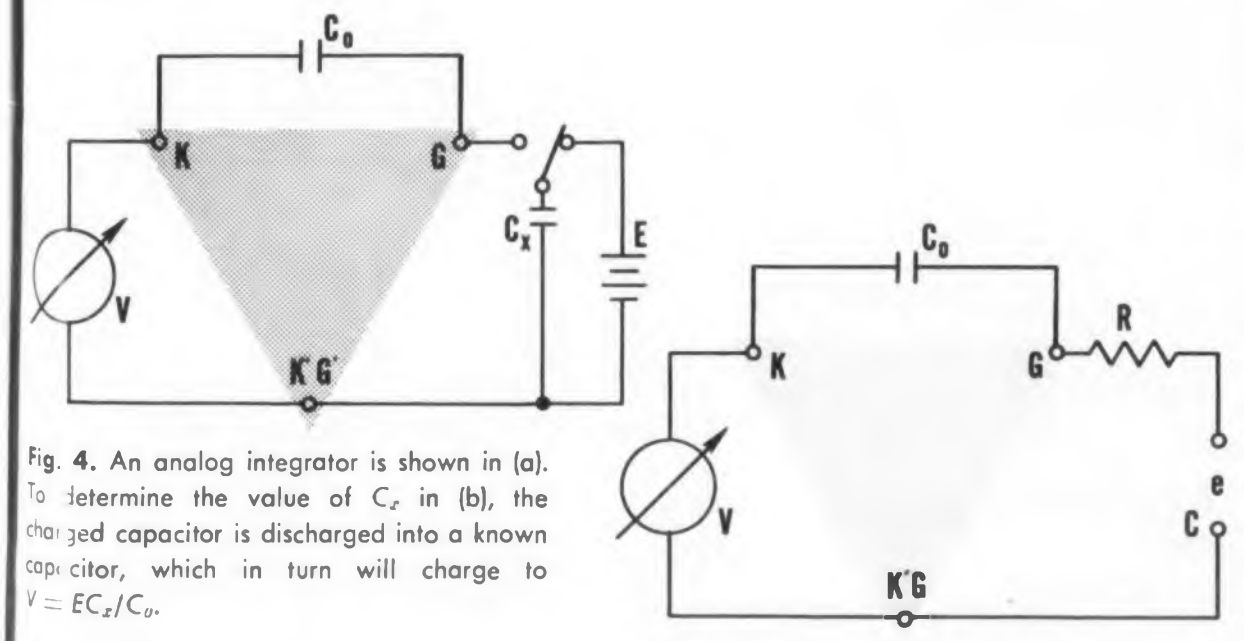


Fig. 4. An analog integrator is shown in (a). To determine the value of C_x in (b), the charged capacitor is discharged into a known capacitor, which in turn will charge to $V = EC_x/C_o$.

Concentrated Filter Passbands

Part 3
LC Filters

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In these days of ultra-subminiaturization and tough environmental requirements, packaged passbands can simplify some sticky problems. These passbands are available in three basic concentrated filter types. In parts 1 and 2 of his article, (*ED*, Aug. 6 and Aug. 20) Mr. Schaner discussed the Electromechanical and the Crystal filters. Here, he concludes with the Electrical or LC filter.

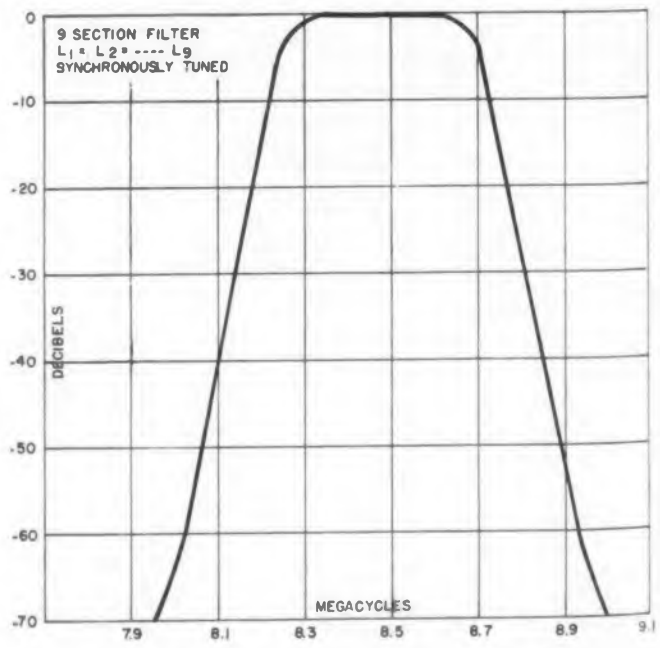


Fig. 1. A typical bandpass selectivity curve for an electrical filter.

Background of the LC Filter

Electrical or LC filters have been used since the first radio circuitry was devised. Following the invention of the superheterodyne, the standard filter was comprised of a number of double tuned LC circuits, cascaded, and separated from each other by tubes. These served as amplifiers and tuned circuit isolators.

These cascaded amplifier-filters were adequate for the many years when radio was used for voice or cw communications only.

But as passband requirements became more and more stringent with respect to shape factor and bandwidth, it was necessary to add more stages and devise special techniques of alignment, such as staggered tuning.

As the number of stages increased, so did the possibility of regeneration, which can cause malformed passbands with poor flatness across the nose, and poor symmetry around the center frequency. To overcome this, many techniques were devised, but they added to the complexity and cost of amplifiers.

Cascaded amplifier filters have inherently poor noise figures because noise generated in the first tube is amplified and added to by all subsequent tubes.

To produce better band characteristics with cascaded amplifiers, some equipment was made with triple and quadruple tuned LC circuits. While these produce much better passband characteristics, alignment difficulty increases many times.

REQUIREMENTS for wide, rectangular passbands, as in data link and some single side band applications, are best met by concentrated electrical (LC) filters. In these filters the passband is formed in one passive array of tuned circuits.

In application in a receiver, this network is inserted as close to the point of lowest noise as possible. The filter is followed by circuitry which furnishes the required amplification and has a passband wide enough to pass the bandwidth of the filter. In such applications, the noise is greatly attenuated compared with what would appear at the output of a conventional cascaded filter-amplifier array.

The shape factor of a concentrated filter with a given number of tuned circuits is compared with shape factors for tuned circuits in single and double tuned configurations in the table at the top of the following two pages.

LC filters have one very important advantage over mechanical and crystal filters. In a well designed LC filter, there are no reversed slopes or spurious responses in the skirts of the passband to degrade the performance of the device using the filter.

Mechanical Characteristics

Concentrated LC filters can be made half as large as conventional cascaded filters. By ingenious design and miniaturization, one of these filters and its wide band amplifier can be made one third the size of its nearest equivalent cascade filter.

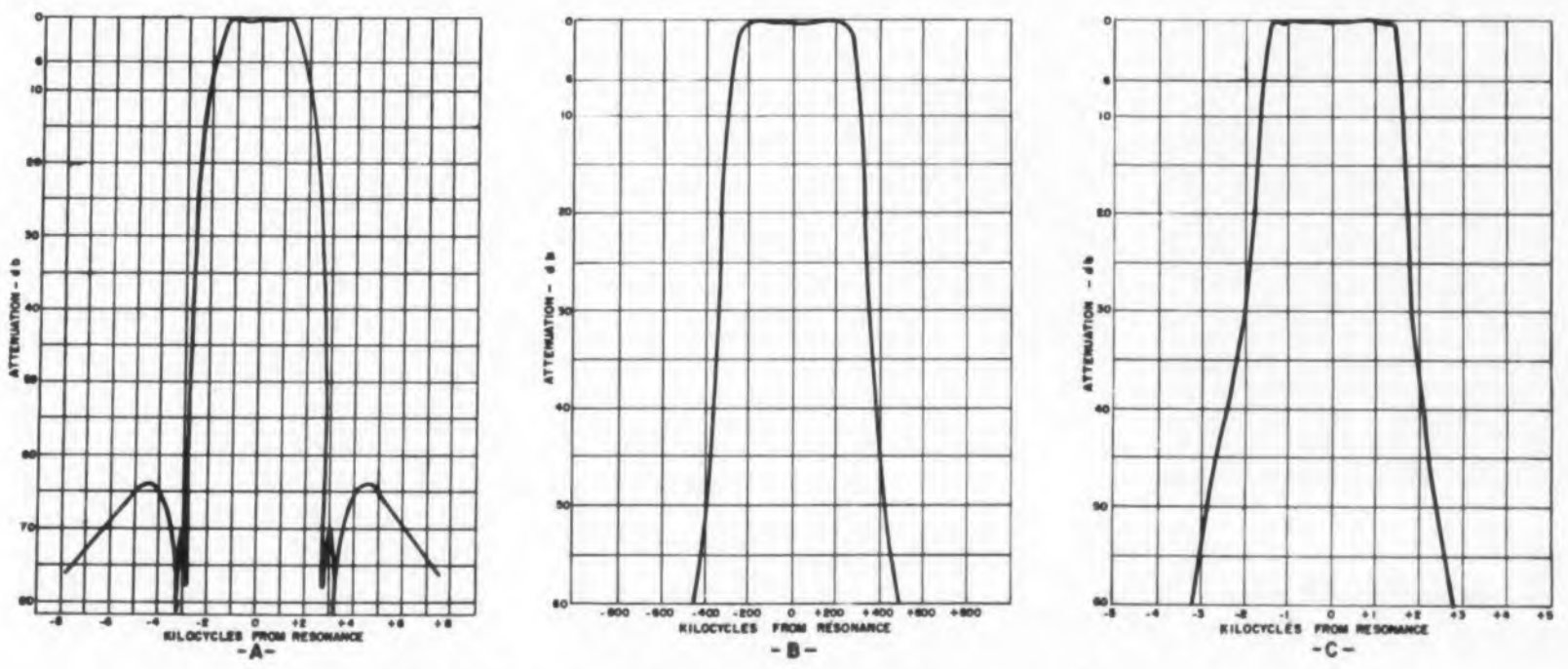
Concentrated LC filters and wide band amplifiers with subminiature tubes have been made to provide 100 db gain, and to occupy less than nine cubic inches. Transistors will reduce this figure further.

In its most efficient form, a concentrated electrical filter uses subminiature toroidal inductors and subminiature capacitors. Each tuned element is housed in a cell-like shielded compartment, and joined to others like it to form an egg-crate like structure. This structure is very rugged, and provides the best isolation between adjacent tuned elements.

The entire filter can be potted. It can then meet any of the existing requirements for resistance to vibration, acceleration, and shock. The filter is then ideal for aircraft and missile applications.

High Temperature Performance

Missile and aircraft applications often call for operation at high temperatures. Since electrical filters are passive devices, they don't generate heat. Heat that gets into the filter from the out-



A. Crystal Filter. Center frequency 100 kc. Shape factor 1.7 (60 db to 6 db);

B. Electrical (LC) Filter. Center frequency 8.5 mc. Shape factor less than 2.1 (60 db to 6 db);

C. Mechanical Filter. Center frequency 455 kc. Shape factor less than 2.1. (60 db to 6 db).

Fig. 2. Typical selectivity for the three basic concentrated filters.

Table 1

COMPARISON OF SHAPE FACTOR OBTAINABLE WITH CONVENTIONAL CIRCUITS AND CONCENTRATED LC FILTER CIRCUITS.

TUNED ELEMENTS	$\frac{B.W.\ 60}{B.W.\ 6}$ SINGLES
2	32
3	13
4	8.7
5	6.8
6	5.9
7	5.1
8	4.9
9	4.6
10	4.4

side is usually evenly distributed.

Stabilized toroids, tuning capacitors with good retrace characteristics, and high quality temperature compensating capacitors can be used to provide a filter with minimum center frequency shift and negligible change in the symmetry of the passband over a wide temperature range.

Impedance

What makes electrical filters exceptionally valuable in subminiature equipment is the fact that the input and output impedances can be tailored to meet almost any requirement without increasing insertion loss materially. They can be terminated in any combination of high and low, input and output impedances.

The fact that low impedance terminations are available makes it possible to place the filter far from circuits preceding and following it. This is important where packaging efficiency is of prime importance.

Tuning Range

Electrical filters are easily tuned over a reasonably wide range, so the designer can change the

Shape Factor $\frac{\text{B.W. 60DB}}{\text{B.W. 6 DB}}$ of "N"

Tuned Circuits when connected as:

1 - Isolated Single Tuned Circuits

2 - Isolated Double Tuned Circuits with Critical Coupling

3 - A Concentrated Filter with Butterworth Response

$\frac{\text{B.W. 60}}{\text{B.W. 6}}$ DOUBLES	$\frac{\text{B.W.60}}{\text{B.W. 6}}$ Conc. FILTER
24	24
-	8.3
5.6	4.9
-	3.6
3.6	2.9
-	2.5
3.0	2.2
-	2.1
2.6	1.9

center frequency of an i-f system without changing filters.

Their flexibility with respect to terminations and tuning makes these filters particularly valuable laboratory tools for front end and detector development.

Passband

The selectivity curve of a typical electrical filter is shown in Fig. 1, while Fig. 2 compares the selectivity of the three basic concentrated filter types.

References

Electromechanical Filters for 100 kc Carrier and Sideband Selection, R. W. George, *Proceedings of the IRE*, Vol. 44, pp 14-18, Jan. 1956.

Survey of Mechanical Filters and Their Applications, J. C. Hathaway and D. F. Babcock, *Proceedings of the IRE*, Vol. 45, pp. 5-16, Jan. 1957.

Quartz Crystals for Electrical Circuits, Raymond A. Heising Chapter 14, D. Van Nostrand Co., Inc., 1946.

Mechanical Filters, Theory and Application, *Bulletin 200*, Collins Radio Co., Cedar Rapids, Iowa.

Designing Broadband Conical Helix Antenna

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Philadelphia 6, Pa.

Circularly polarized antennas are widely used today in such applications as telemetering, missile tracking, and counter-measures. They have the ability to receive (or transmit) electromagnetic energy of arbitrary polarization. But their bandwidth is limited to less than 2:1.

This article traces the evolution of a new type of conical-helix antenna which promises to solve the broadband, circularly polarized requirement. A conical helix having a 2:1 bandwidth has been converted to one with a 6:1 bandwidth by proper parameter choice.

CONICAL helix antennas, apex-fed, inherently offer a broadband structure.[1,2] Previously modified cylindrical helixes and combinations of cylindrical helixes had an optimum bandwidth of only about 2:1.[3]

Experimental work on broadband conical helix antennas at American Electronics Corporation is based on parameters shown in Fig. 1. From Fig. 1:

$$\text{Sin } \gamma = \frac{a}{r}$$

$$\text{Tan } \alpha = \frac{dr}{a d\phi}$$

$$= \frac{dr}{r \text{ Sin } \gamma \, d\phi}$$

Then:

$$\frac{dr}{r} = \text{Sin } \gamma \text{ Tan } \alpha \, d\phi$$

Integrating:

$$r = r_o \, \epsilon^{2\pi r \text{ Sin } \gamma \text{ Tan } \alpha}$$

From the equation, it can be shown that the spacing between turns increases at an exponential rate from top to bottom. If the spacing between turns were constant, the pitch angle would vary all along the helix. This would lead to fabrication difficulties.

21-Degree Conical Helixes

Experimental work on the conical helix began with a family of helixes whose included cone angles were all 21 deg. Many variations of the conical form were tried without realizing any increase in bandwidth over a cylindrical helix. After some intuitive design changes, however, a conical helix was produced (Fig. 2, right rear) which functioned in the axial mode over a 2:1 bandwidth. Its measured characteristics are given in Fig. 3.

Significant features of this new member of the circularly polarized family are:

- Bandwidth in excess of one octave—a significant improvement in itself.
- Physical rigidity far greater than that attainable with a cylindrical helix due to conical form.
- Smaller overall size than cylindrical helix.
- Conical helix is matched inside the feed transmission line which is itself inside the coil volume. The cylindrical helix must be matched behind its base plate.

Larger Cone Angles

Following development of the 21-degree family of conical helixes, a new group of conical helixes was developed with larger cone angles. Data on these are presented in Table I. All of the antennas were designed for low frequency cutoff at 400 mc. Benefits realized from the larger cone angles are apparent, particularly when the relative dimensions of the cylindrical helix are compared with those of the conical helixes.

Use Plastic Base

The 60-deg conical helix (Fig. 2, right front) is mounted on a plastic base plate. The original family of 21-deg conical helixes operated on metallic base plates as do cylindrical helixes. Thus, it was originally thought that the wave was propagated down the helix coil from the feed and was reflected into space by the base plate.

However, too large a metal base plate interferes with the main helix lobe—quite contrary to the benefit derived from an infinite ground plane

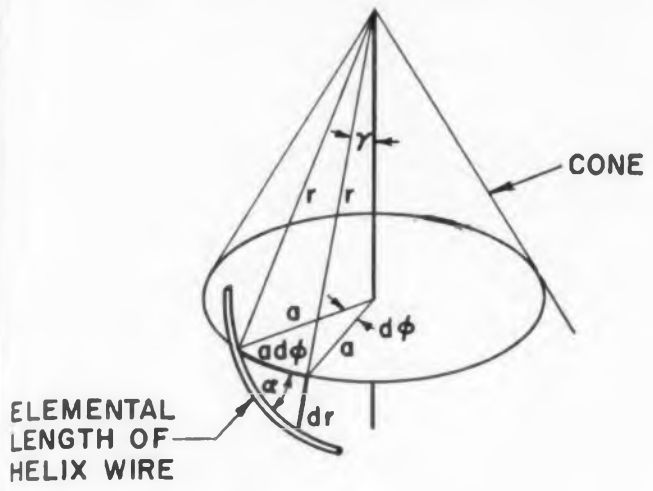
TABLE I. COMPARISON OF CONICAL HELIXES WITH A CYLINDRICAL HELIX

CONICAL HELIXES

FREQUENCY RANGE (mc)	COIL BASE DIAMETER (inches)	COIL HEIGHT (inches)	COIL ANGLE (degrees)	RELATIVE COIL HEIGHTS	RELATIVE COIL VOLUMES
400-800	10.8	22.3	21	0.80	0.47
400-1200	15.1	16.6	42	0.60	0.58
400-1600	14.0	10.8	60	0.38	0.42

CYLINDRICAL HELIX

FREQUENCY RANGE (mc)	COIL DIAMETER (inches)	COIL HEIGHT FOR 5-TURN HELIX (inches)	RELATIVE COIL HEIGHT	RELATIVE COIL VOLUME
400-720 (f_o = 540)	7.0	27.7	1.00	1.00



α = PITCH ANGLE
2γ = CONE ANGLE
r = RADIUS VECTOR WHICH DESCRIBES HELIX
r_0 = RADIUS VECTOR TO HELIX START
ϕ = 2Πn
n = NUMBER OF TURNS

Fig. 1. Parameters for derivation of Conical-Helix Equation.

Fig. 2. Experimental Conical Helixes. Three of these are discussed in the text.

for a cylindrical helix. It was found that the 21-deg conical helix functioned equally well with no ground plane. Therefore, no ground plane was used on any of the subsequent conical helixes.

Can Be Grouped

Multiple groupings of conical helixes have been used in many countermeasures applications by mounting all antennas on a large absorbing plate. This mounting allowed a solid sheet of metal to be placed behind it without interfering with the helix patterns.

In order to mount individual conical helixes by means of metal brackets, individual absorbing plates are required to provide isolation. Such helix configurations have proven successful, and all future conical helixes designed for individual mounting will be fabricated with an absorbing base plate.

Measured data (Fig. 4) on the 60-degree conical helix show one rather unusual characteristic: the fairly constant beam width exhibited over its operating band. This is quite different from the beam width of a cylindrical helix which is an inverse function of frequency. As can be seen, the axial ratio and VSWR are both less than 3:1 from

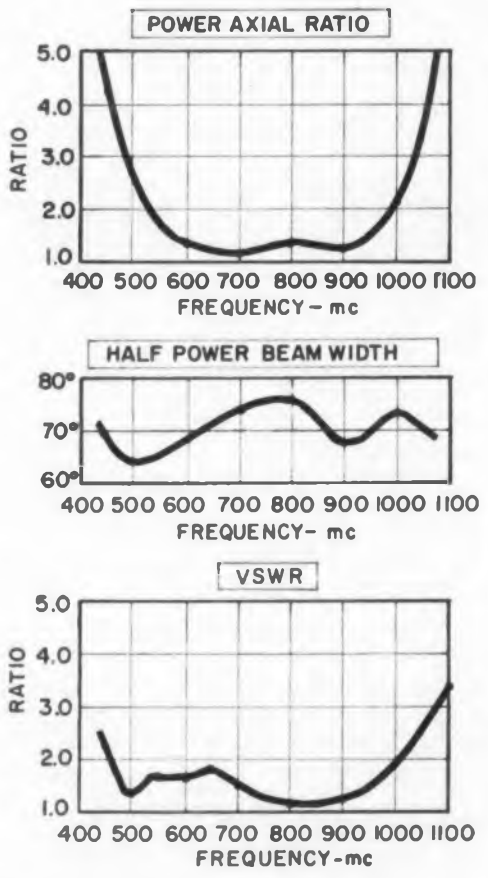


Fig. 3. Measured Characteristics of 21-deg Conical Helix.

Designing Broadband Conical Helix Antenna (continued)

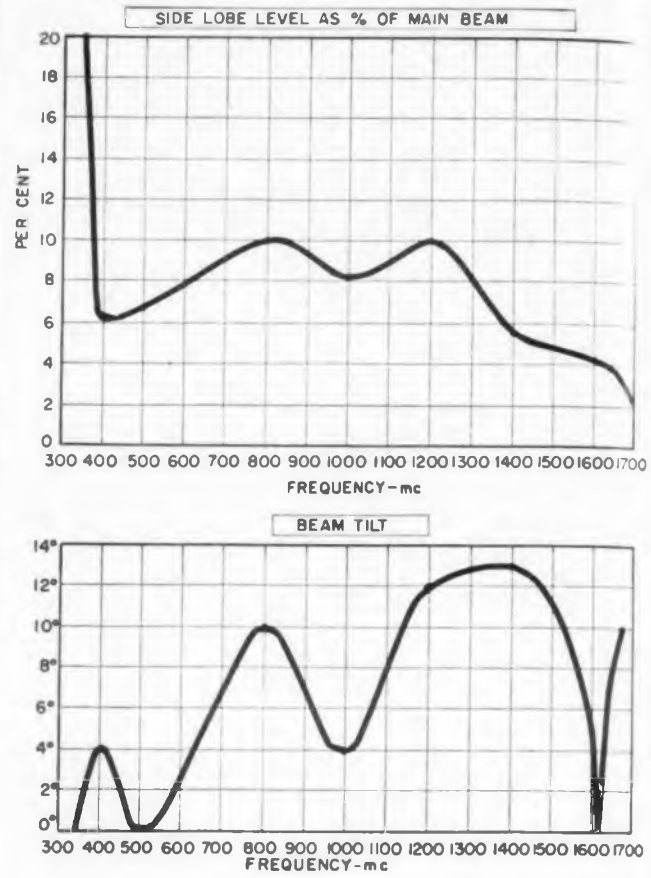


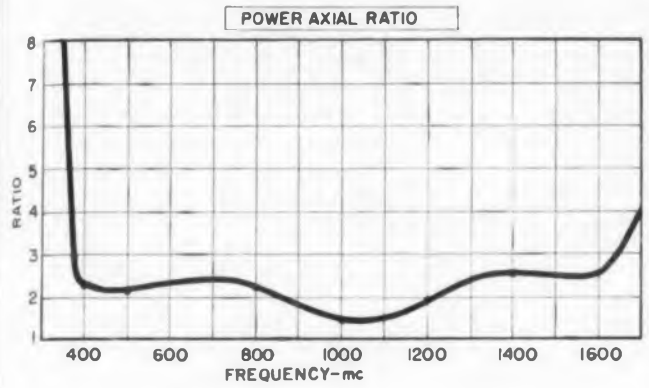
Fig. 4. Measured characteristics of 60-deg Conical Helix.

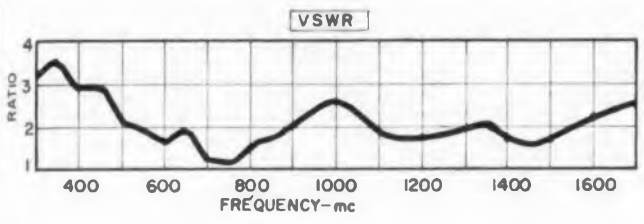
400 to 1600 mc. In Fig. 6, the side lobe curve shows a maximum level of 10 per cent from 400 to 1600 mc.

