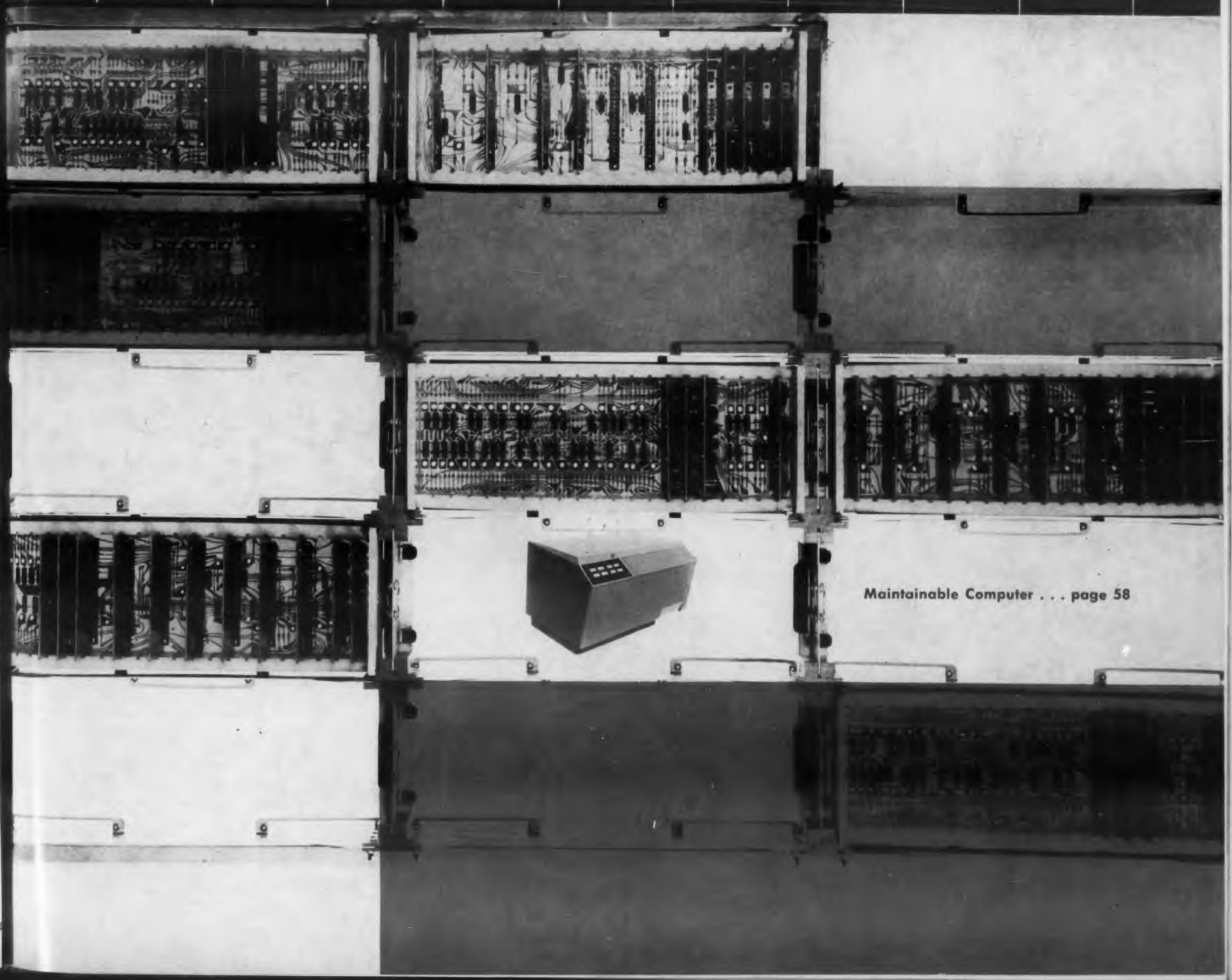
September 1, 1957

ELECTRONIC DESIGN



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Subscription rate for non-qualified subscribers—$12.00 for 1 year only.

Hayden Publishing Company, Inc.
19 East 62nd Street
New York 21, New York

ELECTRONIC DESIGN

Contents

Vol. 5, No. 18

September 15, 1957

ELECTRONIC DESIGN is published semi-monthly by Hayden Publishing Company, Inc., 19 E. 62nd Street, New York 21, N. Y., T. Richard Gascoigne, President; James S. Mulholland Jr., Vice-President & Treasurer and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Acceptance under section 34.64 P. L. & R. authorized. 30,000 Copies this issue.

Editorial

Isn't RFI Your Problem?

"Everybody knows" that the best way to get in terference out of electronic equipment is to desig it out in the first place.

Everybody knows. Yet equipment manufacturin companies and/or equipment users are spendin millions of dollars annually *suppressing* interferenc in their equipment. Why? We submit that perhap "everybody" does *not* know the cheapest, easie and most effective way to assure radio-interferenc free operation of electronics. Either that, or they d not care. The FCC—the only organization so far em powered to use strong measures (such as takin away an offending piece of equipment)—act against the user of the gear, not the manufacture In all fairness we must note that reputable firm usually suppress the equipment for the customer a their own expense for the sake of good will.

And this represents a huge waste of effort, mone and engineering talent. The idea seems to be th for the small or middle-sized manufacturer an ou lay of initial capital to set up screen rooms and i terference-testing equipment is too expensive whe balanced against the *ex-post facto* suppression o the equipment.

We disagree. For what is needed is not elabora screen rooms and expensive testing gear—but th mere acquaintance of electronic design enginee with a few simple (ground cables at both end standard (shield case discontinuities) technique Like reliability in producing complex systems, a awareness of the existence of the problem and little care at the inception of the design will go long, inexpensive way.

The problem of radio interference is no ligh weight proposition. Missiles continue to be deflect and have to be detonated in mid-air, airlines na gation systems are hopelessly, if temporarily, foul by stray radiation, communications are disrupt by motors and generators, diathermy machin broadcast broadband energy for thousands of mil aircraft home in on rf heat-sealing equipment.

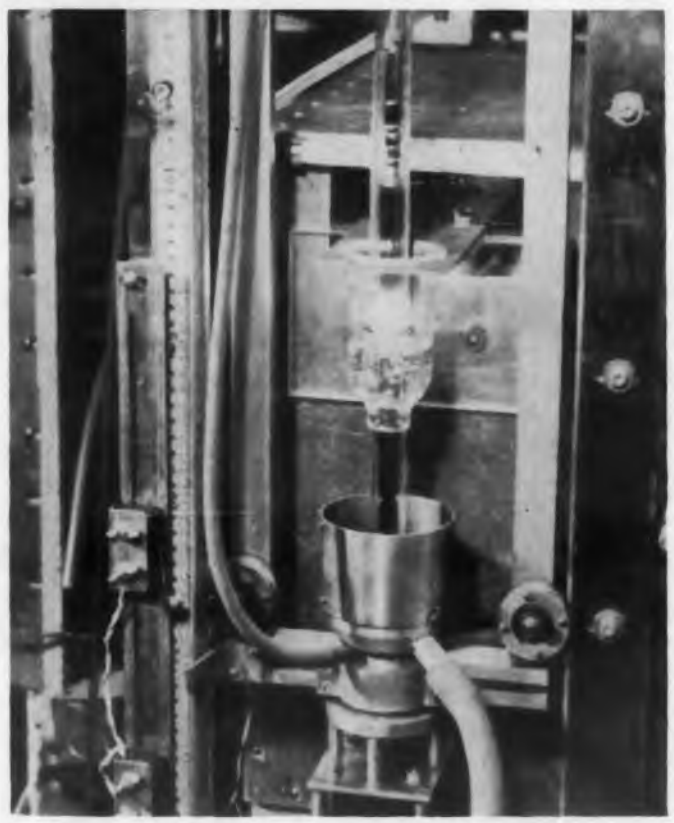
The danger of a guided missile landing in crowded city is problematic. But the fact that bomber's own radars or generators may disrupt i own computers is not. Convair, in producing B-5 sub-subcontracted the problem of shielding the co puter within the airframe, and spent a great deal money doing so. Was it entirely necessary?

The Europeans are ahead in rfi. The density population on the continent and in the British Is precludes any fooling around with stray emissi Too many TV receivers, too many motors and ge erators in too small an area to permit the slight hint of spurious radiation. We ought to follow and surpass—their example: design electron equipment to be interference free from t start.—TM

Engineering Review

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

Purer Refining of Silicon



No crucible is needed for this method of refining. A molten zone, formed in the vertical silicon rod by inductive heating, passes from one end of the rod to the other.

An automatic refining device which will reduce electrically active impurities in silicon to less than one part in one billion has been developed at Bell Telephone Labs. It utilizes the floating zone refining technique in which a molten zone is swept through the silicon, carrying impurities with it. The method can also be used to purify germanium, molybdenum, tungsten, and many other materials.

No satisfactory solid crucible material has been found for containing silicon during the refining process. Fused silica, frequently used in zone refining, is attacked by molten silicon. For example, contact with commercial fused silica for one hour introduces about one to three parts per billion of electrically active impurities to molten silicon at 1450 C. The floating zone process, however, requires no crucible and so is free from such contamination. In this process, the molten zone, supported only by surface tension, is passed along a vertical silicon rod rigidly held at both ends. Refining is performed in a controlled atmosphere by surrounding the rod with a water cooled gas-tight envelope. Inductive heating produces the molten zone and motion of either the heating coil or the rod sweeps the zone along. This process is repeated, with the molten zone always traversing the rod in the same direction, until the desired purity is obtained.

The new automatic apparatus recently developed consists of a 10 kw, 4 mc generator, mechanical means for moving the rod up and down while it is rotating inside a gas-tight silica enclosure, and switching means for automatically recycling the mechanism. Constant length and freedom from mechanical oscillation of the molten zone have been achieved by employing low heating current at a relatively high frequency and by properly proportioning the load and generator impedances. By use of this equipment with a moist hydrogen atmosphere to remove boron, a single crystal of p-type silicon with a resistivity of 16,000 ohm/cm and minority carrier lifetime of 1200 μsec has been obtained after 67 passes. This corresponds to an impurity content of less than one part per billion, thought to be the purest silicon ever produced in significant quantity.

Thermal Photos: This recently declassified photo of Republic Aviation Corp., Farmingdale, N. Y. (on the left) was recorded by an early passive infrared reconnaissance system. The bright areas are regions of greatest heat radiation; the darker regions are less active and therefore will radiate less significant heat.

To the right is a conventional aerial photograph taken from an identical position. Strategic points in this photo blend with all other areas. In contrast, in the infrared photo, the runways with engine exhaust, moving planes, auxiliary trucks,—areas of greatest heat activity—show up clearly as bright spots. The plant itself stands out as brilliant clusters of heat radiations. The system was designed and manufactured by Servo Corp. of America, New Hyde Park, N. Y.

Engineering Review

Sound Delay for Hard-of-Hearing

A method of controlling the spe at which people hear is a major g of current research to benefit the ha of hearing, Dr. William G. Har director of the Johns Hopkins Hear and Speech Center, declared at t annual convention of Zenith Ra Corp.

Hearing aids that merely augm volume of sound do not complet solve the problem of people who fi it difficult to discriminate words they are spoken too rapidly. T difficulty becomes more comm among the hard of hearing with a vancing age, especially in regard women's voices. Regulation of the r at which sound reaches the ear already possible under laboratory c ditions. How to incorporate a sou spacing device into a hearing aid the crucial problem.

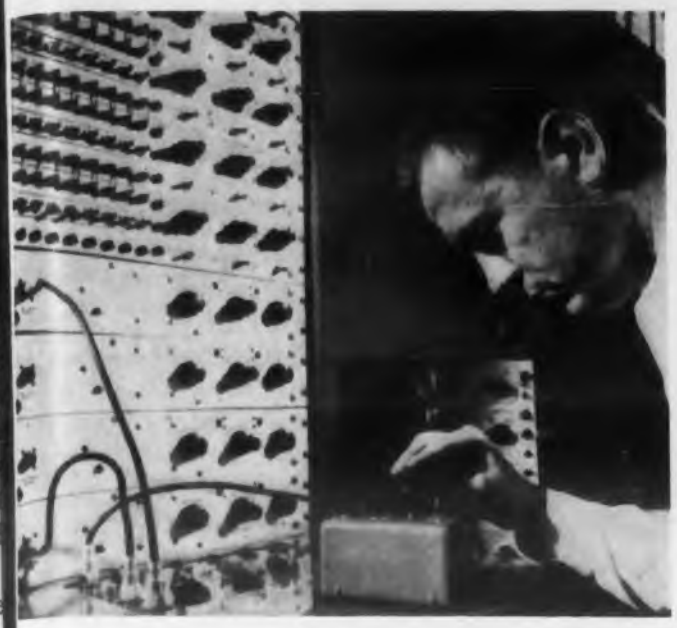
Closed-Circuit Religion

Closed-circuit television is help to solve seating problems for overfl attendance in the Bethel Luther Church of Madison, Wis.

Instead of being forced to stand to attend later services, late arriv are now ushered to seats in an adj ing chapel where services are viewe on two 25-in. TV receivers. In ad tion, services are also transmitted multaneously to a third floor "moth room." Here mothers and child view services on TV sets in nurse room comfort without fear that sm fry capers will distract other worsh pers in the church.

The arrangement is the first s use of closed-circuit TV in the st and possibly in the nation. It w planned by the pastor, Rev. Mo Wee, with cooperation of indus television engineers from Gen Electric Company's Technical Pr ucts Dept., Syracuse, N.Y.

◀ CIRCLE 4 ON READER-SERVICE CARD



Computer Core Testing Equipment: Pulse-testing equipment for checking high permeability matrix memory switching cores used in storage sections of computers has been installed in the specialty transformer plant of Westinghouse Electric Corp., Greenville, Pa. A four-channel output excites the hyper-thin core to simulate any operating sequence actually used in a computer. Outputs can be paralleled or operated singly. The equipment is used to production test every computer core manufactured at the plant. It was supplied by Electrical Pulse, Inc.

Deformation of Metals

In a new approach to the study of deformation of metals, a research team at Battelle Institute, Columbus, Ohio is attempting to correlate variations in electrical properties with structural changes in semiconductors. The study is aimed at creating a better basic understanding of the structural changes in engineering metals when they are deformed and annealed.

It has been found that the intermetallic semiconductor, indium antimonide, exhibits metallic behavior when subjected to various mechanical forces. The electrical properties of this semiconductor undergo extreme changes when defects are introduced into its crystal structure. By comparison, the electrical properties of ordinary metals change relatively little under similar conditions. This sensitivity to introduced defects may make possible a better understanding of the behavior of such defects in common engineering metals.

In current experiments, indium antimonide is plastically deformed at about 200 C, and then its electrical properties are measured at —190 C, where the effects of structural changes are most readily observed. Indium antimonide was chosen for this research because it has the largest electron mobility known for any material and because it deforms plastically at relatively low temperatures.

Engineering Review

35,000 Kw for Chlorine Production

The nation's largest germanium rectifier installation will provide 140,000 a dc for the production of chlorine. Each of 18 air-cooled 250 v, 7778 a cubicles for use by Diamond Alkali Co., Houston, Tex., distributes the load among 216 removable trays. When completed late this year, the total installation will be rated at 35,000 kw.

Flight Path Simulator

A device for simulating the actual flight path of a space vehicle has been developed. Panatrack projects a moving view of the terrain over which the vehicle travels, showing the area as it would be seen by an observer in a space ship or satellite. The apparatus consists essentially of a projector inside a globe, which may be positioned manually or automatically to show on a screen or wall any portion of the earth's surface either at rest or in motion. The rate and direction of motion is adjustable as desired. As a satellite tracking display, the drive motors could be controlled by signals transmitted from the moving object and processed through ground stations so that the current position of the vehicle is continuously displayed on a screen. Originally Panatrack was designed and built at the Corps of Engineers Research and Development Labs, Fort Belvoir, Va., as a training aid for ionospheric studies.

New Components Company

Formation of a new company called CK Components, Inc. has been announced. The company manufactures magnetic shift registers and lumped constant delay lines. Dr. Charles A. Coolidge Jr. and Marshall M. Kincaid, both formerly of Epsco, Inc. and the Harvard Computation Lab. are Treasurer and President respectively. The company occupies a plant of 9000 sq ft at 101 Morse St., Watertown, Mass.

...en for Efficient Telegraphy Fulfilled

Facsimile telegraphy may solve the ...entury-old problem of how to speed ...e transmission of telegrams in Chi...ese. There are more than 9,000 writ...en characters in the Chinese lan...guage, and sending them by telegraph ...s slow and cumbersome. Each Chi...ese character is identified by a four-...igit numeral and must be encoded ...efore transmission. Upon receipt, the ...umerals are decoded. The use of ...Western Union's electronic Desk-Fax ...ould enable Formosa businessmen to ...nd and receive telegrams instantly ...nd automatically in their own hand-...writing simply by pushing a button, ...ccording to Shu-liang Chiang, a lead-...ing communications expert from the ...Chinese Republic.

...ocket-Size FM Receiver

FM radio receivers, which can be ...arried in a shirt pocket, are expected ...o go on the market later this year fol-...lowing additional tests. They will be ...he first commercial pocket-size f-m ...eceivers for mobile communication ...ervice. A fully transistorized, 10-oz ...nstrument, the radio is designed to ...provide extensions of several miles for ...adio systems now operating in the ...50-mc band. The New York Police ...Dept. is currently experimenting with ...he radio receivers for possible appli...ations in extending police communi...ations to foot patrolmen and park ...guards. The radio was developed by ...Radio Corp. of America, Camden, N.J.

...ransistor Field Newcomer

Industro Transistor Corp. an...ounces the completion of its initial ...ransistor manufacturing facilities ...ocated at 87-31 Britton Ave., Elm...urst, N.Y. The firm is now manufac...uring germanium alloy-junction tran...istors for use in computers, audio ...quipment, as well as portable tran...istor radios. Industro Transistor Corp. ...ill market its products to the elec...onic industry in the U.S. through ...ecently appointed sales representa...ives under the supervision of Mr. ...harles A. Tepper, Vice-President in ...harge of sales. Sales offices are ...ocated at 649 Broadway, New York ...2, N.Y.

CIRCLE 7 ON READER-SERVICE CARD ➤

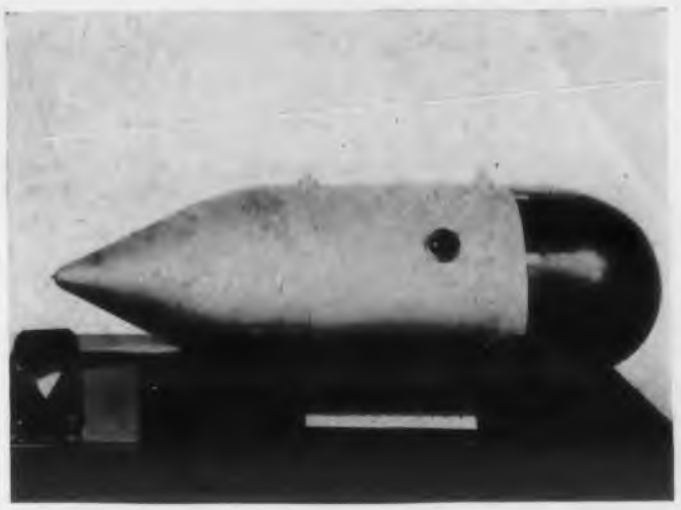
Nuclear Ship Propulsion

The Atomic Energy Commission and the Maritime Administration recently extended an invitation to industry for proposals to develop a nuclear power plant suitable for propelling merchant ships, consisting of a gas-cooled reactor coupled with a closed cycle gas turbine. This action is a continuation of a joint long-range program aimed at the development of advanced reactor systems for commercially competitive propulsive power of ships in the U. S. Merchant Marine.

From among those who submit proposals, it is intended that a contractor will be selected to carry out necessary development work to arrive at a firm design for a land based prototype plant. A balanced research and development effort, building on existing reactor technology, should make possible the construction of such a prototype plant within five to seven years from the initial development contract.

The long-range development program is in addition to the work now progressing on development and construction of the first nuclear powered merchant ship, announced by the President on October 15, 1956.

85 W Power Transistor: A silicon power transistor capable of dissipating 85 w at 25 C mounting base temperature has been developed and will reportedly be placed on the market next year. The 2N451 65 v transistor has a nominal collector saturation resistance of 2 ohms. Beta for the new silicon power transistor is specified as a minimum of 10, while beta cutoff is 400 kc. Maximum collector current rating is 5 a. The transistor is in accelerated pilot-line production at the General Electric Semiconductor Products Department's Electronics Park plant, Syracuse, N. Y.



Storm Dodger: An economical weather avoidance radar, designed for Air Force aircraft normally not equipped with radar, is shown above. The set consists of the scope, left, which is located in the cockpit, and the pod, center, that fits under a wing. ARDC's Wright Air Development Center developed the set in conjunction with the West Coast Div. of the Radio Corporation of America. Its prime purpose is to reveal paths through squall lines.

5-In. Sapphire Disk

A clear crystal sapphire disk, 5 in. in diam, has been grown. These disks have excellent infra-red, ultra-violet and microwave transmission characteristics, as well as high temperature, abrasion and chemical resistance. Before this advance in manufacturing technique, the largest disk grown was about 3 in. in diam. The synthetic sapphire boules are manufactured in oxy-hydrogen furnaces in which aluminum oxide in powder form is fed through the flame and the melted material collected in crystal form on a seed base. From annealed white sapphire boules, windows or disks are fabricated. Sizes are available from 1 mm to 1/8 in. in thickness. Quantity production of the new large size is planned by the Linde Co., Div. of Union Carbide Corp., New York, N.Y.

Semiconductor Irradiation Research

Basic experimental and theoretical research to explain the effects of radiation damage on semiconducting materials is now in progress. Some of the semiconducting materials to be studied in this program at Battelle Memorial Institute, Columbus 1, Ohio are aluminum antimonide, gallium arsenide, indium phosphide, cadmium sulfide, and cadmium telluride. In the course of their research, the effects of neutron and gamma radiation will be investigated. The effects of fast neutrons will be studied because of the profound disruptions they produce in crystal lattices. Slow neutrons lead to atomic transmutations and gamma radiation can also induce chemical and electrical effects that might interfere with device operation in relatively intense radiation fields.

Engineering Review

Ceramic Coats for Aluminum Alloys

Ceramic coatings have been successfully applied to the strong structural aluminum alloys. Heretofore, attempts to porcelain enamel 24-S and 75-S, the most extensively used structural aluminum alloys in the aircraft industry, have resulted in blistering, bubbling, brittleness and excessive warpage. Because of the refractory and insulating properties of new ceramic coatings, these structural aluminum alloys can withstand prolonged heat at 1300 to 1350 F without collapsing.

Tests were performed on 0.040 in. thick aluminum sheet with a coating of 0.0015 in. thickness. Subjected to a flame impingement test for 120 min at a flame temperature of 2200 F, the specimen was not damaged and the temperature at the coated surface was measured at 1700 to 1800 F. The same flame burned a hole in a non-coated aluminum specimen of the same type and thickness in about 30 sec.

Once coated, aluminum alloys can be bent, drilled, punched and sheared without fracture or damage to the coatings. The new coatings may be applied before final heat-treating of the alloys thus combining heat-treating and firing of the coating into a single operation. This not only reduces fabrication time and cost, but insures optimum strength of the metal and best adherence of the coating. The research, in which lithium chromate, lithium borosilicate and lithium fluoride compounds were used, was carried out by Gulton Industries, Inc., Metuchen, N.J.

Beam Tube for Radar Display

A Charactron shaped beam tube has been developed which is small enough for aircraft use and yet able to reproduce a conventional radar display map and then print labels on it. Characters are printed on the phosphor screen at the rate of 20,000 a second and retained by the phosphor while the radar work is displayed between letters and numbers. The tube length is 17-1/2 in. compared with the 40-in.

◀ CIRCLE 9 ON READER-SERVICE CARD

length of the seven-in.-diam shaped beam tube used in Charactron computer readouts and has a diameter of five in.

A wide electron beam is used to flood a matrix containing stencils of all desired letters and numbers. This wide electron beam, then is shaped by the stencils in the form of all characters in the matrix. The bundle of characters thus formed is focused on a tiny aperture which allows only one character at a time to pass. The beam's direction is changed to select each desired letter or number for display on the face of the tube.

All focusing is accomplished by means of internal electrostatic lenses, thereby eliminating the need for external focus and convergence coils. The electron gun is extremely short compared with the conventional gun of a tube and requires fewer electrodes. A deflection yoke is needed to position the characters on the face of the screen.

Ionospheric Forward Scatter

A mode of radio-wave transmission via the upper atmosphere, called ionospheric forward scatter, has recently been observed by beaming tremendous amounts of energy at this region of the atmosphere. Some of this energy scatters when it hits irregularities in the ionosphere so that a small but useful portion of it returns to earth, making possible communication links from 600 to 1200 miles. The signals have been found to have a reliability considerably greater than that of conventional long-distance radio communication, depending on reflection from the various layers of the atmosphere.

Investigation of this method of transmission is being carried on at the Boulder Labs., National Bureau of Standards, Boulder, Colo. Transmission characteristics at the magnetic equator are being particularly observed. The horizontal orientation of the ionospheric irregularities is favorable here to scattering in the lower region of the ionosphere, and there is a possibility that scattering can be obtained here via a higher layer so that considerably increased ranges of transmission may be attained.

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Engineering Review

Surveying Made Easy

A new system of precise measurement of distance, with a range of from about 500 ft to 100 miles and an accuracy stated in inches, has been developed in South Africa and recently introduced into this country. The instrument, called a Tellurometer, was invented by T. L. Wadley, of the Telecommunications Research Lab. of the South African Council for Scientific and Industrial Research. It operates in the 10-cm wavelength region and measures the transit of radio waves over the length to be determined. Measurements can be made in almost any weather, and visibility, for the first time in the history of surveying, is immaterial.

Although the distance between two elevated points 100 miles apart could be measured, in general optical line of sight is required and 35 miles is regarded as a good mean distance. To measure a single line, one master station and one remote station are necessary. Measurements are made from the master station and an operator is required at the remote station. The aerial system in each case is a parabolic mirror of 18 in. aperture. The measurement takes place to the focus via the mirror surface and the instrument is therefore mounted with its center in the directrix plane of the parabola. This is also approximately the center of gravity of the instrument. The instrument and aerial system from an integral unit which in the experimental equipment weighed about 16 lb.

A continuous 3000 mc is radiated from the master aerial system. This is modulated by 10 mc and other frequencies of similar order. The modulated wave is received at the remote station aerial and in effect re-radiated from the transmitting system of the latter station. The return wave as received back at the master station is compared with the transmitted wave, the instrument indicating the phase shift between the outgoing and incoming modulation.

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Highly accurate distance measurements are made with the Tellurometer which measures travel time of radio waves over the length to be determined.

The phase is indicated on an oscilloscope in the form of a circular sweep with 10 major and 100 minor divisions. Each minor scale division is equivalent to just under 6 in., and a complete rotation of phase is equal to approximately 50 ft. The accuracy of the Tellurometer is such that the distance between New York City and New Haven, Conn. could be measured with an error not likely to exceed six or seven in., or perhaps less.

Tubes for Hi-Fi TV

Much finer resolution of detail is possible with a new television tube, which utilizes an extremely thin transparent phosphor layer. This layer, replacing the conventional coating of phosphor powder, enables the picture tube to show lines two or three times thinner than was previously possible. Ordinary phosphor powders tend to scatter the light, bouncing it from particle to particle; the new thin layer, less than one ten-thousandth of an inch thick, keeps each point of light concentrated in a small spot. Researchers at the General Electric Lab., Schenectady, N.Y. have also developed a two color tube, penetron, which operates on the same principle. It is made by applying transparent layers of different phosphors to the tube face. Changes in color are produced by changing the operating voltage, thereby limiting the penetration of the electron beam to the appropriate phosphor layer.

CIRCLE 12 ON READER-SERVICE CARD ➤

Washington Report

Herbert H. Rosen

FCC's Lion by the Tail

Pity the Federal Communications Commission! Industry is spending endless hours telling the Commissioners why their special interests in frequencies above 890 Mc should not be violated. Advocates of pay-TV are threatening to circumvent FCC jurisdiction in order to put their products into the market. And Congress is harrassing the Commissioners because of its stand on pay-TV and its attitude toward the way the major networks tend to discriminate against advertisers and the public.

The 890-Mc hearings are long and drawn out. Of the nearly 200 witnesses, each seems to have his own particular ax to grind. Each appears to have 40- or 50-page legal briefs that he insists on reading completely. And each feels that his particular case has merits that are not duplicated by any other.

On pay-TV, the Commission felt it had everyone happy when it decided it had authority to conduct experiments on the various systems proposed. But Rep. Emanual Celler (D-N.Y.), Chairman of the House Judiciary Committee, felt otherwise. This self-appointed watchdog of the FCC said that the trials could not be run without Congressional approval. He was opposed in this stand by Rep. Chelf (D-Ky.), also a member of the committee. Chelf thought the public should be given a chance to see what pay-TV is like and then be permitted to make up its own mind.

Meanwhile, several companies in the pay-TV business, tiring of the delay, may turn to wire-TV, which should change the complexion of the whole picture markedly.

Today, the Commissioners are nearing the end of their month-long vacation. They should be sufficiently rested to renew the battles facing them and ready to take a new grip on the lion's tail.

EIA/RETMA Tests FCC Intentions

As part of its broadside campaign to renew rules on the allocation of frequencies from 25 mc on up, the FCC has asked for comments on "allocation of frequencies to the various non-Governmental services in the spectrum between 25 and 890 mc." The newly named Electronic Industries Association–formerly RETMA–has petitioned the Commission for an extension of time to get in its comments.

Apparently, the FCC has asked for comments within a period too short for EIA to set up study groups of manufacturers to go thoroughly into the

problem. There just isn't enough time, and EIA should know. It claims to have devoted approximately 6000 man hours to study and data collection for the current FCC hearings on the allocation of frequencies above 890 mc. These hearings have been going on since early June . . . and the end is still not in sight.

EIA has formed special groups for 25-890 mc hearings from its Land Mobile and Broadcast & Closed Circuit TV Sections. The Land Mobile Section alone has estimated that approximately 3000 man hours will be necessary to complete its work. It will be impossible for EIA to have a reasonable presentation by the September 6 deadline.

As can be recognized by the EIA sections concerned, that these hearings could become as involved as the current 890 mc hearings. A large segment of the electronic industry manufactures equipment operating in this (25-890 mc) portion of the frequency spectrum. Therefore, all will want to have something to say about any prospective rule changes the Commission may be contemplating. The test of the Commission's intentions will be if it grants EIA the desired extension of time.

Pentagon Surgery Continues

Outgoing Secretary of Defense Charles E. Wilson is leaving few areas untouched in his efforts to keep defense spending down. None of the three services has escaped unscathed; although, the biggest spender, the Air Force, appears to be the largest "contributor" to the savings campaign. In spite of this trend toward attrition, there is still a note of optimism for the electronics industry. Air Force Secretary James Douglas has forecast a rising employment for our industry. He backs this statement up by estimating an expenditure of $1.3 billion for missile electronics this year. Last year electronics expenditures amounted to about $750 million. However, the cuts and stretchouts in other areas are expected to be felt by many segments of the electronics industry. But the demand for specialists, especially those with missile experience, is expected to remain high.

By now, the Defense Department will know how effective its economy program has been. Indications will also be strong as to in what areas further savings will have to be made. For electronics, it will be another good year, if the word of the more learned observers can be assumed to be correct. However, it will also be a period of realignment. Shortcuts and increased efficiency will be encouraged. The marginal engineer will have to look out for his laurels. For, although the money level will be about the same as in 1956—or maybe a little better—the cost of producing electronic equipment will rise. And the company with the best price will be in a better position than ever to get the military contract.

Letters to the Editor

Engineers Needed

Dear Sir:

As you probably know, paid advertising by the Federal Government for the purpose of recruiting personnel is not permitted. Accordingly, it would be greatly appreciated if this letter could be published in your Editors Column as an announcement of employment opportunities for engineers at this Shipyard.

During the past century and a half the New York Naval Shipyard, Brooklyn 1, N.Y., has grown to be one of the largest of its kind in the world. Its up-to-date laboratories, shops, drydocks and excellent calibre of personnel have enabled it to meet the ever-increasing needs of the Fleet. This Shipyard has built almost every known type of warship afloat. In addition to new construction, we have been engaged in the conversion and repair of ships that have already been in action. The Navy is now embarked upon a program of modernizing its fire power to include the extensive use of rockets and guided missiles.

In order to be prepared for the future, we must have men with new ideas who are trained in engineering and the sciences. A qualified scientist or engineer coming to the Shipyard has excellent opportunities for advancement, as well as challenging research and development projects to enhance his professional growth. For example, some of the projects assigned our Electronics Engineers are as follows: tests, calibrations, measurement, design and development of radio, radar, sonar, teletype, facsimile, loran, direction finder and other electronic equipment aboard naval vessels, investigation of microwave mixer crystals which have wide application in radar, microwave communication receivers and spectrum analyzers, dielectric problems of pulse transformers, and investigation of circuit loading effects on Geiger-Mueller tubes in Fourier spectrum analysis of pulses.

Employment applications (Standard Form 57) are available from any of the Civil Service Commission Offices, Post Offices, or directly from this Shipyard.

J. I. Manning
Commander
New York Naval Shipyard
Naval Base
Brooklyn 1, N.Y.

Dear Sir:

I am writing as one of the 550 private citizens working as engineers or scientists for the Material Laboratory. The Material Laboratory is located in the New York Naval Shipyard, Brooklyn 1, N.Y., and it is one of the Bureau of Ships' largest Research and Technical Laboratories with over $25 million worth of scientific equipment. I thought that since your magazine and our Laboratory both aid in the professional growth and development of the engineer and scientist, that we might perform a service to your readers by explaining what types of positions might be available to them, in one of your columns. As you know, funds to be used for recruiting are not made available to Government agencies, so this is one of the only means in which our needs can be made known to the engineers and scientists in the field.

The qualified engineer or scientist coming into the Laboratory will have the opportunity of helping to carry out the Material Laboratory's mission of providing essential engineering and basic scientific support to the Navy's Bureau of Ships in a vital program of applied research, development investigations, analytical tests, evaluation and standardization in the fields of Electrical, Electronic and Mechanical Engineering, Chemistry, Metallurgy and Physics, including many advanced specializations in these fields.

In addition to familiarization sessions on methods of operation and organization and individual on-the-job guidance, professional employees participate in intra-laboratory technical symposia and sponsored graduate education, related to problem areas of laboratory work. Engineers and scientists are encouraged to prepare papers for publication in technical journals and for presentation before professional societies and similar groups. Opportunities for experience in close cooperation with a broad range of major industries and on operating vessels of the Fleet provide a stimulating atmosphere for professional growth.

Marvin J. Cetron
Material Laboratory
New York Naval Shipyard
Brooklyn 1, N.Y.

We just had an opportunity to visit a Government Service Laboratory for engineering development—one of those which cannot advertise for engineers. It is one of the cleanest, best kept establishments we've seen. The working environment was among the best. And, above all, the engineers were of exceptionally high calibre and enthusiastic in their work. We are happy to call the attention of engineering job seekers to opportunities these establishments offer.

Meetings

Sept. 23-25: Sixth Annual Meeting of the Standards Engineers Society

Commodore Hotel, New York City. For information write to T. J. O'Connor, Rm. 5D-127, Bell Telephone Labs., Inc., Whippany, N.J.

Sept. 24-25: Sixth PGIE Symposium on Industrial Electronics

Morrison Hotel, Chicago, Ill. Sponsored by the IRE Professional Group on Industrial Electronics and AIEE. The main theme for the conference will be the characteristics, use and integration of transducers into complete systems to measure and control complete processes. For further details, write to J. N. Banky, 628 West 18th Street, Chicago, Ill.

Sept. 27-28: Seventh Annual IRE Professional Group on Broadcast Transmission Systems Fall Symposium

Williard Hotel, Washington, D.C. Papers will be read on a variety of subjects ranging from transistor regulated power supplies for video circuits to the application of automation to TV master control rooms and film rooms. More information may be obtained from Clure H. Owen, American Broadcasting Co., 7 W. 66th St., New York 33, N.Y.

Oct. 7-9: 1957 International Systems Meeting

Statler Hotel, Los Angeles, Calif. Sponsored by the Systems and Procedures Association of America. The program will consist of panels, seminars, round table discussions, equipment exhibits, demonstrations, case studies, general sessions, illustrated lectures and study groups. The sessions will cover such subjects as systems survey, analysis, procedures, printed forms, electronic systems, organization analysis, systems and management, records management, work simplification and other techniques. For further information, write to the Systems and Procedures Association of America, 629 S. Hill St., Los Angeles 14, Calif.

Oct. 7-11: Fall General Meeting of the American Institute of Electrical Engineers

Hotel Morrison, Chicago, Ill. The technical program will consist of more than 50 sessions devoted to the lastest advances in electrical engineering and allied arts. Nuclear reactors, telegraph systems, research, ethics, television and aural broadcasting, basic science, safety, computing devices, land transportation, power generation, transmission and distribution, system engineering, computers, mining and metal industry, radio, and the chemical industry are some of the subjects being covered. For details write to the AIEE, 33 W. 39th St., New York, N.Y.

Oct. 8: Isocyanate Symposium

Curtis Hotel, Minneapolis, Minn. Sponsored by the Upper Midwest Section of the SPE. Among the papers to be read are "A Comparison of Properties Between Polyester and Polyether Based Isocyanate Foams" and "High Temperature Urethanes." For details write the Society of Plastics Engineers, Inc., 34 E. Putnam Ave., Suite 116-118, Greenwich, Conn.

Oct. 9-11: Fourth National Symposium on Vacuum Technology

Hotel Somerset, Boston, Mass. Sponsored by the Committee on Vacuum Techniques. Approximately 25 pages will be presented covering fundamental advances in vacuum technique, means of producing, measuring and conducting low pressures, and advances in applications of vacuum to processing. For further information, write the Committee on Vacuum Techniques, Box 1282, Boston 9, Mass.

Oct. 8-12: 1957 Convention of the Audio Engineering Society

New York Trade Show Bldg., New York, N.Y. Between 50 and 60 papers will be presented. Covered will be topics in such fields as disc and tape recording, reception, components and systems, noise control and acoustics. The New York High Fidelity Show, sponsored by the Institute of High Fidelity, will accompany the Convention. More information may be obtained from G. K. Dahl, 230 West 41st St., New York 36, N.Y.

Oct. 14-15: Third Annual Douglas Aircraft Co. Inc. and Bell Helicopter Corp. Integrated Instrument Development Program Conference

Hotel Statler, Los Angeles, Calif. Sponsored by the Army and Navy. For more information send to the News Bureau, Bell Helicopter Corp., P.O. Box 482, Ft. Worth, Tex.

Oct. 16-18: 1957 IRE Canadian Convention and Exposition

Automotive Building, Exhibition Park, Toronto, Canada. Sponsored by the Canadian Sections of the IRE. For information write to Grant Smedmor, IRE Canadian Convention, 745 Mt. Pleasant Rd., Toronto 7, Canada.

Oct. 16-18: AIEE Conference on Computers in Control

Chalfonte and Haddon Hall Hotels, Atlantic City, N.J. Sponsored by the AIEE Committee on Feedback Control Systems. The conference will stress the role of analog and digital computers in automatic control, both as design tools and as components of systems. For more information, write Prof. J. G. Truxal, Dept. of Electrical Engineering, Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn 1, N.Y.

Oct. 18-19: Second Annual Symposium on Digital Computers

O'Henry Hotel, Greensboro, N.C. Sponsored by the Piedmont Sub-Section of the North Carolina-Virginia Section of the IRE. "A Short, Short Course in Digital Computers" is the name given to the conference. Discussion topics will be digital computers, computer mathematics, storage devices and techniques, arithmetic units, input and output devices, column shift units, programmers, computer programming techniques, verifications, and digital computer applications. There will also be exhibits. For more information write M. L. Fox, Western Electric Co., Burlington, N.C.

Oct. 24-25: Fourth Annual Computer Applications Symposium

Hotel Sherman, Chicago, Ill. Sponsored by the Armour Research Foundation of Illinois Institute of Technology. Advances in automatic coding and new computers and applications will be stressed. Both management and engineering applications will be considered. More information may be obtained by writing the Secretary, Computer Applications Symposium, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Oct. 24-25: General Assembly of the Engineers Council for Professional Development and the Engineers Joint Council

Statler Hotel, New York City. Subjects to be discussed are military service and professional development, the community college and technological education, the place of the engineer in industrial management, and new dimensions in post-graduate education for the young engineer. Further details may be obtained from either the Engineer's Council for Professional Development or the Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 28-30: Fourth Annual Atomic Industry Conference

Plaza and Waldorf-Astoria Hotels and Coliseum, New York City. Sponsored by the Atomic Industrial Forum. For information write to AtomForum, 3 [illegible] 54th St., New York 22, N.Y.

Oct. 28-30: Fourth Annual East Coast Conference on Aeronautical and Navigational Electronics

Fifth Regiment Armory and the Lord Baltimore Hotel, Baltimore, Md. Sponsored by the Baltimore Section of the IRE and the Professional Group on Aeronautical and Navigational Electronics. Exhibits will be offered along with the technical sessions. For details write Clayton Knight, 3603 Howard Park Ave., Baltimore, Md.

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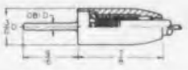
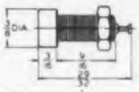
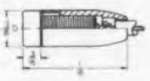
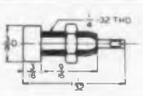
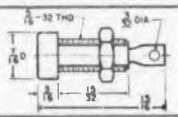
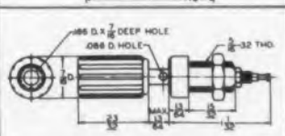
CONNECTOR TYPE	DIMENSIONS	DESCRIPTION
 105-301 to -313		**NYLON TIP PLUG** (Patent Pending) Completely insulated, sleeve is molded of tough nylon and will not chip or crack even when subjected to extreme temperature changes. Recessed metal head prevents exposure of metal surfaces when engaged in any standard tip jack. Current rating: 10 amps. Metal parts are nickel-plated brass. Designed for solderless connection of up to 16 gauge stranded wire.
 105-601 to -613		**NYLON TIP JACK** (U.S. Pat. No. 2,704,357) Completely insulated nylon body with machined beryllium copper contact. Current rating: 10 amps. Voltage breakdown: 11,000 volts DC. Capacity to ⅛" panel: 2.0 mmf. Contact is silver-plated—recessed in head. Solder terminal is hot tin dipped. Single ¼"-32 nut furnished for mounting—no auxiliary mounting hardware needed. Mounts in 17/64" dia. hole.
 105-701 to -713		**NYLON JACK AND SLEEVE** (Jack—U.S. Pat. No. 2,704,357) Complete assembly includes a standard nylon tip jack less mounting nut with an inside threaded, molded nylon insulating sleeve. Ideal for patch cords, this assembly is also excellent for panel mounting where an insulated rear connection of a panel mounted tip jack is desired.
 105-801 to -813		**NYLON TIP JACK** New low cost insulated tip jack. Body molded of tough, low-loss nylon. Formed silver-plated phosphor bronze contact. Current rating: 10 amps. Voltage breakdown: 9,000 volts DC. Capacity to ⅛" panel: 2.0 mmf. Single ¼"-32 nut furnished for mounting—no auxiliary mounting hardware needed. Mounts in 17/64" dia. hole or double flat hole.
 108-301 to -313		**NYLON BANANA PLUG** (Patent Pending) Compact, high voltage insulated plug for a wide variety of applications. Current rating: 10 amps. Easy solderless connection of up to 16 gauge stranded wire. Nylon insulating sleeve retains strength and low-loss characteristics over a wide range of temperatures. Body and pin are of one-piece nickel-plated brass with high grade nickel-silver springs.
 108-901 to -913		**NYLON BANANA JACK** Completely insulated, molded nylon body. Current rating: 10 amps. Voltage breakdown: 12,500 volts DC. Capacity to 1/16" panel: 1.5 mmf. Insert is cadmium-plated. Accommodates banana plugs of a nominal diameter of .175". Single 5/16"-32 nut furnished for mounting—no auxiliary mounting hardware needed. Mounts in 21/64" dia. hole.
 111-101 to -113		**NYLON BINDING POST** (Patent Pending) Compact, completely insulated, pre-assembled 6-way binding post. Molded nylon body. Shank is silver-plated brass—thumb nut is self-captivated and cannot be removed. Insulation resistance greater than 200 meg. after MIL-T-5422B humidity test. Voltage breakdown: 8,000 volts DC. Current carrying capacity: 15 amps. Capacity to ⅛" panel: 3.3 mmf. Single 5/16"-32 nut furnished for mounting—no auxiliary mounting hardware needed. Mounts in 21/64" dia. hole, "D" hole, or double-flat hole.

COLOR CODING BY CATALOG NUMBER All nylon connectors are available in the colors indicated at right. Catalog numbers ending in 1 (for example 105-301) indicate white; 2—red; 3—black; 4—dark green; 5—light blue; 6—orange; 7—yellow; 8—brown; 9—light green; 10—dark blue; 11—ivory; 12—violet; 13—grey.

Johnson also manufactures a complete line of standard connectors in addition to the nylon line illustrated above. For complete information on these as well as other quality Johnson electronic components write for your free copy of our current component catalog.

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CIRCLE 2

ELECTRO

Oct. 28-30: Second Winter Meeting of the American Nuclear Society

Henry Hudson Hotel and Coliseum, New York City. Sponsored by the American Nuclear Society. To obtain details write John Burt, J. M. Mathes, Inc., 260 Madison Ave., New York 16, N.Y.

Oct. 28-30: Fourth Annual East Coast Conference on Aeronautical and Navigational Electronics

Fifth Regiment Armory and the Lord Baltimore Hotel, Baltimore, Md. Sponsored by the Baltimore Section of the IRE and the Professional Group on Aeronautical and Navigational Electronics. There will be exhibits and eight technical sessions. The 41 papers to be read deal with navigational systems, equipment analysis, military navigation techniques, equipment design, civil navigation techniques, microwave components, and electronic components. For details communicate with C. J. Knight, Jr., Mail No. J-376, The Martin Co., Baltimore 3, Md.

Oct. 28-31: 1957 Trade Fair of the Atomic Industry

Coliseum, New York City. Sponsored by the Atomic Industrial Forum. Information and complimentary tickets may be obtained from AtomFair, 3 E. 54th St., New York 22, N.Y.

Oct. 29: Second Annual Conference on "Careers in Nuclear Science and Engineering"

Coliseum, New York City. Sponsored by the Committee on Education of the Atomic Industrial Forum. For information send to the Secretary, Committee on Education, Atomic Industrial Forum, 3 E. 54th St., New York 22, N.Y.

Oct. 31: Conference on Reactor Safety

Coliseum, New York City. Sponsored by the American Nuclear Society, the Atomic Industrial Forum, and the U. S. Atomic Energy Commission. For further details write to Conference Manager, Atomic Industrial Forum, 3 E. 54th St., New York 22, N.Y.

Oct. 31-Nov. 1: Annual Conference, IRE Professional Group on Nuclear Science

Henry Hudson Hotel, New York City. For information write to W. A. Higginbotham, Brookhaven National Lab., Upton, N.Y.

Oct. 31-Nov. 1: Third Annual Technical Conference of the Professional Group on Electron Devices, IRE.

Shoreham Hotel, Washington, D.C. For more information, write W. M. Webster, RCA Semiconductor Div., Somerville, N.J.

CIRCLE 20 ON READER-SERVICE CARD

Class B Transistor Power Amplifier Design

Robert Minton
Semiconductor Div.
Radio Corporation of America

This is the second in a series of two articles on circuit design considerations for audio output stages using power transistors. In *ED July 15*, class A single ended circuits were discussed; in this article class B push-pull designs using pnp alloy-junction transistors, is examined. The effect of source and load impedances on distortion is described. Methods of obtaining a desired degree of bias stability as it is offered by temperature variation are outlined.

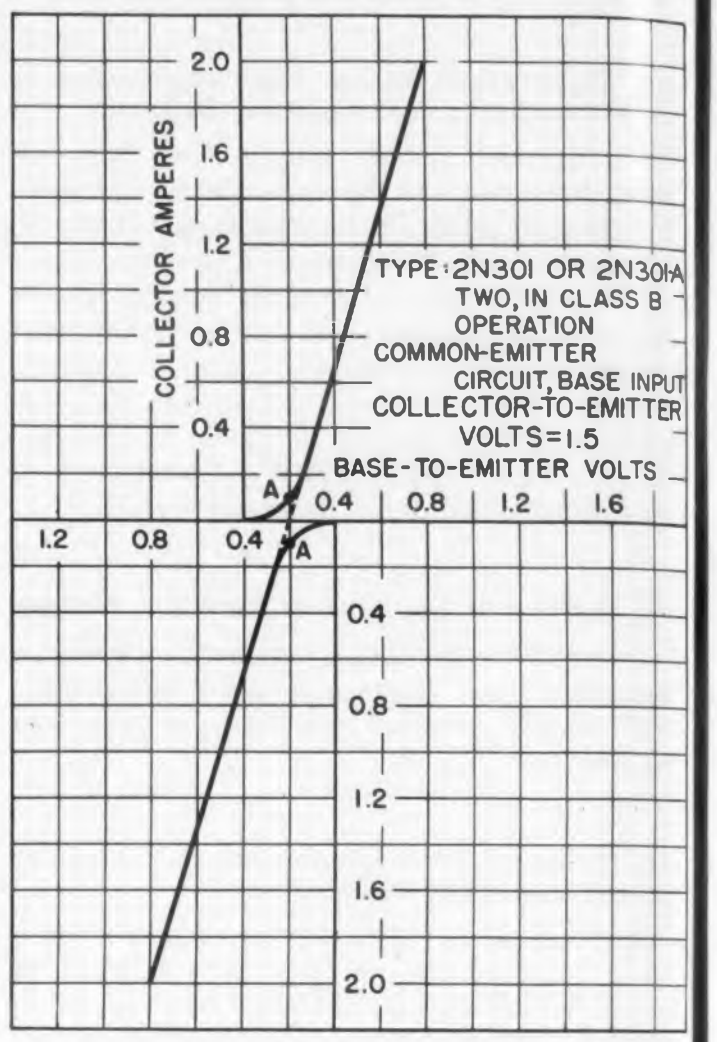

Fig. 1. Composite transfer characteristic for two 2N301 or 2N301-A power transistors in class B operations.

IN THIS design the transistors are biased approximately to cutoff so that amplification occurs over only one-half cycle of the applied input-signal waveform. Class B amplifiers are characterized by good collector-circuit efficiency and relatively high power output in proportion to the average dissipation in the transistors. During periods of zero signal, power-supply drain and collector dissipation are low.

When more power output and efficiency in an audio power amplifier are required than are obtainable through class A design, class B push-pull operation is used. The maximum possible power output is equal to $\frac{N_p}{1-N_p} \times P_{max}\ (dc)$, where N_p is the output circuit efficiency and $P_{max}\ (dc)$ is the maximum rated dc power dissipation.

In the design of class B push-pull audio amplifiers the following transistor characteristics are of importance to the circuit designer:[1,2]

- maximum collector dissipation,
- maximum peak collector current,
- maximum collector voltage,
- input characteristics, and
- base-to-collector current transfer characteristics.

In most cases, the supply voltage, power output, power gain, and maximum distortion limits are specified for a particular application. The first step in the design of the class B amplifier, therefore, is the choice of the zero-signal operating point for the transistors. Class B operation implies that the transistors are biased to cutoff so that the static operating collector current and collector dissipation are reduced to zero. It is impractical to use zero bias, however, because the nonlinearity in the small-signal region causes a high percentage of crossover distortion, especially at low signal levels.

For a given transistor type, there is a particular value of base bias that results in a good balance between crossover distortion and collector-circuit efficiency. Fig. 1 shows the composite transfer characteristic for two *2N301* or *2N301-A* transistors in class B operation. As shown on the curve, a convenient method for determining the operating point is to project the main part of the transfer characteristic curve in a straight line to the cutoff point. The use of this projected cutoff bias appreciably reduces crossover distortion. The remaining distortion can then be reduced by the use of negative feed back.

Choice of Load Impedance

For a given supply voltage, the factors which influence the choice of the load impedance are the maximum power-dissipation and peak-collector-current ratings. The optimum value of collector load impedance should be used to achieve high power gain and good output-circuit efficiency.

Fig. 2 shows a class B push-pull audio power-

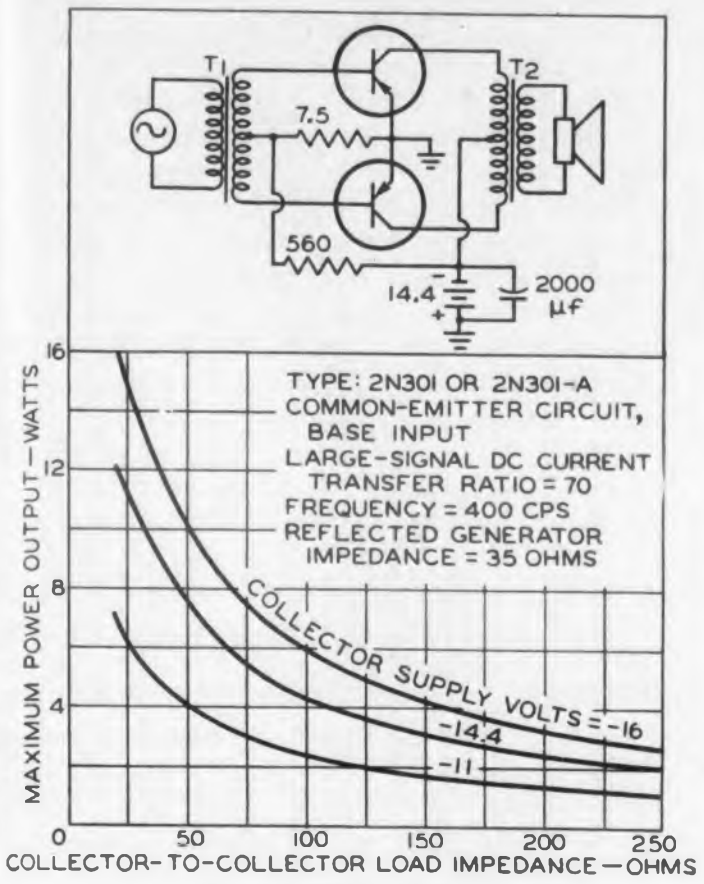

Fig. 2. Class B push-pull audio power-amplifier stage using 2N301 or 2N301-A power transistors, together with curves showing maximum power output as a function of collector-to collector load impedance.

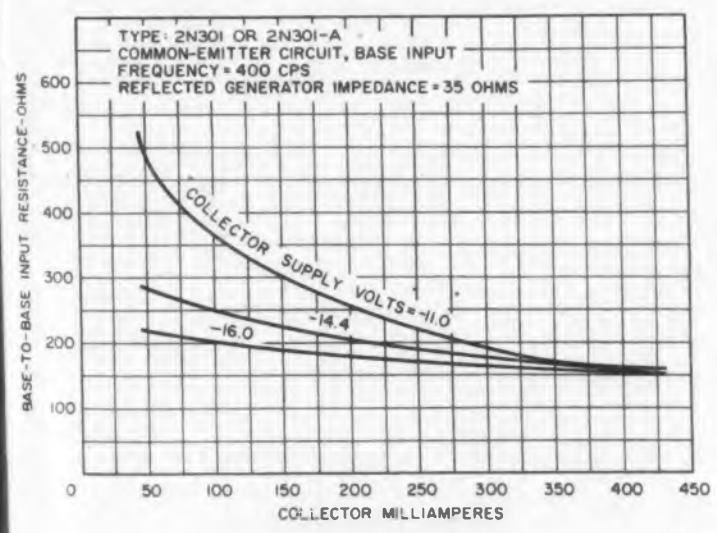

Fig. 3. Base-to-base input resistance of class B circuit as a function of dc collector current.

amplifier stage which uses two RCA-*2N301* or *2N301-A* pnp junction transistors in the base-input, common-emitter circuit configuration. This amplifier stage has high power gain and power efficiency. The transistors used in the circuit must have fairly well matched large-signal characteristics. The average input-resistance is very low and is extremely nonlinear over the operating range. With a collector supply voltage of —14.4 v, low values of load impedance must be used to produce appreciable power output. The minimum value of load impedance is determined by the maximum peak-collector-current ratings of the transistors.

Fig. 2 also shows the maximum power output for various values of collector-to-collector load impedances. The maximum power output is essentially independent of all transistor characteristics except the peak-collector-current capabilities of the transistors. The power gain of junction-transistor class B amplifiers is a function of the input resistance, the load impedance, and the large-signal current transfer ratio. Fig. 3 shows the variation in base-to-base input resistance as a function of dc collector current. Although there is considerable variation in the input resistance, the power gain may not vary appreciably because the magnitude of the large-signal current transfer ratio increases at low values of collector current. This increase tends to offset to some extent the reduction in power gain which results from an increase in input resistance at low signal levels. The power gain of the common-emitter circuit depends to a large extent upon the load impedance and the large-signal amplification factors. As the load impedance is increased, the power gain increases, as shown in Fig. 4.

Efficiency

The efficiency of a common-emitter class B circuit has a maximum theoretical value of 78 per cent. In practice, the efficiency depends upon the quiescent value of collector current, the supply voltage, the efficiency of the output transformer, and the level of power output. The collector-circuit efficiency is greatest at full rated power output and decreases as the power output is reduced, as shown in Fig. 5. For constant values of power output, the efficiency decreases for decreasing values of lead.

Distortion

Distortion in transistor class B amplifiers is a function of the power output, the supply voltage, the driving source, the load impedance, and the large-signal current transfer ratio of the transistor. The effects of these factors are more severe in common-emitter circuits which employ no internal degeneration. Fig. 6 shows the variation of total harmonic distortion with power output. The low-power-level distortion depends primarily on the zero-signal

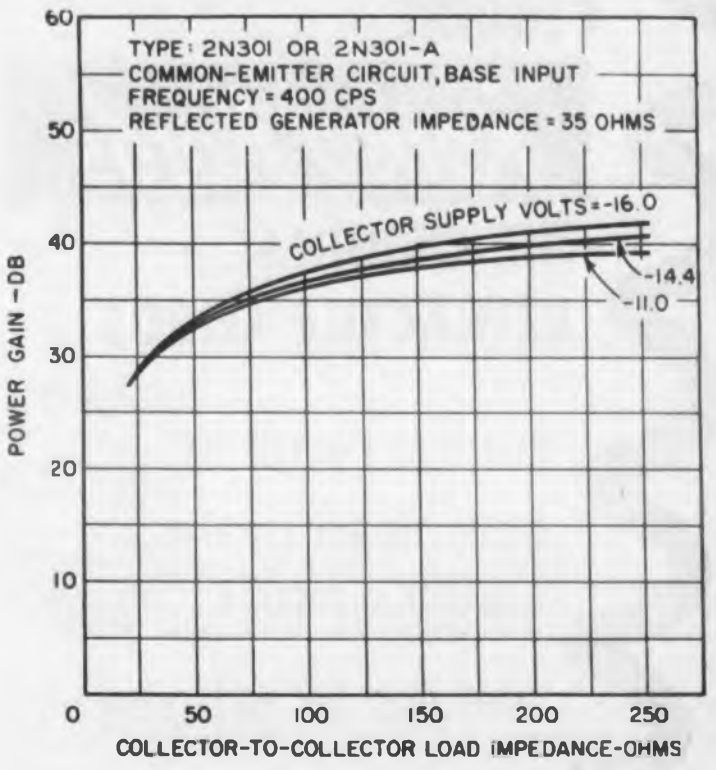

Fig 4. Power gain of class B circuit as a function of load impedance.

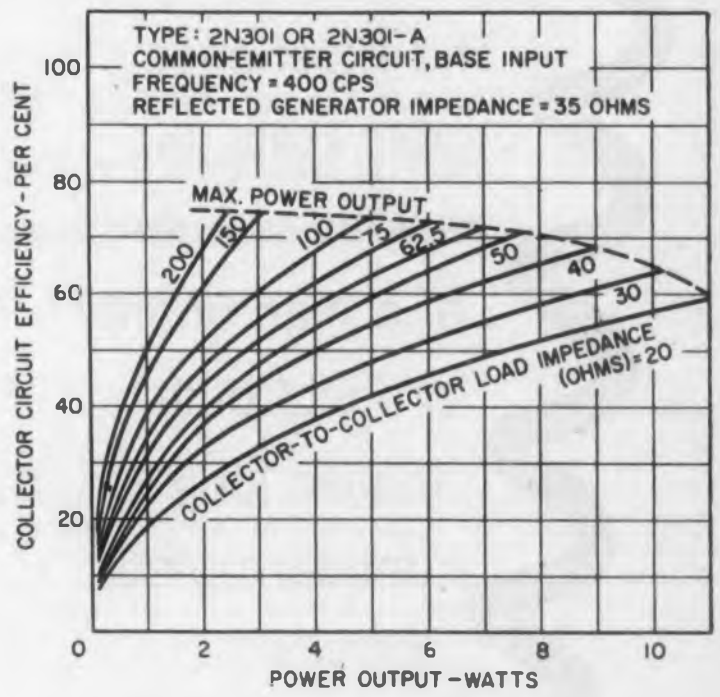

Fig. 5. Collector-circuit efficiency of class B circuit as a function of power output.

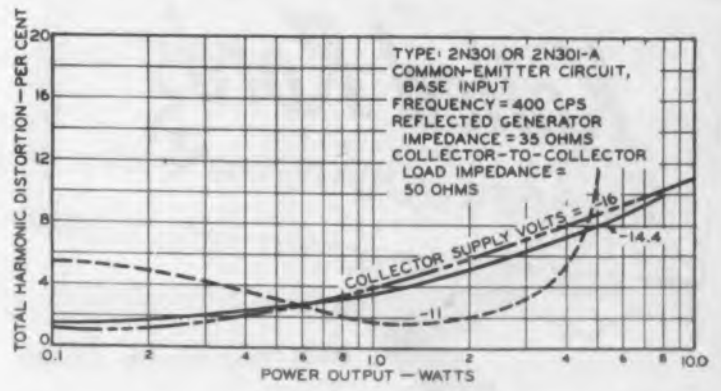

Fig. 6. Total harmonic distortion of class B circuit as a function of power output.

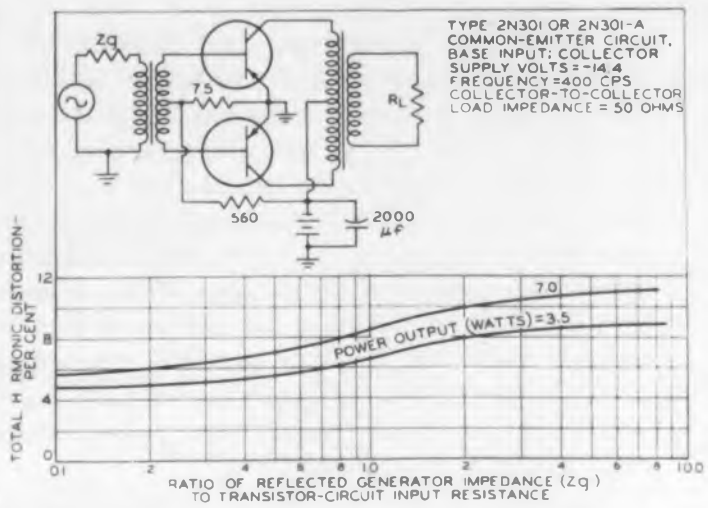

Fig. 7. Total harmonic distortion as a function of the reflected source impedance and the input resistance of the transistor.

operating point. If the bias point is not chosen properly, the distortion will increase considerably, as shown by the curve for a collector supply of —11 v. The extent to which the distortion increases at high power levels depends on the degree of mismatch in the current transfer ratio of the transistor, the load impedance, and the collector supply voltage.

The source impedance presented to the input of the class B stage is determined by the type of driving device and the impedance transfer ratio of the driver transformer used. Fig. 7 shows the variation in total harmonic distortion as a function of the ratio of the reflected source impedance and input resistance of the transistor. As the source impedance is increased, the total harmonic distortion increases considerably. The effects of driving-source impedance on distortion in class B push-pull amplifiers is minimized by the use of a low value of reflected source impedance.

Temperature Effects

The transfer characteristic curves shown in Fig. 8 illustrate the effects of temperature upon transistors in the common-emitter class B circuit. The operating point is designated by point *A* on the 25 *C* curve. If the common-emitter circuit is operated with constant base-to-emitter bias voltage, an increase in temperature causes an appreciable increase in quiescent output current and a consequent decrease in the maximum power output and output-circuit efficiency. As the temperature decreases, the quiescent collector current decreases almost to zero. Although there is an increase in maximum power output and a slight increase in efficiency, the crossover distortion becomes appreciable at low signal levels because the transistor operates over the nonlinear portion of the transfer characteristics.

Fig. 9 shows three practical methods of estab-

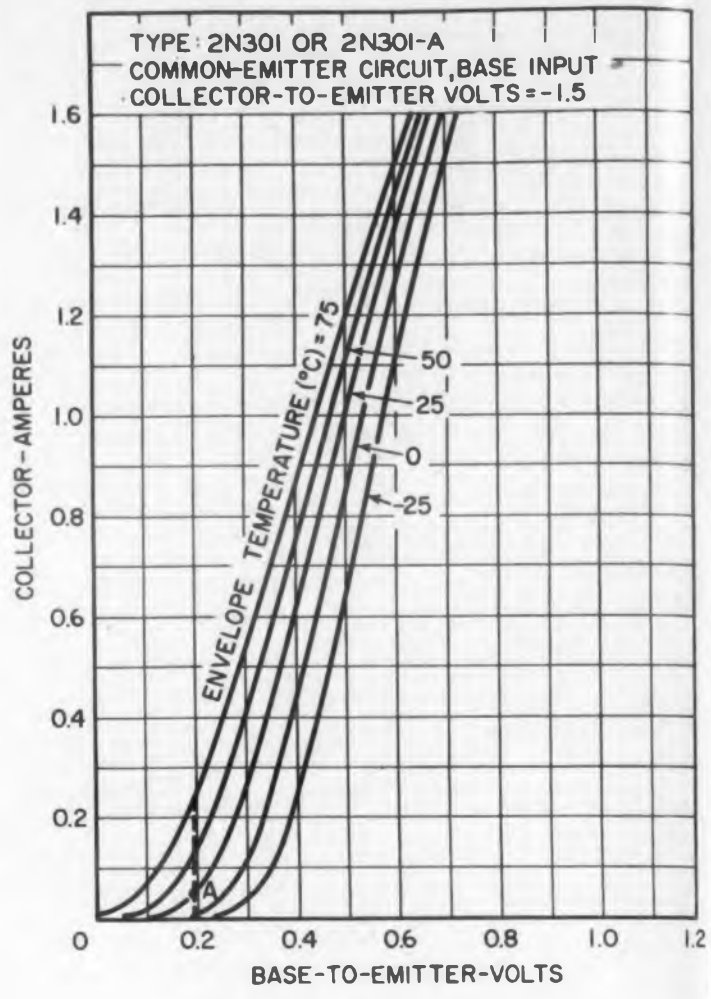

Fig. 8. Curves showing effects of temperature on transistor performance in class B circuit.