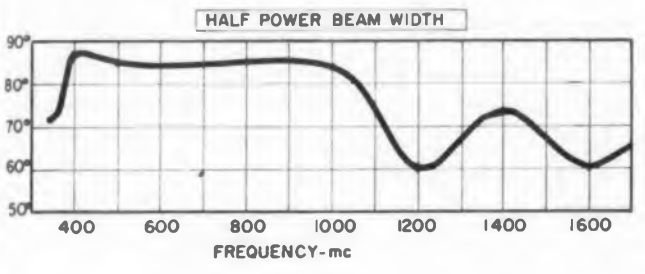
Better Performance Possible

Maximum beam tilt is 13 degrees between 400 to 1600 mc. This is probably due to physical assymmetry which can be eliminated by improved fabrication techniques. More precise coil fabrication will considerably improve the data presented in Fig. 4. The 60-degree helix has 12 turns with a pitch angle of 3.4 degrees and functions, as indicated above, from 400 to 1600 mc. Recently a conical helix was designed for telemetering use. A low-frequency cutoff of 200 mc was considered adequate. Three turns were added to the 60-degree helix which almost doubled the coil base diameter.

This 15-turn, 60-degree telemetering helix model (Fig. 2, center, rear) has a usable range of 200 to 1200 mc. Not only has the low-frequency cutoff been reduced by a factor of two in scaling the 60-degree diameter larger but, equally significant, the high frequency response of the helix







has been only slightly impaired. The original bandwidth of 4:1 has been increased to 6:1. At 1000 mc, moreover, the measured gain of this helix was 5 db greater than that of a dipole.

Two important questions remain to be answered by further experimentation:

- Can the high frequency end of the telemetering helix be increased by making the top coil diameter smaller?
- Can the low frequency cutoff be decreased even further by adding turns to the telemetering helix without impairing the high frequency response?

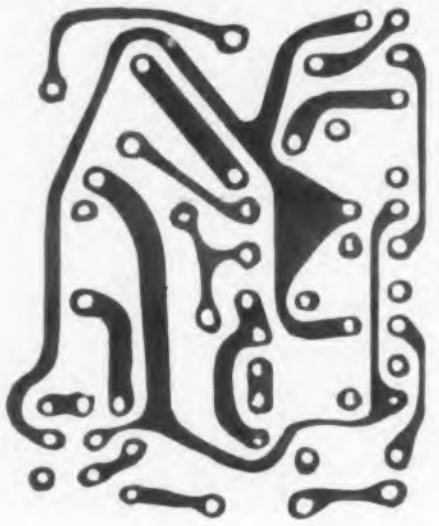
The bandwidth limitations of the conical helix certainly have not been reached to date and will only be reached when these questions are fully resolved.

References

Radiation Field of a Conical Helix, J. S. Chatterjee, *Journal of Applied Physics*, Vol. 25, pp 550-559, May, 1953.

Radiation Characteristics of a Conical Helix of Low Angles, J. S. Chatterjee, *Journal of Applied Physics*, Vol. 26, pp 331-335, March, 1955.

Antennas, J. D. Kraus, McGraw-Hill, 1950, p 173.



Printed Circuit Artwork

The easy way

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Senior Eng.,
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Two techniques have been established which substantially reduce the time required to get art work before the camera. Conventional drafting room practices have been abandoned and a fresh approach made to the problem. This article follows step by step, the development of a working sketch for an experimental circuit board from schematic to finished negative.

ART WORK for printed-wiring layouts is used to produce a negative of proper dimensions and of such quality that a printed circuit can be made to a pre-determined standard. The standard will vary according to the usage. For example, if a "cheap and dirty" printed circuit will fill the need for an experiment, it is folly to prepare art work of top quality.

Preliminary Steps

The experimental printed circuit is quickly laid out when grid lines are disregarded. Take a typical subject as shown in Fig. 1.

Component leads are marked on the schematic with colored pencils to help in orienting components. Black is used to denote common grounds. A red triangle is placed on high voltage component terminations. Colors are selected for other functions to identify them as being common to each other.

Overall dimensions and outline of the printed circuit board are laid out on vellum exactly full scale. A template is used to draw in all chassis mounting holes and other components which must be located to mate with parts not on the board (Fig. 2).

A template having circles and rectangles is recommended for layout work. Half-watt resistors use a template 1/2 in. long. Mounting holes are kept to 5/8 in. The template is used to draw a 1/16 in. hole to mark the holes into which the component leads will be inserted as shown in Fig. 3.

The components are laid in relation to their termination on the tube sockets and a common ground of voltage source. Working from the component side of the board, a drawing is made with pencil (Fig. 3.). As each component is drawn in place, its symbol should be noted to

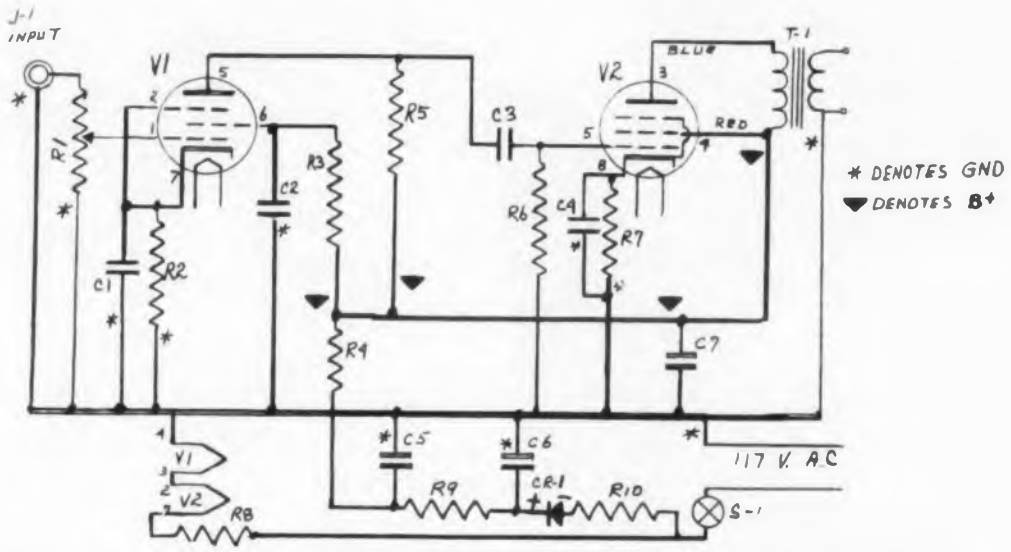


Fig. 1. Typical schematic shows how component leads are identified. Asterisk represents ground connections; triangle represents high voltage terminations.

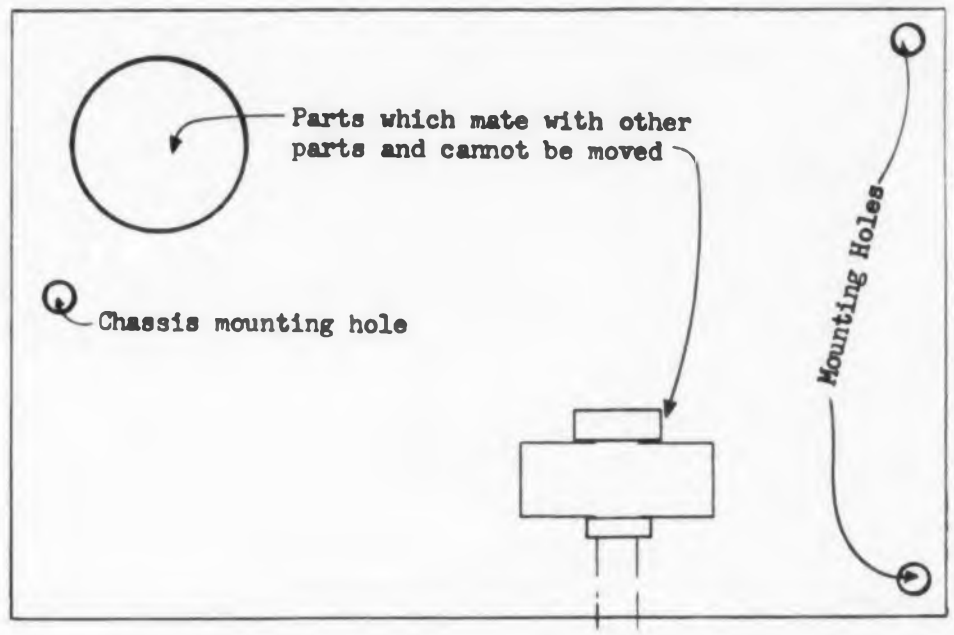


Fig. 2. External outline drawn to scale with fixed components.

identify it with the schematic. All connecting circuitry between components is made with colored pencils on the back side of the vellum (Fig. 4). This will allow erasures and relocations of components without obliterating the connecting circuitry. It is also possible to erase the colored lines without disturbing the outlines of the components. Note that *R*11 and *R*8 have been moved in Fig. 4 to facilitate connecting.

The only dimension which it is important to maintain is the distance between mounting holes for similar components. For example, the mounting holes for all 1/2 watt resistors can be maintained at 5/8 in. while all 1 watt carbon resistors can be mounted on 7/8 in. centers. Holding these dimensions makes it possible to pre-bend these component leads in a "Pigtailer" or on a jig before assembly and materially speeds production.

After all the components have been placed where they can be connected using a one-sided board, the working sketch is finished. Now the problem of producing suitable art work begins.

Carbon Paper Art Work

Where high quality is not required, a carbon paper drawing is more than adequate. The scale drawing or working sketch just described is the basis for this art work.

First, place a clean vellum over the working sketch and trace in all the mounting holes using a 1/16 in. diam template. Be careful to keep component mounting centers within tolerance. During this operation it may be advisable to shift the position of a few components slightly to allow more clearance for printed wiring conductors. This can be determined by examination of the colored lines on the back of the working sketch.

When all the mounting holes have been retraced, the vellum is placed over a clean piece of black carbon paper with the carbon side up (Fig. 5). Using a 5/32 in. diam template, form the solder pads. Carefully circle the 1/16 in. hole in the center of the pad and apply sufficient pressure to make a uniformly black area on the back of the vellum. By observing the colored lines on the working sketch as they appear through the vellum, the conductors can be drawn from pad to pad. Use a french curve as a guide. Since the scale is 1 to 1, the width of the

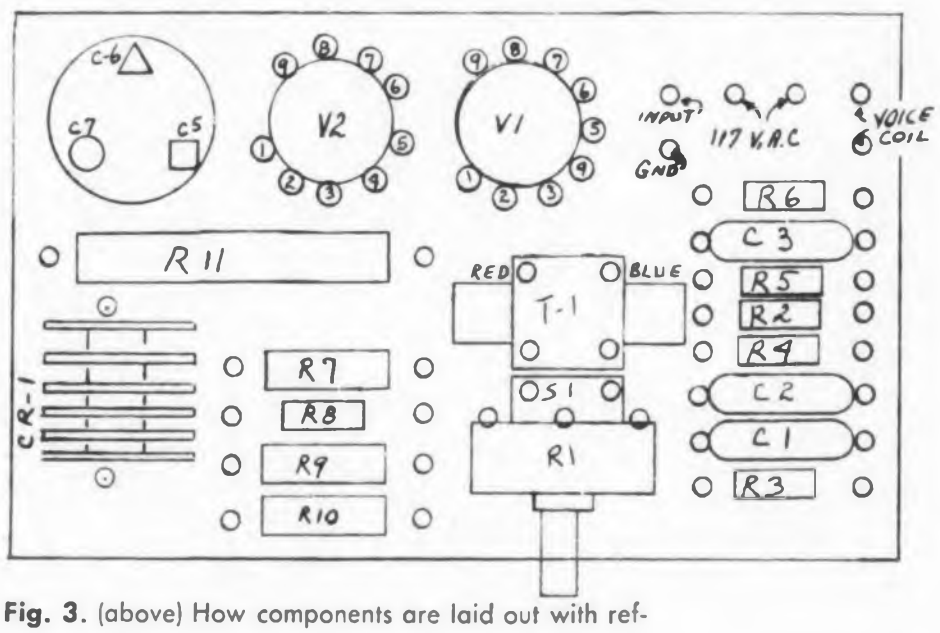


Fig. 3. (above) How components are laid out with reference to the schematic.

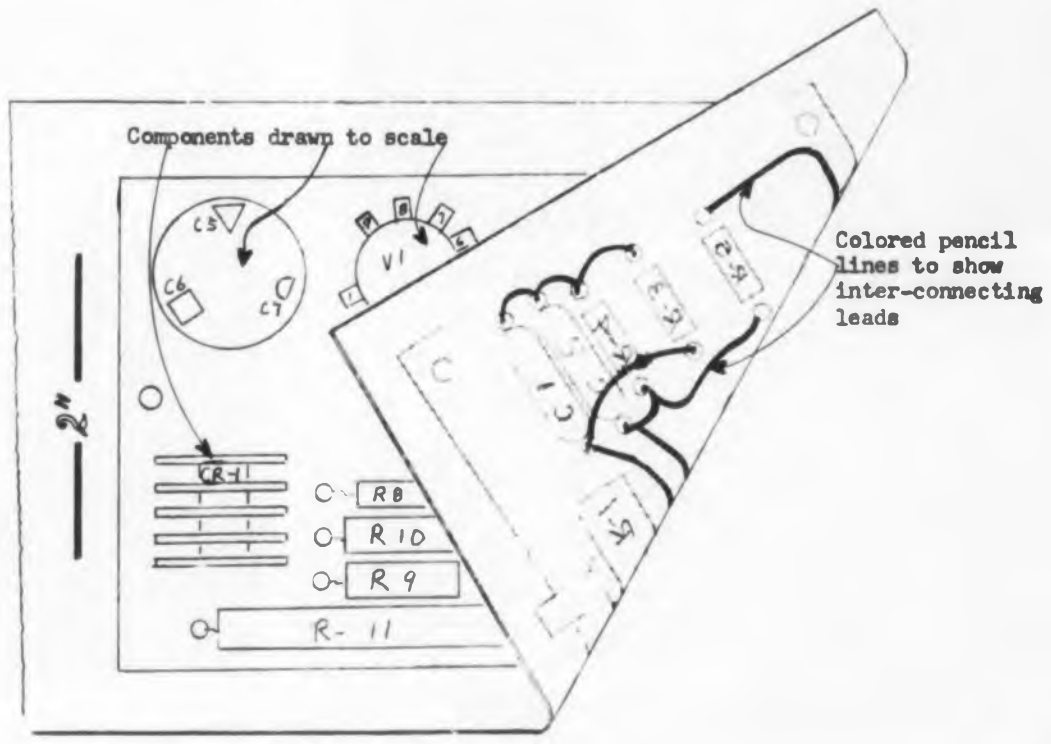


Fig. 4. (right) Colored connecting leads are drawn on the reverse side of the vellum.

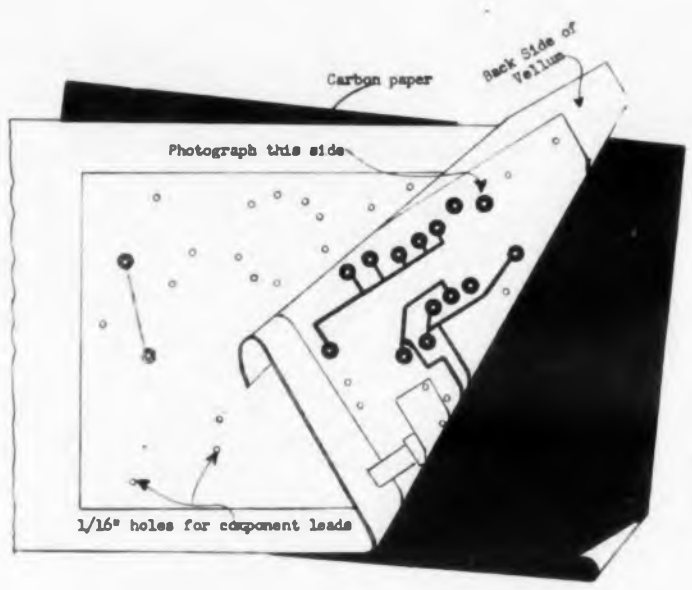


Fig. 5. Using black carbon paper to draw pads and conductors on vellum.

drawn lines and the clearance between conductors or pads can be readily observed and controlled.

After the drawing is complete, the printed circuit will appear in carbon on the back of the vellum as shown in Fig. 5. Because carbon smears easily and is often full of tiny voids, the art work should be sprayed with two or three light coats of Krylon crystal clear No. 1303 spray coating. The Krylon spray dissolves the surface of the carbon and renders it more homogenous in addition to making it resistant to smearing.

Marking and Symbols

Where lettering is required on the printed circuit side of the board, a typewriter can be used. The 1 to 1 scale will permit it. Contrast may be increased by placing carbon paper up-side down between the platen and the vellum.

Lettering The Component Side Of The Board

Place a clean vellum over the working sketch and trace in the general outline of the board. Trace in two of the mounting holes which will be used to secure the printed circuit board to a chassis. These two should be near the corners of the board and must register with similar holes on carbon art work drawing. The outline of the components can be seen through the vellum and their symbols can be either hand lettered in ink or identified by pasting lettered slips of white paper in position over the proper components. Paste two drawings on a plain white sheet side-by-side so that they can be photographed on the same negative. It may be necessary to opaque the negative in order to remove any blemishes.

Fig. 6. Equipment set up for tape and tab art work.

With a little opaque, the clearance between leads or pads can be increased and, with an Exacto knife or etching knife, a conductor can be widened. It is possible to completely obliterate a conductor path and make a new one while retouching the negative. The board can now be made by any method requiring a negative.

Magic Lantern Or Opaque Projector Method

Where a projector is available for the projection of pictures from opaque material, a great deal of time can be saved after the working sketch is finished. Simple equipment is required as shown in Fig. 6.

A large pane of glass is mounted in a suitable frame to support it in a vertical plane. White tracing paper or cloth is taped to the glass on the opposite side from the projector. Set the projector at a proper distance to focus the image on the tracing paper with an enlargement of about 3 to 1. Draw a single straight line on the working sketch exactly 2 in. long and label it as such. Place the working sketch in the projector and focus it.

By working from the back of the tracing paper, the image can be clearly seen. Use black tabs and place one on each component mounting hole. The colored lines on the working sketch will show up and can be plotted with black tape from point to point. Within a few minutes the entire circuit can be laid out with tape and tabs. Since the work is being done on the back side, the operator will not be bothered with shadows and the circuit side of the board is automatically produced while the component side of the working drawing is being projected on the tracing paper.

Maintaining Scale

A piece of tape must be carefully placed over the image of the 2 in. line and cut to exactly coincide with its length. The exact amount of increase in size of the tape and tab drawing over the original full-scale sketch is of no consequence, since the camera will reduce the 2 in. line to its original length. Generally, a magnification of three times is about right, since a 1/8 in. wide tape will then provide a conductor of 1/24 in. wide on a finished board.

The tape and tab technique produces the best art work and is highly recommended where proper equipment is available. However, it is necessary to do all lettering on an enlarged scale, which precludes the use of the typewriter. Art work prepared by the projection method can save as much as 90 per cent over conventional methods. This method also allows the drawing to be made directly on standard drawing forms and is limited in size only by the size of the glass or tracing paper.

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

NON-LINEAR POTENTIOMETER

This 2-in. diameter sine-cosine potentiometer can deliver 0.5 per cent peak to peak accuracy without the use of pads or cams. Resistance range of up to 70 K per quadrant is available. The double wiper is provided with a removable external coupling, permitting any number of pots to be quickly and easily ganged.

Micro Machine Works, Inc., Micro-Lectric Div., Dept. ED, 19 Debevoise Ave., Roosevelt, N.Y.

CIRCLE 46 ON READER-SERVICE CARD

DIGITAL TAPE RECORDER

This recoverable 25-channel digital tape recorder is designed for use in missile and airborne test vehicles. As a complete on-board recording system, the unit ties up no ground facilities. The recorder can be operated to determine time-of-event, magnitude, digital phase relationship and pulse rate frequencies in excess of 100 cps. Data resolution is in excess of 5 msec. Weight of the recorder, including armored protective case, is less than 4-1/2 lb.

Recorder drive motor operates on 28 v dc and requires less than 1.5 amp. Unit has a 4-1/2 in. OD and a height of 4-1/8 in.

Aerophysics Development Corp., Dept. ED, P.O. Box 689, Santa Barbara, Calif.

CIRCLE 47 ON READER-SERVICE CARD

TUBULAR PRINTED CIRCUITS

Direct printing of solderable silver circuits on either the exterior, interior, or both surfaces of tubes is provided. The circuits may be applied to almost any type of non-conducting tubular material including Teflon, Kel-F, epoxy, phenolic, polyester, silicone, glass, ceramic, and thermoplastics. Conductive inks are deposited from 0.0004 to 0.0015 in. depending upon requirements. Pattern tolerance can be held, under some circumstances, to ±0.001 in. The circuits are stable up to 500 F. The tubes have been used as instrument housings, faraday shields, capacitance type fuel gages, resistors, heaters, probes, commutators, and microwave parts.

J. Frank Motson Co., Dept. ED, Flourtown, Pa.

CIRCLE 48 ON READER-SERVICE CARD

TANTALUM CAPACITORS

Offering high capacity per unit volume, the tantalum capacitor shown in the center has ratings of 1300 μfd and 30 v dc, identical to larger units on either side. The miniature units are additions to the XTV line of capacitors. Temperature range is −55 to +175 C. Designed for computer and missile applications.

P. R. Mallory & Co., Inc., Dept. ED, 28 S. Gray St., Indianapolis, Ind.

CIRCLE 49 ON READER-SERVICE CARD

NEW PRODUCTS

Electrolytic Capacitors

Low cost

A small tubular electrolytic capacitor, the low-cost type 31D Cera-lytic is for use in radio receivers. Its low leakage current construction meets requirements of transistor circuitry.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 59 ON READER-SERVICE CARD

Welder

Press Type

Precision press type bench welders, series 93-V, suitable for welding small, intricate electronic parts. Simple welding tip changes can alter the device for 35 to 50 welding combinations, and a selector knob makes 11 heat adjustments. Capable of making 50 to 100 welds per minute, the welders come in four sizes: 1, 2, 3, and 5 kva. They are supplied from 0.5 to 10 cps or more.

Eisler Engineering Co., Inc., Dept. ED, 750 S. 13th St., Newark 3, N.J.

CIRCLE 60 ON READER-SERVICE CARD

Transistor Power Supplies

Dc to high voltage dc or ac

Transistor power supplies with inputs ranging from 6 to 24 v dc, and outputs ranging from 200 to 400 ma. Ambient temperature range is −55 to +70 C. Units are shock and vibration resistant.

Kupfrian Mfg. Corp., Dept. ED, 395 State St., Binghamton, N.Y.

CIRCLE 61 ON READER-SERVICE CARD

Pulse Switch

For momentary contact

Spdt pulse switch for use where momentary contact on make or break is required. Opens or closes a contact for 10 msec when the plunger is depressed. Electrical rating: 3 amp inductive and 4 amp resistive at 30 v dc.

Switch-Lock Inc., Dept. ED, 7131 Vineland Ave., North Hollywood, Calif.

CIRCLE 62 ON READER-SERVICE CARD

Accelerometer

Measures accelerations from 0 to 100 cps

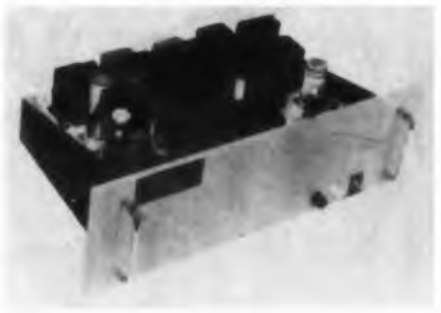
Type 4-260 accelerometer uses variable reluctance to measure accelerations from 0 to 100 cps up to ±12 g. Output is dependent on the unbalance of an initially balanced bridge, and is compatible with data-acquisition systems using other bridge-type transducers.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 63 ON READER-SERVICE CARD

Ratio Computer

Accuracy of 1 per cent



The model 0557-2 precision ratio computer uses chopper and ac circuitry and has almost no drift. It computes to an accuracy of 1 per cent the ratio of two independent dc signals as low as 1 mv full-scale. The level of the inputs is used to control the servo loop gain, allowing for dynamic ranges of input signals of over 50 to 1. Self-contained, the unit operates on 115 v, 60 cps power.

Magnetic Instruments Co., Dept. ED, 546 Commerce St., Thornwood, N.Y.

CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS

Mylar Capacitors

For printed circuit use

Miniature Mylar capacitors Types M and G have radial leads for printed circuit use. Temperature range is —55 to +125 C with derating above 85 C, and resistance capacitance product exceeds 10^6 meg μf at 25 C. Though designed for commercial use, they meet MIL-C-19978 requirements.

ACF Electronics, Dept. ED, 1321 Leslie Ave., Alexandria, Va.