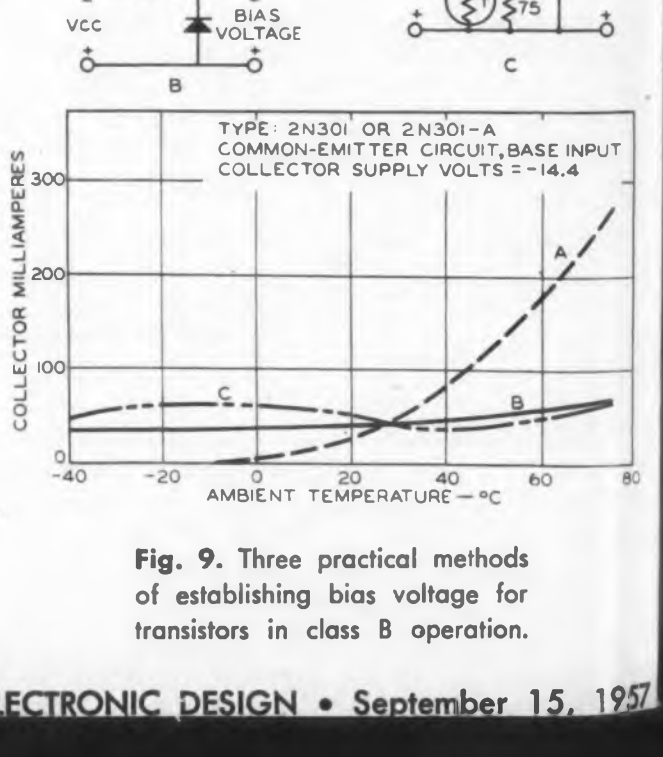

Fig. 9. Three practical methods of establishing bias voltage for transistors in class B operation.

lishing the bias voltage for transistors in class B operation.[3] The resistive bias network of circuit A maintains a constant base-to-emitter voltage which does not vary with temperature changes. In this circuit, the quiescent collector current increases, with an increase in temperature as shown by curve *A*. For optimum performance from a class B power-amplifier circuit over a wide temperature range, some means must be provided to adjust the base-to-emitter bias voltage so that the collector current will remain constant. A temperature-sensitive element may be used in the bias network so that the required change in bias voltage is obtained with changes in temperature.

Circuit *B* incorporates a germanium junction diode designed to provide the required change in bias voltage. This diode has a resistance-vs-temperature curve whose slope approximates that of the transistor input characteristic. Curve *B* shows the variation in collector current with temperature for a class B stage using the "compensating" diode in the bias network.

The bias network of circuit *C* uses a thermistor in conjunction with other resistive components.[4] The desired change in bias voltage is obtained when the resultant network resistance of the bias circuit provides a resistance-vs-temperature curve having a slope approximating that of the transistor input characteristic. The diode used in circuit *B* provides a higher degree of stability than the thermistor used in circuit *C*, and has good bias-voltage regulation for variations in collector supply voltage.

Frequency Response

The frequency response of class A and class B power amplifiers is determined primarily by the characteristics of the transformers and the transistors. The low-frequency response depends on the primary inductance of the transformer. The high-frequency response depends on the leakage reactance and winding capacitance of the transformers, and the frequency at which the current transfer ratio of the transistors drops to 0.707 times the 1000 cycle value. Because of the high currents and low supply voltages used, the dc resistance of the primary of the output transformer should be as low as possible to retain high efficiencies.

References

1. Class B Operation Of Audio Frequency Junction Transistors, K. E. Loofbourrow, ELECTRONIC DESIGN, vol. 3, p. 28, July, 1955.
2. Evaluation Of Transistors For Class B Power Output Amplifiers, W. Hasenberg, Transistor 1; RCA Labs, pp. 361-368, March, 1956.
3. Power Amplifiers, Lo, Endres, Zawels, Waldhauser, & Cheng, Transistor Electronics. Prentice-Hall, Inc., pp. 221-224, September, 1955.
4. Thermistors Compensate Transistor Amplifiers, A. J. Wheeler, *Electronics;* vol. 30, no. 1, pp. 169-171, January, 1957.

A Versatile Phasemeter

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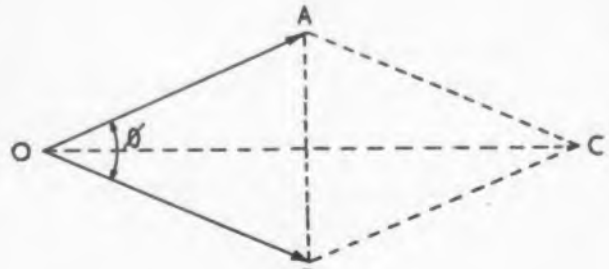


Fig. 1. The vectorial sum (OC), or difference (*AB*) of two equal voltages is a function of the phase angle between them.

DESCRIBED here is a versatile phasemeter capable of being associated with other equipment to increase its field of application beyond that normally associated with phasemeters. Among the fields where it has found application are: low frequency wave analysis, network and filter analysis, aircraft and engine vibration studies, ac and dc feedback amplifier investigations, design of simulators and computers, development of fire control equipment in ships and vehicles, ship stabilization, instruction in servo mechanisms, ac bridge null detection and dynamic balancing.

It is only in recent years that phasemasters, as commercial instruments, have become generally available. The great developments which took place previously in the communications industry were largely based on aural presentation. Since the ear is a poor phase detector there was no strong reason for most engineers to become phase conscious. Today, owing to the enormous importance of feedback systems in every branch of electronics and control engineering the situation is quite different. Based largely on the work of Nyquist and Bode, modern design procedures demand information about phase and amplitude characteristics of all kinds of networks.

The Muirhead D-729 Phasemeter is an instrument capable of measuring the relative phase and amplitude of two electrical sine waves having the same frequency. It can be used to measure transfer functions of active or passive networks and owing to its high input impedance is equally suitable for closed or open loop measurements. Two models are available, the D-729-A with a frequency range 2 cps to 100 kc and the D-729-B, which covers 0.5 cps to 10 kc. Measurement accuracies for both models over the greater part of their frequency ranges are $\pm 1°$ for phase angle and ± 0.2 db for relative levels.

Principle of Measurement

This relies on the fact that the vectorial sum or difference of two equal voltages is a function of the phase angle between them. In Fig. 1 let ϕ represent the phase angle between two equal voltages *OA* and *OB*. Their vectorial difference is represented by *AB* which is equal to 2 (OA) sin $\frac{\phi}{2}$ and their sum is represented by *OC* which is equal to 2 (OA) cos $\frac{\phi}{2}$. In the quadrant 0-90°, for $\phi = 0°$, $AB = 0$, and for $\phi = 90°$, $AB = \frac{2}{\sqrt{2}}(OA)$. In this quadrant it is

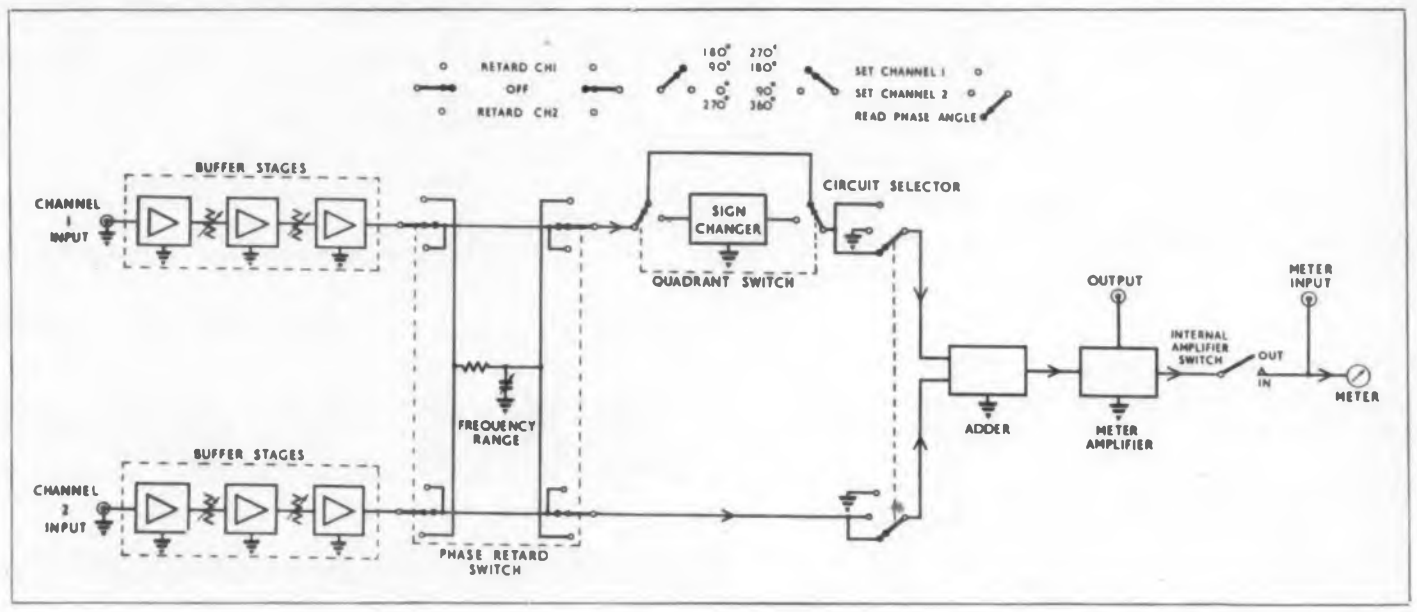


Fig. 2. Block diagram of the phasemeter.

arranged that the voltage *AB* is applied to a meter and that *OA* and *OB* are previously adjusted to give readings of 0.707 full scale deflection. It follows that the meter reads full scale at 90° and zero at 0° and that the scale of the meter is almost linear with phase angle since the reading is proportional to sin $\frac{\phi}{2}$ from 0-45°.

Fig. 2 shows the block diagram of the phasemeter. The reference input is connected to Channel *1* and the unknown to Channel 2. Each channel has an input impedance of 30 meg, attenuators covering a range of 80 db, and a fixed phase lag circuit which can be switched into either channel. The phase of Channel *1* can be reversed by means of a sign changer.

The channel signals are combined in an adder and applied to a voltmeter after amplification. When measuring phase the two channel voltages are each adjusted in turn to $\frac{1}{\sqrt{2}}$ of full scale deflection by means of the channel attenuators. The circuit selector is then switched to PHASE and the 2-position Quadrant switch set to the position which gives a reading on the meter scale. The phase angle is thus identified as being in one of two quadrants. By switching phase lags into each channel consecutively and noting the direction of change of meter reading the proper quadrant is identified and the phase angle read on the meter scale. The difference in level between the two input signals is given by the difference between the two attenuator settings.

Figs. 3a to d show the vector diagrams for the four quadrants. In Fig. 3a the vectors *OB* and *OA* represent the two equal channel voltages. The sign changer is in circuit for this first quadrant and therefore the meter reading is represented by vector *BA* which is zero for 0° and corresponds to full scale reading for 90°. It will be clear that the meter reads on scale for angles between 0-90° and 270-360° but is off scale for angles between 90 and 270°. In Figs. 3b and 3c the sum of the channel voltages are applied to the adder and this sum is represented by the vector *B'A*. In these cases the meter reading is only on the scale for angles between 90° and 270°. In the final quadrant the sign changer is brought into the circuit once more. The meter readings increase with phase angle in the 1st and 3rd quadrant but decrease in the 2nd and 4th as shown by the arrows. Suppose the phase angle to be measured is 45°. The meter reading can only be on scale if the quadrant switch is set to position 0°-90°, 270°-360°. The reading however can be 45° or 315°. If then the phase lags are switched in the reading will decrease for phase lag in Channel 2 and increase for Channel *1*. These directions would have been reversed had the phase angle been 315°.

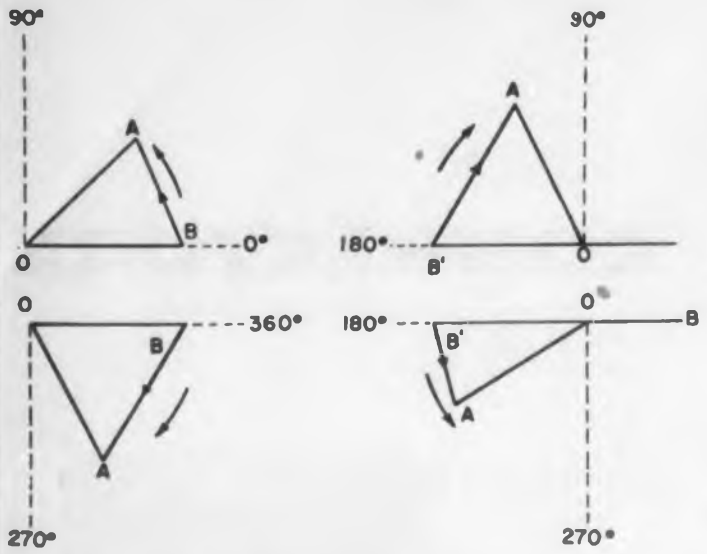


Fig. 3. Vector diagrams for the four quadrants reading clockwise: a. 0-90° b. 90-180° c. 180-270° d. 270-360°

Constructional Details and Performance Characteristics

The equipment comprises a phase measuring unit and a supply unit in separate bench mounting cases. The large illuminated panel meter carries four scales 0°-90°, 180°-90°, 180°-270° and 360°-270°. In addition it carries two voltage scales 0-6 and 0-20 v or mv.

Features of the Instrument

The accuracy of phase measurement depends upon the maintenance of equal phase shifts in the two channels at all frequencies through the buffer amplifiers, attenuators, sign changer and adder. The active elements in this series are all unity gain feedback amplifiers of high stability and very low phase shift. The necessary amplification is applied after the adder when the two channels are commoned and the presence of added phase shift does not affect the result. By the same token, long term drifts in the high gain amplifier section do not affect the accuracy of amplitude comparisons. An important consequence of the fact that the fundamental comparisons are made at low levels in operational amplifiers having a high overload capacity is the ability to scale expand for phase angles in the region of 0° and 180° where the meter indication is near zero. A feature which is of great value when the input signals contain high distortion or noise content is the provision for replacing the internal high gain amplifier with an external selective amplifier.

The phasemeter can readily be used as a high impedance millivoltmeter with an absolute accuracy of 5 per cent. A metered calibrating signal is available from the supply unit for the purpose of standardizing the overall gain of the instrument when used as a millivoltmeter.

At very low frequencies the fluctuations of the meter due to the signal frequency can be largely eliminated in the B model by switching in additional meter damping.

Applications

■ Transfer functions. One of the principal uses of this instrument is the determination of transfer functions. The phase meter will give information about the phase and amplitude response of any network over a predetermined frequency range, so that frequency response diagrams or Nyquist plots can be drawn. In feedback systems open loop characteristics can be measured and the gain and phase margins determined therefrom. It is relatively simple to examine how these margins are affected by environmental changes or by variations in any of the system parameters.

An example of a set up for measurements on a typical servomechanism is illustrated in Fig. 4. In this figure the common supplies to each element have been omitted for the sake of clarity. The servo elements are shown in full lines, the measuring circuit in dotted lines.

An oscillating motion is applied to the rotor of the control transmitter (*CT*) by a variable speed motor and mechanical link (not shown). The input shaft angle Θ_i is compared with the output shaft angle Θ_o in the control transformer (*CX*) and the difference Θ_e is amplified and drives a servo motor which in turn drives the control transformer to the position of zero error when $\Theta_o = \Theta_i$. Stabilization is provided by an induction generator. A reference signal proportional to Θ_i is taken from the stator of the control transmitter, and the Θ_o signal is derived from a linear variometer coupled to the input shaft. Both these signals appear as a modulation of the supply frequency and are synchronously demodulated before being applied to the phase meter. The diagram shows the closed loop set up. For open loop tests the transformer is uncoupled from the output shaft and its electrical zero is carefully aligned with that of the linear variometer at the mid point of the mechanical excursion of the system.

■ Measurements involving distorted waveforms. The instrument will measure phase to the specified accuracy provided the harmonic content of the signals does not exceed 5 per cent. For measurements on distorted waveforms the internal meter amplifier is disconnected and an external tunable selective amplifier plugged into sockets in the front panel.

In this instance the phase meter will compare the phase and amplitude of the fundamental components of the two input wave. Contrast this with the type of phase measurement where the input waves are squared before comparison. In this case no amplitude information is available and the phase indication is linked not to the phase difference of the fundamental but to the points where each wave crosses the zero axis. For example, in comparing a sine wave with three triangular waves, one symmetrical, one saw-tooth and one reverse saw-tooth, the squaring method will give substantially the same answer for each wave. The D-729 on the other hand will indicate the real differences between the fundamental components of these waves.

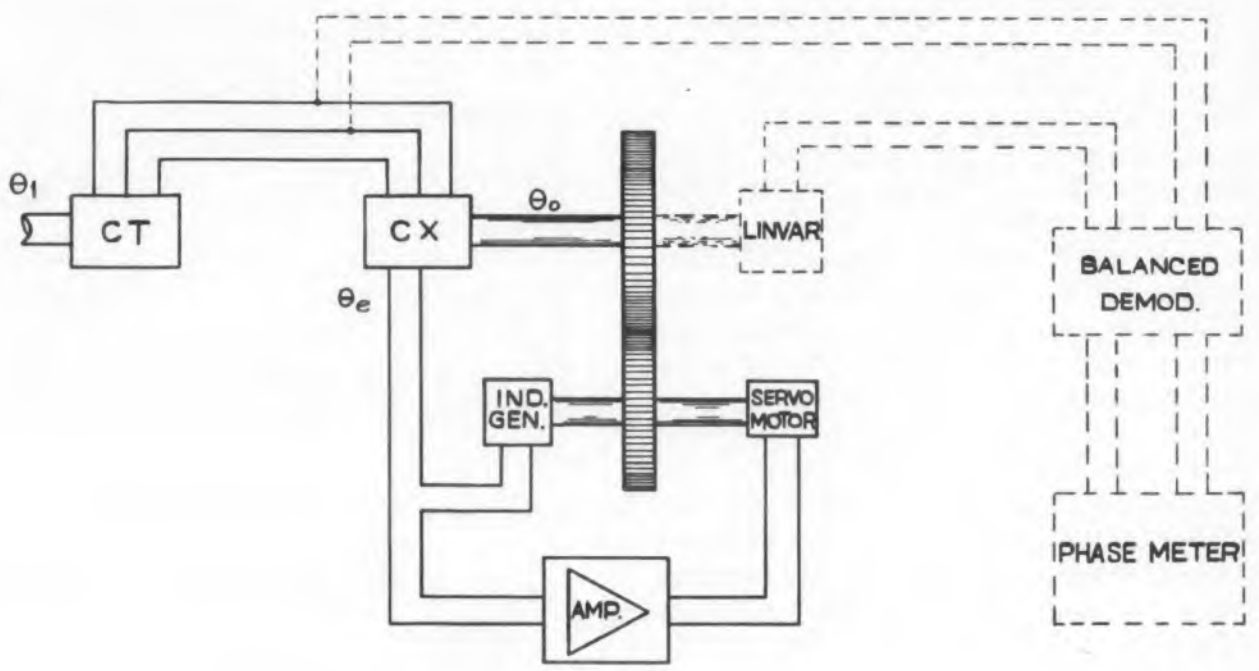


Fig. 4. Instrumentaton for the determination of the transfer function of a typical servo-mechanism (*CT*—control transmitter, *CX*—control transformer, LINVAR—linear variometer)

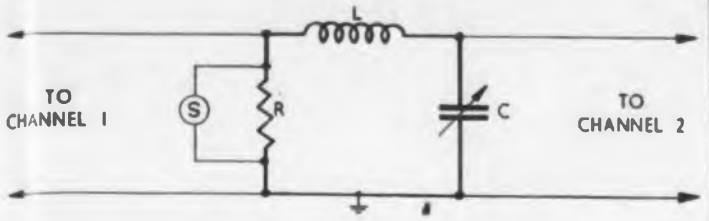


Fig. 5. External circuit for measurement of Q (S is a generator capable of supplying 100 ma into a 0.1 ohm load, *L* is the coil to be measured, C is a low loss variable capacitor, *R* is a low resistance from 0.1 to 1 ohm.)

▪ Scale expansion. For phase angles close to 0° or 180° the two voltages are substantially cancelled and a small reading appears on the meter. Providing the voltage levels are above 15 mv the scale reading can be expanded by decreasing the channel attenuator readings together in 10 db steps until the meter reads beyond 30 per cent of full scale. With this scale expansion it is theoretically possible to read down to 0.2 minutes or 12 seconds. In practice, scale expansion is available in steps with the result that full scale deflection can correspond to ±20°, ±6°, ±2°, ±0.6°, or ±0.2°. It will be appreciated that as the scale expansion is increased, exact balance of the channel voltages and freedom from distortion and noise terms become more important. For full scale deflections of ±6° or less the use of a tuned amplifier is desirable for most measurements if the capabilities of the meter are to be realized to their full extent.

▪ Use as a Q Meter. These phasemeters, by virtue of their two channels and high input impedance can be used to make Q measurements over a much lower frequency range than is provided by normal Q meters. The external circuit is shown in Fig. 5.

The voltage across *R* is set to 10 mv as measured by the phasemeter, which is then switched to Channel 2. The capacitor is then tuned to give maximum reading for *V2*. The voltage *V2* is then read from the phasemeter and the Q value is given by the ratio *V2/V1*. Attractive features of this method are that the input current to the coil may be varied over wide limits and that Q values up to 20,000 are theoretically measurable.

▪ Power factor measurements. By comparing the phase angle of an unknown capacitor with that of a standard capacitor of the same capacity value, the power factor of the unknown can be evaluated. The method has merit in the testing of capacitors or dielectric samples from 50 μμf to 1000 μμf since it can be used down to a few cps and up to 100 kc. It is suitable for measurement of power factors down to the order of 0.0005 if a high grade variable standard having a power factor of 0.00003 or less is used.

Capacitor Insulation Resistance Measurement

F. W. Grahame and D. F. Schmidt
General Electric NPN Silicon Transistors

WITH the increasing emphasis on reliability and circuit performance, the design engineer needs more detailed information on the performance of individual components. A case in point is the insulation resistance of capacitors. As usually reported this is the resistance which the capacitor offers to the flow of dc after a test voltage has been applied for one or two minutes. The engineer may, however, encounter cases where the ability of a capacitor to hold its charge over extended periods is of importance or where the capacitor must be charged from a high impedance voltage source. In such cases the insulation resistance of the capacitor after long time electrification must be very high—in the range of 100 million meg-μf. A technique has been evolved to measure resistances of these magnitudes.

Technique of Measurement

It was recognized that measurement of the insulation resistance of several types of common film dielectric capacitors (Mylar, polystyrene, Teflon, etc.) over long periods of time, particularly at room temperature or below, would not be possible with any bridge or ohmmeter type instrument at our disposal. This was because *1.* the range of such instruments is not great enough to read the resistance of the low capacity (0.022 μf for example) units tested, *2.* the impedance of the detector or the standard resistance arm in such instruments is not high enough to prevent errors from arising due to very small power supply voltage fluctuations, and *3.* the zero of the electronic detector or ohmmeter instrument drifts too far during long periods of test to permit accurate results to be obtained. Accordingly, a less conventional technique was used for these tests.

When a capacitor is fully charged and then disconnected from the power source, the voltage across its terminals will drop with time at a rate which depends on the capacitance and the equivalent parallel resistance. The voltage across a charged capacitor with a parallel resistance decays according to the well known relation:

$$E_t = E_o e^{-t/RC} \qquad (1)$$

where E_t = capacitor voltage at time t, E_o = original charging voltage, t = time of discharge in seconds, C = capacitance in uf, R = parallel resistance in megohms.

This equation may be solved for $R \cdot C$, giving:

$$R \cdot C = \frac{t}{ln\ (E_o/E_t)} \qquad (2)$$

When E_t is no less than $0.90E_o$ eq (2) can be simplified to

$$R \cdot C = \frac{tE_o}{E_o - E_t} \qquad (3)$$

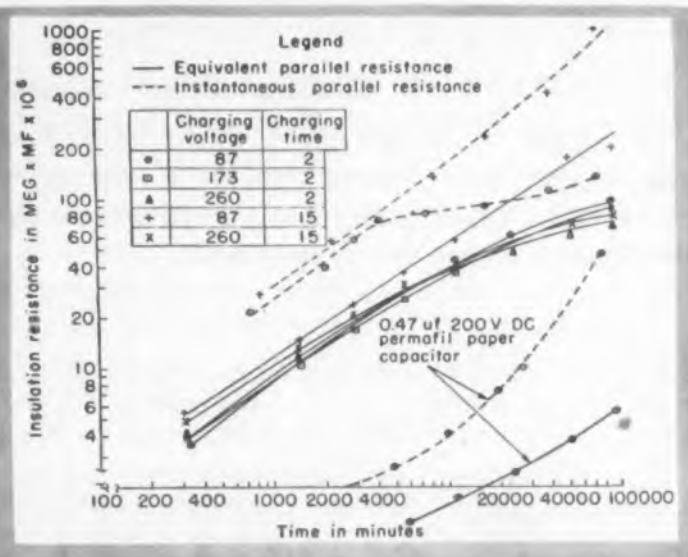


Fig. 2 Equivalent and instantaneous parallel resistance characteristics of 0.022 μf 400 v dc Mylar C dielectric capacitors and 0.47 μf 200 v dc permafil capacitor. Ambient 21 C, 50 per cent relative humidity.

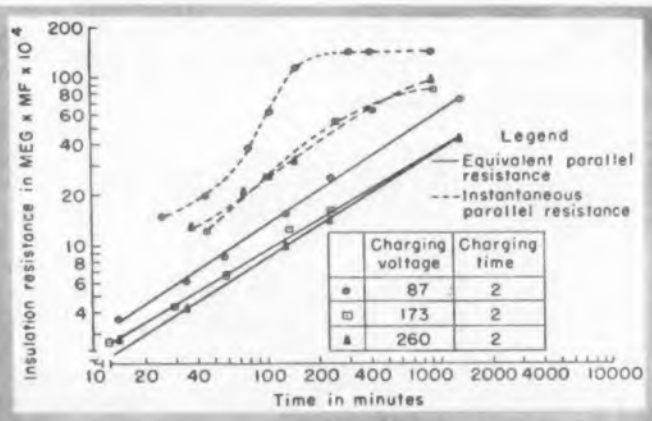


Fig. 3 Equivalent and instantaneous parallel resistance characteristics of 0.022μf 400 v dc Mylar C dielectric capacitors. Ambient condition 75/C.

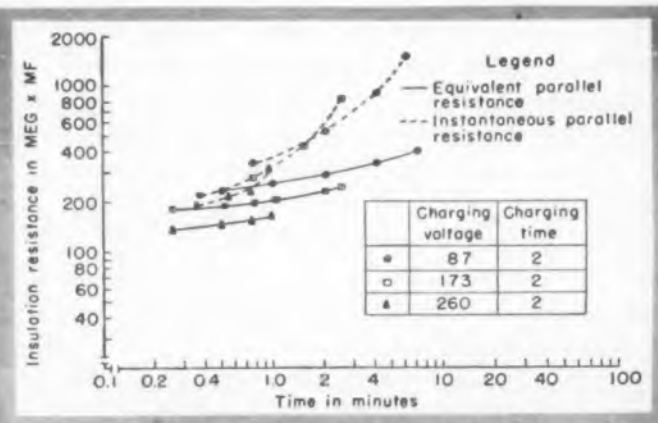


Fig. 4 Equivalent and instantaneous parallel resistance characteristics of 0.022 μf 400 v dc Mylar C dielectric capacitors. Ambient 125 C.

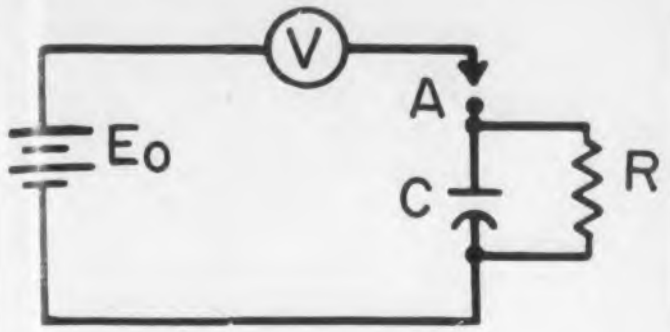


Fig. 1 Differential voltmeter circuit for measuring long-time insulation resistance of capacitors. Voltmeter is a loss range vacuum tube electrometer. *R* represents the parallel resistance of the capacitor and is of the order of magnitude of 100 million megohm-microfarads.

with little more than 5 per cent error at most. It will be observed that equations (1), (2) and (3) are based on the assumption that $R \cdot C$ is constant. In practice only C remains constant while R gradually increases with time. To get around this dificulty two voltage readings are taken close enough together in time so that $\triangle$R is small. Using this technique we obtain our working equation:

$$R \cdot C = \frac{(t_2 - t_1)\, E_o}{E_o - E_2) - (E_o - E_1)} = \frac{tE_o}{E_1 - E_2} = \frac{tE_o}{\Delta E} \qquad (4)$$

The next problem is to measure the voltage across the capacitor accurately.

A little reflection shows that any voltmeter will have a resistance considerably lower than the insulation resistance of the capacitors we wish to measure. As a result we will appreciably discharge the capacitor while measuring the voltage. This is of course intolerable. Secondly, we wish to measure a small change in a relatively high voltage accurately, and this is not ordinarily possible with a voltmeter having a full scale deflection great enough to read the high voltage in the first place. The solution we have adopted is to use a very high input resistance, low voltage range vacuum tube electrometer together with an extremely stable power supply in a differential voltmeter circuit as shown in Fig. 1. In operation the capacitor is first charged to the power supply voltage with the electrometer input shorted. At $t = 0$ the short is removed and the contact at point A is opened. At $t = t_1$, the contact is closed again and the electrometer reads $E_o - E_c = E_1$. The contact is then reopened. At $t = t_2$, soon enough after t_1 so that R has not changed much, the contact at A is again closed and the electrometer reads $E_o - E_c = E_2$. We now have enough data to determine the insulation resistance at the time $(t_2 - t_1)/2$. Because of the high resistance and low input capacity of the electrometer, the small differential voltage, and the

short time that contact is actually made to the test capacitor, no significant change in the capacitor voltage occurs. With this circuit small differential voltages can be accurately measured, and at the same time the act of measurement does not appreciably change them. The electrometer zero is easily adjusted just before each measurement.

The principal requirement of the apparatus is that the power supply for the charging and reference voltage be very stable over long periods of time. If the power supply were to increase its output by as much as 1 v this would look like a 1 v drop in capacitor voltage. Since the total differential voltage is often just a few volts, the error introduced by a power supply fluctuation could be serious. We used a group of type 5651 high stability voltage reference tubes in the power supply. These in turn were driven through a high resistance from a dc source which was itself regulated by the more conventional type OC3 and OD3 voltage regulator tubes. Because the 5651 is a gaseous regulator tube the test voltages are multiples of about 87 v, which is the operating potential of the tubes. The 5651 voltage remains stable within $\pm$ 0.1 per cent over long periods of time.

Another source of error which must be minimized is the input capacity of the voltmeter. If the input capacity is appreciable the charge which must flow into this capacitor also flows either into or out of the test capacitor—depending on the test circuit used—and the voltage across the test capacitor changes accordingly. The electrometer we used has an input capacity of 6 μμf. This source of error is small in our measurements and will remain so unless very low capacity units (under 0.0005 μf) are measured. It should be pointed out that the differential method of voltage decay measurement suffers much less from this source of error than direct measurement since the charge is smaller.

The test capacitors were mounted between two terminals which were in turn mounted on a sheet of polystyrene. The polystyrene was roughened with carbon tetrachloride to increase the resistance path between terminals. For elevated temperature measurements a Mycalex insulating board was used with Teflon-insulated leads connecting the capacitors on the inside of the oven to another Mycalex terminal strip outside the oven.

Discussion of Results

Only one type of capacitor was selected for our testing purposes, being Mylar "C" dielectric capacitors rated at 0.022 μf and 400 v dc. The dielectric consisted of 2 leaves of 0.00025 in. Mylar between foil electrodes. They were of the extended foil type of construction and metal cased with a Kovar-type glass bushing on each end. The physical dimensions of the capacitors were approximately 0.312 in. diam x 13/16 in. long. Precautions were taken to insulate the extended foil section from the case by use of a Mylar tape.

It was desired to know the effects of three variables when measuring the insulation resistance—temperature, charging voltage, and charging time.

Plotted in Fig. 2, 3 and 4 are two sets of curves. The sets plotted with the solid line are the equivalent parallel resistance of the capacitor. The sets plotted with the dashed lines are the instantaneous parallel resistance of the capacitor.

The equivalent parallel resistance, as was pointed out earlier in this article, increases with time. This of course results in a larger E_f than would otherwise be expected had R been constant. This relation of voltage decay can be shown in Fig. 5. The instantaneous parallel resistance is calculated using eq (4) where the change in R is small for a given change in t.

The concept of two kinds of long time insulation resistance is of the greatest importance. The

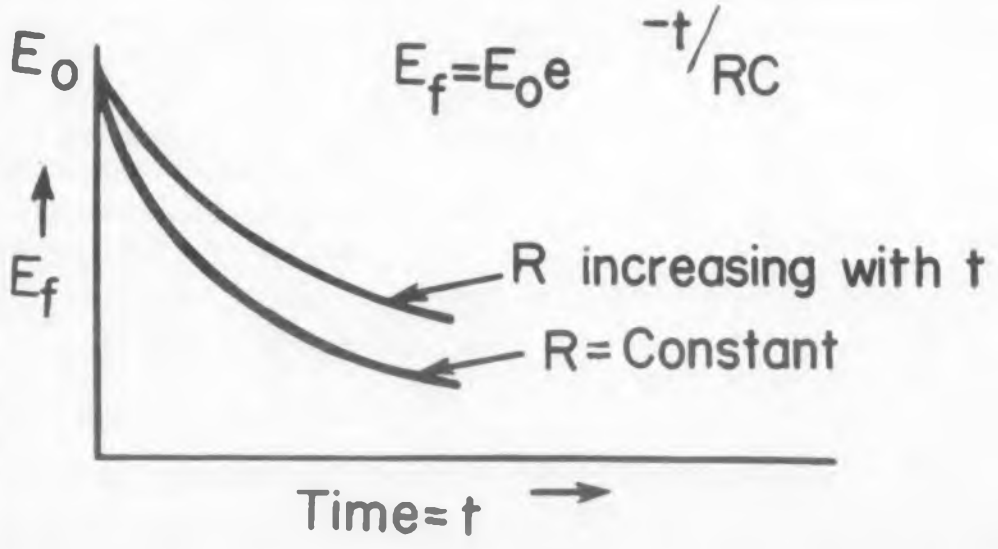


Fig. 5 Relation of true voltage decay to ideal decay in a capacitor. The true instantaneous E_f is appreciably higher than where the insulation resistance remains constant.

6528

MEDIUM MU, HIGH CURRENT TWIN POWER TRIODE

PROVIDES NEW STANDARDS OF PERFORMANCE
FOR SERIES REGULATOR SERVICE

see other side for additional information

CHATHAM

6528

MEDIUM MU, HIGH CURRENT TWIN POWER TRIODE FOR SERIES REGULATOR SERVICE

Requires Fewer Passing Tube Sections

Permits Lower Range Control Circuits

This Chatham Twin Power Triode provides both low internal drop and excellent control sensitivity. Series regulators have previously had to compromise these characteristics. The very low-mu triodes provided adequate low tube drop while the high sensitivity control characteristics could be obtained only from beam power tubes. Where both performance features were demanded it was often necessary to resort to parallel operation of a large number of tubes, or by complicated control amplifier circuits.

Circuitwise, the 6528 may be used with both triodes in parallel for one high current output, or they may be separated to provide two different regulated outputs. The possibilities for circuit simplification, space conservation and production economies are, of course, apparent.

For more information about the 6528, or for help with any special tube problem, write Commercial Engineering Section, Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, N. J.

DESIGN FEATURES

For reliable long life operation the 6528 features:

1. Hard Glass Envelope—permits tube to be more fully out-gassed in manufacture and to run at higher temperatures during life without gas evolution—more resistant to thermal shock.

2. Graphite Anodes—zirconium coated to provide one of the best "gettering" agents known—graphite undergoes virtually no expansion with temperature changes.

3. Extra Rugged Grids—gold plated molybdenum lateral wires supported by massive chrome copper side rods.

4. Oversized Cathodes—provide adequate emission reserve—no deterioration on standby.

5. Rugged Construction—mount is supported by six flexible metal snubbers and ceramic stand off insulators—heavy button stem has widely separated support leads.

RATINGS

Max. Plate Dissipation per tube	60 watts
Max. Plate Dissipation per section	30 watts
Max. Steady State Plate Current per section	300 ma
Max. Plate Voltage	400 volts
Max. Heater Cathode Voltage	300 volts
Amplification Factor*	9
Transconductance per section*	37,000 umhos

*Average characteristics at Eb = 100v, Ec = —4v, Ib = 185 ma.

TYPICAL VALUES FOR REGULATOR SERVICE

Current per Triode Section	Range of Tube Voltage Drop	Minimum Tube Drop	Grid Voltage Swing
200 ma	65 v.	70 v.	10 v.
150	120	60	20
100	225	45	35

CHATHAM

Designers and Manufacturers of Electron Tubes, Selenium Rectifiers, Aircraft Conversion Equipment and Custom Components.

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.
General Offices and Plant: Livingston, N. J.
SALES OFFICES:
CHICAGO, DALLAS, LIVINGSTON, LOS ANGELES

man who has a limited amount of energy available and wishes to store up energy in the capacitor over a long period of time will be concerned with the *equivalent parallel resistance,* whereas the man whose circuit requires that the parallel resistance of the capacitor shall be high enough to avoid circuit malfunction as a result of this resistance being too low will be primarily concerned with the *instantaneous resistance* at the time his equipment is ready to operate.

In Fig. 2, it is observed that there is little difference between units which received a charging time of 2 minutes at the three different voltages. This is not surprising, since the voltage range used was not high. At 75 C, Fig. 3, a significant difference between the various charging voltages begins to be apparent. At 125 C, Fig. 4, it becomes more obvious. In general, the higher the voltage or the test temperature applied to a capacitor the lower the insulation resistance.

In Fig. 4 the instantaneous insulation resistance measurements cross one another. This is a good example of what can happen if $\triangle E$ exceeds 10 per cent of E_o. The result is a significant reduction in charge on the capacitor dielectric. This results in a higher instantaneous insulation resistance measurement.

It can also be seen in Fig. 3 that a charge time of 15 min against 2 min increases the insulation resistance slightly. This is due partly to the fact that the additional 13 min enables the dielectric to absorb more charge before the test starts.

Mylar capacitors are advertised to meet 50,000 to 100,000 meg-μf at 25 C, 10,000 meg-μf at 75 C, and 300 meg-μf at 125 C. A glance at Fig. 2, 3, and 4 reveals that instantaneous values obtained are much higher than those advertised, as a result of the longer electrification time.

For 125 C measurements, we were confined to measurements over a relatively short period of time because of the inability of the electrometer to measure a $\triangle E$ larger than 80 v without auxiliary multiplier resistors. This is a further indication that this type of insulation resistance measurement is not well suited for measuring low values of insulation resistance.

Standard procedures concerning measurement and definition of long time insulation resistance do not exist. Only a few capacitor manufacturers specify or indicate a long time insulation resistance value and then the statement is usually not qualified. It becomes apparent then when discussing long time insulation resistance that we must keep in mind the charging voltage, charging time, ambient temperature and the time after $t = 0$ that the insulation resistance is to be known. Finally, a decision must be made to consider either the equivalent parallel resistance or instantaneous parallel resistance.

CIRCLE 28 ON READER-SERVICE CARD

New Circuit Board

Uses No

Mechanical Clips

—No Solder

Unique conductive "cells" are the heart of a new breadboard aid designed to simplify the mechanics of electronic research and development. These cells take the place of soldered connections between component leads, allowing the engineer or technician to rapidly assemble (or disassemble) experimental circuits without the use of soldering iron or specialized clips, jacks, or fixtures.

The design of the board stresses simplicity. The aim is to provide a working surface that effectively bridges the gap between a printed circuit board and a design engineer's penciled schematic. The surface of the board is white, with a grid of lines that serve, like graph paper, to organize the circuitry into a semblance of order. These lines do not enter into the circuitry, but do help to locate the individual cells (see Fig. 1). The white surface lends itself to grease-pencil marking, allowing the engineer to note the electrical value of components as he assembles them in the circuit. This is of special importance when several men are involved on a single project.

The board pictured consists of 130 individual conductive cells, spaced on a 1 1/4-in. grid. It is one of a series of similar boards now being produced by Van-Dee Products, 300 Ocean Ave., Laguna Beach, Calif. These range from small boards, with only 54 conductive cells, to large, blackboard-like units that can be hung on the wall and used for instruction or demonstration. They may be conveniently stacked or interconnected for assembling exceptionally complex electronic circuits.

The conductive cells are assembled from polyurethane-foam plastic and a conductive metal. The two design requirements that were met in the development of the cells, other than the provision of an electrical connection with essentially no resistance,

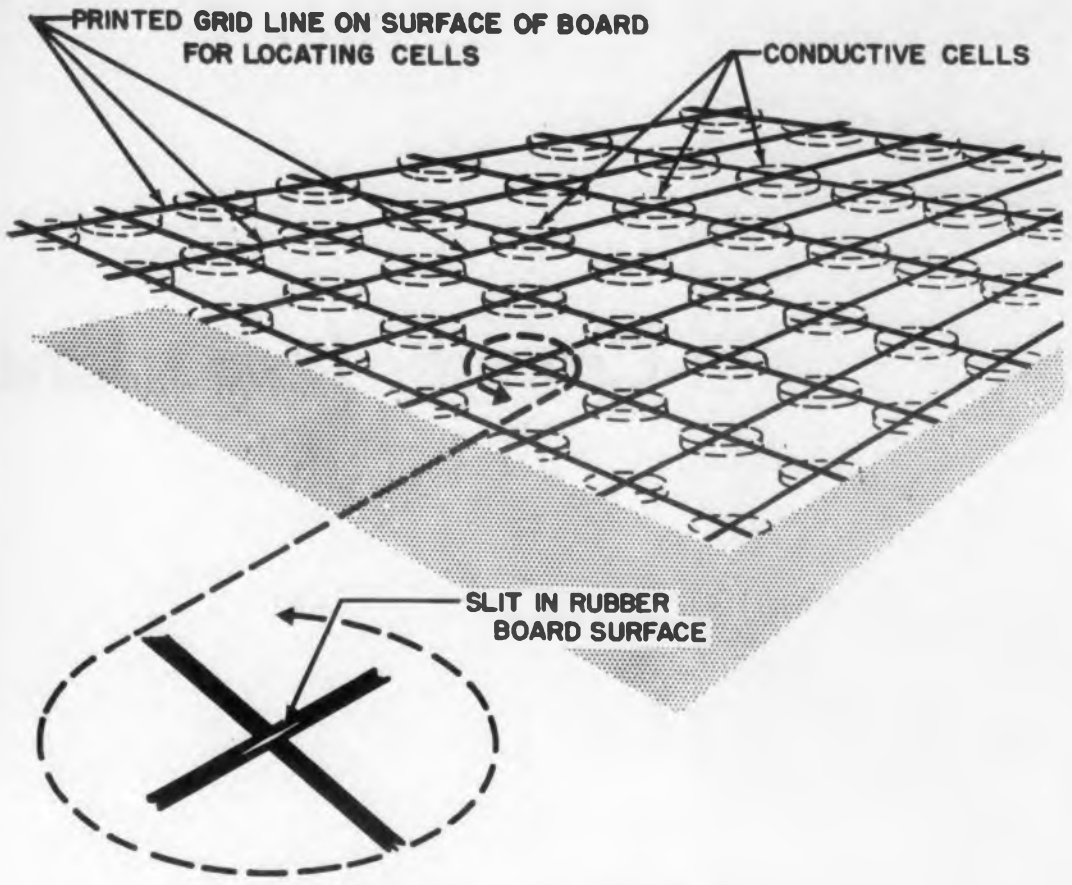


Fig. 1. Grid lines help to locate individual conductive cells.

were: (1) It is possible to slip component leads in and out of the cells without touching or affecting other wires already connected to each cell, and (2) Each cell is able to accommodate at the same time a wide variety of wires, from fine magnet wires to No. 20 solid conductors, without danger of a loose connection.

Wire leads are electrically connected simply by inserting their ends through narrow slits cut into the white neoprene sheet that acts as the surface of the board. The elastic covering serves to grip the wires, holding the circuitry firmly in place, even when the board is in a vertical or tilted position, or when it is being jolted or vibrated. Preparation of the wire leads does not go beyond that normally needed for a solder connection. A non-corrosive flux-like material in the cells serves to eliminate any dirt or oxidation on component leads.

Up to six #20 or ten #22 gauge wires may be inserted into a single conductive cell, although in normal circuit development, no more than three or four leads will connect at a common point. To simplify the circuit design, the bottom row of conductive cells has been internally connected to form a common ground.

The current carrying capacity of the individual cells is in the order of several amperes, more for brief pulses. This permits the use of the circuit board for the assembly of nearly any RF or control circuitry, including amplifiers, multivibrators, filters, oscillators, transistor circuits, and countless others. Since each cell is completely isolated from the others by resins and elastomers of high dielectric strength, potentials in the order of several thousand volts can be safely accommodated.

For more information about these circuit boards, turn to the Reader's Service Card and Circle 31.

In-Circuit Impedance Me

WITHOUT unsoldering the component; without cutting the leads; in some cases without even removing the power; resistors, capacitors and inductors are measured to an accuracy of better than 0.25 per cent. In addition to the desirable time saving advantage of the bridge, damage and changes in component values caused by unsoldering are eliminated. This feature is particularly helpful in testing miniature, modular or printed circuits.

The range of measurements is equally outstanding. Resistance can be measured from 50 micro-ohms to 10 kilo-meg ohms. Capacitance can be measured from 0.0002 micro-micro farads to 0.1 of a farad. Inductance can be measured from 5 milli-micro henries to 10,000 henries.

A true impedance measurement is made by the bridge. It separately indicates both the resistive and the reactive value of the tested component. Bridge accuracy of 0.25 per cent is maintained on all ranges. However, at the range extremes difficulty in reading the last decade can cause a decrease in accuracy. To prevent the number of decades from limiting the maximum resistance which can be measured by the bridge, the dials are calibrated in conductance above 10 ohms. Because of the unique method used to make the measurements, reactance and resistance of the connecting leads do not affect the accuracy of the bridge.

Transfer impedance measurements of 2, 3 or 4 terminal networks can be made by reversing the internal connection of the standards with an external switch. Reversing changes the sign of the voltage and enables the bridge to measure "negative impedance" in a straightforward manner.

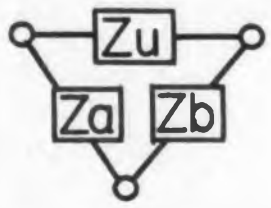


Fig. 1. Most circuits can be resolved into a three terminal network; the unknown impedance Z_u and the two impedances whose effect must be cancelled, Z_a and Z_b.

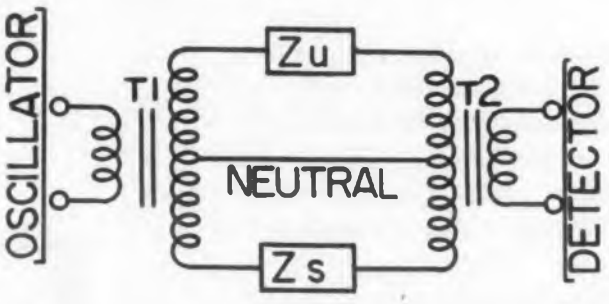


Fig. 2. The most simple type of bridge measurement—a single component without any associated circuitry.

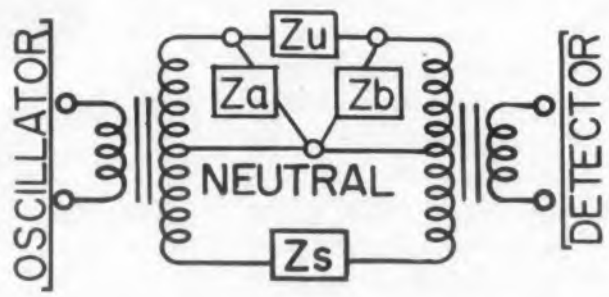


Fig. 3. In situ* measurement. Z_u is the unknown component; Z_a all components on the LHS of Z_u; Z_b all components on the RHS of Z_u.

In Situ*

The bridge, developed by Wayne Kerr of London and distributed by Marconi Instruments, 44 New St., New York 4, N.Y., is free from the restrictions placed on conventional bridges by the difficulty of manufacturing very high and very low precision standards.

Theory behind "in situ" measurements makes use of the fact that an impedance across one arm of a center tapped transformer is reflected across the other arm. Z_u is the impedance to be measured. Z_a and Z_b are the two impedances whose effect must be cancelled out before the measurement can be made (Fig. 1). The most simple type of bridge measurement—a single component without any associated circuitry—is shown in Fig. 2. A center tapped transformer T_1 applies equal ac voltages in opposite phase to the unknown impedance Z_u and the standard impedance Z_s. T_2 is a similar center tapped transformer. For balance $Z_u = Z_s$ so that the currents flowing in each half of T_2 will be equal but in opposite phase. This gives zero output to the detector. When Z_u and Z_s do not have the same impedance, unequal currents in each half of T_2 present an output to the detector. To balance the bridge so that a zero output is presented to the detector, Z_s is varied. The value of standard impedance necessary to exactly cancel the unknown impedance is the measured value of the unknown impedance.

When making the three terminal "in situ" measurement, the component is connected to the bridge

ce Measurements

J. Garthwaite
Marconi Instruments
New York, N.Y.

as shown in Fig. 3. Z_b shunts the unknown side of T_2. Since the transformer is center tapped, the same impedance is reflected across the standards side of the transformer. The only effect of the impedance is to reduce input to the detector and consequently the off balance sensitivity. This reduction in sensitivity can be compensated by increasing detector gain. Accuracy of the bridge at balance is therefore unimpaired. Similarly Z_a shunts the unknown side of T_1 secondary and an equal impedance is reflected across the standards side of the transformer, since T_1 is also center tapped. This shunting causes a drop in the input voltage to the bridge, but it does not affect balance conditions and so no error is introduced. The voltage drop is compensated for by an increase of detector gain. Stray impedances of the leads used to connect the bridge to the component to be measured are cancelled out by screening and connecting the screen to the neutral terminal. The lead strays are returned to neutral and will not affect balance accuracy.

To explain the operation of the bridge ideal transformers were assumed. In practice there are three transformer variables which could affect bridge accuracy: (1) turns ratio, (2) flux linkage, and (3) impedance of the windings. Careful transformer construction will reduce the first two to unmeasurable values. The only error which need be considered is that caused by the impedance of the windings. The total impedance of both the oscil-

*Webster's New Collegiate Dictionary—in situ (L.) In its natural or original position.

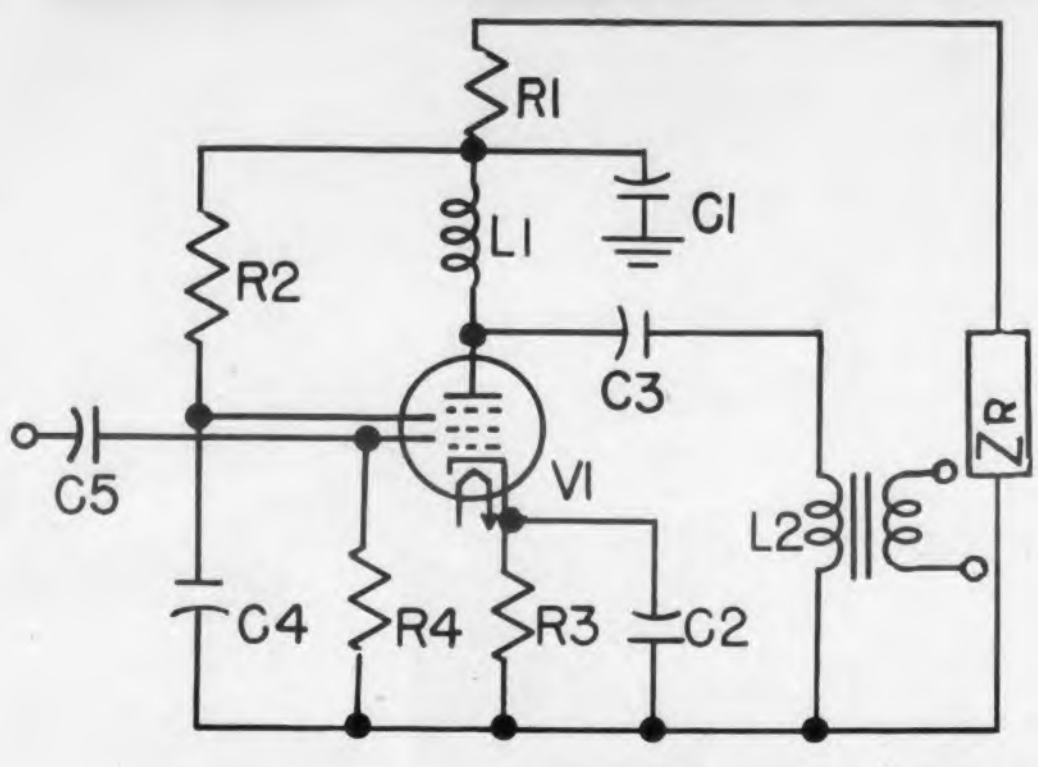


Fig. 4. C_s is measured in situ*. Magnitude of both the capacitive and resistive values of C_3 is indicated on two decade dials. Z_R is the total B+ impedance.

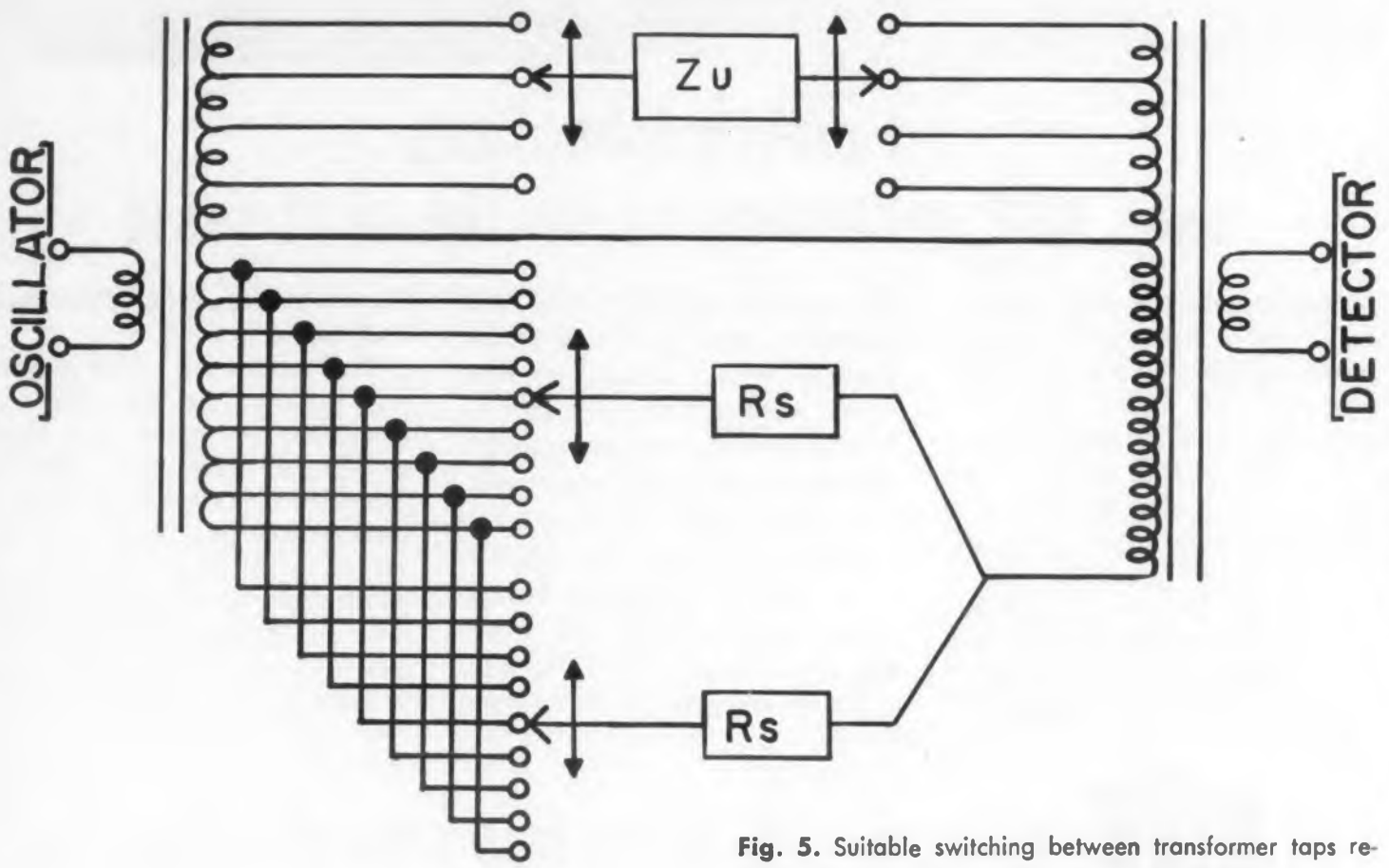


Fig. 5. Suitable switching between transformer taps reduces the required number of standard elements by a factor of 10.

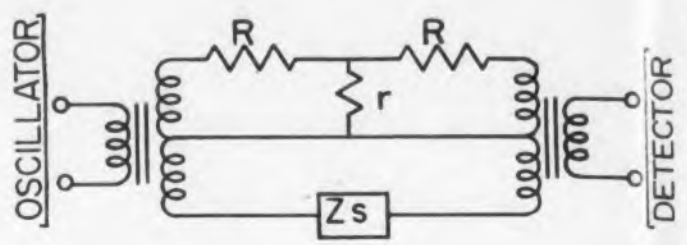


Fig. 6. Extremely low resistive and inductive values and high capacitive values are made by switching the bridge to a T-network arrangement. R is the stan-impedance and r the unknown impedance.

lator and the detector transformer windings is approximately 100 ohms. Even if all this impedance were concentrated in one arm of the bridge, the worst error would only be 0.001 per cent. In practice the error is negligible.

Most circuits can be resolved for 3 terminal connection to the bridge by correct connection of the neutral terminal. Suppose we wish to measure C_3 in the circuit Fig. 4. C_3 is connected to the bridge as Z_u in Fig. 3. With the neutral connected to ground, Z_a represents all impedances from the left of C_3 to ground. This is a multiple path consisting of (a) L_1-R_2-C_4, (b) L_1-C_1, (c) L_1-R_1-Z_r. Similarly Z_b represents all impedances from the right of C_3 to ground. This is simply L_2. When the bridge is balanced, the exact magnitude of both the capacitive and resistive values of C_3 is indicated on two decade dials. Since the component is never removed from the circuit, it is not subjected to impedance changes from soldering heat. When measuring components such as C_4, L_2, which have one side connected to ground, the neutral is connected to B+.

Bridge Construction

Bridge standards are divided into separate resistive and reactive elements. Resistors are used for the resistive standards and capacitors for both capacitive and inductive standards. Inductance measurements are made by internally reversing the capacitive connections to the transformer. This causes a phase shift of 180 deg to the inductive quadrant. The reactive and resistive balances are independent, an important feature in any bridge.

Fig. 5 shows how with suitable switching to multiple transformer tappings, 2 standards are used to give 2 decades. Conventional bridges normally require 20 standard components for 2 decades. For simplicity only the resistive standards are shown. A similar arrangement is employed for the capacitive standards. To change the range of the bridge, the unknown impedance Z_u is switched between successive transformer taps. To accomplish final balancing, continuously variable reactive and resistive controls are provided. The resistive control is easily

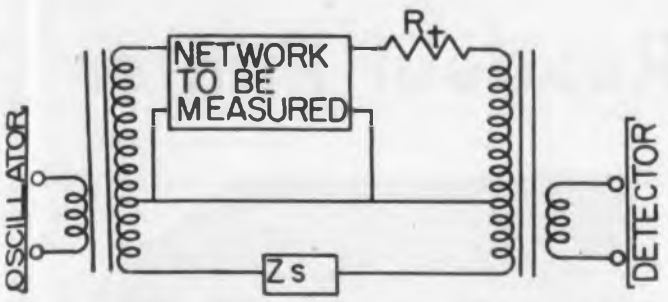


Fig. 7. Transfer admittance is measured by reversing the transformer connections. R_x is the terminating resistor of the network to be measured.

accomplished by combining a variable and fixed resistor. However, for the capacitive variable it is necessary to cancel out the residual capacitance of the capacitor with a preset trimmer connected to a transformer winding 180 deg out of phase.

Two decades and one variable control are used for each conductive and capacitive balance. With the special care given to transformer design and minimization of strays, this arrangement gives the bridge an accuracy of 0.25 per cent or better for all ranges. A stable oscillator and sensitive detector complete the bridge elements. The detector employs two electron beam tuning indicators placed at different gain points in the circuit. This staggering provides a course and fine balance indication.

Very Low Impedance Measurements

When measuring impedances lower than 10 ohms, the series resistance of the leads and switches become significant. To prevent the impedance in the switches and connecting leads from effecting measurement accuracy, the unknown is made the shunt element of a T-network assembly (the series arms are fixed standard resistors). All complex impedances below 10 ohms are measured in this way. For simplicity it is shown in Fig. 6 applied to an unknown pure resistance "r." Several ranges below 10 ohms are provided by switching "R" in pairs, or by range changing the transformer taps, or both. In this way it is possible to make measurements down to a few microhms without difficulty. The same T-network method is used to measure inductors down to 1 mμh and capacitors up to 100 Kμf. A T-network is provided with the bridge.

Transfer admittance of complete networks is measured by the arrangement shown in Fig. 7. A 50 ma dc current can be passed through the transformers on the most sensitive range and up to 1 amp on the least sensitive range without upsetting bridge balance. This bridge is truly an engineer's instrument.

For further information on the transformer ratio-arm bridge, turn to the Reader's Service Card and circle **465.**

No Relays in this

Digital Readout Printer

Digital readout printer with no relays or moving contacts

USING a unique solenoid-lever matrix to convert directly from electrical code pulses into mechanical printing motion, this digital readout printer contains no relays of any sort in its printing circuits. Actuation of mechanical lever movements is accomplished entirely without moving electrical contacts. The device features lightweight replaceable plug-in matrix modules and a low-duty-cycle power supply.

The instrument is incapable of making a mistake. Accuracy of the printed numbers which it produces depends entirely upon the accuracy of the electrical pulses which are fed into the printer. Fig. 1 is a block diagram showing one of the four parallel solenoid circuits required to produce one printed digit on paper.

Designed for use by engineers, either in designing or evaluating electronic products, the printer, manufactured by Computer Measurements Corp., North Hollywood, Calif., is both

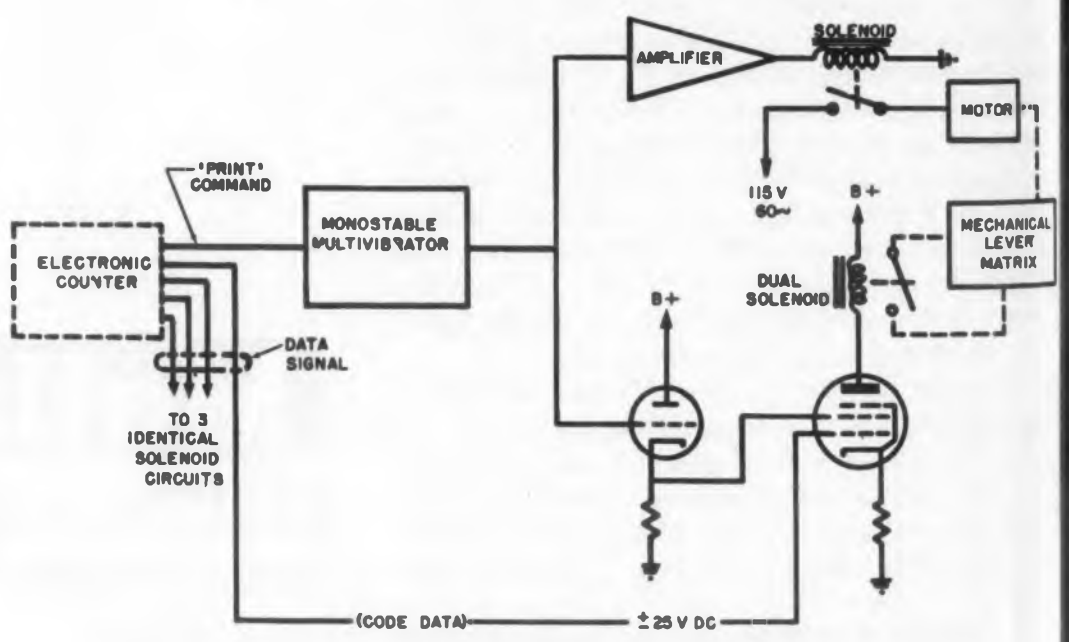


Fig. 1. Block diagram of basic solenoid circuit

economical and dependable. Rapid print-out of up to 12 digits per line at the rate of 4 lines per second is accomplished by converting code pulses out of an electronic counter into mechanical movements by means of the integral lever matrix. For faster printing action, all digits in a line are converted simultaneously rather than in series. Code pulses from the counting equipment are in the form of 1-2-2-4 permuted binary code. Fig. 2 shows how the printer converts various combinations of the 1-2-2-4 code into decimal numbers for printing on ordinary adding machine paper tape.

Requiring no lubrication, each indentical solenoid-lever matrix contains four dual solenoids and a network of mechanical levers. The module converts coded electrical pulses into a motion which positions type against the paper tape which comes out of a slot on the top surface of the printer. Normally, six such modules are furnished in the Model 400B printer; however, up to 12 modules can be included as an optional feature. Each module acts independently of all others, so that identifying information (such as run number) can be automatically printed alongside the digital numerical information which the machine produces.

The printer is useful whenever a printed record is desired of meter reading involving time period counting. Typical applications include laboratory circuit evaluation, precise frequency counting, recording results of special tests, compilation of response data for subsequent graphical evaluation or computer processing, and many others.

For further information about this digital readout printer, turn to the Reader Service Card and circle number 36.

		PERMUTED BINARY CODE			
		1	2	2	4
DECIMAL NUMBERS	0	0	0	0	0
	1	1	0	0	0
	2	0	1	0	0
	3	1	1	0	0
	4	0	1	1	0
	5	1	1	1	0
	6	0	0	1	1
	7	1	0	1	1
	8	0	1	1	1
	9	1	1	1	1

Fig. 2. Coding scheme for the permuted binary code indicating conversion of coded pulses into 10 digit decimal printed numbers

High Frequency Diffused-Meltback Transistors

A. B. Phillips and A. M. Intrator
Semiconductor Products Department
General Electric Co.

PRODUCTION transistors with an alpha cutoff distribution centering at 30 mc and with a considerable proportion in excess of 50 mc can be obtained easily, using the diffused-meltback process. At room temperature, the power dissipation rating of the diffused-meltback transistor is 150 mw, and is derated at a rate of 1 mw per deg C to a level of 25 mw at 150 C. All units are capable of storage at temperatures as high as 200 C, without degradation of characteristics.

As a silicon device, the I_{co} current measured at $V_c = 5$ v is very low. The design center value at room temperature is 0.01 μa, and increases approximately by an order of magnitude for each 40 C temperature rise. Thus, at 150 C the I_{co} current is in the order of 10 μa. In grounded-emitter operation at 150 C, I_{co} is from 0.2 μa to 1 μa, depending on the magnitude of beta.

A typical family of collector characteristics for the grounded-emitter configuration is given in Fig. 1. The slope of the saturation characteristic corresponds to a series saturation resistance of 40 ohms. This low value of R_s is attributed to the unique impurity distribution of the collector region which is characteristic of the diffused-meltback process. All units are rated at a maximum collector current of 30 ma.

The design center values for the grounded-base h-parameters at 25 C are $h_{ib} = 55$ ohms, $h_{rb} = 4 \times 10^{-4}$, and $h_{ob} = 0.6$ μmhos. For grounded-emitter operation, beta peaks at about 2 ma and decreases gradually to between 50 per cent and 75 per cent of the initial value out to 30 μa. As an inherent feature of silicon devices, beta will increase to twice the 25 C value at 150 C and decrease to about 0.4 of the 25 C value at −55 C. The nominal collector capacitance for these devices is 14 μμf at $V_c = 5$ v. Because of the microthin base widths (2 microns) that are obtained, the alpha-cutoff distribution for production units centers at 30 mc, with a considerable portion in excess of 50 mc.

Silicon Transistor Types

Five transistor types are presently available from the npn diffused-meltback silicon line, each designed for a specific application or range of applications. Designated as the 4JD4A series, these transistors types are listed in the Table, along with significant electrical parameters.

The 4JD4A2 is a high-frequency type for which the grounded-emitter cutoff frequency is in excess of 1 mc. This high beta-cutoff frequency makes it suitable for video amplifiers, rf stages and oscillators, and high speed switches. Typical power gain at 5 mc is 16db.

The 4JD4A3 is a low-level, high-speed switching transistor intended particularly for direct-coupled transistor computer logic. This type is characterized by a low series saturation resistance of 40 ohms and

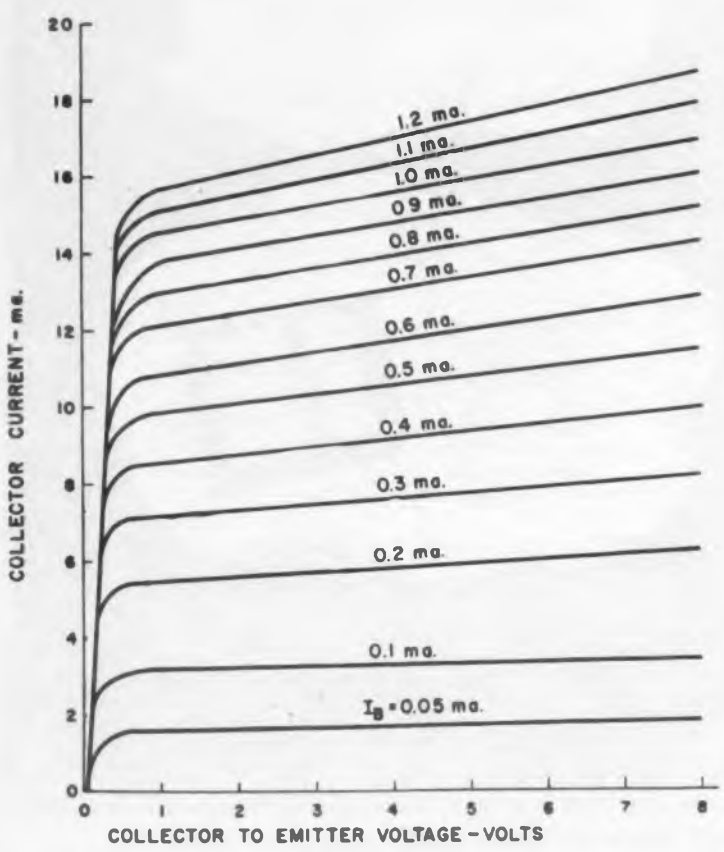


Fig. 1. Family of collector characteristics for grounded-emitter configuration of Type 4JD4A silicon transistor. Ambient temperature is 25 C.

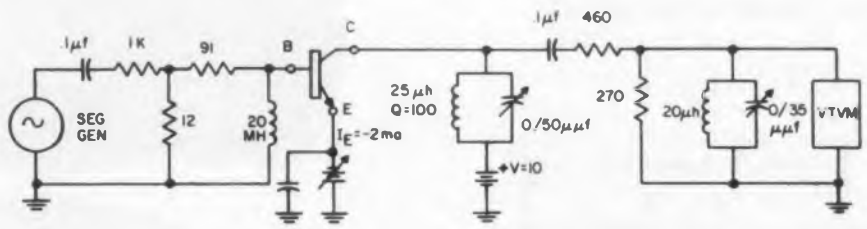


Fig. 2. Five-mc tuned-amplifier circuit for measuring power gain of the 4JD4A2 silicon transistor.

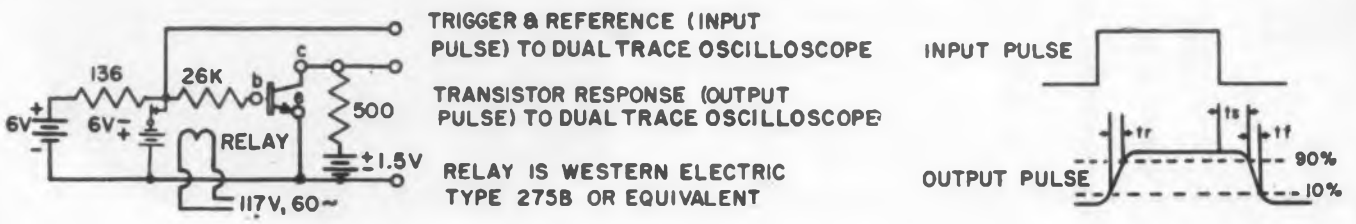


Fig. 3. Switching circuit for measuring transient response of the 4JD4A3.

fast transient response as indicated in the table. Additionally, this transistor features a controlled base-input characteristic at a tolerance of ±20 mv for $I_b = 0.2$ ma.

Finally, a broad range of grounded-emitter current gain, h_{fe}, is provided by types 4JD4A4, 4JD4A5 and 4JD4A6. The respective ranges of beta are 9 to 30, 20 to 50 and greater than 40. This permits a number of amplifier applications in the audio and radio frequency range. The low R_s and high alpha-cutoff make these devices suitable for general purpose switching application. At 5 mc, the matched power gain is nominally 10 db.

A typical measurement circuit illustrating the grounded-emitter power gain performance of the 4JD4A2 silicon transistor is shown in Fig. 2. Measurements are made at a frequency of 5 mc and bias conditions of $V_c = 10$ v and $I_e = -2$ ma. The circuit is a single-tuned amplifier having a source resistance of 103 ohms and an output load of 930 ohms. The tank circuit across the VTVM is used to tune out the input capacitance of the meter. Under these conditions, the measured power gain at 25 C is 16 db. At 80 C the power gain is 15 db., and drops to 13 db at 120 C ambient temperature.

Fig. 3 is a typical switching circuit for determining the transient responses of the 4JD4A3 switching transistor. In the "on" state, the collector current is approximately 3 ma. The "on" and "off" base current drives are $I_{b1} = I_{b2} \approx 0.23$ ma. Under these conditions, the nominal transient response characteristics at 25 C are $t_r = 0.9$ μsec., $t_f = 0.2$ μsec., $t_s = 0.04$ μsec., as measured between the 10 and 90 per cent points of the output pulse.

The inherently high BV_{ebo} rating of 5 v for the 4JD4A series silicon transistors can be used to good advantage in designing high frequency multivibrators. In Fig. 4 an astable symmetrical multivibrator circuit is shown, in which the timing network is in the emitter circuit. For the 270 ohm load resistors shown, $E_2 = 30$ v and $E_1 = 15$ v, this circuit will switch at a rate of 2 mc.

See next page for a description of the diffused-meltback process.

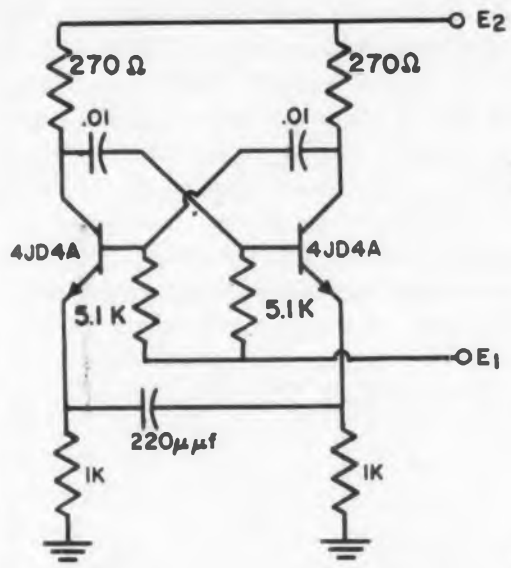


Fig. 4. Non-saturating symmetrical astable high frequency (2 mc) multivibrator.

General Electric NPN Silicon Transistors

Type No.	Applications	Significant Characteristics	Maximum Voltage Ratings
4JD4A2	High-freq. rf amplifiers, oscillators, video amplifiers, switches.	$f_{\alpha e} > 1$ mc 16 de power gain @ 5 mc	$BV_{cbo} = 20$ v $BV_{ceo} = 15$ v $BV_{ebo} = 5$ v
4JD4A3	Low-level switching applications (DCTL)	$R_s = 40$ ohms $V_{be} = .693$v ± 20mv $t_r = 1.3$ μsec (max) $t_s = .3$ μsec (max) $t_f = .4$ μsec (Max)	$BV_{cbo} = 10$ v $BV_{ceo} = 10$ v $BV_{ebo} = 3$ v
4JD4A4	Audio amplifiers Servo and control Dc amplifiers Rf amplifiers General purpose switches	$9 \leq$ beta ≤ 30 $R_s = 40$ ohms $f_{\alpha B} = 25$ mc	
4JD4A5		$20 \leq$ beta ≤ 50 $R_s = 40$ ohms $f_{\alpha B}$ 25 mc	$BV_{cbo} = 30$ v $BV_{ceo} = 15$ v $BV_{ebo} = 5$ v
4JD4A6 (4JX4A-500)		beta ≥ 40 $R_s = 40$ ohms $f_{\alpha B}$ 25 mc	

A description of how diffused-meltback transistors are manufactured will help circuit design engineers evaluate their capabilities.

Diffused-Meltback Process

Solid-state diffusion of impurities offers the most promise of achieving uniformly the thin base regions necessary for very high frequency transistor performance. Because the diffusion cycle usually takes place over a period of several hours, the need for split-second accuracy is eliminated, thereby affording a high degree of process control. Moreover, when impurities which are already within the solid rather than on the surface are diffused the process is not effected by variations in surface properties and concentrations. It is for these reasons that the diffused-meltback process becomes so attractive as a means of making high frequency npn silicon transistors.

The process begins with the growth of a large single-crystal of silicon, which is intentionally doped with both n-type donor and p-type acceptor impurities. The doping concentrations are such that the crystal grows uniformly n-type of low resistivity, corresponding to the emitter region of the final transistor. The crystal is then sawed into wafers and each wafer is then diced into bars approximately 1/8 in. long and 0.020 in. square. In (a) of Fig. 5, the relative impurity concentrations within the bar of silicon are shown. At this step, the bar is everywhere homogenously n-type. One full grown silicon crystal will yield thousands of these bars, each—after subsequent processing—corresponding to a unit transistor. The fact that almost all of the initial crystal is utilized affords an economic advantage.

The second step of the process is called meltback, in which one end of the bar is remelted or melted-back and then solidified again. This forms the teardrop shape shown in (b) of Fig. 5. Because the impurities will segregate as the melted-portion freezes, the distributions shown in (b) are formed. Just at the liquid-solid interface, the initial impurity concentration drops sharply to very low values determined by the concentrations and segregation coefficients of the initial impurities. In this region, the conductivity is still n-type, but the resistivity is much higher—in the order of an ohm-cm or more. It should be noted that this high resistivity plateau extends only a few thousandths of an inch, whereupon the resistivity drops quickly throughout the remainder of the meltback region. The base region has not yet been formed, but simply a junction between two n-type regions of different resistivity.

The last step of the diffused-meltback process is the formation of the base region. This is accomplished by

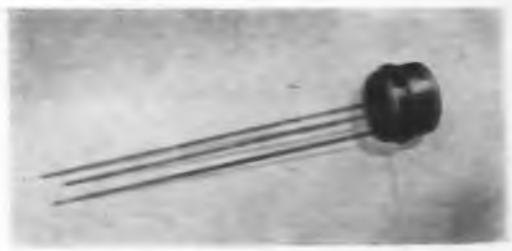


Fig. 6. G. E. 4JD4A npn silicon transistor. Unit shown is actual size.

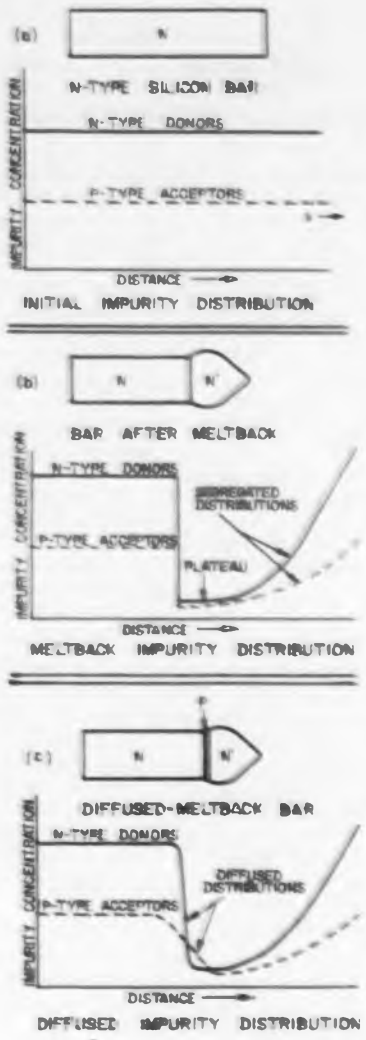


Fig. 5. Impurity distributions at each step of the silicon diffused-meltback process.

subjecting the meltback bar to a long, high-temperature heating cycle, which lasts for many hours. Under these conditions, the impurities on the high concentration side of the meltback junction *diffuse* within the solid semiconductor into the plateau region of lower concentration. The p-type impurity has the property of diffusing almost 20 times faster than the n-type impurity in silicon. On the plateau side of the junction, therefore, there results an excess of p-type impurities over the n-type, corresponding to a thin, p-type base region. By proper choice of the initial impurity concentrations and the time and temperature of the diffusion cycle, heavily-doped bases as thin as 2 microns are obtained with relative ease. The resulting bar is a silicon npn transistor structure, characterized with an inherently high alpha and frequency cutoff.

Ohmic solder connections are made to each end of the bar corresponding to the omitter and collector contacts. Connection to the base region is made by alloying a thin, aluminum ribbon to assure a low base resistance contact. After proper etching and surface treatment, the unit is hermetically-sealed by means of a welded cap. The completed transistor is shown in the photograph of Fig. 6. Case dimensions and lead configuration are suitable for insertion into printed boards by automatic assembly equipment. The unit is painted to withstand 200 C storage and 96 hour salt-spray test.

Editor's Note: Part III completes Mr. Prensky's investigation of electronic current and voltage measuring instruments. Laboratory meters were surveyed in Part I (Aug. 15); service meters in Part II (Sept. 1).

VTVM Survey—III

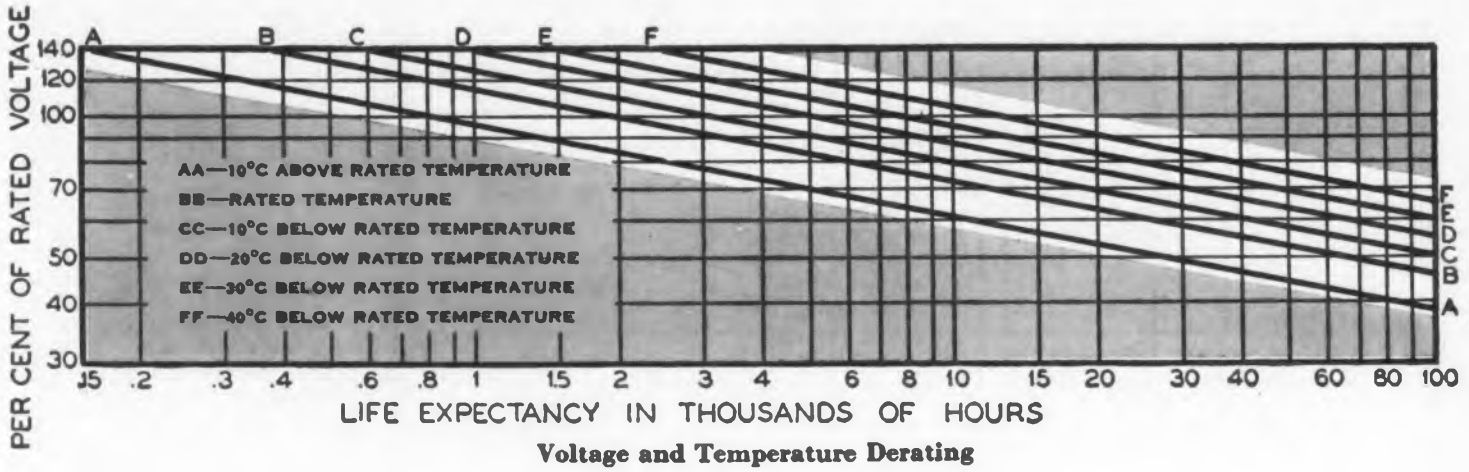
Sol Prensky
Fairleigh Dickinson Univ.

VACUUM tube voltmeters designed for extremely accurate voltage and current measurements in the micro-range are analyzed in the accompanying table. Standard VTVM's with unique methods of indication or novel circuitry, and special meters intended for a particular application complete the "catch-all" tabular survey. These instruments could have been included in either Part-I, Laboratory Meters or Part-II, Service Meters. They are listed separately to prevent burying their unusual features in a detailed table. The survey was conducted to assist the design engineer in selecting the best meter to fit his requirements.

Manufacturer	Model & Price	Type	Measurement Ranges	Circuit Design Features
Alto Scientific Co. 855 Commercial St. Palo Alto Calif.	D 21A $215	Transistor AC Voltmeter	AC Ranges: 0-300v; freq. 10 cps to 1 mc ±5 per cent; 20 cps to 500 kc. ±3 per cent full scale.	Cathode follower input circuit provides 10 M input resistance. Output of CF is amplified by a four stage high feedback transistor amplifier. Unit is only 3½ x 2¾ in. Battery operated.
Bergen Labs. 247 Crooks Ave. Clifton, N.J.	1 $149.50	Automatic Range-Switching	DC Volts: ±0 to ±1500 dc and ac; 0 to 100 Meg Ohms	Automatically selects proper range on ac dc, ohms, and dc polarity. During range switching meter movement is automatically disconnected to prevent overload; also manufactured in special ranges and mill spec versions.
Boonton Elec. Corp. 738 Speedwell Ave. Morris Plains, N.J.	91B $375	RF Voltmeter	AC Ranges: .003—3; 7 ranges; 52 ohm VSWR 1.1 and high Z probe 50 k to 100k 2.5 uuf; freq. range of 50kc to 500 mc. Accuracy 5 percent to 200 mc 10 percent to 500 mc	Full wave crystal diode probes. Freq. response flat within ±1 db from 50 kc to 500 mc. Line voltage may vary ±10 per cent without impairing accuracy.
Curtiss-Wright Corp. 631 Central Avenue Carlstad, N.J.	NA 100 $1075	μμA and millivoltmeter	Voltage: three scale 10 mv to 1000 mv; Current: three scales 10^{-5} to 10^{-15} amp full scale with eight input resistors.	Vibrating capacitor modulating dc; synchronous detection. 1 mv drift per day. Accuracy ±2 per cent three recorder outputs. 4 in. meter. 10^{15} input resistance. Full scale current sensitivity of 10^{-15} amp.
Electro Instruments Inc. 3794 Rosecrans St. San Diego 10, Calif.	4500 over $2000	AC- DC high sensitivity	Voltage Range: 0.001-999.9; Impedance 11 meg. freq. range 30-10,000 cyc.	Fully automatic operation. Acc. 0.01 per cent dc; 0.1 per cent ac.
Federal Tel & Radio Co. 100 Kingsland Rd. Clifton, N.J.	FT-USVH $2700	Tunable voltmeter with extremely high sensitivity.	0.1 mv to 1 v; 20 kc to 30 mc	High selectivity obtained by crystal filter permits measurement of minute ac voltages at high frequencies.
	TFPM-76 2250	Carrier-Frequency Wave-Analyzer	25 mv to 8 v full scale (—90 to ±20 db) 2 kc to 1.35 mc	Wave analyzer with extremely high selectivity and low distortion up to 1.75 mc. Provision is made for automatically synchronizing the Analyzer to that of the driving the Analyzer to that of the driving Generator.
John Fluke Mfg. Co. 111 W Nickerson St. Seattle 99, Wash.	800 $335.	Differential Voltmeter	0-500 v DC, acc. .05 per cent of voltage; input resistance infinite at null.	Has 2 calibrated null ranges of 1-0-1 and 10-0-10 volts plus "search" range of 500-0-500 volts. Internal 500 v reference supply referenced against built in supply standard cell. Input infinite at null.
Franklin Elec. Inc. Bridgeport, Pennsylvania	400 $650.	Digital VTVM (3 Digit) Linear Sweep Type	DC volts ±0 to 1000 v; AC volts 0 to 1000 v RMS; (50 cps to 1 mc; 500 mc w/accessory probe) Acc. relative ±0.1 per cent of full scale; Absolute ±0.5 per cent of full scale	DC (or rectified ac) input is amplified or compared with periodic linear sawtooth voltage sweep. Decade counters receive gated pulse train starting with start of sweep and terminated when sweep equals amplified input. Resulting count is value of input.
General Radio Co. 275 Mass. Ave. Cambridge 39, Mass.	1231-B $250.	Laboratory Amplifier (10 cps-100 kc) and null detector	Sensitivity: less than 8 μv at 1 kc for 1 per cent indication on meter. Input impedance 1 megohm or 10 megohms. 20 μμf filters available.	High-gain general amplifier also arranged for use as a sensitive null detector.
Gertsch Products Inc. 11846 Mississippi Ave. Los Angeles 25, Calif.	VM-1 $405.	Peak Reading Pulse VTVM	Voltage range: 100 v full scale; freq. response: 50 cps to over 100mc acc. ±3 per cent of full scale.	Pair of diodes in probe so arranged that give a positive, negative, or peak to peak voltage as selected by switch on the probe.
Helipot Corp. Newport Beach, Calif.	026	Expanded scale ac and dc meters with D'Arsonval movement	±5 to 20 per cent of any specific value in the range of 5 to 500 v ac or dc.	Highly stable non-linear bridge in balance at one specific input voltage. Any deviation from this voltage results in bridge unbalance which is demodulated and applied to a standard meter movement. This provides truly linear indication over entire voltage range of meter.
Hewson Co. Inc. 443 Broad St. Newark 2, N.J.	63	microampmeter	0-0.01 μamp to 0.-1000 (6 current ranges). Acc. ±4 per cent on all ranges—most sensitive ±5 per cent.	Battery powered vacuum tube dc amp. driving high quality microamp. Circuit has been designed so maximum current is limited to value that will not damage meter.
Industrial Test Equip. 55 E. 11 St. N.Y. 3, N.Y.	200A $349.50	Phase sensitive. Measures in phase, or quadrature components.	Freq. 20 cps—20 kc; full scale may be calibrated to read anywhere from 6 mv to 120 v.	Input and reference signals are multiplied to give meter deflection. Phase shifter in one channel can shift signal 90 deg. Readings not affected by harmonics.
Instrument Electronic Corp. Pt. Washington, N.Y.	247 $297.	Logarithmic Meter	ac-full scale 1.5 mv to 500 v in 13 ranges; Acc. ±2 per cent; Freq. response 10 cps to 50 kc.	Amplifier-rectifier (full wave average) meter protected against burnout. Anti-vibration tube mount; special freq. response features.

Manufacturer	Model & Price	Type	Measurement Ranges	Circuit Design Features
Jennings Radio Mfg. Co. San Jose, Calif.	J-1003 $645.	HV Peak Reading AC VTVM with vacuum capacitor voltage divider input	DC Volt Ranges; 2.5-50,000 single ended; 2.5-100,000 double ended J CD5 series capacitor will double these ranges; Freq. Range 10 cps to 20 meg ±1 db; Input Impedance: 10^{12} ohms.	Separate HV input circuits for positive or negative voltages. Two stage DC amplifier has 300 meg input impedance. Has provision for measuring unbalance voltage of open wire transmission lines. May be rack mounted with remote indication.
Kay Electric Co. 14 Maple Avenue Pine Brook, N.J.	50 $495	Microlter	Volt. Range .001 to 1 v; imp. 5 µµf capacity; resistance 1 meg at 1 mc; acc. ±5 per cent full scale; freq. range 100 cps to 50 mc	Uses wide band video amplifier (max output 0.15 v at 75 ohms, gain over 45 db. Direct reading volts and db indications. Probe employs a subminiature tube as a cathode follower.
	1060 $495.	Transistorized	Volt. range .001 v to 1 v; imp. 5 µµf input cap. to ½ meg at 1 mc. acc. ±5 per cent full scale; freq. range 10 cps to 10 mc.	Freq. response ±1 db; all transistorized; either portable or line operation.
Keithley Instruments Co. Inc. 12415 Euclid Ave. Cleveland, Ohio	200B $335	Portable Battery Portable Battery-operated dc voltmeter Electrometer tube input 10^{14} ohms, 6 µµf	DC volts 0.008-20; acc. ±2 per cent; freq. range dc to 300 cps; accessories permit measurements to 20 ky; currents from 10^{-8} to 5 x 10^{-14}.	Balanced circuit; Entire amplifier driven at potential of input signal to stabilize operating point and gain and to provide low grid current at all times; output to drive recorder pre-amp.
	220 $400	Portable-line operated DC VTVM electro meter tube input, 10^{14} ohms, 6 µµf	DC volts 0.03-100; ±2 per cent; DC to 300 cps; accessories permit measurements to 20 kv; currents from 10^{-8} to 5 x 10^{-14} resistances from 10^4 to 10^{16} ohms.	same as above; Two single-ended outputs, 1 ma and ±5 v are provided.
Kintel (Kay Lab) Box 623 San Diego 12, Calif.	204A $325.	Electronic Galvanometer	DC ranges: ±10 uv to ±10 v FS; Current ranges: $\pm 10^{-9}$ amp to ±1 ma; sensitivity control functions as input attenuator.	All transistor chopper circuit consists of input divider; 4-stage ac amp. and a 3-stage dc amp. Unit not affected by shock; Has constant 10 k input. Power sensitivity is 10^{-16} w full scale.
Lab For Electronics Boston, Mass.	503 $800.	Digital Multitester Analog to digital type three digit display	DC ranges .01-1000 v; AC ranges .01-1000 v rms; resistance range—10 to 10 meg; Acc. 5 per cent	DC-AC voltages converted to analog time—i.e., to pulse width which is proportional to magnitude of voltage. Accurately timed pulses are counted during intervals and registered in decade scalers.
Leitch Engineering 326 Lincoln Street Manchester, N.H.	21-56 $149.50	Automatic Range Selecting on DC, AC or Ohms	DC ranges: ±0-1500 v at 12 meg. input imp.; AC ranges 0-1500 rms.; ohms center scale 100-10 Meg. Six ranges.	Meter bridge drives circuit which operates stepper to advance range. Rectifier & bridge circuit tubes 12AU7, 6X4, 12AT7, OA2.
Metronix Inc. Waterford, Conn.	572 $365	Differential Voltmeter	Voltmeter operation: 0-500 vdc; ±3 per cent fsd. Differential voltmeter 0-500 vdc; ±0.05 per cent actual voltage from 10 to 500 v; ±0.1 cent below 10 volts.	DC input is compared to precisely divided voltage which has been referenced against Weston cell. Input resistance is infinite at null condition. Five digit, in-line divider controls provide direct readout of voltage impressed at input.
Millivac Instrument Corp. P. O. Box 997 Schenectady, N.Y.	MV 45A $310.	Transistor AC Microvoltmeter	AC ranges: 0-104V to 0-1kv; Freq. Res. 10 cps to 150 kc; acc. ±2 per cent full scale; Input 10k at 10 µv; 3.3m at 1 kv.	All transistor amplifiers vitilizing the "hushed" transistor principle. Self contained battery operated.
	MV-51B $385.	Transistor DC Microvoltmeter	DC Ranges: 0-104 v to 0-10 V; Acc. 2 per cent except 104 v—3 per cent; input imp. 1 k at 10 mv; 10 m at 10 v.	All transistor direct coupling amplifier utilizing "hushed" transistor principle. Can be used as AC-DC amp. grain approx. 500, max output 3 v; freq. resp. 0-20 kc (3 db).
Non-Linear Systems Inc. Del Mar Airport Del Mar, Calif.	3511	AC/DC digital display, automatic polarity	Range: .001-999 v; Acc. ±(0.01 per cent +1 digit).	Chopper samples unknown input and internal feedback voltage. Pulses generated in error amp vary feed back voltage to attain electrical balance. Stepping switches in oil assure long life and positive action.
Pamece Inc. Mill Lane Waterford, Conn.	310 $89.50	Panel-Mounted DC voltmeter	Volt. range: 0-1000 VDC 7 ranges; single range version of standard units available with zero center scale.	Self-contained multirange electronic meter incl input attenuator, amp. metering circuit and power supply. Acc. 3 per cent; input resistance 10 meg.
	331 $99.50	Panel-Mounted AC volt-meter	Volt. Range: 0-10-300 v; single range version available.	Requires no more panel area than standard 6 in. panel meter, acc. 3 per cent imp. 1 meg 30 µµf. freq. response 20 cps to 100 kv.
Radio Corp. America Camden, N.J.	WV-84B	Ultra-Sensitive DC Microammeter	Ranges: 0-0.01 to 0-1000; DC ranges: 0-1v—0-100 v; megohmmeter 900-90000 megohms;	Portable, battery operated.
	LV 15 $445.00 (Rack mounted $460.)	Null Detector DC VTVM	DC ranges: 0-1—0-100 (0.1 per cent ±10 mv)	High grain chopper amp. highly stable power supply, precision attenuator, sensitive null indicator. Overload protection, internal standard cell calibration.
Rawson Electrical Instrument Co. Cambridge 42, Mass.	518P 15 $140	Peak Voltage Rectifier	AC volts 0-5000 using 5 kv electrostatic vtvm; lower ranges using other vtvm; practical min. 0-100 v.	High voltage rectifier tube charges low leakage capacitor to accurate peak values.
Rycom Raytown, Missouri	2170	Selective voltmeter	freq. ranges 1 kc to 200 kc and varying in level from —90 to ±32 dbm full scale deflection.	Three selectivities to achieve versatility using 100 cycle bandwidth crystal filter; instrument can be supplied as portable or rack mounted unit. Can be used for voltage measurements and waveform analysis.
Shasta Divison Beckman Instrument Corp. Richmond, Calif.	101 $360	Expanded scale AC voltmeter	AC Range 100 to 5000 v rms; 0.25 per cent accuracy at 50-2000 cps.	Thermal bridge circuit provides essentially true rms sensitivity. Expanded scale for easy readability.
Transvision, Inc. New Rochelle, N.Y.	TR-1 $36.95	Transistorized	DC volt range: 0-5000 v; AC volt range 0-5000 v; AF output volt. 25-40,000 cycles ±1 db.	Transistors replace vacuum tube circuit.
Trio Labs inc. 4025 Merrick Rd. Seaford, N.Y.	J $450.	Multi-range low-level DC Panel-Mounting	Zero center .01-300 v-dc; acc. 3 per cent full scale; input imp. 5 megohms;	Input fed through range selector switch and chopper to four-stage high-grain amp. Amp fed to phase-sensitive diode bridge. Ruggedized.
	D $272.	Multi-range AC panel mounting	Ranges: .01-300 v-ac; acc. 3 per cent full scale; input imp. 1 megohm.	Double-ganged attenuater chain separated by Cathode followers followed by high-gain amp and bridge-rectifier circuit. AC bridge output feedback. Ruggedized.

Reliability Achieved



Voltage and Temperature Derating

ONE electronic component is now so reliable that its quantitative reliability is virtually impossible to measure. In assessing the reliability of Sprague's newest "Hyrel Q" 125 C subminiature metalclad capacitors, Julian Sprague stated that 60 computers using 6000 of these capacitors each would have to operate for 6 months before one failure could be expected to occur. This is reliability, here and now! But, how was it achieved? What did it cost? How can it be applied to other components? What does it mean in overall system reliability?

Sprague was challenged 15 years ago to provide 20 year life for electrolytics for use on long-distance telephone lines. Then, 10 years ago they began working in earnest on a program to provide capacitor reliability based on one field failure in 50,000 units in service. To this end, over 6,250,000 component hours of test data have been assembled.

Reliability Built In

It became clear to Sprague that reliability had to be "built-in" beginning with quality and kind of raw materials used, fabricating methods, cleanliness of tools, equipment, and facilities. Where presently possible processing was automated to eliminate the human error possibilities. X-ray analysis was resorted to at many points of fabrication. Frequent points of inspection and rejection of defective units proved necessary to assure minimum rejects at the end of the production line. Virtually nothing was left to chance. Then, just to be sure, 50 capacitors in every lot are life tested before shipment! The test is carried out at 1.4 times rated voltage at 125 C for 250 hours, and there must not be more than 1 failure. Every failure is disected to see what caused it. If the reason for failure appears to be caused by operator error, all other capacitors in the test lot are individually examined to determine whether there is an incipient weakness. If so, the entire lot is rejected even though it statistically passes the test.

Design

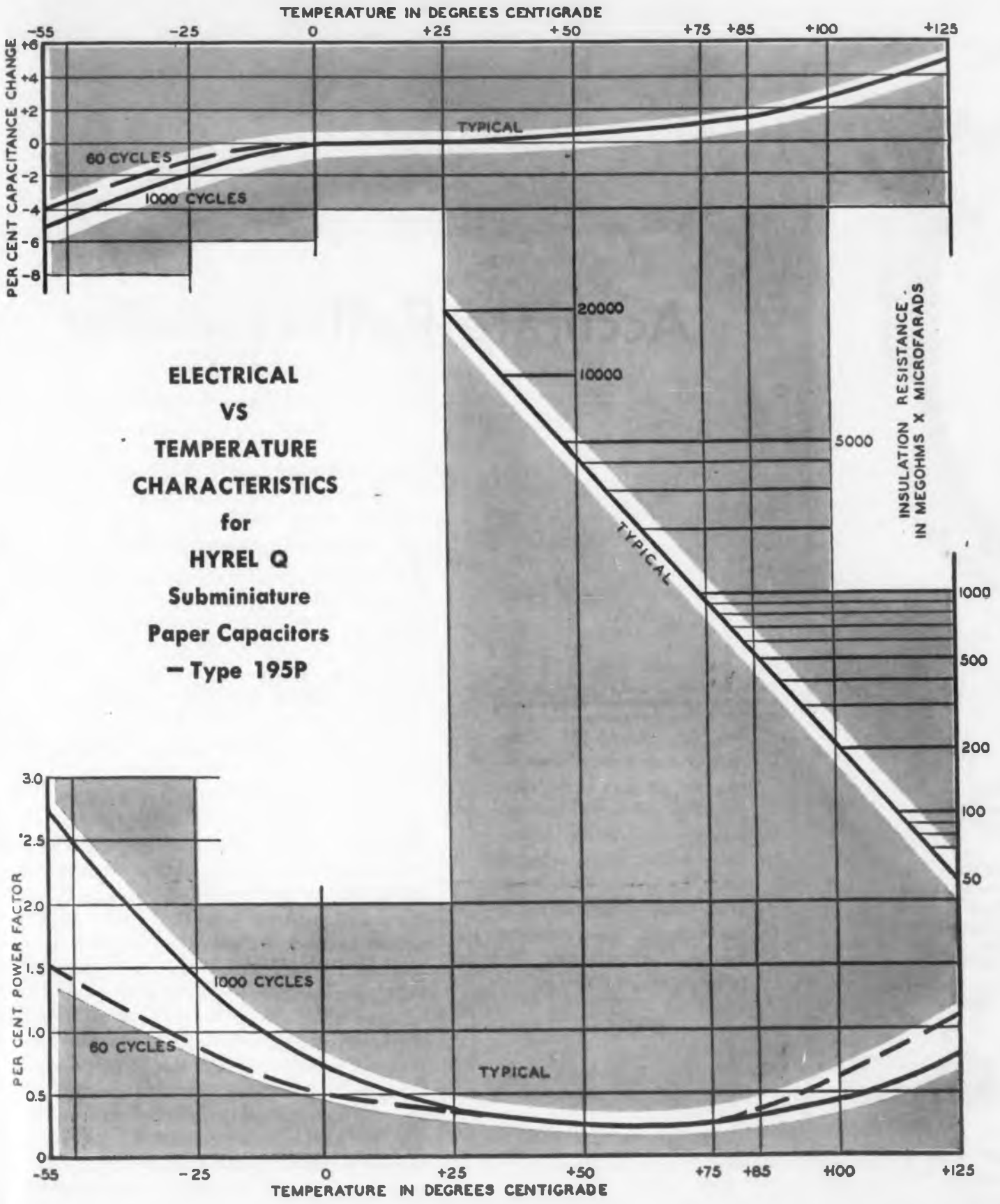
Changes in capacitor materials are of interest. It was found that a combination of film paper dielectric was superior for metal-clad paper capacitors; compression-glass terminals were found best; an improved eyelette was designed, and, margins were extended to 1/8 in. to avoid contact problems. Wire for leads must be free of pitting as determined under a microscope. Tinning must be thorough. To this end, the leads are tinned, cleaned, and tinned again, by Sprague.

Cost

Somewhat surprising is the low cost of these reliable capacitors. In quantity, they cost only 2-1/4 times as much as the standard subminiature capacitors in spite of the extra work put into their manu-

facture and the guarantee of reliability in the form of certified test data supplied with each lot to the customer. It is interesting to note that the price of these "Hyrel Q" capacitors is no higher than the cost of the now standard subminiature metal-clad paper capacitors when they were introduced to the electronics industry by Sprague some eight years ago. The extra cost of the high reliability capacitors is undoubtedly more than offset in savings to the user by eliminating incoming tests and inspection and in avoiding failures in equipment that take time to trouble shoot. Cost will probably be still lower as production volume is stepped up and development costs are absorbed.

One factor in keeping costs down has been standardizing on a relatively few case styles and values of capacitors, for the program. Special styles can be supplied but only at a substantially higher cost, and with considerable delay in delivery. Thus, the use of special units is to be discouraged.



Data Supplied

Typical of the application data supplied to users is the design nomograph on "Electrical vs Temperature characteristics" and the voltage derating curves for various altitudes.

Sprague has made available to the electronics industry its Specification PV-100, written in MIL specification form which gives the complete story on these capacitors including qualification, sampling, and production tests. Referencing of this specification by customers will avoid much unnecessary specification writing and other paper work.

Of particular interest in the specification is the derating and uprating information given for operation under different conditions of voltage and temperature as shown. The chart shows life expectancy from 10 C above the rated 125 C temperature to 40 C below and is based on extensive life test data which shows the failure anticipation rate may be considered consistent over any given period of time whether at the start of the test or at the end.

Sprague claims that its "Hyrel Q" capacitors presently are meeting a failure expectancy of approximately .05 per cent. This means one failure in 2000 capacitors at any point on the chart. If reference is made to Curve BB for rated temperature, at rated voltage the life expectancy is 2000 hours. This may also be expressed by stating that one failure may be expected for each 2000 capacitors at rated voltage and rated temperature for each 2000 hours of operation.

A failure expectancy of .01 per cent may also be expressed as the failure of only one capacitor in 10000 units per 1000 hours of operation or one failure in 2000 units for 5000 hours of operation. To determine the proper derating for this failure expectancy, refer to the point on the chart where BB crosses the 5000 hour line and note that it would be necessary to derate the voltage of the capacitor by about 17 per cent to use it at the rated temperature. To operate these capacitors at full rated voltage for 5000 hours, refer to the point at which the lines indicating 5000 hours expectance and 100 per cent of rated voltage intersect. This point of intersection falls on line DD. The explanatory portion of the chart indicates that line DD is for a 20 C decrease in rated temperature; therefore, it would be possible to obtain a .01 per cent failure expectancy at full rated voltage by derating to a temperature of 105 C.

Implications For Other Components and Systems

Especially significant in Sprague's approach on capacitor reliability is its obvious application to other components. When all components in a system have been made "reliable," the electronic system will have the kind of reliability now enjoyed by mechanical systems or possibly better.

Compact, rugged, this reflectometer will provide laboratory accuracy for routine field testing.

Accurate Reflectometer

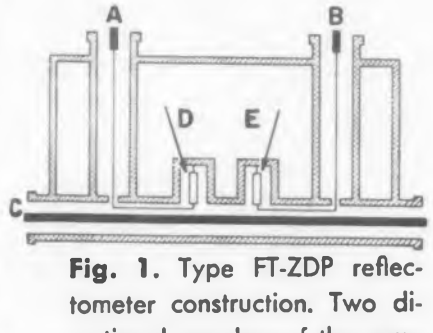


Fig. 1. Type FT-ZDP reflectometer construction. Two directional couplers of the same sensitivity deliver test voltages proportional *A.* to the incident wave, and *B.* to the reflected wave. The coaxial cable is fed at *C.* Resistive terminations to the magnetic loops, matching the loop characteristic impedance, are at *D* and *E.*

DESIGNED to provide laboratory accuracy in measuring load-line mismatch, these reflectometers are constructed so compactly and ruggedly that they can be used for production testing. The two instruments cover the range from 10 to 2400 mc with an inherent error of 0.3 per cent. Using directional couplers, the reflectometer delivers both incident and reflected waves to a sensitive receiver with no loss in linearity.

Distributed by the Industrial Products Div. of Federal Telephone and Radio Co., 100 Kingsland Rd., Clifton, N.J., the Type FT-ZUP and FT-ZDP reflectometers cover an unusually wide frequency range with a reflection coefficient accuracy of $\pm(0.005 + 0.01)$. The FT-ZUP is designed to cover a band extending from 10 to 600 mc; the FT-ZDP from 300 to 2400 mc. Since for rapid, precise determination of the reflection coefficient or of the mismatch between a load and a transmission line directional couplers are preferable, the reflectometers use no crystals or other components that may contribute to the nonlinearity of the incident or reflected signals. Refer to Fig. 1. The measuring coaxial line and two directional couplers of identical sensitivity are contained in one unit. The signals are passed directly

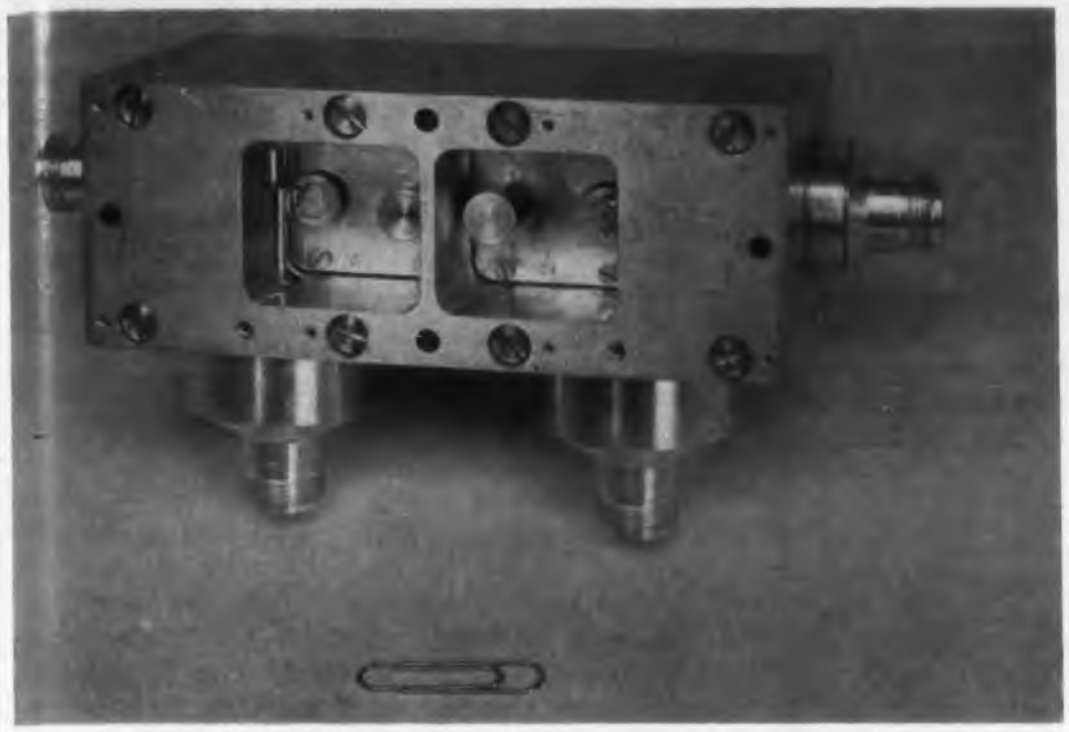


Fig. 2. Partially disassembled view of the FT--ZDP. Visible in the two recessed compartments are the resistor caps of the loop terminations. At the outer sides of the compartments are the output leads from the directional coupler assembly.

to a sensitive receiver via two separate outputs (Fig. 2), and the reflection coefficient determined from the ratio of the two voltages. In the low frequency unit a selector switch is used to apply successively the incident wave, the reflected wave and the resultant voltage of the combined waves to the test receiver. From the ratio of the reflected wave to the incident wave the reflection coefficient is obtained.

Impedance can be determined with the Type FT-ZUP. The ratio of the combined waves to the incident wave yields the sum voltage of the reflected and incident waves referred to the incident wave. With the reflection coefficient and the latter ratio plotted as radii on a Smith diagram, the circle intersections give two complex conjugate impedance values. The value that represents the true impedance can be determined by receiver detuning.

Both reflectometers consist of a die cast box housing the couplers and coaxial line; the FT-ZUP measures 8-5/8 x 15/16 x 4-5/16 in. and weighs 3.5 lb, while the FT-ZDP measures 7-1/4 x 3-3/8 x 3-3/8 in. and weighs 4.5 lb. Both units have a characteristic impedance of 50 ohms. The FT-ZUP has a reflection coefficient range of 0.005 to 1; the FT-ZDP 0.02 to 1. Type N connectors are used with the units.

For further information, turn to the Reader's Service Card and circle 42.

Time Delay Network Design

Louis Weinberg
Hughes Research Laboratories

A practical need often arises for a lumped-constant time-delay network. Modern synthesis satisfies this need quite well. A constant-resistance all-pass network with maximally flat delay permits the design engineer to obtain 1. tap-off points at prescribed fractions of the total delay or, what is equivalent, the possibility of adding delay networks in tandem without using an intermediate isolating amplifier; 2. a magnitude characteristic that is uniform throughout the linear range of the phase function.

The networks with a maximum flat time delay are an elegant solution to the problem[1]. Because of problems involved in working with Bessel and Lommel polynomials and in solving for the roots of high-degree polynomials, these networks are often neglected by the practical engineer. This article, by presenting tables of element values, makes the networks available with little or no computation. The tables are directed primarily to those engineers without synthesis background; they should, moreover, be valuable to the synthesis expert since they allow him to devote his available computing time and facilities to the difficult network problems for which tables do not suffice.

This article is a condensed version of a part of the author's report, *Constant-Resistance All-Pass Networks With Maximally Flat Time Delay,* Technical Memorandum No. 473, Hughes Research Laboratories, Culver City, California. For a complete derivation of the formulas used in this article the reader is referred to the Appendix of TM No. 473.

NORMALIZED element values of the series arms of a lattice network that yields a maximally flat time delay are computed and given in Tables 1-4; the element values of the cross arms are obtained by duality. The lattice may be driven by current source with a shunt conductance or a voltage source with a series resistance; that is, by use of the tables we may realize a transfer impedance $Z_{21} = E_2/I_1$, a transfer admittance $Y_{21} = I_2/E_1$, or a transfer voltage ratio $K = E_2/E_1$.

The lattice that is obtained is a constant-resistance all-pass network. By constant-resistance is meant that the input impedance is constant for all frequencies. This has two desirable features. The first is that a generator with a finite and nonzero internal resistance may be used as the source without changing the desired transfer function except for its constant multiplier. Secondly, lattices with the same value of constant-resistance input can be cascaded without interaction effects. Thus, as in a true transmission line, taps may be made at desired values of time delay. The all-pass designation means that the lattices do not affect the magnitude versus frequency characteristic of the input signal. In short, for signals whose frequency spectrum does not extend beyond the linear range of the phase function of the network, the output time function is of the same shape as the input time function, but delayed by the value of the time delay of the network.

Use of the Tables

A constant-resistance lattice with a one-ohm termination is shown in Fig. 1. The two driving-point impedances labeled Z_a are called series arms and the two labeled Z_b are called cross arms. Because of the constant-resistance property $Z_a Z_b = 1$.

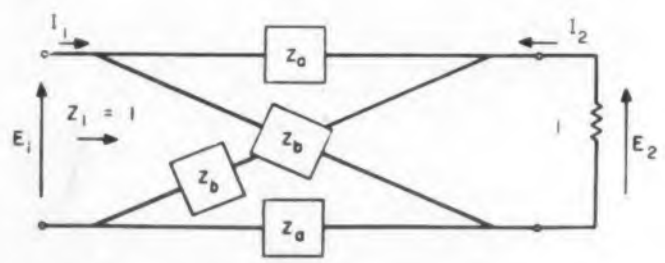


Fig. 1. Circuit diagrams of constant-resistance lattice terminated in one ohm.

Each of Tables 1-4 gives the element values for a different form of realization of the normalized impedances Z_a. The integer n represents the number of poles in Z_{21}: it is the degree of the denominator polynomial. In addition, n is equal to the number of elements in the reactance function Z_a. The general form of network identifying the elements is given along with each table. Note that for convenience (to accommodate even and odd values of n with only one scheme of notation for each table) the subscripts identifying the elements in the figures for Tables 1-3 run from 1 to n or from 2 to $n+1$. As indicated on the tables the values are in henrys and farads; this is also true of all the figures where, in addition, the termination is in ohms.

Any one of the realizations for Z_a given in Tables 1-4 may be chosen. A particular choice may be most satisfactory for meeting the practical requirements of one problem whereas another may best meet a second set of requirements.

For Table 4 it is not necessary to tabulate the element values since for all values of n they are given by a known continued-fraction expansion about the origin. Thus the simple formula for computing the element values is given in Table 4.

The element values for Z_b are found simply by taking the dual of Z_a. Note that in deriving Z_b *any* table for Z_a may be used. In other words, if Table 1 is used for Z_a any one of the Tables 1, 2, 3 or 4 may be used to determine Z_b.

To obtain the dual or reciprocal Z_a, an inductance of L henrys becomes a capacitance of L farads, and conversely a capacitance of C farads becomes an inductance of C henrys. Series connections become parallel connections, and conversely. Thus the reciprocals of Z_a given by Tables 1 and 3 for $n = 4$ are given respectively by Fig. 2 (a) and 2(b).

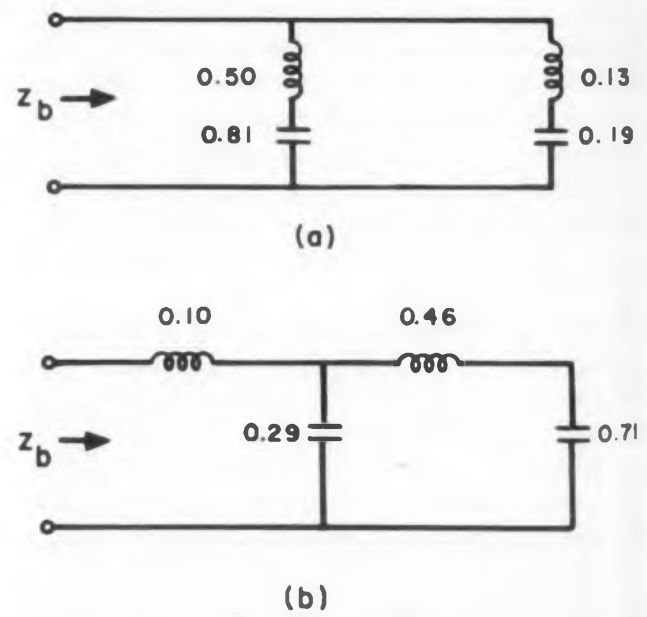


Fig. 2. Networks for Z_b obtained by reciprocation.

The element values obtained for Z_a and Z_b in this manner are normalized with respect to the load resistance R and the time delay T_o, that is, they apply for $R = 1$ and for $\omega T_o = 1$. In this way, the frequency is normalized with respect to $\omega_o \equiv 1/T_o$. To convert the lattice with a one-ohm termination to a lattice with a termination of R ohms (and thus an input impedance of R ohms) we multiply every inductance value by R and divide every capacitance by R, that is, we raise the impedance level of the network by R. To remove the normalization with respect to time delay we consider the desired zero-frequency time delay equal to $2T_o$; then T_o is equal to one half of the desired delay. Every capacitance and inductance is now divided by the radian frequency $\omega_o = 1/T_o$. The removal of the two normalizations can be combined into a single step: multiply every inductance by $R/\omega_o = RT_o$ and every capacitance $1/(R\omega_o) = T_o/R$.

In Table 5 are listed the values of frequency u for which the time delay deviates a specified percentage from its zero-frequency value. The variable u is defined as $\omega T_o = \omega/\omega_o$ and is a normalized radian frequency.

In a typical problem the frequency band over which a specified time delay is desired will be given, and the permissible deviation of the time delay from its zero-frequency value will also be specified. Finally, the input resistance of the lattice or, what is equivalent, the value of the termination R is generally part of the specified data. The steps in using the tables to meet these specifications are:

- Compute T_o as one half the specified time delay; set the desired time delay equal to $2T_o$.
- Assuming zero to ω_1 is the frequency range over which the specified time delay is required, compute $u_1 = \omega_1 T_o$.
- With b representing the allowable percentage deviation of the time delay choose the smallest value of the tabulated deviations—1, 10, 20 and 50 per cent—that is not less than b. Now in the column of Table 5 that corresponds to this choice find the smallest value of $u \geq u_1$. Note the corresponding value of n.
- Use the n determined above and any one of the Tables 1-4 to find the element values of Z_a. Using the configuration given with the selected table draw the network for Z_a.
- Determine Z_b geometrically as the reciprocal of the Z_a given by any one of Tables 1-4.
- Now remove the resistance and time-delay normalizations by multiplying every inductance in Z_a and Z_b by RT_o and every capacitance by T_o/R.

An ideal current source has been assumed, but because of the constant-resistance property of the lattice, this assumption causes no loss in generality; when the source has an internal resistance, the same Z_{21} is realized except for a change in its constant multiplier. If the lattice is matched for maxi-

Table 1. Element values (in henrys, farads) for the normalized impedance Z_a (obtained by a partial-fraction expansion of Z_a).

Value of n	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	L_9	C_{10}	L_{11}
1	1.0000										
2	—	0.3333	1.0000								
3	0.1667	0.4800	0.8333								
4	—	0.4988	0.8120	0.1251	0.1880						
5	0.0667	0.5000	0.8106	0.3192	0.1227						
6	—	0.5000	0.8106	0.4439	0.0988	0.0597	0.0907				
7	0.0357	0.5000	0.8106	0.4889	0.0918	0.1839	0.0620				
8	—	0.5000	0.8106	0.4985	0.0903	0.3201	0.0453	0.0346	0.0538		
9	0.0222	0.5000	0.8106	0.4999	0.0901	0.4239	0.0371	0.1137	0.0400		
10	—	0.5000	0.8106	0.5000	0.0901	0.4769	0.0338	0.2154	0.0300	0.0226	0.0356
11	0.0152	0.5000	0.8106	0.5000	0.0901	0.4949	0.0327	0.3221	0.0234	0.0767	0.0281

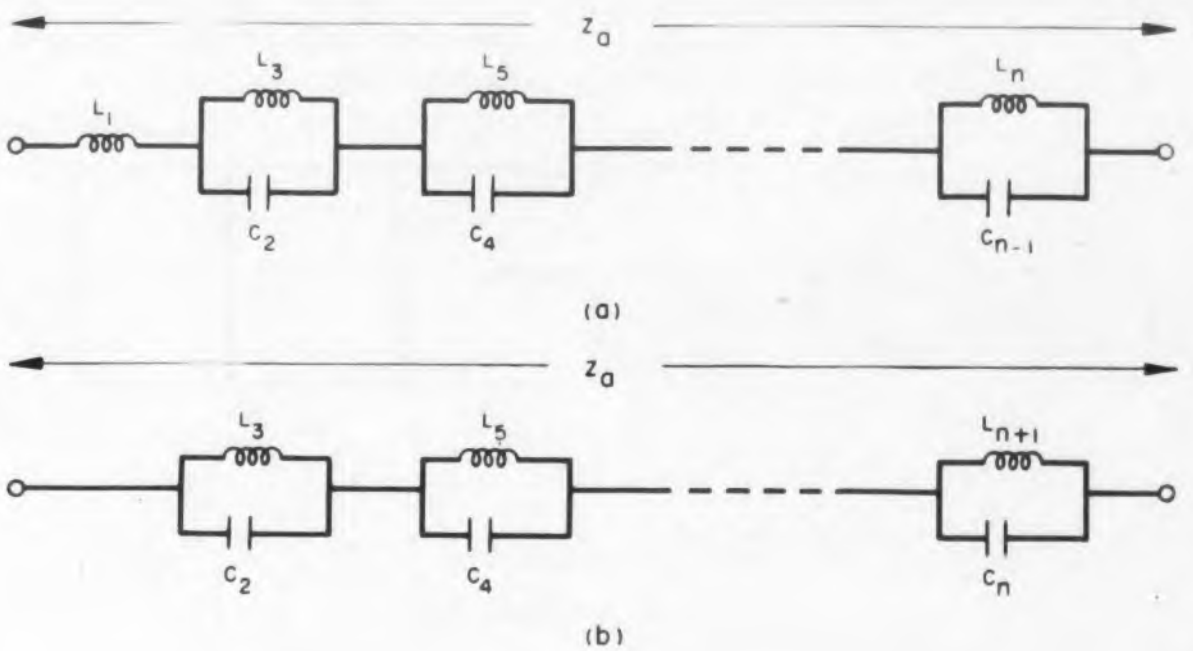


Table 2. Element values (in henrys, farads) for the normalized impedance Z_a (obtained by a partial-fraction expansion of $1/Z_a$).

Value of n	C_1	L_2	C_3	L_4	C_5	L_6	C_7	L_8	C_9	L_{10}	C_{11}	L_{12}
1	—	1.0000										
2	0.3333	1.0000										
3	—	1.0000	0.3333	0.2000								
4	0.1000	1.0000	0.2333	0.4082								
5	—	1.0000	0.2078	0.4841	0.1255	0.0838						
6	0.4762	1.0000	0.2032	0.4983	0.0825	0.2418						
7	—	1.0000	0.2027	0.4999	0.0620	0.3843	0.0687	0.0446				
8	0.2778	1.0000	0.2026	0.5000	0.0538	0.4644	0.0491	0.1429				
9	—	1.0000	0.2026	0.5000	0.0513	0.4925	0.0361	0.2624	0.0433	0.0277		
10	0.1818	1.0000	0.2026	0.5000	0.0508	0.4989	0.0284	0.3736	0.0333	0.0925		
11	—	1.0000	0.2026	0.5000	0.0507	0.4999	0.0247	0.4492	0.0256	0.1786	0.0298	0.0188

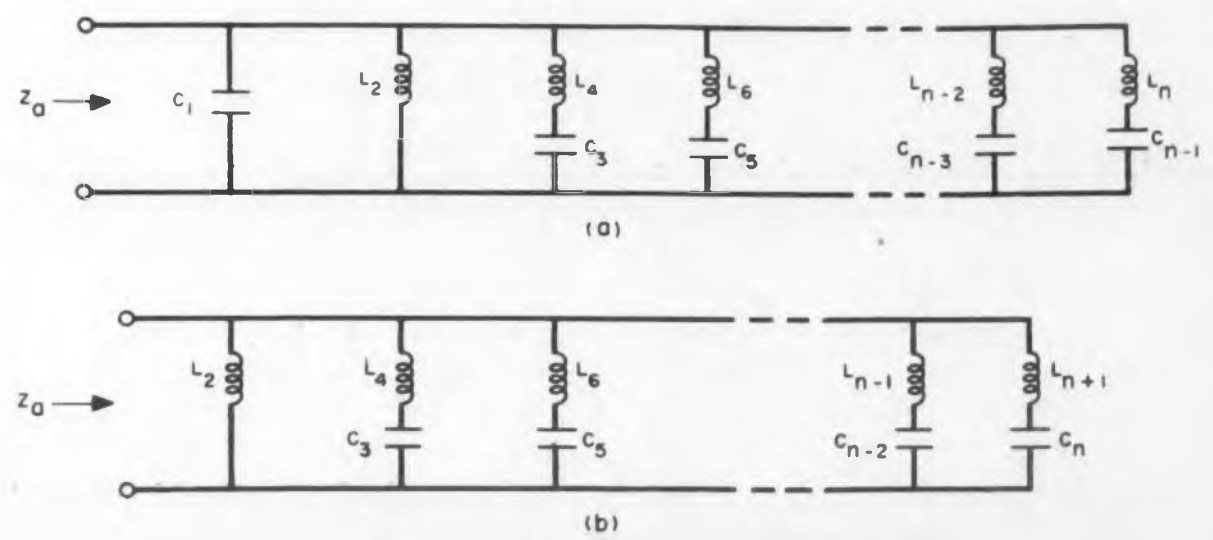
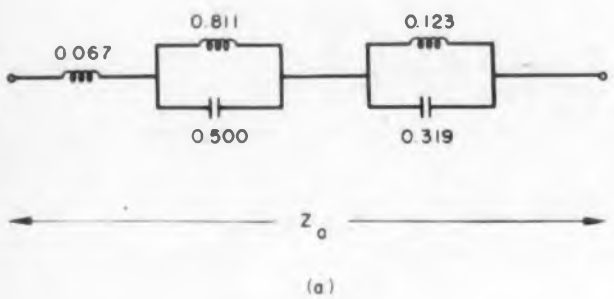
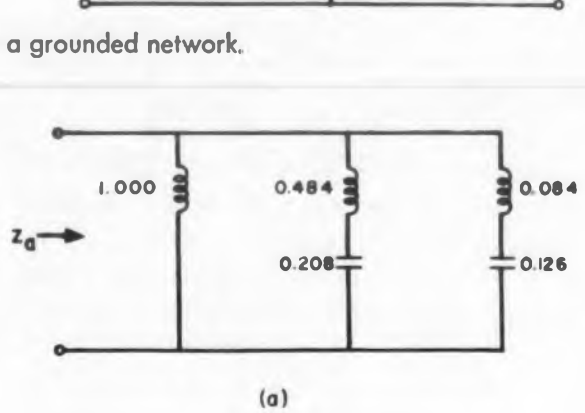
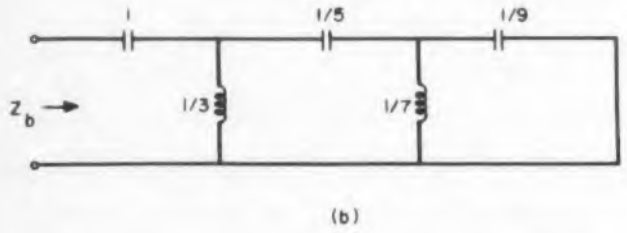


Fig. 3. Reduction of the lattice to a grounded network.