CIRCLE 67 ON READER-SERVICE CARD

Wirewound Resistors

Miniature

The MIN-ISTOR series miniature precision wirewound resistors have higher wattage ratings owing to an insulating compound which encapsulates the units and is applied to the winding. The axial style NS-6AV-SP, 3/16 in. in diam and 1/2 in. long, is rated at 0.5 w to 105 C ambient with a maximum 400 K value.

Eastern Precision Resistor Corp., Dept. ED. 675 Barbey St., Brooklyn 7, N.Y.

CIRCLE 68 ON READER-SERVICE CARD

Strain Gage Indicator

Has digital readout

Strain gage indicator model UDTI-2 has an accuracy of ±0.15 per cent of full scale range. Standard readout ranges are from 0 to 200 to 0 to 5000.

Performance Measurements Co., Dept. ED, 15301 W. McNichols Rd., Detroit 35, Mich.

CIRCLE 69 ON READER-SERVICE CARD

Hysteresis Motor

Has low heat rise

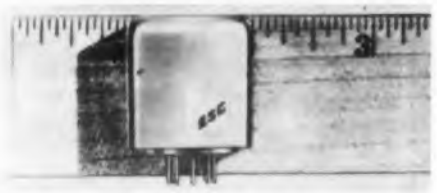
Sub-fractional horsepower hysteresis motor with heat rise of 20 to 38 C. Horsepower ratings from 1/200 to 1/20 with a running torque of 28 to 28 in.-oz. Different rpm's can be selected by varying input frequency.

Dale Products, Inc., Dept. ED, Box 136, Columbus, Nebr.

CIRCLE 70 ON READER-SERVICE CARD

Pulse Generator

0.2 μsec rise time



Available with fixed or variable pulse rate, the Modupulser pulse generator has a prf range of 400 cps to 15 kc. Rise time is 0.2 μsec.

ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N.J.

CIRCLE 71 ON READER-SERVICE CARD

Transistor Test Set

Ranges from 100 cps to 200 kc

The Model KP-2 can be used for frequencies from 100 cps to 200 kc. It offers a current range of from 100 μa to 1 amp with two regulated semiconductor power supplies for bias voltages and currents. Models available for use up to 2 amp.

Baird-Atomic, Inc., Dept. ED, 33 University Rd, Cambridge 38, Mass.

CIRCLE 72 ON READER-SERVICE CARD

NEW PRODUCTS

Panel Meter

Anti-parallax scale

An anti-parallax scale for use with model MM-3 3-1/2 in. meters places dial markings in the same plane as the pointer. The pointer swings under the raised scale.

Marion Electrical Instrument Co., Dept. ED, Grenier Field, Manchester, N.H.

CIRCLE 75 ON READER-SERVICE CARD

Relay

For use with thermoregulators

Model T-681 transistorized relay for use with thermoregulators and other units requiring microampere operation. Using 110 to 120 v ac power, it provides a 5 μa activating current through the thermostat or other sensing element and controls a load up to 1500 w.

Precision Thermometer & Instrument Co., Dept. ED, 1434 Brandywine St., Philadelphia 30, Pa.

CIRCLE 76 ON READER-SERVICE CARD

Converter

Permits plotting of stress-strain curves

When this converter unit is attached to a model 51 electronic re-

◀ CIRCLE 74 ON READER-SERVICE CARD

order, stress-strain curves can be produced with SR-4 strain gages. The unit converts signals from the strain gage into a usable voltage to drive the recorder chart in direct proportion to specimen strain, and the curve is automatically plotted.

Tinius Olsen Testing Machine Co., Dept. ED, 8004 Easton Rd., Willow Grove, Pa.

CIRCLE 77 ON READER-SERVICE CARD

Differential DC Amplifier

Has dual-channel packaging

Model D-3B dc amplifier for airborne thermocouple and strain gage telemetering applications. Features include dual-channel packaging and true differential input, with both sides free from ground to eliminate noise pickup.

Southwestern Industrial Electronics Co., Dept. ED, 2831 S. Post Oak Rd., Houston 19, Tex.

CIRCLE 78 ON READER-SERVICE CARD

Transistorized Amplifier

Gains from 1000 to 10 million

Transistorized model 214G is a high-gain, narrow-band voltage amplifier designed to operate from printed circuit resolvers and other low level sources with carrier frequencies from 60 cps to 20 kc. Available closed-loop gains vary from 1000 to 10 million.

Taber Instrument Corp., Dept. ED, 107 Goundry St., North Tonawanda, N.Y.

CIRCLE 79 ON READER-SERVICE CARD

CIRCLE 80 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Frequency-Period Counter

Has built-in digital readout

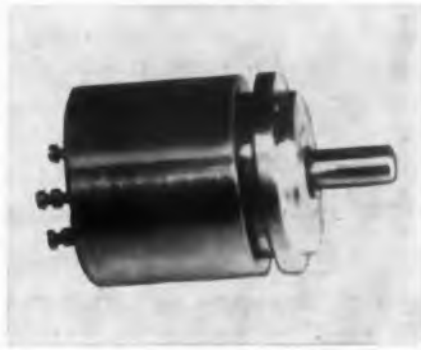
Model 211B frequency-period counter, with built-in digital readout, has 0 to 220 kc frequency range and 10 μsec to 100,000 sec period range. It also features a memory circuit, modular plug-in printed circuit construction, and temperature-regulated crystal controlled time base.

Computer Measurements Corp., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

CIRCLE 81 ON READER-SERVICE CARD

Potentiometer

Torque of 0.2 oz-in.



Independent linearity of model R6 precision potentiometer is 0.5 per cent; torque is 0.2 oz-in. The unit has anodized aluminum housing, stainless steel shaft, and servo mounting. Standard resistances of 1, 2, 5, and 10 K. Custom models with resistance to 100 K.

Precision Line Inc., Dept. ED, 63 Main St., Maynard, Mass.

CIRCLE 82 ON READER-SERVICE CARD

Digital Volt-Ohmeter

Readout to three places

Portable model 400-B digital vtvm measures dc volts and ohms with ±0.5 per cent of full scale

◀ CIRCLE 83 ON READER-SERVICE CARD

bso ute accuracy, and ac within -1 per cent absolute accuracy in ach of 3 ranges. The unit meas- es positive or negative voltages om 0.01 to 1000 v dc, ac voltages 1000 v, and resistances from 10 hms to 1 meg.
Franklin Electronics, Inc., Dept. D, Bridgeport, Pa.
CIRCLE 84 ON READER-SERVICE CARD

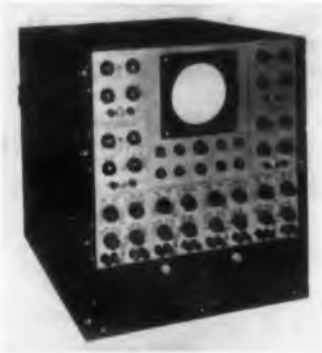
Transistor Tester

5 per cent accuracy

Universal transistor tester model 50 reads junction transistor beta rectly on the meter. Accuracy is ithin 5 per cent. During tests, wer transistors are biased at 0.1 mp collector current, others at 1 a collector current. Four different llector voltages can be selected the front panel.
B&K Mfg. Co., Dept. ED, 3726 Southport Ave., Chicago 13, Ill.
CIRCLE 85 ON READER-SERVICE CARD

Oscilloscope

Four-gun



Model 200-D four-gun oscillo- ope has interchangeable amplifier d sweep generator modules. Five fferent modules are available, mitting over 20 combinations.
Advanced Electronics Mfg. rp., Dept. ED, 2116 S. Sepulveda lvd., Los Angeles 25, Calif.
CIRCLE 86 ON READER SERVICE CARD

CIRCLE 87 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Stepping Motor

Output up to 60 steps per sec

The model 8915 stepping motor provides controlled CW or CCW shaft rotations in 2 deg increments. Stepping output is as rapid as 60 steps per sec, unlimited in either direction, and torque is provided as high as 14 oz-in. The input power requirement of 1 amp at 28 v can be applied for as little as 10 msec per step of output.

G. M. Giannini & Co., Inc., Dept. ED, 918 E. Green St., Pasadena 1, Calif.

CIRCLE 88 ON READER-SERVICE CARD

Switches

Lever lock and toggle lever types

This line of military switches includes lever lock and toggle lever operated units. It features high toggle operating forces, lever seals bonded in place, on to off with 1 deg lever snap action, and positive detent action. Environment or lever sealed, the switches have a variety of arrangements.

Cutler-Hammer Inc., Dept. ED, 538 N. 12th St., Milwaukee 1, Wis.

CIRCLE 89 ON READER-SERVICE CARD

Servo Coupling

Universal joint type

In 16 standard sizes, these miniature universal joints permit angular misalignment to 30 deg. Precision made to insure against backlash at high speeds and torque, they are suited for servos, solenoids, potentiometers, and remote control use.

Fourdee, Inc., Dept. ED, P.O. Box 6006, Orlando, Fla.

CIRCLE 90 ON READER-SERVICE CARD

Magnetic Tachometer

Needs no warm-up time

Transistorized Tach-Pak magnetic tachometer needs no warm-up, is designed to convert a signal frequency from a magnetic transducer to a dc current proportional to frequency and rpm. All series 4400 tachometers have 0.25 per cent linearity in ranges from 0 to 60,000 rpm.

Airpax Products Co., Dept. ED, City of Plantation, Fort Lauderdale, Fla.

CIRCLE 92 ON READER-SERVICE CARD

Piston Capacitor

Completely sealed

Sealcap piston capacitors feature completely sealed interior construction. They come unpotted or encapsulated in epoxy resin. The encapsulated units have the outer electrode band imbedded in resin and a Teflon insulated lead is provided. Dielectric strength of the encapsulated units is over 5000 v d.c. Available in panel mount and printed circuit mount types.

JFD Electronics Corp., Dept. ED, 6101 16th Ave., Brooklyn 4, N.Y.

CIRCLE 93 ON READER-SERVICE CARD

Wirewound Control

Sealed

Type SS wirewound control has triple gland seal between shaft and bushing and hermetically sealed case with glass to metal sealed feed through terminals. It meets MIL-E-5272A requirements. The unit will operate above 200 C ambient, has a power rating of 5 w at 145 C derated to 0 at 250 C.

P. R. Mallory & Co., Inc., Dept. ED, 28 S. Gray St., Indianapolis 6, Ind.

CIRCLE 94 ON READER-SERVICE CARD

CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

VHF Attenuator

Remotely controlled

The model 200 vhf attenuator is non-contacting, continuously variable, and has less than 0.2 db insertion loss. It consists of two units: the attenuator and a remote control chassis. The attenuator unit is inserted in the transmission line between the receiving antenna and receiver.

Rantec Corp., Dept. ED, P.O. Box 18, Calabasas, Calif.

CIRCLE 96 ON READER-SERVICE CARD

Audio Transistors

Collector dissipation of 200 mw

A series of transistors under EIA numbers 2N650 through 2N655. They feature a maximum junction temperature of 100 C and collector dissipation ratings of 200 mw.

Motorola Inc., Dept. ED, 4545 W. Augusta Blvd., Chicago 51, Ill.

CIRCLE 97 ON READER-SERVICE CARD

Oscilloscope

Flat from dc to 15 mc

Model LA 260 provides plug-in single or dual trace vertical preamplifier design. Frequency response is flat from dc up to 15 mc, and useable beyond 30 mc.

Lavoie Labs, Inc., Dept. ED, Matawan-Freehold Rd., Morganville, N.J.

CIRCLE 98 ON READER-SERVICE CARD

FLIGHT IN THREE MEDIUMS

Several things set the Polaris apart from other outer space weapons in the ballistic missile category, for the Polaris program involves a wholly new concept of weaponry:

1. It will be dispatched from beneath the surface of the sea.
2. It will be radically smaller than currently developed land-launched missiles, yet its payload will be as effective and its range the same as other IRBMs.
3. It will be the first operational outer space missile to employ solid fuel as a propellant.
4. It will travel through three mediums in a single flight: water, air, outer space.
5. Its launching base—a submarine—is not fixed but a mobile vehicle.

OUTER SPACE PROGRAM

Very little can be said about the Earth Satellite program at this time except that its success will necessitate advancing the state of the art in all sciences.

The Earth Satellite Project is perhaps the most sophisticated outer space program to reach the "hardware" stage in the U.S. today.

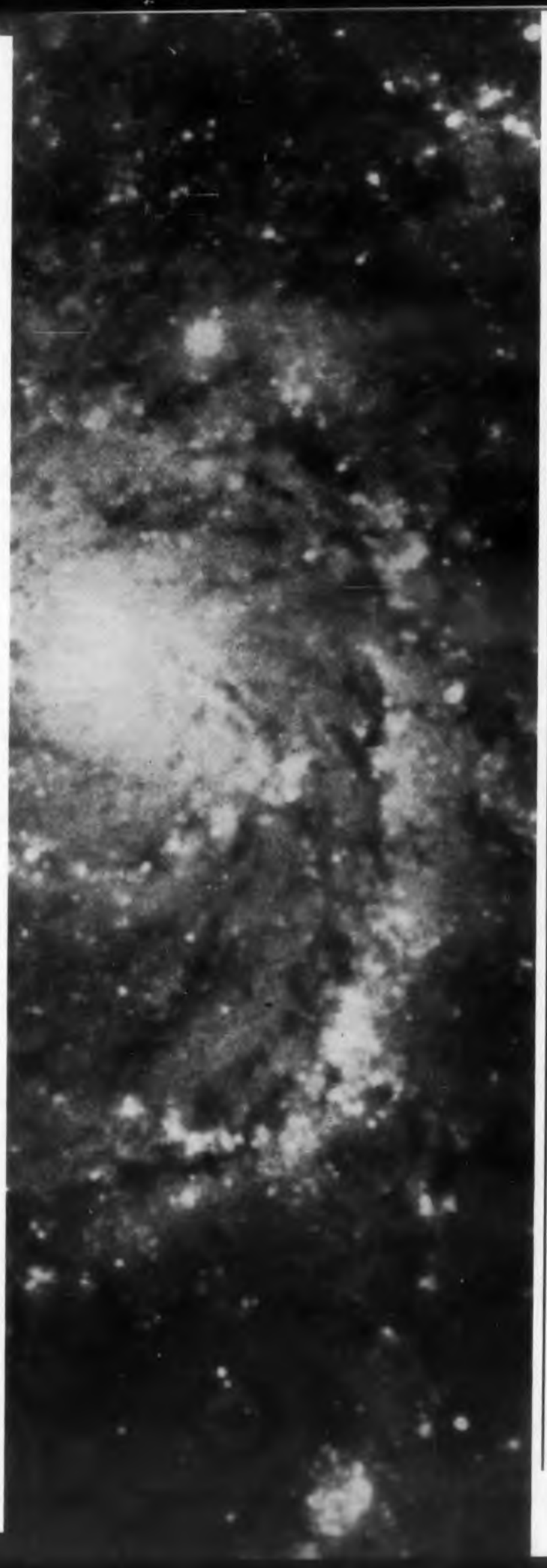
TECHNOLOGY

ENEMY SIMULATOR

The Kingfisher is the nation's fastest target missile, developed for the Air Force and currently being manufactured for the Army to test the accuracy of our newest supersonic weapons.

It is a ramjet target vehicle with Mach 2-plus capabilities. The Kingfisher not only has the speed to match the defensive missiles, but can also simulate a vast array of supersonic enemy missiles and airplanes attacking from great height. It is instrumented to score near misses and even theoretical hits without itself being destroyed.

It is recoverable from flight by parachute to be flown again, permitting weapon system evaluation to be conducted at greatly reduced cost.



VU Meters

Occupy less panel space

These meters meet American Standard C16.5-1954, but occupy at least 15 per cent less panel space than comparable units. They have a response time for a step change of 0.3 sec, ±10 per cent. Overshoot is 1 to 1.5 per cent.

Assembly Products, Inc., Dept. ED, Wilson Mills Rd., Chesterland, Ohio.

CIRCLE 99 ON READER-SERVICE CARD

Centrifuge

For high-quantity test programs

G-range of the A903 centrifuge is 1 to 800 g with an aggregate payload capacity of 1000 g-lb. Wow is 1 per cent; drift is 0.2 per cent of operating rate per minute. Tests objects up to 8 in. high.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 102 ON READER-SERVICE CARD

Differential

½-in. diameter

Optimum performance in balance of backlash and breakaway torque is achieved by this 1/16 in. hollow shaft differential. Made from stainless steel parts, the unit has double bearing supports on end bevels.

Arch Instrument Co., Inc., Dept. ED, 101 Holmes St., North Quincy 71, Mass.

CIRCLE 103 ON READER-SERVICE CARD

◀ CIRCLE 550 ON READER-SERVICE CARD

RESISTANCE NETWORKS

Maintain Precise Voltage/Current Ratios

In missiles, computers, instruments . . . in ac or dc circuits . . . wherever voltage or current must be adjusted within close limits . . . Shallcross Networks provide accuracy and dependability.

FROM A RELIABILITY STANDPOINT, use of sealed networks is recommended in preference to individual resistors to eliminate harmful preventive maintenance. In field servicing the technician is often not aware of the precise T.C. and reactance matching of otherwise seemingly ordinary MIL resistors. In addition to special winding techniques the individual resistors in critical networks are usually stabilized. Replacement of any resistor with a standard MIL type could cause equipment malfunction, and must be prevented.

FROM A DESIGN STANDPOINT Shallcross' skill and ability assure adherence to the most exacting temperature, stability, shock, size, and weight requirements. Shallcross precision engineered networks have proven effective both in ground-based and airborne equipment.
Two typical Shallcross resistance networks are described below. Many others with specialized electrical and mechanical characteristics are regularly manufactured.

SECONDARY-STANDARD VOLTAGE REFERENCE SOURCE is built around this 24 terminal Shallcross resistance network. Using an oil-filled enclosed network of 21 matched T.C. resistors with stabilities of 0.001%, the instrument maintains an absolute accuracy of 0.01% from 0° to 50°C.

Shallcross

GROUND-SUPPORT COMPUTERS employ a number of these hermetically-sealed, standard, octal, plug-in networks. Networks have up to 10 specially wound resistors which are critically located and lead-dressed to meet specifications at 400 cycles. All units are production tested for voltage division accuracy and quadrature error using a precise 400 cycle bridge.

New Address

SHALLCROSS MANUFACTURING COMPANY • Selma, N. C.

See Us At The ISA Show, Booths 1417-1419

CIRCLE 104 ON READER-SERVICE CARD

NEW PRODUCTS

Logarithmic Attenuators

Have wide dynamic range

These logarithmic attenuators are nonlinear attenuator networks whose output voltage amplitude is a linear function of the logarithm of the input voltage amplitude. Four models in dynamic ranges to 60 db are available.

CES Electronic Products, Dept. ED, P.O. Box 7504, San Diego 7, Calif.

CIRCLE 105 ON READER-SERVICE CARD

Transducer

Measures high-intensity noise

For measuring high-intensity noise, the 4-340 sound pressure level transducer senses complex waves from sonic vibrations and blast pressures. Decibel response is 70 to 210 db; pressure range, 10^{-5} to 100 psig.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 106 ON READER-SERVICE CARD

Calorimetric Power Meter

Reads RF powers 10 mw to 10 w

The model 434A calorimetric power meter measures power from 10 mw to 10 w, full scale, and at any frequency from dc to 10 kmc. Power is read directly in watts and DBW. The unit has a response time of less than 5 sec on all ranges, and its accuracy is ±5 per cent or better.

Hewlett-Packard Co., Dept. ED, 275 Page Mill Rd., Palo Alto, Calif.

CIRCLE 107 ON READER-SERVICE CARD

TEAR OUT and Keep this Folder for Reference

Plastics for Electronics

Emerson & Cuming Standard Resins

Emerson & Cuming Sta

EMERSON & CUMING, Inc., 869 Washington Stree

Trade Name/General Use	Designation	Specific Gravity GM/CM³	Viscosity (with Catalyst) Centipoises R.T. (75°F)	Thermal Expansion Coefficient x 10⁻⁶/°C	Thermal Conductivity BTU/ft²/hr/°F/in.	Izod Impact ft. lbs. in. of Notch	Water Absorption Wgt. % Gain 24 hrs.	Machinability
			Physical Properties					
Stycast® Casting Resins (Yellow Brochure)	Stycast TPM-2	0.95	1,200	60	1.1	3	0.5	Fair
	" TPM-3	0.95	3,000	60	1.1	3	0.5	Fair
	" 2850 GT	1.8	16,000 (100°F)	15	2.4	0.24	0.1	Must Grind
	" 2340 M	1.25	2,000 (150°F)	50	1.3	11	0.2	Good
	" 1090	0.7	10,000	19	0.8	0.25	0.3	Good
	" 1095	0.7	8,000	19	0.8	0.2	0.2	Good
	" 2741	1.3	40,000	28	1.2	4.0	0.3	Fair
★	" 2651	1.55	20,000	25	1.5	0.3	0.1	Fair
★	" 2651 MM	1.55	4,000	25	1.5	0.2	0.15	Excellent
	" 2662	1.4	14,000	28	1.4	0.44	0.01	Fair
	" 2762	1.6	30,000	15	2.5	0.3	0.02	Grind
	" 2980 (1)	1.5	8,000 (120°F)	25	1.5	0.5	0.03	Excellent
	" 3020	1.5	5,000	18	1.9	0.8	0.2	Excellent
	" 3050	1.45	1,000	30	1.5	1.0	0.1	Excellent
	" 3070	1.5	10,000	20	1.6	1.0	0.1	Excellent
Eccocoat Plastic Surface Coatings (Purple Brochure)	Eccocoat EC200		500				0.2	
	" PCA		1,000 (150°F)				0.1	
	" C26		2,000				0.01	
	Eccoseal HiQ		5,500				0.1	
Eccobond Adhesives, Cements, Sealants (Maroon Brochure)	Eccobond 55	1.1	8,000	55			0.1	Excellent
	" 45	1.4	40,000	28			0.2	Fair
	" 56C	3.7	Paste	12				Good
	" 58C (1)	3.7	"	12				Good
	Eccobond Paste 88 (1)	1.6	"	15			0.1	Must Grind
Eccoseal Impregnating Resins (Gray Brochure)	Eccoseal W28G (1)	1.22	10 (300°F)				0.1	Excellent
	Stycast 62	1.05	0.9				0.15	Good
	Eccoseal W44HT	1.35	4,000				0.05	Good
	Eccoseal W66	1.2	12,000				0.05	Good
	Eccoseal W19	1.2	1,500				0.2	Good
Eccomold Laminating Resins (Brown Brochure)	Eccomold L65	1.0	2,000				0.2	
	Eccomold L28	1.1	12,000				0.09	
	Eccomold L266	1.2	16,000				0.01	
Eccobild Tooling Resins (Black Brochure)	Eccobild 121	1.2	10				0.15	
	" 127	1.2	10,000				0.05	
	" 314	1.4	20,000	28	1.2	9	0.2	Fair
	" 318	1.6	Paste	15	1.8	1.0	0.1	Fair
	" 420	1.5	10,000	16	1.85	0.5	0.1	Excellent
	" 450	1.4	1,500	16	1.5	0.5	0.1	Excellent
	" 470	1.5	10,000	15	1.6	1.0	0.15	Excellent
	" 490	0.7	16,000	25	0.9	0.2	0.25	Good

Any of these E & C Resins can be **Color Coded** to meet your requirements

Technical Service and **Customized Formulation** are readily available. Consult your nearest Representative.