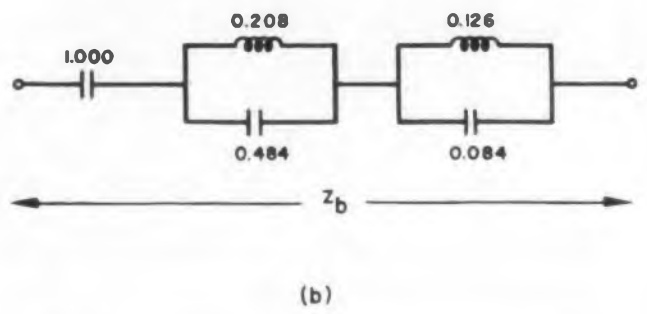


Fig. 4. Normalized impedances of first lattice.

Fig. 5. Normalized impedances of second lattice.

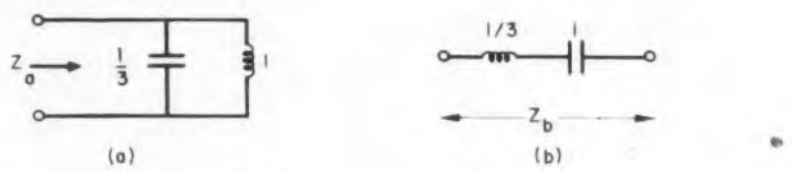


Fig. 6. Normalized impedance arms of lattices.

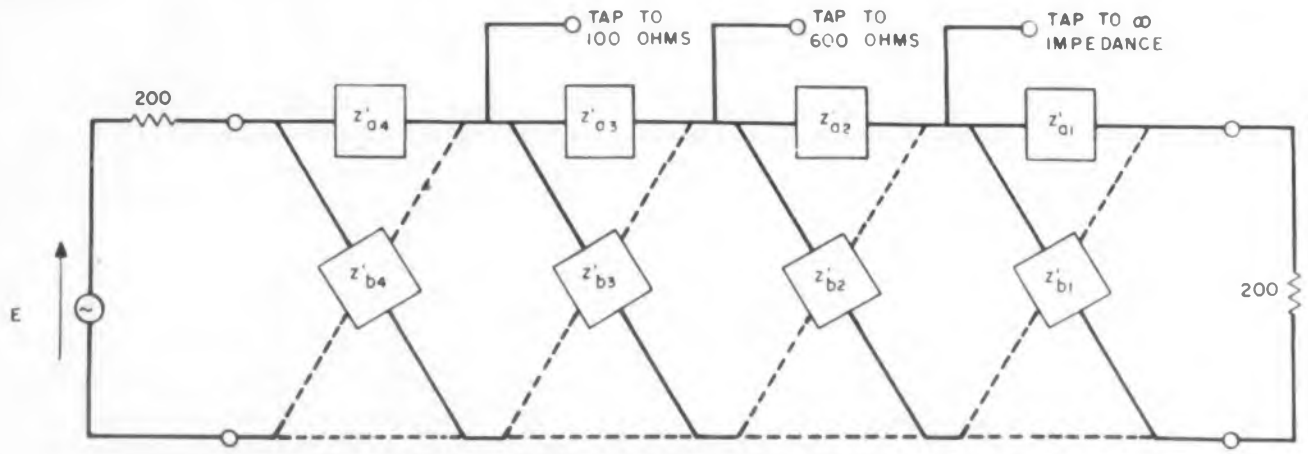


Fig. 7. Network realization for the data of ex (2).

mum power transfer to a current source I with a shunt resistance R, then I_1 is equal to $1/2$ by a current-divider relationship, so that the over-all transfer impedance is $Z'_{21} = E_2/I = E_2/2I_1 = Z_{21}/2$. Also by a Thevenin transformation of the input current source and its associated shunt resistance it becomes clear that a voltage source with a series resistance may also provide the input. In this way a transfer voltage ratio or transfer admittance is realized by the same lattice.

It is most often necessary that the total delay be realized by a cascade of lattices because tap-off points at fractions of the total delay are required. Then only the last lattice in the cascade chain is terminated in a resistance; the termination of each of the preceding lattices is automatically provided by the input impedance of the lattice at its output terminals in parallel with the input impedance of the tap-off network. The modification in the procedure for such problems is straightforward and is made clear by the illustrative examples.

Two final points are the introduction of dissipation into Z_a and Z_b and the reduction of the achieved lattice into a grounded bridged-T network. It is possible to take account of the losses in the coils without changing the frequency characteristic by introducing a flat loss[2]. If a grounded network is desired, the lattice transformation of Fig. 3 may be used[3]. Then if Z_a has a shunt inductance branch and Z_b a series inductance the ideal transformer may be converted to a real transformer by incorporation of these inductances.

Illustrative Examples

1. An all-pass constant-resistance lattice is desired with a time delay of one msec over a frequency range of 0 to 1000 cycles. The time delay is not to deviate more than 10 per cent over this frequency range. The lattice is to provide maximum power transfer to its load. A cathode follower, which approximates quite closely a voltage source with an internal resistance of 200 ohms, is the input.

From the given data, $2T_0 = 10^{-3}$, $T_0 = 0.5 \times 10^{-3}$ and $\omega_1 = 2\pi \times f_1 = 6.28 \times 10^3$. Thus $u_1 = \omega_1 T_0 = 3.14$.

Consulting Table 5 for 10 per cent deviation we find $u_1 = 3.14$ lies between $n = 4$ and $n = 5$. We therefore need $n = 5$.

Since any one of Tables 1-4 may be used for Z_a and Z_b independently there are 16 possible networks provided by the tables. We show two of these networks. The first obtains Z_a from Table 1 and Z_b as the reciprocal of the Z_a of Table 4; these impedances are shown in Fig. 4. The second has Z_a and Z_b given by Table 2; these are given in Fig. 5.

The normalizations are now removed by multiplying every inductance by $RT_0 = 200 \times 0.5 \times 10^{-3} = 0.1$ and every capacitance by $T_0/R = 2.5 \times 10^{-6}$. The final impedances Z'_a and Z'_b are the arms of a lattice terminated in 200 ohms.

2. Assume some of the same data as in example *1*, namely, $f_1 = 1000$ cps; total delay is 1 msec; maximum deviation in total delay = 10 per cent; the input is an E-source with an internal resistance of 200 ohms; the load resistance is 200 ohms. Maximum power transfer is not, however, required.

In addition, it is required that a tap be made at every 1/4 msec delay. The 3/4 msec tap introduces no loading; the 1/2 msec tap is fed to a network with a 600 ohm input resistance; the 1/4 msec tap feeds a network with a 100 ohm input resistance.

Because of the three tap-off points four lattices are required. These lattices will be identified by numbers *1*, *2*, *3* and *4*, beginning at the output.

The input resistance of the lattice *1* is equal to the output resistance. The design resistance for lattice *2* is then 200 ohms. However the load on lattice *3* is comprised of the input resistance of the network connected to the tap at 1/2 msec in parallel with 200 ohms; similarly, the load on lattice *1* consists of R_3, the input resistance of lattice *3*, in parallel with the 100 ohms of the tap-off network. Therefore

$$R_1 = 200, \quad R_2 = 200$$

$$R_3 = \frac{600 \times 200}{800} = 150, \quad R_4 = \frac{150 \times 100}{250} = 60.$$

Since for each lattice $2T_0 = 0.25 \times 10^{-3}$, T_0 is 0.125×10^{-3} msec. Also $u_1 = \omega_1 T_0 = 0.785$. Consulting Table 5 for 10 per cent deviation we find that 2 is the smallest acceptable value of n. (For this small value of n the networks given by continued-fraction or partial-fraction expansions are the same; that is, all the tables yield the same Z_a.) Using Table 3 for Z_a and Z_b, we get the normalized impedances of Fig. 6. To remove the normalizations we multiply the inductances of the respective lattices by $R_1T_0 = R_2T_0 = 2.5 \times 10^{-2}$; $R_3T_0 = 1.875 \times 10^{-2}$; $R_4T_0 = 7.5 \times 10^{-3}$ and the capacitances by $T_0/R_1 = T_0/R_2 = 6.25 \times 10^{-7}$ $T_0/R_3 = 8.33 \times 10^{-7}$; $T_0/R_4 = 2.08 \times 10^{-6}$. The complete network is shown in Fig. 7.

Acknowledgement: The author expresses his thanks to the members of the Mathematics Section, Systems Analysis Department, Hughes Aircraft Company, who carried through almost all of the calculations for this paper.

References

1. The excellent papers by W. E. Thomson provide the complete theory of these networks: Delay Networks Having Maximally Flat Frequency Characteristics, *Proc. I.E.E.*, Part 3, Vol. 96, pp. 487-490, November 1949; and Networks With Maximally-Flat Delay, *Wireless Engineer*, October 1952, pp. 256-263.
2. Delay Equalization of Eight-Kilocycle Carrier Program Circuits, C. H. Dagnall and P. W. Rounds, *Bell System Tech. Journal*, Vol. XXVIII No. 2, April 1949, pp. 181-195.
3. Note on Bartlett's Bisection Theorem for 4-Terminal Electrical Networks, O. Brune, *Phil. Mag.*, Vol 14 No. 93, November 1952, pp. 806-811.

Value of n	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	L_9	C_{10}	L_{11}
1	1.0000										
2	—	0.3333	1.0000								
3	0.1667	0.4800	0.8333								
4	—	0.1000	0.2899	0.4627	0.7101						
5	0.0667	0.1948	0.3103	0.4215	0.6231						
6	—	0.0476	0.1400	0.2246	0.3005	0.3821	0.5595				
7	0.0357	0.1055	0.1704	0.2288	0.2827	0.3487	0.5111				
8	—	0.0278	0.0823	0.1338	0.1806	0.2227	0.2639	0.3212	0.4732		
9	0.0222	0.0660	0.1077	0.1463	0.1811	0.2129	0.2465	0.2986	0.4424		
10	—	0.0182	0.0541	0.0886	0.1209	0.1549	0.1880	0.2057	0.2209	0.2712	0.4161
11	0.0152	0.0451	0.0741	0.1016	0.1269	0.1499	0.1708	0.1916	0.2175	0.2639	0.3955

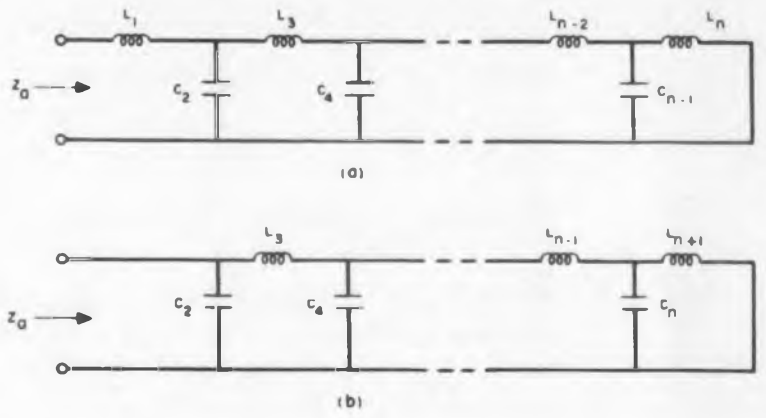


Table 3. Element values (in henrys, farads) for the normalized impedance Z_a (obtained by a continued-fraction expansion about infinity).

Value of n	L_1	C_2	L_3	C_4	L_5	C_6	L_7	C_8	L_9	C_{10}	L_{11}
1	1.0000										
2	1.0000	0.3333									
3	1.0000	0.3333	0.2000								

The above values are given only as illustrative examples. It is not necessary to tabulate all the values because the continued-fraction expansion about the origin has a simple formula for the L's and C's valid for all values of n.

The formula is

$$A_m = \frac{1}{2m-1} \qquad m = 1, 2, 3, \ldots, n-1, n$$

where A_m is L_m for m odd, and A_m is C_m for m even.

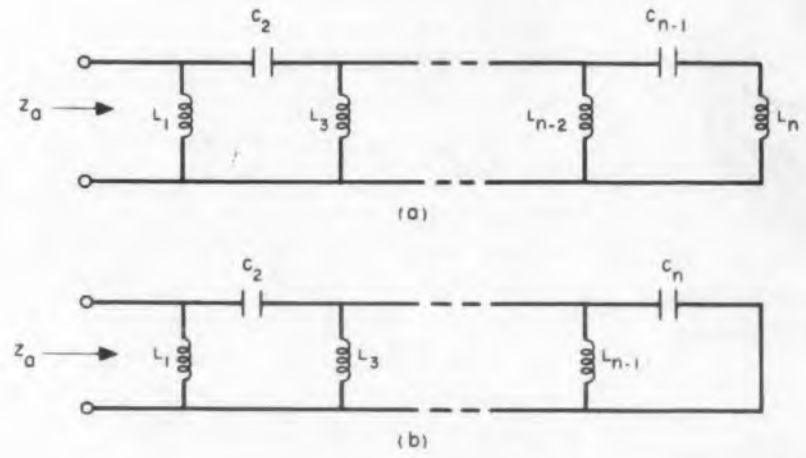


Table 4. Element values (in henrys, farads) for the normalized impedance Z_a (obtained by a continued-fraction expansion about the origin).

Table 5. Significant values of *u* for time delay of a maximally flat time-delay network (giving frequencies (u) at which time delay deviates a specified value from its zero-frequency value).

n	u for 1% deviation	u for 10% deviation	u for 20% deviation	u for 50% deviation
1	0.10	0.34	0.50	1.00
2	0.56	1.09	1.39	2.20
3	1.21	1.94	2.29	3.40
4	1.93	2.84	3.31	4.60
5	2.71	3.76	4.20	5.78
6	3.52	4.69	5.95	6.97
7	4.36	5.64	6.30	8.15
8	5.22	6.59	7.30	9.33
9	6.08	7.55	8.31	10.50
10	6.96	8.52	9.33	11.67
11	7.85	9.49	10.34	12.84

Maintainable Computer

RELIABILITY, simplicity and adaptability were designed into this transistorized industrial computer. The result is a unit that provides completely automatic control for process plants with a 500-hour mean time between failures. When a failure does occur the circuit malfunction can be detected and repaired within minutes.

As a preliminary approach, Ramo-Wooldridge Corp., 5500 W. El Segundo Blvd., Los Angeles adopted modular design techniques for the RW-300 computer. Each switching circuit is mounted on a printed wiring board called an *insert;* all switching circuits necessary to perform a particular function are installed in a single printed *module;* the modules are plugged into *subframes;* and the subframes are interconnected with cables. It is plain that the addition or subtraction of input-output—analog-digital—units is a simple procedure, and contributes to the ease with which the computer may be adapted to meet special conditions.

Four engineering goals were kept in mind during the design of the computer: reliability, maintainability, rapid serviceability, adaptability. The techniques used are not new, but the fact that they were applied, in the best reliability tradition, from the inception of the unit design and carried through to the finished product merits attention.

Reliability. Experience in the design of reliable equipment for military applications was applied. Each component—resistors, transformers, capacitors, wire and printed circuit base laminates—had to meet special qualification tests. The quality of components is exceptionally high for a commercial equipment, but the reliability required in industrial process control justifies these standards.

Circuits were designed to operate with maximum tolerance to component variation. Improved bond strength between the copper and resin in the printed circuits is provided by a flush circuit technique. The copper is embedded in the epoxy resin. Component replacement is easier as a result, and boards can be handled or stacked without damaging the circuitry. The printed circuits used in the module have dip soldered connections.

Maintainability. The modular design described above represents the kind of thinking that went into the mechanical construction of the computer. Quick release panels permit rapid exposure of any portion of the electronic assembly. Handles for the panels are accessible and located out of sight beneath the main computer frame.

Any subframe can be reached and removed as an independent unit. The analog-digital unit can be reached by removing the side panel. The computer subframe is accessible by removing the back, and the magnetic drum is removable by the use of slides after the front panel is removed. Each module in a subframe can be removed and serviced independently, to minimize computer "down time."

Serviceability. The RW-300 includes a test and maintenance unit. This unit provides manual control of the speed at which the program runs, for program checkout and computer test and maintenance. The entire system can be checked at this reduced speed, during initial computer checkout and periodic preventive maintenance.

The test unit also includes a built-in oscilloscope which can be switched to any of the circulating arithmetic and control registers or other points, and a bank of neon lights which can be connected by switch to various groups of flip flops to determine their static condition. There are marginal checking controls and program breakpoint switches in addition.

Trouble-shooting is accordingly simplified. The test unit, in conjunction with the modular design, keeps repair time to a minimum.

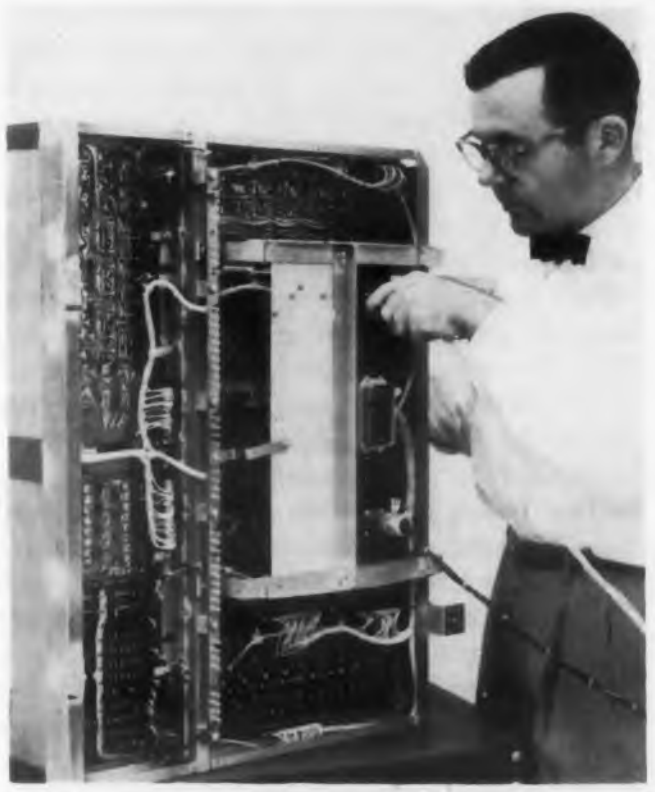
Adaptability. The computer can be tailored to fit specific applications with few equipment changes. Input-output units can be added easily. With only instruction program and external connection changes the computer functions can be altered to modify and improve its control actions.

For further information on this computer, turn to Reader's Service Card and circle 66.

1. Computer inserts consist of active circuits mounted on printed circuit boards. These inserts, also constructed with printed circuit techniques, are attached to the modules, which are fitted with plastic racks and handles for easy handling.

2. Modules are plugged into subframes like this analog-digital unit. It is here that analog inputs are converted to digital information for use by the computer assembly, and digital outputs of the computer into quantities for process control. Construction is simple; the frames are of a size suitable for handling.

3. Analog-digital subframe with modules inserted. Individual modules can be serviced independently or replaced by spare modules during servicing to minimize computer "down time." Any subframe in the RW-300 can be exposed by removing a quick release panel and can be removed as an independent unit.



4. Rear view of the input-output subframe shown in (3). The modular design eliminates extensive hand wiring, printed circuits being used as extensively as practicable. Subframes in the computer are interconnected by cables as in the photograph. Simply unplugging the cables and freeing the unit is all that is required for removal.

High Frequency Ferrite Phase Modulator

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Syracuse, N. Y.

MAXIMUM benefit from the use of phase or frequency modulation as a communications technique comes about when several hundred degrees of phase shift are obtained. Under this condition, noise disturbances have a negligible effect on the demodulated signal. Presently available techniques usually require many stages of frequency doubling or tripling in order to obtain the required phase deviation at the transmitted frequency. For example, one common method is an active element (vacuum tube or transistor) with the proper type of feedback so that input impedance appears inductive or capacities. This reactance can then be modulated through the control of one of the bias voltages. Though the amount of necessary modulation power in this procedure is small, the change in phase is limited to ± 90 deg. Additional stages of frequency multiplication are then necessary.

The phase modulation system here described would permit modulation directly at or near the final carrier frequency. One method is to use a distributed constant delay line, Fig. 1, which is physically small but electrically many wavelengths long at the desired high-frequency carrier signal. In addition, if the delay line were constructed with high permeability ferrite materials it would be possible to modulate the permeability ferrite by controlling an applied magnetic field. Since the time delay per unit length of a distributed constant delay line is given by

$$T_d = \sqrt{LC}$$

where L is the distributed inductance and C the distributed capacitance, the high permeability of the ferrite is its extremely low loss for high frequency operation.

Ferrite Delay Line

The basic problem revolves about the ability to obtain sufficient time delay at high frequencies (e.g. to 10 mc to 30 mc). In order to accomplish this it is necessary to increase the inductance per unit length as can be seen from equation (1). Though this can also be effected by increasing the value of C, this procedure would yield a very low value for the characteristic impedance. Figure (1) illustrates one possible delay line configuration. A uniformly wound solenoid is placed on a ferrite rod which has several silver ground strips connected together at one end. The distributed capacitance is formed by the ground plane and the coil. The purpose of the strips is to prevent a short-circuiting current from shielding the ferrite.

Both experiment and theory indicate that the inductance (L) does not remain constant with frequency but decreases rapidly as frequency increases. Fig. 2 is a normalized plot of the ratio of inductance (L) at low frequencies vs the generalized parameter $\pi DT_d f$; where, D = diameter of rod, and T_d = time delay per unit length. The family of curves shows the still greater decrease in L as the ratio of the permeability of the ferrite (μ_1) to the free space value (μ_0) is increased. This additional feature is due solely to the geometry of the line and not the variation of the ferrite permeability

with frequency. Ferrites can be produced whose permeability over the frequency range is relatively constant.

Hence, in order to compensate for this reduction it is necessary to use a ferrite sleeve over the entire structure. Further analysis of this configuration indicates that a useful ferrite delay line should have a rather thin construction, i.e. thin rods and thin-walled sleeves.

Another viewpoint on the problem is indicated by the general curves shown in Fig. 3. Here time delay vs frequency is plotted for two different values of the permeability. It should be noted that although one starts with a large μ, and an increase in the applied magnetic field reduces the permeability to μ_s, the total change in time delay is much larger at the low frequencies than at the high.

The curves in Figs. 2 and 3 show the same geometric effect. In effect, the inductive coupling between neighboring turns becomes less as the frequency increases. Since there is phase delay on the line, the adjacent turns have currents which become more out-of-phase as the frequency is raised.

Construction of Delay Line

A schematic of the final delay line is shown in Fig. 4. The center ferrite rod is 0.080 in. in diam. The closely wound solenoid was constructed of No. 40 gage single formex wire The outer ferrite sleeve had an 0.125 in. outside diameter. The mechanical fit was made as tight as feasible. The ground plane was silver paint placed on the outside surface of the sleeve. This formed the delay line proper. To modulate the ferrite, another coil was placed on a glass tube which was slipped over the entire ferrite line.

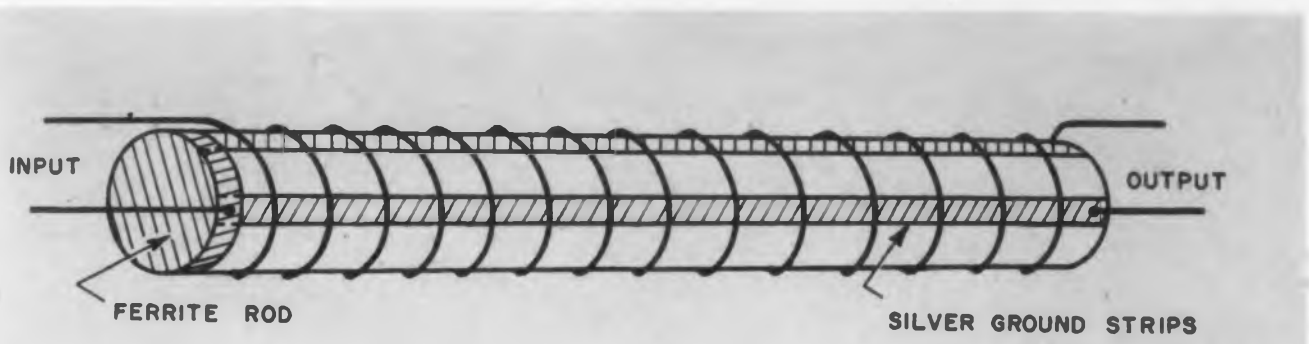


Fig. 1. Construction of ferrite modulator

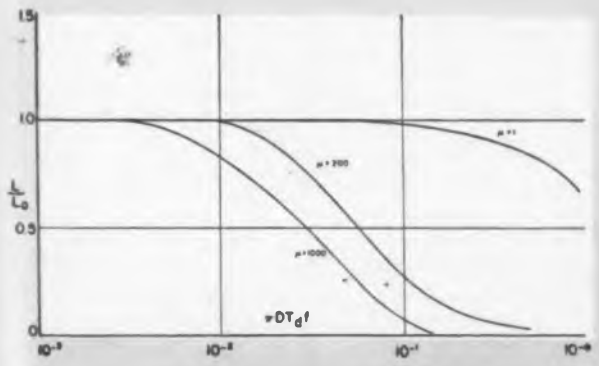


Fig. 2. Plot of L/L_o VS parameter including frequency for various values of permeability.

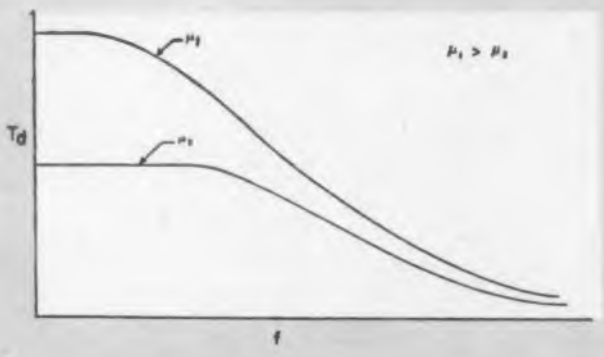
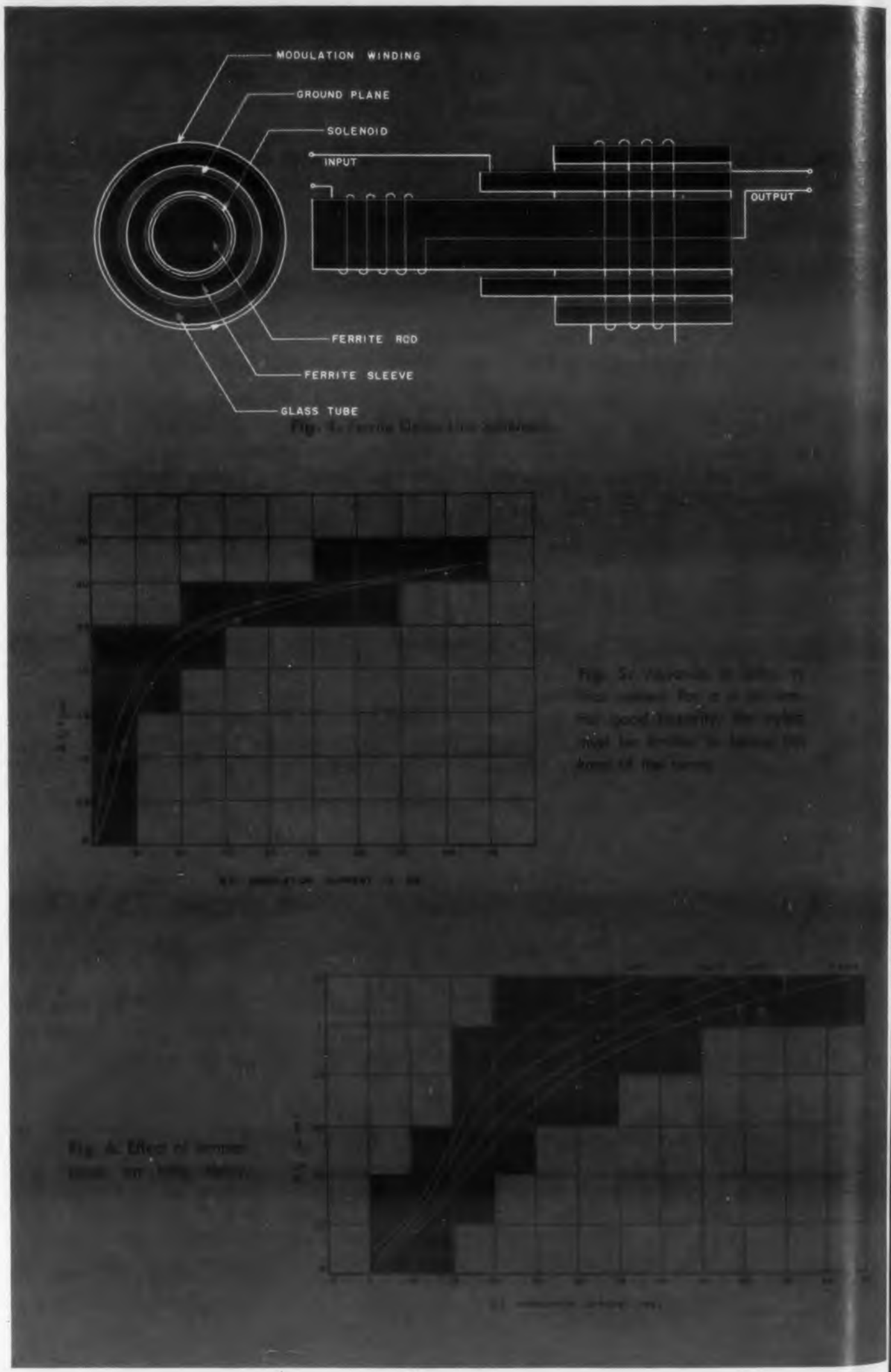


Fig. 3. Variation of time delay per unit length of delay line (T_d) with frequency (f). Note the effect of ferrite permeability on the shape of the curve.



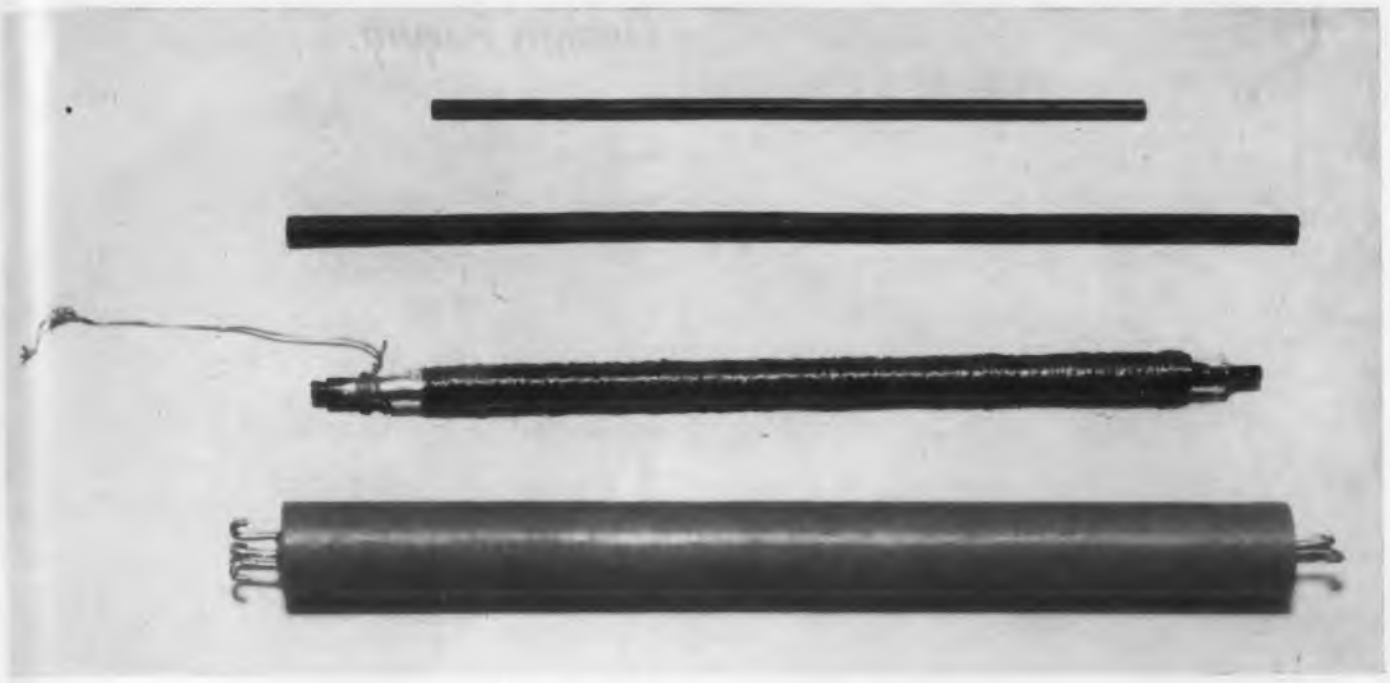


Fig. 7. Ferrite delay construction is illustrated by these elements. From top to bottom the pieces are: rod with solenoid winding, ferrite tube, assembled line with modulation winding and final encapsulation.

Fig. 1 is a pictorial diagram of the unit and shows the silver ground strips. Photographs of the various stages are shown in Fig. 7.

Measurements

The modulation characteristics of the delay line were determined from dc and dynamic measurements. A 10 mc carrier was inserted at the input to the line. With an oscilloscope synchronized to the input waveform, it was possible to observe the change in phase or time delay as the dc current in the modulation winding was varied. A typical plot of change in time delay vs bias current for a 4 in. line is shown in Fig. 5. This curve illustrates the typical saturating effect of the ferrite and the resultant hysteresis. Under actual operating conditions the modulation current would not be permitted to swing over the knee of the curve. The hysteresis effect is thus minimized.

Under modulation conditions a dc bias current of 6 ma was inserted into the modulation winding. A permanent magnet could also have been used. An audio signal of 1000 cps was used for the modulation frequency. With a calibrated detector it was possible to obtain $\pm$ 0.1 μsec change in time delay which corresponds to $\pm$ 360 deg at 10 mc. The audio power required was less than 50 mw, and the distortion less than 5 per cent. A similar experiment carried out at 30 mc, with a 2 in. line, produced $\pm$ 0.02 μsec change in delay.

Thus, it is extremely feasible to produce large amounts of phase modulation with negligible audio power directly at the carrier frequency or with at most one additional stage of frequency multiplication. At lower carrier frequencies (e.g., 1.0 mc) it is possible to produce even larger changes in delay.

Conversion of Phase To Frequency Modulation

This device also performs one additional function. In order to convert phase modulation to frequency modulation, it is necessary to de-emphasize the higher audio frequencies; i.e. the degree of modulation should vary inversely as the audio frequency. This process is accomplished automatically in the modulation winding. If a low-impedance generator feeds the modulation winding, then the current through the winding will vary inversely as the audio frequency due to the inductive nature of the winding.

Temperature Sensitivity

A family of curves with temperature as the parameter is shown in Fig. 6. As the temperature increases, there is an increase in the permeability of the ferrite, and hence, a somewhat greater change in time delay for a given bias current. If this effect is objectionable in a given application, then a temperature sensitive resistor in the bias circuit could compensate for the temperature variation.

The actual line is shown in Fig. 7. Beginning at the top there is the original rod with its solenoid winding. Below this is a ferrite tube. The assembled line, with modulation winding and the final encapsulation, is also shown. The materials were developed by the Magnetic Materials Subsection of the Electronics Laboratory, under contract with WADC.

Acknowledgement

The author wishes to express his appreciation to Mr. P. Lieberman who carried out the final development and to Mr. A. Simone, who greatly aided in the constructional details. A paper on this same subject was presented at the 1957 Electronic Components Symposium in Chicago.

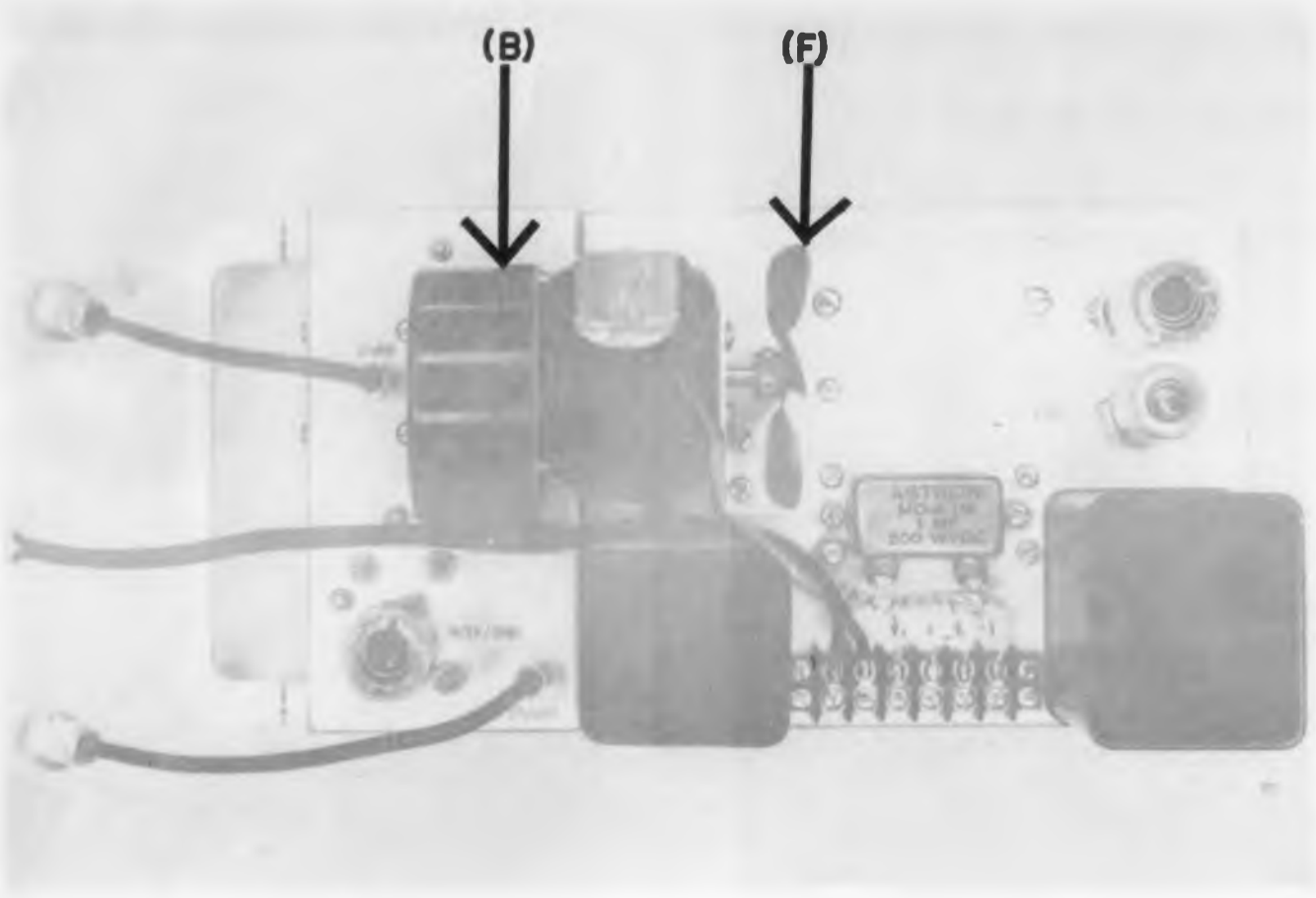
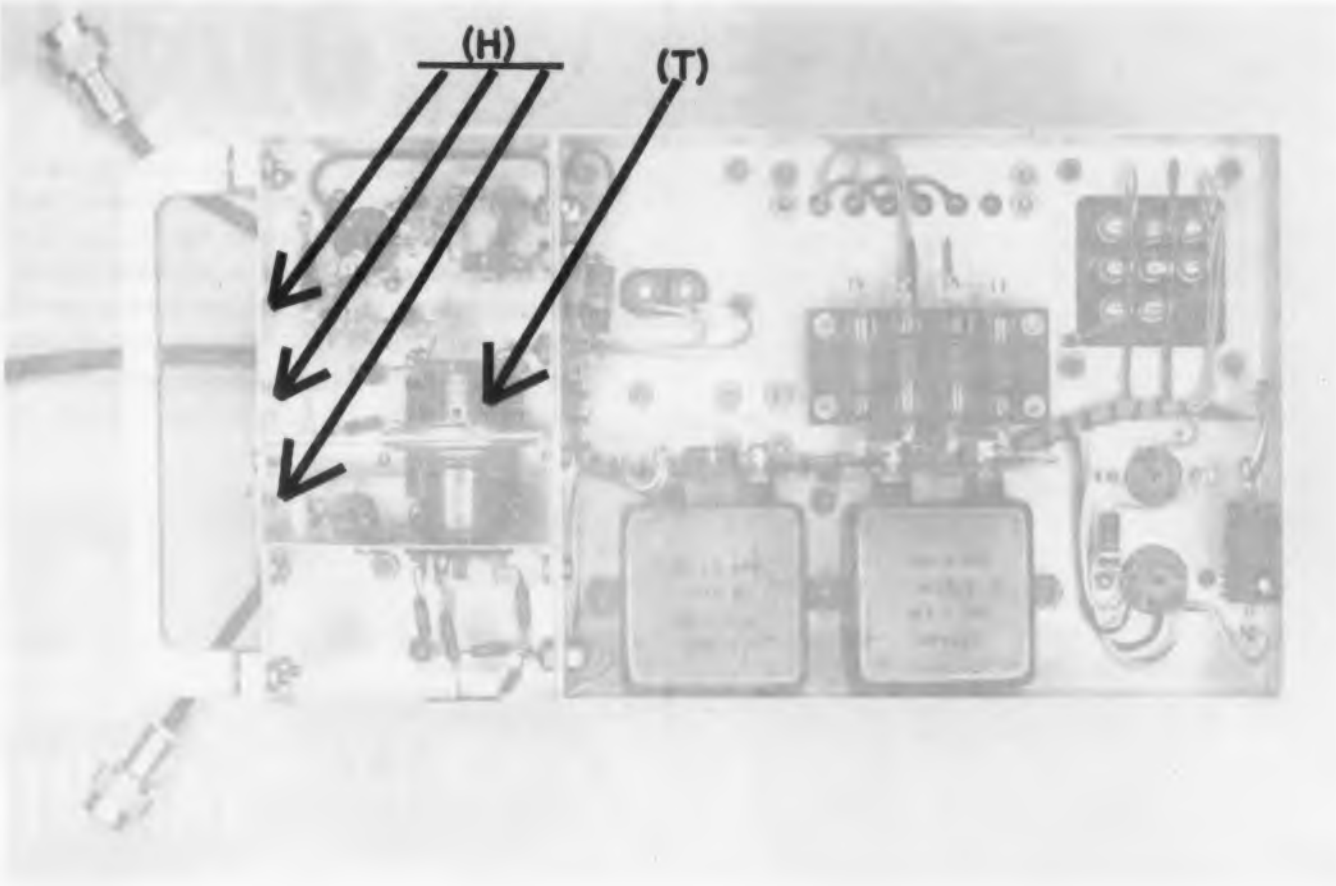


Fig. 1. Blower (B) forces air across 6280/416B tube (B). Air returns via holes (H) to space above chassis, where it is kept in turbulence by fan (F).



Low Noise Preamplifier

M. S. Redden, Jr.
Nems-Clarke, Inc.
Silver Spring, Md.

MOUNTING a receiving system preamplifier at the top of the tower next to the antenna greatly increases receiver sensitivity. Even when the very best low-loss cable is used between the antenna and the pre-amp on the ground, voltage standing waves result in a loss of 2 or 3 db. To compensate for this reduction in receiving system sensitivity, transmitter output power would have to be almost doubled. For airborne telemetry this is impractical. A more reasonable solution is to take the pre-amp out of the ground receiving system rack—weatherproof it—and mount it at the antenna.

Past experience in mounting a preamplifier at the antenna has shown that the principal difficulties result from the equipment "breathing" salt, moisture laden air. The air eventually condenses on vulnerable areas within the equipment, causing failure. This of course results from the preamplifier not being completely sealed. To prevent moisture from getting into the PR-200 preamplifier the housing is sealed and pressurized with dry air. Normally, a pressure of about ten pounds is used. Even if a minute leak should develop, the direction of flow is from the inside of the preamplifier to the outside instead of the opposite direction, which would bring contaminated air into the unit. Leaks induced in pre-production testing had a tendency to "reseal" without a complete loss in pressure. As a final precaution, a silico gel cartridge is clipped inside the housing to absorb any residual moisture present after pressurization of the unit.

The preamplifier PR-200, developed by Nems-Clarke, Inc., 919 Jesup-Blair Drive, Silver Spring, Md., is designed for the most unfavorable environ-

Pre-amp is placed at top of antenna tower to increase receiver sensitivity.

mental conditions. All finishes are salt-spray resistant. Designing for tropical sun ambient temperatures as high as 115 F resulted in the unusual appearance of the preamplifier (*Fig. 1*).

Cooling

The major cooling problem is keeping the seals of the 6280/416B within ratings under the worst possible operating conditions. *Fig. 1* shows the blower used to force air directly across the seals of the 6280/416B. This air returns via a set of holes in the end of the chassis to the space above the chassis, where it is kept in turbulence by a fan on the other end of the blower motor shaft. The turbulence, aided by the high pressure inside the housing, permits an efficient heat transfer to the walls of the housing. From here the problem is to transfer the heat to the surrounding atmosphere and at the same time prevent heating of the preamplifier housing by solar energy. This is accomplished by putting the preamplifier inside a silver-finished louvered box (sun shielded) which is mounted at the antenna (*Fig. 2*). Now the purpose of fins on the preamplifier becomes more evident. As the preamplifier heats the air in the space between it and the sun shield, flow of convection currents of air is from the underside of the sun shield, which is open, up along the fins of the preamplifier housing, and out of the sun shield. The sun shield is vented around the top. These air currents aid in cooling the unit.

Some thought was given to the possibility of mounting only the RF section of the preamplifier at the antenna and installing the power supply and

Fig. 2. Louvered box protects preamplifier from sun.

controls in the receiving station. This arrangement proved cumbersome because of the number of interconnecting leads required and the problem of filament drop to the 6280/416B tube. A decision was made to combine the RF section and power supply in one antenna-mounted unit with only a small control panel mounted in the receiving station. This panel contains the off-on switch, fuse, and pilot light. The preamplifier is supplied through a two-conductor cable, which carries 117 v 60 cycle power to the unit. Because of the critical filament requirements of the 6280/416B, it is recommended that the power be supplied from the receiving station regulated line.

Amplifier Response

Overall response of the preamplifier, when used between a 50 ohm source and 50 ohm load, is flat within 3 db from 215 to 245 mc. Gain is approximately 23 db in the center of the pass band (*Fig. 3*). This is sufficient to have the preamplifier determine the system noise figure, assuming a good receiver and reasonable loss in the line connecting preamplifier and receiver.

Noise figure varies from approximately 4.2 to 5.2 db. This is considerably higher than that specified on similar preamplifiers, and for a while was a source of some concern. To resolve the difficulty, a direct comparison was made using identical test equipment and changing only preamplifiers in the measuring setup. Tests showed that the PR-200 is equal to or better than preamplifiers specified to have noise figures as low as 2.5 db. Differences are probably the result of test equipment and techniques. Since it equals or surpasses preamplifiers designed to do the same job and specified as being a great deal more sensitive, it does not represent a regression of the art. Authoritative noise figure standards would eliminate this problem.

Power Supply

Since the power supply is an integral part of the preamplifier, its efficiency is an important factor in the cooling problem. The power transformer is especially designed to keep heat dissipation to a minimum. Silicon diode rectifiers are used because of their high efficiency and ability to operate in elevated temperatures. A 5651 voltage reference tube is used as a stable source of voltage to provide an 8 v bias on the grid of the 6280/416B. A high impedance divider insures that the grid current rating is never exceeded, even when plate voltage is zero.

A thermal time delay tube is used to delay plate voltage for approximately 90 seconds after turn on. The time delay tube heater is part of the 6280/416B filament series resistance circuits, which is supplied from a 12.6 v winding on the power transformer. Total series resistance is the proper value to drop filament voltage to 6.3 v when the preamplifier is in operation. Under turn-on conditions, the filament resistance of the 6280/416B is quite low; and an excessive current, detrimental to tube life, would flow if it were not limited by some series resistance. The arrangement described has been quite satisfactory in obtaining long tube life, a helpful feature in view of the price of the tube.

The design technique of placing the preamplifier as close as possible to the signal picked up by the antenna substantially increased receiving system sensitivity. The qualtitative value of sensitivity increase is equal to the transmission line loss incurred in connecting the antenna to a preamplifier on the ground.

For further information on the PR-200 preamplifier, turn to the Reader's Service Card and circle 52.

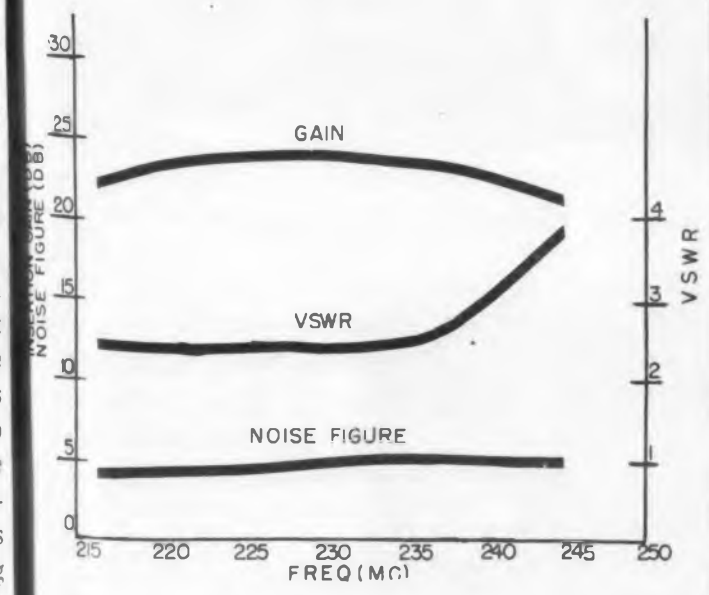


Fig. 3. Preamplifier characteristics for frequency range of 215 to 245 mc.

24 Hour Recorder

THERE is nothing unusual or noteworthy about a tape recorder with a frequency response of 200 to 3500 cps. However, when this is accomplished with a linear tape speed of 2-1/2 in. per minute, it merits investigation. The obvious advantages of such a slow tape-speed are manifested in a new recorder/reproducer manufactured by SoundScriber Corp., of North Haven, Conn.

The machine, (Fig. 1), known as the "24", is capable of unattended continuous recording for 24-1/4 hours on a 300 foot reel of 1.5 mil Mylar base tape. The reel has a diameter of only 3-3/4 in. At 2-1/2 in. per min, head wear, and wear on mechanical drive parts are substantially reduced.

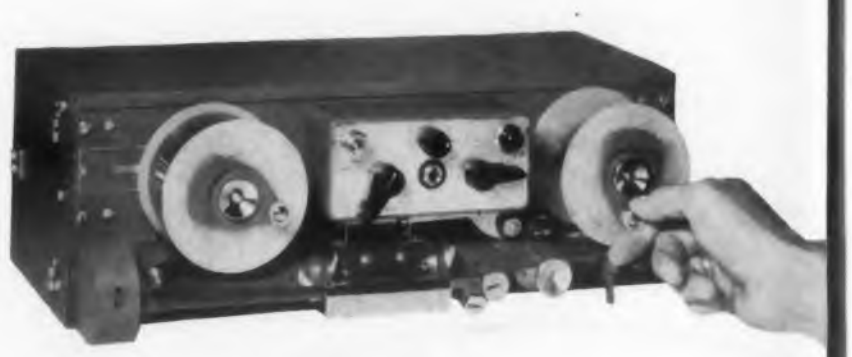


Fig. 1. Twenty-four hour recorder/reproducer.

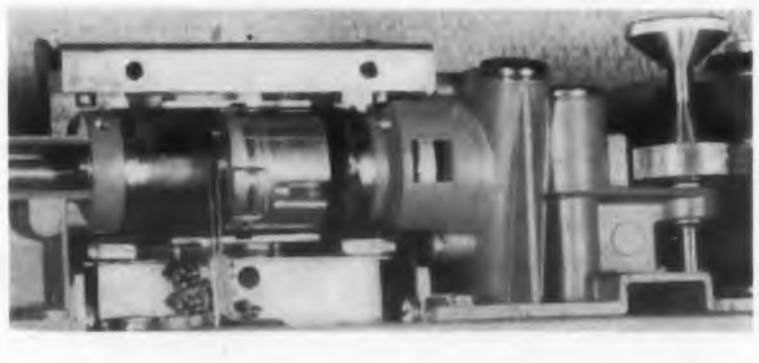


Fig. 2. Underside view of the gate and head wheel assemblies. At the right may be seen the ratcheted top drive capstan.

Fig. 3. Head wheel assembly showing slip rings.

The slow speed is made possible by the use of a transverse recording pattern, similar to that employed in video tape-recording (headpiece, showing transverse recording pattern on 2 in. wide tape). A clamping action between a gear-driven capstan and a rubber pressure roller draws the tape through a gate assembly with spring-loaded contact shoes holding the tape in contact with a head wheel assembly rotating at 30 rpm (Fig. 2). This assembly has two matched magnetic recording-reproducing heads spaced 180 deg apart (Fig. 3). The effective recording speed is thus 1-7/8 in. per sec. A synchronous motor, flexible couplings, and a flywheel mounted on the head wheel assembly drive shaft serve to maintain constant head speed.

A calibrated time scale is printed on the tape for positive logging and place finding. The tape feed roller is equipped with a ratchet device to permit rapidly moving the tape forward or backward manually. The detent action in the roller mechanism is an exact multiple of the track spacing. Thus, when the tape is moved manually, the head and tracks line up without further adjustment.

By recording transversely, with only 0.020 in. between recording tracks, 80 per cent of the available recording space on a two in. wide tape is utilized. The wide tape reduces the possibility of breakage, and its thickness reduces the effect of "print-through" during long storage periods.

The tape cannot be erased accidentally. An accessory demagnetizer may be used to demagnetize an entire reel in 15 sec.

The machine's flexibility is manifested in the fact that it may be modified for two channel simultaneous recording, and its frequency response may be increased by increasing tape and recording speed. For further information circle 469 on the Reader's Service Card.

British Component Show

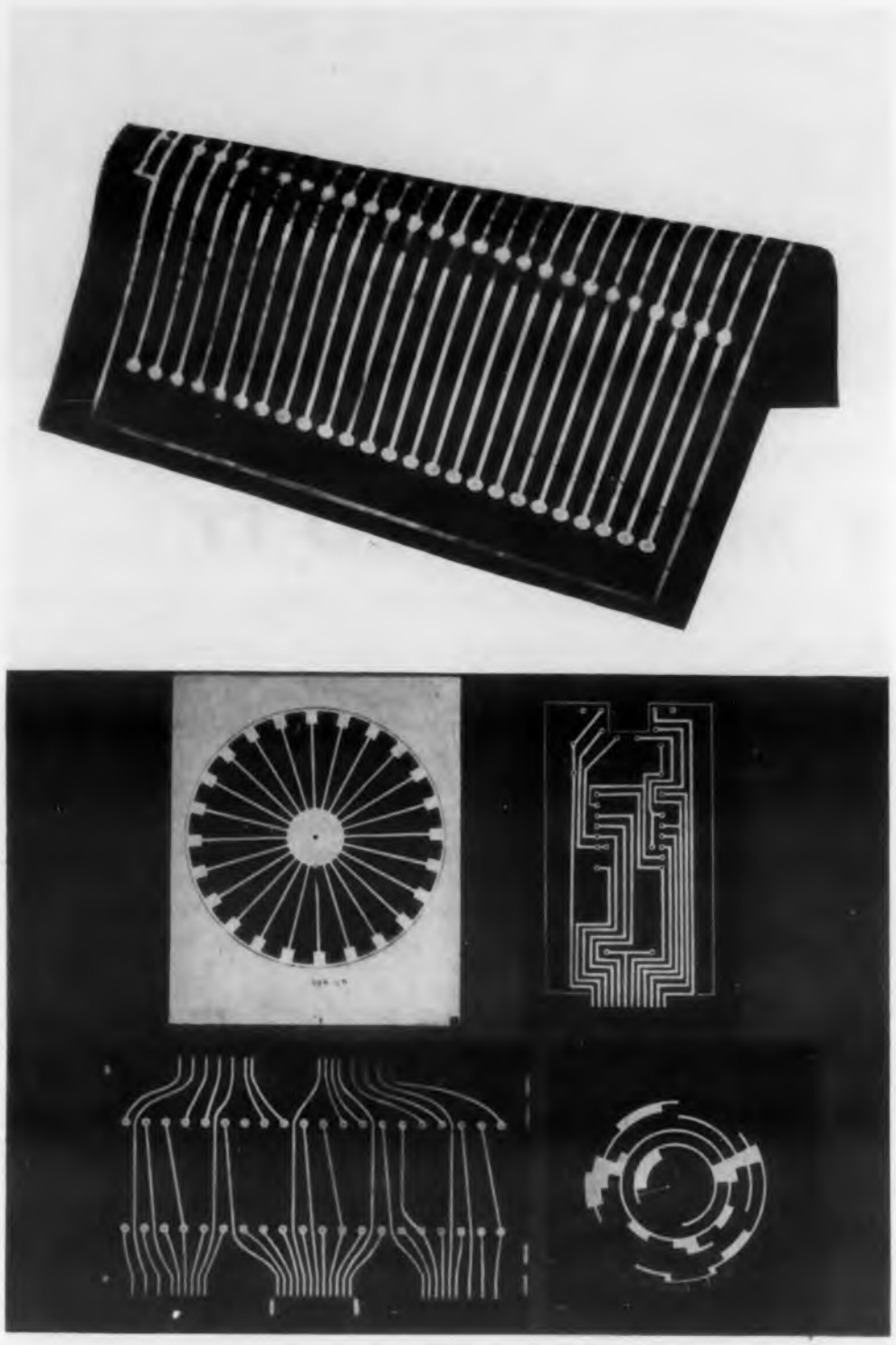


Fig. 1 Flexible printed circuit (top); Printed circuit patterns used in the Mercury digital computer (bottom).

ENGINEERS, buyers and executives from all over the world met recently at Grosvenor House, London for the annual British Radio and Electronic Components Show. One hundred and sixty-four exhibitors displayed their equipment and components. ELECTRONIC DESIGN has chosen some of the more outstanding developments presented at the show to pass on to American engineers. Many of the products listed can be purchased through an American Representative. When a company is represented in this country, the name and address of the American Representative are in the product description.

The exhibition, in past years, was generally known as the Radio Component Show, but this year a significant change to "The Radio and Electronic Component Show" was made. This fact, coupled with dividing the show between two hotels, indicates that British electronics is a thriving industry. Visitors who were able to survive the walk around all 164 booths noticed several new names.

The show appeared to be bustling with potential prosperity. Most manufacturers spoke of full order books for months ahead. Electronic firms located in the new "satellite" towns built around London since World War II are prospering. Electronic components made in these factories are being exported all over the world.

Electronics Industry Changing

The present boom in electronics is, however, undergoing a slow and subtle change—a change that has only recently become apparent. Up till now the mainstay of the British electronics industry has been domestic radio and television. There have been many instances where development of professional electronic equipment was hindered because certain components, not used for domestic purposes, were not available at a reasonable price.

Now the position is beginning to reverse. Guided missile and government contracts are responsible for the shift in emphasis to industrial equipment.

Much of the work in components has been guided by the results of two Ministry of Supply sponsored committees—the Radio Component Research Development Committee and the Radio Component Standardization Committee. This standardization trend was very apparent at the show. Capacitors of the same basic type are almost identical whether made by manufacturer A or B. The same applies to many other components such as resistors and switches. Choice of a supplier in Great Britain is mainly determined by whether he can supply the components by a given date.

Disappointing Speech

The rate of progress in electronics, however, lies very much with the Ministry of Supply, which holds the key both in regard to research and development, and to increased exports. In this connection, the speech by the new Minister of Supply, the Rt. Hon. Aubrey Jones, M.P., at the opening luncheon of the R.E.C.M.F. exhibition was both vague and disappointing to British Manufacturers. Although the Minister called for "a new balanced relationship between the Ministry of Supply and the industry," it is interesting to note that a British electronics magazine commenting on the speech sarcastically pointed out to its readers that at the IRE "conference on missiles and electronics, which is to be held in Washington, D. C., from June 17 to 19, there will be some 130 professional papers delivered on subjects which it is almost completely impossible to discuss in this country. The first step in the new relationship suggested by the Minister must surely be to allow manufacturers more freedom to release information on the more advanced of their electronic developments."

Printed Circuits

The British are experiencing the same "trial and error" development of printed circuit techniques common in the United States. The flexible base, silicone-glass laminate printed circuit board is beginning to receive rather widespread adoption.

One interesting example shown at the show by Bakelite Ltd., 12/18 Grosvenor Gardens, London S.W. 1, is incorporated in the Ferranti "Mercury" digital computer (Fig. 1). Another circuit, one of six making up a sub-miniature Elliott radar receiver, typifies the current British tendency to bring out all connections to the periphery of the printed circuit panel. Modular boards using periphery connections and plug-in-assembly are produced by a number of firms.

Many of the technical features of a product are omitted in product literature released by British manufacturers. For this reason American readers may find product descriptions do not contain the technical information they desire. We feel sure that the manufacturers' response to a *Reader's Service Card* inquiry will supply any desired technical information.

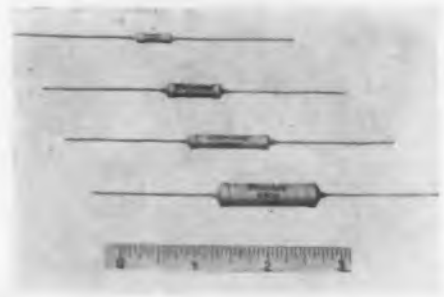
Typical English vocabulary has been retained to give the reader an insight into British description. *Ruggedized* tubes in London are "values of a particularly robust nature."

British Products

Tubes, R-L-C Components

Precision Resistor

4 Types



The 4300 type of resistor is designed to meet the need of projects where a reliable high stability, close tolerance, resistor is required for critical circuits.

The range comprises four types: 1/4, 1/2, 3/4, 1 w with tolerances of ±1 per cent in each type as shown. Maximum dc voltage ranges from 150v for the 1/4 w resistors to 400v for the 1 w. Resistance valves as low as 10 ohms are available.

Standard Telephones & Cables Ltd., Dept. ED, Aldwych, London.

CIRCLE 58 ON READER-SERVICE CARD FOR MORE INFORMATION

Pre-set Potentiometers

Sub-Miniature

Sub-miniature pre-set rotary and strip potentiometers type 170 (left), 171 (center), and 172 (right) are good, inexpensive components of minimum size. No larger than postage stamps, they have few parts and therefore promise high reliability. The potentiometers are provided with several types of connectors for various means of fixing.

Egen Electric Ltd., Dept. ED, Charfleet Industrial Estate, Canvey Island, Essex.

CIRCLE 60 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulsed Magnetron

High-Power, X-Band, Fixed Frequency

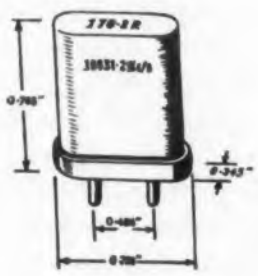
The VF-10 a high-power, pulse X-band magnetron is capable of producing a peak power output of 1 mw at mean power levels up to 1 kw. Frequencies in the range 9000-9500 mc are available from the design presently available; this range may be extended to meet specific requirements.

The anode, which is a "rising-sun" type, is water cooled and fitted with integral polepieces. Drawings of a suitable electro-magnet for use with the valve, are available on request.

Ratings include a pulse length of 1.0 μsec; a duty ratio of of 0.0015 and a rate of rise in voltage of 220 kv/μsec.

Ferranti Ltd., Dept. ED, Lancashire, England; Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N.Y.

CIRCLE 59 ON READER-SERVICE CARD FOR MORE INFORMATION



VHF Crystals

High Stability

These close tolerance fundamental mode crystals are designed for close channel spacing in mobile and airborne vhf equipment. Oven control is *not* necessary. The units contain specially processed AT-Cut crystals having very low frequency-temperature and ageing characteristics. They have a standard fundamental frequency range of 5 to 15 mc, with a frequency/temperature deviation as low as ±0.003 per cent at 25 C. This is easily trimmed out in the user's circuit.

The holder is a Type 2M, equivalent to American H.C. 6/U, and finish is a bright nickel-silver metal case.

Cathodeon Crystals Ltd., Dept. ED, Linton, Cambridgeshire.

CIRCLE 61 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulse Forming Networks

Reduced Weight and Size

Encapsulated in epoxy resin, this pulse forming network has an advantage of reduced weight and size over liquid filled types. It is particularly suitable for use under extreme climatic conditions.

The model shown DNE 226 is a 45 ohm 2 μsec network. Peak working voltage is 6 kv.

Dubilier Condenser Co., Ltd., Ducon Works, Dept. ED, Victoria Road, North Acton, London, W. 3.

CIRCLE 63 ON READER-SERVICE CARD FOR MORE INFORMATION

Ceramic Valve

Peak Power output at 15 KW

Capable of reliable operation where severe shock and high ambient temperatures are encountered, the UL-11 rf oscillator/amplifier operates at 1 k-mc cw or 2 k-mc pulse operation. Mean anode dissipation without forced air-cooling is 30 w. Max peak power output 15 kw.

Ferranti Ltd., Dept. ED, Hollinwood, Lancs.

CIRCLE 64 ON READER-SERVICE CARD FOR MORE INFORMATION

Twin Capacitor

Variable

A miniature variable twin capacitor, designed especially for transistorized receivers, with a maximum capacity of 208 pf (front) and 176 pf (rear). The cadmium-plate steel frame is 1-1/32 in. (long) and has a frontal area of 1-3/8 in. x 1-17/32 in. This includes the sweep of the aluminium vanes. The spindle is 1/4 in. diam by 3/4 in. long; the air gap .0085 in and weight 2-1/4 oz.

Jackson Bros., Ltd., Dept. ED, London, M. Swedgal Electronics, Dept. ED, 258 Bway., New York 7, N.Y.

CIRCLE 65 ON READER-SERVICE CARD FOR MORE INFORMATION

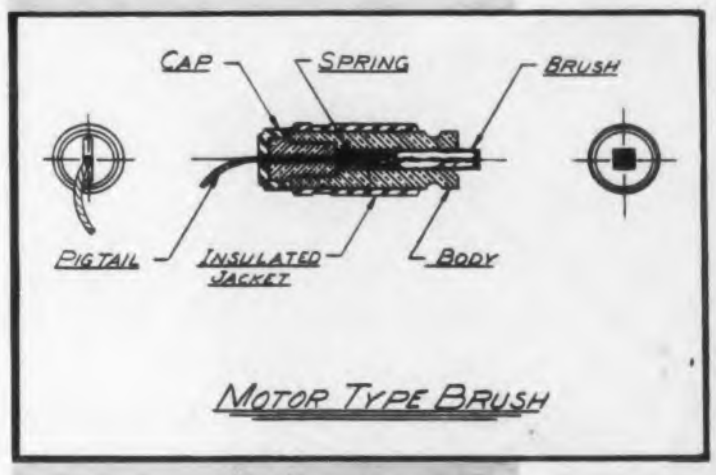
FUNDAMENTAL DESCRIPTION OF

POWER SLIP RINGS

NO. 2

of a Series of Data Sheets

In many cases, slip rings and brushes used for power circuits can be the same design and materials as found in rotating electric machines. However, when circuit, space and environmental requirements impose more severe problems, they can be solved by special design and advanced techniques.



MOTOR TYPE BRUSH

Currents carrying in excess of 20 amperes at power voltages and frequencies are considered power circuits.

As in the case of rotating electric machinery, copper or copper alloy rings can be used with graphite or metal graphite brushes. To achieve the maximum performance in minimum space and to satisfy environmental requirements, silver rings and silver graphite brushes are used. The ring hardness is specified to be 125BHN for good surface wear.

Leaf type brushes may be used with definite cost and space advantage at currents up to about 100 amperes. The leaf spring material is beryllium copper. By using shunts or jumpers made from finely braided copper wire, the current capacity of the brush assembly can be greatly increased.

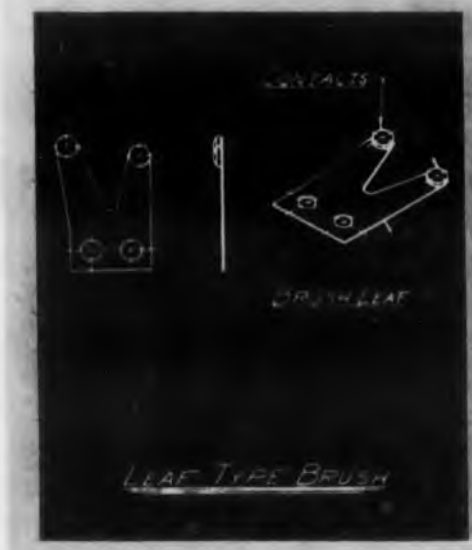
High currents require calculation of the entire slip ring circuit for power loss and temperature rise. The ring is thermally insulated by the electrical insulation, and therefore the area for dissipating heat is limited almost to the surface exposed to the brush.

The ring cable within the tube may be surrounded by other cables which are also dissipating heat, and this complicates the cooling problem. The size of the cable chosen must take this into consideration. Heat dissipation is assisted within the tube if the tube is vertical and if the ends are not blocked.

Very high currents have been carried by leaf type brushes with relatively small contacts of properly selected material.

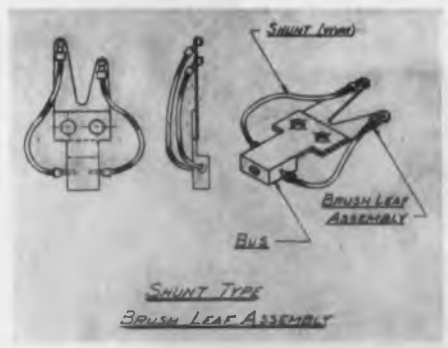
For motor type brushes, the brush is the limiting element in the circuit, and the temperature rise of the brush is greatest at that portion between the ring contact surface and the end of the brush holder.

If current surges exist in the circuit, they must be examined for magnitude and time duration, and the effect of the surge on the temperature rise of the circuit elements must be determined.



Extremely high currents require the examination of the electromagnetic forces on the ring and circuit elements.

There is electromagnetic cross talk in alternating current circuits generated particularly in the tube. The magnitude of this cross talk is not greater than that produced by the same set of parallel lines in an electric conduit; and the slip ring circuit does not contribute further to this cross talk.



SHUNT TYPE BRUSH LEAF ASSEMBLY

British Products

Connectors-Terminals

Miniature Cable Connectors

Waterproof

Low standing wave ratio, greater mechanical strength and the fact that they are completely waterproof are the main features of these connectors. They are interchangeable with their American counterparts and according to the manufacturer offer certain improvements. The cable grip is designed to secure the connector firmly to the end of the cable. They are sealed when loaded on the cable.

The connectors can be used for frequencies up to at least 3 k mc with a nominal characteristic impedance throughout the range of 51 ohms. Contact resistance is less than one milliohm and leakage (sealing) less than 1 c. c. per hour.

Belling & Lee Ltd., Dept. ED, Great Cambridge Road, Enfield, Middlesex.

CIRCLE 68 ON READER-SERVICE CARD FOR MORE INFORMATION

Stand-Off

Smallest in Britain

Claimed to be the smallest insulated stand-off made in Britain, and possibly smallest in the world, the W.8003 is only 3/8 in. high. For 1 KV working, it is available with either 8BA stud or tapped 8BA bases. Either a single or double top-solder tipped for ease of soldering—can be supplied.

Harwin Engineers Ltd., Dept. ED, 101 Nibthwaite Road, Harrow, Middlesex.

CIRCLE 69 ON READER-SERVICE CARD FOR MORE INFORMATION

Plugs and Sockets

"J" Type

"J" type plugs and sockets have twelve resilient fingers engaged with each flat plug pin to provide exceptionally low contact resistance, high current carrying capacity and minimum insertion and withdrawal forces. These special features combined with small overall dimensions and Mikacin mouldings support the claims for consistency of electrical and mechanical performance after some thousands of insertion and withdrawal operations.

The Carr Fastener Co. Ltd., Dept. ED, Stamplеford, Nottingham; Carr Fastener Corp., Cambridge, Mass.

CIRCLE 72 ON READER-SERVICE CARD FOR MORE INFORMATION

Terminal Blocks

Flexible

Where space is at a premium, this flexible terminal block will bend to any curved or irregular surface. Another unique feature is the ability to hold terminal screws captive. Even when the blocks are mounted upside down and the screws totally disengaged from their inserts they cannot fall out.

The blocks can be easily cut with a knife into smaller sections. Three fixing holes are provided between each pair of terminals so that even a 2-way section cannot twist on its mounting. The terminal screws are fully shrouded in the moulding and protected against accidental contacts and short circuits, and the shrouds will not break.

Peak working voltage is 2 kv between terminals or between terminals and chassis. Insulation resistance exceeds 10,000 megohms and current rating is 2 amp.

Belling and Lee Ltd., Dept. ED, Great Cambridge Rd., Enfield, Middlesex.

CIRCLE 73 ON READER-SERVICE CARD FOR MORE INFORMATION

British Products

Ferrities

Ferrite Isolator
Medium Power X-Band

Reverse attenuation of this ferrite isolator is greater than 20 db over a 10 per cent frequency band from 8500 to 9400 mc with a forward attenuation of less than 0.8 db. It is designed for operation up to a peak incident power level of 75 kw or mean incident level of 75 w. VSWR is less than 1.2 over the frequency band.

The isolator can decouple an oscillator from its load so that optimum oscillator performance can be obtained, with the elimination of such problems as frequency pulling and spectrum deterioration.

Ferranti Ltd., Dept. ED, Ferry Rd., Edinburgh 5.

CIRCLE 76 ON READER-SERVICE CARD FOR MORE INFORMATION

Ferrite Switch
9600 to 9800 mc

Designed to operate in the frequency band 9600 to 9800 mc this ferrite switch provides a maximum attenuation of 30 db. By applying a current pulse of suitable magnitude to the solenoid the switch acts as a pulsed reflective attenuator so having an obvious application to aerial switching. The device can act similarly as a controlled calibrated attenuator providing a method of agc and as an amplitude modulator, if a suitable periodic current waveform is applied to the solenoid. This latter application is most important since it permits detection of microwave signals at audio frequencies without the usual disadvantages of frequency modulation introduced by modulation of a klystron control grid or reflector.

The insertion loss is 0.5 db; and peak attenuation 30 db min.; coil inductance is 0.63 mh; coil capacitance 127 pf and coil resistance 3.2 ohms, current for peak attenuation at 9750 mc is 0.70 amp dc. Delay of microwave modulation pulse with respect to current pulse is 1 μsec, and power handling capacity is 30 w.

Ferranti Ltd., Ferry Road, Dept. ED, Edinburgh 5.

CIRCLE 77 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscilloscope

General Purpose

This oscilloscope is of a particularly robust nature and is designed for use as a general purpose instrument. A flat faced cathode-ray tube 4 in. diam is utilized.

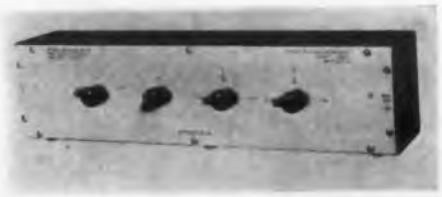
A new type of graticule is used allowing reaay measurements in both axes. A hard time base having extremely good synchronization characteristics is provided covering the wide range of frequencies from 2 cps to 100 kc and can be operated either free running or triggered. Horizontal and vertical amplifiers with push-pull output are provided. The latter is of high gain and has a frequency range extending from ten cycles to 6 mc + 1/2 db and −3 db. Both amplifiers have outputs corresponding to several screen diameters.

Taylor Electrical Instruments Ltd., Dept. ED, 419 Montrose Ave., Slough, Bucks, England.

CIRCLE 80 ON READER-SERVICE CARD FOR MORE INFORMATION

Variable Attenuator

Wide Frequency Range



Practically independent of frequency up to 100 mc these attenuators can be used with minor corrections up to 300 mc. Because they have an accuracy of ± 2 per cent, they can be used for gain measurement of amplifiers or for use in conjunction with existing signal sources.

They are unaffected by external fields. Attenuation range is from 1 db to 99 db in steps of 1 db. Characteristic impedance is 75 ohms and maximum input voltage 3v.

British Physical Labs., Dept. ED, Radlett, Herts.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION

This product sampling of the British Electronics Industry was compiled for two reasons. As always, our first goal was to inform the Design Engineer of new electronic equipment and components. Our second purpose was to give the engineer an opportunity to compare the "state of the art" in America with that in England.

New Products

450 F Synchros

High Accuracy

This size 10 synchro has passed tests at 450 F for 100 hr and 350 F for 1000 hr. High accuracies are maintained. Available as transmitters, transformers, differentials, and resolvers, the synchros are made of stainless steel. Transmitter characteristics with rotor as primary include 26 v input, 0.145 a input, 0.61 w input, 11.8 v output, sensitivity 206 mv/deg, phase shift 8 deg dc; resistance is −22.5 ohms for the rotor, 9 ohms for the stator. Impedances are: Zro, 32 + j176; Zso, 9 + j31; Zrss, 61 + j21. Maximum null is 30 wv and length is 1.241 in.

Clifton Precision Products Co., Inc., Dept. ED, 9014 West Chester Pike, Upper Darby, Pa.

CIRCLE 83 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetically-Held Switches

Prevent Continuity Errors

These automatic-disconnect switches are magnetically-held and are automatically disarmed when the energizing voltage drops between 13 and 5 v. A fail-safe feature ensures that the solenoid will not pull the switch closed. Company engineers state that the units will withstand vibration frequencies up to 500 cps at 10 g loads, and that the normal feel of toggle-switch operation is retained. The units occupy less than 2.5 cu. in. and weigh 4 oz. Errors of circuit continuity which ordinarily result from residual magnetic fields after a power failure are reportedly effectively eliminated and the necessity for on-off warning lights and similar devices is avoided. Switches are available in single-pole and double-pole models in corrosion-resistant casings.

Lear, Inc., Dept. ED, 110 Ionia Ave., N.W., Grand Rapids, Mich.

CIRCLE 84 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency Deviation Meter

1 to 10,000 CPS Range, Digital Display

The Model 6005 permits rapid direct read-out of the deviation of a frequency from 1 to 10,000 cps in parts per million ±1 count. The unit consists of a preset counter section, gating and controlling circuits, a temperature regulated crystal controlled 1 mc oscillator and a display section. Specifications include: frequency range of 1 to 10,000 cps; accuracy of ±1 count ± stability; stability for short term is 1 part in 1,000,000 and for long term is 3 parts per 1,000,000 per week; display time of 1 sec; read-out of 6 digits; time base of 1 sec when preset decades are set to frequency of unknown. The meter weighs 48 lb, measures 8-3/4 x 18-3/4 x 13-3/4 in.

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

CIRCLE 85 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Flip-Flop

DC to 20 Kc Range

These transistorized flip-flops, Series 7-1000, are for airborne data handling and control circuits. Each unit measures 1.5 x 0.75 x 0.25 in. plus terminals. It consists of two transistors in an Eccles-Jordan circuit, and a third transistor used as an output buffer amplifier. Frequency ranges from dc to 20 kc, and the temperature from 0 to 85 c. Supply voltage is 28 v, and required signal voltage is −8 v, pulse or sq wave. Output swing is from 6.5 to 25 v with no load and 5 to 18 v with 1500 ohm load. Input and reset signals are diode isolated.

Dynalysis Development Labs., Inc., Dept. ED, 11941 Wilshire Blvd., Los Angeles 25, Calif.

CIRCLE 86 ON READER-SERVICE CARD FOR MORE INFORMATION

Semiconductor Diode Tester

Instant Quantitative Measurement

The diode tester quickly checks all common types of semiconductor diodes for irregularities by means of the dynamic curve projected on a calibrated oscilloscope screen. Circuitry is designed for minimum noise and hum and provides instantaneous and accurate quantitative measurements for use in research labs or for volume testing on production lines. The cathode-ray indicator, having high deflection sensitivity, is a companion instrument.

Technitrol Engineering Co., Dept. ED, 1952 E. Allegheny Ave., Philadelphia 34, Pa.

CIRCLE 87 ON READER-SERVICE CARD FOR MORE INFORMATION

Shipping Containers

Vulcanized Fibre

This reusable vulcanized fibre shipping container for the transportation of delicate instruments and equipment consists of side walls and bottoms which are of sandwich-type construction, with plywood protected on both sides by vulcanized fibre. The plywood provides a rigid core while the scuff-resistant fibre armors exterior surfaces. This bonded construction gives minimum weight and maximum strength, durability and shock resistance with a total wall thickness of only 1/8 in. Maximum protection to contents is provided by a thick, shock-absorbing internal padding, mounted on plywood panels and covered with durable cotton duck. The lid, constructed of 1/4-in. bone fibre and hinged to the recessed metal top molding, is secured for shipment with two recessed Southco-type fasteners. It closes flush and features a spring clip for freedom from vibration and easy opening.

National Vulcanized Fibre Co., Dept. ED, 1057 Beech St., Wilmington 99, Del.

CIRCLE 88 ON READER-SERVICE CARD FOR MORE INFORMATION

Industrial Pressure Switch

Burst Pressures to 600 psi

The GIS-8000 is an industrial pressure switch designed for use in machine tool control panels, hydraulic test stands and lubrication systems. The vibration-proof switch is 2-1/2 in. in diam with an overall height of 2-1/2 in. The pressure sensing chamber is sealed and contains a diaphragm of suitable material for use with a variety of fluids and gases. Factory pre-set, the switch will make or break electrical loads of 110/220 v to 15 a in response to pressure changes up to 225 psi with burst pressure up to 600 psi. A companion series, 2 in. in diam, GIS-8060 will similarly control systems with burst pressures to 1800 psi. Each unit can be supplied for operation in temperature to 275 F.

Gorn Electric Co., Inc., Dept. ED, 845 Main St., Stamford, Conn.

CIRCLE 89 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Time Delay Switch

Thermal Operation

Time delay switches offering delay ranges from 5 to 20 sec up to 1 to 5 min operate thermally and are generally used in conjunction with magnetic relays. The delay can be set at any point within the limits of the timing range by means of an adjustment screw that varies the contact gap. Switches with or without immediate recycling are available. The principle difference between the two is that the immediate recycling type has two sets of contacts, one normally open and one normally closed. The other type has only one set of contacts, either normally open or normally closed. Both types can be supplied with contacts rated 1 or 2 a at 115 v ac. The switches can be had in versions with temperature compensation for applications where an accurate delay is required over widely varying ambient conditions. Typical units measure 3 x 7/8 x 7/8 in.

Betts & Betts Corp., Dept. ED, 213 W. 14 St., New York, N.Y.

CIRCLE 91 ON READER-SERVICE CARD FOR MORE INFORMATION

Push-Button Actuator

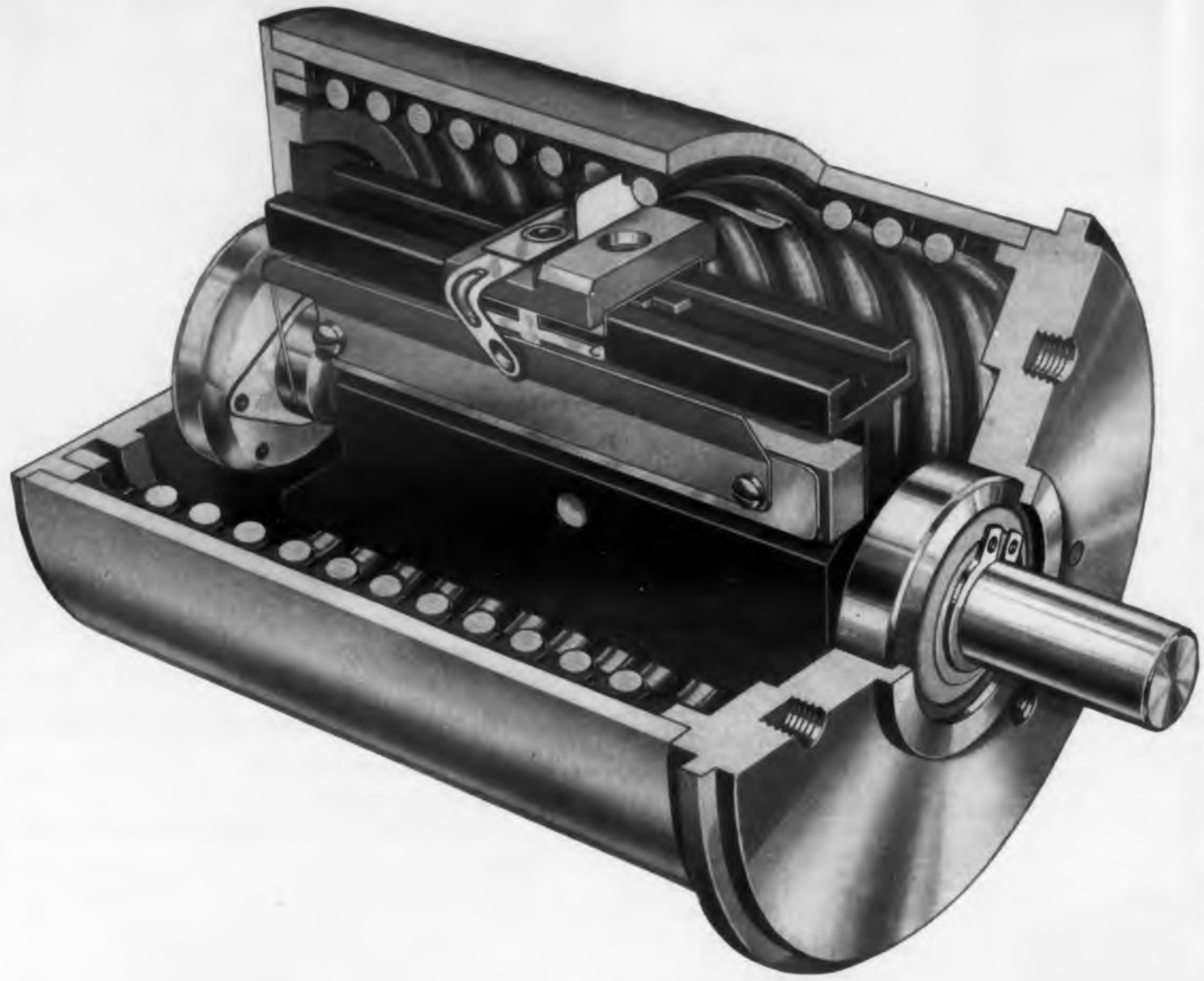
For Several Switching Circuits

The manually operated A4-67 actuator is designed to accept any one of the manufacturer's three standard basic switches without altering the actuator bracket. This feature permits a wide range of circuit arrangements from spst to tpdt-6 circuit. The actuator button is housed in an independent threaded bushing unit which screws into the bracket to act as an adjustment for panel thickness variations and also as a lock nut for panel mounting. Actuator can be mounted to panels from 1/16 in. to 1/8 in. thickness. The knurled ring nut permits fast, hand installation. All metal parts are corrosion resistant treated. The large actuator button is available in standard colors of black, red and green. Other special colored buttons are available upon request.

Electro Snap Switch & Mfg. Co., Dept. ED, 4218 W. Lake St., Chicago 24, Ill.

CIRCLE 92 ON READER-SERVICE CARD FOR MORE INFORMATION

Your choice of 3 basic designs in... MULTI-TURN P



Design #1 ***This unique mechanical drive in a machined case minimizes winding wear and electrical backlash***

Here is a standard-for-quality line of multi-turn potentiometers (shown at the right), which will hold tight tolerances over their entire ranges because backlash has been reduced to an absolute minimum.

These units utilize a unique mechanical drive perfected by Fairchild, which is *separate* from the helical coil of resistance wire. The contact wiper is advanced along the winding by a guide tab that rides in a groove parallel to the winding (see cutaway above). This design minimizes winding wear and electrical backlash, thereby extending both life and accuracy.

These precision units also offer you the advantages of tight linearity tolerances, high temperature performance, and low noise levels. This Fairchild design is available with resistance ranges between 1K ohms and 2 megohms, and in ⅞", 1" and 1 3/16" diameters. Mounting plates are bushing, servo or 3-hole pilot types.

Standard temperature ratings for these units range from −55°C to +85°C. However, Types 930 and 933 are regularly available in ratings up to 150°C and Type 908 to 125°C. Other types can be had with these higher ratings on special order.

CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

PRECISION POTENTIOMETERS

Fairchild's complete line of precision potentiometers offers three basic designs giving complete coverage for most applications: 1. A machined aluminum case with insulating liner and unique mechanical drive; 2. All stainless steel case with wiper tab drive; 3. Economical phenolic case. All these designs are available as linear or multi-tapped non-linear units. Whichever design you select, you'll get consistent performance to meet your specifications in *every* potentiometer — even on a production basis. Fairchild assures you of this by insisting on rigid incoming materials inspection, sub-assembly and final inspection, plus performance testing, and environmental testing to destruction of random samples.

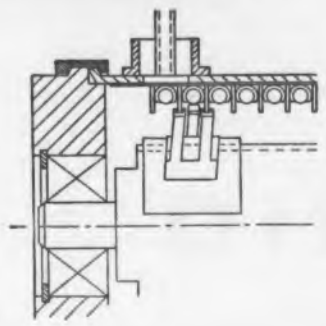
1-3/16" 10-turn Metal Case Type 930. Elec. Rotation: 3600°; Res. Range: 1K to 2 Meg.; Tol. ±5% (±1% on specials); Std. Lin.: ±0.1 ot ±.025%; Power Rating: 5 Watts; Gangable.

1" 10-turn Metal Case Type 920. Elec. Rotation: 3600°; Res. Range 1K to 1 Meg.; Tol. ±5%; Std. Lin.: ±.25 to ±.05%; Power Rating: 3.5 Watts. Gangable.

⅞" 10-turn Metal Case Type 908. Elec. Rotation: 3600°; Res. Range: 100 to 100K ohms; Tol: ±5%; Std. Lin.: ±.25 to ±.05%; Power Rating: 2.5 Watts.

1-13/16" 3-turn Metal Case Type 933. Elec. Rotation: 1080°; Res. Range: 350 to 600K ohms; Tol.: ±5% (±1% on specials); Std. Lin.: ±.25 to ±.05%; Power Rating: 5 Watts; Gangable.

Design #2



Elec. Rotation: 3600°; Res. Range: 100 to 200K ohms; Power Rating: 2.5 Watts at 40°C; Amb. operating temp.: —55°C to +150°C (on special order). Std. Linearity ±0.5 to ±0.05%. Unit is gangable.

Type 909—STAINLESS STEEL CASE ⅞" 10-turn standard. (Available from 3 to 20 turns.) The only nominally priced *metal case* ⅞" 10-turn on the market. Features all-stainless steel structural parts, and individually-insulated terminals welded to the case. This new design concept utilizes cylinders of stainless steel for the case, insulated from the mandrel by a dielectric film. Instead of the conventional slip ring, it uses a helical slip bar, which serves also as a guide for the wiper. The wiper assembly straddles the slip bar, the wiper riding the resistance winding in the middle, thus eliminating wear at this point and improving the life characteristics of the unit.

Design #3

Most economical 7/8" 10-turn PHENOLIC CASE. Elec. Rotation: 3600°; Res. Range: 100 to 100K; Tol.: ±5%; Std. Lin: ±0.5 to ±0.1%; Power Rating: 2 Watts.

No matter what factors govern your choice, you'll find the best potentiometers for your application in Fairchild's complete line. Write for a free folder or call Fairchild Controls Corporation, Components Division, Dept. 140-90N.

EAST COAST
225 Park Avenue
Hicksville, L.I., N.Y.

WEST COAST
6111 E. Washington Blvd.
Los Angeles, Calif.

FAIRCHILD
PRECISION POTENTIOMETERS and COMPONENTS

CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

AC and DC Impedance Bridge

High Frequency

This impedance bridge assembly, Model 291, contains ac and dc generator and detector units. For dc measurements of resistance and conductance, the built-in dc generator, operated from a 115 v, 50 to 60 cps ac power line, can provide either 10 or 300 v to the bridge. During the balancing operation, bridge nulls are detected on a light beam type galvanometer having a deflection sensitivity of 30 mm per μa. An adjustable 0 to 15 v power supply, operable from 100 cps through 10 kc, is available for ac impedance measurements. Frequency selections are made by means of plug-in networks. Visual detection of bridge balance is provided for by use of a dual electronic ray indicator having instantaneous response to a wide range of signal changes. Terminals are provided for accommodating other types of detectors when desired. Null indicator sensitivity is 20 μv or less.

Accuracies are 0.1 mohms to 1.2 megohms, accurate to ±0.1 per cent; 0.1 μμmhos to 1.2 mhos, accurate to ±0.1 per cent; 0.1 μμf to 1200 μf, accurate to ±0.2 per cent; and 0.1 μh to 1200 h, accurate to ±0.3 per cent. The main LRC dial has a scale with 11,000 effective graduations spaced approximately 1 mm apart.

Electro-Measurements, Inc., Dept. ED, 7524 S.W. Macadam Ave., Portland, Ore.

CIRCLE 94 ON READER-SERVICE CARD FOR MORE INFORMATION

TV Bridging Amplifiers

1, 10, and 25 Db Gain

Vhf TV bridging amplifiers with unity gain, 10, and 25 db gain are for 75 ohm systems and will handle up to 0.2 v per channel, maximum output. The amplifiers feature single control adjustable equalization and adjustable gain. Plug-in attenuators insure less than 0.5 db thru-line loss. Silicon power rectifiers contribute to low power consumption and very long life.

Entron, Inc., Dept. ED, P. O. Box 287, Bladensburg, Md.

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Buffer Storage Unit

Holds 1092 Characters

Type 1092-BQ-8 coincident-current magnetic core storage unit can be used as a temporary store or buffer unit in data processing, computing and automation systems. Each of the 1092 characters has a capacity of eight binary digits in length. The storage unit is completely transistorized.

Telemeter Magnetics, Inc., Dept. ED, 2245 Pontius Ave., Los Angeles 64, Calif.

CIRCLE 97 ON READER-SERVICE CARD

Electromagnetic Brake

Servo Mounting, High Torque

Electromagnetic brakes, normally free running with the output shaft braked when energized, are servo mounted units designed with the shaft out either or both ends. The brakes are available from 6 to 100 v dc. Four standard sizes are available with typical performances extending from a minimum brake torque of 4 oz in. to a minimum brake torque of 64 oz in. The units weight from 0.75 to 7.5 oz.

Autotronics Inc., Dept. ED, Route 1, Box 812, Florissant, Mo.

CIRCLE 98 ON READER-SERVICE CARD

◀ CIRCLE 96 ON READER-SERVICE CARD

New Products

16 Mm High-Speed Camera

For Missiles and Aircraft

This 16 mm intermediate high-speed camera with 200-ft film capacity and daylight loading spools is designed to operate remotely while mounted on aircraft, missiles, sleds, or any vehicle where photographic information is required for test data or documentary purposes. The recorder movement is an intermittent walking claw type which insures accuracy and against loss of loop while operating. Co-axially mounted film spools make recorder case extremely small and light. Timing lights, boresight, mount, C lenses, carrying case, interchangeable shutters, and speed change gears are available accessories.

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

CIRCLE 170 ON READER-SERVICE CARD FOR MORE INFORMATION

Stable Amplifier

For Proportional Counting

This Model 255S amplifier is a non-overloading, stable instrument designed for use with gas flow counters operating in the proportional region. The amplifier is designed to receive power from an associated scaler. High voltage for the instrument's detector can be supplied from a scaler or separate high voltage supply. The unit measures 9-1/2 x 4 x 2 in. plus tube height; weight is 4 lbs; shipping weight is 10 lbs. The amplifier has a gain of approximately 300 with a minimum output of 6 v negative, of 2 μsec duration. Peak-to-peak noise at output is 50 mv. The unit contains a built-in double hv filter and delay line for pulse shaping.

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

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Directional Couplers

Cover 68 to 73 Kmc

The MA-668A and B side-wall directional couplers for the range 68 to 73 kmc have nominal coupling values of 20 and 30 db, respectively. Directivity is 25 db minimum while maximum vswr in the main arm is 1.1 and in the auxiliary arm 1.15 for both. These measurements are performed at mid-band and at specified band extremes. The coupling accuracy is within ±1/4 db. UG-385/U coupling flanges are used on all arms. Overall length is 3-5/32. The height from the center line of the main arm to the auxiliary arm flange surface is 13/16 in. Each coupler is fabricated from coin silver waveguide. Mating surfaces are flat and mirror smooth to prevent rf leaks. All surfaces are silver plated. A coat of blue-gray lacquer is applied to external non-contacting surfaces.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 103 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Gage Power Supply

For 120 Ohm Model

This unit is designed primarily for use as a power supply for a 120 ohm strain gage bridge. The output of the power supply is available on the front panel for other than bridge applications as desired. The unit contains a wired bridge with front panel facilities for using from one to four strain gages as either active or dummy elements. Provided are initial balancing facilities with both coarse and fine adjustments. Specifications are as follows: internal impedance, less than 0.25 ohm; ripple, less than 0.1 per cent of the output voltage; output range, 0.25 v dc, 500 ma. The unit is 11 x 19 x 7 in.

Spar Engineering & Development, Inc., Dept. ED, Paxson and South Aves., Wyncote, Pa.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION

Adjustable Motor Base

Reduces Down Time

Lost production due to stretched and sagging belts may be eliminated with the Adjusto-Slide motor base. With this base, belt take-up is accomplished by adjusting only one screw, an adjustment that is made without stopping the motor. Replacement of belts is made simple, since the adjusting screw on most models can be loosened and swung aside, freeing the top plate and the motor to move far enough for removing the old and installing the new belt. Once the new belt is in place, the motor is moved back in place, the adjusting screw swung back, tightened and the machine is back in operation. The motor base accommodates NEMA frame sizes from 182 through 326 v in both old and new designations, from 1 to 30 hp. The base can be mounted vertically, horizontally or in an inclined position.

American Pulley Co., Power-Transmission Div., Dept. ED, 4200 Wissahickon Ave., Philadelphia 29, Pa.

CIRCLE 105 ON READER-SERVICE CARD FOR MORE INFORMATION

Angular Positioner

For Synchros and Pots

The angular positioning of such components as synchros and potentiometers is accomplished with the Dial Assembly. A simple operation attaches the component to the dial assembly through use of a spring-loaded collet and two housing clips. Adequate control of the dial position is obtained with a geared vernier knob. Specifications include: dial diameter, 5 in.; handles component sizes 15 and less; dial graduated in steps of 1 deg through 360 deg with a vernier which indicates 0.1 deg. Overall angular accuracy, 0.1 deg.

Theta Instrument Corp., Dept. ED, 204 Market St., E. Paterson, N.J.

CIRCLE 106 ON READER-SERVICE CARD FOR MORE INFORMATION

Microwave cooking shaves hours from food preparation time. This is a home-type electronic oven developed by Raytheon for production by appliance manufacturers.

New Products

Brush Spring Caps

For Rapid Motor Attachment

A method of attaching caps to carbon motor brush springs has been designed for use with the manufacturer's automatic soldering machine to make brush cap attachments 2 to 3 times faster than old methods. The tandem caps are packaged on disposable reels and, since they are machine-fed, reduce work spoilage and eliminate loose-parts loss. The self-soldering machine automatically crimps, solders and cuts off the caps in one operation and completely eliminates the need for handling individual caps, open flames and soldering irons. Caps are now available in standard size from 7/32 to 1/2 in. diam and special sizes are available on request.

Patton-MacGuyer Co., Dept. ED, 15 Virginia Ave., Providence 5, R.I.

CIRCLE 109 ON READER-SERVICE CARD

35 Kmc Balanced Mixers

For Waveguide Transmission Systems

A series of millimeter wave balanced mixers has been designed for use with RG-96/U waveguide transmission systems. When used with matched pairs of 1N53 or 1N53A coaxial mixer crystals, the series provides high local oscillator noise suppression in Ka-band radar receivers over the 34 to 36 kmc range. Ratings and general characteristics of the MA-1026 series include: vswr of 1.3 max; balance of 1/2 db; cross talk of 20 db (min); and output capacity of 3 μμf (nominal). Maximum overall dimensions are 1-25/32 x 1-17/32 x 1-61/64 in.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 110 ON READER-SERVICE CARD

Crystal Oscillator

Stability of 1 Part in 10^6

Miniature packaged crystal oscillators, ruggedized for missile and other airborne applications, have the following specifications designed to provide optimum frequency control: frequency stability, up to ± 1 part in 10^6

with a frequency range of 180 kc to 50 mc; harmonic content, less than 5 per cent with an available output voltage up to 50 v peak to peak; and input voltages, 75, 150, 250 v for tube circuits and 6 to 24 v for transistorized circuits. The unit measures 1 x 1-1/2 x 4 in. These oscillators are available in the standard 7 pin plug-in type and other mountings.

Bulova Watch Co., Electronics Div., Dept. ED, Woodside 77, N.Y.

CIRCLE 111 ON READER-SERVICE CARD

RF Crystal Calibrator Diode Clips

1 Part in 10^6 Stability

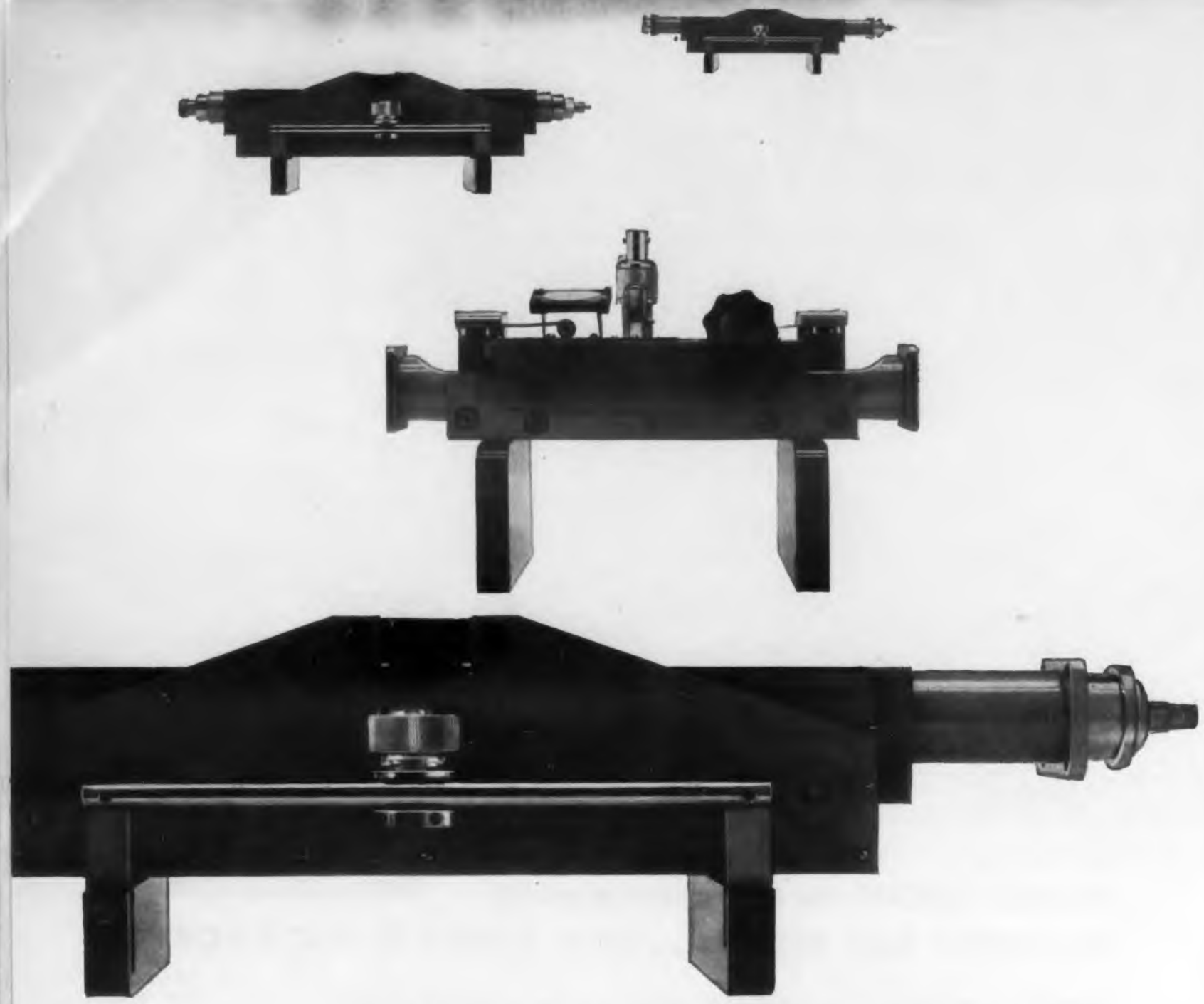
The Model 542B rf Crystal Calibrator is a compact, portable source of accurate signals at 1 mc, 100 kc, 10 kc and the respective harmonics of these frequencies. The instrument finds application in frequency measurements procedures or in the calibration of receivers and transmitters throughout the specified ranges. Provision is made for the comparison and adjustment of the basic crystal oscillator frequency to the standard frequency transmissions originating from the National Bureau of Standard's Station WWV. The heart of the Model 542B is an accurate (0.005 per cent) and stable (1 part in 10^6 per deg C) crystal controlled oscillator which is made to serve as both the generator of harmonics and a control for two stable multivibrators, one at 100 kc and the other at 10 kc.

Incorporated is a mixer and a three-stage audio amplifier to facilitate the comparison of the fundamental and harmonic frequencies of its source with external signals. The unit can utilize the mixer circuitry for comparison of two completely external signals in the range of 10 kc to 500 mc.

Metronix Inc., Dept. ED, Mill Lane, Waterford, Conn.

CIRCLE 112 ON READER-SERVICE CARD

CIRCLE 113 ON READER-SERVICE CARD ➤



FINEST, MOST COMPLETE LINE of Precision Slotted Sections

TYPICAL SPECIFICATIONS

Model	Line Size	Equivalent Wave Guide Type	Frequency Range kmc/sec	Insertion Length
200-C	7/8"		1.0 to 4.0	17"
215-A	3/8"		1.0 to 4.0	14 3/8"
203-E		RG-52/U	8.20 to 12.4	7 1/8"
210-A		RG-91/U	12.4 to 18.0	8 1/8"

For full technical details on the complete line of PRD Slotted Sections, or for consultation on the particular model best suited to your needs, call your local PRD Engineering Representative: or write to Applications Engineering Group H.

Be sure to take in the PRD Exhibit at the NEC Show, Booth 162-163.

Ready for IMMEDIATE Delivery!

Whether you are working up VSWR or impedance data in the design or testing of new transmission line components, or are designing an impedance matching device for monitoring antenna and transmission line VSWR in communications systems . . . PRD Slotted Sections provide the superlative answer for precise and accurate information with simplicity and dependability of use.

They have no equal in providing precise standing wave and impedance measurements. PRD Slotted Sections are built of precision-machined "micro-finished" transmission line.

The probe is secured to a ball-bearing carriage that travels in precision-ground, hardened grooved runways. Thus the probe travels in a path exactly parallel to the axis of the transmission line. A marked advantage of PRD Slotted Sections is their permanent adjustment, at the factory, to zero slope—there is no need for adjustment to correct for changing slope characteristics. PRD Slotted Sections are designed to mate with standard MIL type connectors and flanges. Low reflection adaptors are available where additional types of connectors are used.

The ultimate in precision measurements is achieved when PRD accessory items such as Type 250-A Broadband Probe and Type 218-K Accessory Kit are used.

POLYTECHNIC RESEARCH & DEVELOPMENT CO., Inc.

202 Tillary Street, Brooklyn 1, N. Y.

CIRCLE 114 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Test Instruments Line

For Service and Research

Three improved test instruments have been developed for immediate inclusion in the company's test equipment line. A highly sensitive dc microammeter, WV-84B, is a battery-operated vacuum tube microammeter, featuring 6 dc ranges for measuring currents from 0.0002 to 1000 μa. The WR-49B rf signal generator, a portable all-purpose radio and television service signal generator, is offered for uses requiring a modulated or unmodulated rf sine wave signal between 85 kc and 30 mc. The video test adapter, WG-306B, a plug-in adapter designed for simplified service troubleshooting in the video output stages of color TV receivers, makes it possible to inject video signals from the adapter directly into the control grid circuit of the video amplifier stages.

Radio Corp. of America, Components Div. Engineering Labs., Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

CIRCLE 497 ON READER-SERVICE CARD

High Output Pressure Pickup

±0.5 Per Cent Accuracy

A new line of flange mounted pressure transducers combines high output and small size with high accuracy of measurement. Output of the unit varies from 25 to 100 mv full scale depending on the pressure range. The minimum output is 5 mv per v of excitation; the maximum, 10 mv per v of excitation. The total weight of the unit is 7 g. The dimensions are as follows: the diaphragm diam, 1/2 in., the flange diam. 5/8 in., and the height including the terminal pins, 7/16 in. The 18-8 stainless steel unit is designed so that it may be mounted flush with the inner surface of the pressure chamber to measure fast pressure variations. Accuracy of ±0.5 per cent full scale (with hysteresis of 0.25 per cent) has been achieved. Temperatures may vary from −100 to +300 F.

Dynamic Instrument Co., Dept. ED, 28 Carleton St., Cambridge 42, Mass.

CIRCLE 115 ON READER-SERVICE CARD

AM, FM, and CW Receiver
40 to 180 Mc Range

The special purpose receiver, Type 1503, is an am, fm, and cw receiver operating in the frequency range of 40 to 180 mc.

News-Clarke, Inc., Dept. ED, 919 Jesup-Blair Dr., Silver Spring, Md.

CIRCLE 116 ON READER-SERVICE CARD

Miniature DC Motor
Continuous 1 Oz-In. Torque

Operating on 12 to 16 v dc, a motor capable of operating in dry nitrogen gas at 30 mm of mercury pressure absolute for 200 hr has been developed. This motor is rated 1/100 hp at 10,000 rpm. It draws 2.5 a at full load and 0.7 a no load, and it develops 1 oz-in. of torque in continuous duty or 1.85 oz.-in. intermittent service. Designed for missile application, it measures 1.127 in. in diam and 1.75 in. in length.

Western Gear Corp., Dept. ED, P. O. Box 182, Lynwood, Calif.

CIRCLE 117 ON READER-SERVICE CARD

Pressure Calibrator
0.05 Per Cent Accuracy

Designed either for the calibration of pressure instruments or for direct pressure measurements, this pressure standard has an overall accuracy of ±0.05 per cent up to 2500 psi, and ±0.1 per cent up to 10,000 psi. Weighing approximately 25 lb, the unit can be adapted to measure other parameters such as force, acceleration, and displacement.

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

CIRCLE 118 ON READER-SERVICE CARD

CIRCLE 119 ON READER-SERVICE CARD ➤

New Products

Triode Modulator

For Instrumentation Radar

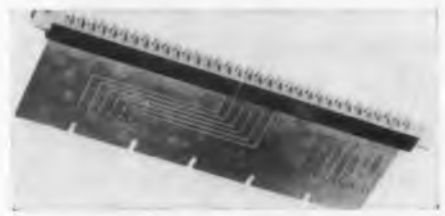
A hard tube triode modulator, the F-6920, for use in instrumentation radar, has a peak plate current and hold-off voltage of 150 a and 35 kv respectively. The unit is intended for switching applications within the range of 0.002 duty factor and 15 μsec pulse length. The anode is forced air cooled and is capable of dissipating 10 kw at ambient air temperatures of 50 C. The filament is designed to operate over a voltage range of 11 to 11.9 v depending on the peak plate current requirements. Filament current is approximately 300 a. The F-6920 has a maximum overall length of 24 in., a maximum overall width of 8 in. and an approximate weight of 60 lb.

International Telephone and Telegraph Corp., Components Div., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 121 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Connector

Measures 9-7/32 In. Long



This connector is a one piece molding of Plaskon reinforced (glass) Alkyd. The 34 contacts have 0.25 in. spacing including heavy barriers for extra protection and long creepage path. Patented Bellows Action contacts are conservatively rated to accept printed circuit board thickness of 0.054 to 0.072 in. while maintaining low contact resistance and posi-

tive spring action grip over the entire printed circuit contact area. Self-alignment of Bellows contacts allows for any residual warpage of printed circuit board. The connector accepts a board length of 8-3/4 in. An anodized aluminum shield for dissipating heat is available as an optional accessory.

DeJur Amsco Corp., Electronic Sales Div., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 123 ON READER-SERVICE CARD FOR MORE INFORMATION

14-Stage Multiplier Phototube

For Scintillation Counters

This 14-stage head-on type of multiplier phototube (RCA-6810-A) is intended for use in scintillation counters for the detection and measurement of nuclear radiation and in applications involving the measurement of low-level light sources. The tube supersedes the 6810. The spectral response of the 6810-A covers the range from about 3000 to 6500 A, with maximum response occurring at approximately 4400 A, and is, therefore, highly sensitive to blue-rich light with negligible sensitivity to red radiation.

Among its design features are a semi-transparent cathode on the curved inner surface of the face end of the bulb; a minimum cathode diam of 1-11/16 in.; a faceplate with a flat external surface to facilitate the mounting of flat phosphor crystals in direct contact with the surface; fourteen electrostatically focused multiplying (dynode) stages; a focusing electrode with external connection for shaping the field which directs photoelectrons from the cathode onto the first dynode, and an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No. 12.

Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 498 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Miniature Yokes

For 7/8 In. CRT

Miniature yokes for the 7/8 in. neck cathode-ray tubes have been developed for transistorized deflection circuits. The yokes can be supplied in a wide range of inductance and resistance for horizontal and vertical deflection coils. For high altitude and high humidity operation, yokes are manufactured with epoxy encapsulation and eight external leads. Standard units measure 2-3/8 OD x 1 ID x 1-5/8 in. long for minimum weight and space requirements.

Celco, Constantine Engineering Labs. Co., Dept. ED, 70 Island Ave., Mahwah 1, N.J.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Time Delay Relay

With Adjustable Recycling

This double head time delay relay, Model DED, provides adjustable recycling, which is accomplished by a two-way action. In addition, a separate time delay can be set on each head to allow an adjustable on and an adjustable off from 0.1 sec to 15 min. The time delay occurs in the upper portion of the unit immediately upon energization. At completion of the delay interval, a switch breaks one set of contacts and makes another. The switch remains in the transferred position as long as the control circuit is energized. Upon deenergization, the relay recycles slowly, depending upon the time delay setting of the lower timing head.

The relay is available in two types. Type DED-11, spdt, double-break, has a contact rating of 15 a at 115 v, 60 cps resistive load. Type DED-12, dpdt, single-break, is rated at 8 a per contact at 115 v, 60 cps resistive load. They are available for both ac and dc operation.

Elastic Stop Nut Corp. of America, AGA Div., Dept. ED, Elizabeth, N.J.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

TEXAS INSTRUMENTS

MILGRAY ELECTRONICS

Distributors of electronics to industry

For your magnetic amplifiers, modulators, demodulators, networks, or subminiature power supplies, Texas Instruments new diode/rectifier series – with its extremely wide 225 to 600 voltage range along with a 2 million-to-1 forward-to-reverse current ratio – will meet your exacting circuitry needs.

To see why, check these significant parameters *(match parameter title to parameter value by number)* –

maximum ratings

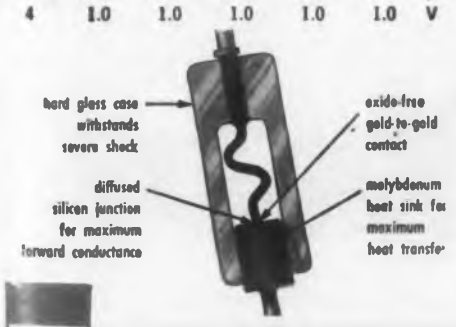
1 Peak Inverse Voltage at –65 to +150°C
2 Average Rectified Forward Current at +25°C
3 Average Rectified Forward Current at +150°C
4 Recurrent Peak Forward Current at +25°C
5 Surge Current, 1 Second DC at +25 to +150°C
6 Power Dissipation at +25°C

	1N645	1N646	1N647	1N648	1N649	Unit
1	225	300	400	500	600	V
2	400	400	400	400	400	mA
3	150	150	150	150	150	mA
4	1.25	1.25	1.25	1.25	1.25	amp
5	3	3	3	3	3	Amp
6	600	600	600	600	600	mW

specifications

1 Minimum Breakdown Voltage at +100°C
2 Maximum Reverse Current at PIV at +25°C
3 Maximum Reverse Current at PIV at +100°C
4 Maximum Voltage Drop at I_o = 400 mA; at = +25°C

	1N645	1N646	1N647	1N648	1N649	Unit
1	275	360	480	600	720	V
2	0.2	0.2	0.2	0.2	0.2	μA
3	15	15	20	20	25	μA
4	1.0	1.0	1.0	1.0	1.0	V



MILGRAY ELECTRONICS INCORPORATED

REctor 2-4400
136 LIBERTY ST., NEW YORK 6, N. Y.

CIRCLE 463 ON READER-SERVICE CARD

CIRCLE 130 ON READER-SERVICE CARD

precision circuit control demands precision indicating instruments

insure pin-point circuit accuracy with TI panel instruments

Performance relies on circuit control . . . made possible by output measuring instruments. When you use TI panel instruments, you can measure the exact output of your expertly designed equipment . . . you can *control this output for peak performance*. Regardless of the high quality, close-tolerance components in your applications, your precision circuitry is only as accurate as your indicating instruments. Rely on TI!

All TI panel instruments are built to exceed MIL-M-6A and MIL-M-10304A . . . and are accurate to within 2% or less of full scale deflection. Custom-designed instruments can be built to your closer tolerance requirements. For reliable measuring instruments with lasting calibration plus long service life, specify TI.

T/I **select from a wide choice**

movement – ac, dc, thermocouple, rectifier, elapsed time, vu, db
style – front-of-board, semi-flush, flush
enclosure – phenolic, hermetic, ruggedized
shape – square, rectangular, round, fan
case – molded phenolic, metal
size (inches) – 1½, 2½, 3, 3½, 4¼, 4½
special – any modification to your specifications

For rapid delivery of panel instruments . . . depend on Texas Instruments

WRITE FOR BULLETIN No. DL-C 631

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 312 • DALLAS, TEXAS

New Products

High Power Diode

25 Kv Max Peak Invers

A high power, high vacuum diode, designated the F-7030, for use in charging, shunt or rectifier applications, has a maximum peak inverse voltage rating of 25 kv. Under shunt conditions, maximum peak plate current of 75 a and average plate current of 200 ma are obtainable. In rectifier applications the ratings are 30 a maximum peak plate current and 6 a maximum average plate current, respectively. Tube impedance at 250 plate volts is within the range of 65-80 ohms. The external anode is forced-air cooled and is capable of dissipating 2.5 kw at 2.5 in. of water, static air pressure, and 150 cu ft per min air flow. The tube is also obtainable with the anode liquid cooled with plate dissipation ratings up to 6 kw. Filament excitation requirements are 13 and 13.75 v for rectification and shunt applications respectively at approximately 36 a. It measures 7 x 3-17/32 in. and weighs 6 lbs.

International Telephone & Telegraph Corp., Components Div., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Transformers

Transistor Impedance Matched

Two types of transformers, audio and rectifier, are available for transistor requirements. The audio transformers, ranging in size from 1/8 to cu in., are wound to match the impedances of

CIRCLE 132 ON READER-SERVICE CARD

NOW 10 MC!

New Beckman®/Berkeley Universal EPUT® and Timer... a completely self-contained unit!

Capable of direct measurements up to 10 mc—without heterodyning or requiring plug-ins—Model 7370 meets growing test instrumentation needs with the design and performance superiority characteristic of Beckman/Berkeley timer-counters, acknowledged standards of the field.

Providing three input channels, selectable time base and 7 Decimal Counting Units, Model 7370 handles every phase of counting and timing, including frequency ratio measurements. A simple switch permits the operator to select any of the following functions: "Events/Unit Time", "Period", "Time Interval Measurement", "Events/Time A-B", "Count Events", "Gate", "Events/Unit Time × 10","Period × 10","Events/Time A-B × 10","Scan", and "Test".

The EPUT function permits accurate measurement of frequencies up to 10 mc by direct counting for a precise period of time. The versatile Model 7370 also serves as a reliable secondary frequency standard. Other applications include phase measurement, telemetry, stability check, calibration of frequency or pulse generators, events timing, and ballistics, viscosity, and elasticity measurement.

For further description, design specifications, and prices of Beckman/Berkeley 7000 series EPUT meters, timers, and accessories—see following pages.

KEY FEATURES

- No meter indicators—7-place direct digital readout
- Frequency measurements at 0.1 v. rms
- Three input channels for greater flexibility, more logical operation
- 10 operating functions without plug-ins
- Small, compact, moderately priced
- 0.1 microsecond resolution

Preset Universal EPUT and Timers Models 7351 (100 kc) and 7361 (1 mc)

With their variable preset "count down" time bases, Models 7351 and 7361 Preset Universal EPUT Meters are unique multipurpose instruments. Regardless of transducer conversion factors, results may be read in direct digital form by merely selecting the proper time base. These instruments make fast, accurate measurements of time intervals of any *preset* number of periods from 1 to 10,000 over the frequency range 0 to 10 kc. They totalize a selectable sequence of events, divide frequency, function as single preset counters, generate pulses of varying frequency.
Applications include precise measurement of velocity, pressure, flow, viscosity, low and high frequency, frequency ratio and period, and tachometry.

10 MC EPUT TIMER Model 7170

The 10 mc Model 7170 EPUT Timer automatically counts and displays the number of events that occur during a precise time interval. This new instrument has been developed for applications requiring the measurement of frequencies above the range of conventional EPUT meters. Its range is from 10 cps to 10 mc. Seven Decimal Counting Units are employed to give direct readout up to 9,999,999. The time base consists of a 1 mc, oven-stabilized, crystal-controlled oscillator and a series of frequency dividers. Connections are provided for driving Berkeley digital recording and readout units.

0.1 μSEC. TIME INTERVAL METER Model 7270

The Beckman/Berkeley Model 7270 Time Interval Meter will measure elapsed time between two events to an accuracy of ±0.1 microsecond. Time intervals of 0.1 or 1 microsecond may be selected, and time intervals of 1 or 10 seconds may be displayed. Accurate timing signals are provided by a 1 mc, oven-stabilized, crystal-controlled oscillator and frequency multiplier. Externally generated timing signals up to 10 mc may also be used. The Model 7270 makes Period and Time Interval Measurements to a minimum of 0.3 microseconds and, with two independent input channels and an X10 function, performs exceedingly accurate frequency ratio measurements. The timing signals are available for external use, and four-line binary-coded information from the Decimal Counting Units is also provided.

STANDARD FEATURES
All 7000 Series Models

1. 0.1 v rms sensitivity
2. AC or DC coupling of input circuits
3. Step attenuators—trigger-adjusted noise discriminators
4. Binary-coded output with direct connection to digital printers, data converters, in-line readouts, etc.
5. Stable frequency dividers
6. Electronic reset—not relay type
7. External frequency standard input connection
8. Multivoltage accessory socket to power photocells, etc.
9. Crystal-controlled time marker output
10. Unitized modular design
11. Large, bright, direct digital readout
12. Modern all-aluminum cabinets

Portable Universal EPUT and Timer Model 5230 (100 kc)

Combines many features of the popular Beckman/Berkeley 7000 series in a new, lightweight, portable instrument to perform the functions of a counter, timer, time interval meter, EPUT meter, frequency ratio or period meter. Printed circuitry contributes to compact design, increased reliability, and low cost.

DIGITAL PRINTER Model 1452

Automatically and permanently records information from any 7000 series instrument or the 5200 portable series. Prints data in digital form on standard adding machine tape, with printer and scanner in one compact unit. May be modified to print "Time" or "Code" information simultaneously with data. Rack or bench mounted . . . available in up to eight digits . . . one printout every 0.85 seconds. Price (8-digit unit) $950.00.

Standard Universal EPUT and Timers Models 7350 (100 kc) and 7360 (1 mc)

These Beckman/Berkeley universal instruments are standard in the 7000 series. They combine high-speed electronic counting with a precision time base in multipurpose circuitry. They function as counters, timers, time interval meters, EPUT meters, frequency, frequency ratio or period meters, or as secondary frequency standards.

All 7000 series universal models have provisions for standardization against WWV and may be coupled to external frequency standards. Connections are provided for driving Berkeley digital printers, data converters, or in-line remote readout indicators.

SPECIFICATIONS & PRICES

BRIEF SPECIFICATIONS	Model 5230	Model 7170	Model 7270	Model 7350	Model 7351	Model 7360	Model 7361	Model 7370
RANGES-FREQUENCY	0 cps to 100 kc	10 cps to 10 mc		0 cps to 100 kc	0 cps to 100 kc	0 cps to 1 mc	0 cps to 1 mc	10 cps to 10 mc
TIME INTERVAL	100 μsec to 10^4 sec		0.3 μsec to 10^7 sec	10 μsec to 10^6 sec	10 μsec to 10^2 sec	1 μsec to 10^7 sec	10 μsec to 10^3 sec	0.3 μsec to 10^7 sec
PERIOD	0 cps to 10 kc		0 to 3 mc	0 cps to 100 kc	0 cps to 10 kc	0 cps to 1 mc	0 cps to 10 kc	0 to 3 mc
TIME BASES	0.1 and 1 sec	0.1 μsec to 10 sec	0.1 μsec and 1 μsec	10 μsec to 10 sec	Time Interval* Generator	1 μsec to 10 sec	Time Interval* Generator	0.1 μsec to 10 sec
CODED OUTPUT FOR DRIVING DIGITAL RECORDER, ETC.	$30.00 extra	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COUNT CAPACITY (READOUT)	4 digit	7 digit	7 digit	6 digit	5 digit	7 digit	6 digit	7 digit
ACCURACY	± 1 count, ± oscillator stability							
OSCILLATOR STABILITY	1 part in 10^4 per day	3 parts in 10^7 per week	3 parts in 10^7 per week	3 parts in 10^6 per week	1 part in 10^6 per day	3 parts in 10^6 per week	1 part in 10^6 per day	3 parts in 10^7 per week
INPUT SENSITIVITY	0.25 v. rms	0.1 v. rms	0.2 v. rms	0.1 volt rms**				A & B—0.2 v. rms E—0.1 v. rms
INPUT IMPEDANCE	1 megohm, direct	1 megohm, ac coupled	1 megohm, ac or direct coupled	10 megohm, ac or direct coupled				A & B—1 megohm, ac or direct coupled E—1 megohm, ac coupled
TRIGGER SLOPES	Positive or Negative		Positive or negative					
CABINET DIMENSIONS	12" H x 8" W x 14" D	10¼" H x 20¾" W x 16½" D (Rack Panel—8¾" x 19")						
APPROX. SHIPPING WT. LB.	30	60	60	60	50	60	50	70
PRICE: (F.O.B. FACTORY)	$575.00	$1675.00	$1675.00	$945.00	$1295.00	$1245.00	$1445.00	$1975.00

*Variable from 0.1 millisec to 0.9999 sec in 0.1 millisec increments and from 1 millisec to 9.999 sec in 1 millisec increments

**Modification for 5 millivolt sens. @ 5 cps available, $50.00 extra

IN-LINE READOUT Model 5916

Large, illuminated, in-line *in-plane* figures reduce fatigue and error. Ideal for remote observation of data. It can connect directly to any 7000 series instrument or 5200 series portable. Presentation rate up to 15 per second; accepts binary voltages. Price (6-digit unit) $775.00.

TRANSDUCERS—A large number of transducers especially designed for use with Berkeley counting, timing, and frequency measuring equipment is available. These include tachometer pickups, photocells, and light sources. Specifications and technical description on request.

See us at NEC...

For a close look at these advanced counting and timing instruments, be sure to visit Booths 241-244 at the NEC show in Chicago, October 7-9. Technical data and specifications are available from Beckman/Berkeley representatives or at the factory. Please address Dept. D9.

Beckman® / *Berkeley Division*

2200 Wright Avenue • Richmond 3, California
a division of Beckman Instruments, Inc.

Beckman® / Berkeley Representatives

Berkeley's world-wide staff of factory trained engineering representatives work closely with our sales office and the customer. They help the customer set up newly-purchased equipment, acquaint personnel with its operation and application, and make sure that it stays in operating order. The representative's job is not completed until he has "followed-up" to insure that the customer receives maximum use from his instruments. These men will be glad to give you personal assistance at any time. A list of Berkeley representatives follows.

ALBUQUERQUE, NEW MEXICO
V. T. Rupp Co.
8009 Bellamah, N.E.
Phone: Albuquerque 3-3585

ATLANTA 9, GEORGIA
Murphy & Cota
2110 Peachtree St., N.W.
Phone: Trinity 6-3020

BINGHAMTON, N. Y.
Edward A. Ossmann & Associates
147 Front St., Vestal, N. Y.
Phone: Endicott 5-0296

BOSTON, MASSACHUSETTS
Broger Instrument Sales Co.
48 Pearl St., Brookline, Mass.
Phone: Beacon 2-4804

CHARLOTTE, NORTH CAROLINA
Murphy & Cota
2036 Norton Rd.
Phone: Edison 2-7356

CHICAGO 39, ILLINOIS
Ridgway Engineering Assoc.
6100 W. North Ave.
Phone: Tuxedo 9-5715

CLEVELAND 28, OHIO
J. R. Dannemiller Assoc.
3955 Lee Road
Phone: Longacre 1-4567

DALLAS 9, TEXAS
John A. Green Co.
6815 Oriole Drive
Phone: Fleetwood 2-9918

DAYTON 2, OHIO
J. R. Dannemiller Assoc.
384 W. First St.
Phone: Hemlock 0662

DENVER, COLORADO
F. Y. Gates Co.
4910 South Huron
Englewood, Colorado
Phone: Sunset 1-8566

DETROIT, MICHIGAN
J. R. Dannemiller Assoc.
1204 North Woodward
Royal Oak, Michigan
Phone: Lincoln 8-4440

HONOLULU 17, HAWAII
Gene Piety
2030 Home Rule St.
Phone: 8-3105

HOUSTON 6, TEXAS
John A. Green Co.
P.O. Box 6445
(Fairview Station)
Phone: Jackson 6-2959

INDIANAPOLIS 2, INDIANA
Ridgway Engineering Assoc.
1606 N. Illinois St.
Phone: Walnut 5-6464

KANSAS CITY 14, MO.
Lee Mark Associates
706 E. 73rd St.
Phone: Jackson 3-9299

LOS ANGELES, CALIFORNIA
V. T. Rupp Co.
307 Parkman Ave.
Phone: Dunkirk 7-8224

MIAMI 43, FLORIDA
Murphy & Cota
11375 S.W. 46th St.
Phone: Mohawk 5-1563

MINNEAPOLIS 3, MINNESOTA
Pinkney & Hine
1925 Nicollet Ave.
Phone: Federal 8-0523

NEW HAVEN 10, CONNECTICUT
Broger Instrument Sales Co., Inc.
42 Church Street
Phone: Spruce 7-6279

PHILADELPHIA, PENNSYLVANIA
Gawler-Knoop Co.
835 Glenside Ave., Wyncote, Pa.
Phone: Waverly 7-1820

PORTLAND 14, OREGON
Hawthorne Electronics
703 S. E. Hawthorne Blvd.
Phone: Belmont 4-9375

ROCHESTER 10, NEW YORK
Edward A. Ossmann & Assoc.
830 Linden Ave.
Phone: Hillside 5-0460

NEW YORK, NEW YORK
Gawler-Knoop Co.
178 Eagle Rock Ave., Roseland, N. J.
Phone: New Jersey, Caldwell 6-4545

ST. LOUIS 17, MISSOURI
Lee Mark Associates
2683 Big Bend Blvd.
Phone: Mission 7-1470

SALT LAKE CITY 1, UTAH
Gates Company
200 South Main St.,
Phone: Elgin 9-1101

SAN DIEGO 4, CALIFORNIA
V. T. Rupp Company
3150 El Cajon Blvd.
Phone: Cypress 6-0483

SAN FRANCISCO, CALIFORNIA
Berkeley Division, Beckman Inst.
2200 Wright Ave., Richmond
Phone: Landscape 6-7730

SEATTLE, WASHINGTON
Hawthorne Electronics
107 Administration Bldg.
Boeing Field
Phone: Mohawk 3962

SYRACUSE, NEW YORK
Edward A. Ossmann & Associates
308 Merritt Ave.
Phone: Howard 9-3825

TULSA 1, OKLAHOMA
John A. Green Co.
P.O. Box 911
Phone: Riverside 2-4657

WASHINGTON, D. C.
Gawler-Knoop Co.
8732 Flower Avenue
Silver Spring, Md.
Phone: Juniper 5-7550

WINSTON-SALEM, NO. CAROLINA
Murphy & Cota
1102 Burke St.
Phone: 4-0750

CANADA

ALBERTA & BRITISH COLUMBIA
Hawthorne Electronics
107 Administration Bldg.
Boeing Field, Seattle
Phone: Mohawk 3962

MONTREAL, QUEBEC
R-O-R Associates
6201 Cote St. Luc Road
Phone: Dexter 0845

TORONTO, ONTARIO
R-O-R Associates
1470 Don Mills Rd., Don Mills, Ontario
Phone: Hickory 4-4429

particular transistor paired with the transformer. Used in audio amplifiers, they have power-handling abilities from 1 mw to 10 w. A complete circuit diagram is supplied with each transformer showing its use in transistor audio amplifiers.