(1) This indicates a **One Part System**

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hing Standard Resins

869 Washington Street, Canton, Massachusetts

es				Electrical Properties				Interesting Fea			
/in.	Izod Impact ft. lbs. in. of Notch	Water Absorption Wgt. % Gain 24 hrs.	Machinability	Dissipation Factor 3KMC-10KMC	Dielectric Constant 3KMC-10KMC	Volume Resistivity Ohm Cm 20°C/150°C	Dielectric Strength Volts/MIL 20°C	Maximum Use Temperature °F Continuous *	Maximum Use Temperature °F Intermittent	Minimum Use Temperature °F **	Major Physical Characteristi
	3	0.5	Fair	.0006	2.32	10^{13}	450	250	350	—94	Tough, Waxy
	3	0.5	Fair	.0006	2.32	10^{13}	450	250	350	—94	Tough, Waxy
	0.24	0.1	Must Grind	0.02	4.7	$5x10^{16}/1x10^{13}$	455	350	400	—100	Extremely Rugge
	11	0.2	Good	0.05	3.5	10^{15}	500	300	400	—100	Rubbery
	0.25	0.3	Good	0.015	1.9	10^{13}	300	300	400	—100	Light Weight
	0.2	0.2	Good	0.015	1.9	10^{16}	450	450	600	—100	Hi. Temp./Light W
	4.0	0.3	Fair	0.02	3.5	10^{14}	400	300	375	—90	Flexible
	0.3	0.1	Fair	0.02	4.4	$5x10^{16}/1x10^{13}$	455	400	500	—100	Very Strong and Easy to Handle
	0.2	0.15	Excellent	0.02	4.2	$4x10^{16}/7x10^{12}$	440	400	500	—100	Exceptional Handleability
	0.44	0.01	Fair	0.011	3.4	10^{16}	420	500	600	—55	High Temperatur & Moisture Resista
	0.3	0.02	Grind	0.012	3.5	10^{16}	410	500	600	—90	Fair Thermal Conductivity
	0.5	0.03	Excellent	0.01	3.5	2×10^{16}	400	400	450	—65	Low Viscosity at Moderate Tem
	0.8	0.2	Excellent	0.03	4.5	2×10^{15}	450	350	400	—65	Low Viscosity No Shrinkage
	1.0	0.1	Excellent	0.03	4.4		400	350	400	—100	Very Low Viscosi Very Low Shrinka
	1.0	0.1	Excellent	0.02	4.2	2×10^{16}	550	450	600	—100	High Temperatur Easy Machining
		0.2		0.01	2.9	10^{13}	480	300	400	—70	Clear
C Resins		0.1		0.008	3.0	10^{15}	480	350	450	—70	Very Moisture Resistan
oded rements		0.01		0.01	3.0	5×10^{16}	500	450*	600	—70	High Temperatur
		0.1		0.0004	2.55	2.1×10^{16}	2200	150	200	—70	Clear
		0.1	Excellent	0.015	3.3	5×10^{16}	440	350	400	—70	Rigid
al Service and ed Formulation dily available. arest Representative.		0.2	Fair	0.02	3.2	3×10^{13}	410	300	400	—70	Flexible
			Good			0.1		350	450	—70	Conductive
			Good			0.1		1000		—65	Conductive
		0.1	Must Grind	0.02	4.2	10^{16}	410	400	500	—70	Exceptional Shear Strength
		0.1	Excellent	0.02	3.4	$2.3x10/4x10^{12}$	412	400	482	—70	Resilient
dicates a rt System		0.15	Good	0.0003	2.6	10^{16}	500	302	400	—67	Rigid
		0.05	Good	0.005	3.9	10^{15}	450	400		—90	Easy to Handle
		0.05	Good	0.02	3.2	10^{15}	500	450	600	—55	Very Hard
		0.2	Good	0.02	3.5	10^{12}	400	300	350	—55	Low Viscosity
		0.2		0.0005	2.6	10^{16}	700	300			Rigid
		0.09		0.02	3.4		415	350	400		Tough
		0.01		0.02	3.3			450	600		Very Hard
		0.15						300	350		Very Low Viscosity
		0.05						450	600		Moisture Resistanc
	9	0.2	Fair					300		—70	Flexible
	1.0	0.1	Fair					450	500	—70	Paste
	0.5	0.1	Excellent					300	350		Low Viscosity Dimensionally Stab
	0.5	0.1	Excellent					300	400		Very Low Viscosity
	1.0	0.15	Excellent					450	500		Moisture Resistanc
	0.2	0.25	Good					350	400		Light Weight

Special formulations are readily available to meet the exacting needs of special situations. Tell us your problem. We'll do our best to solve it.

* Defined as 1000 Hours Without Loss in Volume Resistivity

** Defined as Minimum Temperature it Exhibits no Cracking in its Ma

PLASTICS for ELECTRONICS

ALL EPOXIES EXCEPT

- **Stycast TPM-2,3 — Cross Linked Polystyrene**
- **Stycast 62 — Cross Linked Polystyrene**
- **Eccomold L65 — Cross Linked Polystyrene**
- **Eccocoat Hi Q — Polystyrene**
- **Eccoseal W44HT — Polyester**

Features

Major Uses

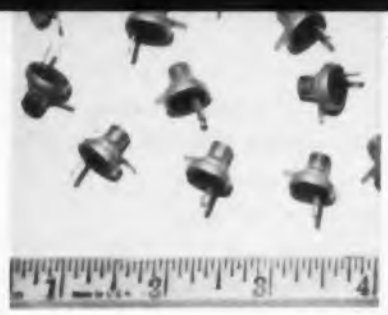
ajor sical teristics	Outstanding Properties	General Cost Range	Trans-formers	Coils	Circuitry	Component Protection	Metal Adhesive	Plastic Adhesive	Important Specific Applications	GENERAL REMARKS
Waxy	Electrical Excellence	High		✔	✔			✔	Hi Q Coils	Can be used as impregnant
Waxy	Electrical Excellence	High		✔	✔			✔	Low Loss Embedments — Delay Lines	Class A, MIL I 16923C Type Material
Rugged	Dimensional Stability	Medium	✔+		✔		✔		Potting of Impregnated Transformers	Practically indestructible within its temp. limits. Amazing vibration resistance.
pery	Impact Strength	Medium	✔		✔	✔			AN Connector Potting	Also used successfully as tooling resin
Weight	Adhesion	Low	✔		✔				Instrument Transformer Potting	Thixotropic at room temp., needs lots of stirring
Light Wgt.	Low Specific Gravity	Low	✔		✔				Airborne Instruments	Same as 1090 but pours easier
ible	Adjustable Flexibility	Low	✔+		✔	✔	✔	✔+	Mil-T27 Transformers	Widely used as adhesive
ong and Handle	Adhesion Shock Resistance	Low	✔+	✔	✔+	✔+	✔+	✔+	Capacitor End Filling	This resin has solved countless production problems. Best all-around material available ★
tional ability	Low Viscosity and Hi. Temp. Resistance	Low	✔+	✔	✔	✔+	✔	✔	Potting Amplifier Circuits	Really flows at room temperature! Machines like brass ★
perature Resistance	I. R. at Hi. Temp.	High	✔			✔	✔+		Resistor Embedment	Complete(!) moisture resistance, hard to use. Not for amateurs.
ermal ctivity	Thermal Shock Resistance	High			✔	✔	✔		Hi. Temp. Rigid Connectors	Thixotropic; lots of hard stirring
scosity te Temp.	Adhesion Non-Flammable	Medium	✔+	✔	✔	✔	✔+	✔	Transformer Potting ❶	Will also impregnate!
scosity nkage		Low		✔	✔	✔			Diode Sealing	Very simple to use; a junior grade 2651
Viscosity Shrinkage		Low		✔	✔	✔			Magnetic Clutch Coil Embedment	Impregnates and pots simultaneously
perature ching		High	✔		✔	✔+			Motor Stator Potting	Easy to use hi temp. material
ar	Easy to Spray	Low			✔				Foam Coating	General purpose — good adhesion
y Resistant		Medium			✔+	✔			Printed Circuits	Try it — you'll like it. Smooth Gloss Coat
perature	I. R. at Hi. Temp.	High		✔+	✔+	✔			Corrosion Protection Alum. Dipped Capacitors	Long Cure but worth it Very high moisture resistance
ar	Electrical Excellence	Low	✔	✔		✔			Coil Dope	Low temperature limits; polystyrene
d	Adhesion	Medium					✔	✔	Pots	All pot mfgs. should use it; most do
ble	Hi Peel Strength	Low					✔	✔	TV Tube Bases (Nylon to Glass Seal)	Best nylon-adhesive we know
ctive	Low Curing Temp.	High							Printed Circuits	Not easy to use — but what else is like it; except —
ctive	Hi. Temp. Resistance	High							Hi. Temp. De-Icers ❶	—This stuff (1000°F)
onal rength	Hi. Temp. Resistance Properties	Medium					✔+	✔	Electrical Generator Anode ❶ Dissimilar Metal Bonding Cell ❶	High temp. cure; will bond all kinds of metals Long life (5000 hrs. at 300°F)
ent	Thermal Shock Resistance	Medium	✔+				✔+	✔	Class H Transformers-various ❶	Best epoxy impregnant on market
d	Electrically Excellent	Low	✔	✔					Capacitors	Low temperature capability but will maintain Q
Handle	Non-Flammable	Low	✔	✔			✔		Stacked Metal Lamination Adhesive	This will not burn! (believe us)
ard	Hi-Temp.	High	✔	✔						Sort of brittle but good for 500°F
cosity	Ease of Use	Medium	✔	✔					Capacitors	Like water, when warm
d	Electrical Excellence	High							Low Loss Glass Laminates	Hard to polymerize right, long low temp. cure
h	Easy to Use	Medium							Tooling Laminates	Good general purpose resin — you'll like it
ard	Rigid at Hi Temp.	High							Dimensionally Stable Laminates @ 500°F	This too is Tough to handle — not for amateurs
iscosity	Quick Curing	Low							Jigs and Fixtures	This is for anybody; real easy
sistance	Dimensionally Stable Laminates	High							Stretch Dies	Tough cure, but worth it for tooling game
le	Adjustable Flexibility	Low							Punch Facing	Impact Strength
	No Mixing	Medium							Spinning	We believe this is what you were looking for
osity y Stable	No Shrinkage	Low							Back Filling	Best general purpose resin in line
iscosity	Non-Settling	Low							General Purpose Tool Castings	Next best: very easy to handle
sistance	High Temp.	High							Hi-Temp. Stretch Die Backing	Long hi temp. cure
ight	High Temp.	Low							Light Weight Dies	Nothing like it

✔+ Indicates an Outstanding Product for this Specific Application

LAMINATING

TOOLING

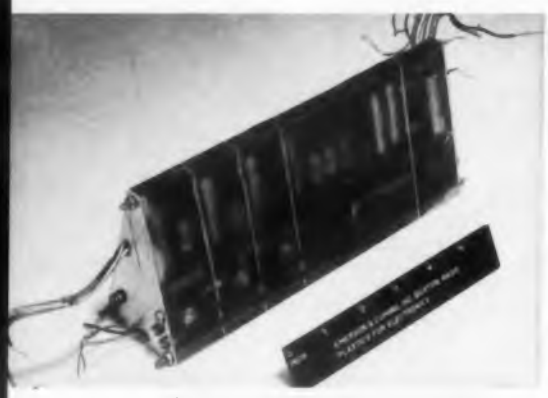
erature at Which
its Major Fields of Use



Button capacitors sealed with Stycast 2762 against extremes of moisture and thermal shock.

Three small transformers dip coated in Stycast 2651.

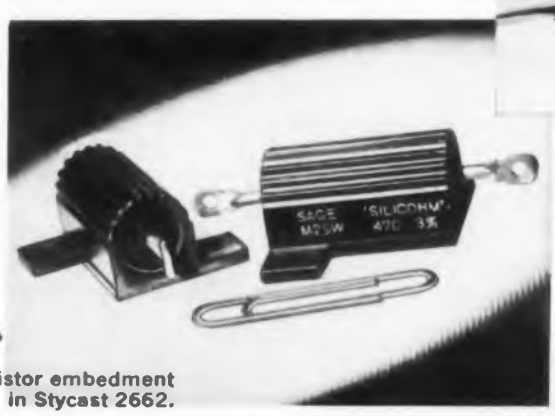
Stator impregnated with Stycast 2651 for mechanical protection and moisture sealing.



One of thousands of a large amplifier circuit potted in Stycast TPM-3 for moisture resistance and extreme low temperature.

A large potted transformer in Stycast 2850 GT — rugged and of excellent heat dissipation characteristics.

Terminal leads of an Electro-Snap Switch potted in Stycast 2850 GT. The only resin found to completely reist jet aircraft vibration in this landing gear switch application.



Precision resistor embedment in Stycast 2662.

Stycast 2741 seals Waters Mfg. Co. epoxy encapsulated choke completely. It is a beautiful blue.

One of the oldest potting jobs in existence. This G. E. Binary Scaler circuitry is potted in Stycast 4030 CM.

Underwater thermistors sealed against high sea water pressure and protected from shock by Stycast 2651.

Ecco Dispenser automatically proportions, mixes and dispenses controlled quantities of Plastic at exact temperature for production use.

Circle
Reader-Serv

Circle 5
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Circle **537** on
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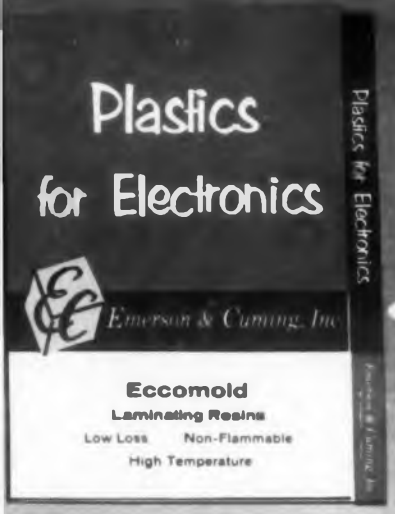

Circle **540** on
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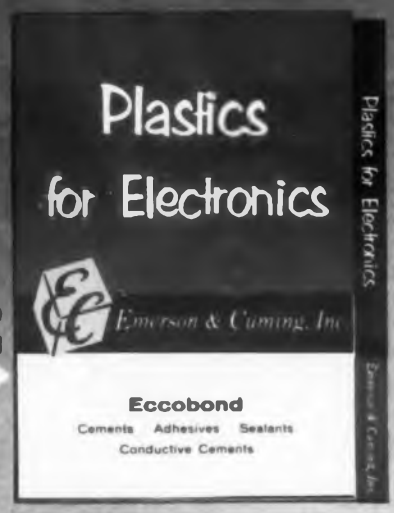

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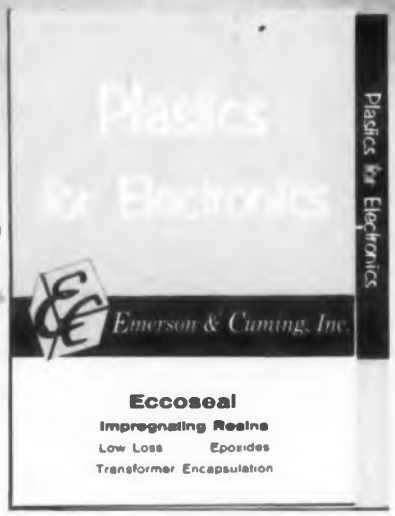
Coil embedment in Stycast 5050 C
A missile production job which
has been going on for years.



539 on
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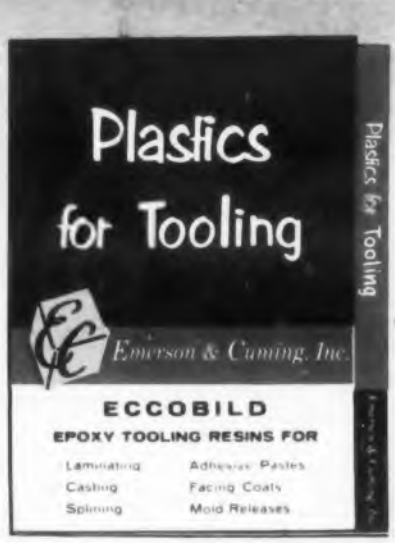

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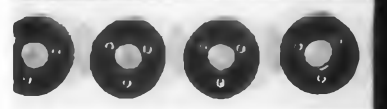

rything in Plastics for Electronics

Write for brochures containing complete data on these other Emerson & Cuming products. Just circle these numbers on the Reader-Service Card:

For information on ECCOSORB Microwave Absorbers, Circle 542;
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For ECCOSPHERES Hollow Glass Microspheres, Circle 548.

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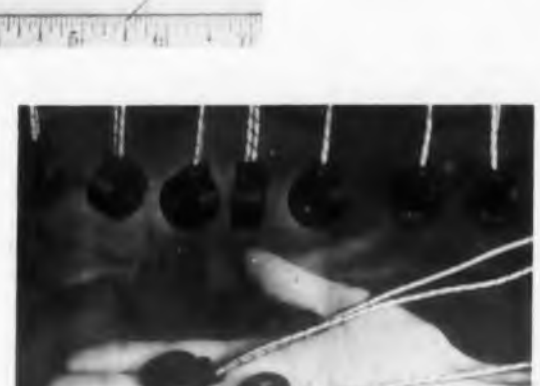
EMERSON & CUMING, INC. **869 Washington Street, Canton, Massachusetts**

This transformer is embedded in Eccoseal W28G using Filler A21 around the transformer winding. An extremely rugged Class H Mil T-27 unit.

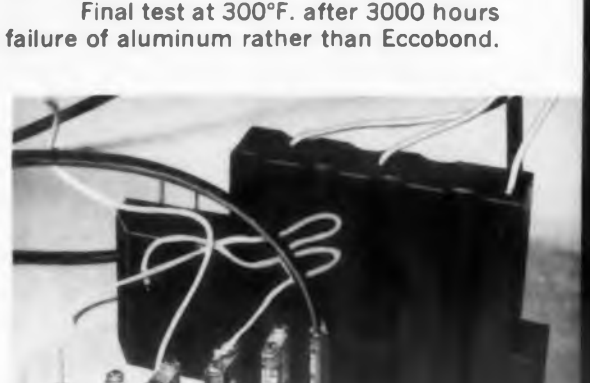
Instrument pick-off coils embedded in Stycast 2980. Close tolerance casting in a rugged high impact strength resin.

Test specimen showing shear strength of Eccobond 88 to exceed 6000 psi at 300°F. Final test at 300°F. after 3000 hours shows failure of aluminum rather than Eccobond.

A silicon diode circuit embedded in Stycast 2850 GT — almost indestructible.



Coil embedment in Stycast 5050 CM. A missile production job which has been going on for years.



A typical use of Stycast 2651. The embedment of a high voltage resistor bank for moisture and shock resistance.

Silicon diode sealed against moisture with Stycast 3020 passes all Mil Spec humidity cycling. This new technique paves the way for a more ruggedized production unit.

A capacitor circuit embedded in Stycast 2651. (Believe us, not the print.) A neat and rugged assembly.

An ultra precision slip-ring assembly molded in Stycast 2651 by Cossor, Canada, Ltd., another of the many production applications of this most versatile resin.

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Rome 6302

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Franklin 7-2546

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Mayfair 1-7410

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Plastics for Electronics

Emerson & Cuming Standard Resins

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Test Chamber

650 F or 800 F operating temperature

The test cycle of this oven includes elevating the temperature at a prescribed rate and decreasing at an accelerated rate greater than would be possible ordinarily. Continuous operating temperature is 650 F or 800 F if required. The unit has a 60 kw heat input capacity and six, finned-pipe cold water cooling elements for quick temperature drop.

Grieve-Hendry Co., Inc., Dept. ED, 1401 W. Carroll Ave., Chicago 7, Ill.

CIRCLE 110 ON READER-SERVICE CARD

Rectifier Diodes

50 to 900 v piv ratings

These medium power axial lead rectifier diodes are single diffused silicon junction type. Piv rating is 50 to 900 v, with high forward conduction and minimum saturation current. Case size is 0.25 x 0.29 in.

U. S. Semiconductor Products, Inc., Dept. ED, 3536 W. Osborn Rd., Phoenix, Ariz.

CIRCLE 111 ON READER-SERVICE CARD

Connector

Utilizes 6 coax contacts

This push-pull, quick disconnect environmental connector utilizes six coaxial contacts. Pins or sockets are available in either the plug or the receptacle, and coax contacts will accept RG-196/U cable.

The Deutsch Co., ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 112 ON READER-SERVICE CARD

NEW PRODUCTS

Delay Line

Delay to rise time ratio of 145 to 1

The 145 to 1 delay to rise time ratio of these extended bandwidth lumped-constant delay lines permits the design of delay line memories with 72 bit storage capacity. Temperature coefficient of delay is less than 65 ppm per deg C.

ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N.J.

CIRCLE 115 ON READER-SERVICE CARD

Accelerometers

Up to ±25 g range

Series A1000 accelerometers operate under temperatures from −65 to +200 F. Weighing less than 10 oz, they contain an input isolation transformer. Ranges are from ±0.5 to ±25 g.

Wiancko Engineering Co., Dept. ED, 255 N. Halstead Ave., Pasadena, Calif.

CIRCLE 116 ON READER-SERVICE CARD

Miniature Capacitors

Layer-built

Designed for transistorized circuitry, Monolythic ceramic capacitors 31C3 through 31C9 are built in layers. Ceramic dielectric material and silver electrodes are sprayed alternately until the desired capacitance is reached. The units are homogeneous blocks with a voltage rating of 25 v dc and a flash rating of 100 v dc. Capacitances range from 0.075 to 0.75 μf.

Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE 117 ON READER-SERVICE CARD

Battery

Operates at −100 F

The Arctic primary battery operates from +200 to −100 F. Terminal potential approximates 2.3 v at −100 F. Because it is hermetically sealed and has no chemical reaction, the unit is expected to have infinite shelf life.

Yardney Electric Corp., Dept. ED, 40-50 Leonard St., New York, N.Y.

CIRCLE 120 ON READER-SERVICE CARD

Airborne Recorder

Operates to 100,000 ft

Airborne type 5-702 recorders operate to 100,000 ft and 100 C. Six tape speeds, from 1-7/8 to 60 ips, are selected by a switch. Available for 7 or 14 track operation, the units use 1/2 or 1 in. tape.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 121 ON READER-SERVICE CARD

Pressure Transducer

Diaphragm type

A dual coil, diaphragm type differential pressure transducer, the model S-15 is for measuring liquid oxygen differential pressures in missile and other cryogenic applications. It provides high output, rapid response, and continuous resolution.

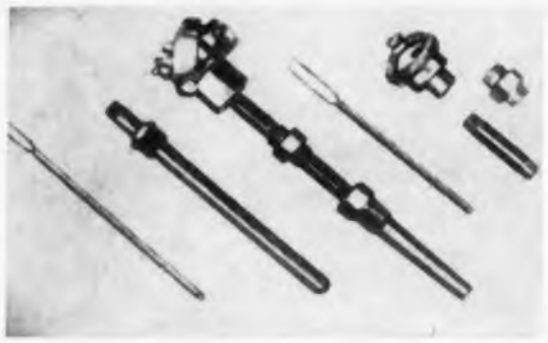
Ultradyne, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 122 ON READER-SERVICE CARD

NEW PRODUCTS

Thermocouple Assemblies

Covers —300 to +2200 F temperature range



Assemblies consist of standard wire-type and Ceramo thermocouples, connection heads, thermowells, fittings, and mounting attachments. Thermocouple materials of copper-constantan, iron-constantan, and chromel-alumel cover temperature ranges from —300 to +2200 F.

Thermo Electric Co., Inc., Dept. ED, Saddle Brook, N.J.

CIRCLE 124 ON READER-SERVICE CARD

Servomotor-Rate Generator

0.25 oz-in. stall torque

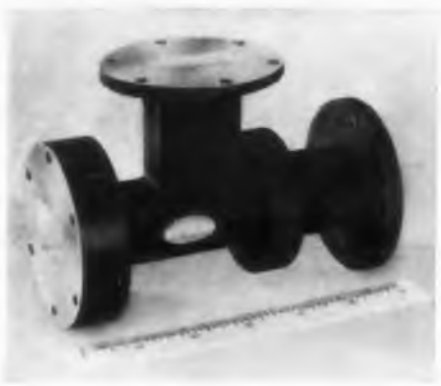
A size 8 ac 2-phase control unit, the 8MG 420/410 servomotor-rate generator has a rotor inertia of 0.1 gm cm^2. Stall torque is 0.25 oz-in. and acceleration at stall is 110,000 rad/sec^2. The unit exceeds MIL-E-5272A specs.

Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 125 ON READER-SERVICE CARD

Microwave Ferrite Circulator

For use in C-band systems



The model CCMI microwave ferrite circulator is for use in C-band transmission and reception systems. Weighing under 5 lb, this differential phase shifter replaces conventional gas-tube duplexers. Minimum transmit-receive isolation is 20 db; maximum insertion loss is 5 db.

Raytheon Mfg. Co., Dept. ED, Waltham 54, Mass.

CIRCLE 126 ON READER-SERVICE CARD

Permanent Magnet Motors

Efficiencies to 45 per cent

This line of dc permanent magnet motors features reduction in length and bulk, ceramic magnetics, and efficiencies as high as 45 per cent. The Index I field structure is enclosed within a steel shell, providing complete self-shielding. The assembly can be mounted or dismounted without affecting its magnetic characteristics. Stock models can be obtained varying from a 4 to 30 v dc input range.

The Reflectone Corp., Dept. ED, Post Rd. and Myano Lane, Stamford, Conn.

CIRCLE 128 ON READER-SERVICE CARD

Buffer Memory

144 character

Model 144M4A is a 144 character, 4 bit sequential-in, sequential-out buffer memory. Maximum rate of operation is 100 kc. Initial application will be as a time buffer between equipments of different operational speeds.

General Ceramics Corp., Dept. ED, Keasbey, N.J.

CIRCLE 129 ON READER-SERVICE CARD

VTVM

Three per cent accuracy

Model 208 vtvm provides seven dc, seven ac, and seven ordinary ohm ranges, plus a scale to check standard color coded resistance values and tolerance limits. Accuracy is within 3 per cent. The unit has a shift-lever switch with all functions separated by positive stops.

Seco Mfg. Co., Dept. ED, 5015 Penn Ave. S., Minneapolis, Minn.