The rectifier transformers operate from 110 v ac, 60 cps to deliver the low voltages needed for semiconductor power supplies. They will withstand a 1000 v rms primary to secondary breakdown voltage.

The transformers are supplied in hermetically-sealed cans using compression type, multi-lead glass headers or standard transformer terminals. They are constructed to meet the shock and vibration requirements of military specifications.

Ferrotran Electronics Co., Dept. ED, 693 Broadway, New York 12, N. Y.

CIRCLE 135 ON READER-SERVICE CARD FOR MORE INFORMATION

Quartz Crystals

High Stability Under Shock

Vibration-resistant quartz crystals for precise frequency control have been specially designed for missile and aircraft applications. They require no internal or external shock mounting. Frequency range is 20 to 150 kc. Crystals will operate through vibration frequencies of 0 to 2000 cycles at 10 g over temperature range of —65 to 105 C and maintain a frequency stability of ±0.025 per cent under actual dynamic conditions of shock, vibration and temperature as given. When smaller ambient temperature ranges are encountered frequency stability as close as ∓0.002 per cent can be achieved. Where greater frequency stability is required, temperature-controlling ovens to house these crystals and withstand the same shock and vibrations are available. At oven temperatures up to 95 C, frequency stability of ±0.001 per cent can be maintained under the conditions of shock and vibrations specified with increasing accuracy at lower temperatures.

Hill Electronic Engineering & Mfg. Co., Inc., Dept. ED, New Kingstown, Pa.

CIRCLE 136 ON READER-SERVICE CARD FOR MORE INFORMATION

‹ CIRCLE 132 ON READER-SERVICE CARD

New Products

Over-Voltage Relay

For High Altitude and Speed

For multiple generator systems and for high speed, high altitude aircraft, a hermetically sealed over-voltage relay, described as Model TD-812A, has been introduced. The relay is insensitive to high frequency vibrations in the order of 10 g to 500 cps. The unit has a selector winding to detect the generator that has gone over-voltage.

Hartman Electrical Manufacturing Co., Dept. ED, Mansfield, Ohio.

CIRCLE 139 ON READER-SERVICE CARD FOR MORE INFORMATION

Bandpass Filter

Insertion Loss of 0.15 Db

The bandpass filter, Model HFF-T-3, has an insertion loss of 0.15 db, with an input-output vswr of 1.03 in the pass band. The filter incorporates triple-tuned distributed constant networks and operates at a center frequency of 425 mc with a bandwidth of 50 mc. The unit has a power rating of 100 w and an impedance of 50 ohms. Bandpass filters with similar characteristics and center frequencies of 30 to 2000 mc are available.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N.Y.

CIRCLE 140 ON READER-SERVICE CARD FOR MORE INFORMATION

Coaxial Relay

VHF and UHF Switching

The Type K-18 relay is a spdt coaxial relay assembly in a protective housing for switching vhf and uhf at low voltage and low current. It is packaged into a box in a manner such that the installer need not manufacture his own special mounting,

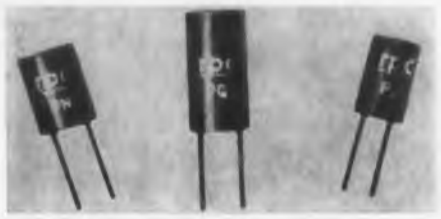
connector, and protective housing. The relay can be used for switching one antenna to a choice of transmitters or receivers, or one transmitter or receiver to a choice of antennas. The unit is normally for use in aircraft where frequencies are from 100 to 400 mc and where 24 to 28 v dc are available for actuating the relay, which pulls in at 20 v. Cross-talk factor exceeds 60 db.

Aircraft Radio Corp., Dept. ED, Boonton, N.J.

CIRCLE 141 ON READER-SERVICE CARD FOR MORE INFORMATION

Flat-Top Resistors

For Printed Circuits



The flat top, encapsulated wire wound precision Type P resistor is designed for easy, rapid mounting on printed circuit panels with no support required other than the wire leads. The resistor is a single ended, miniature series available in 7 sizes—from 1/4 in. diam by 5/16 in. long up to 3/8 in. diam by 3/4 in. long. Resistance values are to 3 megohms. Ratings from 1/10 w to 0.4 w. These units can be operated in ambient temperatures up to 125 C. Tolerances from 1 per cent to 0.02 per cent.

Resistance Products Co., Dept. ED, 914 South 13 St., Harrisburg, Pa.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Solenoid Valves

Two- and Three-Way

Two- and three-way solenoid valves suitable for manifold mounting are of forged brass with crown type seats. Valve solenoids have stainless steel cores and soft composition discs for tight closure. Each valve can be quickly removed from the manifold body without disturbing other valves or pipe connections. They may be mounted in any position without affecting operation and are suitable for handling air, gas, water, light oil, and refrigerants, up to a maximum temperature of 212 F. Pressure range is 0 to 300 psi. The 3-way valves may be changed from normally closed to normally open operation or vice versa by merely revolving the valve body 180 deg.

Automatic Switch Co., Dept. ED, Florham Park, N.J.

CIRCLE 143 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Pressurizing Window

For S-Band

This pressurizing window for the S-band, BL713, can be used on RG-48/U waveguide and UG54A/U choke flange. The frequency range is from 2600 to 3700 mc with a pressure differential of 30 psi.

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

CIRCLE 145 ON READER-SERVICE CARD

Instruments and Control Shunts

15 to 10,000 A

Mercury conduction heating equipment for shunt soldering operations creates idea soldering temperatures assuring a better bond between shunt block and manganin blades. Shunts from 15 to 10,000 a, in 50, 75 and 100 mv sizes, are available. A specially designed multi-contact calibrating machine is used to assure greatest possible accuracy, indicating to less than 1/10 of 1 per cent.

Ram Meter Inc., Dept. ED, 1100 Hilton Rd., Ferndale, Detroit 20, Mich.

CIRCLE 146 ON READER-SERVICE CARD

Printed Circuit Digital Cards

For Digital System Assembly

Eight transistorized printed circuit digital element cards may be plugged into a special mounting chassis capable of holding a total of 15 cards for rapid assembly of digital systems. Six additional logic cards are also available which, in combination with the digital element cards, form logical inter-connections for any type of computer or control system.

Comptron Corp., Dept. ED, Belmont, Mass.

CIRCLE 125 ON READER-SERVICE CARD

◀ CIRCLE 144 ON READER-SERVICE CARD

Temperature Rise Bridge

Accuracy of ±1 C

Designed for direct measurement of the temperature rise of electric motors, transformers, and similar devices, the Thermo-Bridge is essentially a special purpose bridge with a calibrated dial, reading directly in Centigrade. The unit is easily incorporated into a circuit and readings may be taken to an accuracy of ± C sec in less than 5 sec of operating time.

Dynamic Development Co., Dept. ED, 59 New York Ave., Westbury, L.I., N.Y.

CIRCLE 147 ON READER-SERVICE CARD

2-In. Rectifier Unit

Operates 115 V DC Switch

A rectifier unit to rectify 115 v 60 cycle ac to operate any 115 v dc stepping switch is available. The device will operate either a single switch or a group of switches, one at a time. Within its ratings, it may also be used to operate a relay or a group of relays. The device measures 2 x 2-1/4 x 2-5/16 in. It can be mounted on either of two surfaces by two No. 6-32 machine screws. The tapped mounting holes are on 2-in. centers.

C. P. Clare & Co., Dept. ED, 3101 Pratt Blvd., Chicago, Ill.

CIRCLE 148 ON READER-SERVICE CARD

Lightweight Molded Transformers

1/5 to 1-1/2 Lb

Ten standardized mold sizes are available for units ranging from 1/5 to 1-1/2 lb. The dimensions of Type M1, the smallest, are 1-3/4 x 1-5/8 x 2 in. The largest, Type M10, is 2-13/16 x 2-7/8 x 3 in. The units meet military specs and are available for standard and high temperature uses.

United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N.Y.

CIRCLE 149 ON READER-SERVICE CARD

CIRCLE 134 ON READER-SERVICE CARD ➤

New Products

Carbon Film Resistors
1/10 to 2 Watts

Carbon film resistors which exceed the requirements of MIL-R-105909B, characteristic B, are produced in seven sizes rated from 1/10 to 2 w. The five key types, KC60 through KC80, correspond to the five military types RN60 through RN80. Key types KC50 and KC55, rated at 1/10 and 1/8 w respectively, are smaller than the military style.

Key Resistor Corp., Dept. ED, 321 W. Redondo Beach Blvd., Gardena, Calif.

CIRCLE 151 ON READER-SERVICE CARD FOR MORE INFORMATION

Blocking Oscillator Circuits
0.1 to 5 μsec Pulse Widths

A series of six plug-in blocking oscillator circuits, covering pulse widths of 0.1, 0.2, 0.5, 1, 2, and 5 μsec and designed for triggered operation, will accept high pulse repetition frequencies. Two separate outputs are available: a positive output and a reversible positive or negative output. Each complete unit is encapsulated in epoxy resin. The tube used is a 12AU7. Where individual requirements must be met, a free engineering service is provided. This service includes the design of the pulse transformer alone or the design of the complete blocking oscillator circuit. No obligation or limitation is placed on the engineering service, and orders may be for pre-production or sample quantities.

CBC Electronics Co., Inc., Dept. ED, 2601 N. Howard St., Philadelphia 33, Pa.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

Capacitance Bridge

0 to 120 μf Measurement

This capacitance bridge was designed specifically for laboratories, production lines and incoming or outgoing inspection stations where critical measurements are required. Seven ranges are supplied, providing an accuracy of better than 0.2 per cent from zero to 120 μf. Measurement can be made to within 0.01μμf on the lowest range. Dissipation factors from 0 to 1.05 at 1 kc can be measured on the three ranges provided, and readings of 0.0001 per dial div. are available on the lowest range. The capacitance dial has 12,000 effective graduations, spaced approximately 1 mm apart.

For selecting the oscillator's frequency of operation, a single plug-in set of networks sharply peaks the gain of the generator-detector at the frequency of operation, and provides for maximum harmonic rejection. Ample gain allows null indicator sensitivity to 20 μv or less. Plug-in networks are available for any frequency of operation between 100 cps and 10 kc. The Model 270 capacitance bridge operates from a 105 to 125 v, 50 to 60 cycle power source. The bridge weighs less than 22 lb and measures 13 x 9 x 7 in.

Electro-Measurements, Inc., Dept. ED, 7524 S.W. Macadam Ave., Portland, Ore.

CIRCLE 155 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Amplifier

Regulates 60 CPS Alternators

This voltage regulator maintains output voltage of 60 cps alternators constant. The unit is a single-stage magnetic amplifier unit utilizing selenium rectifiers and wire wound resistors. It is extremely simple to install, with only six terminal connections. It works into a 20 to 100 ohm exciter field resistance without adjustment, and supplies exciter field current within a range of 0.15 to 1.35 a. It connects directly into any 208 to 240 v alternator without need of a potential transformer. When used with a 500 va potential transformer, it operates with alternators of any output voltage.

Vickers Inc., Dept. ED, 1815 Locust St., St. Louis 3, Mo.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Frequency Detector

Bands from 10 CPS to 10 Kc

This frequency detector operates directly from the transistor amplifier of a tachometer, speed meter, frequency meter, telemetering receiver, or automatic control. Designated the Magmeter Detector, this component can be driven from a push-pull class-C transistor amplifier. It develops a dc output that is linearly proportional to input frequency. The detector is made for any band from 0 to 50 cps to 0 to 10 kc. Output is independent of input waveshape and amplitude over wide ranges. Linearity is better than 1 per cent of full scale. Plug-in types are available for convenience during circuit development. Types with solder lugs are available for production equipment. The detectors are available for operation from 6, 12, or 24 v transistors.

Airpax Products Co., Dept. ED, Middle River, Baltimore 20, Md.

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

Gear Trains

3-1 to 32,400-1 Reduction

This Gear-Train Series GT-1 incorporates a completely enclosed train with 0.047 in. input shaft and 1/8 in. steel output shaft. Reductions may be provided in ratios of from 3 to 1 up to 32,400 to 1. The gearing is engineered to withstand a static loading of 5 in.-lbs and a 20 in.-oz continuous running load. The reductions are supplied with a 3/64 in. hardened steel shaft rotating in oil-impregnated sintered bronze bearings. The output shaft also rotates in bronze bearings. Intermediate gear assemblies are made of brass while the steel pinions rotate on fixed polished steel studs. At the time of assembly lifetime lubrication is applied assuring trouble free operation. The gear train is 2 in. in diam and 5/16 in. deep. The reduction can be mounted from either side through the tapped 4-40 mounting studs.

Vocaline Company of America, Inc., Bristol Motor Div., Dept. ED, Old Saybrook, Conn.

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

PROVEN RELIABILITY. Yes, KIN TEL DC amplifiers have more than 500 years' cumulative operating time. In one installation alone, they have logged an amazing record of over a million hours of stable, trouble-free operation. This kind of record is the result of stringent quality controls in every stage of manufacture ...of thorough testing and calibration prior to delivery...and of years of experience gained in the design and manufacture of thousands of chopper-stabilized DC amplifiers.

AMPLIFY MICROVOLTS WITH STABILITY. KIN TEL 111 series DC amplifiers provide unsurpassed dynamic performance, maximum stability and the lowest drift of any commercially available wideband DC amplifiers. They incorporate KIN TEL's proven chopper-amplifier circuitry and provide ten extremely precise, feedback-controlled gain ranges, plus continuously-variable gain adjustment between normal gain settings. Several feedback loops assure high accuracy, stability and uniform frequency response, unaffected by load or gain changes.

REPLACE COMPLEX, OBSOLETE CARRIER SYSTEMS. Existing carrier systems can be replaced by a KIN TEL packaged "plug-in" DC instrumentation system. These systems are complete from input transducer to output device. They provide greater accuracy and bandwidth, operational simplicity, and eliminate the capacitive balance problems of carrier systems.

WIDE CHOICE OF MODELS. The operational version of the KIN TEL DC amplifier permits the user to employ his own external feedback networks to provide up to 100% resistive or capacitive feedback around the amplifier...to obtain many desired amplifier characteristics, such as specific gains, integration, active filters, bandwidth limitations, and the generation of complex linear transfer functions. Floating input models eliminate the problem of ground loops, and are especially useful for grounded thermocouple measurements.

NATIONWIDE ENGINEERING STAFF. There are KIN TEL representatives in every major city. An experienced application engineer is always available to assist in solving your needs, and to prepare a detailed proposal.

FAST DELIVERY. KIN TEL offers immediate delivery from stock on reasonable quantities of standard amplifiers. Call the KIN TEL representative nearest you for information, or write us direct.

Six standard amplifiers in compact 19-inch rack mountable module – ideal for multiple channel installations.

model 111BF DC Amplifier

Gain (Phase Inverting)...Steps of 0, 20, 30, 50, 70, 100, 200, 300, 500, 700, 1000 with continuous variation between steps by potentiometer.
Gain Accuracy....±1%, DC to 2 KC; 3 db down at 40 KC.
Input Impedance.....100,000 ohms.
Output Impedance....Less than 1 ohm in series with 25 μh.
Equivalent Input Drift.....±2 μv.
Equivalent Input Noise....0 to 3 cps, less than 5 μv peak to peak. 0 to 750 cps, less than 5 μv RMS. 0 to 50 kc, less than 12 μv RMS.
Chopper Intermodulation.....Less than 0.1%.
Maximum Output Cable Capacity.....1.0 μf (external).
Linearity.....Better than 0.1% to 2 KC.
Output Capability.....0 to 35V where Rl> 1000 ohms. 0 to ±40 MA where Rl is 10 to 400 ohms.
Frequency Response.....0.3 db (±3%) DC to 10 KC, less than 3 db down at 40 KC.
Rise Time.....Less than 10 μ sec.
Phase Shift.....Less than 5° to 2 KC.
Overload Recovery Time.....Less than 3 sec.
Dimensions:
Amplifier Unit.....2⅞" wide, 7⅝" high, 14⅝" deep.
Unit in Cabinet.....5-7/16" wide, 10" high, 18¼" deep.
Rack Adaptor Module for 6 Amplifiers.....19" wide, 8¾" high, 18¼" deep.
Power Requirements:
Amplifier.....117V (105-125V), 60 cycles, 70 VA.
Cabinet.....117V, 60 cycles, 15 VA.
6-Unit Module.....117V, 60 cycles, 45 VA.
Net Weight (Amplifier).....11 pounds.
Price: Amplifier.....$575.00*
Cabinet, with fan and connector.....$105.00
6-Unit Module, with fans and connectors....$200.00

Amplifier must be operated in Module or Cabinet

5725 Kearny Villa Road
San Diego 12, Calif.
Phone: BRowning 7-6700

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Arkansas	E. Lipscomb Assoc., Dallas, Texas, FLeetwood 7-1881
California	North Hollywood: Neely Enterprises, STanley 7-0721 Sacramento: Neely Enterprises, GIlbert 2-8901 San Carlos: Neely Enterprises, LYtell 1-2626 San Diego: Neely Enterprises, ACademy 3-8106
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Indiana	Crossley Associates, Inc., Indianapolis, Indiana, CLifford 1-9255
Iowa	Eastern: Crossley Associates, Inc., Chicago, Illinois, SHeldrake 3-8500 Western: Crossley Associates, Inc., St. Paul, Minn. Midway 5-4955
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Nevada	Northern: Neely Enterprises, Sacramento, Calif., Gilbert 2-8901 Southeastern: Neely Enterprises, North Hollywood, California, STanley 7-0721
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New Jersey	Northern: RMC Associates, Bogota, New Jersey Diamond 3-5926 Southern: I. E. Robinson Company, Asbury Park, New Jersey, KEllogg 1-3150
New Mexico	Albuquerque: Neely Enterprises, Phone: 5-5586 Las Cruces: Neely Enterprises, JAckson 6-2486
New York	New York City: RMC Associates, New York City, TRafalgar 9-2023 Southeastern: Yewell Associates, Bridgeport, Conn., FOrest 6-3456 Northwestern: J. D. Ryerson Associates, Inc., Syracuse, New York, GRanite 6-8344
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Oregon	ARVA, Portland, Oregon, CApital 7-1281
Pennsylvania	Eastern: I. E. Robinson Company, Upper Darby, Pennsylvania, FLanders 2-7017 Central: I. E. Robinson Company, Camp Hill, Pennsylvania, REgent 7-6791 Western: H. E. Ransford Company, Pittsburgh, Pennsylvania, TUxedo 4-3425
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Wyoming	Lahana & Company, Denver, Colo., PEarl 3-3791

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Oscilloscope

Improved Synchronization

Smooth, automatic trigger synchronization by the vertical input signal over the whole pass band from less than 10 cps to more than 10 mc are features in the latest improvement of the Model 411A oscilloscope. Synchronization is attained by the use of a single control and is independent of positioning or amplitude adjustments. Vertical amplifier sensitivity is 20 mv/cm of display with a pass band of dc to 10 mc. Sweep speeds range from 0.1 μsec/cm to 0.1 sec/cm. Diversification of the instrument is obtained through the use of several plug-in units. For example, one unit introduces trigger delays between 1 μsec and 0.1 sec. Other plug-ins are a dual trace video switch, a TV trigger shaper, and a long sweeps generator.

Laboratory for Electronics, Inc., Dept. ED, 75 Pitts St., Boston 14, Mass.

CIRCLE 162 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Amplifier

Controls Low Power Devices

This miniaturized magnetic amplifier offers high gain and fast response which is achieved in the single stage unit by operating at a supply frequency of 5000 or 3600 cps. The amplifier is suitable for controlling low power output devices such as hydraulic servo valves. The amplifier characteristics are such that a complete high performance electro-hydraulic servo loop can be achieved without the use of additional amplifying elements. The magnetic amplifier is supplied with dual input windings to facilitate signal mixing. Additional control windings can be furnished. These units may be cascaded if necessary for additional gain. A static converter from 400 to 5000 or 3600 cps is available from the manufacturer.

Magnetic Amplifiers, Inc., Dept. ED, 632 Tinton Ave., New York 55, N.Y.

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

SPECIFY

Chassis-Trak

ROLLER BEARING
CABINET
SLIDES

New Chassis-Trak roller bearing slides make your electronic equipment more accessible . . . faster and easier to service. Chassis Trak's ultra thin design, wider bearing rollers support up to 175 lbs. with chassis extended. Rollers assure permanent, smooth slide operation.

PLUS:

- Ultra thin slide design (.350") for maximum use of cabinet interior
- Permanent, dust-repellent, dry lubricant finish
- High corrosion resistance
- Easy installation
- 8 stock lengths, standard width
- Push button emergency chassis removal

WRITE: DEPT. 2ED

Chassis-Trak, Inc.

525 S. WEBSTER AVENUE
INDIANAPOLIS 19, IND.

CIRCLE 165 ON READER-SERVICE CARD

Power Factor Correction Coils

For 400 CPS Lines

A series of power factor correction coils for reducing capacitive current in filtered power lines of screen rooms has been introduced. Correction is usually necessary when 400 cps (or higher) power line frequencies cause an excessive reactive-capacitive load component to be applied to the generator. Since screen room filters apply a fixed capacitive reactive load to the power line, there is a possibility of no-load current problems when high attentuation is required in the range of 14 kc to 100 mc due to the large capacitive component. If the power source has enough reserve to furnish this additional reactive current, there is no difficulty. On the other hand, if the course is limited, power factor correction coils must be employed to cancel the undesired capacitive-reactive load component.

Filtron Co., Inc., Dept. ED, Flushing 55, N.Y.

CIRCLE 166 ON READER-SERVICE CARD FOR MORE INFORMATION

Ultrasonic Cleaning System

For Small Precision Parts

This three stage ultrasonic cleaning system washes, rinses, and dries transistor parts, precision valve parts, bearing assemblies, lapped surfaces, instrument parts, and potentiometers. With its accessories, it constitutes a complete cleaning system and can be used with almost any combination of solvents. High frequency permits removal of contaminating particles down to a few microns in size. The unit features stainless steel lift-out transducer cleaning chambers, parts holding baskets and covers. It is finished in gold alumilite and is the smallest in the WC series of wash-rinse-dry ultrasonic units. Operating at about 35 w at a frequency of one mc, the units provide suitable power for such applications as dispersion, degassing, agitation, chemical reaction study, and aging experiments.

McKenna Labs., Dept. ED, 2503 Main St., Santa Monica, Calif.

CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

I say it's Venus!
I say it's Mars!

Thomas & Skinner says: This is a hell'uva way to run a space ship!

But we're not blaming the space crew — just the engineer who designed the highly complex astral navigation equipment. He didn't know about T & S's new, exclusive *three-phase* laminations . . . which offer *balanced voltages in all three phases* and *completely eliminate third harmonics.*

These compact laminations are now available in standard production sizes . . . for 400-cycle applications, 4 mil thicknesses with leg widths from 1/4 to 7/8 inches . . . for 60-cycle applications, 14 and 18.5 mil thicknesses with leg widths from 1.2 to 3.6 inches.

This is just one more reason why you can depend on T & S for all your magnetic material needs . . . for permanent magnets . . . wound cores . . . laminations . . . and SiFeMag tapes.

SPECIALISTS IN MAGNETIC MATERIALS

Permanent Magnets · Magnetic Tapes · Laminations · and Wound Cores

Thomas & Skinner, Inc.

1157 East 23rd Street, Indianapolis 7, Indiana

CIRCLE 168 ON READER-SERVICE CARD FOR MORE INFORMATION

Measuring Receiver
100 Db Range

A laboratory receiver, Type 2000, operates in effect as a linear voltmeter having a 100 db range in 20 db steps. The receiver contains an output meter which has a logarithmic scale calibrated between 1 and 10. An i-f gain control and a 20 db step attenuator in this receiver permits the microvoltmeter to be set at any desired full-scale range from 10 μv to 0.1 v. Audio frequency circuits in the receiver permit oral monitoring of both am and fm transmission. An output is provided for connection to an Esterline-Angus 1 ma recorder and has provisions for making either linear or compressed scale (log) recordings of signal input. The power supply is self contained and operates from a 115 v ac, 50 to 60 cycle power source. The receiver is supplied in a cabinet and the panel is a light blue smooth finish.

Nems-Clarke, Inc., Dept. ED, 919 Jesup-Blair Drive, Silver Spring, Md.

CIRCLE 99 ON READER-SERVICE CARD

Cathode-Ray Recording Oscillograph
16 Channels, up to 100,000 CPS

A recording oscillograph, which can record simultaneously up to 16 channels of phenomena at frequencies as high as 100,000 ps with exceptional clarity on a single 8 in. wide record, is now available. The CR-1B oscillograph uses eight dual-gun, cathode-ray tubes. Traces developed across the faces of the tubes are sharply focused by the optical system and recorded on photographic film or paper. Eight speeds, from 3 to 400 in. per sec, may be selected through front-panel push-buttons, which actuate separate magnetic clutches. No gear or pulley changes are required. Continuous 400-ft records can be run, or shorter records from 1 to 50 ft long can be taken automatically by means of a preset length selector. Standard commercial film and paper are used. The unit is 48 x 65 x 27 in. and weighs 1500 lb.

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

CIRCLE 100 ON READER-SERVICE CARD

◀ CIRCLE 101 ON READER-SERVICE CARD

Transistorized Electrocardiograph

Weighs 18 Lb

This direct-writing Model 300 electrocardiograph weighs 18 lb complete, as compared to about double the size and 32 to 36 lb weight of other comparable instruments. Three vacuum tubes and a dozen transistors and diodes are used in the circuit, which records fractional mv action potentials of the heart as a permanent tracing on a strip chart, by means of a recording galvonometer. A three-stage vacuum tube input amplifier drives a three-stage transistor amplifier, which uses pairs of 2N104's, 2N108's and matched 2N156's from which the galvanometer power is taken. All amplifier circuitry is contained on plug-in printed wiring panels, to facilitate any servicing that may be necessary. The power supply uses selenium and germanium rectifiers, and both high and low voltage outputs are regulated.

Sanborn Co., Dept. ED, Waltham, Mass.

CIRCLE 174 ON READER-SERVICE CARD FOR MORE INFORMATION

Differential Transformer

2 Mv Null Voltage

This linear transducer meets specifications for a null voltage of less than 2 mv. Frictionless, with no sliding or bearing surfaces, the differential transformer makes possible simple, reliable, low-impedance circuitry. The unit, measuring 7/8 in. long with 7/8 in. OD, has a coil designed for an armature range of ±0.02 in. Output, from two series aiding secondaries to a transistorized amplifier, is linear within 0.1 per cent. Input is 6.3 v at 400 cps. Continuous operation at any temperatures up to 400 F is assured by use of glass impregnated melamine bobbin, silicone vacuum impregnated coil, and teflon insulated wire. The case is cut with micrometer threads (40 per in.), which permit precise positioning after installation.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

CIRCLE 175 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Power Control Systems

Minimize System Downtime

These control systems for the application of power and protection of electronic equipment are constructed to minimize downtime for the entire system. They contain the following features: automatic application and removal of power, gradual increase of filament voltage, sequencing of dc voltages, voltage and temperature monitors, indications and alarms for quick trouble shooting, detection of power line transients, and automatic or manual marginal checking for the detection of weak components.

Dynamic Controls Co., Dept. ED, 1955 Massachusetts Ave., Cambridge, Mass.

CIRCLE 178 ON READER-SERVICE CARD FOR MORE INFORMATION

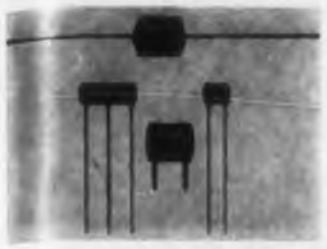
Telemetering and Control Terminals

Dual-Channel

These self-contained units are designed for telephone lines or cables with up to 20 db attenuation between associated transmitter and receiver. When keyed by switches for control applications or pulse-width signaling transducers for metering, the Model 55 transmitter provides two independent signaling tones in the frequency range 2.8 to 100 kc. The plug-in relays can control up to 1 hp motors without the need for auxiliary contactors. The stable plug-in networks permit channel spacing closer than 1.5 per cent in frequency. This makes available more than 200 separate control channels over one telephone line using frequencies between 3 and 100 kc without interfering with the use of the line for normal voice communication. Their design objective has been toward simplicity, versatility, and low initial and operating cost to make them especially suitable for use where it is desired to control a few functions initially but where future expansion of the system is expected.

Moore Associates, Dept. ED, 2628 Spring St., Redwood City, Calif.

CIRCLE 179 ON READER-SERVICE CARD FOR MORE INFORMATION



Axial Wirewound Resistors

Tension Free Windings

Wirewound resistors featuring tension-free windings are now available with axial leads. The tension-free windings practically eliminate resistance drift with age and shorts or opens. For maximum strength, resistive elements are welded to wire terminals, and welds are protected by cones of epoxy plastic cast to the ends of bobbins. The units are available in standard resistance ranges of 150 K to 8 megohms over an ambient temperature range of −55 to +85 C. Windings are coated and filled with a resin-base varnish to permit normal operation under conditions of high humidity.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

CIRCLE 180 ON READER-SERVICE CARD FOR MORE INFORMATION

AVC Amplifier

Constant Output ±1 Db

An automatic volume control amplifier which maintains a constant output within ±1 db with input changes of 30 db has been developed. Exceedingly rapid automatic gain reduction prevents syllable clipping, and slow automatic gain increase avoids automatic control at syllabic frequencies. The AVC Amplifier basically consists of a two stage push-pull circuit. The input may be connected directly either to a balanced 600 ohm line (with either or neither side grounded), or it may be bridged across a 600 ohm line without upsetting line impedance.

Its frequency response is rated at ±1 db from 20 to 20,000 cps. It has an overall gain of 35 to 38 db with a signal-to-noise ratio or 60 db. Its rated power output is 6 mw at 2 per cent total distortion. Maximum distortion is less than 5 per cent under conditions of full 30 db compression. An adjustable gain reduction and gain increase speed control enables variation in its attack and release timing. Equipped with a self-contained power supply which is designed for 110/220 v, 50/60 cycles with a power consumption of 30 w, it is housed in a ventilated and shielded cabinet designed for standard rack-panel mounting. It is 19 x 7 x 8-3/4 in.

Amplifier Corp. of America, Dept. ED, 398 Broadway, New York 13, N.Y.

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Coaxial Cable Connector

Snap-Lock

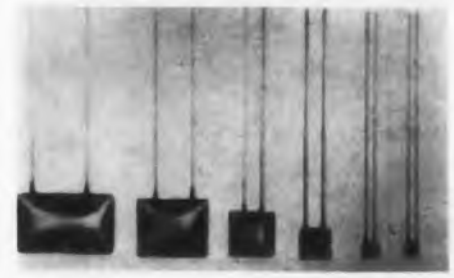
The sub-miniature snap-lock coaxial cable connector and mating receptacle is available in 50, 75, and 95 ohm sizes. This design of coaxial cable plug is spring loaded and snaps into position to engage its special receptacle firmly. The plug cannot be removed by pulling on the cable, or by vibration, but only by sliding the knurled sleeve toward the cable end. These connectors will withstand a temperature range of −70 to +550 F and shock of 100 g on any axis. Vibration at 5 g from 10 to 20,000 cps.

Automation-Engineering Corp., Dept. ED, 723 Sonora Ave., Glendale 1, Calif.

CIRCLE 184 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Ceramic Capacitors

47 μμF to 0.1 μF



A ceramic capacitor, maintaining 90 per cent of room temperature capacitance at critical temperatures up to 150 C and down to −55 C, is offered through the full RETMA decade of capacitance ratings from 47 μμf to 0.1 μf. The smallest measures 0.1 x 0.1 x 0.1. Rated voltage is 100 to 200 wvdc, with up to 1000 wvdc.

National-El Ray Corp., Dept. ED, North Hollywood, Calif.

CIRCLE 185 ON READER-SERVICE CARD FOR MORE INFORMATION

CRT Adapter

For Testing Color TV

A CRT adapter for testing and rejuvenating color TV and 110 deg picture tubes is designed for use

with all the Models 400 and 350 CRT's in the field. The C40 tests each gun of the color picture tube separately for continuity, inter-element shorts, opens or leakage and checks each gun for emission and cut-off voltage. By comparing the emission readings of red, green, and blue guns, difficult color troubles can be isolated and detected. If the emission of one color gun is low, that gun can be rejuvenated. Life or slump test indicates variation between color guns which will cause difficulty in color response. The adapter weighs only 1 lb.

B & K Manufacturing Co., Dept. ED, 3731 N. Southport Ave., Chicago 13, Ill.

CIRCLE 186 ON READER-SERVICE CARD FOR MORE INFORMATION

Codes for Digi-Coder

Three New Outputs

Three more code outputs with the Digi-Coder, the manufacturer's shaft position analog-to-digital converter, are available. With these new codes, a Digi-Coder can convert angular position into digital output in the form of: degrees and tenths of a deg with a full scale capacity of 0 to 359.9 deg and through zero; any part of a 24-hr time cycle, expressed in hr and min; and an 8-channel Teletype or Flexowriter code. These new codes are in addition to the decimal, binary, binary-coded decimal, and 5-channel Teletype codes presently available.

Fischer & Porter Co., Dept. ED, 94 Jacksonville Rd., Hatboro, Pa.

CIRCLE 187 ON READER-SERVICE CARD FOR MORE INFORMATION

Coaxial Connector

Push-Button Disconnect

Rf coaxial connectors with a built-in push-button disconnect switch permit quick disconnect without the necessity of removal of cable from the assembly. The hermetically sealed 50-ohm rf connectors are available with type N or HN hermetically sealed coaxial receptacles. In the off position, the isolation exceeds 60 db down from 500 to 5000 mc, and 30 db down from 5000 to 10,000 mc. The unit weighs 0.6 oz.

Don-Lan Electronics Co., Dept., ED, 1101 Olympic Blvd., Santa Monica, Calif.

CIRCLE 188 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Pulsating Relay

Contact Burning Eliminated

Incorporating a variable multivibrator driving one or more mercury-wetted contact relays, the F-2C Flasher provides rate control of pulsation and eliminates the burning of contacts. Sturdiness of the mercury relay is attested to by the manufacturer, who rates its operation in the billions before failure is anticipated. One feature is that the circuit is completed through a resistance, so that if the relay is used to flash an indicator, the indicator will stay lit despite relay malfunction.

General Electronic Corp., Dept. ED, 17 Madison Ave., Montgomery, Ala.

CIRCLE 190 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Low Pass Filter

Insertion Loss of 0.75 Db

This 400 mc low pass filter, using air dielectric trimmer capacitors, measures 1 x 1 x 4 in. The filter combines low maximum insertion loss from 200 to 400 mc of 0.75 db with rapid attenuation above the passband. Minimum attenuation above 450 mc is 45 db; and at 1000 mc, 60 db. Maximum rated power handling capacity of the miniature filter is 100 w. Passband swr is 1.5:1, and input and output impedance are both 50 ohms.

Radio Condenser Co., Dept. ED, Davis & Copewood Sts., Camden 3, N.J.

CIRCLE 191 ON READER-SERVICE CARD FOR MORE INFORMATION

Potentiometer

2 In. Diameter

A high resolution 2 in. diam potentiometer has been developed with a small diameter cylindrical

Kohlrausch resistance element enclosed in slim, one piece housing molded of glass reinforced Alkyd.

Series HP-200 can be supplied singly or as multiple ganged units. Mountings include piloted servo or three tapped holes. Power dissipation is 3 w. Mechanical rotation is 360 deg. Up to 16 taps can be provided, depending on spacing. Precious metal brush, collector and tap contacts, together with hard gold plated terminals and slip rings are standard design features.

DeJur-Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 192 ON READER-SERVICE CARD FOR MORE INFORMATION

Non-Resonant Inverter

Over 75 Variations

The Syncroverter Switch, a precision, non-resonant inverter, is available in over 75 optimized variations in contact ratings, vibration and shock resistance, and frequency ranges for low power and dry circuit applications. Mounting arrangements to meet particular conditions are offered, including standard 7-pin plug-in bases or solder lug connectors with mounting flanges. The chopper can be furnished in either spdt or dpdt switching action.

The Bristol Co., Dept. ED, Waterbury 20, Conn.

CIRCLE 193 ON READER-SERVICE CARD FOR MORE INFORMATION

Weather Proof Housings

Cast-Aluminum

Cast-aluminum weatherproof housings with clear glass windows provide easy visual inspection of the housing interiors. Housings can be supplied with clear plastic windows. The hinged-type cast-aluminum housing illustrated is an enclosure for a refinery installation. The 6 x 6 glass windows allow easy visual access to the ammeter mounted within the housing.

Adalet Manufacturing Co., Dept. ED, 14300 Lorain Ave., Cleveland 11, Ohio.

CIRCLE 194 ON READER-SERVICE CARD FOR MORE INFORMATION

The CTC family of kollet knobs, taking, from left to right, a ⅛" shaft only, a ⅛" to ¼" shaft, and a ¼" shaft only.

Three who'll dress to please you

CTC's family of kollet knobs is carefully made of prime materials, as are all CTC components. And they have this added feature, being in the open as they are: They're good-looking and adaptable.

Made of molded Tenite II in matte finish their metal face plates snap into place, completing the design and covering the kollet locking device. You have a choice of ten color inserts for instrument panel coding, and can have the knobs with or without skirts or indicating lines.

Reliability is the key characteristic of every component CTC makes. Every component is unconditionally guaranteed in quantities from one to millions. Other CTC components include coil forms, coils, terminal boards, terminals, diode clips, insulated terminals and hardware.

For sample specifications and prices, write now to Sales Engineering Dept., Cambridge Thermionic Corporation, 457 Concord Ave., Cambridge 38, Mass. West Coast stocks maintained by E. V. Roberts Associates, Inc., 5068 West Washington Blvd., Los Angeles 16, and 61 Renato Court, Redwood City, California.

CTC Panel Hardware meets or betters government specifications. Typical quality hardware shown: oval handle, adjustable handle, folding handle, thumb screw, plug and jack, shaft lock. Other quality hardware includes battery clips, terminal boards, diode clips, dial locks. Variety of finishes available.

CTC

CAMBRIDGE THERMIONIC CORPORATION

makers of guaranteed electronic components
custom or standard

CIRCLE 195 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

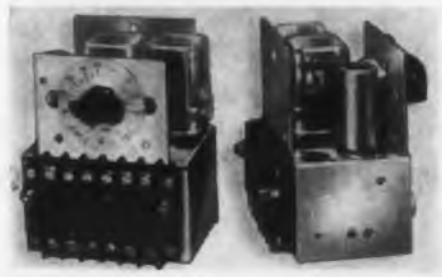
Teflon Wire
Adhesive

A Teflon insulated flexible lead wire that has had its surface treated with sodium will provide adequate adhesion with impregnated and casting materials. Heretofore, the lack of adhesion caused serious moisture paths, which greatly degraded the hermetic seal. The treated Teflon wire exhibits the same thermal and electrical characteristics as conventional Teflon insulated conductors. Pilot production runs indicate that it is now possible to provide the new lead wire in all the available color codings.

Hitemp Wires Inc., Dept. ED, 1200 Shames Dr., Westbury, L.I., N.Y.

CIRCLE 196 ON READER-SERVICE CARD FOR MORE INFORMATION

Electronic Timer
Multiple Functions



The CK Electronic Timer, Model 120, provides all the features found in over 40 timers designed and developed for special applications. These special features include: stop-motion control by means of an external control switch that discharges the timing condenser; self-reset timing with several units in sequence by hold-in of load relay; momentary-start with non-repeat, self-reset feature; sustained starting with immediate reset on opening of start switch; emergency timing-out in middle of time cycle to permit delay circuit conditions; adjustable timing between fixed pulses, repeat-cycle timing; dc starting relay to permit use of 115 v, 25 to 400 cps; load contacts isolated from timer and line circuits; two sets of spdt 8 a contacts, one set to operate at start, one set at end of time delay; identical enclosed plug-in dc relays for reliability and easy servicing. Eight time ranges are available, namely 0.2, 0.5, 1, 3, 6, 12 or 24 sec.

Farmer Electric Products Co., Inc., Dept. ED, 2300 Washington St., Newton Lower Falls, Mass.

CIRCLE 197 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulse Generator
1.6 to 10.4 Mc

This pulse generator, Type 1050, operates in the range from 1.6 to 10.4 mc. The unit produces half sine wave voltage pulses continuously variable over its operating range in four overlapping frequency bands. The generator is equipped with amplitude and pulse duration controls and an output pulse polarity switch. The output amplitude is adjustable from 1 to 30 v and the pulse duration may be selected from one of five different widths ranging from 0.03 to 0.07 μsec. The generator is mounted with its own power supply in an individual cabinet, but can be mounted in a standard 19 in. relay panel rack.

Burroughs Corp., Electronic Instruments Div., Dept. ED, 1209 Vine St., Philadelphia 7, Pa.

CIRCLE 198 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency Meter
200 to 2400 Mc

A series of direct reading uhf detectors cover the frequency range from 200 to 2400 mc. The models are absorption-type frequency meters with very low insertion loss. Each instrument includes a resonant cavity, coaxial switch, crystal detector, current meter, sensitivity control, and Type N input and output terminals. The input signal causes a meter deflection approximately proportional to the signal level. Frequency is indicated on the direct reading dial by a sharp dip in meter reading when the cavity dial is tuned to resonance. Alternatively, the instrument may be inserted in a transmission line and the resonant dip may be detected in the external circuit. In this manner the meter may be used as a high-Q absorption marker when used with fm signal generators. Continuous coverage in frequency measurements from 200 to 18,000 mc is now provided by these units, Models 804, 805, and 806, in conjunction with previously announced Models 802 and 809 through 812.

The Narda Corp., Dept. ED, 160 Herricks Rd., Mineola, N.Y.

CIRCLE 199 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Thermocouple Reference Junction
48 Channels

The series of bridge stabilized thermocouple reference junctions provide a controlled temperature reference for multi-channel thermocouple measurements, with precision beyond the capabilities of ice bath and cold junction compensators now in general use. Up to 48 channels are available in cabinet or rack-mounting standard models. Also available in standard models are three-wire junctions allowing a choice of thermocouple materials in each channel. Long-term temperature stability within 1/5 F is achieved with an integral resistance bridge temperature sensing system and magnetic-amplifier controlled heater. The reference temperature may be set to any specified level from 25 deg above ambient to 250 F; thermocouple tables are available for the standard temperature of 150 F. The unit weighs 25 lb, measures 10 x 10 x 15 in., and operates from the 115 v 60 cps line.

Pace Engineering Co., Dept. ED, 6914 Beck Ave., North Hollywood, Calif.

CIRCLE 201 ON READER-SERVICE CARD FOR MORE INFORMATION

VHF-UHF Sweep Generator
15 to 400 Mc

The Model SG-132 combines all the essential features of a standard cw and a-m signal generator and a wide sweep generator. Among its many applications are testing and aligning vhf-uhf communication receivers, measuring sensitivity, selectivity, image rejection and gain of receivers, i-f amplifiers, broadband amplifiers, TV, and other equipment. It offers a very wide sweep width—40 per cent of the center freq, from 15 to 400 mc, with a dial accuracy 0.01 per cent crystal corrected. The output, which is entirely fundamental (not beat-freq oscillators), is calibrated from 0.1 to 150,000 μv throughout the freq range. Output varies less than ±0.2 db over the entire range. The equipment also has an integral dc coupled oscilloscope.

Transitron, Inc., Dept. ED, 186 Granite St., Manchester, N.H.

CIRCLE 202 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Relay Test Set

For Polar Relay Adjustment

The Model 4501 Relay Test Set permits five separate testing and adjustment measurements to be made on high speed polar relays of the type commonly used in pulse equipment, such as computers and teletypewriters. The operations it performs are: measurement of trip or operate currents manually; automatic indication of trip currents, for making adjustments; measurement of contact bias and percent-break, under various operating conditions; and application of 500 v rms ac hipot between coils and frame. All tests except hipot may be made on either or both coils of dual coil relays. Hipot is applied to both coils simultaneously. Terminals are also provided for connecting an external drive directly on coils, and for connecting an oscilloscope for observing contact performance during bias and break tests.

Sigma Instruments, Inc., Dept. ED, 47 Pearl St., So. Braintree 85, Mass.

CIRCLE 209 ON READER-SERVICE CARD FOR MORE INFORMATION

Null Indicator

For Relay Rack Mounting

This null indicator for dc bridge measurement is designed for mounting on any standard 19 in. telephone relay rack. Designated as Model 2HG-1R, this instrument retains all the performance features of the portable Model 2HG-1P. Either instrument may be used as a null balance detector or for linear deflection measurements. Both instruments utilize a contactless magnetic converter to provide complete input isolation and extra immunity to power frequency interference. Performance characteristics include: a sensitivity less than 2 μv per division; an input circuit which may be as much as 500 v dc above ground; a low noise level with less than 2 μv equivalent input; high stability where zero drift is less than 1 division per hr after warm-up. Moreover, linearity over full scale range is ±5 per cent. The unit can withstand inputs up to 10 v dc and momentary overrange of up to 45 v dc.

Minneapolis-Honeywell, Boston Div., Dept. ED, 1400 Soldiers Field Rd., Boston 35, Mass.

CIRCLE 210 ON READER-SERVICE CARD FOR MORE INFORMATION

Thermocouple Vacuum Gage

Battery-Operated

Designated TG-025, this single-station, panel-mounted thermocouple vacuum gage operates on two size D flashlight batteries contained within its housing. Two terminals are provided on the bottom of the instrument for connection to an external battery power supply. A range of from 0 to 1000 microns Hg of dry air pressure is covered on one non-linear scale, with 5 microns the smallest indicated marking. The pressure range from 0 to 60 microns Hg extends over more than half of the entire scale. The gage is equipped with an all-metal sensing tube and is not harmed by exposure to atmospheric pressure. Low heater current reduces zero drift by decreasing the rate of thermal decomposition of organic vapors. The gage is also operable as a moderately sensitive leak detector in the range from 1 to 1000 microns Hg.

Consolidated Electrodynamics Corp., Rochester Div., Dept. ED, 1775 Mt. Read Blvd., Rochester 3, N.Y.

CIRCLE 213 ON READER-SERVICE CARD FOR MORE INFORMATION

Forced-Air Cooled Triode

2 to 5 Kw Output

This transmitting tube, ML-6623, for power amplifiers and oscillators in the 2 to 5 kw power level is particularly suitable for induction heaters in this power range. Brazed radiator construction is used to prevent anode hot-spotting and its unwanted effects. Quick final seal-in by rf heat provides a contaminant-free stress-free tube. Maximum ratings of 5 kv plate voltage and 5 kw plate input apply at frequencies to 30 mc. A large radiator reduces air-flow requirements to 150 cfm at 0.9 in. water for full dissipation. Low power thoriated tungsten filament operates at 6 v, 60 a.

Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.

CIRCLE 214 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Power Supply

Current Regulated

A current regulated power supply which will maintain the output current at a set value regardless of a change in the resistance of the load has been developed. The output of the supply is variable from 2 to 10 a, 0 to 100 v. Ripple is less than 0.5 per cent peak. The supply will maintain current within 1 per cent for a 50 per cent change in load resistance. The current regulated supply is useful for exciting focus coils and electromagnets or any application where it is desirable to maintain a constant current.

Jobbins Electronics, Dept. ED, 771 Hamilton Ave., Menlo Park, Calif.

CIRCLE 216 ON READER-SERVICE CARD

L-Band Slotted Line

Low Level Radiation

L-Band slotted section, Model OXZ-L, covers the entire L-Band frequency range of 1120 to 1700 mc. Accurate probe travel along the length of the slot is assured by employing 4 hardened and precision ground ways on both sides of the waveguide body. Radiation from the slot and carriage assembly is held to a very low level by the design of both the slot and the carriage. The line is designed to accommodate many of the presently available probe assemblies.

Omega Labs., Inc., Dept. ED, Rowley, Mass.

CIRCLE 217 ON READER-SERVICE CARD

Duplex Cycling Timer

1/4 Per Cent Repeat Accuracy

The Type 742 duplex timer can control the operation of process work equipment, regulate both idle and operating time on a wide variey of production machinery, or perform a large number of in-plant functions automatically. After an initial starting circuit is closed, each of two motor driven automatic reset timers operates in turn providing a timed interval of delay, restarting the other at the conclusion of each timed period, and then resetting within 1/2 sec ready for it

next cycle. Each load switch is operated within a repeat accuracy of 1/4 per cent of the full scale reading and is rated at 15 a, 125 v non-inductive. The unit is rated for operation on 115 v or 220 v, 60 or 50 cps power supplies. Adjustment on each timer is independent of the other. Standard time ranges list 11 choices from 6 sec to 24 hr, offering more than 60 possible timer combinations.

Cramer Controls Corp., Dept. ED, Centerbrook, Conn.

CIRCLE 218 ON READER-SERVICE CARD

Broadband Mixer Diode

From 3 to 12.4 Kmc

This broadband mixer diode, the 1N1132, is of tripolar construction and covers the frequency range from 3 to 12.4 kmc in a single coaxial holder. Its characteristics contribute to a simplified, more compact system for radar applications. The unit is 3/4 in. long and about 0.2 in. in diam, and is the mixer counterpart of the manufacturer's low-level tripolar video detector. With a built-in rf bypass capacitor, the diode has a separate output terminal for i-f which eliminates rf chokes. At 25 C, maximum over-all noise figure is 9.5 db, if impedance is 100 to 200 ohms, and rf impedance (vswr max) is 2. Ambient temperature rating is −40 to +70 C.

Sylvania Electric Products Inc., Dept. ED, 1740 Broadway, New York 19, N.Y.

CIRCLE 219 ON READER-SERVICE CARD

New Products

Pulse Delay Unit
0.005 to 0.1 μSec Delay

This Pulse Delay Unit allows delays of 5, 10, 15, 25, 50 and 100 mμsec and combinations of these delays. Standard co-axial cables of 53, 73 and 93 ohms are used for these delays in order to maintain a fast rise time and minimize pulse shape distortions. The rise time for a step function input is less than 1 mμsec for pulse delays of 25 mμsec or less and less than 5 mμsec for a 100 mμsec delay. BNC connectors are mounted on the front panel at the beginning and end of each delay. Adaptors from BNC to either uhf or Type N are provided so that variation of the delay inserted in a cable with these connectors can be effected in a simple manner. The unit measures 12 x 7 x 7 in.

Electrical and Physical Instrument Corp., Engineering Div., Dept. ED, 42-19 27th St., Long Island City 1, N.Y.

CIRCLE 222 ON READER-SERVICE CARD FOR MORE INFORMATION

High Temperature Strain Gage
Operates to 1100 F

A new line of precision high temperature strain gages for measurements up to 1100 F is offered, in standard, rosette and cross types. The gages have all the design features required for use in high temperature test work without any on-the-spot fabrication. The strain sensitive element is Karma wire, the nominal resistance is 120 ohms, and the gage factor is 2.25. Each unit is furnished with 6 ft long fiberglas-covered Nichrome V lead wires and a supply of AP-1 ceramic cement for installation.

Columbia Research Labs., Dept. ED, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

CIRCLE 223 ON READER-SERVICE CARD FOR MORE INFORMATION

Nylon Strap

For Wire Assembly

This self-locking nylon strap, which secures wire bundles against vibration or loadings, is replacing nylon cord and twin as a securing means and permits faster production of wire harnesses. The unit, designated as Model IT 1 Bundle Tie, is a one-piece detented strip of Zytel nylon with a buckle on one end and a tab on the other. The strap is wrapped around a wire bundle, and the tab passed through the buckle and pulled tight. Excess strap may then be trimmed off with cutters. No special tools are needed for installation. Unit is adjustable to any size wire bundle from 1/2 to 3 in. diam. It is resistant to solvents and non-nutrient to fungi.

Dakota Engineering, Inc., Dept. ED, 6641 Crenshaw Blvd., Los Angeles, Calif.

CIRCLE 226 ON READER-SERVICE CARD FOR MORE INFORMATION

Limit Stop Devices

Mechanical and Electrical

Two types of limit stop devices for controlling mechanical or electromechanical functions, such as the drive or a limited rotation potentiometer, have been developed. Limit stop BP-525 is a cam-operated actuating or limiting device which consists of an spdt microswitch and two adjustable matching cams which may be preset to provide circuit make-or-break points over any desired rotational arc. Cam assemblies are available to cover a combined range in degrees of valley or either 0 to 180 deg or 180 to 270 deg. BP-522 is designed to provide both electric and mechanical stop operation by de-energizing the driving motor just before the mechanical shock. Manually adjustable to limits between 1 and 100 rev of the input shaft, the stop positions are indicated on a large direct-reading scale.

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

CIRCLE 227 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

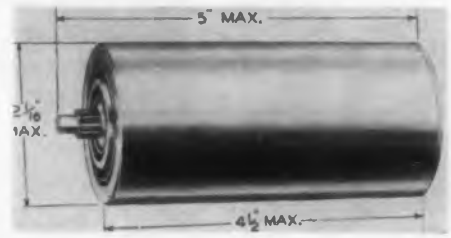
Guarded Wheatstone Bridge
Speeds Resistance Readings

The 4735 Guarded Wheatstone Bridge has a range of 0.01 ohm to 1111 meg with a limit of error of ±0.05 per cent +0.001 ohm up to 100 meg and ±0.5 per cent above 100 meg. Features include guarding of measuring circuit against effects of static, leakage and humidity; elimination of plug and block connections by the use of a single multiplier dial; and a table on top plate giving ratio settings for each resistance decade value throughout the range of the bridge. The instrument is designed for bench use and is housed in a gray metal case. Another model is available for mounting in a 19 in. relay rack.

Leeds & Northrup Co., Dept. ED, 4934 Stenton Ave., Philadelphia 44, Pa.

CIRCLE 230 ON READER-SERVICE CARD FOR MORE INFORMATION

Servo Motor
1/4 HP



This 200 v ac, three phase, 400 cps induction motor for intermittent duty application requires a maximum of 1/4 hp. Designed to operate servo and similar mechanisms, the motor is of internal planetary gear construction. The rotor shaft is supported on precision, anti-friction bearings. Motor housing, shafts and driving gears are of stainless steel. All parts not stainless are protected with corrosion-resistant plating. Stator laminations are heat treated and zinc phosphate coated to reduce eddy current losses. The motor is reversible and is designed to operate at ambient temperatures of from —100 to +200 F. Models are available with output shaft speeds of 20,000, 4000, 800 or 200 rpm under full load, but gear ratios may be altered to suit application.

American Bosch Arma Corp., Dept. ED, Springfield 7, Mass.

CIRCLE 231 ON READER-SERVICE CARD FOR MORE INFORMATION

Vacuum-Tube Voltmeter

Independent Zero Adjustments

Independent zero adjustments for ac, dc, and resistance measurements insure accurate meter readings in this laboratory-type vtvm that can be bench or rack-mounted. High stability is achieved by regulation of both plate and filament voltages in the power supply. The unit has 9 full scale dc ranges from 0.1 to 1000 v (plus or minus), 8 ac ranges from 0.1 to 300 v, 9 dc current ranges from 0.001 μa to 100 ma, 9 resistance ranges from 0.2 to 500 with X0.1 to X10 megohm multipliers. Dc accuracy is ±2 per cent and ac accuracy is ±3 per cent, both on the l-v range and higher. Frequency response is 15 cps to 100 mc. Dc input impedance is 100 megohms; ac input impedance is 5 μμf and 10 megohms.

Acton Labs., Inc., Dept. ED, 533 Main St., Acton, Mass.

CIRCLE 234 ON READER-SERVICE CARD FOR MORE INFORMATION

Shaft Position Transmitter

Infinite Resolution

This shaft position transmitter having infinite resolution and a null point at the center of rotation consists of a standard three turn, slide-wire spiralpot potentiometer. Incorporated within its case are fixed resistors wired in a bridge circuit. One leg of the bridge is shunted with the variable section, and output can be read on a sensitive light beam galvanometer. Linearity over ±360 deg rotation is about ∓0.11 per cent. Over the entire ∓540 deg range linearity is ±0.37 per cent or better. Physical configuration consists of a bushing mounted black anodized aluminum case 1.5 in. diam by 1.5 in. long. The precision ground, corrosion resistant shaft is supported in miniature ball bearings and an indexing pin is provided for precise panel alignment.

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

CIRCLE 235 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Custom Meters

Interchangeable Range Scales

Custom meters, 2-1/2, 3-1/2, and 4-1/2 in. rectangular, with a special patent-pending design feature consisting of interchangeable scale faces, shunting and multiplier resistors, will permit coverage of more than 100 voltage and current ac and dc ranges. The meters feature D'Arsonval moving coil design, accurately polished jewels and pivots, fatigue-tested springs, and stress-released assembled units, within 2 per cent accuracy, enclosed in a plastic case. Six meters are available to cover the following ranges: dc 1000 ohms/v from 0.05 through 1500 v in 19 ranges; dc 2000 ohms/v from 0.05 to 1500 v in 19 ranges; dc 20,000 ohms/v from 0.1 through 1500 v in 19 scale faces; ac 1000 ohms/v from 1 to 1500 in 17 ranges; dc current from 50 μa to 1 a in 15 ranges; and ac current from 1 ma to 1 a in 10 scale faces. Special scales such as VU, db, as well as zero center galvanometers are also available.

Precise Development Corp., Dept. ED, 2 Neil Ct., Oceanside, N.Y.

CIRCLE 238 ON READER-SERVICE CARD FOR MORE INFORMATION

Data Recorder

Logs 50 Analog Variables

The Data-Master will sequentially log up to 50 analog variables, continuously, on demand or at timed intervals. Data can be presented in tabular form on a typewriter, or on punched cards for further processing. Standard models will record the outputs of strain gages, thermocouples, resistance bulbs, pressure transmitters, flow meters, tachometers and all other standard transducers. Optional features include high and low limit alarms, red print-out of off-limit variables, digital printing timer, and thermocouple linearizing and cold end compensation.

Hanson-Gorrill-Brian, Inc., Dept. ED, 85 Hazel St., Glen Cove, N.Y.

CIRCLE 239 ON READER-SERVICE CARD FOR MORE INFORMATION

Using Thermistors

Edited by
FENWAL ELECTRONICS

Thermistors, with their almost incredible sensitivity to temperature change, now get a news column all their own.

The cases in point for the first column: temperature measurement and temperature control.

Three basic circuits for temperature measurement with thermistors:

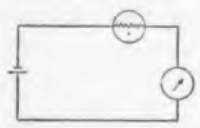


FIG. 1

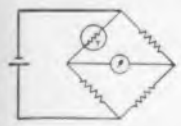


FIG. 2

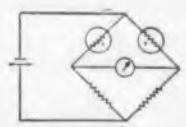


FIG. 3

The first is a battery, a thermistor, and a micro-ammeter. The second, more sensitive, has a thermistor as one leg of a bridge circuit. The third incorporates two thermistors in a bridge, making possible even more precise temperature differential measurements.

Two basic circuits for temperature control with thermistors:

FIG. 4

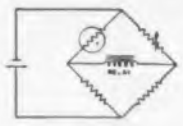


FIG. 5

The first has a thermistor in series with a relay, a battery, and a variable resistor. By adjusting the resistor, it is possible to make the relay operate at any desired temperature of the thermistor.

The second is more sensitive, and has a thermistor as one leg of a bridge circuit, a variable resistor in another leg, and a polarized relay across the output. Even more sensitive control can be had by applying AC to the bridge and placing a high-gain amplifier between the bridge and the relay.

Designers: if you are not already familiar with the tremendous possibilities of thermistors, write for details to FENWAL ELECTRONICS, INC., 310 Mellen St., Framingham, Massachusetts.

Fenwal Electronics

Makers of Precision Thermistors

CIRCLE 241 ON READER-SERVICE CARD

Printed-Circuit Toroids

For Automatic Production

Printed circuit subminiature toroids for use with automatic production techniques, are available with inductance values up to 4 h. These toroids are round case type with a 0.675 in. OD and a height of 0.312 in. They have Q values of 45 at 5 kc to 165 at 5 mc.

Torotel Inc., Dept. ED, 11505 Belmont, Hickman Mills, Mo.

CIRCLE 242 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Transistor Analyzer

Measures DC Characteristics

This power transistor analyzer, PTA Model 3, measures the dc characteristics of power transistors over a collector voltage range from 2 to 36 v and from zero to 15 a of collector current. The measurements are made in the common emitter connection, with the input and output voltages and currents being presented simultaneously on four 1 per cent dc meters. I_{cbo} is measured on a separate meter with a separate variable regulated power supply. A constant current base supply which is continuously variable from 100 μa to 1.5 a provides ease of operation and permits testing large numbers of transistors with only one setup of base current.

A meter and power supply patch panel permits any meter or power supply to be replaced, shorted, removed from the circuit, or brought out separately to any test point desired. Break points for insertion of special circuitry or bringing out test terminals are available on the panel.

Quantum Electronics, Inc., Dept. ED, 1921 Virginia St., N. E., Albuquerque, N. Mex.

CIRCLE 243 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Germanium Transistors

For Computer Use

Three transistors, types 2N385, 2N377 and 2N388, specifically designed for computer use, are npn germanium alloy junction transistors, hermetically sealed in cases which meet EIA size group 30 dimensions. Total dissipation of each of the transistor types is conservatively rated at 150 mw, with ambient temperature at 25 C. Junction temperature is 100 C.

Sylvania Electric Products Inc., Dept. ED, 1740 Broadway, New York 19, N.Y.

CIRCLE 246 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Measuring Thermistor

Fits Standard Crystal Holder

This thermistor, the MA-677, for power measurements in the frequency range from 10 to 12,400 mc is mechanically interchangeable with the 1N21 and 1N23 series of microwave silicon mixer diodes and the 1N32 and MA-408 series of microwave video diodes. This feature allows its use in coaxial or waveguide holders designed for these crystals. Operating resistance is 200 ohms and the bias is 6 ma approximately. Power rating of the thermistor is 10 mw. Proper operation over the frequency range listed above is dependent upon the type of transmission system and detector mount with which the thermistor is used. The exact value of bias current for an operating resistance of 200 ohms is delivered with each unit.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 247 ON READER-SERVICE CARD FOR MORE INFORMATION

Xerographic Printer

Prints Drawings from Microfilm

A low-cost method of producing enlarged engineering drawings from microfilm is done in a XeroX Copyflo 24-in. continuous printer, an automatic device that produces drawings up to two ft wide at a speed of 20 fpm. The time for any one frame is only a few seconds. No ink is issued. The prints are dry on emergence and may be used immediately. The printing process is completely automatic. Individual microfilm frames are mounted in die cut apertures of cards punch-coded for various sorting purposes, and emerge from the printer in the order of entry. Up to 400 prints of a single frame may be had via push button that repeats the exposure. A miss detector is built into the film head and will stop the card-feed mechanism if a card fails to appear. Another function of the detector is to stop the machine when the card stock is exhausted.

The Haloid Co., Dept. ED, 2-20 Haloid St., Rochester 3, N.Y.

CIRCLE 250 ON READER-SERVICE CARD FOR MORE INFORMATION

Ceramic Planar Triode

Replaces 2C39 Series

A ceramic planar triode, 3CX100A5, has been designed to overcome all disadvantages of the 2C39 types, and is mechanically and electrically interchangeable with that series. Among the advantages achieved over the 2C39 family are: longer life, 10 per cent more power output at 2500 mc, full ratings to 60,000 ft, lower inter-electrode leakage and sustained performance at temperatures to 300 C. It can be used to 3000 mc. High quality and close tube-to-tube uniformity are achieved by a series of rigid production tests, including a long pulse cathode evaluation test and a positive grid voltage-current division test.

Eitel-McCullough, Inc., Application Engineering Dept., Dept. ED, 198 San Mateo Ave., San Bruno, Calif.

CIRCLE 251 ON READER-SERVICE CARD FOR MORE INFORMATION

An early photograph of the Earth Satellite. Dr. John Hagen — Director, Project Vanguard Naval Research Lab.

New Products

Filtered DC Power Supply
3/4 Per Cent Ripple

This filtered dc power supply, with less than 3/4 per cent ripple at top load, is designed for voltages from 0 to 32 with current loads from 0 to 15 a while operating on a 115 v 50/60 cps input. Characteristics of the supply include a front panel circuit breaker, full view voltmeter, and a heavy duty transformer and choker.

Electro Products Lab., Dept. ED, 4500 N. Ravenswood Ave., Chicago 40, Ill.

CIRCLE 253 ON READER-SERVICE CARD

DC Power Supplies
Up to 1 Kw

Transistorized regulated dc power supplies with voltages from 3 to 350 v and current ratings from 50 ma to 2 a, are available. These units are used in applications which may require power levels up to 1 kw. Typical performance characteristics are: ±0.5 v at 300 v, 0-1 a, or ±50 mv at 30 v 0-10 a; internal impedance of 0.5 ohms max at 300 v, 0-1 a, or 0.1 ohm max at 30 v, 0-10 a; ripple and noise of 10 mv rms max at 300 v, 0-1 a, or 1 mv rms max at 30 v, 0-10 a.

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

CIRCLE 254 ON READER-SERVICE CARD

High-Speed Sampling Switches

60 to 170 Shorting Channels Per Pole

This switch, having miniature multipin connectors attached to cables of convenient length, consists of two to eight poles and 60 to 170 shorting channels or 30 to 85 non-shorting channels per pole. The switch is easily adapted to a variety of motor drives. It is equipped with a precision machined ball bearing output shaft, constant force perma brushes, and lifetime semi-molded contact plates for long service-free life. The inside-out construction of the switch affords replacement of all brushes in a matter of minutes without force or phase adjustments. The two cover plates are easily removed for inspection while the switch is in operation. Both of the two rotors and all brushes may be replaced as a unit. Typical dimensions are 3.653 in. in diam x 4.225 in. in length plus shaft extensions 1/4 in. in diam x 1 in. in length.

General Devices, Inc., Dept. ED, P. O. Box 253, Princeton, N.J.

CIRCLE 257 ON READER-SERVICE CARD FOR MORE INFORMATION

Subcarrier Oscillator

For FM/FM Telemetering

This transistorized voltage-controlled subcarrier oscillator for fm/fm telemetering system will operate with specified performance under vibrations of 50 g up to 500 cps and 20 g up to 2000 cps. It will similarly withstand shocks and accelerations of 200 g or greater and is unaffected by altitude. The unit includes a precision, temperature stabilized band-pass filter. An input impedance of 500,000 ohms assures successful operation with high impedance sources. Linearity and stability are maintained over an operating temperature range up to +180 F. The unit is packaged in a modular form employing a single connector. Dimensions are approximately 2 x 1.9 x 3 in. with an approximate weight of 12 oz. Units operating at all standard frequencies and deviations with standard input signal levels are available.

United Electrodynamics, Dept. ED, 1200 S. Marengo Ave., Pasadena, Calif.

CIRCLE 258 ON READER-SERVICE CARD FOR MORE INFORMATION

Services for Designers

2700-3600 mc Hybrid T's

Hybrid T's are available for a wide range of frequencies from 2700-3600 mc, for most waveguides from 3 in. x 1 in. to 0.360 in. x 0.220 in. O.D. They are precision cast in either aluminum or beryllium copper, and are normally supplied terminated in flat flanges but are available on request with special adapters.

Operational characteristics include broad band width, low S.W.R., and high isolation. Developed and licensed by Hughes Aircraft Co., the Hybrid T is made available in production quantities by Microwave Development Laboratories, Inc., 92 Broad St., Wellesley 57, Mass.

Electron Accelerator Rental

A ten million electron volt linear accelerator, Mark 1-F2, is available on a rental basis by the kw hr to organizations interested in radiation processing. The facilities are owned and operated by Applied Radiation Corp., 2404 North Main St., Walnut Creek, Calif. ARCO assists in planning experimental programs to the extent desired and users are under no obligation to divulge results or the nature of experiments. The Center may be leased for long-term programs, for a single series of experiments, and for limited commercial radiation processing.

The Mark 1-F2 generates electrons, x-rays, or neutrons. Its electron beam is equivalent to 140,000 curies of radioactive Cobalt-60 permitting deep penetration and uniform dosage with depth. Electrons will effectively penetrate materials of unit density about 1-1/4 in. X-rays will treat similar material up to 8 in. thick. High pressure chemical reactions occurring in heavy-walled reaction vessels may, therefore, be irradiated. Since the accelerator beam is scanned in air, ample space is available adjacent to the beam for auxiliary experimental apparatus. Temperature and other experimental conditions are easily controlled.

Ceramic Printed Circuit Boards

Ceramic printed circuit boards capable of withstanding temperatures up to 2000 degs F and all extremes of humidity have been developed by Gladding, McBean & Co., 2901 Los Feliz Blvd., Los Angeles 39, Calif. In quantity production, the finished cost of the new board should be substantially the same as a standard XXXP phenolic board. The development permits the use of much larger ceramic boards with the major limitation being the design strength of the board at the thickness chosen. Sheets 12 in. square or larger with excellent flatness and uniform thickness are possible.

In a manner very similar to punch pressing sheet metal, the shapes are blanked prior to the final firing. Tolerances of 0.5 to 1.0 per cent are maintained on hold locations and outside dimensions. Tolerances of plus 0.001 to 0.002 in. may be obtained by impact (ultrasonic) and diamond grinding, if required. A variety of metals such as silver, gold, platinum, palladium and copper can be silk screened directly on the ceramic board.

Custom Molding Services

Epoxy Products, Inc., 137 Coit St., Irvington, N.J., will make its compression and transfer techniques available for custom molding of electronic and chemical resistant products. Facilities have been expanded to insure efficient handling of all quality products, with or without inserts, which require the qualities of epoxy plastic. Many products, such as connectors, electronic embedments, impellers and housings, coil forms, slip rings, spacers, metal forming dies, and stators, can be custom molded. High precision and tolerances result from this molding. The molding of small parts for miniaturization is particularly well suited for this operation. The Epoxy Products engineering staff will aid in product design and selection of the correct epoxy compound for application requirements. Pilot and production runs will receive prompt attention.

New Materials

Phenolic Resin Base
Chemical Building Block

Trimethylolphenol in sample quantities is available for research testing and field evaluation from Bakelite Company, Division of Union Carbide Corporation, 260 Madison Ave., New York 16, N.Y.

Tests conducted at the company's laboratories indicate that trimethylolphenol has a broad potential for use in industrial coatings, impregnations, plastics alloy in the formation of resins, and wherever its unique structure and high reactivity could be of advantage.

The material represents a significant advance over previous water-soluble phenolic resins in that it is a single chemical species; whereas previously the available phenolic resins were not monomeric. Thus it can be used as a building block to form new chemical compounds.

The 70 per cent aqueous solution, BRLA 1030, is dark red in color as is typical of phenolic derivatives. The viscosity of the solution is 50 to 70 centistokes at 25 C. It can be mixed with methyl alcohol, ethyl alcohol and acetone. It will react as a one-step phenolic resin, slowly converting to a resin at room temperature. But in the range of 150 to 160 C, it will harden in 80 to 100 sec. The reaction may be catalyzed by acids such as oxalic, phosphoric, or any water-soluble acid. Used as a treatment for paper-base battery separators, trimethylolphenol reduced water absorption and improved electrical properties in laboratory tests. When used where polar surfaces were involved, it improved adhesion. It improved the cure rate and lowered water absorption when used in electrical-grade alminates.

Bakelite Co., Div. Union Carbide Corp., Dept. ED, 260 Madison Ave., New York 16, N.Y.

CIRCLE 273 ON READER-SERVICE CARD FOR MORE INFORMATION

Teflon Adhesive Tape
Provides Firm Bond to 500 F

This pressure sensitive self-stick Teflon adhesive tape can be readily attached to any metal, glass, plastic, and most other surfaces. The silicone adhesive used will provide a firm bond with high peel strength at temperatures up to 500 F. The tape is available in widths up to 2 in. in 36-yd rolls of 0.006 in. thickness and 18 yd rolls of 0.013 in. thickness. Both types can also be supplied in 12 in. sheets. The tape can be used as Class H insulation. It can be used as an antifriction surfacing and to provide dry lubrication for moving parts.

Chicago Gasket Co., Dept. ED, 1271 W. North Ave., Chicago 22, Ill.

CIRCLE 274 ON READER-SERVICE CARD FOR MORE INFORMATION

Insulating Varnish

High Arc Resistance

This varnish provides protective insulation for electronics equipment circuitry. It is ideal for solder connections, high voltage points and anti-corona protection. Excellent adhesive qualities and resistance to heat, oil and acids are listed as additional features. Available in 4 oz bottles to 55 gal drums.

General Cement Mfg. Co., Dept. ED, 400 S. Wyman St., Rockford, Ill.

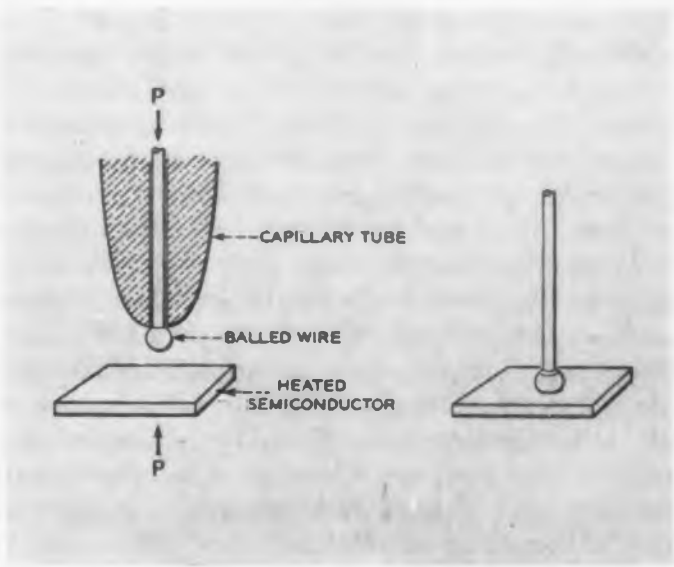
CIRCLE 279 ON READER-SERVICE CARD FOR MORE INFORMATION

Binding Leads to Semiconductors

A combination of heat and pressure is being used to provide a firm bond between soft metal leads and clean, single crystal semiconductor surfaces, providing a bond that is stronger than the lead itself. Temperatures and pressures required are not high enough to affect the electrical properties of the semiconductor material. The method, called thermo-compression, was developed at Bell Telephone Labs., New York, N. Y.

One technique of forming a suitable bond is to employ a heated element such as a wedge, a flat or a point, to press the metal against the heated semiconductor with a pressure sufficient to cause a slight deformation of the lead. Adhesion occurs within a matter of seconds. Another useful connection may be made by butting the balled (or headed) end of a wire against the heated semiconductor by means of a capillary tube.

Adhesion takes place in seconds with pressures of a few thousand lb per sq in. and temperatures well below the melting point of the alloy of the metal and semiconductor. A gold-germanium bond appears to be the easiest to make, but gold, silver, aluminum and a number of alloys can be readily bonded to either germanium or silicon.



Forcing the balled end of a wire against a heated semiconductor by means of a capillary tube is one of the techniques developed for attaching leads.

CIRCLE 280 ON READER-SERVICE CARD FOR MORE INFORMATION

New Materials

Humidity Test Chamber

No Condensation

The 48-C series of environmental cabinets are specifically designed and guaranteed to simulate high temperature and high humidity without condensation on the walls of the testing space, the door and door jambs or the specimens themselves. The cabinet will hold 48 cups, which can be taken in and out of the cabinet by means of a thermopane glass door located in the side of the cabinet. The temperature variation is from room temperature to 140 F and the relative humidity is accurately controlled between 80 per cent and slightly under 100 per cent. By adding a freon compressor, the temperature can be reduced to 45 F and the humidity to 35 per cent. Dry air circulation governs the temperature of the inside surface of the cabinet. By this method the humidity of the air is accurately controlled without the use of a wet bulb control. This patented feature permits accurate control at high humidities without any precipitation.

Atmosphere Control Co., Inc., Dept. ED, 5315 Chester Ave., Philadelphia 43, Pa.

CIRCLE 284 ON READER-SERVICE CARD FOR MORE INFORMATION

Epoxy Resin Flexibilizer

Gives Longer Pot Life

This epoxy resin flexibilizer reduces resin viscosity, extends the resin's pot life and improves its heat aging characteristics. Called Cardolite NC 513, the flexibilizer is a clear, deep amber liquid resin that has epoxy groups in its chemical structure. It can be used in encapsulating electrical components and electrical potting compounds, tooling resin applications and plastic forming molds, epoxy resin adhesives, patching and splining compounds, glass fiber reinforced epoxy resins, and coatings.

The flexibilizer can be utilized with the same curing systems that are commonly used with epoxy resins. The working life of the mixed resin is extended about 80 per cent and the cure time is unchanged from that of the unflexibilized resin, according to the manufacturer. Electrical properties for potting or encapsulating applications are maintained with the use of the flexibilizer when the total resin contains no more than 20 per cent flexibilizer. In ratios of over 1 to 4, the electrical properties begin to fall off. Of importance is the permanence of NC 513 under heat aging. Cured samples were heat-aged for 100 hr at 400 F with no detectable loss of flexibilizer or change in hardness due to loss or degradation of the flexibilizer.

Minnesota Mining and Manufacturing Co., Irvington Chemical Div., Dept. ED, 6 Argyle Terrace, Irvington 11, N.J.

CIRCLE 285 ON READER-SERVICE CARD FOR MORE INFORMATION

Ceramoplastics

For Missile Radomes

Supramica 555 ceramoplastic is a molding material utilizing Synthamica synthetic mica. It has electrical properties superior to those of glass-bonded mica; total, permanent dimensional stability; thermal expansion matching that of steel, and the ability to withstand temperatures as high as 950 F. Mounting rings or metal reinforcements can be molded in as part of the manufacturing process, and will remain tightly anchored over the entire operating temperature range of the material, providing increased resistance to shock, impact and the high bending stresses resulting from flight directional changes. Ceramoplastics have a toughness that is not present in ceramics or glass, due to the presence of platelets of synthetic mica which act as crack-stoppers. The material has low loss tangent and a stable dielectric constant. Wall thickness during molding can be held to ± 0.005 in., and machining tolerances of ± 0.001 in.

Mycalex Corporation of America, Dept. ED, 125 Clifton Rd., Clifton, N.J.

CIRCLE 290 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Cores

Powder and Alloy

Sendust Powder Cores are being sold by the company in this country under exclusive license from The Tohoku Metal Industries Co., Ltd., of Japan. They are available in sizes ranging from 0.8 to 3.346 in. od, and in permeabilities of 10, 13, 25, 30, 50 and 80, although not all sizes are available in all permeabilities. The cores possess magnetic properties that are generally superior to iron powder cores, but inferior to Mo-Permalloy powder cores in the audio and carrier frequency range. The eddy current loss for Sendust cores is lower than that of Mo-Permalloy powder cores, but the hysteresis loss of Sendust cores is substantially higher, and they also have higher values of electrical resistivity.

Another material, called Supermendur, is offered for such applications as power transformers, pulse transformers, magnetic amplifiers, telephone receiver diaphragms, and switching and memory devices. Composed of vanadium, iron and cobalt, it work hardens slowly and can be rolled from 0.09 to less than 0.001 in. without intermediate softening treatments. Even after severe cold reduction, it remains ductile and can be bent back upon itself without fracture. Experimental cores measured at room temperature showed a coercive force of 0.26 oersted, a residual induction of 21,000 gausses, and a maximum permeability of 66,000 to 20,000 gausses.

The Arnold Engineering Co., Dept. ED, Marengo, Ill.

CIRCLE 291 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Temperature Sensitive Device 295

"The Story of the Spencer Disc," second edition, is a 32-page pamphlet describing how this thermostatic device works. Discussed are the various applications and history of this disc. Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.

Meter-Relays 296

Very high sensitivity meter-relay models featuring recent design improvements are catalogued in Bulletin 104-A, a revision of 104. Other units covered in the 12-page booklet are thermistor temperature controls, thermocouple temperature controls, and plug-in controls for both internal and external meter-relays. The text gives detailed attention to the specifications, construction, operation, and circuitry of all devices listed. Prices and ordering information are also given. The bulletin is illustrated with photographs, cutaways, dimensional drawings, and many circuit diagrams. Assembly Products, Inc., P.O. Box XX, Palm Springs, Calif.

Control Cables 297

Detailed technical and engineering information is now available on control cables designed for industrial, utility and mechanized research applications. The catalog is in loose-leaf binder form and subsequent product developments can be supplied to keep catalog up-to-date. Described in the illustrated catalog are many uses of plastic cables. The various types of cables available are explained in detail, specifications and characteristics for each cable are given and physical properties of plastic used as insulation material are listed. For further information about these cables write directly to the manufacturer. Ansonia Wire & Cable Co., 111 Martin St., Ashton, R.I.

Cable Fatigue

The fatigue characteristics of aluminum EC (Electrical Conductor Grade) wire drawn from redraw rod produced by slit-sheet process have been demonstrated in tests conducted at three independent research laboratories. Results of the tests are discussed in a new laboratory report.

All three laboratories reached the same conclusion—that the fatigue strength of EC aluminum wire is equal to wire drawn by conventional methods. The tests, according to the report, were undertaken to supply complete experimental data on fatigue properties of the product. *For a copy of the report write directly to Reynolds Metals Co., 2500 S. Third St., Louisville, Ky.*

Core Design Manual 298

Written for production and design people concerned with manufacture of transformers and reactors this 24-page booklet B 7048 entitled "Type 'C' Hipersil Core Design and Application Manual" is now available. It is illustrated with photographs, diagrams, and data charts which explain what the type 'C' core is, how these cores are made, and how they are best applied. Examples are given to illustrate how transformer cost can be reduced through use of 'C' cores. Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh, Pa.

Butyl Rubber 299

The resistance of butyl rubber to various solvents and chemicals is described in a 16-page booklet just released. Quick reference charts and tables show reaction to certain hydrocarbons, corrosive solutions and halogen gases. Also covered is volume increase in rubber when immersed in many of chemicals. Thiokol Chemical Corp., 780 No. Clinton Ave., Trenton 7, N.J.

Data File 301

Among the subjects covered in the 9-page booklet entitled "Time Interval Measurements and How to Make Them" just released, are a description of time interval meters, measurement of pulse width and elapsed time, low frequency period measurements, timing relay operations, testing camera shutter speeds with a time interval meter, and measuring velocity with a time interval meter.

Well illustrated, Data File 112 contains diagrams, photos and schematics describing techniques for using time interval meters. Beckman/Berkeley Corp., 2200 Wright Ave., Richmond, Calif.

Induction Brazing 302

Technical article covering advantages of induction brazing is now available. Bulletin 1332 discusses the properties, formula for estimating power requirements, and necessary tables for computing coupling efficiency for various metals and coil types. General Electric Co., Schenectady 5, N.Y.

Ideas for Increasing Efficiency 303

Fifty-nine shortcuts to speed drafting and computation work are described in a handy booklet entitled "Time Saving Tips for the Draftsman and Engineer." Leading engineers and draftsmen were asked what techniques they used to save time without sacrificing precision in their work.

This booklet shows new approaches to old problems. The section on Engineering Data contains nine time-saving tips, including "Determining Gear Inertia" and "Interpolating Between Family of Curves." Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

Audio Frequency Equalizers 304

"Audio Frequency Equalizers" is a 16-page catalog with product illustrations and two dozen charts. The catalog index is by subject and also by catalog identification. Listed are wave filters, variable equalizers, diameter equalizers, broadcast line equalizers, recording equalizers, variable high and low pass filters, graphic equalizers, program equalizers, variable dip filters, equalizer kits, and equalizer knobs and dials. Also presented are eight case studies of problems and solutions. Cinema Engineering, Div. of Aerovox Corp., Burbank, Calif.

Dust-Free Enclosures 305

Catalog No. 255 and a bulletin describing dust-free plastic enclosures are now available. These enclosures are used for assembly of tubes, transistors, gyros, small instruments, and other applications. Controlled Atmosphere Enclosures Corp., 230-11 141st Ave., Springfield Gardens 13, N.Y.

High Variable Transformers 306

A concise, illustrated 28-page bulletin P 257H features ratings and complete information on standard line of powerstat variable transformers for high frequency applications is now available. It gives full data on 35 types of miniaturized manual and motor-driven powerstat transformers for 28, 120, 240 and 480 v, single and three phase service in ratings from 56 va to 8.7 kva. Superior Electric Co., 83 Laurel St., Bristol, Conn.

Industrial Thermowells 307

Bulletin No. D deals with an expanded line of industrial thermowells which protect temperature sensing elements against mechanical injury and corrosive or contaminating atmospheres. It contains complete descriptions of various types of thermowells, both bar stock and built-up, and the alloys in which they are available. Specifications for individual types are listed in chart form with corresponding ordering instructions. The four-page brochure is amply illustrated with photographs and drawings. Thermo Electric Co., Inc., Saddle Brook, N.J.

Springs 308

A visual presentation of several types of springs is contained in a recent 8-page booklet. Shown are photographs of a diversity of springs in each of the following categories: extension springs, torsion springs, flat springs, wire forms, and compression springs. Superb Spring Works, Inc., 34A E. Sidney Ave., Mt. Vernon, N.Y.

Eyelets Catalog 309

The 1957 catalog of eyelets, ferrules and terminals for which tools are available has just been released. It includes detailed specifications on copper, brass and steel stampings—flat flange eyelets, rolled flange eyelets, special eyelets, regular and special ferrules and terminals. Waterbury Companies, Inc., Waterbury 20, Conn.

New Literature

Interval Timer 312

Catalog and technical data on manually set, motor driven interval timer, Model 271, are now available in bulletin PB-271 just released. Details of construction, operation and application are included. The bulletin also shows time range selections, ratings, switch capacity and special accessory information. Cramer Controls Corp., Centerbrook, Conn.

Radiant Heat Elements 313

All the facts and figures on Thermflex, the radiant heat element that can be sprayed, dipped, or printed on any material or shape where heat is required is described in 8-page catalog just released. Unique is the inclusion of an actual sample of Thermflex which can be used in a manufacturer's experimental department for testing. Verrall Moe Eectronics Inc., Thermflex Div., 1008 Center St., Jefferson, Wis.

Standard Terminal Insulators 314

A line of standard terminal insulators is discussed in Bulletin 657. Combining the characteristics of a superior ceramic material with an improved high temperature metallizing and brazing process, these insulators offer high quality.

The technique described involves coating areas of the ceramic to be metallized with a molybdenum-manganese mixture and firing in a high-temperature, hydrogen atmosphere furnace. Coors Porcelain Co., 680 9th St., Golden, Colo.

Metal Hardness Tester 315

The outstanding features of an easily operated, accurate, portable 30 oz instrument which can be used in any position to test the hardness of any size, shape or type metal is described in 4-page folder recently released. Eliminating the need for calculations or conversions since the operator places the unit on metal, presses the handles toward material and reads large dial to get accurate answer in seconds in Rockwell or Brinell ranges is one of the features of the instrument as stated in the booklet. Newage Industries Inc., 222 York Rd., Jenkintown, Pa.

Servomotor-Rate Generator 316

Data Sheet 869 features the Model 18 MG 490/460 servomotor-rate generator. The 2-page leaflet gives a description, complete specifications, and the electrical characteristics of this size 18, 115 v, 400 cy generator. It is illustrated with a two-view drawing, a schematic, and a torque-speed curve. Beckman/Helipot Corp., Newport Beach, Calif.

Sound Films 317

With illustrations, Booklet B-7077 describes 47 16 mm sound films offered free. Listed in the 28-page catalog are general interest films, product information films, and training films. Also presented is a description of instruction courses available to electric utility companies. Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.

Dynamotors 318

Data Sheet 15F5 presents engineering drawing of typical unit in the series and includes a performance curve on efficiency versus output. All motors in the 1500 series are designed to withstand vibration of 3 g's from 5-600 cps along 3 mutually-perpendicular axes; duration 30 minutes minimum in accordance with MIL-T-5422C (ASG). Motors operate in ambient temperature range of from —40 to +71 C standard, with special units available for operation up to 100 C ambient. Induction Motors Corp., 570 Main St., Westbury, N.Y.

Engineering Manual 319

"Design Engineering Specification" C-101 is available to designers, engineers and purchasing agents. This comprehensive engineering manual describes materials, construction, design criteria, specification conformance and other important features for determining correct electronic cable for specific uses. Pacific Automation Products Inc., 1000 Air Way, Glendale 1, Calif.

Screen Process 320

A variety of products for the many phases in which screen process printing is an integral method of manufacturing is discussed in a bulletin just released. The pamphlet describes the various items in detail as well as the characteristics and specifications of such products. Wornow Process Paint Co., 1218 Long Beach Ave., Los Angeles 21, Calif.

Nickel Alloy Springs 321

To help them choose the proper alloy and treatment for suggested applications, designers are offered a selector guide for nickel alloy spring wire. The publication discusses five methods of heat treating nickel alloys and processing springs: stress equalizing, stress relieving for uniform moduli, soft annealing, age hardening, and solution annealing. The selector guide also points out recommended thermal treatments for nickel alloy springs. A chart lists 13 nickel alloy springs with the specific values of temperature and time for stress equalizing and age hardening. Techalloy Co., Inc., Rahns, Pa.

Plastics Molding 322

Of particular interest to manufacturers who call on the services of a custom plastics molder is a brochure just published. The brochure describes the facilities for compression, transfer and injection plastic molding, and their associated operations of mold making, engineering and design, research and assembly. Waterbury Companies, Inc., Waterbury 20, Conn.

Power Supplies 323

Semi-conductor voltage regulated power supplies, dc to dc converters and magnetic amplifier voltage regulated power supplies are described in brochure B 576 just released. The brochure is well illustrated and lists the latest improved specifications on wide range and narrow range electronic type voltage regulated power supplies. Kepco Labs. Inc., 131-38 Sanford Ave., Flushing 55, N.Y.

Timing Devices 324

Full information on a complete line of electric timing motors, timing devices, and clock movements is offered in a recent catalog of 30 pages. Hysteresis, inductor, clutch, reversible, dc, miniature, and heavy duty electric timing motors; time delay, interval, and cycle timers; commercial elapsed time indicators; and rectangular and round electric clock movements are some of the products pictured and described. Dimensional drawings, circuit diagrams, and data on standard specifications and ratings are given for each unit. The Haydon Mfg. Co., Inc., Torrington, Conn.

New Literature

Electrical Equipment 330

Dual-service electrical distribution system comprised of two runs of metal duct under a single screw-type cover is reviewed in an illustrated, 4-page bulletin just published for architects, engineers, electrical contractors, home builders and other specifiers of electrical equipment. Featured in the bulletin are photographs of a finished installation and a series of drawings that emphasize ease of mounting and wiring. National Electric Products Corp., 2 Gateway Center, Pittsburgh, Pa.

Telephone-Type Relay 331

A comprehensive report on a miniaturized telephone-type relay, the type 9, is available in an engineering bulletin of four pages. The illustrated folder has standard stock and contract listings, technical data, and descriptions of characteristics and features. Both enclosed and hermetically-sealed types are covered. Phillips Control Corp., Joliet, Ill.

Mobile Air Monitor 332

Mobile air particle monitor for continuously monitoring and recording beta and gamma levels is described in 2-page form 3004-7 now available. It states that the unit conforms to ORNL specifications Q-1740 and the bulletin outlines special design features including block schematic showing applications, and listing detailed specification data. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

Nickel Alloy Wire 333

"How to Design with Nickel Alloy Wire" is a 6-page handbook on designing with alloy wire such as Monel, nickel, Inconel, Inconel X, and stainless and heat-resisting steels. Taking actual situations, the article shows how successful answers were worked out to solve corrosion and heat-resisting problems. Along with case studies, the booklet contains a guide for selecting materials and using them in product design and manufacture. Graphs and photographs illustrate the text. Techalloy Co., Inc., Rahns, Pa.

Insulation Samples

Samples of high temperature insulations are being offered on pocket-size cards. Typical samples available are Teflon and silicone insulated magnet wires, lead wires, sleeving, tubing, shielded and jacketed miniature cables, and multiconductor cables. *To obtain the cards, write on company letterhead, specifying type, size and application, to American Super-Temperature Wires, Inc., West Canal St. Winooski, Vt.*

Heating Problems 334

"Heating Problems Solved" is an 8-page booklet of technical data which describes solutions to four difficult problems created by odd contour shapes, space and weight limitations, and other characteristics. With illustrations, it describes sprayed-on, film type heating elements adaptable to missile applications. Electrofilm, Inc., P.O. Box 106, North Hollywood, Calif.

Composition Resistors 335

Molded composition resistors only 0.067 in. in diam and 0.140 in. long are described in Bulletin 150 now available. Expanding the line of 1/2, 1 and 2 w "Little Devil" resistors, these tiny units are rated at 1/10 w. Construction, dimensions, stock resistance values and prices are covered in the bulletin. Ohmite Manufacturing Co., 3650 Howard St., Skokie, Ill.

Film Comparator 336

Ballistic powered film comparator which utilizes precision lead screws and decimal digitizers to convert linear distances on film into digital data for automatic recording is described in bulletin CR 190 now available. It consists of photographs showing close-up details of film handling mechanism with the cowling removed. Coleman Eng. Co., Inc., 6040 West Jefferson Blvd., Los Angeles, Calif.

Magnetic Hum & Electrostatic Shielding 337

How to wrap audio transformers, chokes and other square or rectangular components using newly developed "Co-netic" flexible foil to prevent magnetic hum is described in Data Sheet 129 now available. The illustrated sheet includes 14 photos as well as complete information on the process. Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.

Phase Sensitive Demodulator 338

Phase sensitive demodulator, and associated 400 cycle power supply, which serves as the link between a guidance system and a telemetering system is described in 4-page brochure now available.

The folder gives the design features and the specifications of this power supply. Hoover Electronics Co., 3906 Liberty Hts. Ave., Baltimore 7, Md.

Plastic Coatings 339

"Fluidized Plastic Coatings for Corrosion Resistance" is the title of a special report now available. This 6-page reprint of a feature article, covers such topics as the mechanism of fluidization, coatings available, cost factors, and applications. Two tables provide technical data on corrosion resistance of fluidized polyethylene coating, and fluidized coating materials. American Agile Corp., P.O. Box 168, Bedford, Ohio.

Corona Type Voltage Regulators 340

A bulletin has been issued to describe a line of corona type voltage regulators. The 4-page pamphlet, Form 3003-7, covers both glass and metal types of construction. It contains complete specification data with dimensions, as well as suggested applications. Photographs, performance curves, drawings, and diagrams are provided for illustration. The Victoreen Instrument Co., 3806 Hough Ave., Cleveland 3, Ohio.

Ceramic Design Helps 341

A summary of the principal standard design tolerances for alumina parts is given in this new single-sheet bulletin. Joint Army-Navy specifications are used as guides for these design helps. JAN-1-8 is the reference on which this bulletin is based. It gives complete details concerning definitions and tests as they may apply to alumina ceramics. Electro-Ceramics, Inc., 975 E. Fifth St., Salt Lake City, Utah.

Diodes 342

To help meet the needs of both commercial and military applications, a booklet describing germanium point contact diodes has been released, as well as one on silicon junction diodes. Both booklets are well illustrated and offer a complete description of the various types of diodes available including the characteristics and specifications. Hughes Aircraft Co., Intnl. Airport Station, Los Angeles 45, Calif.

Variable Voltage Adjustors 343

Variable voltage adjustors are catalogued with illustrations in Bulletin VA 312. Sizes ranging from 150 w to 15 kva are tabulated with specifications and dimensions. The descriptive text emphasizes the importance of maintaining a constant voltage to obtain the maximum performance from electric powered or electric driven equipment. It also briefly covers the problem of voltage drop and voltage fluctuation as a result of overloads on distribution systems. Acme Electric Corp., Cuba, N.Y.

Static Switching Systems 344

Another tool for automation—static switching systems—is described in Bulletin 6364A just released. The 8-page pamphlet gives examples of the uses of each of the eight basic static elements; describes operation of units; explains how various unit combinations are wedded to make up an integrated system; and cites typical applications of static switching. It also lists the advantages of using static control in selected applications. General Electric Co., Schenectady 5. N.Y.

Reliable Relays 345

Handy engineering catalog No. 157 describing printed circuit relays, miniature and subminiature 6PDT and power relays, snap action relays, 400 cps relays, rectified relays for quiet operation and increased reliability on ac is now available. It includes a wide selection of relays with hermetically sealed and dust tight enclosures; with removable dust covers; and with dust tight observation window enclosures. Magnecraft Electric Co., 3350D W. Grand Ave., Chicago 51, Ill.

Waveguide Pressure Windows 346

A brochure describing waveguide pressure windows and their uses has just been released. Performance curves, outline dimensions and drawings, and complete electrical and manufacturing data are given in the brochure for each window type. Broadband-width, high power, cover-flange-mounted windows for direct mounting between standard flanges in the frequency range from 2.5 kmc to 75 kmc, are listed. Microwave Associates, Inc., Burlington, Mass.

New Literature

X-Ray Inspection 348

Reprint of article giving details on methods used for automatic x-ray inspection of subminiature electron tubes is available. Illustrated with photos and radiographs, the bulletin describes mass quantity inspection of components for missiles and aircraft systems. The text deals with x-ray work that involves welds on wire stock measuring 0.003 to 0.015 in. in diam. Philips Electronics Inc., Instruments Div., 750 S. Fulton Ave., Mt. Vernon, N.Y.

Weight-Saver Locknuts 349

Self-locking nuts, 49 per cent lighter than their standard counterparts, are reviewed in a 4-page catalog folder now released.

The lightweight locknuts, approved under government specifications AN-N-10A and MIL-N-25027, are forged, all-metal nuts. Threads employ a three-point locking action. The nuts, cadmium plated to QQ-P-416 specifications, are available in five sizes ranging from No. 8 through 3/8 in. Standard Pressed Steel Co., Jenkintown, Pa.

"Cats Eye" Photoelectric Controls 350

An extremely efficient optical system coupled with a unique "cats eye" slit for a photoelectric control allowing over 1000 different uses is discussed in folder now available. It includes technical data, prices and partial list of multitude of uses. The high speed, sensitive control answers the demands of modern automation. Mason Instrument Co., 27 Elm Ave., Mt. Vernon, N.Y.

Cycling Timer 351

Complete technical information on a new motor driven cycle timer, Type 571, is described in Bulletin PB-571 now available. Application and operation data are presented in detail together with time ranges, ratings, material and construction specifications. Several non-standard arrangement for special applications are suggested. A

set of graphic instructions on specifying program schedules is also included. Cramer Controls Corp., Centerbrook, Conn.

Transducer & Force Rings 355

Unique miniature rotary transducer employing variable permeance inductive principle to meet severe environmental requirements and provide high accuracy and sensitivity is described in bulletin now available. Also force applied to a ring causing change in its configuration which is sensed by a linear transducer mounted within the ring is discussed in data sheet also released. Crescent Engineering & Research Co., 5440 N. Peck Rd., El Monte, Calif.

Wire & Cable Assemblies 356

Complete reference file on cord set assemblies, insulated wire and insulated cable and other products both standard and customized is described in catalog 57 now available. The data is up to date and 18 pages of the 40-page catalog are devoted to specification drawings. Contents include information on operations and quality control, physical characteristics and qualities. Phalo Plastics Corp., 25 Foster St., Worcester, Mass.

Rapid Reversing Motor 357

Bulletin 6645 gives design and application information on motors from 1-1/2 to 125 hp which have been developed specifically to operate machine tools requiring frequency stops, starts and reversals under heavy load. The 4 page bulletin describes the special rotor and stator design which reduces heat generation in the stator, resulting in longer insulation life and a greater number of permissible starts. General Electric Co., Schenectady 5, N.Y.

Stainless Steel Hinges 358

Covering more than 30 different sizes in continuous or piano type stainless steel hinges as well as butt hinges, fixed pin type and loose pin type, the bulletin just released shows length, gauge, pin, joint and open width measurements. The bulletin also points up proper specifications for sound hinge practices and gives helpful suggestions for most efficient ordering. Star Stainless Screw Co., 655 Union Blvd., Paterson 2, N.J.

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

DYNAMIC AND STATIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

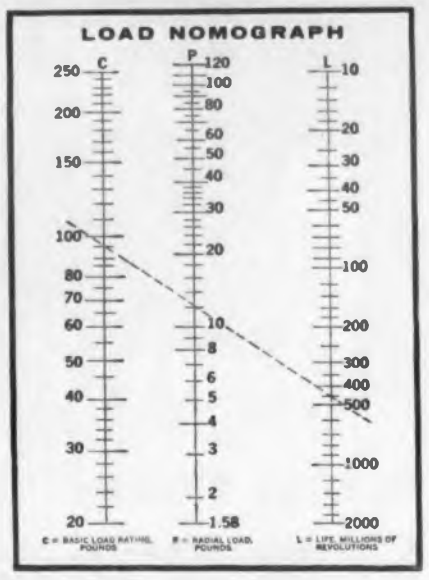
For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e., The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges, rating life for any load is a constant number of revolutions, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L=rating life in millions of revolutions
where, C=basic load rating in pounds
P=applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with



12 pounds, P, a straight edge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

"EQUIVALENT LOAD"

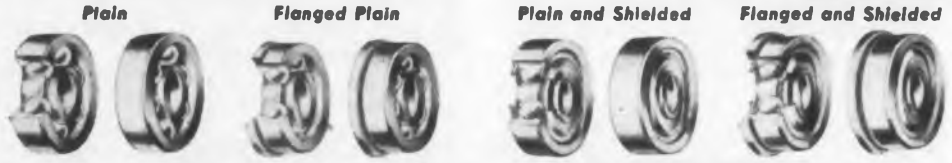
Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the actual conditions of load and rotation.

A formula for determining "equivalent load" and a more comprehensive discussion of static and dynamic loads is found in our design handbook.

DESIGN HANDBOOK OFFERED *FREE*

You'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.



Typical cut-away views of instrument-type retainer ball bearings.

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

CIRCLE 363 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Silicon Rectifiers 364

Designed to meet stringent military requirements, the rectifiers described in this bulletin give you the ultimate in hermetic seal protection. The standard RETMA stud is of copper for optimum performance, and the hex base assures high-torque chassis mounting. High voltage insulation between stud and chassis can be eliminated by proper choice of either 1N1130 or 1N1131. Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.

Industrial Wheels 365

All data for an entire line of industrial wheels is presented in a recent catalog. Design and construction details are given for the "Loadmaster" wheel with duPont neoprene tires and for standard aluminum, balloon-cushioned, pressed steel, and micarta wheels. Also listed are specifications and uses for various types of bearings, seals and rubber compounds. R & K Industrial Products Co., 1945 N. 7th St., Richmond, Calif.

Electronic Components Guide 366

Comprehensive data on the complete line of resistors and other electronic components are listed in the 1957-1958 Electronic Components Guide now available. Data given includes JAN or MIL equivalent, rated wattage, standard tolerance, temperature rise, temperature coefficient, maximum operating temperature, ohmic values and dimensions. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Indicating Silica Gels 367

Data are being offered on indicating silica gel products, which show changes in relative humidity by changes in color. Described is a recent product in this field, the Indicating Gel 327. It operates from 0 to 4 per cent relative humidity. The long established indicator, Tel-Tale Silica Gel, which functions between 20 and 60 per cent R.H., is also discussed. Davison Chemical Co., Industrial Chemicals Div., Baltimore 3, Md.

Mercury Plunger Relay 368

Engineers' fact file on mercury plunger relays and related products is now available. It includes load ratings and contact

data, coil characteristics mounting dimensions, diagrams and illustrations, and general information of particular interest to the engineer. Typical applications of the relays are air conditioning and heating, automation equipment and communications equipment. Ebert Electronics Corp., 212 Jamaica Ave., Queens Village, N.Y.

Electrical Tapes 371

Properties, recommended application procedures and advantages of electrical tapes with thermosetting adhesives are discussed in 4 page booklet entitled "Thermosetting Electrical Tapes." Property table listing physical and electrical properties for 15 tapes with paper, cloth, film and laminated backings ranging from Class A through Class H temperature classifications is also included. Minnesota Mining & Mfg. Co., 900 Bush St., St. Paul, Minn.

DC Voltage Meter 372

A compact variable dc standard and null voltmeter is described in Bulletin 13-3 now available. Direct reading calibrated dials provide instant voltage selection with standard cell accuracy and can be used to read input voltage or output voltage of supply. Other features included in the bulletin are the 0.01 per cent stability, 0.02 per cent accuracy, and 0.002 per cent line and load regulation. Kin Tel, 5725 Kearny Villa Rd., San Diego, Calif.

Anodized Aluminum 373

A six-page brochure entitled "How Anodized Aluminum This Thin . . ." has been released. The booklet describes in detail the versatility of Thinplates. These anodized aluminum nameplates are widely used for decorative trim, identification and information purposes, by manufacturers of appliances, automobiles, military equipment, electronics equipment and many other industrial and consumer products.

Information on the flexibility of Thinplates is also contained in the brochure. It tells how they can be mounted on most surfaces over inside or outside corners, around shafts and on concave or convex surfaces.

The booklet described how production costs are reduced by eliminating drilling, tapping or riveting operations. Park Nameplate Co., Inc., 34-10 Linden Pl., Flushing 54, N.Y.

New Literature

Environmental Cabinets 380

Testonic environmental cabinets featuring combination of patented power-o-matic control system and constant-flow mechanical refrigeration to give extreme accurate temperatures throughout entire temperature range, from 0 C to 180 C, are discussed in 2-page illustrated pamphlet now available. The Brochure No. 5690 gives complete construction details, including prices, sizes of units available, and chart giving temperature cooling rate. Blue M Electric Co., 138th & Chatham St., Blue Island, Ill.

Thermostats 381

A 4-page bulletin 8400 on bimetal thermostats has been released. Printed in two-colors, the bulletin covers most thermostats in the company's line. They are illustrated in half-tone cuts, and information is presented on temperature ranges, ratings, mountings and terminal arrangements. A handy temperature conversion chart is also included. Stevens Mfg. Co. Inc., 45 N. Plymouth St., Lexington, Ohio.

Strain Transducers 382

A high temperature strain transducer to meet the needs for a gage to measure strain without requiring complex installation is described in 8 page illustrated booklet now available. Complete information, including schematics, characteristics and installation instructions are shown. Columbia Research Labs., MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

Mobile Equipment Racks 383

Strong, lightweight racks for mobile electronic equipment installations are listed in a 4-page folder. Described in brief are some of their outstanding features and several accessories. The folder contains illustrations of the empty racks, the accessories, and a number of installations. A table gives weights, dimensions, and stock numbers. Craig Systems, Inc., Danvers, Mass.

White Print Machine 384

A bulletin describing Streamliner 200 white print machine is now available. Included in the bulletin are the specifications, advantages and features of the 200. This low cost, table model, which can be used

extensively by engineers will accommodate materials of any length up to 42 in. wide. General Aniline & Film Corp., Ozalid Div., 4 Corliss Lane, Johnson City, N.Y.

A2 Series Epoxy Putty 387

A2 series of aluminum-filled epoxy resin compounds are shown in 4-page illustrated bulletin recently published. These products are designed for use in the aircraft, and metal-working industries and for any repair or maintenance activity requiring a chemically-stable, non-shrinking, and nonflammable putty with good adhesion to iron, steel, aluminum, wood, glass or ceramics.

Bulletin 11 outlines many uses of Metalset and describes its numerous advantages, such as ease of mixing, convenient room-temperature curing, and machinability. In addition, detailed illustrated descriptions are given as to how the oil and waterproof material should be used for successful application. The various curing agents available are enumerated. A description of the sizes and packing of Metalset A2 is included, as well as the proper proportions for mixing of the epoxy compound and various curing agents. Smooth-On Mfg. Co., 572 Communipaw Ave., Jersey City 4, N.J.

Semiconductors 388

A 24-page booklet has been issued on transistors and semiconductor diodes. It contains a general explanation of transistor theory and operation, with a special section devoted to a drift type transistor. Complete characteristic data on 18 types of transistor and four semiconductor diodes are supplemented by equivalent circuits and dimensional outlines. A feature of the booklet is an Interchangeability Directory. This directory has been prepared in a handy form to guide the designer, experimenter, and serviceman in selecting the proper replacement, and to help identify and describe many transistor types introduced by different manufacturers. The listings contain more than 500 type designations including junction and point contact types. The booklet has eight pages of circuit diagrams illustrating 20 applications. Among these schematics, complete with values of components and coil winding details, are two- four- and six-transistor receivers, phonograph preamplifiers, a sensitive relay, a low-drain power supply and a code practice oscillator. A copy of the booklet may be obtained by sending $0.25 directly to RCA Commercial Engineering, 415 S. 5th St., Harrison, N.J.

New Literature

DC Hypots Test to 75,000 V 396

Three mobile type dc hypots for high-potential testing of high-voltage cables, insulation materials, large rotating machinery and related high-voltage equipment are described in Bulletin 5-1.1. now available.

Among the features shown are the low-ripple dc output obtained by use of amplivolt power unit, and a rectifier-amp. employing long-life selenium rectifiers. This sealed unit also contains kilovoltmeter multipliers to keep all high potential circuit components oil-insulated and corona-free. No rectifier tubes or filament transformers are used. Controls on the sloped panel are simple and incorporate safety interlocks to prevent accidental energizing of test circuits. Full details on the dc hypots as well as discussion of direct-current high-potential testing merits are included in the bulletin. Associated Research Inc., 3769 Belmont Ave., Chicago 18, Ill.

Staked Fastener 397

Catalog M-200 pictures and describes the Type M staked fastener which provides load bearing threads in thin free flowing material such as aluminum, brass, panel steels and copper. The 4-page brochure offers detailed views of the fastener, installation drawings and a chart showing torque values obtainable with the fastener. There are tables showing the correct fastener for various sheet thicknesses of metals. My-T-Grip Mfg. Co., Inc., 176 Broadway, New York 38, N.Y.

Freeze-Drying Equipment 398

"New freeze-drying laboratory equipment" is the topic of a four-page brochure now available.

It describes automatic freeze-drying equipment, new types of tray dryers, manifold-type freeze-dryers with faster speeds and greater capacities, and combination units that can be used for either manifold or tray freeze-drying.

This brochure is a supplement to the 36-page catalog on "Freeze-drying equipment for laboratories" published in 1956. Arthur S. LaPine & Co., 6001 So. Knox Ave., Chicago 29, Ill.

ulse Transformers 403

A new Pulse Transformer Encyclopedia available to engineers who ask for it by iting on company letterhead. It has a mprehensive summary of applications ta and design criteria on low power lse transformers. The encyclopedia lists different turns ratios, data on each unit four different impedance levels, and cking oscillator circuits with perform- ce data on different transformers in the me circuits. There are 13 pages of text d 39 pages of data. Aladdin Electronics, shville 10, Tenn.

reen Process Printing 404

Brochures available on printing and corating and thermo-jet dryer describe many applications and specifications of ch item.

The process decorating presses show they particularly adaptable to volume pro- ction of printed electronic circuits and decorating wide variety of sheet mate- ls.

The thermo-jet dryer brochure indicates principle is applicable to all types of poration drying. General Research & pply Co., 572 So. Division Ave., Grand pids, Mich.

"G" Type Oil Capacitors 405

High reliability "G" type oil impregnated capacitors are shown in Catalog 1134 now released. These capacitors are specifically designed for applications where limited space and mounting ease are major problems. The "G" type capacitor features a threaded, molded mounting neck.

The catalog indicates this capacitor is especially desirable where application of high reliability under stringent operating conditions is required. Industrial Condenser Corp., 3243-65 N. California Ave., Chicago 18, Ill.

Electronic Test Equipment 406

Complete line of waveguide test equipment, radar test equipment, bolometers and thermistors, and coaxial and uhf equipment are described in 48-page edition of catalog "Microwave and UHF Electronic Test Equipment" now released.

The edition includes all the recent additions such as uhf frequency meter detectors, coaxial detectors, broadband disc bolometers and thermistors, coaxial turret attenuators, coaxial pads and wave and power meters. Narda Corp., 160 Herricks Rd., Mineola, N.Y.

New Literature

Standard Samples 413

The second edition of NBS Circular 552 contains an up-to-date descriptive listing of the various standard samples issued by the National Bureau of Standards. Entitled "Standard Samples and Reference Standards," the 24-page booklet supersedes Circular 552 issued in August 1954. A schedule of weights and fees and directions for ordering are given. Summarized tables of analyses are presented to indicate the type of standards of composition presently available. The current status of the various standards will be indicated by a mimeographed insert. To obtain this booklet send $0.25 to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. Prospective purchasers of standard samples may obtain the circular without charge from the National Bureau of Standards, U. S. Dept. of Commerce, Washington 25, D.C.

Meter Relays 414

Catalog No. 4C offers 40 pages of information on contact meter relays. A detailed general discussion of the instruments and their operation, circuitry and specifications is followed by full descriptions of specific models and types. In addition to meter relays, the booklet covers very high sensitivity relays, load relays and plug-in units, automatic temperature controls, panel meters, and indicating pyrometers. Photographs and circuit and dimensional drawings afford ample illustration. An alphabetical index provides a quick key to contents. Assembly Products, Inc., Chesterland, Ohio.

Permanent Magnets 415

The three vital functions of a magnetic engineering laboratory are discussed in a 12-page illustrated brochure. The publication points out how to get more for your money with permanent magnets. It covers the engineering activities required in evaluating magnetic circuit design, establishing test methods and standards and investigating basic magnetic phenomena. It also illustrates the facilities involved

in accomplishing these engineering tasks, and describes how the engineering work and facilities assist users of magnetic materials. General Electric Co., Metallurgical Products Dept., Detroit 32, Mich.

Adhesives 419

Four pages of data on adhesives, protective coatings and sealers are contained in Bulletin 650A. The recommended use, method of application and properties of eight typical adhesives are summarized in tables. Covered are thermosetting types with phenolic, rubber-phenolic, and synthetic resin bases; a base primer with a phenolic resin base; a thermoplastic with a neoprene base; a modified phenolic resin base; a thermoplastic with a synthetic resin base; and a synthetic resin base requiring an activator for cure. Raybestos-Manhattan, Inc., Adhesives Dept., Bridgeport 2, Conn.

Rheostats and Resistors 420

Complete information on resistors and rheostats is contained in a recent catalog. Illustrated in multicolor, the catalog lists resistor selection data and provides full descriptions of fixed enameled, adjustable enameled, oval - vitreous axial, caged, printed circular, Blue X-60 Series and "Tru-Rib" resistors. The catalog also presents a full line of power rheostats with a page illustrating samples and giving information on dustproof, caged and 360 deg rheostats. Tru-Ohm Products, Div. of Model Engineering & Mfg. Inc., 2800 N. Milwaukee Ave., Chicago 18, Ill.

Data Systems, Lab Instruments 421

Short Form Catalog 58-100 lists digital data systems equipment, rf laboratory test instruments, and nuclear instruments for medical and industrial use. Set up in table form, the listings contain a brief description for each unit. Under the data systems heading, digital pressure transducers, an accelerometer, miniature and subminiature amplifiers, and several accessories and components are mentioned. In the rf test instrument category, signal generators, a uhf local oscillator, vswr indicators, and accessory equipment are listed. The nuclear test instruments include a linear amplifier, an electrometer, binary and decade scalers, and high-voltage power supplies. The four-page illustrated folder also outlines company facilities. BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.

New Printed-Circuit Board

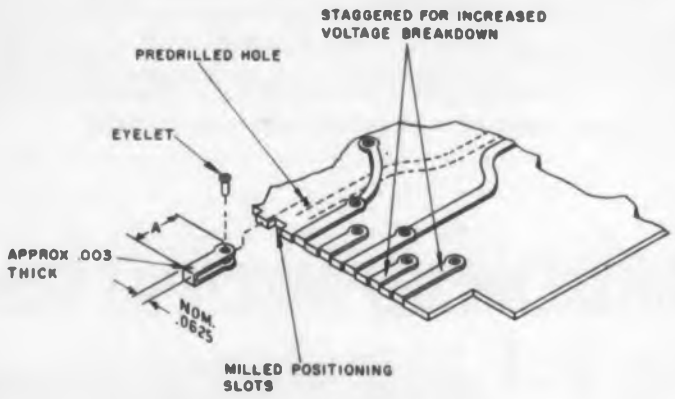


Fig. 1. Techniques for improving reliability of plug-in boards.

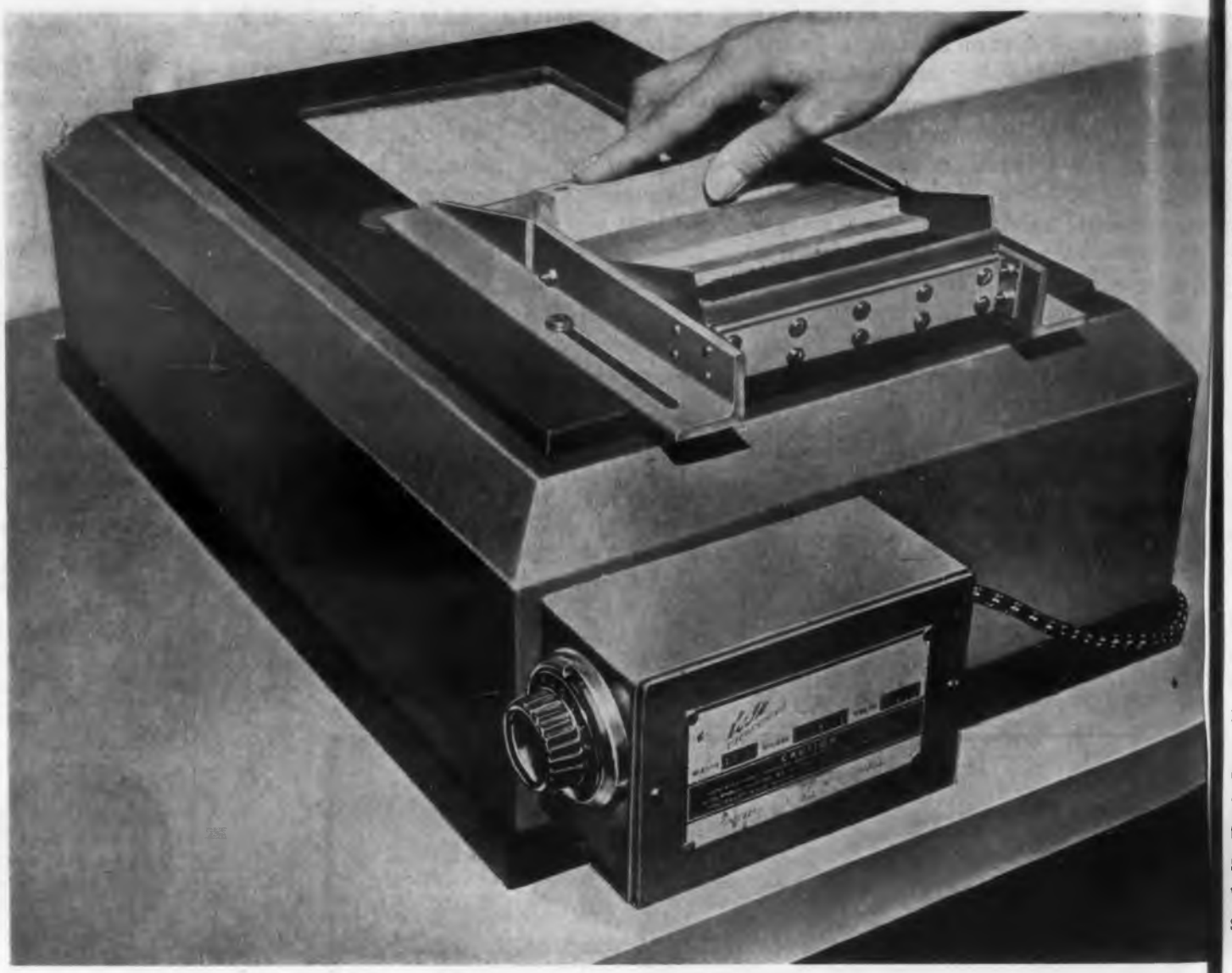


Fig. 2. Conventional solder-bath with new wiping-squeegee attachment.

INCREASED reliability has been attained in the fabrication of photo-etched, copper-laminated, printed-circuit boards by the use of two new techniques. One technique concerns the improvement of the contact elements on the plug-in-edge of the board; the other is a solder-coat method, superior in several respects to the solder-plate process. Developed jointly by Herbert Winsker and Horace L. Walters of the Norden Laboratories Division, Norden-Ketay Corporation, these techniques have been applied, with notable success, to printed circuits for military applications.

Plug-In Board Contacts

The contact-element improvement resulted from investigations concerning the tendency of conventional printed- circuit contact strips to become loose. This tendency has been attributed to insufficient bond strength between the contact strip and the board. As a result, the rubbing action that occurs each time the board is inserted into a receptacle eventually loosens the strip. Occasionally, the application of heat, while soldering will also cause a strip to be raised from the board. Because there is no practical way of refastening a loosened strip the entire board must be rejected—a costly action for a relatively minor defect.

To avoid these casualties, the general practice has been to fasten a right-angle connector to the board in permanent contact with the strips. At best, though, this solution is unsatisfactory for two reasons: the cost of an additional connector and the increased bulk and weight of the final assembly. By contrast, an ideal solution would be cheaper and, more important, would be compatible with the overall emphasis on miniaturization.

The new technique utilizes preformed U-shaped beryllium copper strips which are mechanically fastened to the board in position to engage a suitable receptacle. These strips are positioned in milled slots along the board's mating edge and secured either by eyeleting or riveting through previously punched holes. The positioning slots are cut during the key-slot milling operation, obviating the need for an additional operation.

Applicable To Double-Sided Circuitry

To provide a superior conductive and protective

coating, the strips can be plated before assembly. Additional strips can be added conveniently at any time to accommodate new circuit requirements. The outstanding feature of this technique lies in the fact that the metal strips, while providing a more positive contact with the receptacle, will not loosen after long usage. Since eyelets can be used to secure the strips, the application of this technique is especially suitable to double-sided circuit-board designs where eyeleting is a normal method of completing the circuits from one side of the board to the other.

Solder Coating

The development of the second technique, the solder-coat, was undertaken in an effort to simplify the over-all process of fabricating photo-etched boards. More specifically, a method was sought for applying an equivalent protective coating to copper conductors in a manner requiring fewer operations than plating.

Experiments with solder-coating proved successful. Etched boards containing unplated copper conductors were dipped in a 60-40 solder-bath at approximately 500 F for three seconds. Upon removal from the bath, the boards were wiped on a silicon-rubber squeegee so that smooth coats of even thickness were formed both on top and along the edges of the conductors. After the coating, the boards were drilled; tinned eyelets were inserted; components were mounted; and the boards were again solder-dipped—this time to make the soldered connections.

Advantages

Several advantages were gained using this technique: *1.* etching was simplified because the reverse-negative procedure, using the plated conductors as the etching resist, was no longer necessary; 2. additional protection was provided by the solder coating along the edges of the conductors; and 3. the over-all time and cost for the process, which required no extra equipment aside from the wiping squeegee, were considerably reduced. The combined effect of these advantages resulted in a significant reduction of the rejection rate.

It should be noted that both of the techniques described here were used exclusively with copper conductors. Whether they can be applied effectively to precious-metal conductors has not been determined.

Herbert Winsker, Horace T. Walters, and Harold White, Norden-Ketay Corp., Commerce Rd., Stamford, Conn.

Ideas for Design

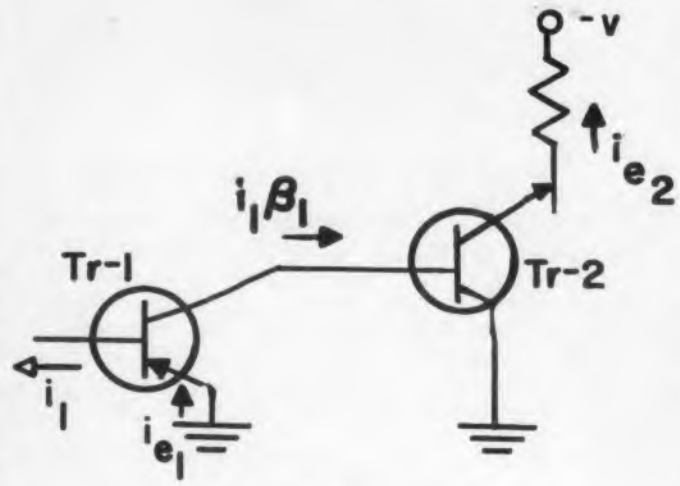
Simplified Transistorized Audio Circuit

The circuit element described evolved as a result of the following objective: To devise a two-transistor circuit element to replace the conventional transistor and transformer pair. Its features should include *a.* higher current amplification and greater ease of cascading than the aforementioned paid; *b.* a broader frequency pass band; and *c.* lower cost.

$$i_{e1} = i_1 (1 + \beta_1)$$
$$i_{e2} = i_1\beta_1 + i_1\beta_1\beta_2$$
$$\beta_{total} = \frac{i_{e2}}{i_1} = \beta_1 (1 + \beta_2)$$

Basic Schematic Diagram

This value exceeds that obtainable with the transistor and transformer pair.



Ease of Cascading

Maximum power transfer occurs when output and input impedances are matched, within and outside the element. This condition can be realized using the suggested configurations. Using the equivalent T circuit, with a voltage generator in the collector branch;

Input Impedance (1st stage):

$$R_{i_1} = R_{e_1} + R_{b_1} - \frac{R_{e_1} (R_{e_1} - R_{m_1})}{R_{e_1} + R_{c_1} - R_{m_1} + R_{L_1}}$$

where R_{L1} = load impedance for TR-1

Output impedance (2nd Stage):

$$R_{o_2} = R_{e_2} + R_{c_2} - R_{m_2} - \frac{(R_{c_2} - R_{m_e})\, R_{c_2}}{R_{b_2} + R_{c_2} + R_{G_2}}$$

where, R_{G_2} = generator impedance feeding Tr-2

Input impedance (2nd Stage):

$$R_{i_2} = R_{b_2} + R_{c_2} - \frac{(R_{c_2} - R_{m_2})\, R_{c_2}}{R_{e_2} + R_{c_2} - R_{m_2} + R_2}$$

where, R_L = actual load impedance.

Output impedance (1st stage):

$$R_{o1} = R_{e1} + R_{c1} - R_{m1} - \frac{R_{e1}(R_{e1} - R_m)}{R_{G1} + R_{e1} + R_{b1}}$$

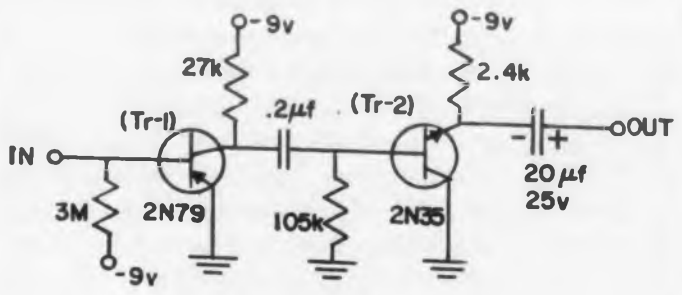
where, R_{G1} = generator impedance feeding Tr-1.

$$R_{G1} = R_{o2} = R_{i1;}\ R_{o1} = R_{i2}$$

Equating this we have:

$$R_{o2} = F\ (R_{e1;2}\ R_{b1;2}\ R_{c1;2}\ R_{m1;2} \text{ and } R_L)$$

Thus, a wide variety of combinations of transistors and terminating loads are possible to fulfill any requirements.



Frequency Limitations

No analytical approach was considered necessary as the device covered the "Hi-Fi" audio band using regular low frequency transistors.

Frequency response of Tr-1 will mainly be responsible for the frequency response of the device as would be expected. Using a 2N79 and a 2N35 resulted in a bandwidth of 60 cycles to 21kc—flat within 3 db. Actual circuit readings are:

$$I_{dc} = 2.5 \text{ ma}$$

Max. ac voltage amplitude: ± 2 v: (with less than 5 per cent distortion)

Voltage amplification ≈ 650

current amplification ≈ 1200

output and input impedances ≈ 1800

N. Porsth, Design Eng., Remington Rand, 19th & Alleghany, Philadelphia 29, Pa.

Transistorized Deflection Amplifier

The problem was to design direct coupled transistor deflection amplifiers for a 3 in. cathode-ray oscilloscope. Minimum peak to peak voltage requirement was 160 v. Bandwidth required was from dc to approximately 150 kc at 3 db down.