CIRCLE 131 ON READER-SERVICE CARD

NEW PRODUCTS

Diode Test Set

Automatic

Model 5002AB diode test set automatically compares the dc forward and reverse characters of semiconductor diodes against preset limits and gives the results in go-no-go form.

Measurements Research Co., Dept. ED, 3801 Castor Ave., Philadelphia 24, Pa.

CIRCLE 132 ON READER-SERVICE CARD

Ferrite Isolator

For C-band

The W277-5A-4 ferrite isolator operates over the common carrier and mobile bands between 5.9 and 6.5 kmc. Isolation is 40 db, and insertion loss is 1 db over the full range. The magnets don't extend beyond the flange area.

Kearfott Co., Microwave Div., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

CIRCLE 133 ON READER-SERVICE CARD

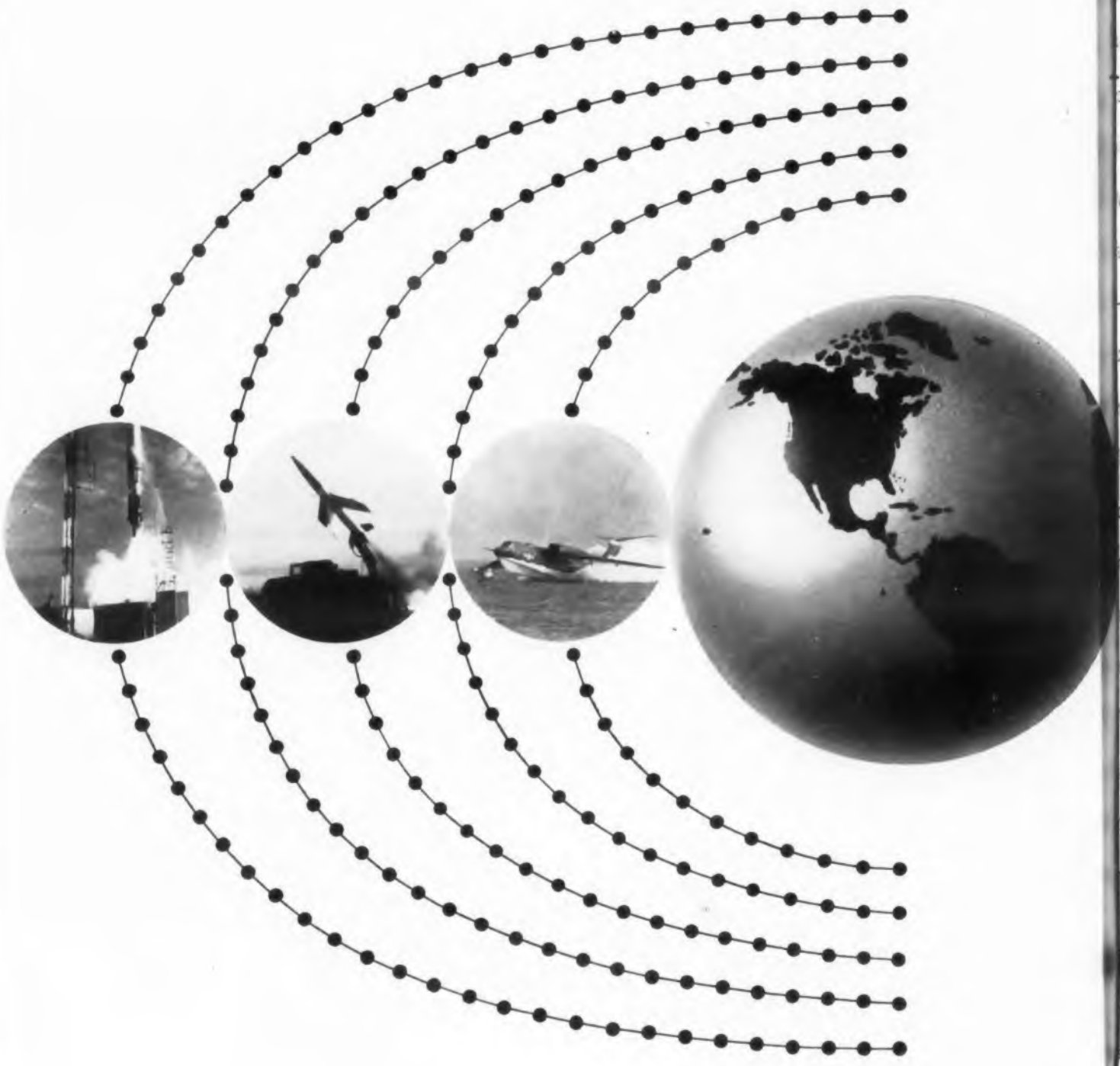
Frequency Meters

Direct-reading accuracy of 0.08 per cent

These direct-reading, TE_{111} mode frequency meters cover a full waveguide band in the frequency range from 3.95 to 40 kmc. Designated types 532 through 538F1, the meters have a direct-reading accuracy of 0.08 per cent for most ranges.

Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

CIRCLE 134 ON READER-SERVICE CARD



Booster Amplifier

60 db minimum feedback gain

For resolver systems, this dual transistorized booster amplifier has an input impedance of over 5 megohms and a feedback gain of 60 db minimum. It maintains zero phase shift and a constant transformation ratio of unity from −65 to +85 C. Each amplifier section is individually encapsulated.

Reeves Instrument Corp., Dept. ED, Roosevelt Field, Garden City, N.Y.

CIRCLE 135 ON READER-SERVICE CARD

Recorder/Reproducers

3 μsec start and stop

Type 5-680 recorder/reproducers are all transistorized with start and stop under 3 μsec. They come in speeds from 30 to 150 ips and use tapes 1/4 to 1 in. wide.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 136 ON READER-SERVICE CARD

Sweeping Oscillator

Two simultaneous sweeps

The Dual Rada-Sweep features two individual outputs centered at 37.5 mc. The low-to-high sweep is from 30 mc to 45 mc; the high-to-low sweep is from 45 mc to 30 mc. It has a built-in age circuit that equalizes the amplitudes of both sweeping outputs. The instrument also presents simultaneously on the oscilloscope both the wide and narrow sweeps around a common center.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N.J.

CIRCLE 137 ON READER-SERVICE CARD

NEW PRODUCTS

Diplexer
For S-band

The BL-584 S-band diplexer connects two transmitters operating at different frequencies to a common antenna feed, with low cross talk between them. Ganged plungers provide continuous variation of the two diplexing frequencies. A replaceable section permits diplexing of many frequency combinations.

Bomac Labs, Inc., Dept. ED, Salem Rd., Beverly, Mass.

CIRCLE 140 ON READER-SERVICE CARD

Phase Shifter
For radar use

Designed to operate on 81.95 kc, this phase shifter maintains accuracies of ±20 minutes from 0 to 50 C ambient. Output phase shift of 720 deg is provided for each 360 deg of input shaft rotation.

Reeves Instrument Corp., Dept. ED, Roosevelt Field, Garden City, N.Y.

CIRCLE 141 ON READER-SERVICE CARD

Flowmeters
Readings independent of temperature

By using a heated thermopile element in a flow tube, these flowmeters provide direct reading of total mass flow independent of temperature and pressure variations. Model MF-1 has a range from 0 to 10,000 mg of air per minute; model SM-1, 0 to 500 mg per minute.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

CIRCLE 142 ON READER-SERVICE CARD

FLIGHT DATA and CONTROL ENGINEERS

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS A wide choice of opportunities exists for creative R & D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo-mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

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1) DESIGN ANALYSIS Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

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4. PROPOSAL AND QUALTEST ENGINEER For specification review, proposal and qualtest analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

Forward resume to:
Mr. G. D. Bradley

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AiResearch Industrial
Rex • Aero Engineering
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AiResearch Aviation Service

CIRCLE 555 ON READER-SERVICE CARD

NEW AiResearch steering control system

Combines Acceleration Switching Valves And Hydraulic "Printed Circuit"

More reliable and responsive... this lightweight electro-hydraulic steering control system converts low-level electronic signals from the main guidance system into hydraulic energy which actuates the mechanisms steering the missile.

Packaged as an integrated unit, the three servo valves and six control actuators are mounted on a common manifold and powered by fluid or hot gases. The simplified "printed circuit" system of integral passageways within the manifold eliminates all external plumbing and leakage.

The acceleration switching servo valves provide positive control of spool velocity, thereby achieving greater resolution, reliability and response even at extreme temperatures.

Easily installed and removed as a complete, interchangeable unit, acceptance testing of this compact system can be accomplished prior to missile installation. Suggested applications are: missile surface controls, jetavator controls, and vector and nozzle steering controls. Your inquiries are invited.

Specifications

Actuator load (range)	*90 to 150 in. lbs.*
Electrical input (nominal)	*28 volts DC—10 Milliamperes*
Pressure range	*500 to 3000 psi*
Rated flow	*½ to 2 gpm*
Mounting	*Manifold*
External leakage	*None*
Proof Pressure	*4500 psi*
Burst Pressure	*7500 psi*
Temperature operating range	
Fluid	*-65°F to 450°F*
Ambient	*-65°F to 750°F*
System filtration	*10 microns*

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CIRCLE 130 ON READER-SERVICE CARD

NEW PRODUCTS

Fans

Variety of shapes

These propeller type units deliver low pressure, high volume air. The line includes a variety of shapes and sizes. Shown is model 89C15, 1/6 hp, which delivers 1300 cfm of air at zero static pressure and 1725 rpm.

American-Standard, American Blower Div., Dept. ED, Detroit 32, Mich.

CIRCLE 145 ON READER-SERVICE CARD

Signal Generators

Have plug-in rf oscillators

Model 82 signal generator series have power supply and five plug-in rf oscillators with frequency ranges between 20 to 80 mc and 2700 to 3000 mc. Units have 1000 to 2000 v dc continuously variable power supply.

BJ Electronics, Borg-Warner Corp., Dept. ED, 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 146 ON READER-SERVICE CARD

Coaxial Ferrite Load Isolators

No waveguide transitions

Ferrite strips placed directly in the coaxial line eliminate the bulky transitions to and from waveguide formerly required for isolators in

coaxial systems. The CN121 series have a maximum diameter of 1-1/2 in., and are intended for use in low and medium power coaxial systems. Four models cover a 2.5 to 7 kmc band, providing from 10 to 20 db isolation with insertion loss of 1 db.

Cascade Research, Div. of Monogram Precision Industries, Inc., Dept. ED, 53 Victory Lane, Los Gatos, Calif.

CIRCLE 149 ON READER-SERVICE CARD

RF Waveguide Filters

Features sharp cutoff

The rf waveguide filter illustrated is of the low-pass type cutting off at 5 kmc, matched to achieve a maximum loss of 0.75 db in the passband, with a minimum attenuation of 60 db from 5.4 kmc out to 12 kmc. It is designed to handle up to 100 w of power and is fitted with UG-149A/U and UG-148B/U flanges. Similar performance can be achieved with units in the S through X bands.

Microphase Corp., Dept. ED, Box 1166, Greenwich, Conn.

CIRCLE 150 ON READER-SERVICE CARD

Expandable Rectifier

With, without cooling discs

Cooling discs, when used in this series assembly, increase the maximum forward current from the in-air to the heat sink rating. Quickly assembled from nine A750 individual rectifier units, the string has an inverse peak voltage rating of 3600 v. Current rating of the assembly is 500 ma without the cooling discs, 750 ma with the discs. With cooling fins and the addition of fan cooling the rating of the series chain can be raised to 5 amp.

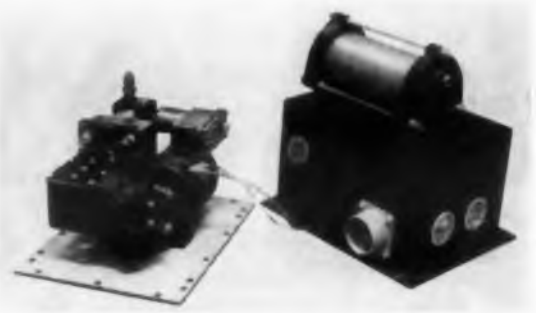
Audio Devices, Inc., Dept. ED, 444 Madison Ave., New York 22, N.Y.

CIRCLE 151 ON READER-SERVICE CARD

NEW PRODUCTS

Waveguide Pressurizer

Maintains 17 psig



Model E/AP-150, type 205, provides pressurization and circulation of dehydrated air to the waveguide radar system for missile control. Weighing 8 lb, it has a delivery of 160 cu in. per min. An operating switch maintains a pressure of 17 psig.

Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden, Conn.

CIRCLE 154 ON READER-SERVICE CARD

Relay

Increased magnetic force

Series 300 hermetically-sealed relays feature an increased magnetic force providing higher contact pressures and greater travel. The design of the 6pdt unit incorporates a solenoid type of magnetic assembly with two dynamically balanced plungers.

Price Electric Corp., Dept. ED, Frederick, Md.

CIRCLE 155 ON READER-SERVICE CARD

Pulse Generator

Wide range of applications

A general-purpose source of high-amplitude positive and negative pulses, the model 179 standard pulse generator provides a continuously variable output pulse amplitude. It has a wide calibrated frequency range, and provides high output with short rise time.

Measurements, A McGraw-Edison Div., Dept. ED, Boonton, N.J.

CIRCLE 156 ON READER-SERVICE CARD

BACKGROUND OF QUALITY

. . . and the quality *starts* in the foreground!

For when it comes to Roebling Magnet Wire, *quality* means—unsurpassed ingredients of consistent excellence . . . wire-making skill based on decades of experience . . . and exacting testing and inspection.

You pay no more for Roebling Magnet Wire—you get more in terms of satisfying performance. And *you* choose the packaging that will give you utmost efficiency and economy. Write today to Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey, for information about types and sizes of Roebling Magnet Wire exactly suited to your applications.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

Tilt Accessory

For rate-of-turn table

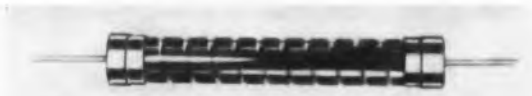
The Model C181 enables the machine to test and evaluate components on any plane of rotation from horizontal to vertical. This tilt feature permits complete tests to be made without changing the test setup, provided the table is statically balanced. Over-all performance of the table is unaffected.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 159 ON READER-SERVICE CARD

Custom Metal Film Resistors

Controlled temperature coefficients



Precision metal film resistors with controlled positive temperature coefficients will be built to customer requirements. Temperature coefficients, not dependent on the ohmic value of the resistor, will range from —300 to —2500 ppm per degree C.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 160 ON READER-SERVICE CARD

Erase Head

50 db erasures

The dc erase head provides 50 db erasure with 5.5 ma of current through the coil. This head is currently manufactured in a 20-mil track width configuration.

Michigan Magnetics, Inc., Dept. ED, Vermontville, Mich.

CIRCLE 161 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Ferrite Tuner

3-circuit

This 3-circuit, rotary-axial ferrite tuner is slightly larger than a flashlight battery. It produces linear frequency variations from 500 to 1600 kc and can be extended to cover frequencies to 15 mc. It is suitable for use in aircraft, missiles, and pocket radios.

Emerson Radio & Phonograph Corp., Dept. ED, 14th and Coles Sts., Jersey City 2, N.J.

CIRCLE 164 ON READER-SERVICE CARD

Shock Tester

Versatile and fast

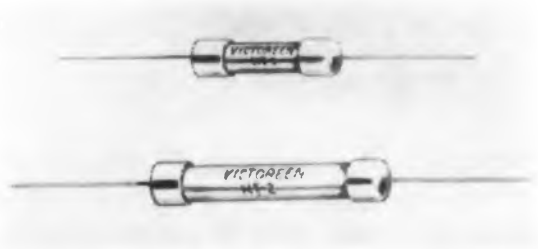
The Model S-200-V performs shock tests from 20 to 250 g at time durations of from 3 to 30 msec. The carriage table will accommodate abstract-shaped test specimens to a volume of a 2 ft cube and a weight of 200 lb.

Jan Hardware Mfg. Co., Inc., Dept. ED, 75 N. 11th St., Brooklyn 11, N.Y.

CIRCLE 165 ON READER-SERVICE CARD

Resistors

For high temperatures



Stable 1 and 2 w resistors, the HT-1 and HT-2 maintain their full rating up to 200 and 275 C, respectively, and derate to 0 at 325 C. Resistance

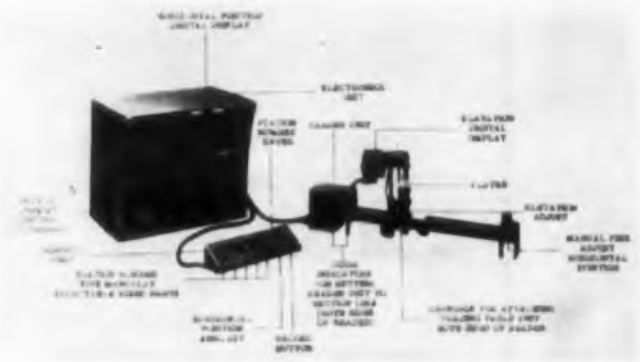
of the HT-1 is from 200 ohms to 360 K with a 600 v maximum voltage. Resistance of the HT-2 is 200 ohms to 1 meg with a maximum voltage of 1500 v.

The Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 169 ON READER-SERVICE CARD

Graphic to Digital Translator

For aerial mapping



The Terrain Data Translator (TDT) is the first of a series of graphic to digital translating machines. It can be used to convert data from aerial photographs to digital form for input to computers. The device consists of a precision reading unit and an electronic counter. It has resolution of 1000 counts per inch, push-button choice of zero position, and true positive and negative numbers about the zero point. Two-axis output can be punched paper tape, punched cards, or hard copy.

Benson-Lehner Corp., Dept. ED, 11930 Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 170 ON READER-SERVICE CARD

X Band Microwave Wattmeter

2 per cent accuracy

X band microwave wattmeter Type U-182 is intended to replace the water calorimeter. Makes possible rapid production checks on magnetrons, klystrons; has in-line wattmeter for radar. Measurements can be made in 10 to 200 w power range with 2 per cent accuracy.

Wayne Kerr Instruments, Dept. ED, P.O. Box 801, Philadelphia 5, Pa.

CIRCLE 171 ON READER-SERVICE CARD

NEW PRODUCTS

Radar Power Supplies

Two models

On the left is model M763 pulse generator which operates from a 13.8 v 120 ma 400 cps input and provides 120 v peak min and 320 v max. On the right is high voltage power supply providing 8 kv at 100 μa from 115 v 400 cps.

Perkin Engineering Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

CIRCLE 174 ON READER-SERVICE CARD

Strip Terminals

For solderless staking

Continuous strip terminals for solderless staking of terminals to wires. Snap-on ring, spade, and hook types. Straight and flag varieties, with or without insulation grips.

Kent Mfg. Corp., Dept. ED, Newton, Mass.

CIRCLE 175 ON READER-SERVICE CARD

Temperature Recorder

Accurate to 0.001 deg C

Using a Brown instrument strip chart recorder, model 102 temperature recorder covers a 20 to 30 C range. With a selector switch, any 0.5 deg C portion of this range can be recorded with 0.001 deg C accuracy.

Fenwal Electronics, Inc., Dept. ED, Mellen St., Framingham, Mass.

CIRCLE 176 ON READER-SERVICE CARD

Recording Spectrometer

Stability of 0.25 per cent per day

Model N-1250R is a complete recording spectrometer including a scintillation detector with lead shielding. It provides direct calibration in terms of energy. Stability is 0.25 per cent per day; linearity, better than 1 per cent; energy range, 25 kev to 8 mev.

Hamner Electronics Co., Inc., Dept. ED, P.O. Box 531, Princeton, N.J.

CIRCLE 177 ON READER-SERVICE CARD

Flexible Harness

500 F flat cable

This flexible harness assembly is a flat cable which accepts any type plug or connector. Tensile strength is 650 psi; brittle point, 130 F; and maximum operating temperature, 500 F.

Topp Industries, Inc., Dept. ED, Beverly Hills, Calif.

CIRCLE 178 ON READER-SERVICE CARD

Bilateral Transistors

For switching applications

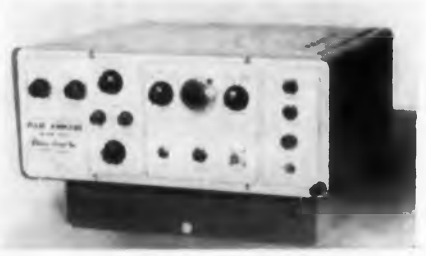
Types 2N592 through 2N596 are used in bilateral mediums and high speed switching applications. Units can be supplied in compliance with MIL-T-19500A.

General Transistor Corp., Dept. ED, 91-27 138 Pl., Jamaica 35, N.Y.

CIRCLE 179 ON READER-SERVICE CARD

Pulse Amplifier

Provides ±50 ma to ±5 amp



For magnetic, crystal, and capacitance element testing, pulse amplifier 325A is a wide band unit compatible with series 5000 and 5100 pulse code generating equipment. It provides ±50 ma to ±5 amp around ground with automatic overload protection, insensitivity to input signal duty cycle variation, and low shunt capacitance.

Electro-Pulse, Inc., Dept. ED, 11861 Teale St., Culver City, Calif.

CIRCLE 180 ON READER-SERVICE CARD

Servomotor

Develops 1 oz in. stall torque

Size 11 servomotor develops 1 oz in. stall torque in a standard size 11 frame. Type 11-5101-42 is a 115 v 2 phase servomotor with control phase rated at 115/57.5 v. Power input is 6.2 w per phase at stall, no load speed 7000 rpm, and weight is 4.5 oz.

John Oster Mfg. Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 181 ON READER-SERVICE CARD

Precision Film Resistors

1/8 to 1/2 w

In three sizes, from 1/8 to 1/2 w, series 125 film resistors have values from 10 ohms to 5 meg. Subjected to 1000 hours of load life at 125 C, they change less than 1 per cent.

Electra Mfg. Co., Dept. ED, 4051 Broadway, Kansas City, Mo.

CIRCLE 182 ON READER-SERVICE CARD

Semiconductor Devices

Utilizes Hall effect

Halltron type HS-51 intermetallic compound semiconductor devices operate as a function of the Hall effect. The device can be used as a dc to ac inverter, a gyrator, a circulator, and to measure power, position, or magnetic field. With an input of 0.5 amp in a field of 10 kilogauss, output exceeds 0.5 v. Input impedance at 0 kilogauss is 0.8 ohms; output impedance at 9 kilogauss is 2.5 ohms. The units are 0.03 in. thick and have an output power of 35 mw.

Ohio Semiconductors, Inc., Dept. ED, 1035 W. Third Ave., Columbus 8, Ohio.

CIRCLE 183 ON READER-SERVICE CARD

Relay Amplifier

Operates on 3 μw

A sensitive relay magnetic amplifier, model 701 operates on 3 μw and delivers 0.4 w of output. Can be connected as either a linear amplifier or as a bi-stable amplifier.

Acromag, Inc., Dept. ED, 22519 Telegraph Rd., Detroit 41, Mich.

CIRCLE 184 ON READER-SERVICE CARD

Speed Reduction Units

Feature small size

One unit of these speed reducers with motor will fit into 2 cu. in. The speed reduction ratios range from 10 to 1 to 663 to 1. They can be operated by a 3, 6, or 12 v dc motor.

Wilson's of Cleveland, Dept. ED, 425 Lakeside Ave. N.W., Cleveland 13, Ohio.

CIRCLE 185 ON READER-SERVICE CARD

NEW PRODUCTS

Pressure Switch

Withstands 100 g

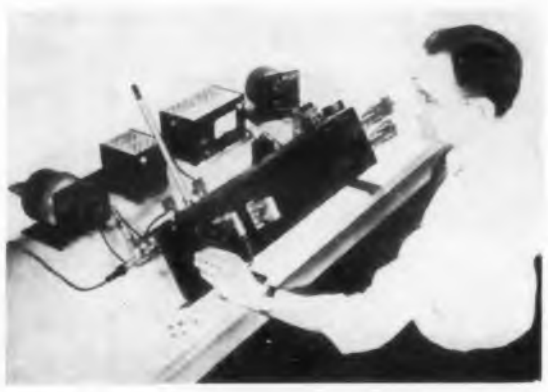
Types 6607-1 through -9 pressure switches operate satisfactorily following shocks of 100 g. They withstand temperatures from —65 to +250 F, and encompass pressure ranges up to 3000 psi.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

CIRCLE 188 ON READER-SERVICE CARD

Transfer-Function Meter

For vhf-uhf range



Type 1607-A transfer-function meter measures functions over the 25 to 1500 mc frequency range. It also measures any 2-terminal impedance or admittance over the same range. The rf signal level can be held below 5 mv for low-level transistor measurements.

General Radio Co., Dept. ED, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 189 ON READER-SERVICE CARD

Metallized Mylar Capacitors

Operate to 125 C without derating

These miniature metallized Mylar capacitors operate at temperatures up to 125 C without de-

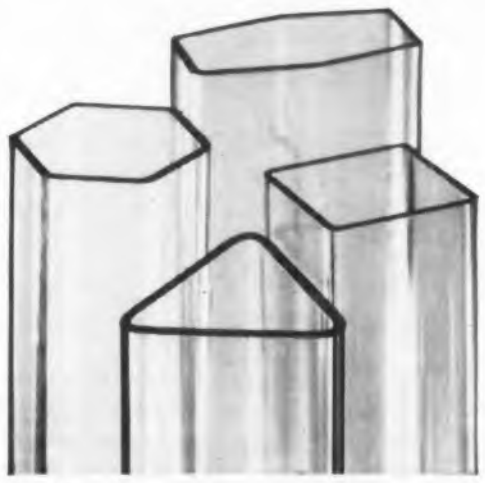
NEW DEVELOPMENT FROM GENERAL ELECTRIC . . .

QUARTZ TUBING IN NEW SHAPES!

- **Same high standards of purity and precision as regular cylindrical tubing**
- **Special shapes can be made to your specifications . . . in virtually any polygonal shape**

Now you can get non-circular quartz tubing! Priced only slightly higher than standard round tubing, it will be sold by the piece, foot or pound—according to type. Lengths up to six feet or more, circumferences up to two inches per side on a square. Excellent optical and insulating properties—softening point is 1667°C. Low coefficient of expansion . . . essentially free of Boron impurities.

Immediate demand seen in electronics industry in the production of semi-conductor transistor instruments. Special shapes can be made and cut for use as insulators and liners in the production of radio and electronic components. For full particulars, write: General Electric Co., Lamp Glass Dept., Nela Park, Cleveland 12, Ohio.



Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 191 ON READER-SERVICE CARD

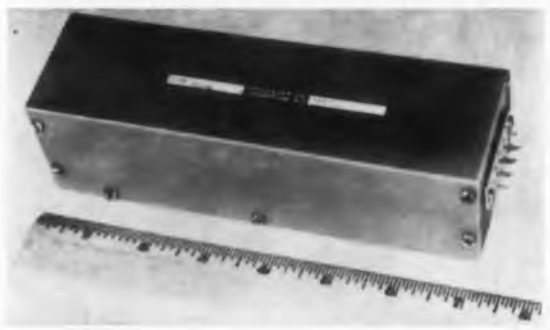
rating. They are rated up to 600 v dc in any capacity desired, with insulation resistance of 100,000 meg per microfarad.

Film Capacitors Inc., Dept. ED, 3400-06 Park Ave., New York 56, N.Y.

CIRCLE 192 ON READER-SERVICE CARD

Power Supply

250 ma output at 100 v dc



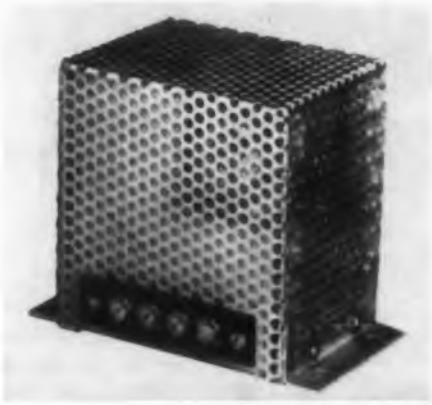
Series 60A regulated transistor power supplies permit continuous operation at full load in ambient temperature of 85 C without heat sink. Input, 24 to 30 v dc; output, 250 ma at 100 v dc. Less than 1 v change for ambient temperature variation from −55 to +85 C; less than 0.125 v change for an input voltage variation from 24 to 30 v; and less than 0.125 v change from full load to half load. Ripple is less than 10 mv rms. Output impedance is less than 5 ohms from dc to 200 kc.

The Daven Co., Dept. ED, Livingston, N.J.

CIRCLE 193 ON READER-SERVICE CARD

Transistorized Power Supply

For mobile receivers



For mobile receivers, type QH-020 transistorized power supply has a dc input of 12.6 v ±20 per cent at 1.6 amp, 20 w. Dc output is 210 v at 87 ma, 20 w. The unit has 6 per cent regulation, 90 per cent efficiency, and a ripple of less than 0.5 per cent. Temperature range is −55 to +75 C.

International Telephone and Telegraph Corp., Industrial Products Div., Dept. ED, 15191 Bledsoe St., San Fernando, Calif.

CIRCLE 194 ON READER-SERVICE CARD

CONQUEST OF SPACE

There are some who find fulfillment in boundless outer space. And more power to them!

But those of us who still have our feet on the ground also find real challenges in less expansive surroundings.

With the aid of a medium-power microscope and several years' experience with fluoro-chemical designs, we successfully pack 4 filter reactors and a 350 VA power transformer into 60 cubic inches of hermetically sealed inner space. Result is 6 pounds of streamlined reliable power for small space platforms...proved in performance in '58-model missiles and (pardon the expression) aircraft.

Have slide rule... will travel. You can reach us at:

Raytheon Manufacturing Company
Magnetic Components Department
Section 6120
Waltham 54, Massachusetts

RAYTHEON

Excellence in Electronics

CIRCLE 195 ON READER-SERVICE CARD

NEW PRODUCTS

Rotary Selector Switches

Variety of sequences

Millions of operating sequences are available with series 20AS rotary selector switches. The assemblies are available with 4, 6, 8, 10, 12, 14, 16, 18, or 20 spdt basic switching units. Electrical rating is 10 amp, 125, 250, or 460 v ac; 0.5 amp, 125 v dc; 0.25 amp, 250 v dc.

Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Dept. ED, Freeport, Ill.

CIRCLE 197 ON READER-SERVICE CARD

Data Handling System

Five digit display

The DVA-512 data handling system automatically measures ac or dc voltage and types out the result. The unit provides a 5-digit display, 0.0001 to 999.99 v range, automatic ranging and polarity, and accuracy of ± 0.01 per cent ± 1 digit.

Electro Instruments, Inc., Dept. ED, 3540 Aero Ct., San Diego 11, Calif.

CIRCLE 198 ON READER-SERVICE CARD

Digital-to-Analog Converter

Transistorized

Ladder network 141A converts 10-bit binary-coded data into proportional dc voltage of both polarities. Fully transistorized, the digital-to-

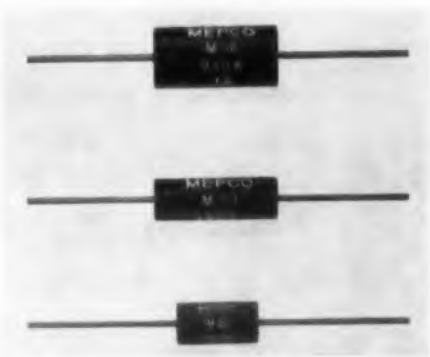
analog unit accepts inputs from a ten flip-flop storage register and, within 0.4 μsec, presents a ±15 ma output into 10 ohms. Linearity is ±1 per cent. Signal inputs are 0 v ±5 v for binary zero and −15 v ±5 v for binary one. Decimal 512 and 511 binary equivalents represent maximum positive and negative excursion, respectively.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

CIRCLE 200 ON READER-SERVICE CARD

Wirewound Resistors

Power range of 1/8 to 1/3 w



The units M58, M59, and M60 are produced in MIL styles 9444 AFRT 10, 11, and 12, in a power range of 1/8 to 1/3 w at 125 C. Their operating range is −65 to +145 C with a temperature coefficient of 0.003 per cent per deg C.

Mepco, Inc., Dept. ED, Morristown, N.J.

CIRCLE 201 ON READER-SERVICE CARD

Portable Voltmeter

Electrometer input

The SIE Model R-3 voltmeter measures ac voltages from 1 mv to 1000 v full scale, positive and negative dc voltages from 1 v to 1000 v full scale, and half-scale resistance readings from 10 ohms to 10 meg at an over-all 3 per cent accuracy on all readings. It also has an electrometer input for measuring 0 to 1 v dc at an impedance greater than 10,000 meg.

Southwestern Industrial Electronics Co., Dept. ED, 2831 Post Oak Rd., Houston 19, Tex.

CIRCLE 202 ON READER-SERVICE CARD

NEW PRODUCTS

Cathode Ray Tube

Two-color

The 5CGP29 is a 5-in., 2-color crt useful in terrain clearance, collison warning, and weather radar indicators. Its persistent phosphor screen consists of 80 color strips per inch, 40 of each color.

Litton Industries, Electronic Display Lab, Dept. ED, 1476 66th St., Emeryville, Calif.

CIRCLE 205 ON READER-SERVICE CARD

Voltage Limiter

For power supplies

For use with power supplies rated up to 3 amp, this voltage limiter protects transistors and other devices from low- and high-speed voltage excursion damage. Adjustable, it gives protection between 0 and 50 v.

Electronic Measurements Co., Inc., Dept. ED, Eatontown, N.J.

CIRCLE 206 ON READER-SERVICE CARD

Transistorized Servo Amplifier

Has own power supply

Designed to operate between —55 and +190 C, the A-400 integrated servo amplifier has its own power supply. The hermetically sealed, plug-in type unit weighs 4-1/2 oz.

Westamp Co., Dept. ED, 11277 Massachusetts Ave., West Los Angeles 25, Calif.

CIRCLE 207 ON READER-SERVICE CARD

Meter Relay

Non-locking contacts

High torque model 1091 sensitive relay has nonlocking, nonmag-

netic contacts that may be set as close as −5 to +5 μa. Dc sensitivity is 25 μa for full scale. Ac sensitivity is 50 μa for contact closure. Contact capacity is 50 or 200 ma at 6 v dc.

Weston Instruments, Div. of Daystrom, Inc., Dept. ED, Newark 12, N.J.

CIRCLE 209 ON READER-SERVICE CARD

Potentiometer

For nonlinear functions

Model 106 miniature potentiometers are available with resistance up to 50 K and 0.07 per cent resolution. For a variety of nonlinear functions, the units feature an electronically-wound resistance element.

George Rattray and Co., Dept. ED, 116-08 Myrtle Ave., Richmond Hill 18, N.Y.

CIRCLE 210 ON READER-SERVICE CARD

Gyro Test Equipment

Modular design

This gyro modular test equipment line includes precision test tables, gyro control circuits and panels, turntable control units, metering circuits, system self checking circuits, amplifiers, and power supplies.

Sterling Precision Corp., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 211 ON READER-SERVICE CARD

Punched Card Reader

Reads 200 cards per minute

By photoelectric means, the Speedreader 2000 can read 2000 punched cards a minute. The machine delivers information to electronic computers and converts punched card data to magnetic tape.

Uptime Corp., Dept. ED, 620 Gould Lane, Hermosa Beach, Calif.

CIRCLE 212 ON READER-SERVICE CARD

CIRCLE 215 ON READER-SERVICE CARD

NEW PRODUCTS

Oscilloscope

2-channel

Model K-260, is a 2-channel oscilloscope covering bandwidths from dc to 500 kc with a sensitivity of 200 μv per centimeter. The two channels may be used simultaneously to compare two different phenomena on a common time base.

Electronic Tube Corporation, Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 216 ON READER-SERVICE CARD

Servo Motor

Reversible operation

Type 1034 size 10 servo motor features reversible operation and high torque-to-inertia ratio. Rated at 0.00159 hp, the unit has a speed of 5300 rpm at 0.3 oz-in. torque. Duty cycle is continuous. Input are from 28 to 115 v and 60 to 800 cps.

Motordyne, Inc., Dept. ED, 2661 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 217 ON READER-SERVICE CARD

Ferrite Isolator

Eliminates frequency skipping

The R307/S142 ferrite load isolator is designed to eliminate frequency skipping. For use with the DR19 waveguide at high cw power levels, it gives a minimum of 10 db isolation over an 1800 mc bandwidth. Insertion loss is 1 db maximum.

Litton Industries, Components Div., Dept. ED, 5873 Rodeo Rd., Los Angeles 16, Calif.

CIRCLE 218 ON READER-SERVICE CARD

CIRCLE 219 ON READER-SERVICE CARD

Commutator

1 per cent input-output accuracy

This solid state multichannel sampling switch has an input-to-output accuracy of 1 per cent or better for any mixed source impedances up to 5 K. This accuracy figure includes linearity and offset factors. A back current of less than 1 μa is developed during the time a channel is off, eliminating the problem of transducer loading. The commutator will handle 0 to 5 v input signals in all IRIG standard pam and pdm sampling rates. Standard channel configurations are 30 and 45, including synchronization pulses. Applied Science Corporation of Princeton, Dept. ED, P.O. Box 44, Princeton, N.J.

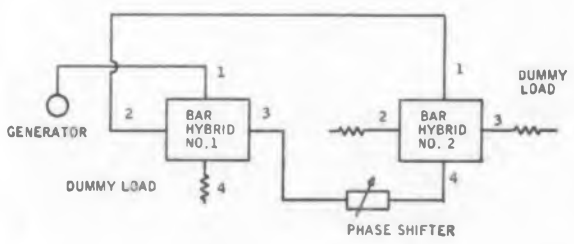
CIRCLE 220 ON READER-SERVICE CARD

Correction

Industrial Marketing Associates does *not* manufacture the 10 amp spdt and 3pdt time delay relays announced on page 84 in our July 23 New Products section. The manufacturer is Tempo Instrument Inc., 240 Old Country Rd., Hicksville, N.Y.

Phased-Out Diagram

In our article "Application of Coaxial Bar Hybrids" starting on page 26 of the August 6th issue, we proposed connecting two of these devices in tandem for one of the applications. We became somewhat alarmed when we thought that the two units were out of phase and had canceled each other out (Fig. 3). But we discovered, to our relief, that the printer inadvertently left out the circuit diagram. Here it is:



NEW PRODUCTS

Silicon Rectifiers

For 100 and 125 C operation

Two groups of low-priced silicon rectifiers. JETEC types 1N1692 through 1N1695 have peak inverse voltage ratings from 100 to 400 v and are capable of 250 ma dc rectified current output at 100 C ambient.

JETEC types 1N1487 through 1N1492 have peak inverse voltage ratings from 100 to 600 v and rectifier dc current output of 250 ma at 125 C, 750 ma at 25 C, ambient.

General Electric Co., Semiconductor Products Dept., Dept. ED, Clyde, N.Y.

CIRCLE 225 ON READER-SERVICE CARD

Signal Generator

AM-FM telemetering

Model 115 am-fm signal generator is used for testing alignment, bandwidth, sensitivity and distortion of am and fm sub-carrier receivers in a telemetering system. Frequency is adjustable from 2kc to 100kc.

New London Instrument Co. Inc., Dept. ED, 82 Union Street, New London, Connecticut.

CIRCLE 229 ON READER-SERVICE CARD

Servo Monitor Preamplifier

Phase sensitive demodulator

Servo monitor preamplifier 450-200 is a phase sensitive demodulator with built-in power supply. DC output voltage is proportional to an in-phase component of an ac signal with respect to a reference. Sensitivity is 5 mv, in-phase, to produce 1 v under maximum output load conditions. Frequency response is 3 db down at 20 per cent of carrier frequency.

Sanborn Co., Dept. ED, 175 Wyman St., Waltham 54, Mass.

CIRCLE 230 ON READER-SERVICE CARD

Coolers

For transistors

Compact and corrosion-resistant, these anodized aluminum coolers for transistors, rectifiers, and diodes conduct heat away through contact with a finned plate. Units come in two module sizes, 2-1/2 and 3-3/4 in.

Modine Mfg. Co., Dept. ED, 1500 De Koven Ave., Racine, Wis.

CIRCLE 231 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Potentiometer

Cavity tuning

Contained in the F-1810 10-turn potentiometer, this cavity tuning unit is housed in high temperature resistant glass-epoxy or anodized aluminum. Cavity tuning is within 0.025 per cent of total frequency variation.

Analogue Controls, Inc., Dept. ED, 39 Roselle St., Mineola, N.Y.

CIRCLE 235 ON READER-SERVICE CARD

Tetrode

Has g_m of 34,000 μmhos

Designed for use in broadband amplifiers from audio frequencies to about 300 mc, the 7150 tetrode has a g_m of 34,000 μmhos. It has a favorable figure of merit owing to low output capacitance. Short transit time loading and low cathode lead inductance are obtained by a closed spaced structure and triple cathode leads. Input conductance is about 11 μmhos at 70 mc. Pentode-like characteristics make the 7150 suitable in output stages.

State Labs Inc., Dept. ED, 649 Broadway, New York 12, N.Y.

CIRCLE 236 ON READER-SERVICE CARD

Differential DC Amplifier

Wide-band unit

A wide-band, chopper-stabilized unit, the DA-102 differential low-level dc amplifier has 3 db response at 20 kc for a gain of 1000. It features 6.5 μv noise at 10 kc; 200,000 to 1 dc common mode rejection; 50,000 to 1 ac common mode rejection; and 0.1 per cent stability.

Epsco, Inc., Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 237 ON READER-SERVICE CARD

Converter Transformers

DC to DC

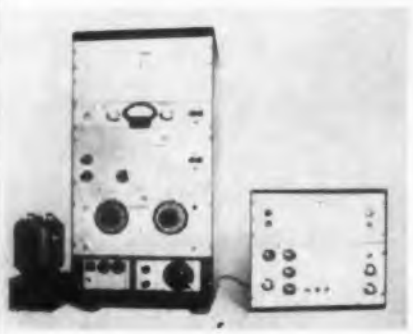
These dc and dc converter transformers have inputs of 13.6 and 28 dc. Output voltage range is 125 500 v dc; output power range, 25 to 125 va. The units are hermetically sealed and have 10,000 hr life.

Microtran Co., Inc., Dept. ED, 145 E. Mineola Ave., Valley Stream, N.Y.

CIRCLE 239 ON READER-SERVICE CARD

Scintillation Spectrometer

Automatic



Automatic histogram plotting of integral or differential spectra is provided by the B-A scintillation spectrometer. The unit can be used for isotope analysis, activation analysis, and studies of physical interactions, absorption, and particle scattering.

Baird-Atomic, Inc., Dept. ED, 33 University Rd., Cambridge 38, Mass.

CIRCLE 240 ON READER-SERVICE CARD

Cold Junction Compensator

For all thermocouple types

Autocomp I gives automatic cold junction compensation to most devices for measuring or controlling with thermocouples. Without auxiliary dials or computations, it compensates to ±1 F accuracy from 32 to 120 F ambient.

Technique Associates, Inc., Dept. ED, P.O. Box 91, Indianapolis 6, Ind.

CIRCLE 241 ON READER-SERVICE CARD

NEW PRODUCTS

Pre-amplifier

Used with ultrasonic transducers

Preamplifier PA-620 makes available at ultrasonic transducer outputs a tuning coil which will resonate at all frequencies from 6 to 70 mc with the fixed capacity of the crystals. The general purpose unit has input band widths of 0.5 to 17 mc with 100 μμf.

Arenberg Ultrasonic Lab, Inc., Dept. ED, 94 Green St., Jamaica Plain 30, Mass.

CIRCLE 245 ON READER-SERVICE CARD

Solderless Terminals

For high temperatures

Temp-Terms, high temperature solderless terminals and connectors, are for continuous duty at 650 F. Ring terminals and butt connectors come in screw sizes 6, 8, and 10 for wire ranges 22 to 16, 16 to 14, and 12 to 10.

Electrix Terminals and Connectors, Inc., Dept. ED, 990 E. 67th St., Cleveland 3, Ohio.

CIRCLE 246 ON READER-SERVICE CARD

Mounting System

Protects gyroscope

Model 1995 mounting system is a center-of-gravity all-metal mounting.

With an input acceleration of 10 g it provides 94 per cent vibra-

isolation in the 200 to 350 cps quency range.

Robinson Aviation, Inc., Dept. D, Teterboro Air Terminal, terboro, N.J.

CIRCLE 248 ON READER-SERVICE CARD

Analog-Punched Tape Data System

oduces 8-level punched tape output

Analog-punched tape data sys- n ZA-750 produces an 8-level nched tape output from a 20- annel, quasi-static, dc input. The pe may be used as the input to gital computers which use stand- d 8-level coding.

Electronic Engineering Company California, Dept. ED, 1601 E. estnut Ave., Santa Ana, Calif.

CIRCLE 249 ON READER-SERVICE CARD

Oscilloscope

AC bar graph type

AC bar graph oscilloscope model C-40BG displays 40 signals at ce. It has a 400 channel per sec scanning rate and a 10 per sec frame rate. Sensitivity for each channel is 10 mv for 9 in. vertical deflection. Frequency response is ±2 per cent from 10 cps to 10 kc, down 3 db at 50 kc.

International Telephone and Telegraph Corp., Dept. ED, Lodi, N.J.

CIRCLE 250 ON READER-SERVICE CARD

Gear Boxes

Ratios to 600 to 1

Ratios from 1.5 to 1 to 600 to 1 are offered in this line of size 8 gear boxes. The units have backlash as low as 45 minutes and handle 50 in.-oz of torque. Starting torque is 0.015 in.-oz or less.

Ellison Engineering Co., Dept. ED, 4350 San Fernando Rd., Glendale, Calif.

CIRCLE 251 ON READER-SERVICE CARD

NEW PRODUCTS

Speed Reductors

Ratios up to 1000 to 1

This series of in-line shaft speed reductors is available with exactly repeatable ratios up to 1000 to 1. They are remommended for continuous duty up to 1500 rpm, intermittent to 3000 rpm, with output torque capacity to 50 oz-in.

Insco Co., Div. of Barry Controls Inc., Dept. ED, Hollis St., Groton, Mass.

CIRCLE 256 ON READER-SERVICE CARD

TAPE LOOP ADAPTER.—For use with the company's type 5-752 recorder/reproducer, this loop adapter permits detailed repetitive spectrum analyses of information recorded on magnetic tape.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 257 ON READER-SERVICE CARD

SAFE CONNECTOR.—No. 14905 miniature arm-and-safe connector provides safe system.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 258 ON READER-SERVICE CARD

RELAY.—Series 8000 4pdt unit with rating of 5 amp resistive at 30 v dc or 115 v ac, or dry circuit, 5 μa at 5 mv.

Electro-Mechanical Specialties Co., Inc., Dept. ED, 1016 N. Highland Ave., Los Angeles 38, Calif.

CIRCLE 259 ON READER-SERVICE CARD

OSCILLOSCOPE BEZELS.—Series of plastic bezels in 1 and 3 in. sizes and a variety of colors.

Electronic Plastics Corp., Dept. Ed, 675 Barbey St., Brooklyn 7, N.Y.

CIRCLE 260 ON READER-SERVICE CARD

REVERSIBLE FAN.—For cooling electronic systems in trailers and vans. Variety of cfm's.

McLean Engineering Labs, Dept. ED, P.O. Box 228, Princeton, N.J.

CIRCLE 261 ON READER-SERVICE CARD

MICROWAVE TEST SET.—For testing relay systems, model 7100 combines a signal generator, frequency meter, and power meter. It checks transmitters and receivers operating from 5825 to 7725 mc.

Lambda-Pacific Engineering, Inc., Dept. ED, 14725 Arminta St., Van Nuys, Calif.

CIRCLE 264 ON READER-SERVICE CARD

SINE AND SQUARE WAVE GENERATOR.—Model E-310 features sine and square wave output over 5 cps to 600 kc range.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N.Y.

CIRCLE 265 ON READER-SERVICE CARD

CASTING RESINS.—Types R-86006, R-86007, R-86008, and R-86010 epoxies and modified epoxies for most casting, encapsulating, and potting applications.

Raybestos-Manhattan, Inc., Dept. ED, Bridgeport 2, Conn.

CIRCLE 266 ON READER-SERVICE CARD

MINIATURE LAMP HOLDER.—Model I Color-Lite holder uses standard no. 327 and 328 bulbs, produces flat wedge of light parallel to panel.

The Sloan Co., Dept. ED, 4101 Burbank Blvd., Burbank, Calif.

CIRCLE 267 ON READER-SERVICE CARD

PREAMPLIFIER POWER SUPPLY.—Type 127 is designed for use with the company's type 53/54 plug-in preamplifiers.

Tektronix, Inc., Dept. ED, P.O. Box 831, Portland 7, Ore.

CIRCLE 268 ON READER-SERVICE CARD

VARIABLE TRANSFORMERS.—Types T21U and T51U are added to the Adjust-A-Volt line. Interchangeable with W2 and W5 units, they are rated at 2.4 and 6 amp respectively.

Standard Electrical Products Co., Dept. ED, 2240 E. Third St., Dayton, Ohio.

CIRCLE 269 ON READER-SERVICE CARD

CONTROL VALVES.—Speed King ¼ in. 4-way foot mounted remote-operated units for use in hazardous locations.

Valvair Corp., Dept. ED, 454 Morgan Ave., Akron 11, Ohio.

CIRCLE 270 ON READER-SERVICE CARD

LOCK WASHER TERMINALS.—Made from 0.018 brass or phosphor bronze, hot tinned, with No. 4, 6 and 8 holes.