The circuit illustrated was designed using transistors in series to develop the required signal voltage without exceeding the transistor V_{cb} ratings. Texas Instruments 953 Grown Junction Silicon transistors were used, although lower voltage transistors would be satisfactory provided enough were added in series to stay within V_{cb} ratings on each transistor. *Dan R. Bromaghim, Engineer, Massachusetts Institute of Technology, Lincoln Labs., Lexington 73, Mass.*

Report Briefs

Heat-Storage Cooling

The feasibility of using non-expendable latent-heat sinks for protection of electronic equipment on high speed aircraft during cruise—cruise flight conditions was investigated. Several hundred chemical compounds were considered for possible use as non-expendable heat sinks. Of these, a list of thirty possible compounds having the best combination of properties for the intended application was prepared. A study was also made of the methods of application of heat storage chemicals in various types of heat sinks. Advantages and disadvantages of each method was studied, considering transient heat flow in the heat storage substances. Typical pieces of electronic equipment were subjected to ambient temperature increases from 50 to 400 F in a twenty minute period. The tests indicated that heat storage materials of the type considered would not adequately protect electronic equipment under the conditions stated. *Final Report on Heat-Storage Cooling of Electronic Equipment, J. Kaye, R. M. Fand, W. G. Nance, and R. J. Nickerson, Mass. Institute of Technology, PB 121980, Feb. 1957, 108 pp, $2.75. Order from OTS, U.S. Dept. of Commerce, Washington 25, D.C.*

Optimum Transistor Amp Design

An analytical procedure of design of common emitter transistor audio amplifiers is given. The conditions of optimum design for maximum power output are derived for resistance-capacitance and transformer coupled amplifiers, taking into consideration the limitations of the collector characteristics. Finally the distortion due to nonlinearity of the collector characteristic is computed. *Optimum Design of Common Emitter Transistor Audio Amplifiers, L. M. Vallese, Polytechnic Institute of Brooklyn, and Microwave Research Institute, Brooklyn, N.Y., PB 123970, Sept. 1955, 26 pp, microfilm $2.70, photocopy $4.80. Order from Library of Congress, Washington 25, D.C.*

Ferrite Losses

The work presented in this report covers the investigation of losses and loss mechanisms at small signal levels for various ferrites. An evaluation of samples of known processing history is given, and initial results of a pressure, pellet-size study are indicated. The results of the study of the effects of humidity on apparent losses at low signal levels are also given. *Nonmetallic Ferromagnetic Materials. Nathan Schwartz and Aaron P. Greifer, General Electric Co., PB 131052, Dec. 1956, 36 pp, $1.00. Order from OTS, U.S. Dept. of Commerce, Washington 25, D.C.*

Time Delay Relay

This report describes the development of a new type of time delay relay. All known types of timing elements were considered with respect to the specifications; models were built around several types. The development was unsuccessful in meeting *all* the requirements of the specifications, but a new type of thermal timing element was evolved. *Time Delay Relay, F. B. Foody, General Electric Co., PB 124798, Sept. 1954, 101 p, Microfilm $5.70, Photocopy $16.80. Order from Library of Congress, Washington 25, D. C.*

Wideband Transistor Equivalents

The problem of choosing a transistor equivalent circuit of practical usefulness for wideband, low-pass (video) amplifiers is studied experimentally. The calculated response of several equivalent circuits of varying complexities is compared with the actual measured response. Approximate formulas are found which enable the cutoff frequency of such an amplifier to be calculated for all values of source and load resistance. An instrument was developed to measure accurately the phase response of the transistor amplifier. This resulted in a device, with a high input impedance, that could measure the relative phase shift between a reference signal and the low-level collector signal at frequencies from the audio range up to 10 Mc. *PB 121752, Common-base transistor equivalent circuits for wide-band application, J. M. Mathias. Stanford University, Electronics Research Lab., Stanford, Calif. OTS, U.S. Dept. of Commerce, Washington 25, D.C., Dec. 1955, 50 pp, $1.25.*

Xtals at Mm Waves

The art of crystal harmonic generation at microwave and millimeter wave frequencies is reviewed and the results of a theoretical and experimental study are discussed. The causes of low efficiency are understood. Multipliers were constructed which gave better performance (4 to 10 db) for the second and third harmonics, than previously reported multipliers. Improvement was achieved by improving the power transfer to the crystal and by control of the length, contact, and pressure of the whisker. Some improvement was also achieved by a two phase arrangement. Power inputs of the order of 30 mw were employed with harmonic outputs exceeding 1 mw in many cases. *PB 122997 Harmonic Generation by Crystals at Microwave and Millimeter Wave Frequencies, Y. C. Hwang, University of Maryland, College of Engineering, Glenn L. Martin Institute of Technology, College Park, Md., Library of Congress, Washington 25, D.C. Jan 1956, 85 pp. Microfilm $4.80, photostat $13.80.*

Patents

Circuit Resonance Indicator

Patent No. 2,784,375. S. J. Mehlman. (Assigned to Dynamic Electronics)

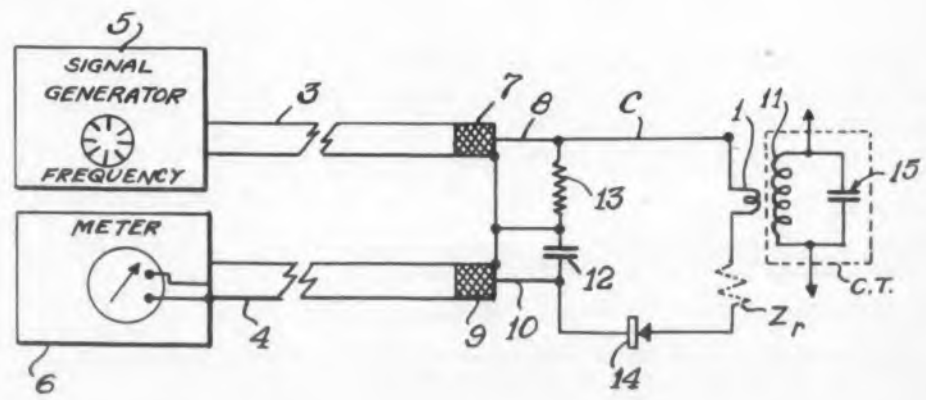
The resonance indicators presently used for determining resonant frequency of a circuit component are usually portable and of the grid-dip type. They are subject to certain inaccuracies inherent in their construction particularly at high frequencies. At such frequencies, the coupling loop will change the frequency calibration of the oscillator with the result that accurate determinations are not made. Also at the very high frequencies such as in the range from 400 to 1000 mc the coupling inductance used as the probe is of such small size that adequate coupling is practically impossible. Again such indicators can measure over a limited range only, the range being determined by the frequencies to which the oscillator can be tuned. Also the coupling probe is of critical size for each particular range of frequencies. As a consequence, the probe may be too large to secure an accurate measurement particularly when the resonant circuits to be tested are located close together. The grid-dip indicators frequently are lacking in adequate stability, overheat and are somewhat fragile and subject to the effect of rough handling. The indicator of the patent overcomes most or all of these difficulties.

In the indicator of the figure, the probe *1* may be a limited number of turns and in fact may even be a half turn. It is an untuned coupling means and hence can be used for the entire range. One side of the probe is connected with a frequency generator through the center conductor *8* of a coaxial conductor *3* and the other side of the probe is connected to a meter through the center conductor *10* of a second coaxial conductor *4* and a crystal rectifier *14*. The two center conductors of the coaxial con ductors are connected through a load re sistor *13* in series with a by-pass capacito *12*. The resistor *13* has a value of about 5 ohms to match the resistance of the coaxia conductor. The shields of the conductor are connected together and to the junctio of the resistor and capacitor. The meter a sensitive dc meter having a range fro 0 to 100 μa.

The resistor *13*, by-pass capacitor, an rectifier *14* can be housed in a small uni of about 2 inches long and about a squar inch in cross section so that it can be pro jected into the confined space of a circui the resonant elements of which are to b tested. The C.T. circuit is illustrative of circuit component, the resonant frequenc of which is to be determined. The ge erator should have an output of at lea 10 kμv and the frequency range may exte from less than 10 to more than 1 k The capacitor *12* will be of the order 1000 μμf. The generator being an ind pendent source such as commonly fou in laboratories can be accurately calibrate

In using the indicator the frequency the generator is changed until a sharp d on the meter is observed and the frequen of the generator is therefore the resona frequency of the circuit element bei tested or a harmonic of this frequency. T frequency of the generator is then adjust to the harmonic frequencies to determi this fact. The indicator may be used f determination of the Q of a circuit comp nent and as a wave meter to determine t resonant frequency of an oscillator.

It is pointed out in the patent that t rectifier may shunt the probe if desire Also an ac volt meter can be used if t radio frequency output of the generator modulated with an audio frequency.



Diode Pulse Amplifier

Patent No. 2,791,725. C. R. Williams. (Assigned to Northrop Aircraft, Inc.)

The diode pulse amplifier uses a gas-filled glow tube with the gas at glow discharge pressure. Two symmetrical cold electrodes are provided one serving as an anode and the other as a cathode. A high dc voltage is supplied to the anode through a current limiting resistor to maintain the glow tube in a normally conducting condition. A pulse is applied across the electrodes through suitable coupling means. The pulse source is of a predetermined polarity so as to quench pulses which tend to decrease the conducting potential of the glow tube and place it momentarily in a non-conducting condition. The output circuit across the electrodes comprises a series combination of a capacitor, a crystal diode, and a low resistance load in which the capacitor and the crystal diode reduce the shunting effect of the low resistance load.

Device for Deflecting Atmospheric and Other Static Disturbances

Patent No. 2,794,118. A. A. Kiriloff, W. A. Lary, and B. Sergievsky.

The invention, recently released by the Atomic Energy Commission, is concerned with a device for deflecting from electronic apparatus disturbances caused by statics. It makes use of an ionized by-path which bridges disturbances from the apparatus. The terminal of the apparatus at which the potential disturbances might enter is bridge to ground. This by-path includes a collecting electrode and a leading-off electrode. One is connected conductively to the terminal and the other to ground. The electrodes have a gap between them. A carrier with a radio-active surface is placed in the vicinity of the gap. Gap to carrier distance coincides with the zone of maximum ionization made by the material.

High Frequency Negative Resistance Device

Patent No. 2,794,917. W. Shockley. (Assigned to Bell Telephone Laboratories, Inc.)

The diode oscillator uses a semi-conductive material having a first zone containing a predominance of mobile charge carriers of one type and a second zone which is characteristically essentially free of mobile charge carriers of this one type. A barrier exists between the zones. An injector of minority charge carriers of the one type is associated with the second zone. An electrode is connected to the first zone and a voltage bias is provided between the injector and the electrode which biases the junction in its high resistance direction. An impedance having a reactive component in series resonance with the reactance of the semi-conductive material at a frequency—the period of which falls between two-thirds and twice the effective transit time of the one type of charge carrier—is provided between the injector and the carrier.

Deflection Circuit For Cathode-Ray Tubes

Patent No. 2,794,148. J. G. Haberkost. (Assigned to Allen B. DuMont Laboratories)

The deflection circuit uses an electron tube having a cathode, a control grid, a screen grid and an anode. A sweep signal is applied to the control grid of the tube. A coupling transformer has its primary winding in the anode circuit of the tube and its secondary winding connected to the deflection coils of the cathode-ray tube. The secondary of the coupling transformer is connected to the screen grid of the electron tube to apply a positive potential during retrace. So connected, the electron tube continues to be conductive after the tube is biased to cut off by the sweep signal input to the control grid. This prolongation of conduction prevents the application of the high voltage to the anode of the electron tube, which voltage is induced by the collapse of the magnetic field of the deflection coils and the transformer windings.

Transmission Amplifier

Patent No. 2,791,645. C. E. Bessey. (Assigned to United States of America)

The amplifier circuit includes a pnp transistor and an npn transistor with their base electrodes connected together. A positive potential is applied to the base electrode of the npn transistor and a negative potential is applied to the base electrode of the pnp transistor. A first load impedance is provided between the npn collector and the source of positive potential. A second load impedance is also provided between the pnp collector and the source of negative potential. A decoupling resitor connects the emitter of the pnp transistor to a voltage dividing tap on the first load impedance. A decoupling resistor connects the emitter of the npn transistor to a voltage dividing tap on the second load impedance. A capacitor couples the emitters of the two transistors. The input is applied to one of the emitters and the output is taken from the collectors of the transistors.

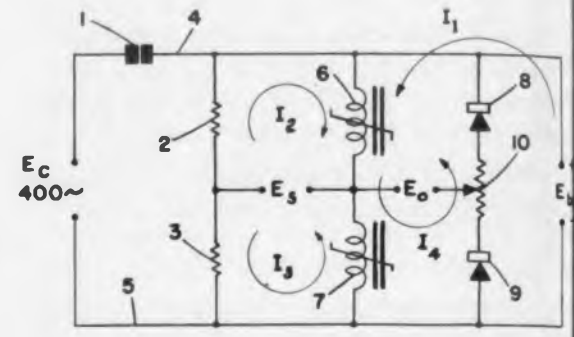
Patents

Amplifier

Patent No. 2,781,420. R. F. Eno. (Assigned to North American Aviation, Inc.)

Varying direct current signals which are required to be amplified have obtained such amplification such as by a direct current amplifier or by converting the signal into an interrupted signal and amplifying the latter through a known ac amplifier. Such circuits are more or less complex and when a dc amplifier is used the circuit is unstable, requires a high bias voltage on the grid and due to inherent capacity the circuit is incapable of high frequency response. The circuit of the patent does not have the objections enumerated and also dispenses with balancing and negative feedback for the purpose of securing stability.

The circuit is clear from the figure and its simplicity is apparent. In operation, an alternating frequency is applied across the coils 6 and 7 from the E_c source through the blocking capacitor 1. A dc bias potential E_b is applied across the coils and provides a current I_1. The signal potential is applied at the terminals E_s, which results in currents I_2 and I_3 in the direction shown by the arrows. The current I_2, through the coil 6, is additive to the current I_1 whereas the current I_3 is in opposition to the current I_1 through the coil 7. The output is taken from the terminal E_o. With diodes 8 and 9 in series with a resistor 10, a demodulated output signal is secured. The sliding contact on resistor 10 enables adjustment of the circuit. The bias current flowing in coils 6 and 7 from the bias source E_b determines where the circuit is operating on the B-H curves of the cores of the coils. With a high bias current, the position is in the nonlinear portion of this curve.



If a modulated output signal is desired the diodes 8 and 9 are dispensed with and

the other circuit elements remain unchanged. There is also disclosed a circuit which uses the basic concept of the figure illustrated which is designed particularly for a signal source of low impedance. This circuit couples the signal potential E_s to the inductors 6 and 7 through series connected choke coils and primary windings.

Synchronizing System

Patent No. 2,794,858. W. D. Houghton. (Assigned to Radio Corp. of America)

The circuit arrangement described is used for synchronizing a first or locally-generated wave with a second wave. The two waves are applied to a comparator circuit. A variable time delay circuit is coupled to the comparator circuit so that the application of the locally-generated wave to the comparator circuit is delayed. The comparator circuit developes a direct potential which is proportional to the time phase between the second wave and the time delayed locally-generated wave. This direct potential is then applied to the time delay circuit to vary the extent of the time delay provided by the circuit.

Voltage Stabilizer Circuit Arrangement

Patent No. 2,794,939. C. H. Tosswill et al. (Assigned to North American Philips Co. Inc.)

The patent discloses avoltage stabilizer circuit having a pair of output terminals with a reservoir capacitor connected across these terminals. The circuit also includes a source of charging potential for charging the capacitor through a first resistor in accordance with the value of an unstabilized input voltage. A first cold cathode trigger-controlled gas discharge tube has a second resistor in series with this tube. The series combination is connected across the capacitor.

A second capacitor is provided between the anode and the cathode of the tube. Finally suitable means samples the voltage across the reservoir capacitor at intervals of time. This sampling means is coupled to a terminal of the reservoir capacitor to apply a signal having an amplitude which is dependent upon the voltage across this capacitor to a trigger electrode of the tube. A periodic conduction in the tube is produced at a rate determined by the value of the output voltage.

Books

Electrical Applied Physics

N. F. Astbury, Philosophical Library, 15 East 40 St., New York 16, N.Y., 241 pages, $10.00.

An insight into the author's purpose in writing this text can be gained by carefully examining the title. He is groping for the proper group of words to identify the merging which has occurred in the past twenty-five years between theoretical physics and electrical engineering. Electrical theory is approached neither as a pure science of physics nor an engineering science.

In his attempts to bring together the classical and the practical aspects of the subject, Mr. Astbury has restricted his book to a fairly modest compass of the field. At times the reader is frustrated because of a lack of detail on a particular subject. In fairness to the writer, it should be realized that inclusion of sufficient detail to satisfy a majority of readers would completely bury the purpose of this text.

Over abundant use of mathematical analysis is avoided. In most instances mathematical treatments are presented in company with the relevant physical problem and is not objectionable to a serious reader.

The engineer or scientist desiring to coordinate his theoretical and practical thinking should find the text interesting.

Foundations of Physics

Robert Bruce Lindsay and Henry Margenau, Dover Publications, Inc., 920 Broadway, New York 10, N.Y., 542 pages, $2.45.

A bridge between semipopular works for the general reader and technical treatises

written for specialists, the book discusses the foundation, ideas and background of modern physics. It treats the methods of physical description and construction of theory, and is not a text on theoretical physics. The physicist with a background in elementary calculus, who is interested in the ideas which give meaning to the data and tools of modern physics, should find it especially helpful.

Contents include a thorough discussion of theory, data, symbolism, mathematical equations; space and time in physics, foundations of mechanics; probability and its application; the statistical point of view; the physics and continua; the electron theory and special relativity; the general theory of relativity; quantum mechanics; the problem of casuality.

Elements of Pure and Applied Mathematics

Harry Lass, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y., 491 pages, $7.50

A thorough treatment of the various subjects in classical mathematics useful to the engineer and physicist is presented by Mr. Lass. He covers most of the subjects that an undergraduate math major encounters in his course work. The treatment of vector and tensor analysis, along with probability theory and statistics, is unusually complete. There is a short treatment of nonlinear mechanics and game theory, and a chapter on group theory and algebraic equations. The material has been so written that each chapter is independent of the others although many cross references tend to unify the subjects at hand.

Nuclear Engineering

Edited by Charles F. Bonilla, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y., 850 pages, $12.50.

Engineering disciplines necessary in the design of nuclear reactor cores and power plants are discussed by twelve experts in various fields of engineering and science. In each of the twelve fields, fundamentals are discussed briefly and clearly, with illustrations and advanced specific analyses. The book will be useful as a tabulation of advantages and disadvantages of the principal reactor types in use or under design and for constructional details of many current reactors.

Non-Linear Function Generators Using Piecewise Linear Approximation

J. George Adashko

NON-LINEAR converter circuits are usually made up of diode elements connected in parallel. In universal function converters, the diode elements are, as a rule, connected only at the input of the summing amplifier. This places a severe limitation on the capabilities of the universal converter, but simplifies the operation.

In the design of special function converters, the circuits can be made up of diode elements of various types and can be connected either at the input, or in the feedback loop, or simultaneously in both.

The literature contains no indication to date in what cases and in what manner a given function should be reproduced by means of individual diode circuits connected in the input and in the feedback loop, and therefore each circuit of a specialized function converter reflects the taste and the intuition of the designer.

The non-linear relationships encountered in the investigation of automatic-regulation systems are conveniently broken down into the following forms:

- Typical relationships, characterized by intermittent changes in the transfer functions of some elements of the system (backlash, dry friction, relay, dead zone, limit stop, and others)
- Relationships leading either to elementary functions of a single argument ($y = x^2$, $y = \sin x$, $y = \cos x$, $y = x^3$, etc.), or to a product or quotient of two functions of different arguments
- Functions of two or more arguments
- Experimental functions of a single argument given in the form of tables or graphs

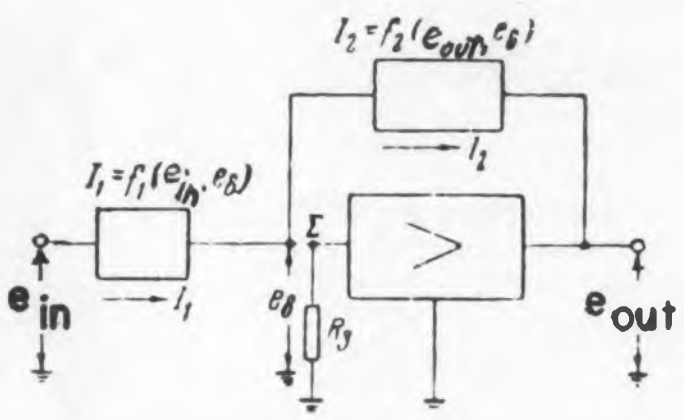


Fig. 1. A non-linear solution element in the form of an operational amplifier having a non-linear admittance in series with its input and another in the feedback loop.

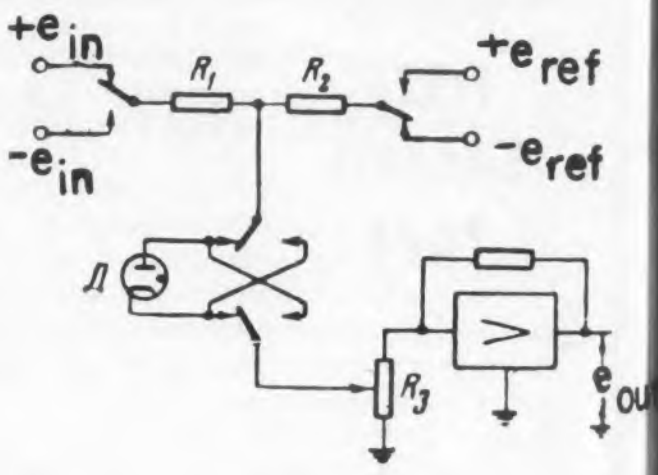


Fig. 2. A universal diode function converter built up of single diode elements.

All these relationships may be reproduced with the aid of diode function converters. Universal diode function converters, employed to reproduce non-linear equations obtained experimentally are usually built up of single-type diode elements (Fig. 2). To reproduce typical elementary non-linear functions, it is more advantageous to employ the diode elements of Fig. 3, which shows three types of elements. These elements employ a smaller number of impedances in each element, are simpler to design, and make it possible to obtain element characteristics with a higher slope. In addition, elements with virtually grounded diodes can perform summation. In both cases characteristics may be obtained in all four quadrants by re-connecting the diodes, by reversing the polarity of the standard voltage, or by connecting a sign inverter at the input.

Analysis of the errors of diode-element circuits

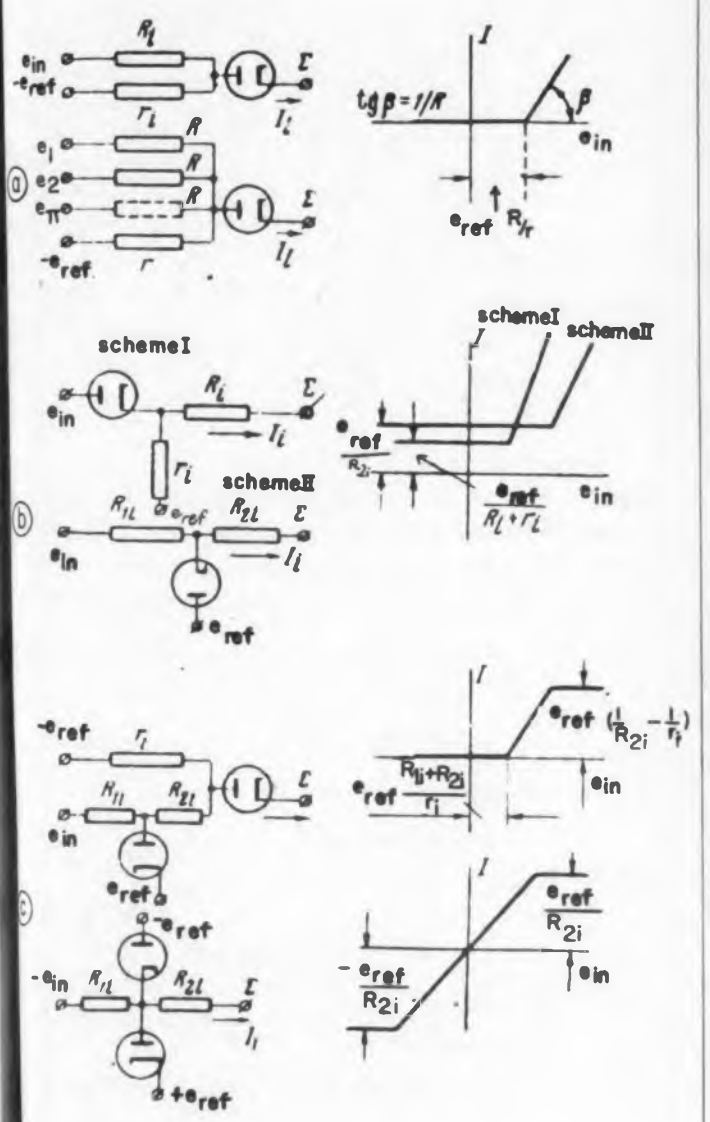


Fig. 3. a—Elements with virtually grounded diodes b—Limiter type diodes c—Dual diode elements—representing a combination of the first two types.

has shown that the relative error they introduce increases with the equivalent slope of the current characteristics and with the number of the diode-elements connected simultaneously. By "equivalent slope of current characteristics" are meant

$$S_{I_1} = \frac{dI_1}{de_{in}} \frac{e_{in\,m}}{I_{1m}} = Y_1 \frac{e_{in\,m}}{I_{1m}}$$

$$S_{I_2} = \frac{dI_2}{de_{out}} \frac{e_{out\,m}}{I_{2m}} = Y_2 \frac{e_{out\,m}}{I_{2m}}$$

where m indicates the maximum value of the quantity.

Many methods can be proposed for the synthesis of diode elements so as to reproduce a specified non-linear function, the slope of which varies over a wide range. With this, the slope of the current characteristics of the individual diode circuits does not go outside the permissible limits and at the same time, the design insures the least number of

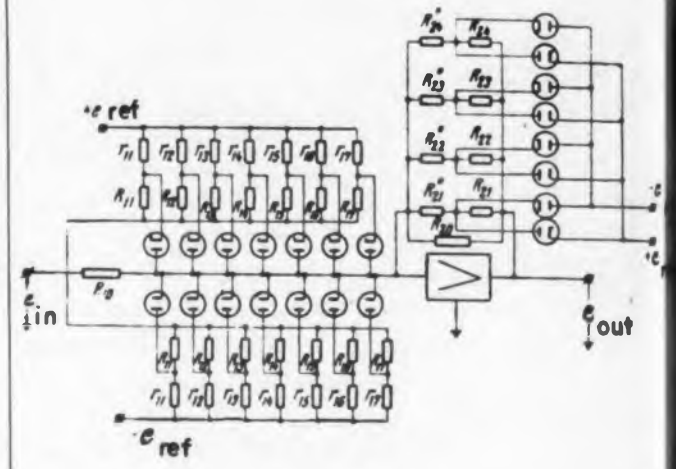


Fig. 4. Plot of the diode circuit current characteristic derived from the expression $e_{out} = 10^{-4} e^3_{in}$. The current characteristics are obtained by integrating the corresponding characteristics of the slopes of the current characteristics.

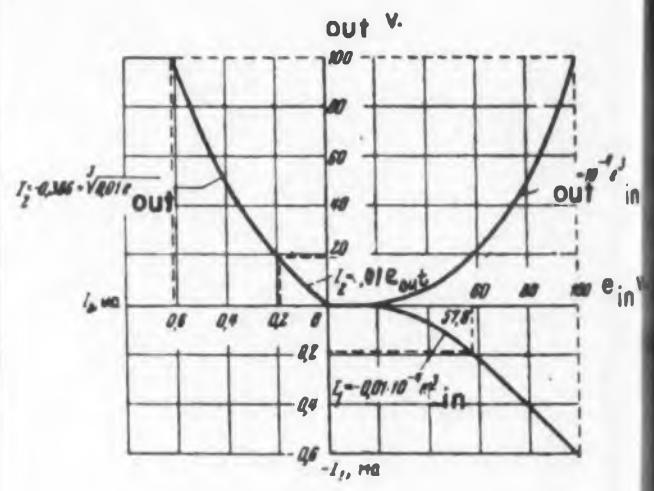


Fig. 5. Complete basic diagram of a non-linear converter with diodes in the input circuit and in the feedback loop. Provision is made for operation with two polarities of the input and output signals.

multaneously-connected diode elements.

These methods are based on the use of the quation

$$\frac{de_{out}}{de_{in}} = S_e = -\frac{Y_1(e_{in})}{Y_2(e_{out})}$$

hich after introducing the values of the slopes can e rewritten as

$$S_e = -\frac{S_{I_1}}{S_{I_2}}$$

The value of S_e and its variation in the function f the input signal are usually given by the initial on-linear relationship, and the problem consists f distributing the quantity S_e between S_{I_1} and S_{I_2} o that neither exceeds the permissible limit.

Abstracted from "On The Theory of Non-Linear olution Elements, Employing Piecewise Linear pproximation" by B. Ia. Kogan, which appeared in utomatika i Telemekhanika, December, 1956.

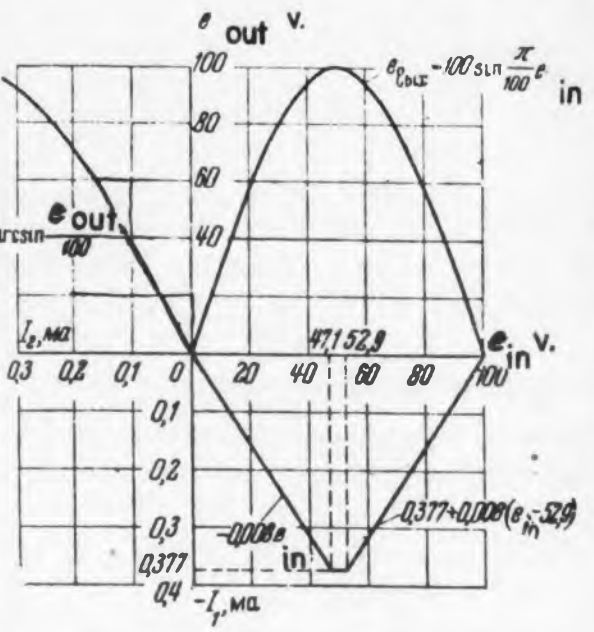


Fig. 6. Plot of the current characteristics derived from the expression $e_{out} = 100 \sin\frac{\pi}{100} e_{in}$.

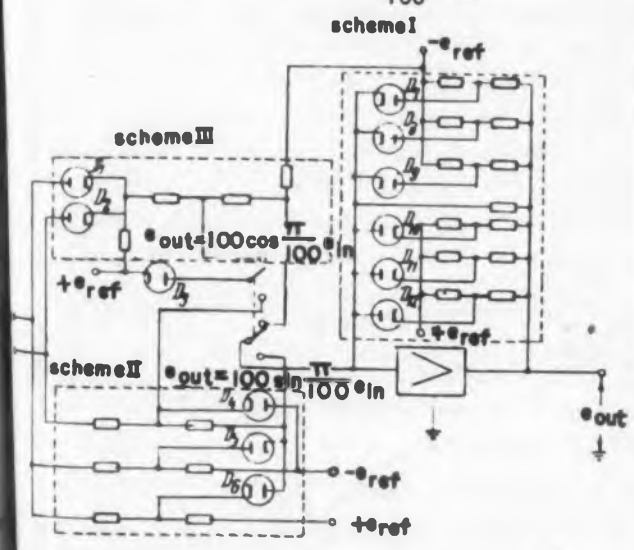
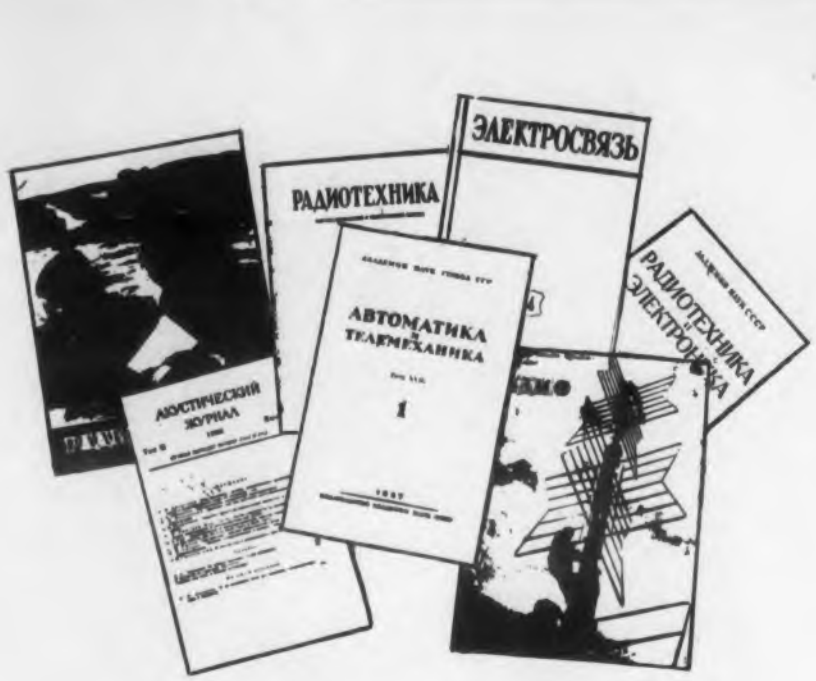


Fig. 7. Principal diagram of a function converter used to generate a function such as the one plotted in Fig. 6.



What the Russians are Writing

J. George Adashko

RADIO ENGINEERING

(*Contents of Radiotekhnika, No. 2, 1957*)

INFORMATION THEORY AND RECEPTION

Method for Increasing the Noise Rejection in Autocorrelation Reception of Pulse Signals, M. I. Karnovski, V. I. Chaikovski, (6 pp, 5 figs.).

The addition of synchronous keying to one of the channels of a conventional autocorrelation circuit for the reception of pulse signals results in a noticeable increase in the noise rejection. A detailed statistical treatment of the improvement in signal to noise ratio is given. Reference is made to "Statistical Errors in Measurements on Random Time Functions" by Davenport, Johnson, and Middleton (*J. Appl. Phys.*, 1952, 23, April). (See Figs. 1 and 2)

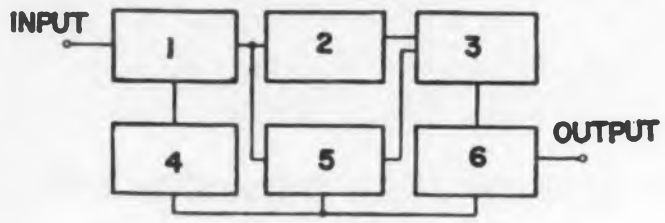


Fig. 1. Modified Autocorrelation Reception Scheme for Pulsed Signals. Legend: 1—Input filter 2—Delay Channel 3—Multiplier 4—Synchronization channel 5—Keying circuit 6—Integrator (averaging device)

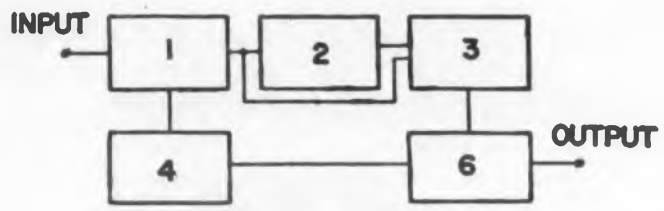


Fig. 2. Standard Autocorrelation Reception Scheme. Legend: 1—Input filter 2—Delay Channel 3—Multiplier 4—Synchronization channel 6—Integrator

Probability of Signal Reception with a Receiver Having a Finite Recovery Time, A. M. Vasil'ev, (11 pp).

A detailed statistical study, in which an equation is derived for the reception probability density, given the probability density of signal appearance at the receiver input. The receiver recovery time is assumed to be finite. The equation is solved in general form, and simplified solutions are given for several practical cases. The theory is applicable to the reception of pulses over noisy channels.

Effect of Fluctuations on a Phase Detector, V. N. Tikhonov, N. I. Amiantov (12 pp, 6 figs).

Analysis of the response of a phase detector to the combined effect of a useful signal and extraneous noise, leading to approximate equations for the mean value of the voltage and for the correlation function of the detector-load fluctuations. The systematic and random errors produced when the phase detector is used in a target-tracking radar are calculated. The author points out that the detector error alone does not determine the tracking error, for the characteristics of the mechanical portion of the system (which has a large time constant) must also be taken into account. In addition, the time variation of the phase error, which is also a random function of time, must be allowed for. Refers to "An Expansion for Some Second Order Probability Distributions And Its Application To Noise Problems," by J. F. Barret and D. G. Lampard, *Trans. IRE, Professional Group on Information Theory, January 1955.*

RADIO WAVE PROPAGATION

Long-Distance Tropospheric Propagation of UHF Waves B. A. Vvedenski, A. G. Arenberg, (12 pp, 6 figs).

Conclusion of a survey article (begun in the January 1957 Radioteknika, *ED* August 15, 1957). The present status of theory and experiment concerning coherent scattering, refraction, and diffraction of UHF waves in the troposphere is discussed in detail. There are still many contradictory and little-understood facts both in the theoretical and in the practical data accumulated on the subject, but the authors feel quite certain that once the antenna sizes and transmitted powers become economically justified, forward scattering will be able to take its place as a useful means of communication along with conventional microwave relay systems. Numerous American references are cited.

ANTENNAS

Effect of a Dielectric Coating on the Reflecting Properties of a Perforated Reflector, V. G. Iampol'ski, (6 pp, 5 figs).

A similar article by V. K. Paranov, dealing with wire mesh in which each wire is covered by a concentric coating of ice, appeared in the September 1956 Radiotekhnika (*ED*, June 15, 1957). This article deals with the passage of electromagnetic

aves through a perforated material (such as wire esh or expanded metal) coated with a thin layer f dielectric. The straightforward series-expansion nalysis is applicable to many antenna structures, in hich the perforations have a regular periodicity, nd applies to protective coatings as well as to armful agents such as rain or ice. The conclusions ndicate that maximum transmission occurs when e dielectric is somewhat thinner than half the cident wavelength. It is shown that under certain onditions ice may completely destroy the reflector ffectiveness.

MICROWAVES

easuring Electric Field Intensity in Resonant Cavi-es by Shifting the Resonant Frequency with a ielectric Probe, G. N. Rapoport, (8 pp, 1 fig).

A theorem for the frequency shift produced in a avity by deformation of the boundaries between arious dielectrics inside the cavity is derived and sed to formulate a technique for the measurement f field intensity in the cavity. Detailed classical heory is used. Spherical, spheroidal, and needle-ke probes are discussed. The measurement pro-edure is described, and equations are given for e determination of the field intensity from the ower input.

TUBES

as-Discharge Counter Tubes, I. Ia. Breido, G. M. nkin, (6 pp, 5 figs, 1 table).

A survey article on the most popular gas-scharge counter tubes, with particular attention to cade counters. The principal types of representa-e British and German tubes, their operational atures, and control circuits are described.

POWER SUPPLIES

ndition for Maximum Accuracy of Ferroresonant oltage Stabilizers, B. Z. Zil'berman, (1 page)

Derives optimum ratios of the weight of the steel maximum power, as well as other stabilizer-sign parameters.

BIOGRAPHY

inrich Hertz, 1857–1894, I. G. Kliatskin, (7 pp)

AUTOMATION AND TELEMECHANICS

Contents of Avtomatika i Telemekhanika, No. 2, 1957)

SYSTEMS ANALYSIS

ermination of Periodic Modes in Systems with sponse Curves Composed of two Straight Lines Prescribed Slopes. Part I., M. A. Ayzerman, F. R. imakher (14 pp, 8 figs).

Advanced Fourier analysis by which special trans-ms are obtained for a function represented by

Russian Translations

SERVO STABILITY

Stability of Two-Phase Servomotor with Negative Velocity Feedback, E. I. Slepushkin, (11 pp, 8 figs

Continuation of work previously reported by the author (Avtomatika i Telemekhanika, July and November 1956, *ED.* Jan. 15 and July 1, 1956). The negative-feedback parameters are determined by linearizing the mechanical characteristics of the servo motor at low speeds. The gain and maximum permissible time constant of the feedback loop required for continuous stable regulation are determined in most practical cases by the parameters of the starting point of the mechanical characteristic for a specified static torque.

Corrections for Pulsed Regulation and Control Systems, Ya. Z. Tsypkin, (15 pp, 21 figs, 1 table).

A pulsed system consists essentially of a linear element and a pulse element, and any correction which results essentially in a change in the transfer function of the system as a whole, must modify either one of the elements alone or both elements together. The author describes various techniques for calculating the correction elements and extends his analysis to the use of sampled-data feedback and to the possibility of employing digital computers as correction elements.

Dual-Channel Automatic-Regulations Systems with Antisymmetric Cross Connections, A. A. Krasovs (10 pp, 12 figs).

Systems of this type are encountered, for example, in angle tracking or in gyro verticals, where identical servo loops are used for the individual variables. These loops are sometimes independent and under other conditions (such as phase shifts in the set-point voltage or gyroscopic torques due to the rotating elements) they are coupled. The author classifies these couplings and introduces transfer functions with complex coefficients for the analysis of the system and for calculation of the stability margin and of the critical gain. It is shown that dual-channel systems offer greater opportunities for the synthesis of corrective networks than single-channel systems, and that the use of the cross connections can greatly extend the stability region.

SPEED REGULATION

Speed Regulation of Three-Phase Induction Motor Using a Bridge-Type Transducer, V. S. Kuleba S. M. Domanitski, (8 pp, 10 figs).

This control is suitable for low-power motors. A ridge circuit produces a voltage proportional to the motor speed; this voltage is amplified and controls a saturable reactor in the supply line to the motor. The method is thus usable for both squirrel-age and wound-rotor motors.

SWITCHING CIRCUITS

ethod for Synthesis of Switching Circuits for Com-utation and Control. G. N. Novarov (18 pp, 18 gs, 10 tables).

Abstract of a dissertation. Standard techniques nd the usual Boolean algebra are used, and the uthor claims his methods yield better results, for ome cases, than Shannon's earlier procedures.

MAGNETIC AMPLIFIERS

se of Derivative Feedback to Reduce the Time elay of Magnetic Amplifiers, O. I. Aven, (8 pp, 16 gs).

Describes various modifications of magnetic am-ifiers with derivative feedback, and suggests sim-ified techniques for the determination of the feed-ck-loop parameters. The effect of the feedback on e gain and on the time constant of the magnetic mplifier is discussed in detail, and experimental sults are given for several amplifiers.

NNOUNCEMENT

Massachusetts Institute of Technology has just announced t three Russian electronics journals, (among those regu-y reviewed by ELECTRONIC DESIGN) are to be trans-ed into English. This is made possible by a $70,000 nt from the National Science Foundation.

The M.I.T. Research Laboratory of Electronics had pro-ed this for the purpose of making available to Ameri-engineers, information about the progress and methods Russian electronics research.

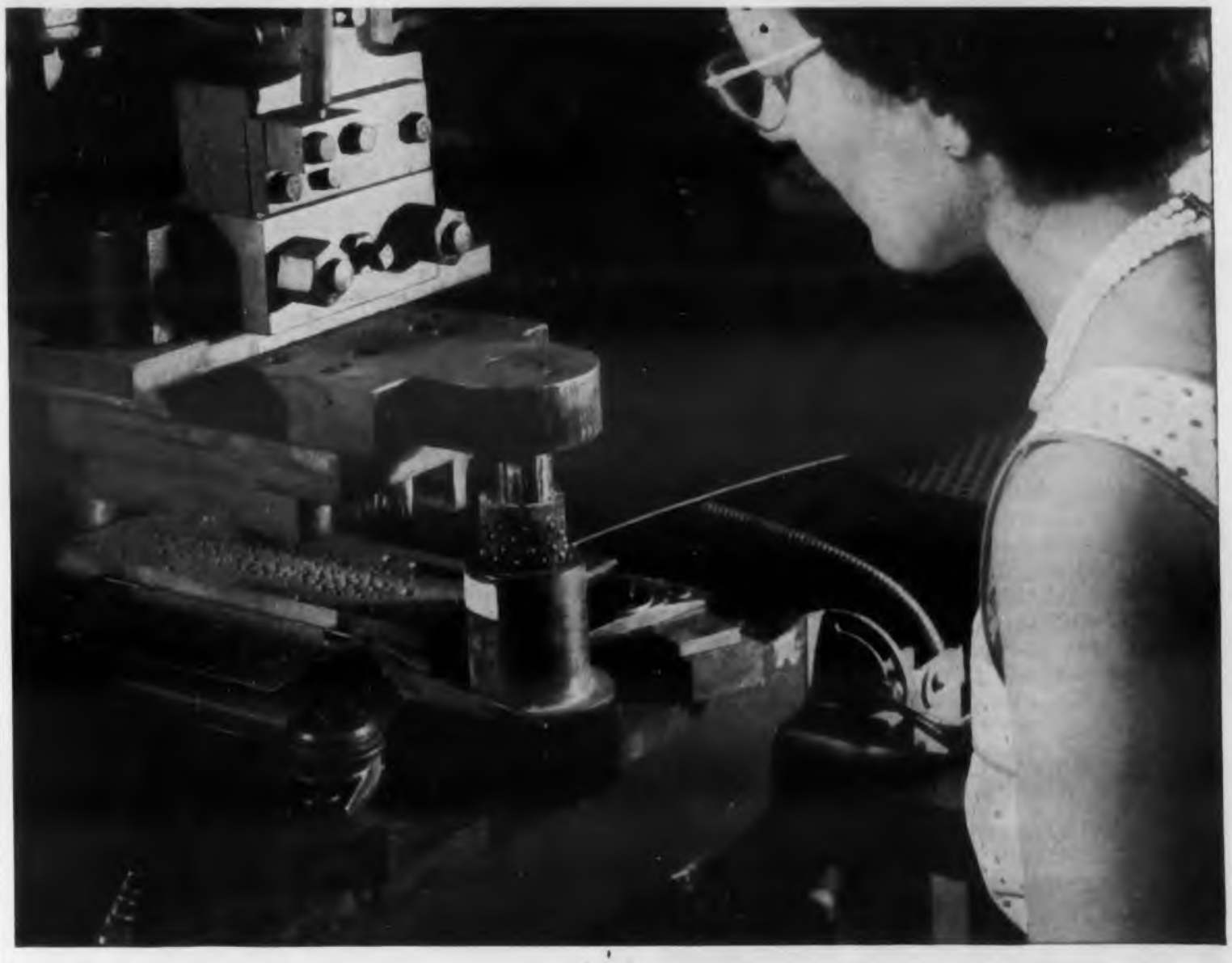
merican libraries and researchers will be able to sub-be to the English versions of the three journals, *Radio-nika i Elektronika, Radiotekhnika,* and *Elektrosviaz.* pproximately 3500 pages of the journals may be trans-d during 1957.

RATA

number of errors appeared in "What the Russians Are ing" in ELECTRONIC DESIGN, August 1, 1957.

e categories *Frequency Control,* and *Modulation* on 118 are from the magazine RADIO ENGINEERING. her *Articles In This Issue*" on pg 120 is associated with TRICAL COMMUNICATIONS, while "*Other Articles his Issue*" on pg 121 is properly associated with RADIO INEERING AND ELECTRONICS.

r apologies for the inconvenience this may have ed our readers.



German Abstracts

A Network Theorem

IF THE driving point impedance of a linear network is Z and the current flowing into the input terminals is I then the current I_b which flows in any branch whose impedance is Z_b is related to the driving point impedance and the input current through the formula

$$I_b^2 = I^2 \frac{\partial Z}{\partial Z_b} \qquad (1)$$

This formula is proved in the original article by straightforward application of the mesh equations for any linear network. This generalized current division thereon requires only that the driving point impedance function be expressed with Z_b as the variable. It is sometimes possible to use the converse of the formula to formulate the driving point impedance if the other functions are known. Thus

$$Z = \int (I_b^2/I^2)\, dZ_b + F \qquad (2)$$

where F, which depends on all impedance except Z_b, can sometimes be evaluated from open or short circuit conditions (Z_b infinite or zero). In terms of the voltage at the input terminals the formula becomes:

$$I_b^2 = V^2 \frac{\partial (-1/Z)}{\partial Z_b} \qquad (3)$$

The voltage across any branch, V_b is related to the voltage at the input terminals through the formul

$$V_b^2 = V^2 \frac{\partial Y}{\partial Y_b} \qquad (4$$

where Y and Y_b are the driving point and branch ad mittances respectively.

As an example consider the Wheatstone bridg circuit shown in the Figure has a driving point im pedance

$$Z = \frac{Z_1Z_2\,(Z_3+Z_4) + Z_3Z_4\,(Z_1+Z_2) + Z_5\,(Z_1+Z_3)\,(Z_2+Z}{(Z_1+Z_2)\,(Z_3+Z_4) + Z_5\,(Z_1+Z_2+Z_3+Z_4)}$$

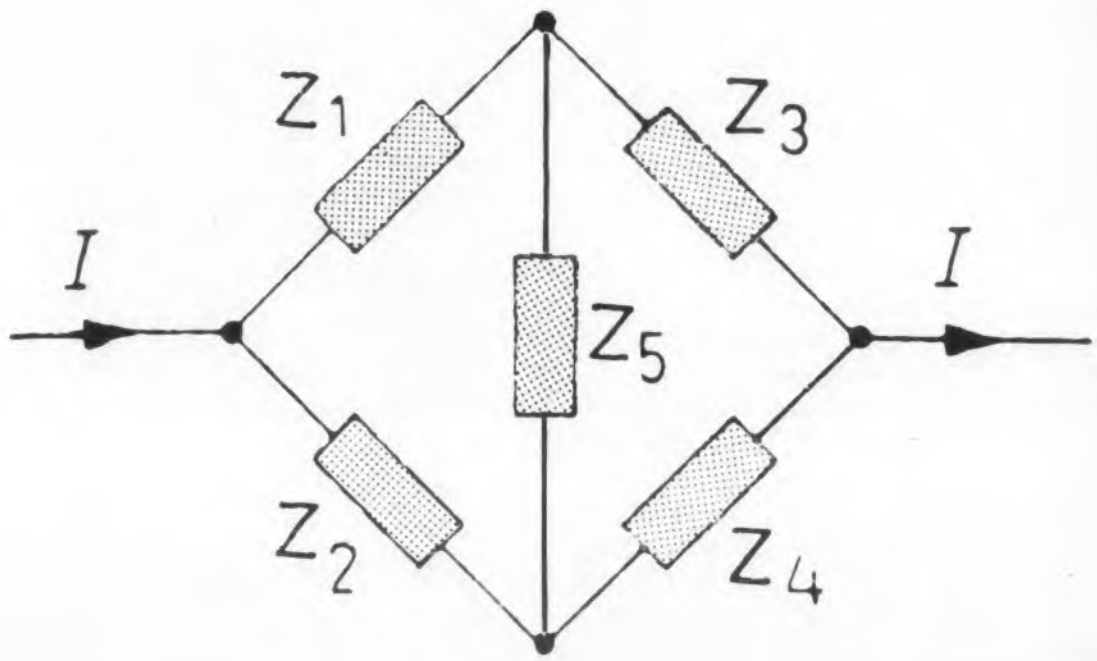
The current in Z_5, L_5 is given by application of th basic formula

$$I_5 = I\sqrt{\frac{\partial Z}{\partial Z_5}}$$

as

$$I_5 = I \cdot \frac{Z_2Z_3 - Z_1Z_4}{D}$$

where D is the denominator function of the drivi point impedance. *(Abstracted from an article b Joannis (Jannulis) Vratsanos,* Archiv der Ele trischen Uebertragung, *Vol. 11, No. 2, Febru 1957, pp 76-80).*



Survey Of Microwave Tubes

MICROWAVE tubes, for the purpose of this survey are defined as those tubes for which the transit time of the electrons, τ, has appreciable effect on the operation of the tube. In particular those tubes with which the angle which corresponds to the transit time exceeds 0.3 radians ($\omega\tau \geq 0.3$) are designated as microwave tubes. Two types of such tubes may be distinguished. They are the "disc seal" or "lighthouse" tubes and the "transit-time" or "velocity controlled" tubes. The present article deals with the disc-seal type tubes.

The upper frequency limit of conventional triodes is determined by the inductance of the lead-in wires and the interelectrode capacitance. The inductive effects are eliminated by using discs as lead-in "wires." The upper frequency limit of a disc-seal tube is determined by the transit time of the electron beam in the cathode-grid region. The highest frequency achieved with such tubes has been 10 KMcps.

Disc seal type tubes are constructed so that they can be integrally incorporated in coaxial systems. While in low frequency tubes the cathode is generally grounded, in microwave triodes the grid is grounded. Not only does this permit the incorporation in a coaxial structure but the input admittance variation with transit time is more favorable. Since the gain of the tube is inversely proportional to the input admittance, the grounded grid connection gives favorable gain characteristics.

There is overlap in the frequency spectrum so that there is a region where both types of microwave tubes can be used. The disc seal type tubes have the advantage of wide band operation and comparatively low voltage supply requirements. The efficiency however decreases with increasing frequency; 10 per cent is a typical value at 10 cm. Power output has the magnitudes between 10 mw and 10 w.

The original paper also describes the details of construction and the problems associated with the larger grid-wire spacing in disc-seal type tubes. A particularly complete bibliography consisting of 58 references is included. *(Abstracted from an article by R. Mueller and W. Stetter,* Electronische Rundschau, *Vol. 11, No. 6, June, 1957, pp 168-171.)*

Abstract

A NEW approach to modular construction to solve the problem of adapting hand wired turret type modules to printed circuitry: self-supporting structural columns made out of the printed circuit boards themselves are used. From both a manufacturing and a structural point of view, the cross or *plus* shape shown in Fig. 1 is optimum. It is formed by two printed wiring boards of any standard material, interlocking at right angles by means of matching slots in the center. In a sense this is a third dimension in printed circuitry. One or both ends of the column interlock with other circuitry such as the tube socket support shown at the top of Fig. 1, or the octal plug support at the bottom may be permanently connected to other circuit boards.

The "Plus Module" has a number of interesting features from a manufacturing point of view. It uses standard printed circuit materials and techniques and standard components. The printed wiring boards can be assembled and dip soldered while flat, by existing standard automatic equipment. This avoids the serious problems that arise in designing and building special equipment.

After the individual boards are assembled and dip soldered, they are interlocked and any cross-overs from one board to the other are soldered. This includes the connections from the tube socket board and the base plug board. After dip soldering this is an easy job; the solder flows together very readily. Other possible approaches are *1.* the use of selective dip soldering; *2.* flowing molten solder down the corner where the connections are to be made; *3.* use of a heat torch with a blast of heated air or gas, at 450-500 F on the joint.

After the cross-over points are soldered, the whole structure is reinforced by flowing an epoxy cement down all of the corners. The number of contacts on existing plug connectors, such as the standard octal, is limited and the mechanical support not all that could be desired. A new plug-in base was designed (Fig. 2). The *Plus* base provides up to 32 contacts coming out of the module using double side circuit boards or 16 using single side foil. Connections on the boards are made to circuit tabs just as with the standard type of flat board connectors. This base also provides support out to the edges of the boards and makes for good mechanical strength.

3-D Printed Circuit Module

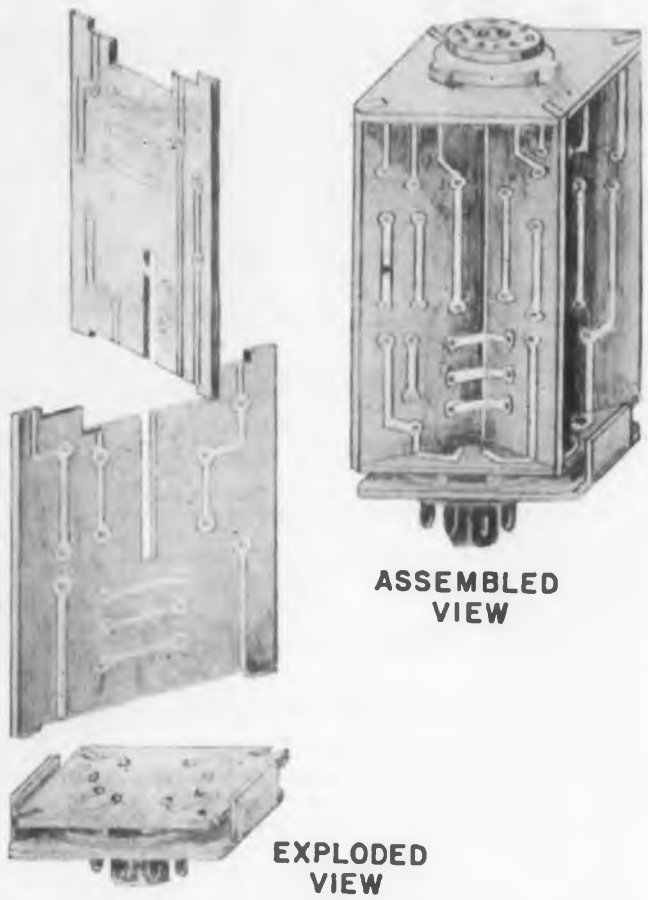
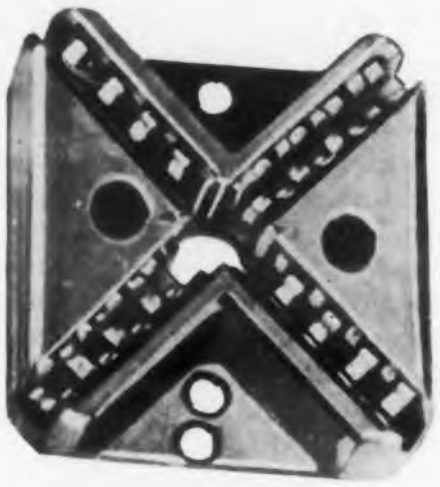


Fig. 1. *Plus* or cross-shaped printed circuit module is self-supporting and easy to manufacture. Space factor is comparable to flat printed circuit boards using minimum practical spacing.

Fig. 2. Base designed for installation of printed circuit module. Using double-side printing techniques, base provides 32 outlets, single-side 16.



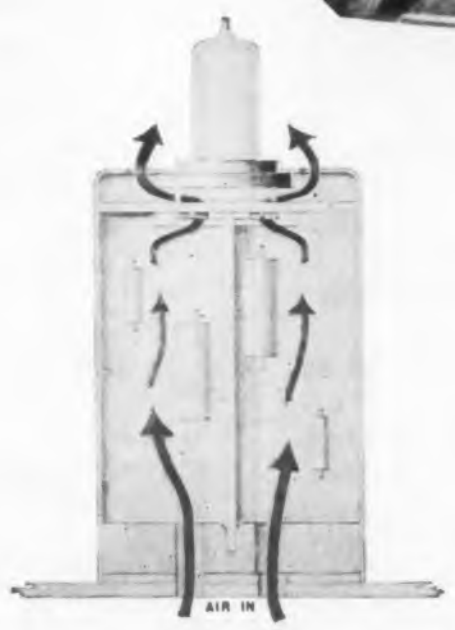


Fig. 3. Forced or convection air circulation in *Plus* module.

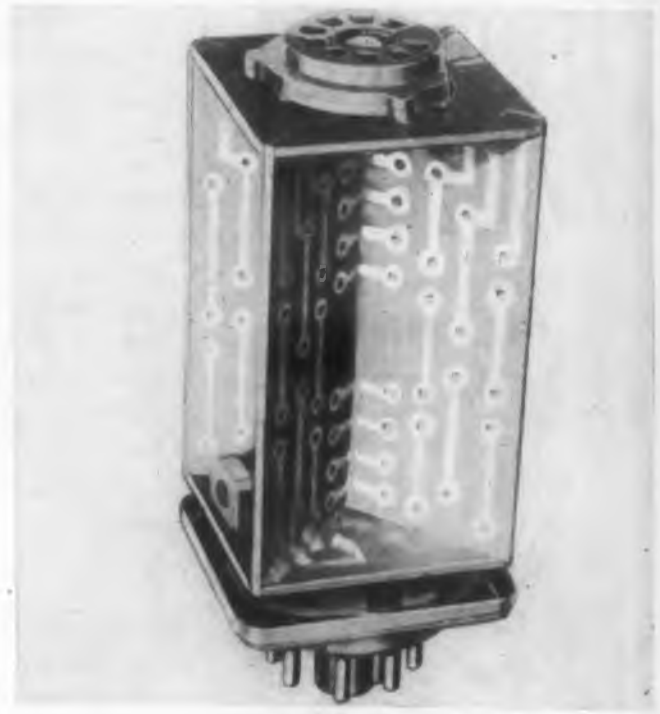


Fig. 4. Lab model of *Plus* printed circuit element provides design engineer with an experimental circuit layout. Circuits can be completed with a drop of solder and the addition of components.

Use of the *Plus* base eliminates a mounting board for the bottom octal plug and the soldering of the plug and base to the module. A vent hole in the center is provided and the channel ends opened, to avoid trapping moisture under conditions of extreme humidity. If the module is canned, holes through the *Plus* base in each of the four segments permit connection air circulation for cooling (Fig. 3).

The spring contacts are made of beryllium copper and are gold plated. The contact tabs in the circuit boards are plated with nickel and rhodium. This gives a good combination of low contact resistance and long life.

Production of the printed circuit boards presents no special problems. They are printed either by the silk screen or photo-resist processes according to the line width, spacing and detail required. Short run techniques often make it practical to make the modules, even with special circuitry, in lots as small as 20 units at costs that are competitive with hand wired modules. Larger quantities, of course, show greater savings.

A laboratory model of the module (Fig. 4) was designed having a gridwork of vertical and horizontal circuit lines that can be tied together with components and jumpers to form circuits. The vertical lines at the top carry the numbers of the tube socket terminals to which they are attached. If an octal plug is used on the bottom, the lower vertical lines are numbered to correspond with the octal terminals. Horizontal lines in the center of each board provide for as many as eight cross-overs from one board to the other which can be completed with a drop of solder. Design engineers in this way can lay out experimental circuits.

The standard size module that fits the *Plus* base, and is generally used with the octal base, fits in a can 1-3/8 in. square and 2-3/4 in. high. This occupies 5.2 cu. in. The height can be increased or decreased quite easily and special sizes do not involve any very expensive tooling.

The space factor possible with the *Plus* modular construction works out quite well and is comparable to that of flat plug-in printed circuit boards using the minimum practical spacing. The boards use the diagonals of the square mounting space, so even with the use of shielding cans having a corner radius, two 1-3/4 in. boards will fit in the 1-3/8 in. square space. The structure is rigid and self supporting so no space is wasted or additional cost involved for supporting brackets or channels. The unsupported area is small enough so that warpage is not a problem. *Abstracted from* A Three Dimensional Modular Construction for Electronic Equipment *by Arthur C. Ansley, a paper presented at the First National Symposium on Production Techniques, June 1957.*

Standards and Specs

Sherman H. Hubelbank

Lubricants

MIL-L-17192C(Navy), General Specification for Lubrication Design, Lubricants, and Lubrication Information for Electronic Equipment, 15 March 1957

The selection and application of lubricants for electronic equipment, and the preparation of lubrication instructions is covered in this spec. Electronic equipment shall be designed to use as few lubricants as practicable. It shall be possible to lubricate the equipment quickly and conveniently. Due consideration shall be given to access, probable location and the number of tools and accessories required. Special consideration shall be given to relatively inaccessible units such as antenna pedestals and sonar transducers.

All points requiring periodic lubrication shall be conveniently accessible from the front of the unit. In general, the required bearing and gear parts shall be consolidated into the minimum number of grease or oiltight cases with only the operating shafts protruding through adequate seals. Cases too small for inspection covers shall be placed so that their removal for bench inspection would not necessitate the disturbance of any wiring except that fastened to the case.

Wherever possible, prelubricated, sealed-for-life bearings shall be used. Where use of sealed-for-life bearings is not practicable, double shielded, single shielded, or open-type bearings may be used, as applicable. Double shielded bearings are preferred to single shield or open type bearings and grease is preferred over oil.

Unless otherwise specified in the contract or order, all lubricating points shall have individual lubrication instruction plates affixed nearby. These plates shall specify the lubrication interval in hours or months, the specs for the lubricants, the amount to be applied, and any necessary cautions.

In addition to the lubrication information in the maintenance manuals and the lubrication plates, a bulk quantity of sets of lubrication charts shall be furnished in accordance with the bulk quantity of instruction books specified in the contract or order. Two sets of charts shall be furnished with each equipment. All lubrication charts shall be sent to the bureau or agency concerned for approval of content and material, and for the assignment of an identifying number. Each group, separately mounted unit, and accessory requiring lubrication shall have an individual lubrication chart or chart. As many charts as are necessary to indicate the lubrication points clearly shall be supplied.

Capacitors

MIL-C-19683(SHIPS), CAPACITOR, FIXED, CERAMIC-DIELECTRIC, DISC TYPE, 150° C, OPERATION, 4 MARCH 1957

This spec covers the detail requirements for disc-type, fixed ceramic-dielectric capacitors for 150° C operation for use in by-pass, filter, and noncritical coupling circuits. A typical type designation for a capacitor meeting this spec is CK50C150T.

Automation Stations

USA C37.2-1956, AUTOMATIC STATION CONTROL, SUPERVISORY, AND TELEMETERING EQUIPMENTS

This standard provides specs covering service conditions, ratings, definitions, temperature limitations, tests, suggested minimum protection to be provided, method of representing device contacts on drawings, and a list of function numbers. Copies of this standard are available from American Standards Association, 70 East 45th Street, New York 17, New York for $1.30 each.

Varnish

MIL-V-173A, MOISTURE- AND FUNGUS-RESISTANT VARNISH FOR THE TREATMENT OF COMMUNICATIONS, ELECTRONIC, AND ASSOCIATED EQUIPMENT, AMENDMENT 3, 22 JANUARY 1957

The type II classification varnish now contains 5 per cent salicylanilide instead of 5 per cent. The procedure for testing insulation resistance has been changed to require that both the coated and uncoated specimens be exposed to the atmosphere for seven days prior to testing, and tested while still in the specified atmosphere.

Resistors

MIL-R-19365A(SHIPS), RESISTORS, ADJUSTABLE, WIREWOUND, POWER, 13 FEBRUARY 1957

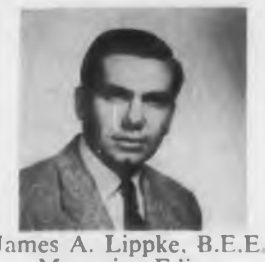
Power-type, wirewound, adjustable resistors for use in electronic, electrical, communication, and associated equipment are covered in this spec. These resistors have a resistance tolerance of plus and minus 5 and 10 per cent. The wattage ratings for these resistors is applicable only when the maximum obtainable resistance is engaged in the circuit. A typical type designation for a resistor meeting this spec is RX10G100J.

Insulating Tubing

MIL-I-631C, INSULATION, ELECTRICAL, SYNTHETIC-RESIN COMPOSITION, NONRIGID, AMENDMENT 2, 19 MARCH 1957

This amendment specifies that tubing furnished on reels shall be wound on the reels in such a manner that the tubing shall not be flattened or kinked to an extent that printing of circuit identification by machine, if desired, cannot be accomplished.

Edward E. Grazda, E.E.
Editor



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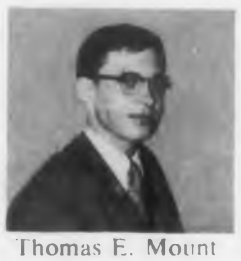

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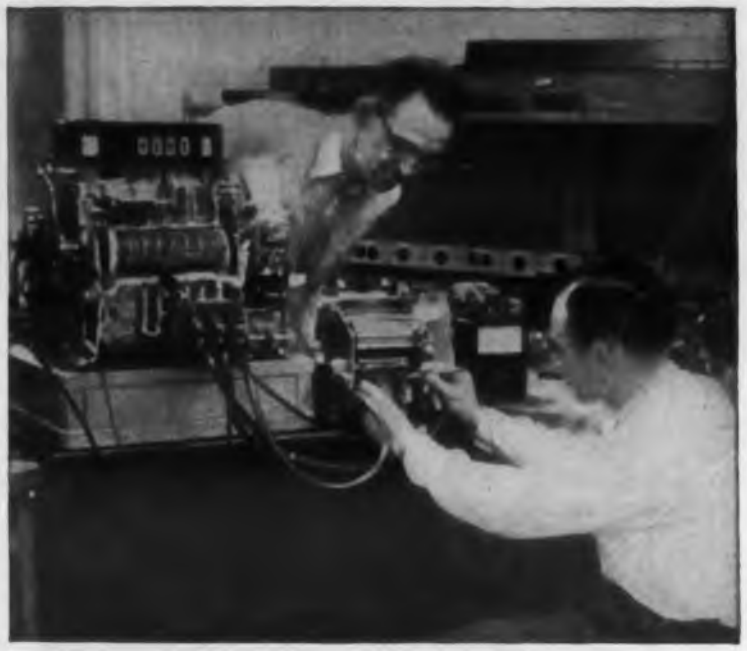
MECHANICAL ENGINEERS are using their skills in the design and development of new mechanisms required for business machines and for those mechanical products which are associated with electronic data processing equipment.



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September 15, 1957

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	10	20	30	40	50	60	70	80	90	300	310	320	330	340	350	360	370	380	390
1	11	21	31	41	51	61	71	81	91	301	311	321	331	341	351	361	371	381	391
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207	217	227	237	247	257	267	277	287	297	507	517	527	537	547					
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209	219	229	239	249	259	269	279	289	299	509	519	529	539	549					

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