Zierick Mfg. Corp., Dept. ED, 110 Beechwood Ave., New Rochelle, N.Y.

CIRCLE 271 ON READER-SERVICE CARD

NEW PRODUCTS

COUNTER.—The Decitron counter is now available with an in-line Nixie tube readout unit.

Post Electronics, Div. of Post Machinery, Dept. ED, Beverly, Mass.

CIRCLE 275 ON READER-SERVICE CARD

TERMINAL BLOCKS.—Fanning strips for use with medium duty sectional Pres-Sure blocks. They eliminate handling of individual wires and reduce errors.

Buchanan Electrical Products Corp., Dept. ED, Hillside, N.J.

CIRCLE 276 ON READER-SERVICE CARD

P-C DRAFTING AIDS.—Decimal sizes and several new shapes have been added to this line of black or white pressure sensitive donut pads, teardrops, corners, T's, and narrow tape.

By-Buk Co., Dept. ED, 4314 W. Pico Blvd., Los Angeles 19, Calif.

CIRCLE 277 ON READER-SERVICE CARD

TERMINAL.—A double-ended Teflon standoff terminal, No. 2167, is available in ½ or ¾ in. standing height.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 278 ON READER-SERVICE CARD

PRESSURE SCANNER.—The SP-101B provides long operation with minimum maintenance. Range is from vacuum to 350 psig.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 279 ON READER-SERVICE CARD

PRESSURE TRANSDUCER.—TP-100 weighs less than 2 oz, can measure absolute, gauge, or differential in the range from 0 to 5 psi to 0 to 350 psi with linearity of ±1 per cent.

Fairchild Controls Corp., Dept. ED, 225 Park Ave., Hicksville, N.Y.

CIRCLE 280 ON READER-SERVICE CARD

VACUUM GAUGE.—For direct reading in the hard-to-measure range of 0.1 to 20 mm Hg.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

CIRCLE 281 ON READER-SERVICE CARD

PHOTOHEAD.—Miniature unit with 5000 hr light source life.

Post Electronics, Div. of Post Machinery, Dept. ED, Beverly, Mass.

CIRCLE 282 ON READER-SERVICE CARD

PHOTOJUNCTION CELL.—Miniature type 7223 for computer, punched-tape, punched-card, and sound-pickup-from-film applications.

Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 470 ON READER-SERVICE CARD

WIRE.—Oxaloy 28 is a copper wire clad with a chrome-iron alloy for high temperature, corrosive, and oxidizing conditions.

Sylvania Electric Products Inc., Dept. ED, Warran, Pa.

CIRCLE 285 ON READER-SERVICE CARD

MOUNTINGS.—These mountings have operating temperature of −80 to +250 F, and are effective against vibration from 5 to 500 cps. Load capacities range from 0.25 to 90 lb per mounting.

Jayme Organization, Inc., Dept. ED, 3091 Mayfield Road, Cleveland 18, Ohio.

CIRCLE 286 ON READER-SERVICE CARD

THREE NEW SERIES OF NYLON INSULATED JACKS.—The series is a low cost nylon tip jack with formed silver plated phosphor bronze contact. Voltage breakdown is 7000 v dc. Capacity to ⅛ in. panel is 3.8 μμf.

E. F. Johnson Co., Dept. ED, Waseca, Minn.

CIRCLE 287 ON READER-SERVICE CARD

VTVM.—Input impedance of 22 meg. Model 311 gives peak-topeak readings of complex ac voltages, as well as sine waves. Peak-to-peak and rms values are located on the same scale for simultaneous reading.

Simpson Electric Co., Dept. ED, 5200-18 W. Kinzie St., Chicago 44, Ill.

CIRCLE 288 ON READER-SERVICE CARD

VERNIER DIALS.—Each of these dials has a planetary drive of approximately 8 x 1 ratio.

Lafayette Radio, Dept. ED, 165-08 Liberty Ave., Jamaica 33, N.Y.

CIRCLE 289 ON READER-SERVICE CARD

SOLDERLESS TERMINALS.—36 block spade solderless terminals are available for 22-16, 16-14 and 12-10 wire size.

Hollingsworth Co., Dept. ED, Solderless Terminal Div., Phoenixville, Pa.

CIRCLE 290 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS.—Measures the pressures of conducting fluids such as salt water in differential, gage, or absolute ranges from 0 to 10 psi up to 0 to 3500 psi.

Datran Electronics, Dept. ED, 1836 Rosecrans Ave., Manhattan Beach, Calif.

CIRCLE 291 ON READER-SERVICE CARD

NEW LITERATURE

Infrared Detectors 295

An 8-page report on the properties of Infratron lead sulfide detectors is offered. With illustrations, it covers performance characteristics of a wide range of detectors and shows how they are produced with long wavelength response and other improvements. Infrared Industries, Inc., 163 Highland Ave., Needham Heights 94, Mass.

Drift Transistors 296

Brochure G-180 features complete specifications on seven pnp drift transistors. Types 2N602, 2N604, for very high speed switching applications, offer a dc current gain range of 25 to 100, and a gain-bandwidth product range of 10 mc to 70 mc. Types 2N605-2N608 are used for high and very high frequency small signal amplifiers, oscillators and converters. General Transistor Corp., 91-27 138th Place, Jamaaica 35, N.Y.

Test Systems 297

Description of instruments for measurement and analysis, complete instrumentation systems, improved features and details on more than 50 instruments are contained in this 12-page illustrated catalog. Sections cover spectrum analyzers, special purpose analysis instrumentation; accessory instruments; and telemetering equipment. A summary of applications and specifications is provided. Panoramic Radio Products, Inc., 514 So. Fulton Ave., Mt. Vernon, N.Y.

Measuring Instruments 298

Four-page list describes and provides specifications and prices for six products including: electrometer, linear amplifier, electrometer and vacuum tube voltmeter, 300 volt power supplies, exponential pulse generator, and reference voltage source. Gyra Electronics Corp., 515 N. Spring Ave., La Grange Park, Ill.

Selenium Rectifiers 300

Uses are described in a two-color four-page folder, which briefly discusses arc suppression. Listing of physical and electrical characteristics of the vacuum processed selenium rectifiers for ac and dc use is provided. Bradley Laboratories, Inc., New Haven 11, Conn.

Servo Valves 301

Detailed descriptions of servo valve operation and of the components in the basic valve design are considered in Bulletin No. 5801. Operational performance curves provide data on load pressure sensitivity, dynamic response characteristics, and differential current vs. flow. Borg-Warner Corp., Pesco Products Div., 24700 N. Miles Rd., Bedford, Ohio.

Microwave Filters 302

Catalog C3-58 lists standard low-pass and high-pass filters of the block, tubular and shell types operating in ranges from 10 mc to 12,000 mc. Supplement I to catalog C2 illustrates typical waveguide rf filters with very sharp cutoff and low insertion loss in the passband. Microphase Corp., Box 1166, Greenwich, Conn.

Headers 303

This catalog describes one-piece construction headers which aid electronic manufacturers using square or rectangular cans to package their units. Sizes are listed and three types of construction headers are illustrated. Glasseal Products Co., Inc., 1111 E. Elizabeth Ave., Linden, N.J.

Relays 304

A four-page color brochure, no. 58-3, describes 132 relays, including a complete line of miniature, sensitive, power, antenna, telephone type and hermetically sealed relays. Electrical and/or mechanical equivalents of 17 leading relay manufacturers are shown on cross-reference relay chart S200-A. Kurman Electric Co., Div. of Norbute Corp., 191 Newel St., Brooklyn 22, N.Y.

PATENTS

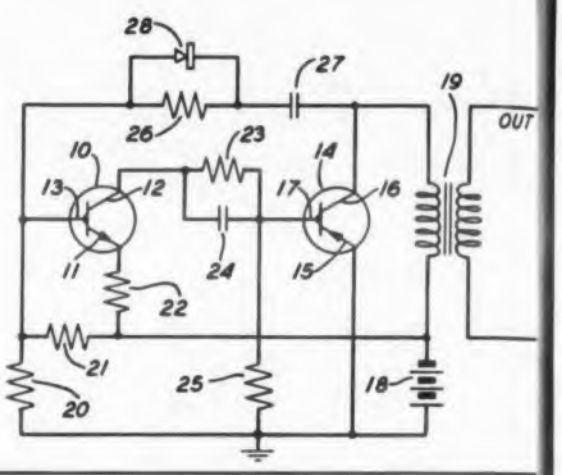
Transistor Relaxation Circuit

Patent No. 2,831,113. David C. Weller. (Assigned to Bell Telephone Labs., Inc.)

In this relaxation circuit, a low power npn transistor, 10, controls the current flowing through the high power pnp transistor, 14, such that the duty cycle is independent of the load impedance. In the free running oscillator shown, both transistors are simultaneously either conducting or cut off. If it is assumed that initially both transistors are slightly conducting, the voltage feedback transient through condenser 27 increases the base current of transistor 10 which in turn increases the base current of transistor 14. As a result the emitter-collector current of transistor 14 increases until both transistors saturate.

Condenser 27 charges exponentially until the base current of transistor 10 is reduced below the critical value. Transistor 10 is cut off, the base current of transistor 14 goes to zero, condenser 27 discharges to further reduce the current through transistor 14. The action accumulates until the current in the transformer primary reduces to zero. When condenser 27 stops discharging, both transistors 10 and 14 begin to conduct.

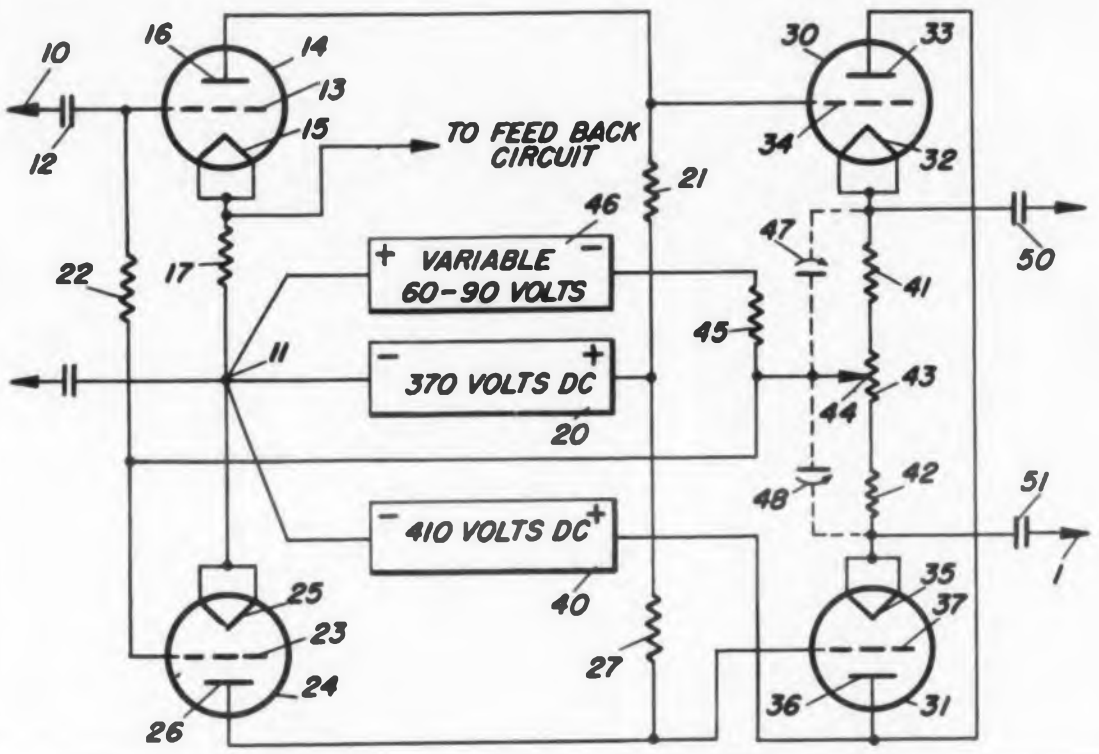
Voltage feedback causes both transistors to conduct saturation current within a short time. A tabulation is provided in the patent of the circuit components for a 300 cps oscillator generating 3 watts. A bistable relaxation circuit based upon the identical principle is also suggested.



Phase Inverter
Patent No. 2,833,871. Elgin Fremont Worthern.

This phase inverter consists of amplifier 14 dc coupled to cathode follower 30 which drives amplifier 24 to produce the control signal on the grid of cathode follower 31. As a result, balanced signals of opposite phase can be ac coupled through condensers 50 and 51.

When used with a 12AX7 (triodes 14 and 24) and a 12AU7 (triodes 30 and 31), the circuit has a frequency response which is flat within 1 db from dc to 85 kc. Gain is 135 at 1 kc, negligible distortion occurs to at least 40 v push-pull output.



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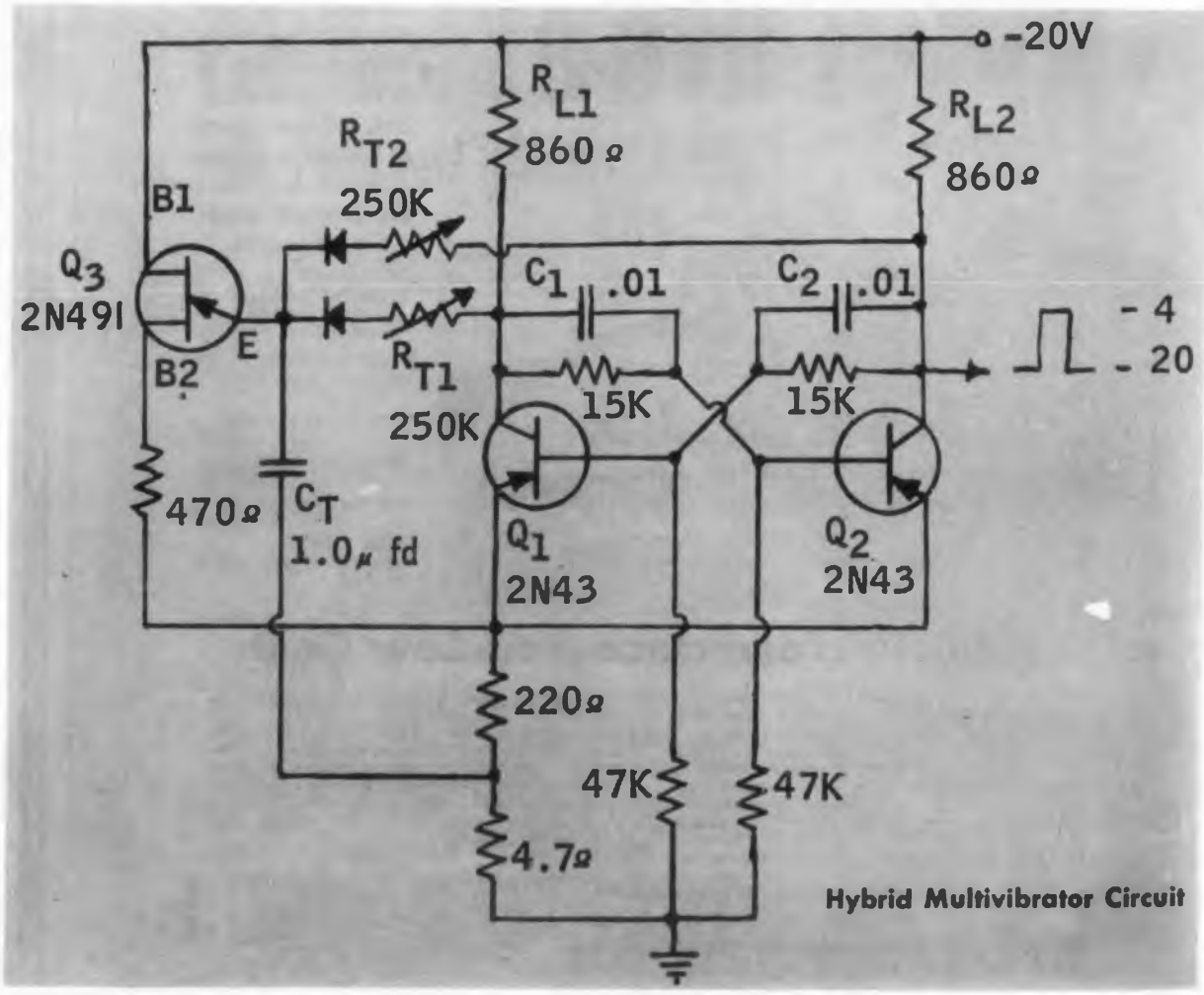
Wide Range Transistor Multivibrator

CONVENTIONAL transistor multivibrators have a number of serious disadvantages which limit their use in timing circuits and rectangular wave generators. The coupling capacitors must also serve as timing capacitors and thus must be quite large.

If long timing periods are required, electrolytic capacitors must be used. They severely limit the accuracy and stability of the timing periods. The coupling capacitors also distort the collector voltage waveforms, so it is difficult to obtain satisfactory rectangular waveforms. This



Hybrid Multivibrator Circuit

is particularly true if there is an appreciable difference in the lengths of the two parts of the timing period.

New Multivibrator

A new multivibrator circuit which has considerable flexibility is shown in the diagram. Transistors Q_1 and Q_2 are used in a conventional flip-flop circuit with a common emitter biasing resistor. The two capacitors C_1 and C_2 can have fairly low values since they are used only for coupling to ensure reliable switching. The unijunction transistor Q_3 functions as a relaxation oscillator and triggers the flip-flop by generating 2 v negative pulses across the 4.7 ohm resistor. The capacitor C_T serves as the timing capacitor and is charged alternately through the two resistors R_{T_1} and R_{T_2}. This permits the two parts of the period to be adjusted independently over a wide range of about 1000 to 1. The periods of the circuit shown are given by the equations.

$$C_1 = R_{T_1} C_T$$
$$C_2 = R_{T_2} C_T$$

With the circuit shown, periods up to 250 msec are possible with longer periods obtained by increasing the size of C_T. In contrast, a period of 250 msec with a conventional transistor multivibrator circuit would require capacitors of about 25 μf.

Some of the more important advantages of this circuit are:

- The output is very nearly an ideal rectangular waveform with little dependence on the ratio of the periods.
- The periods may be varied independently over a range of 1000 to 1 by adjusting the potentiometers R_{T1} and R_{T2}. If desired, the periods may be varied in such a way that their ratio is constant by means of a potentiometer (not shown) across the unijunction transistor from base-one to base-two.
- Very long periods may be obtained with a single small timing capacitor. This permits a stable paper capacitor to be used in many applications where otherwise an electrolytic capacitor would have to be used.
- Good timing stability can be obtained with respect to variations in temperature and supply voltage. The temperature variations in the two transistors Q_1 and Q_2 are relatively unimportant in their effects on the timing stability.
- The load may be changed over a wide range without affecting the timing. Since the trigger pulse is developed across a small resistance, the same basic circuit can be used in high power applications.

T. P. Sylvan, Engineer, General Electric Co., Electronic Components Div., Syracuse, N.Y.

IDEAS FOR DESIGN

Cake Decorator for Potting

It's difficult to inject very viscous potting compounds into inaccessible parts of electronic assemblies. When production quantities are small, the method should be very inexpensive.

A 49 cent cake decorator solves the problem neatly. It is disassembled easily for the very thorough cleaning required after use.

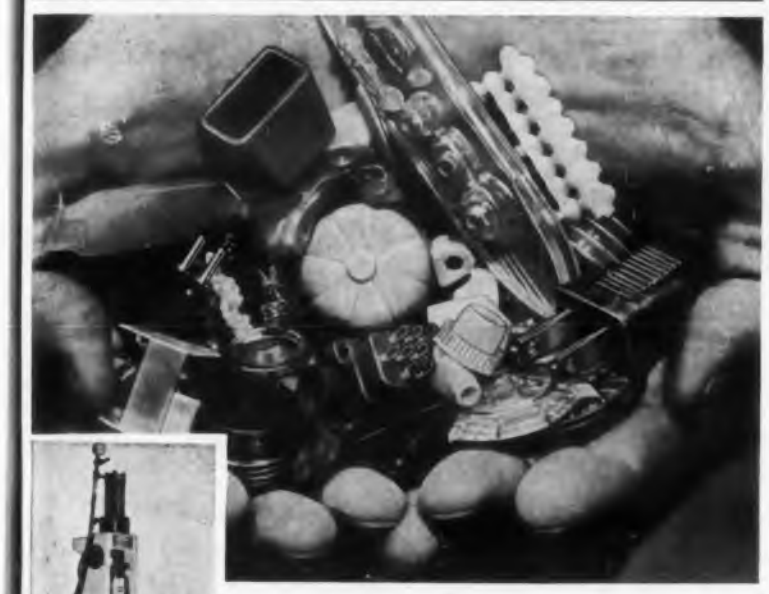
T. H. Goodenough, Project Engineer, General Devices, Inc., Princeton, N.J.

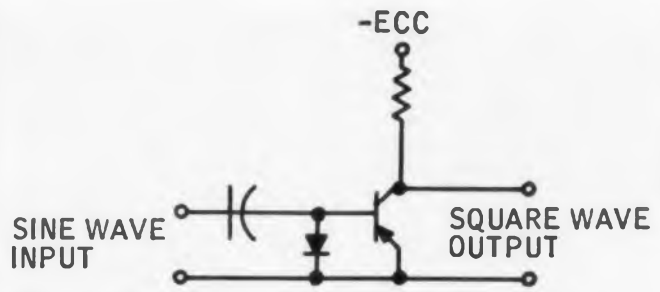
Double Duty Formex Skinner

Removing insulation from Formex transformer wire is tricky. The usual technique of burning it off with a soldering iron doesn't work because most irons aren't hot enough.

About the handiest way to do it consists in rigging some Nichrome resistance wire to a 6 v transformer. This gets hot enough to melt off the Formex insulation, and serves as a handy cigarette lighter to boot.

Richard S. Muller, Member of Technical Staff, Hughes Aircraft Co., Culver City, Calif.





Diode helps clipper make better square waves.

Better Sine Wave Clipper

When using a transistorized clipper to form square waves from sine waves, clipping often fails to take place at the "zero crossing" of the sine wave. This is due to the transistor's asymmetrical input impedances. A bias resistor can solve the problem at one temperature– but only one.

Since a germanium diode has an impedance similar to a germanium transistor's input impedance, the two can complement each other to provide more symmetrical impedances. The addition of the diode helps clip the sine wave at the same "zero" level over a much wider temperature range.

Frank Kelly, Senior Eng., Hallamore Electronics Co., Anaheim, Calif.

Low Tower Broadcast

J. George Adashko

Antenna height for medium and long waves can often be reduced by using slot antennas. These are widely used for centimeter and decimeter waves; they are simpler structurally, and considerably less expensive than antenna towers.

For operation at 600 meters with a 7.5 kc bandwidth and 100 kw of power, a slot antenna must be 30 meters high, 150 meters long, and must have a 40 meter horizontal roof width. The potential at the end of the roof is 35 kv.

For equivalent performance, a tower or mast antenna must be about 100 meters high. Its additional disadvantage is that it often cannot be used near airfields.

TRANSMITTING antennas must have high efficiency at their required bandwidth. Voltages on the antennas must not exceed a certain safe value.

Efficiency dictates a high antenna mast. For high efficiency, the antenna must be at least 0.1 to 0.15 wavelength high. If the antenna is too low, grounding losses increase. The only way to reduce these losses is to increase the complexity of the grounding system.

Efficiency is also affected by tuning element losses. If these elements are tuned with lumped constants, losses in the lumped constants can re-

Medium Wave Antennas

duce antenna efficiency considerably. If line sections (distributed parameters) are used for tuning, tuning element losses can be reduced.

Bandwidth and maximum potential on the antenna also depend on height. To obtain required bandwidth and stay within the maximum permissible potential with a power level of about 100 kw, calls for an antenna at least 0.15 to 0.2 wavelength high.

Slot Antennas

Slot antennas provide the necessary performance, even if they are much lower than mast antennas. In the decimeter band, flat slot radiators are formed of rectangular or round flat metallic plates, excited by the slot. Cylindrical types have slots cut on the surfaces of metal cylinders. (See Fig. 1.)

The outstanding feature of slot radiators for long and medium waves, is that the shield dimensions are much smaller than the wavelength.

For long and medium waves, only half the radiator is built, the role of the second half being played by its mirror image. Also, the solid metal surfaces are replaced by metal wire grids. A horizontal metal wire lattice is used to extend the bandwidth and reduce potentials.

The current in a slot radiator is distributed over the perimeter, so the current density in the ground near the antenna is less than for a single radiator with the same height as the slot. Hence grounding losses are reduced and antenna efficiency is increased.

Transverse dimensions of slot antennas are much larger than those of ordinary antennas for the same ranges. The perimeter of the cylindrical

(Continued on following page)

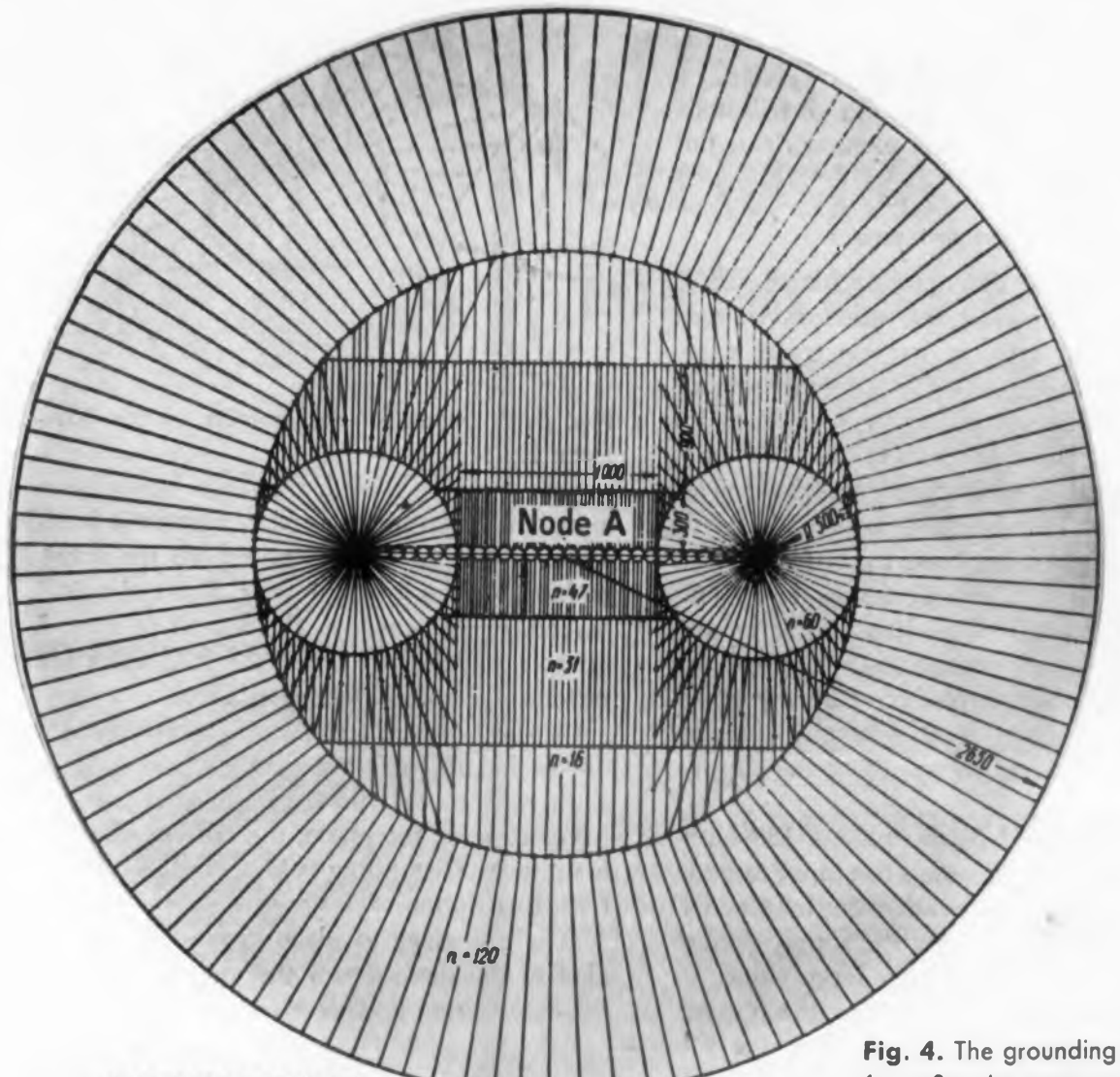


Fig. 4. The grounding scheme for a flat slot antenna is quite complex. (Dimensions are in cm).

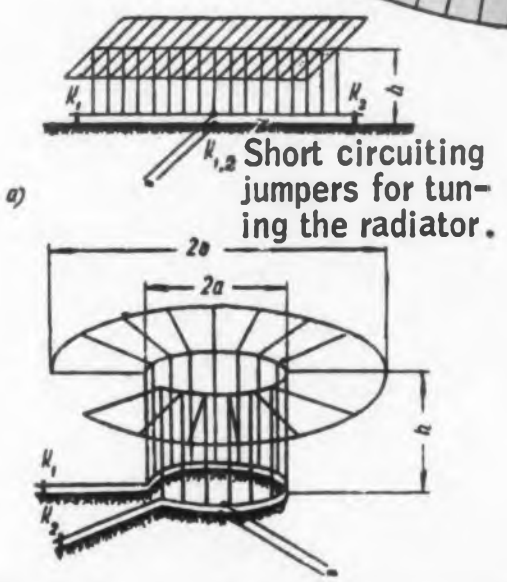


Fig. 1. Flat and cylindrical slot antennas for long and medium waves.

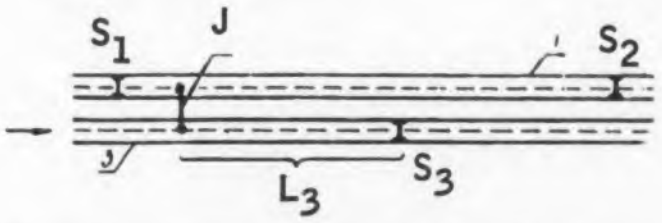
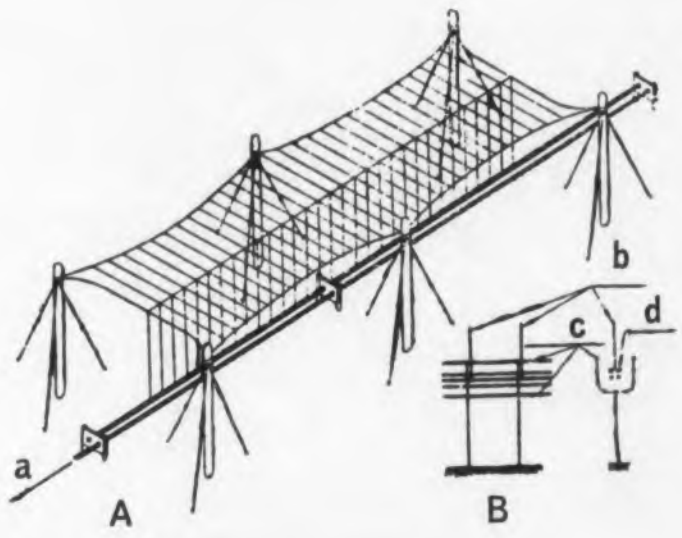


Fig. 3. The scheme used to feed and tune the antenna in Fig. 2. *1* is the distribution feeder, *3* the supply feeder, $S_{1,2,3}$ are short circuits, L_3 is a loop, and *J* is a jumper.)



a. To transmitter
b. Lead-down wires
c. Internal wires of feeder
d. Wires of feeder shield

Fig. 2. A flat slot antenna for the 200—600 meter band (a), and its asymmetrical wire feeder (b).

slot antenna is about quarter wavelength, as is the length of the flat slot antenna. This leads to smaller potentials and increased bandwidth.

Slot antennas can be tuned with distributed parameters, so losses in tuning elements can be made negligibly small.

The Flat Slot Antenna

Fig. 2a shows a flat slot antenna for the 200-600 meter band. For long and medium waves, the slot is formed into an asymmetrical wire feeder, as shown in Fig. 2b. The internal wire of the feeder, with the vertical wires connected to it, acts as the upper edge of the slot, and the feeder's grounded shield serves as the lower edge. This feeder is the distribution feeder.

Fig. 3 shows the scheme used to feed and tune the antenna in Fig. 2. Supply feeder (*3*), from the transmitter is parallel to distribution feeder (*1*). The supply feeder can be connected to any point of the distribution feeder with a jumper (*J*). The antenna is tuned by moving the shorting bars, S_1, S_2, and S_3, and by selecting the supply point.

Shorting bars S_1 and S_2 are placed 180 electrical degrees apart. This makes the input impedance at every point of the distribution feeder purely resistive. It varies along the supply feeder from zero, at the short, to a very large value, at the center of the antenna. By moving the jumper

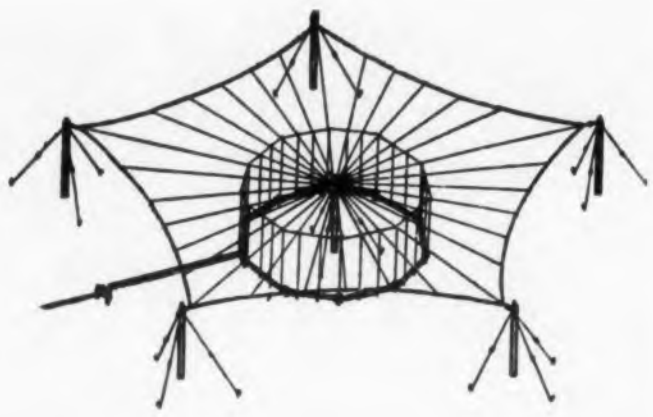


Fig. 5. A cylindrical slot antenna for the 200—600 meter band.

along the distribution feeder, a point is found at which the input impedance equals the wave impedance of the supply feeder. Short circuit S_3, is placed, in this case, so the length of loop L_3 is quarter wavelength. Then the loop does not affect the antenna input impedance.

Currents in a flat slot antenna are distributed unequally. In the outside wires, and those close to them, the currents are higher; in the remaining portion of the plane, the current distribution is uniform. Grounding is in accordance with current distribution.

It is necessary to place grounding wires parallel to the direction of the current-density vector in the ground. This is easy where the lines of current density are straight, but where the current lines curve, it may be necessary to use a grid of intersecting wires. The grounding wires are welded at their intersection. Under each lead-down wire, there is a local ground, in the form of a 36 wire star with a radius of 2.5 meters.

The recommended grounding scheme is shown in Fig. 4. Grounding is more complicated than with a tower or mast antenna. But this doesn't increase the cost of the antenna substantially, since grounding constitutes only a small fraction of the total cost. Nevertheless, the length of grounding wires for a flat slot antenna, operating in the 200-600 meter band is about 30 to 35 km compared with 20 to 24 km to ground a 120 meter high tower antenna.

Cylindrical Slot Antenna

A cylindrical slot antenna is obtained by rolling a flat slot antenna into a cylinder. A typical one for 200-600 meters is shown in Fig. 5. The cylindrical antenna has a uniform current distribution. Ground currents also, are uniformly distributed over the perimeter and flow radially from the antenna. A simple 120 wire grounding system can provide about the same efficiency as in high antennas.

The necessary bandwidth requires a height of only 20 meters, a cylinder diameter of 50 meters, and an external diameter of 120 meters for the

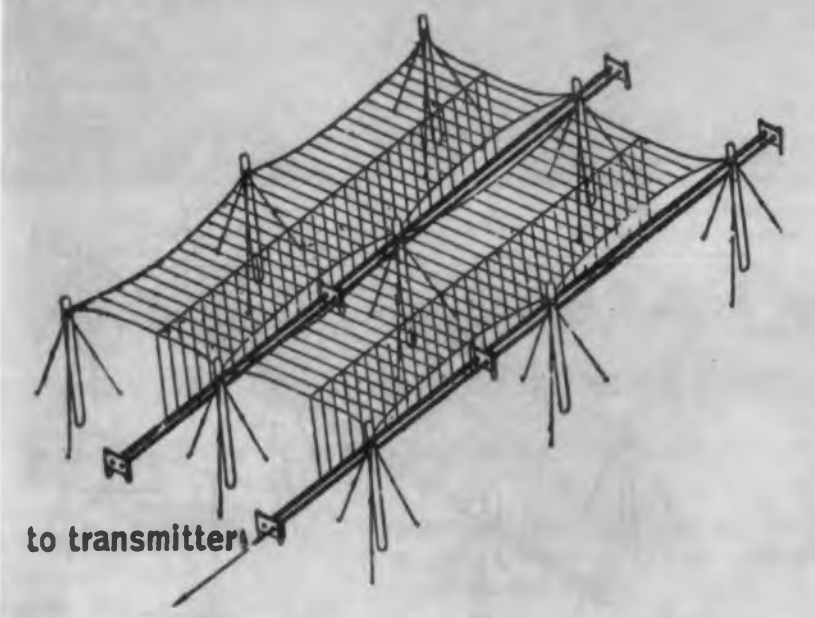
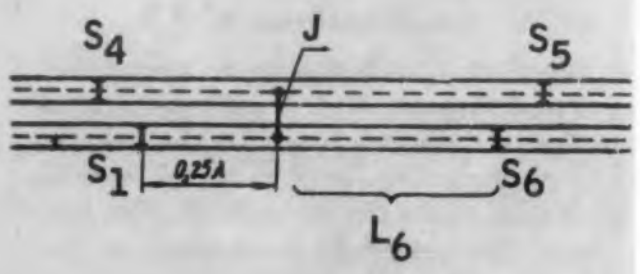


Fig. 6. A low tower directional antenna for the 200—600 meter band.

Fig. 7. A passive reflector and its tuning elements.



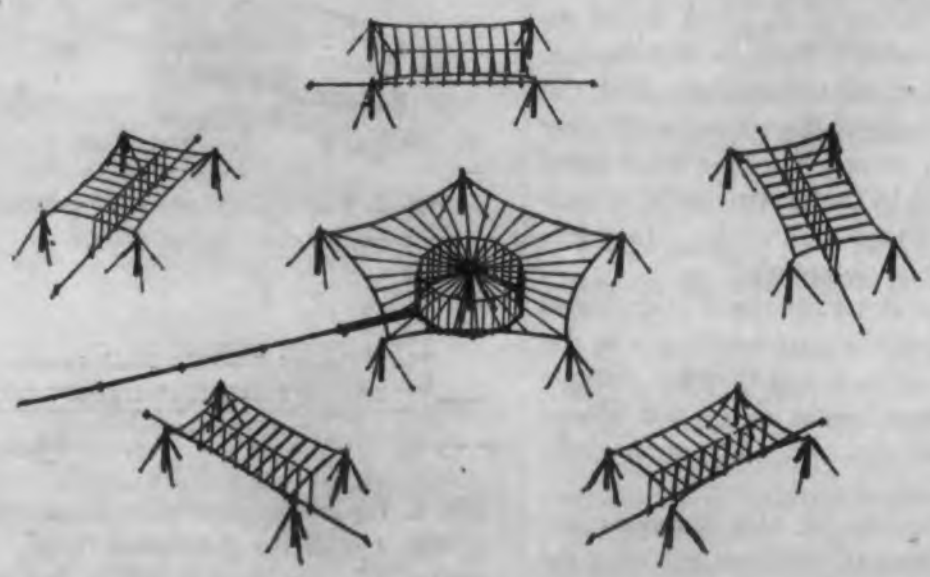


Fig. 8. An overall view of an anti-fading polygon antenna.

or zontal portion. In principle, the feeding and n ng is the same as for the flat antenna.

Construction costs of cylindrical slot antennas r 200-600 meters are several times less than sts of mast antennas.

Directional Antennas

If the broadcast station is not in the center of e territory it serves, directional antennas may e used. These use reflectors.

Easiest to construct is the passive reflector. alculations and experiments show that passive flectors can provide good directivity at 200-600 eters. Antenna gain with a reflector varies from 5 to 3.5 compared with a low dipole.

The active dipole and passive reflector are flat ot radiators. Fig. 6 shows a low directional antnna for the 200-600 meter band.

Tuning a passive reflector is illustrated in Fig. Tuning is by means of shorting bars S_4, S_5, S_6, nd S_7. Over most of the working range, satisctory tuning is achieved by moving only S_4 nd S_5. In this case jumper J is removed. In the hort wave part of the band, the attenuation of e distribution feeder and passive reflector bemes great. Small displacements of shorts S_4 nd S_5 can change the modulus and phase of the rrent.

In this case, it is necessary to use loop L_6, hich is connected to various points of the disibution feeder. Then S_7 is mounted quarter avelength from the jumper.

Anti-Fading Antennas

An anti-fading antenna can be built of slot diators using the scheme of the so-called polynal antenna. A typical one is shown in Fig. 8. he antenna has a central radiator in the form of cylindrical slot radiator, and five peripheral diators, representing flat slot radiators.

The peripheral radiators are on a circle with radius of about 0.4 wavelength. They are exted, either directly from the transmitter, or rough space coupling from the central radiator. In the former case, the anti-fading directivity tterns can be achieved over a wide range of avelengths but the supply circuit is quite comlicated.

The use of passive excitation for the peripheral tennas simplifies the supply. Investigations ve shown that the range of anti-fading action the same in this case as with a high mast anna 0.53 wavelength high.

Peripheral antennas, when excited passively, e tuned by moving shorting wires along their ops.

Abstracted from an article by B. S. Nadenenko d L. P. Poednyakov in Vestnik Svyazi (Comnications Journal), *May 1957, pp 11-14, 12*

GERMAN ABSTRACTS

E. Brenner

Hall Effect Multipliers For Analog Computers

WHILE LINEAR operations (addition and integration) in analog computers are easily performed with operational amplifiers, the problem of multiplication still offers considerable difficulty especially when speed of response is important. The Hall effect makes it possible to obtain a voltage which is the product of two voltages.

If a conductor carries a current I_c (Fig. 1) and is subjected to a magnetic field B, oriented perpendicularly to the direction of the current, there a voltage V_H proportional to the product of I and B is produced between the longitudinal edges of the conductor. To achieve sufficiently large Hall voltages, semi-conductors must be used. Although it has already been demonstrated that germanium and especially silicon are best suited for this application, this report deals with the use of Indium Arsenid (InAs) since Hall generators using this material are commercially available in Germany.

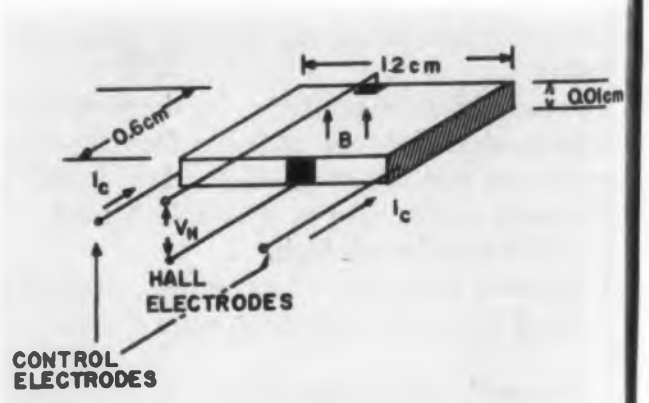


Fig. 1. Schematic diagram of a Hall Generator. The dimensions given are for the InAs semiconductor used.

For the dimensions given in Fig. 1, it can be shown that for values of B below 1 kilogauss, the Hall voltage is given by

$$V_H = 80\, I_c\, B$$

where I_c is in microamperes, B in gauss and V_H in volts. This equation is an approximation; Hall voltage is not exactly proportional to the product of control current and control field strength for several reasons:

- crystal resistance is temperature dependent;
- proportionality "constant" is a function of B and varies appreciably near and above 1 kilogauss;
- three noise voltages are generated. One results from the Hall contacts not lying on an equipotential line. This error can be compensated by use of the bridge arrangement of Fig. 2. Another is due to the uneven heating of the crystal caused by the control current. For a control current of 0.4 amp this voltage is of the order of 0.07 mv. External circuitry cannot compensate for this effect. Finally, voltage proportional to dB/dt and independent of I_c is generated when the Hall contacts are not located on the axis of symmetry of the crystal. One can compensate for this effect by use of an inhomogeneous control field.

Two types of multipliers have been constructed. In one type a single Hall generator is used and a linear relationship between B and one of the variables is assured by use of a nonferromagnetic core. In the second type a ferromagnetic core is used; the magnetic field is measured with a second Hall generator and the exciting current of the coil is regulated to give the desired proportionality.

In the original paper a multiplier using a single Hall generator is described. All static errors in this model were below one per cent; dynamic errors were judged negligible at frequencies below one kc.

Abstracted from an article by J. Oxenius Nachrichtentechnische Zeitschrift, *Vol. 11, No. 5, May 1958, pp 263-268.*

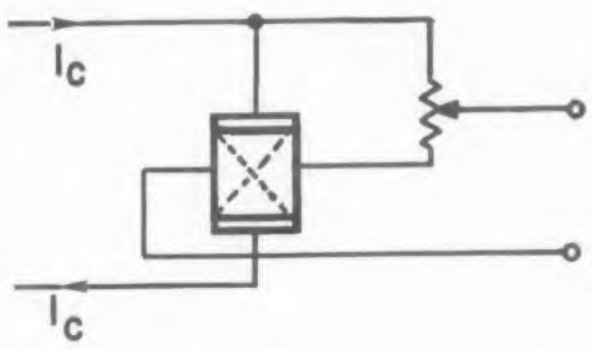


Fig. 2. Scheme for compensating the effect of not having the Hall contacts on an equipotential line.

Nuclear Radiation Effects On Electronic Components

HIGH ENERGY radiation can be considered as a new environment that material and components must withstand in the atmosphere. Arma has tested circuit boards and other inertial guidance system components at the Brookhaven National Lab to determine how they will react when an operational system is placed in this environment. Among the results noted are the following:

- **Wire-wound resistors** have shown themselves to be generally very radiation resistant. The general trend is toward a slight increase of ohmic resistance associated with atomic displacements in the nickel-chromium alloy.
- **Composition resistors.** These components are made up primarily of a carbon dispersed in a ceramic material and are sensitive to the dispersion characteristics of the carbon. They show a fairly high sensitivity to nuclear radiation fields. The type of change usually seen is a decrease of resistivity. This decrease seems to be associated with a change in the conducting material rather than a change in the ceramic body. D. S. Billington has suggested that this is a result of recoil atoms which heat small volumes of the material and cause these volumes to be highly conductive.
- **Carbon film resistors.** No general statements are vigorously valid here. Generally it has been reported that there is an initial decrease of resistivity with a gradual recovery of resistivity sometimes exceeding the initial value.
- **Capacitors.** Mica, glass and ceramic capacitors show little change of their capacity, significant change of the tan δ, and fairly large change of their voltage breakdown resistance.
- **Oil impregnated capacitors.** All show changes in capacitance dissipation factors under nuclear radiations. There is generally a decrease in capacity with a large increase in dissipation factor. In sealed units, major problems exist since there is evidence of gas evolution which in time causes

rupture and results in complete failure of the unit as a capacitor.

- **Vacuum tubes** are fairly sensitive to radiation damage though a great deal depends on the materials used for fabrication, i.e., glass envelopes having a high boron content show more rapid failure than those made of non-borated glass. Semi-conductors and transistors show a high degree of radiation damage sensitivity as might be expected from the fundamental mechanisms that are used in obtaining their characteristics. Again, however, individual differences are very large depending on the manufacturer's fabrication techniques. Recently, one manufacturer used small quantities of Kel-F polymer, which has the unpleasant property of gassing, destroying the transistor casing and causing a failure that was not associated with the semiconducting material itself.

Extensive data has been collected on plastics degnotation and much of this information appears in the original article.

Abstracted from an article by J. E. Heffernan and J. J. Regazzi, Arma Engineering, *Vol. 1, No. 6, May-June 1958, pp 5-7.*

SSB in Land Mobile Radio

INVESTIGATION at GE of the possible use of SSB in Land Mobile Radio Services for purposes of frequency spectrum conservation have led to the following conclusions:

- SSB does not appear to save spectrum space over ±2.5 kc fm.
- SSB is considerably inferior in the presence of spike noise unless a blanking scheme is used.
- SSB can provide longer range but only at poor readability. Closer in, the readability is not as good as that obtained with fm. It will be hard to keep SSB equipment at peak performance with voltage variation and tube aging.
- SSB equipment would be 1.7 to 2 times the size and cost of comparable fm equipment.
- Since there is basically more "fussing" in producing and receiving an SSB signal, the basic relationship between fm or am and SSB is not likely to change.

Abstracted from a paper "SSB and Similar Systems in Terms of Spectrum, Spikes, Service, Size and $" by R. P. Gifford, Manager of Engineering delivered at American Gas Association Meeting.

INERTIAL GUIDANCE ENGINEER John V. Prikazsky tells why airborne computer development at IBM Owego, N. Y., offers him the creative engineering career he always wanted.

What it's like to be a Creative Engineer at IBM

"Inertial guidance," explains John Prikazsky, "means aerial navigation without recourse to external reference. As an inertial guidance engineer with IBM, I have the opportunity to work on completely integrated bombing-radar-navigational systems. My work is broad — from lab studies to the analytics involved in system design—everything from shooting the North Star to heat transfer problems. That's why I like it — plus the chance I have to take on as much responsibility as I can handle."

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ADVERTISERS' INDEX
September 3, 1958

ELECTRONIC DESIGN
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